GE Nuclear Energy

General Electric Company
P.O. Box 780, Wilmington, NC 28402
910 675-5000

June 5, 1998

Mr. Cass R. Chappell
Package Certification Section
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Chappell:

Subject: Application to (1) Reinstate the Provision for Loose Fuel Rods to be Shipped in the RA-3 Packaging, (2) Provide Revised Drawings with Improved Details and (3) Remove the RA-2 Metal Inner

Reference: (1) NRC Certificate of Compliance (COC) USA/4986/AF
Docket Number 71-4986
(2) COC 4986, Revision 35, 4/2/98

GE's Nuclear Energy Production facility in Wilmington, N.C. hereby requests that the referenced COC be amended to: (1) reinstate loose fuel rods as an authorized content, (2) provide revised drawings with improved details for both the RA-3 inner and outer packaging and (3) remove authorization in the COC for the RA-2 metal inner container.

This application replaces in its entirety all previous applications involving the shipment of loose rods, RA-2 metal inners and drawings referenced in the COC.

General Electric has determined that portions of the information contained in this application are proprietary in nature. Therefore, pursuant to 10CFR2.790(b), the required affidavit, Attachment 1, requests that the information in this submittal designated as proprietary be withheld from public disclosure.

Attachment 2 is the proprietary version of the criticality safety analysis for this submittal. The criticality safety analysis provided in this submittal demonstrates safety for the shipment of loose fuel rods placed in the five-inch, Schedule 40, stainless steel pipe (product container) or placed loose in the RA-3 inner channel assembly. This analysis replaces all previous analyses for loose fuel rods contained in the current consolidated application. This attachment is identified as tab number 8L and should be placed in the current consolidated application books for the RA that are marked as proprietary.

Change: LA 4 0
Ltr. Encl.

Attachment 3 is the non-proprietary version of the criticality safety analysis for this submittal. The proprietary information in this attachment has been deleted and an asterisk (*) has been placed in the right hand column adjacent to where the information has been removed. It is identified as tab number 7L and should be placed in all the current consolidated application books (both the proprietary and non-proprietary books).

Attachment 4 is a detailed explanation of the changes made to the drawings for the RA-3 inner and outer container. These two drawings and the new drawing for the product container are in Attachment 7 behind page 3-1 of this submittal.

Attachment 5 is a Description of the Changes in authorized content made as a result of this application.

Attachment 6 are the replacement pages for the Index that should be inserted in the appropriate section of the consolidated application book.

Attachment 7 contains the replacement pages to the consolidated application for: (1) changes to page 3-1 of Section 3.0, revising the RA-3 inner and outer drawings and adding a new drawing for the product container (these three drawings are found behind page 3-1), (2) changes to Section 6.0 describing the Operating Procedures, Acceptance Tests and Maintenance Program, and (3) page changes to Sections 7.0 and 8.0. An asterisk (*) has been placed in the right hand column where information has been changed or added.

GE no longer uses the RA-2 inner metal container and requests that it no longer be referenced in the COC.

The following is suggested changes and new wording that may be used in the Conditions of the COC.

Under 5.(a)(1) Packaging. Change "Model Nos.:" to "Model No.:" and delete the words "RA-2 and".

Under 5.(a)(3) Drawings. Delete reference to the RA-2 drawing 769E232, Revision 5, change the revision numbers of the remaining drawings and add the Product Container drawing as follows:
769E229, Revision 9, Model RA-3 Outer Container.
769E231, Revision 6, Model RA-3 Inner Container.
0028B98, Revision 0, Shipping Container Loose Fuel Rods

Create new condition 5.(a)(4) Product Container.
Five-inch, Schedule 40, stainless steel pipe fitted with screw type or flange closure. Container shall be vented in the event it contains material which decomposes at less than 1475 degrees F.

Create new Condition 5.(b)(1)(iv) found under the existing title "Type and form of material".

"Unirradiated UO2 fuel rods with a maximum U-235 enrichment of 5.0% by weight. The fuel rods are clad with zircaloy, incaloy, inconel or stainless steel in accordance with the provisions in the G.E. Supplement dated June 5, 1998.

Under 5.(b)(2) titled "Maximum quantity of material per package," number the existing item as (i), and create a new Condition 5.(b)(2)(ii) to read:

"For the contents described in 5.(b)(1)(iv):
Two (2) fuel bundles.
(A "bundle" is defined as an arrangement of rods which are either contained within a product container or shipped loose in each side (channel) of the RA-3 inner container.)"

The total number of loose fuel rods that may be placed in each channel of the RA-3 inner is 20 (20 on each side for a total of 40). If the total number of loose fuel rods to be shipped is greater than 20 on each side (channel) of the RA-3 inner, the product container described in 5.(a)(4) must be used.

There is no upper or lower limit for the number of fuel rods that may be placed in the product container specified in Condition 5.(a)(4). Also, if dunnage is used to fill the void space, the dunnage must be metal tubes welded shut on both ends with end plugs. Any number of these empty metal tubes may be placed in the product container.

A combination of loose fuel rods in a channel and fuel rods in the product container may not be shipped in a single RA-3 packaging.

Under 5.(c) reword the title to read: "Transport Index (TI) and Other Restrictions for Criticality Control", and replace the wording as follows:

(1) for contents described in 5.(b)(1)(i), (ii) and (iii), the minimum TI to be shown on the label for nuclear criticality control is: 0.4

(2) for loose fuel rods placed in each side (channel) of the RA-3 inner container as described in 5.(b)(1)(iv) and 5.(b)(2)(ii), the TI to be shown on the label for nuclear criticality control is: 0.0

(3) for loose fuel rods placed in the product container as described in 5.(b)(1)(iv), and 5.(b)(2)(ii), the minimum TI to be shown on the label for nuclear criticality control is: 4.2

Create new Condition 9., and renumber the existing Conditions 9. through 12. as 11. through 13.

> New Condition 9. should read:
> "For contents described in 5.(b)(1)(iv), in lieu of the product container specified in 5(a)(4), the fuel rods may be bound with strapping at two or more locations for quality assurance purposes. No credit for strapping is taken in the criticality analysis, therefore, strapping is not required."

This supplement application should be referenced under References on the last page of the COC.

Ten (10) copies of this application are being provided for your use. Two of these copies have had the proprietary information removed and are so marked.

Please contact Rick Foleck on (910)675-6299 or me on (910) 675-5950 if you have any questions or would like to discuss this matter further.

Sincerely,

GE NUCLEAR ENERGY

Scott P. Murray
Manager
Facility Licensing

/zb
attachments

cc: SPM 98-010

Attachment 1

Affidavit of

Proprietary Information

GENERAL ELECTRIC COMPANY
(GE)

AFFIDAVIT

I, Charles M. Vaughan, being duly sworn, depose and state as follows:

(1) I am the Manager, Strategic Planning & Policies, at the GE Nuclear Energy Production facility in Wilmington, N.C., and have been delegated the function of reviewing the information described in paragraph 2 which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in portions of the letter to reinstate the provisions for loose rods to be shipped in the RA Packaging and other changes dated June 5, 1998, to Mr. Cass R. Chappell (NRC) from Mr. Scott P. Murray (GE), and has been identified as "GE COMPANY PROPRIETARY INFORMATION". The information contains details supporting an application for revision of radioactive material packaging NRC Certificate of Compliance USA/4986/AF.

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

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

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric 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 Electric, its customers, or its suppliers;

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

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

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraph (4)b., above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in (6) and (7) following. The information sought to be withheld has to the best of my knowledge and belief, consistently been held in confidence by GE, 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.

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

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

(8) The information identified in paragraph (2) is classified as proprietary because it contains the data and details of the analytical models used in performing the criticality safety calculations, the results of which are part of the justification of safety.

The development of the criticality safety analyses was achieved at a significant cost to GE.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical, and NRC review costs comprise a substantial investment of time and money by GE.

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

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

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

STATE OF NORTH CAROLINA)
) SS:
COUNTY OF NEW HANOVER)

Charles M. Vaughan, being duly sworn, deposes and says:

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

Executed at Wilmington, North Carolina, this 5th day of June, 1998.

ROSA L. DAVIS
NOTARY
PUBLIC
NEW HANOVER COUNTY, NC

Charles M. Vaughan
General Electric Company

Subscribed and sworn before me this 5th day of June, 1998.

Notary Public, State of North Carolina

My commission expires:

12-14-2002

GE COMPANY PROPRIETARY INFORMATION

HAS BEEN REMOVED FROM THIS SUBMITTAL

GE Nuclear Energy

General Electric Company
P.O. Box 780, Wilmington, NC 28402
910 675-5000

June 5, 1998

Mr. Cass R. Chappell
Package Certification Section
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Chappell:

Subject: Application to (1) Reinstate the Provision for Loose Fuel Rods to be Shipped in the RA-3 Packaging, (2) Provide Revised Drawings with Improved Details and (3) Remove the RA-2 Metal Inner

Reference: (1) NRC Certificate of Compliance (COC) USA/4986/AF Docket Number 71-4986
(2) COC 4986, Revision 35, 4/2/98

GE's Nuclear Energy Production facility in Wilmington, N.C. hereby requests that the referenced COC be amended to: (1) reinstate loose fuel rods as an authorized content, (2) provide revised drawings with improved details for both the RA-3 inner and outer packaging and (3) remove authorization in the COC for the RA-2 metal inner container.

This application replaces in its entirety all previous applications involving the shipment of loose rods, RA-2 metal inners and drawings referenced in the COC.

General Electric has determined that portions of the information contained in this application are proprietary in nature. Therefore, pursuant to 10CFR2.790(b), the required affidavit, Attachment 1, requests that the information in this submittal designated as proprietary be withheld from public disclosure.

Attachment 2 is the proprietary version of the criticality safety analysis for this submittal. The criticality safety analysis provided in this submittal demonstrates safety for the shipment of loose fuel rods placed in the five-inch, Schedule 40, stainless steel pipe (product container) or placed loose in the RA-3 inner channel assembly. This analysis replaces all previous analyses for loose fuel rods contained in the current consolidated application. This attachment is identified as tab number 8L and should be placed in the current consolidated application books for the RA that are marked as proprietary.

Attachment 3 is the non-proprietary version of the criticality safety analysis for this submittal. The proprietary information in this attachment has been deleted and an asterisk (*) has been placed in the right hand column adjacent to where the information has been removed. It is identified as tab number 7L and should be placed in all the current consolidated application books (both the proprietary and non-proprietary books).

Attachment 4 is a detailed explanation of the changes made to the drawings for the RA-3 inner and outer container. These two drawings and the new drawing for the product container are in Attachment 7 behind page 3-1 of this submittal.

Attachment 5 is a Description of the Changes in authorized content made as a result of this application.

Attachment 6 are the replacement pages for the Index that should be inserted in the appropriate section of the consolidated application book.

Attachment 7 contains the replacement pages to the consolidated application for: (1) changes to page 3-1 of Section 3.0, revising the RA-3 inner and outer drawings and adding a new drawing for the product container (these three drawings are found behind page 3-1), (2) changes to Section 6.0 describing the Operating Procedures, Acceptance Tests and Maintenance Program, and (3) page changes to Sections 7.0 and 8.0. An asterisk (*) has been placed in the right hand column where information has been changed or added.

GE no longer uses the RA-2 inner metal container and requests that it no longer be referenced in the COC.

The following is suggested changes and new wording that may be used in the Conditions of the COC.

Under 5.(a)(1) Packaging. Change "Model Nos.:" to "Model No.:" and delete the words "RA-2 and".

Under 5.(a)(3) Drawings. Delete reference to the RA-2 drawing 769E232, Revision 5, change the revision numbers of the remaining drawings and add the Product Container drawing as follows:
769E229, Revision 9, Model RA-3 Outer Container.
769E231, Revision 6, Model RA-3 Inner Container.
0028B98, Revision 0, Shipping Container Loose Fuel Rods

Create new condition 5.(a)(4) Product Container.
Five-inch, Schedule 40, stainless steel pipe fitted with screw type or flange closure. Container shall be vented in the event it contains material which decomposes at less than 1475 degrees F.

Create new Condition 5.(b)(1)(iv) found under the existing title "Type and form of material".

"Unirradiated UO2 fuel rods with a maximum U-235 enrichment of 5.0% by weight. The fuel rods are clad with zircaloy, incaloy, inconel or stainless steel in accordance with the provisions in the G.E. Supplement dated June 5, 1998.

Under 5.(b)(2) titled "Maximum quantity of material per package," number the existing item as (i), and create a new Condition 5.(b)(2)(ii) to read:

"For the contents described in 5.(b)(1)(iv):
Two (2) fuel bundles.
(A "bundle" is defined as an arrangement of rods which are either contained within a product container or shipped loose in each side (channel) of the RA-3 inner container.)"

The total number of loose fuel rods that may be placed in each channel of the RA-3 inner is 20 (20 on each side for a total of 40). If the total number of loose fuel rods to be shipped is greater than 20 on each side (channel) of the RA-3 inner, the product container described in 5.(a)(4) must be used.

There is no upper or lower limit for the number of fuel rods that may be placed in the product container specified in Condition 5.(a)(4). Also, if dunnage is used to fill the void space, the dunnage must be metal tubes welded shut on both ends with end plugs. Any number of these empty metal tubes may be placed in the product container.

A combination of loose fuel rods in a channel and fuel rods in the product container may not be shipped in a single RA-3 packaging.

Under 5.(c) reword the title to read: "Transport Index (TI) and Other Restrictions for Criticality Control", and replace the wording as follows:

(1) for contents described in 5.(b)(1)(i), (ii) and (iii), the minimum TI to be shown on the label for nuclear criticality control is: 0.4

(2) for loose fuel rods placed in each side (channel) of the RA-3 inner container as described in 5.(b)(1)(iv) and 5.(b)(2)(ii), the TI to be shown on the label for nuclear criticality control is: 0.0

(3) for loose fuel rods placed in the product container as described in 5.(b)(1)(iv), and 5.(b)(2)(ii), the minimum TI to be shown on the label for nuclear criticality control is: 4.2

Create new Condition 9., and renumber the existing Conditions 9. through 12. as 11. through 13.

> New Condition 9. should read:
> "For contents described in 5.(b)(1)(iv), in lieu of the product container specified in 5(a)(4), the fuel rods may be bound with strapping at two or more locations for quality assurance purposes. No credit for strapping is taken in the criticality analysis, therefore, strapping is not required."

This supplement application should be referenced under References on the last page of the COC.

Ten (10) copies of this application are being provided for your use. Two of these copies have had the proprietary information removed and are so marked.

Please contact Rick Foleck on (910)675-6299 or me on (910) 675-5950 if you have any questions or would like to discuss this matter further.

Sincerely,

GE NUCLEAR ENERGY

Scott P. Murray
Manager
Facility Licensing

/zb
attachments

cc: SPM 98-010

Attachment 1

Affidavit of

Proprietary Information

GENERAL ELECTRIC COMPANY
(GE)

AFFIDAVIT

I, Charles M. Vaughan, being duly sworn, depose and state as follows:

(1) I am the Manager, Strategic Planning & Policies, at the GE Nuclear Energy Production facility in Wilmington, N.C., and have been delegated the function of reviewing the information described in paragraph 2 which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in portions of the letter to reinstate the provisions for loose rods to be shipped in the RA Packaging and other changes dated June 5, 1998, to Mr. Cass R. Chappell (NRC) from Mr. Scott P. Murray (GE), and has been identified as "GE COMPANY PROPRIETARY INFORMATION". The information contains details supporting an application for revision of radioactive material packaging NRC Certificate of Compliance USA/4986/AF.

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

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

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric 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 Electric, its customers, or its suppliers;

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

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

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraph (4)b., above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in (6) and (7) following. The information sought to be withheld has to the best of my knowledge and belief, consistently been held in confidence by GE, 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.

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

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

(8) The information identified in paragraph (2) is classified as proprietary because it contains the data and details of the analytical models used in performing the criticality safety calculations, the results of which are part of the justification of safety.

The development of the criticality safety analyses was achieved at a significant cost to GE.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical, and NRC review costs comprise a substantial investment of time and money by GE.

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

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

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

STATE OF NORTH CAROLINA)
) SS:
COUNTY OF NEW HANOVER)

Charles M. Vaughan, being duly sworn, deposes and says:

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

Executed at Wilmington, North Carolina, this 5th day of June, 1998.

ROSA L. DAVIS
NOTARY PUBLIC
NEW HANOVER COUNTY, NC

Charles M. Vaughan
Charles M. Vaughan
General Electric Company

Subscribed and sworn before me this 5th day of June, 1998.

Notary Public, State of North Carolina

My commission expires:

12-14-2002

Attachment 2

Proprietary Version of the "Criticality Safety Evaluation -
RA-3 Fuel Bundle Contents" Dated 6/5/98

Attachment 3

Non-Proprietary Version of the "Criticality Safety Evaluation - RA-3 Fuel Bundle Contents" Dated 6/5/98

(An asterisk (*) has been placed in the right hand column adjacent to where the information has been removed.)

CRITICALITY SAFETY EVALUATION
RA-3 FUEL BUNDLE CONTENTS

1. GENERAL DESCRIPTION

The RA-3 transport package consists of a wooden outer container surrounding a carbon steel inner container holding one or two fuel bundles. A fuel bundle may be either a nuclear fuel assembly or an accumulation of loose fuel rods. Loose fuel rods may be transported in accumulations of no more than 20 rods per bundle which may be held together by metal bands or other equivalent fasteners. Accumulations of more than 20 fuel rods per bundle must be shipped within 5 inch Schedule 40 304L stainless steel product containers as described in the following sections in this evaluation.

In this evaluation there is no requirement to fill the empty space in either the channel assembly or the product container, but quality requirements may dictate filling the empty space. It is important that anything used to fill the empty space is not a more effective moderator than water. The preferred method for filling the empty space is to use empty sealed rods.

The maximum pellet enrichment in loose rods covered by this evaluation is 5.00 wt % U-235. The RA-3 shipping container with loose rods is a Type A fissile package with the following restrictions:

Product container	not required	required
Maximum number of fuel rods per bundle	20	> 20
Allowable number of packages, N	infinite	12
Transport Index	0.0	4.2

2. PACKAGE DESCRIPTION

2.1 CONTENTS

The RA-3 may be used to transport up to two fuel bundles each containing unirradiated uranium dioxide pellets. The pellets have a nominal outside diameter between 0.340 and 0.515 inch. The maximum fuel pellet enrichment is 5.00 weight percent U-235. Typical fuel rod dimensions are shown in Table 1.

Table 1 Fuel rod dimensions

Rod type	Pellet outer diameter (inch)	Pellet-clad gap (inch)	Clad thickness (inch)
10 X 10	0.346	0.006	0.023
9 X 9	0.377	0.0065	0.025
8 X 8	0.411	0.007	0.029
7 X 7	0.508	0.0055	0.030

2.2 PACKAGING

The packaging consists of the zircaloy or stainless steel fuel rods that contain the fuel pellets, product container (DWG No. 0028B98), RA-3 inner shipping container (DWG No. 769E231), RA-3 outer shipping container (DWG No. 769E229).

2.2.1 Fuel Rods

Pellets and end plugs are contained in fuel rods up to 174 inches (441.96 cm) with dimensions in the range indicated in Table 1. The composition and atom densities of the tubes and other package materials is given in Table 6.2.

The fuel rods are sealed at both ends with zirconium or stainless steel plugs that are welded in place. The structural evaluation has shown that the fuel rods remain intact, and the pellets remain inside the fuel rod, under normal conditions of transport and hypothetical accident conditions.

For transport in the RA-3 container the fuel rods are sheathed in a 0.004 inch (0.010 mm) nominal thickness plastic sleeve and loaded directly into the inner container channel assembly or product container. Empty space in the channel assembly is filled with ethafoam, polyethylene, or wood packaging and empty space in the product container is usually filled with empty fuel tubes fitted with end plugs welded at both ends. A maximum of one bundle may be loaded into each channel in the channel assembly within the RA-3 inner container.

2.2.2 Product container

The product container is detailed in Drawing No. 0028B98. For the purpose of general discussion in this evaluation, the product container is a pipe that is fabricated from 5-inch, Schedule 40 304 stainless steel. The outside diameter of the pipe is 5.563 inches (141.30 mm) and the nominal wall thickness is 0.258 inches (6.55 mm) per ASTM Specification A 731/A 731M. The minimum wall thickness is 0.226 inches (5.74 mm) per ASTM Specification
A 530/A530M. Both ends of the pipe are fitted with a 6.50 inch square, 0.50 inch thick 304 stainless steel plate flange and cover. The pipe length is 167.00 inches from flange to flange. Covers are fastened to each flanged end with four 5/16-18 x 1.50 inch 304 stainless steel bolts and hex nuts. A collar for lifting is installed at two positions typically 6.00 from each end of the pipe. One of the covers is fitted with a breather valve .

2.2.3 RA-3 Inner Shipping Container

The product container is detailed in Drawing No. 769E231. For the purpose of general discussion in this evaluation, the inner container is fabricated from 1.5 mm (16 gauge) carbon steel. The inner container [18 1/8 inch (460 mm) by 11 7/16 inch (290 mm) by 182 15/16 inch (4647 mm)] is a welded construction. A channel assembly inside the inner container [6 7/8 inch (175 mm) by 6 7/8 inch (175 mm) by 179 1/4 inch (4553 mm)] retains up to two fuel bundles. The space between the fuel assembly and channel assembly is filled with 5/8 to ¾ inch (15.9 to 19.1 mm) ethafoam cushion and there is 1 inch (25.4 mm) ethafoam in the cover. There are ¾ inch (19 mm) diameter hole on 1 ¾ inch center-to-center spacing fabricated in each channel assembly side and top cover. The top cover and end cap are connected to the body through fourteen lugs on the cover and four lugs on each end cap using 3/8 - 16 UNC mild steel bolts, washers, and nuts. Gasket material that is either neoprene or isoprene 30-55 DURO seals the cover and end cap to the body and a breather plug is located in the end cap of the inner container.

2.2.4 RA-3 Outer Shipping Container

The product container is detailed in Drawing No. 769E229. For the purpose of general discussion in this evaluation, the transport package uses a wooden outer container (29 ¾ inch (756 mm) by 31inch (787 mm) by 206 ¾ inch (5251 mm). The RA-3 outer container exterior sides are constructed of ½ inch (13 mm) plywood and 2x4 inch (51x102 mm) thick pine or fir support beams. Honeycomb padding and ethafoam pads evenly spaced over the length of the container fill the space between the wooden over pack and inner container. A single inner shipping container is loaded into the outer shipping container.

Table 2. Material Specifications

Material	Density (g/cm3)	Constituent	Atomic density (atoms / b-cm)
U(5.00)O2	10.96	U235	1.237780E-03
		U238	2.322070E-02
		O	4.891270E-02
Water	1.000	H	6.686600E-02
		O	3.343300E-02
304 stainless steel	7.92	C	3.169100E-04
		Si	1.694000E-03
		Cr	1.647100E-02
		Fe	6.036000E-02
		Ni	6.483400E-03
		Mn	1.732100E-03
High density polyethylene	0.92	H	8.293800E-02
		C	4.146900E-02
Ethafoam	0.035	H	3.030000E-03
		C	1.515000E-03
Honeycomb	0.45	H	3.013100E-03
		C	2.092900E-03
		O	1.221970E-03
Wood	0.64	H	2.133400E-02
		C	1.185800E-02
		O	8.593300E-03
Zirconium	6.51	Zr	4.070910E-02
Carbon steel	7.82	C	3.921000E-03
		Fe	8.349100E-02

3. CRITICALITY SAFETY **ANALYSIS MODELS**

3.1.1 GENERAL MODEL

3.1.2 Dimensions

Figure 1a and 1b represent the vertical elevations of the RA-3 inner shipping container and Figure 2 represents the vertical elevations of the RA-3 outer shipping container both seen along vertical centerline of the package. A cross section of the package along A-A of Figure 2 is displayed in Figure 3. The figure's dimensions are used in the calculations.

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 1a Radial cross section of single-package inner container with rod bundle w/o product container

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 1.b Radial cross section of single-package inner container with rod bundle w/ product container

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 2. Radial cross section of single-package outer container

GEMPLOT: ra-3d **85/85/98** **up:** +Z across: +X units: **NA** slice: 2.2121

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 3. Axial cross section of single-package outer container

3.1.3 Materials

Figures 1a, 1b, 2 and 3 show the cross sections of the single-package models used for the calculations. Table 3a and 3b identify the regions and materials.

Table 3a Material specifications for Figures 1a and 1b - Inner shipping container

Material No.	Material	Density (g/cm3)	Model mass (kg)	Actual mass (kg)
1	UO2	10.96	2.9 - 640.5	2.8 - 506.6
2	High density polyethylene	0.92	.034 - 7.44	0.03 - 5.4
3	Carbon steel	7.82	191.1	198.1
4	Water	0.00 - 1.00	0.0 - 149	0.0
5	Wood	0.64	0.0	1.0
6	Carbon steel	0.85 x 7.82	50.1	49.9
7	Zr	6.51	0.5 - 111.4	.55 - 100.0
8	SS-304	7.92	84.5	102

Table 3b Material specifications for Figures 2 and 3 - Outer shipping container

Material No.	Material	Density (g/cm3)	Model mass (kg)	Actual mass (kg)
1	Ethafoam	0.5 x 0.035	4.65	6.94
2	Honeycomb	0.058	27.7	39.2
3	Wood	0.64	111.0	294.0
4	Carbon Steel	7.82	0	19.3

3.1.4 Models-Actual Package Differences

The contents evaluated were 20 loose fuel rods in each channel assembly and a variable number of fuel rods in 304L SS product container. The fuel rods evaluated have the minimum fuel pellet diameter which is conservative for 5.0 wt % enrichment in U-235. The number of loose fuel rods may actually be as few as one per shipping container, and approximately 90 fuel rods is the maximum that can actually be loaded in the 304L SS product container. Loose rods may actually be banded together using steel clamps, but the model does not assume the fuel rod spacing is constrained. Empty space in the 304L SS product container may be filled with sealed rods that contain no fuel pellets.

Loose rods are modeled at a variable pitch to determine the water-to-fuel ratio that results in a maximum package reactivity. Empty space in the model is filled with water at density varying from void condition to full density water to determine the optimum moderation. None of the packaging material actually used to fill space in the channel assembly or shipping container for loose rods is a more effective moderator than water, with the exception of polyethylene plastic sheath used to package individual rods. The 0.004 inch thick polyethylene sheath is modeled as a 0.010 inch thickness of high density polyethylene material in direct contact with the fuel rods. All fuel rods are modeled to contain uranium dioxide enriched to 5.00 wt % U-235, but any fuel rod containing fuel pellets up to an enrichment of 5.00 wt % may be loaded in the RA-3 package.

3.2 CONTENTS MODEL

Figures 1a and 1b show the package contents consisting of pellets in fuel rods as configured for both the single-package and package-array calculations. Each fuel rod is modeled as 174 inches long. Partial-loading configurations are allowed, as are variation in pellet enrichment up to 5.00 wt % U235. Partial loadings do not require further analysis because they are bounded by the more reactive configuration of full loading.

Fuel rod spacing is variable from about 1.08 cm to 3.83 cm depending on either the constraint of the inner container channel dimensions or the product container inner diameter for both normal conditions of transport and accident conditions. The space available for fuel rods in the channel assembly is approximately 6- 7/8 inches (175 mm x 175 mm). The maximum pitch for 20 fuel rods in a triangular lattice arrangement in the channel assembly is 3.83 cm. The fuel rod spacing for a triangular lattice in the product container is restricted to 2.33 cm. The product container has a nominal inside diameter of 5.047 inches (128 mm). Each fuel rod is encased in 0.010 inch (0.254 mm) thick polyethylene and the remaining space between the fuel rods is filled water. Water may leak into the product container, and the interstitial water density is varied to determine the most reactive condition.

3.3 SINGLE PACKAGES

The single package model is used to determine the most reactive configuration of contents material and optimum moderation. Water is a more effective reflector than the wood, honeycomb, and ethafoam materials in the outer shipping container; therefore, only close reflection by water on all sides of a single package consisting of the RA-3 inner shipping container is modeled. The only difference between the normal transport condition and hypothetical condition is the presence of the RA-3 outer container; therefore, the model for a single package for normal transport conditions and hypothetical accident conditions is the same.

The RA-3 package was subjected to the tests specified in 10 CFR 71.55, General requirements for all fissile material packages, with a fuel assembly contents, and the geometric form of the package was not substantially altered. No differences between the RA-3 package containing the fuel assembly and the RA-3 package containing loose fuel rods have been identified that invalidate application of RA-3 test conclusions to the RA-3 with the loose rods content.

3.4 PACKAGE ARRAYS

Rectangular parallelepiped packages such as the RA-3 may be shipped in a tightly packed square pitch configuration or shift to that configuration because of hypothetical accident conditions.

Two array model types are included in this evaluation. The first model type consists of an infinite array of close packed, square-pitch, undamaged inner and outer container consistent with the normal condition of transport. The second model type consists of a variable array size of close-packed damaged packages consisting of the inner container only. The array size is dimensioned for the second model to minimize surface-to-volume ratio. This results in the most reactive configuration because the overall dimensions minimize neutron leakage at the boundary. As required by 10 CFR 71.59, the damaged packages are evaluated with optimum interspersed hydrogenous moderation consistent with tests specified in 10 CFR 71.73, Hypothetical Accident Conditions.

4. METHOD OF ANALYSIS

GEMER, a proprietary General Electric company standard criticality analysis computer codes was used in the analysis of these computational models. All calculations were performed using Pentium processors running under Windows 95 or Windows NT.

4.1 COMPUTER CODE SYSTEM

GEMER is a Monte Carlo program which solves the neutron transport equation as an eigenvalue or a fixed source problem including the neutron shielding problem. GEMER adds an advanced geometry input package to the problem solving capability of the Monte Carlo code which is very similar to KENO.

4.2 CROSS SECTIONS AND CROSS-SECTION PROCESSING

GEMER uses cross sections processed from the ENDF/B-IV library tapes. These cross section are prepared in 190 group format and those in the resonance region may have the form of the resonance parameters or Doppler broadened multigroup cross section. Thermal scattering of hydrogen in water is represented by the $S(\alpha,\beta)$ data in the ENDF/B-IV library. The types of reactions considered in the Monte Carlo calculation are fission, elastic, inelastic, and (n,2n) reactions; the absorption is implicitly treated by reducing the neutron weight by the non-absorption probability on each collision.

4.3 CODE INPUT

All problems were started with a flat neutron distribution over the system, in the fissile material only. All problems were run for at least 110 generations of 1000 neutrons per generation, skipping the first five generations, for a total of 110,000 histories. Mirror reflection was applied to the orthogonal-plane boundaries of the single package model to simulate infinite array-package models. Close, full-density, 30.48 cm (12 inch) thick water reflector was modeled explicitly.

Figures 3a through 3d are sample input files. The files correspond to single packages and package arrays typically used in the calculation of k_{eff}.

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

CONTAINS *
GE COMPANY PROPRIETARY INFORMATION *
WITHHELD FROM PUBLIC DISCLOSURE *

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

Figure 3a. Single-package with bundle of rods, accident condition, file bnd9uful.in

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3b Single-package with product container, accident condition, file ra10p000.in

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

Figure 3b Single-package with product container, accident condition, file ra10p000.in (continued)

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3c Package Array with product container, normal condition, file ra10su7.in

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3d Package Array with product container, accident condition, file ra10-s7e.in

4.4 CONVERGENCE OF CALCULATIONS

Problem convergence was determined by examining plots of k_{eff} by generation run and skipped, as well as the final k_{eff} edit tables. No trends were observed either in k_{eff} by generation run over the last half of total generations or, correspondingly in k_{eff} by generation skipped over the first half of total generation. No sudden changes of greater than one standard deviation in k_{eff} by generation run or skipped, resulting from an abnormal k_{eff} generation, were found. Frequency distribution bar graphs appear to approximate normal distributions with single peaks and no significant outlying values.

5. VALIDATION OF CALCULATION METHOD

Validation of GEMER consists of performing calculation of benchmark experiments including the area of applicable to the low enriched fuel rod lattice. Bias for GEMER and the ENDF/B-IV library has been established for the area of applicability for the RA-3 package. The bias determined using a set of 79 critical benchmark experiments specific to UO2 rod lattices is no greater than 0.012 $(\Delta k_u + \beta)$ at a 99% confidence level. The area of applicability for the benchmark calculations are enrichment ranges from 1.29 to 9.83 weight percent U-235 and H/U-235 ratio 41 to 866.

Using a general equation for the upper safety limit (USL) and requirements of 10 CFR 71, calculations are considered subcritical, if the following condition is satisfied:

$$k_{eff} + 2\sigma \leq 0.95 - \Delta k_u + \beta$$
$$k_{eff} + 2\sigma \leq 0.938$$

6. CRITICALITY CALCULATIONS AND RESULTS

This evaluation demonstrates the subcriticality of a single package (Section 6.1) and an array of packages (Section 6.2) during normal conditions of transport and hypothetical accident conditions. The transport index (TI) is determined for criticality control (Section 6.3).

6.1 SINGLE PACKAGE

Calculations show that a single package remains subcritical under general requirements for fissile material packages for both normal conditions of transport and hypothetical accident conditions. The effect of increasing fuel rod pitch is evaluated to determine the most reactive contents for a single damaged package for two configurations of rod bundles. The first configuration is loose fuel rods in the channel assembly, and the second configuration is loose fuel rods in a product container. Full-density water is optimum for both content configurations.

Fuel rod pitch is directly related to water-to-fuel ratio within the contents. Optimum moderation for fuel rods occurs at a fuel rod pitch intermediate between a close packed lattice and the maximum lattice spacing possible within the constraint of the channel assembly or product container. The number of fuel rods in the product container is reduced to less than the actual capacity to obtain a maximum reactive contents.

The mass limit of 20 fuel rods determines the pitch at which the maximum reactivity occurs for rod bundles in the channel assembly without the product container. The geometry limit of the stainless steel pipe determines the pitch at which the maximum reactivity occurs for fuel rods loaded in a product container. The effect of moderation on reactivity of a single damaged package is displayed in Figure 4 for both content configurations. Table 4 summarizes the most reactive condition for a single package.

Table 4. Single-package calculation

Case	Description	$k_{eff} \pm \sigma$
bnd9uful	Optimally moderated, damaged package w/o product container (20 fuel rods)	0.55817 ± 0.00236
rasu7ful	Optimally moderated, damaged package w/ product container	0.57146 ± 0.00211

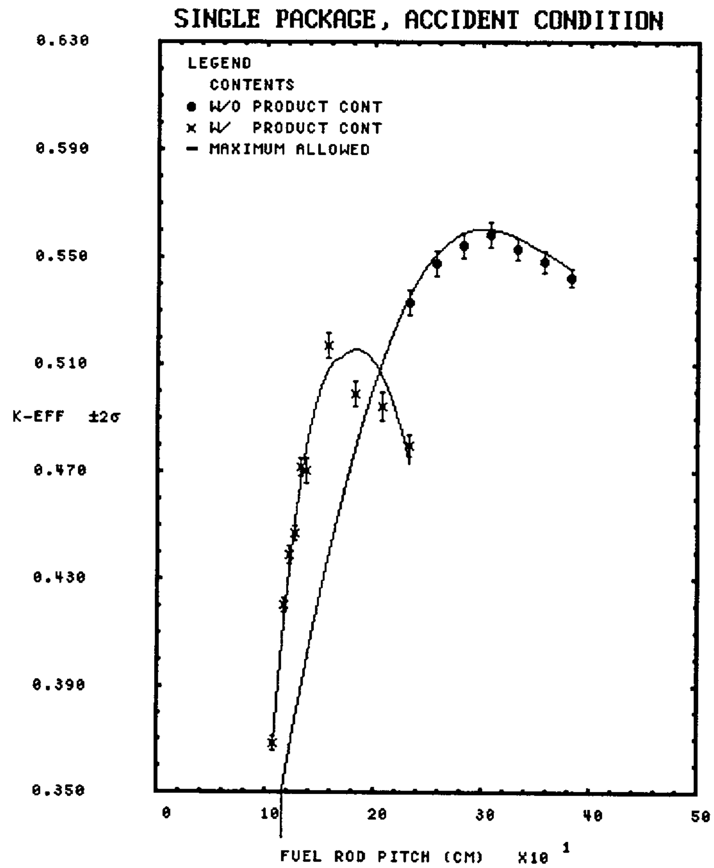

Figure 4 Typical reactivity, k_{eff}, vs contents moderation for single package

6.2 PACKAGE ARRAYS

The calculation results displayed in Table 5 demonstrate that an infinite array of packages is adequately subcritical under normal conditions of transport. The package arrays evaluated using the damaged single package are more reactive than those arrays using the undamaged single package. The accident condition array assumes the hypothetical accident condition for all packages.

The allowed number of damaged packages for the 20 fuel rod bundle without the product container is unlimited. The maximum allowed number of damaged packages with the product container contents is determined for a range fuel rod pitches within the product container. The number of rods in the product container decreases as the fuel rod pitch increases. Optimum moderation of the contents is full density water as demonstrated by the most single package calculations. But, void in the inner shipping package outside the product container results in maximum interaction between the contents of the single packages. Therefore, the package arrays are most reactive with no interstitial moderation outside the product container.

Table 5 summarizes the cases used to determine the maximum allowed number of damaged packages, 2N, for a range of fuel rod pitches. Fuel rod pitch corresponds to a specific number of rods that fit into the product container. The maximum allowed k_{eff} is the USL specified in Section 5.

Table 5. Results for array calculations

Case	Description		$k_{eff} \pm \sigma$
ra10b000	Infinite array, optimum moderation, undamaged package w/ product container		0.85872 ± 0.00255
bn12i125	Infinite array, optimum moderation, damaged package w/o product container		0.85271 ± 0.00179
ra10-s1	Damaged package,	10 x 15 x 1	0.92429 ± 0.00139
ra10-s1a	finite array,	8 x 12 x 1	0.90051 ± 0.00133
ra10-s1b	full water reflection,	6 x 9 x 1	0.85031 ± 0.00127
ra10-s1c	optimum moderation,	5 x 7 x 1	0.80441 ± 0.00154
ra10-s1d	w/ product container,	4 x 8 x 1	0.79575 ± 0.00148
ra10-s1e	fuel rod pitch 1.077 cm,	4 x 6 x 1	0.75885 ± 0.00200
ra10-s1f	no. fuel rods 109	4 x 5 x 1	0.72779 ± 0.00194
ra10-s2	Damaged package,	10 x 15 x 1	0.99215 ± 0.00152
ra10-s2a	finite array,	8 x 12 x 1	0.96575 ± 0.00153
ra10-s2b	full water reflection,	6 x 9 x 1	0.92001 ± 0.00152
ra10-s2c	optimum moderation,	5 x 7 x 1	0.87514 ± 0.00158
ra10-s2d	w/ product container,	4 x 8 x 1	0.86290 ± 0.00158
ra10-s2e	fuel rod pitch 1.177 cm,	4 x 6 x 1	0.82827 ± 0.00153
ra10-s2f	no. fuel rods 92	4 x 5 x 1	0.80381 ± 0.00231
ra10-s3	Damaged package,	10 x 15 x 1	1.01564 ± 0.00149
ra10-s3a	finite array,	8 x 12 x 1	0.99079 ± 0.00157
ra10-s3b	full water reflection,	6 x 9 x 1	0.94598 ± 0.00164
ra10-s3c	optimum moderation,	5 x 7 x 1	0.89884 ± 0.00159
ra10-s3d	w/ product container,	4 x 8 x 1	0.88773 ± 0.00151
ra10-s3e	fuel rod pitch 1.227 cm,	4 x 6 x 1	0.85655 ± 0.00163
ra10-s3f	no. fuel rods 84	4 x 5 x 1	0.83091 ± 0.00217

Table 5. Results for array calculations (continued)

ra10-s4	Damaged package,	10 x 15 x 1	1.02236 ± 0.00177
ra10-s4a	finite array,	8 x 12 x 1	0.99758 ± 0.00162
ra10-s4b	full water reflection,	6 x 9 x 1	0.95600 ± 0.00164
ra10-s4c	optimum moderation,	5 x 7 x 1	0.91137 ± 0.00162
ra10-s4d	w/ product container,	4 x 8 x 1	0.90418 ± 0.00176
ra10-s4e	fuel rod pitch 1.277 cm,	4 x 6 x 1	0.86651 ± 0.00161
ra10-s4f	no. fuel rods 76	4 x 5 x 1	0.84094 ± 0.00199
ra10-s5	Damaged package,	10 x 15 x 1	1.04891 ± 0.00155
ra10-s5a	finite array,	8 x 12 x 1	1.02520 ± 0.00164
ra10-s5b	full water reflection,	6 x 9 x 1	0.97702 ± 0.00157
ra10-s5c	optimum moderation,	5 x 7 x 1	0.93548 ± 0.00159
ra10-s5d	w/ product container,	4 x 8 x 1	0.93070 ± 0.00162
ra10-s5e	fuel rod pitch 1.327 cm,	4 x 6 x 1	0.89639 ± 0.00182
ra10-s5f	no. fuel rods 73	4 x 5 x 1	0.87062 ± 0.00199
ra10-s6	Damaged package,	10 x 15 x 1	1.08883 ± 0.00160
ra10-s6a	finite array,	8 x 12 x 1	1.06036 ± 0.00159
ra10-s6b	full water reflection,	6 x 9 x 1	1.01781 ± 0.00143
ra10-s6c	optimum moderation,	5 x 7 x 1	0.97167 ± 0.00155
ra10-s6d	w/ product container,	4 x 8 x 1	0.95890 ± 0.00186
ra10-s6e	fuel rod pitch 1.377 cm,	4 x 6 x 1	0.92932 ± 0.00223
ra10-s6f	no. fuel rods 75	4 x 5 x 1	0.90121 ± 0.00215
ra10-s7	Damaged package,	10 x 15 x 1	1.07766 ± 0.00193
ra10-s7a	finite array,	8 x 12 x 1	1.05544 ± 0.00230
ra10-s7b	full water reflection,	6 x 9 x 1	1.00542 ± 0.00213
ra10-s7c	optimum moderation,	5 x 7 x 1	0.96973 ± 0.00211
ra10-s7d	w/ product container,	4 x 8 x 1	0.95861 ± 0.00268
ra10-s7e	fuel rod pitch 1.477 cm,	4 x 6 x 1	0.92410 ± 0.00261
ra10-s7	no. fuel rods 55	4 x 5 x 1	0.89870 ± 0.00211
ra10-s8	Damaged package,	10 x 15 x 1	1.08508 ± 0.00147
ra10-s8a	finite array,	8 x 12 x 1	1.06262 ± 0.00146
ra10-s8b	full water reflection,	6 x 9 x 1	1.02191 ± 0.00167
ra10-s8c	optimum moderation,	5 x 7 x 1	0.98169 ± 0.00162
ra10-s8d	w/ product container,	4 x 8 x 1	0.96797 ± 0.00161
ra10-s8e	fuel rod pitch 1.577 cm,	4 x 6 x 1	0.93445 ± 0.00174
ra10-s8f	no. fuel rods 37	4 x 5 x 1	0.91320 ± 0.00159

Table 5. Results for array calculations (continued)

ra10-s9	Damaged package,	10 x 15 x 1	1.01056 ± 0.00202
ra10-s9a	finite array,	8 x 12 x 1	0.99237 ± 0.00205
ra10-s9b	full water reflection,	6 x 9 x 1	0.91668 ± 0.00192
ra10-s9c	optimum moderation,	5 x 7 x 1	0.91459 ± 0.00213
ra10-s9d	w/ product container,	4 x 8 x 1	0.90652 ± 0.00245
ra10-s9e	fuel rod pitch 1.827 cm,	4 x 6 x 1	0.88407 ± 0.00229
ra10-s9f	no. fuel rods 30	4 x 5 x 1	0.86219 ± 0.00214
ra10s10	Damaged package,	10 x 15 x 1	0.97282 ± 0.00225
ra10s10a	finite array,	8 x 12 x 1	0.95380 ± 0.00228
ra10s10b	full water reflection,	6 x 9 x 1	0.91668 ± 0.00192
ra10s10c	optimum moderation,	5 x 7 x 1	0.88515 ± 0.00225
ra10s10d	w/ product container,	4 x 8 x 1	0.87633 ± 0.00251
ra10s10e	fuel rod pitch 2.077 cm,	4 x 6 x 1	0.85097 ± 0.00253
ra10s10f	no. fuel rods 26	4 x 5 x 1	0.83855 ± 0.00223

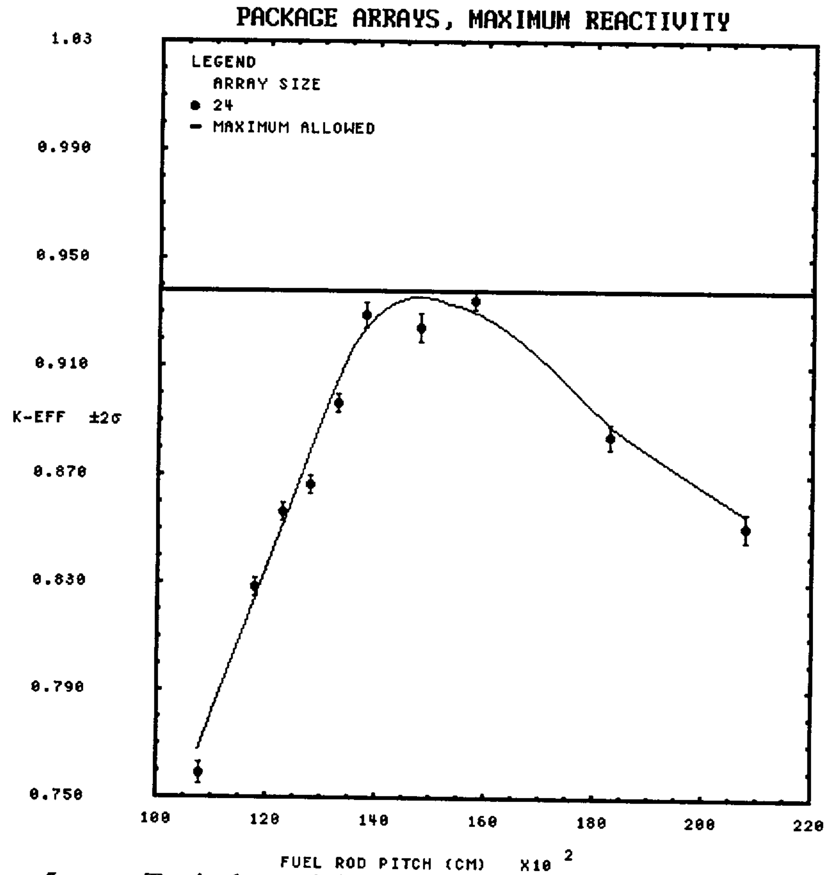

Figure 5a Typical reactivity, k_{eff}, vs moderation of product container for package array (4 x 6 x 1)

The k_{eff} results may be plotted for a specific array size to determine the optimum fuel rod pitch. Figure 5a displays a the relationship between k_{eff} and moderation typical for the package array with the product container. The optimum moderation occurs in at a fuel rod pitch 1.4 cm to 1.6 cm for any array size. This is consistent with the most reactive condition for a single package with the product container and typical of k_{eff} calculations or infinite fuel rod lattices.

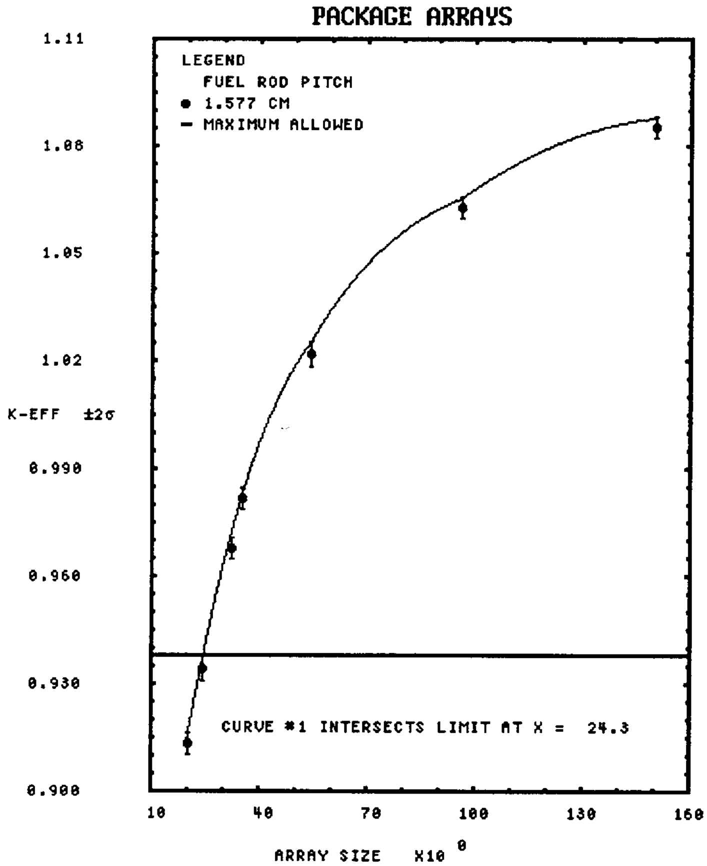

Figure 5b Typical reactivity, k_{eff}, vs array size for a product container moderation (fuel rod pitch 1.577 cm , 55 fuel rods)

The k_{eff} results for each array size are plotted to determine a maximum allowed value for 2N for a range of fuel rod pitches. Figure 5b displays a typical relationship between k_{eff} and array size for specific fuel rod pitch. The maximum allowed number of damaged packages, 2N, is about 26 for optimum moderation of the product container that occurs at a fuel rod pitch of 1.577 cm.

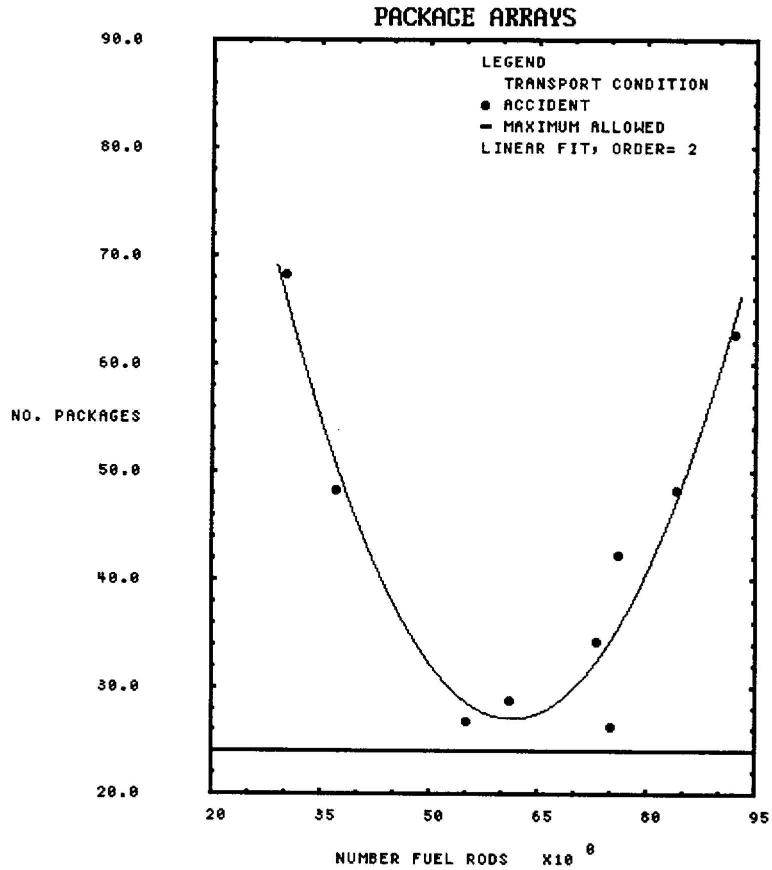

Figure 5c Maximum allowed number of damaged packages, 2N, with product container contents

Each value for 2N is plotted versus the number of fuel rods that corresponds to the value determined for a specific array size as shown in Figure 5b. This demonstrates that there is a maximum number of packages allowed for which the damaged array is subcritical independent of the number of fuel rods loaded in the product container. This maximum value for 2N is no less than 24 as shown in Figure 5c.

6.3 CRITICALITY SAFETY INDEX

The criticality safety index. (TI) for criticality control is determined by the number of packages that remain below the upper safety limit (USL). For normal conditions of transport, and infinite array of packages with either the rod bundle contents is subcritical. Therefore, the maximum allowed number of undamaged packages that may be in any arrangement is unlimited, and 5N is equal to infinity.

Under hypothetical accident conditions, an infinite number of packages with a bundle of 20 fuel rods loaded directly in the channel assembly is subcritical. Therefore, 2N is equal to infinity when the product container is not used. A maximum of only 24 damaged packages remain subcritical when the product container is used, and 2N is equal to 24 when the product container is used.

The transport indexes assigned to the RA-3 package with a rod bundle contents depends on the packaging used for the fuel rods. A TI = 0.0 may be assigned when the number of fuel rods is limited to 20 per side of the channel assembly for a total of 40 fuel rods per RA-3 package. However, a TI = 4.2 must be assigned when the product container is used, but there is no limit on the number of fuel rods loaded in the product container.

Attachment 4

Detailed Explanation of Changes Made to the
Drawings for the RA-3 Inner and Outer Container

DETAILED EXPLANATION OF CHANGES MADE TO THE DRAWINGS FOR THE RA-3 INNER AND OUTER CONTAINER

THE FOLLOWING IS A DESCRIPTION AND EXPLANATION OF THE CHANGES MADE TO THE RA-3 OUTER SHIPPING CONTAINER LICENSING DRAWING 769E229 REV. 9 .

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
1.	B-4	REV 8: ETHAFOAM PAD 3 X 18 X 20-1/2 SEE NOTE 4 REV 9: ETHAFOAM PAD 3 +/- ¼" THK X 18 +/- ½" WD. X 20-1/2 +/- ½" LG. TYP. 10 PLS. COVER AND BODY - SEE NOTE 4 **(TOLERANCED THE ETHAFOAM PADS AND SPECIFIED THE LOCATIONS)**
2.	B-4	REV 8: 3/8" DIA. BOLTS, NUTS, WASHERS, MILD CBN STEEL EA. LOCATION REV 9: 3/8" DIA. BOLTS, NUTS, WASHERS, MILD CBN STEEL EA. LOCATION (10 MM BOLTS, NUTS, WASHERS MAY BE SUBSTITUTED) **(PERMITS THE USE OF EQUIVALENT METRIC HARDWARE WHICH IS LARGER AND STRONGER THAN THE 3/8" HARDWARE AND IS PREFERRED OVERSEAS)**
3.	B-12	REV 8: DRAWING NOTE 1: ALL DIMENSIONS SHOWN ARE NOMINAL UNLESS OTHERWISE SPECIFIED. REV 9: DRAWING NOTE 1: ALL DIMENSIONS SHOWN ARE IN INCHES UNLESS OTHERWISE SPECIFIED. **(REFERENCE TO NOMINAL NOT NEEDED SINCE ALL DIMENSIONS ARE NOW TOLERANCED)**
4.	C-10	REV 9: ADDED NEW DRAWING NOTE 5: TABLE COMPARING DIMENSIONS OF WOOD MEMBERS AS NOTED ON THE DRAWING VERSUS THE ACTUAL DIMENSIONS. **(CLARIFIED THE ACTUAL SIZES OF WOOD MEMBERS VERSUS THEIR COMMON NOMENCLATURE)**
5.	H-2	REV 8: 1/8 THK CARBON STL 15 X 20-1/2
	G-2	REV 9: 1/8" MIN. THK. CARBON STL. 15" MIN. X 20" MIN. **(TOLERANCED THE SIZE OF THE STEEL PLATE)**

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
6.	H-3	DELETED: ETHAFOAM PAD 3 IN. THICK SEE NOTES 4
		(THE ETHAFOAM PADS ARE DESCRIBED IN CHANGE 1. ABOVE)
7.	D-9	REV 8: HONEYCOMB 3 IN THICK SEE NOTE 3
	C-8	REV 9: HONEYCOMB 3 +/- ¼ THICK SEE NOTE 3
		(TOLERANCED THE THICKNESS OF THE HONEYCOMB IN THE COVER OF THE CONTAINER)
8.	H-10	REV 8: ETHAFOAM PAD ½ X 12 X 18 SEE NOTES 4
	G-10	REV 9: ETHAFOAM PAD 3/8" MIN. THK. SEE NOTE 4 10 PLS.
		(TOLERANCED THE PAD THICKNESS, LENGTH AND WIDTH CONTROLLED ELSEWHERE ON THE DRAWING)
9.	H-2	ADDED NOTE: AN ADDITIONAL 5/8" MAX. THK. ETHAFOAM PAD X 11" MAX WD. MAY BE ADDED ON TOP OF EACH OF THE FIVE ETHAFOAM PADS IN THE BOTTOM OF THE CONTAINER.
		(ADDITIONAL PAD IS FOR REDUCING THE VIBRATION FREQUENCY OF INNER CONTAINER DURING TRANSPORTATION)
10.	L-8	REV 8: SKIDS, 4 X 4 (NOM) OAK
	I-8	REV 9: SKIDS 4 X 4 OAK 9 PLS.
		(CLARIFIED QUANTITY AND SIZE OF OAK SKIDS)
11.	M-7	DELETED NOTE: 3/8 DIA. BOLTS, NUTS, WASHERS, MILD CBN STL. (TYP)
		(BOLTS ARE CALLED OUT IN NOTE AT ZONE I-11)
12.	L-11	REV 7: 3/8 DIA. BOLTS,NUTS, WASHERS MILD CBN STL. (TYP)
	I-11	REV 8: 3/8 DIA. BOLTS,NUTS, WASHERS MILD CBN STL. (TYP) SIDES AND ENDS
		(SIMPLIFICATION OF CALLOUT FOR 3/8" BOLTS, NUTS AND WASHERS)

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
13.	J-4,L-7	REV 8: HONEYCOMB PAD, 2 IN. THICK (SEE NOTE 3)
	I-6	REV 9: HONEYCOMB PAD 2 +/- ¼" THICK SEE NOTE 3
		(TOLERANCED THE THICKNESS OF THE HONEYCOMB IN THE SIDE OF THE CONTAINER)
14.	K-6	REV 8: HONEYCOMB PAD , 3 IN. THICK (SEE NOTE 3)
	H-5	REV 9: HONEYCOMB PAD 3 +/- ¼" THICK SEE NOTE 3
		(TOLERANCED THE THICKNESS OF THE HONEYCOMB IN THE BOTTOM OF THE CONTAINER)
15.	G-13	ADDED NOTE: 2 X 4 CLEAT (6 PLS) UNIFORMLY SPACED
		(ADDED NOTE TO CLARIFY CONSTRUCTION OF COVER)
16.	K,L-12	REV 8: FOUR SEPARATE DRAWING NOTES REFERRING TO COVER CLEATS, SIDE PANEL SHORT CLEAT, SIDE PANEL LOWER CLEAT, AND END PANEL CLEAT (ZONES K,L -12)
		REV 9: DELETED THE "NOM" AFTER 2 X 4 IN EACH OF THE FOUR NOTES ABOVE
		(CLARIFIED THE SIZE OF THE 2 X 4 MEMBERS)
17.	M-10	DELETED 3 - 5/8 DIMENSION ON LOCATION OF BOLT HOLE IN SKID
		(NO CHANGE IN STRENGTH OF SKIDS AND NO EFFECT ON SAFETY)
18.		THE FOLLOWING CHANGES ARE BEING MADE TO TOLERANCE DRAWING DIMENSIONS WHICH PREVIOUSLY WERE UNTOLERANCED NOMINAL DIMENSIONS AND ALSO TO DELETE CERTAIN DIMENSIONS WHICH WERE NO LONGER NECESSARY. THESE CHANGES HAVE NO EFFECT ON THE STRENGTH OR SAFETY OF THE CONTAINER:

DWG. ZONE REV 8/ REV 9	REV 8	REV 9
B-7	60 - ¾ TYP	DELETED
C-9	182 - ¾	181 - ½ MIN
E-11/E-9	23 ¼ TYP	20 MIN 4 PLS.
E-12	18 TYP 5 PLS.	DELETED - REDUNDANT TO NOTE @ B-3
E-12	12 TYP	12 +/- ½
H-13/F-12	29 - ¾	29 - ¾ +/- ¼
F-9	20 - ½ TYP	DELETED - COVERED IN NOTE @ B-3
E-8	206 - ¾ ON LID	206 - ¾ +/- 3/8 @E-7 ON BODY
D-4	9 TYP	9 MIN. TYP.
E-5/D-4	18	17 MIN (10 PLS)
E-5/D-5	39 TYP.	38 MIN. TYP. 4 PLS.
F-5/E-5	12 TYP.	11 - ½ MIN.
E-3	4 - ½	4 - ½ +/- ½
F-8/E-8	202 - ¾	202 - ¾ +/- 3/8
F-8	89 - ¾	89 MIN. TYP. 2 PLS.
F-4	20 - ½	DELETED - COVERED IN NOTE @ B-3
D-3/D-2	25 - ½	25 - ½ +/- ¼
E-2	24	24 - +/- ¼

DWG. ZONE **REV 8/ REV 9**	**REV 8**	**REV 9**
I-10		ADDED 29 - ½ +/- ¼ BOX WIDTH
M-10/J-9	29 - ¾	29 MIN (5 PLS)

THE FOLLOWING IS A DESCRIPTION AND EXPLANATION OF THE CHANGES MADE TO THE RA-3 INNER SHIPPING CONTAINER LICENSING DRAWING 769E231 REV. 6

<u>NO.</u>	<u>DRAW. ZONE</u>	<u>DESCRIPTION OF CHANGE</u>
1.	E-12	DRAWING NOTE 1: CHANGED: ½ IN. LONG AND SPACED 6 IN. CENTER TO CENTER TO: 3/8" MIN. LG. AND SPACED 6 - ¼" MAX. CENTER TO CENTER **(TOLERANCED OPTIONAL WELDING OF CHANNEL ASS'Y. TO BODY ASS'Y.)**
2.	F-12	DRAWING NOTE 2: CHANGED: ½ IN. LONG AND 6 IN. CENTER TO CENTER TO: 3/8" MIN. LG. AND 6 - ¼" MAX. CENTER TO CENTER **(SAME AS 1. ABOVE)**
3.	F-12	DRAWING NOTE 3: DELETED "IN ACCIDENT CONDITIONS" **(WATER FLOW IS NOT TO BE RESTRICTED UNDER ANY CONDITIONS)**
4.	F-12	DRAWING NOTE 4: SUBSTITUTE "IN INCHES" IN PLACE OF "NOMINAL" **(ALL DIMENSIONS ARE NOW TOLERANCED)**
5.	B-12	ADDED DRAWING NOTE 5: STAINLESS STEEL MAY BE SUBSTITUTED FOR CARBON STEEL **(STAINLESS STEEL HAS BETTER PERFORMANCE CHARACTERISTICS THAN CARBON STEEL)**
6.	E-10	ADDED TO 3/8" BOLT NOTE: "SUBSTITUTION OF 10MM BOLTS, NUTS AND WASHERS ACCEPTABLE" **(PERMITS THE USE OF EQUIVALENT METRIC HARDWARE WHICH IS LARGER AND STRONGER THAN THE 3/8" HARDWARE AND IS PREFERRED OVERSEAS)**
7.	E-9	REV 5: ¾ DIA. HOLE 1.75 X 1.75 SPACING TYP COVER & BODY
	D-11	REV 6: ¾" +/- 1/16" DIA. HOLES 1 - 7/8 X 1 - 7/8 MAX. SPACING TYP. **(TOLERANCES THE DRAIN HOLES SIZE AND SPACING)**

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
8.	A-5	REV 5: HANDLE , 4 REQ ON COVER SEE DET. L/M-4
	A-4	REV 6: HANDLE , 4 REQ ON COVER SYMMETRICALLY LOCATED SEE ZONE J-4
		(NO EFFECT ON SAFETY OF CONTAINER)
9.	.	REV 6: SUPPORT BLOCK - DETAIL FROM REV 5, AT J-1,2, HAS BEEN DELETED
	D-1,2	REV 5 SUPPORT BLOCK SEE DET J-2
	C-1	REV 6: WOOD, PLASTIC, OR METAL SUPPORT BLOCK AS REQ'D.
		(MORE FLEXIBLE WAY TO CALL OUT SUPPORT BLOCK WHICH CAN VARY DEPENDING UPON BUNDLE DESIGN)
10.	D-2	REV 5: DELETED: END BRACE, 4 REQ. 2 X 2 X 1/8 CBN STL ANGLE
	K-13	REV 5: DELETED: 2 X 2 X1/8 CBN STL ANGLE, 4 REQ
	D-2	REV 5: DELETED: 1/16 WELD CALLOUT WITH 3/8 - 1-1/2 SPACING AND 1 -1/2" DIMENSION AT ZONE E-2
	K-12	REV 5: DELETED DIMENSIONS 3 - 7/8" 2 PLCS TYP,1-1/2 REF, 3 - 1/16" TYP, 4 - ¼" TYP, AND 11"
	I-10	REV 6: ADDED 1/16 WELD CALLOUT WITH NOTE: "WELD MAY BE INTERMITTENT OR CONTINUOUS WITH MINIMUM 1-1/2" OF WELD PER SIDE OF ANGLE - 4 ANGLES EACH END OF CONTAINER
	I-13	REV 6: ADDED NOTE: 2 X 2X 1/8 X 10 - ¾ MIN. LG. CBN STL ANGLE 4 REQ'D. APPROX. EQUALLY SPACED BOTH ENDS OF CONTAINER
		(SIMPLIFIED THE CALLOUT FOR END BRACES WHILE MAINTAINING THE QUANTITY, LOCATION AND SUFFICIENT WELD STRENGTH TO SECURE THE ATTACHMENT OF THE BRACES TO THE END CAP AND CONTAINER BODY)
11.	H-3	REV 5: HANDLE , 4 REQ ON BODY, SEE DET L/M-4. HANDLE LOCATION TYP.

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
	F-1	REV 6: HANDLE, MINIMUM OF 4 REQ'D. ON BODY SYMMETRICALLY LOCATED SEE ZONE J-4
		(SIMPLIFIED THE CALLOUT FOR LOCATION OF THE BODY HANDLES)
12.	H-5	REV 5: 6 EQ SP @ 28.50 = 171 (TOL. IS NON-ACCUMULATIVE)
	D-1	REV 6: 28 -1/2 +/-1 TYP. 12 PL'S. TOLERANCE NOT ACCUMULATIVE
		(TOLERANCED THE BODY LUG POSITIONS)
13.	H-9	IN CHANNEL ASSEMBLY NOTE, CHANGED 3 ½ IN SPACING TO 4" MAX SPACING.
		(TOLERANCED THE SPACING OF RIVETS IN THE CHANNEL ASSEMBLY)
14.	F-13	ADDED SIDE VIEW OF COVER END CAP TO BETTER SHOW THE APPLICABLE DIMENSIONS.
	J-11	REV 5:COVER END CAP, 2 REQ FORM FROM 16 GA. CBN STL.
	G-12	REV 6: <u>COVER END CAP</u> 2 REQ'D. FORM FROM 16 GA. CBN STL. WELD TO COVER. ALL DIM'S ARE NOMINAL +/- 1/8 AND ADJUSTED AS REQ'D FOR PROPER WELD FITUP WITH COVER
		(BETTER DEFINED THE GEOMETRY OF THE COVER END CAP)
15.	J,K-5	IN COVER STRINGER DETAIL, DELETE ¼ (2 PLCS), 17 -1/2 , 90 DEGREES +/-10, 2 - 5/8
	K-6	CHANGE WELD CALLOUT FROM: 1/8" WELD SPACED AT ½ - 1 - ½ TO: 1/16" WELD 3/8" MIN. LG. - 2 PLS.
	K-5	CHANGE FROM: <u>COVER STRINGER</u> FORM FROM 1/8 CBN STL LENGTH = 177 -1/2 2 REQ. TO: <u>COVER - REINFORCING ANGLE</u>
	J-5	CHANGE FROM: PLATE 1/8 X 2 X3 CBN STL. 11 REQ. TO: PLATE 1/8" THK. X 2" MIN. X LG. AS REQ'D. CBN. STL. 11 REQ. EQUALLY SPACED

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
		(SIMPLIFIED CALLOUT FOR REINFORCING ANGLES IN COVER - STRUCTURAL INTEGRITY MAINTAINED)
16.	C-10	REV 5: COVER STRINGER ANGLE, 2 -5/8 X 2 -5/8 X1/8 X 177 - ½ LONG CBN STL. SEE DET. J/K - 5-6
		REV 6: COVER REINFORCING ANGLE CBN STL. 1/8" THK. X 177 - ½ " MIN LG. X 90 DEGREES +/- 10 CENTRALLY LOCATED SEE ZONE H-4 2 PLS.
		(TOLERANCED THE COVER REINFORCING ANGLES)
17.	K-2	REV 6: ADDED "36 PL'S. TOTAL" TO LUG DETAIL
		(CLARIFICATION OF LUG QUANTITY ONLY)
18.	L-7,8	DELETED : 1 -3/4 BETWEEN HOLES, 101 SPACES, 3 SIDES, 3 EQ. SPACES BETWEEN HOLES, 3 SIDES OF CHANNEL, 13/16 TYP, ¾ DIA 1224 HOLES
	J-7	ADDED NOTE: ¾" HOLES SAME AS ZONE D-11
		(SIMPLIFIED CALLOUT OF ¾' HOLES - NO CHANGE IN GEOMETRY)
19.	J-9	DELETED: 2.00 AND 5.00 DIMENSIONS AT ZONE J-9 AND 1 -1/4 DIMENSION AT ZONE K-9 AND ADDED TO REV 6 AT ZONE H-11,12: 1" MIN 1 -3/4" MAX. TYP. 8 PLS. TOTAL END CAP AND BODY.
		(SIMPLIFIED LUG LOCATION DIMENSIONS WITH NO CHANGE TO GEOMETRY OR FUNCTION)
20.	J-10	DELETE: 1/16 WELD SYMBOL FOR LUG WELD @ J-11, J-7, D-4 AND K-11
	H-8	ADDED 1/16 WELD AND NOTE: 3 SIDES OF LUG 36 LUGS TOTAL BODY, COVER AND END CAP
		(NO CHANGE IN LUG WELDING, ONLY SIMPLIFICATION OF LUG WELD CALLOUT)

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
21	K-8-10	DELETED: 5", 8", AND 5 - ½" DIMENSIONS. CHANGED BODY REINFORCING ANGLE NOTE FROM: 2 - 21/32 X 2 -21/32 X 1/8 CBN STL 90 DEGREE ANGLE END SLOT 1 -1/4 DP X 2 LONG, 4 ANGLES REQ TO: BODY REINFORCING ANGLES CBN. STL. 1/8" THK. X 179 MIN. LG. X 90 DEGREES +20/-10 4 PLACES CENTRALLY LOCATED AROUND CHANNELS. ANGLES ARE SLOTTED AS REQ'D. AT EXIT FROM BODY. **(NO CHANGE IN GEOMETRY OF BODY REINFORCING ANGLES)**
22.	J-10	REV 5: ½ IN. SLOT, 6 IN. SPACING TYP.
	H-11	REV 6: 3/8" MIN. SLOT X 6 - ½" MAX SPACING TYP. FOR WELD ATTACHMENT TO BODY **(TOLERANCED WELDING OF BODY REINFORCING ANGLE TO BODY)**
23.	L-9,10	REV 5: DELETED ½ - 6 WELD CALLOUT AND "OPTIONAL "U CLAMP" REINFORCEMENT". DELETED NOTE AT M-9: <u>ALTERNATE METHOD:</u> RIVET CHANNELS TOGETHER WITH 3/16 DIA STEEL RIVETS, 52 PLCS
	J-8	REV 6: ADDED NOTE: CHANNELS MAY BE WELDED OR RIVETED AND OPTIONALLY "U" CLAMPED TOGETHER. TOP EDGE OF THIS SURFACE MAY HAVE IRREGULAR PROFILE
	M-10	REV 6: SUBSTITUTED THE WORD "FASTENED" FOR "WELDED" IN NOTE UNDER <u>CHANNEL ASSY</u> **(SIMPLIFIED CALLOUT FOR FASTENING THE CHANNELS TOGETHER- NO CHANGE IN GEOMETRY)**
24.	L-10	REV 5: 1 X 1X 1/8 STL ANGLE
	J-11	REV 6: 1 X 1X 1/8 CBN. STL. ANGLE BOTTOM AND SIDES **CLARIFIED POSITION OF ANGLES ONLY)**
25.	L-11	REV 5: LUG SEE DET. L-2
	I-11	REV 6: LUG 4 REQ'D. ON END CAP TO MATCH BODY LUGS SEE ZONE J-2 **(CLARIFICATION ONLY OF END CAP LUGS)**

NO.	DRAW. ZONE	DESCRIPTION OF CHANGE
26.	D-4	REV 5: 5/8" OR ¾" THK. ETHAFOAM CUSHION TYP 6 SURFACES. 1" ETHAFOAM ON COVER. HOLES IN ETHAFOAM TO MATCH HOLES IN METAL. SEE NOTE 3.
	G-3	REV 6: 9/16" MIN. / 13/16" MAX. THK. ETHAFOAM CUSHION TYP. 6 SURFACES 1" +/- 1/8" THK. ETHAFOAM ON COVER HOLES IN ETHAFOAM TO MATCH HOLES IN METAL SUFFICIENTLY TO ALLOW FREE FLOW OF WATER SEE NOTE 3 **(TOLERANCED ETHAFOAM THICKNESSES AND CLARIFIED THE MATCH OF HOLES IN ETHAFOAM AND METAL)**
27.	K-5	REV 6: ADDED THE FOLLOWING NOTE AT THE END OF THE MATERIAL CALLOUT FOR THE HANDLE: 1/8" MIN. MAT'L. THK. AFTER HANDLE INSTALLATION **(THIS CALLOUT INSURES ADEQUATE MATERIAL THICKNESS TO SUPPORT THE HANDLES.)**
28.		THE FOLLOWING CHANGES ARE BEING MADE TO TOLERANCE DRAWING DIMENSIONS WHICH PREVIOUSLY WERE UNTOLERANCED NOMINAL DIMENSIONS AND ALSO TO DELETE CERTAIN DIMENSIONS WHICH WERE NO LONGER NECESSARY. THESE CHANGES HAVE NO EFFECT ON THE STRENGTH OR SAFETY OF THE CONTAINER:

DWG. ZONE REV5/REV6	REV 5	REV 6
B-3/A-2	18 - 1/8	18 -1/8 +/- 1/8
C-6/D-9	179 -1/2	179 -3/4 +/- 3/8
E-2/C-1	1 - 7/8	1 -3/4 +/- ¼
E-2/G-11	9	9 +/- 1/8
E-3	40" TYP	40 +/- 1
F-10/E-11	2	2 +/- 1/8
H-6	96 - ½ TYP	DELETED

DWG. ZONE REV5/REV6	REV 5	REV 6
F-9/E-11	2 - 1/8	2 -1/8 +/- 1/8
H-9/B-1	15 - ¾ TYP	15 MIN/20 MAX
F-10	7 EQ SP	DELETED
L-13/I-13	9	9 +/- 1/8
M-12/I-10	18 - 1/8	18 - 1/8 +/- 1/8
J-3/B-9	1 - 3/8	1 - 3/8 +/-3/8
H-3/A-10	1 - 7/8	1 - 7/8 +/- 3/8
K-9	2" TYP 18 PLCS	DELETED
J-7	4 - ½	4 - ½ +/- 3/8
J-5/G-5	177 - 5/8	177 - ¾ +/- 3/8
L-2/I-2	1 - ½	1 - ½ +1/4/-1/2
L-1/J-1	2	2 +/- ¼
M-1/J-2	1 - ¼	1 - ¼ +1/4/-1/8
L-2	5/8	DELETED
M-2	¾	DELETED
L-1/J-1	½"	½" +/- 1/16
K-4/I-4	4	4 +/- ¼
L-3/J-3	2	2 +/- 1/8
M-5	¼ IN CBN STL	DELETED
M-3/J-3	½ DIA CBN STL	½ +/- 1/32 DIA CBN TL

DWG. ZONE REV5/REV6	REV 5	REV 6
M-7/J-8	6 - 7/8	6 - 7/8 +/- 1/8 INSIDE HEIGHT
L-6/K-8	6 - 7/8	6 - 7/8 +/- 1/8 AT BOTTOM ONLY
L-8	179 - 15/16	179 ¼ +/- 3/8
L-12	2	2 +/- 1/8
J-10/H-11	1	1 +/- ¼
F-6	179 - 1/8	DELETED
H-11	2 - 1/16	DELETED
M-3/K-3	1 - ¼	1 - ¼ +/- ¼
M-3	¾	DELETED

Attachment 5

Description of the Changes

Section / Appendix	Page(s)	Description of Change
Index	i and iii	Changed references in the Index to reflect changes made in Sections of the application as described below.
3.0	3-1	Removed all of Section 3.1 for the RA-2 inner container, renumbered sections 3.2 and 3.3 as 3.1 and 3.2, also added a new section 3.3 for the Shipping Container Loose Fuel Rods (this is the product container).
3.0		Replaced the drawings of the RA-3 metal inner and wooden outer container, and removed the drawing of the RA-2 metal inner container. Also, added a new drawing for the product container.
6.0		Added information regarding the use of loose fuel rods packed in the five-inch, Schedule 40 pipes or in the channels. All changes are indicated with an asterisk (*) in the right hand column.
7.0	7-2	Added to the listing of non-proprietary criticality safety information contained in Section 7.0
7L		Added a non-proprietary version of the criticality safety analysis for the shipment of unassembled fuel rods in the RA packaging.
8.0	8-2	Added to the listing of proprietary criticality safety information contained in Section 8.0
8L		Added a proprietary version of the criticality safety analysis for the shipment of loose fuel rods in the RA packaging.

Attachment 6

Replacement Pages for the Index

INDEX

Attachment 7

1) Changes to Section 3.0 Updating the Drawing Revision Numbers and Adding the Product Container Drawing

2) Copies of the Following Drawings:
   769E229, Revision 9, Model RA-3 Outer Container
   769E231, Revision 6, Model RA-3 Inner Container
   0028B98, Revision 0, Shipping Container Loose Fuel Rods

3) Changes to Section 6.0 Describing the Operating Procedures, Acceptance Tests and Maintenance Program

and

4) Changes to Sections 7.0 and 8.0

3.0 DRAWINGS

The General Electric drawings, to which RA-series packages are constructed, are enclosed in this section.

		GE Dwg.	Revision #	
3.1	Model RA-3 Inner Container The RA-3 model inner container is constructed in accordance with	769E231	Rev. 6	*
3.2	Model RA-3 Wooden Outer Container The RA-series wooden outer container is constructed in accordance with	769E229	Rev. 9	*
3.3	Shipping Container Loose Fuel Rods (Product Container) The five-inch, Schedule 40, stainless steel pipe is constructed in accordance with	0028B98	Rev. 0	*

6.0 OPERATING PROCEDURES, ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

6.1 Operating Procedures - Fuel Assemblies *

The following describes procedures for loading the fuel assemblies into the RA packaging.

6.1.1 Verification is performed to assure that the fuel assemblies have been completed satisfactorily with all acceptance criteria.

6.1.2 Verify that the fuel assemblies are visually clean (i.e., free of oil, rust, foreign particles), comply with assembly requirements and that the polyethylene sheath is open at both ends and does not exceed the length of the assembly. *

6.1.3 Prior to placing fuel assemblies into the RA inner, visually verify the RA inner for overall physical condition including: *

- Handles and brackets
- Exterior welds
- Foam padding
- Gasket
- Cleanliness

6.1.4 Raise the RA inner to the vertical position.

6.1.5 Place fuel assemblies into RA inner and secure with hold down bars. Verify that the lower tie plate of assembly fits into a fixture within the RA inner to assure positioning. *

6.1.6 Lower RA inner to the horizontal position and remove the hold down bars.

6.1.7 Prior to putting the lid on the loaded RA inner, verify that the polyethylene sheath does not extend beyond the ends of the assembly and the ends of the sheath are left open. * *

6.1.8 Verify that the correct assemblies have been loaded into the RA inner.

6.1.9 Bolt lid and end cap onto RA inner.

6.1.10 Apply tampersafe seals to RA inner.

6.1.11 Place RA inner into RA outer using a handling device. This is done in the horizontal position. * *

6.1.12 Verify the loaded RA outer prior to putting on lid to assure: *

- RA outer has been refurbished, verified and released
- Tampersafe seals on RA inner are not broken
- The RA inner is resting properly in the RA outer
- Cleanliness
- Packing material is in place
- No damage to RA inner container.

6.1.13 Bolt lid onto RA outer. *

6.1.14 Apply tamper safe seals. *

6.1.15 Band RA outer. *

6.1.16 Verify loaded RA outer for proper closure and tampersafe seals. *

6.1.17 Survey and release loaded RA outer for compliance to DOT shipping regulations. *

6.2 Operating Procedures - Loose Rods in Channel or Pipe *

The following describes procedures for packing loose rods into the RA-3 inner container as necessary for quality assurance and criticality safety purposes. *

6.2.1 A maximum of 20 rods may be placed in each side (channel) of the RA-3 inner container for a total of 40 rods. The rods may be banded together. Banding is not required for criticality safety purposes. *

6.2.1.1 Sleeve each rod in polyethylene not to exceed a 5 mil maximum thickness. The ends of the sleeve may be closed in a manner such as knotting or taping with the excess trimmed away. *

6.2.1.2 Protective pads such as ethafoam are used to protect the rods when the clamps are tightened where banding is used. *

6.2.1.3 The loose rods and/or banded rods are securely packed inside the RA side (channel) with packing material to minimize movement during shipment. *

6.2.1.4 Section 6.1.9 through 6.1.17 describes activities to be conducted after packing the loose rods into the inner container for closing the RA inner and outer container. *

6.2.2 For loose rods in the five-inch, Schedule 40 Pipe. *

6.2.2.1 Sleeve each fuel rod in polyethylene not to exceed a 5 mil maximum thickness. The ends of the sleeve may be closed in a manner such as knotting or taping with the excess trimmed away. *

6.2.2.2 Ethafoam pads may be placed inside the capped ends to prevent damage to the rods. *

6.2.2.3 Insert sleeved fuel rods into the pipe (product) container. There is no upper or lower limit for the number of fuel rods that may be placed in the pipe container. If dunnage is used to fill the void space, any number of empty metal tubes welded shut with end plugs on both ends may be placed in the pipe container. The empty tubes do not need to have polyethylene sleeving. *

6.2.2.4 Close the pipe by installing the gasket, cover and bolts. *

6.2.2.5 Once placed inside the inner metal RA, ethafoam padding may be placed against the outside of the pipe to provide padding during shipment. *

6.2.2.6 Section 6.1.9 through 6.1.17 describes activities to be conducted after placing the five-inch, Schedule 40 pipe(s) into the RA metal inner. *

6.2.2.7 It is allowable to ship only one five-inch, Schedule 40 pipe in an RA-3 inner. *

6.3 Acceptance Tests *

6.3.1 Quality Assurance Program *

Construction and use of the RA series transportation packages is accomplished in conformance with the General Electric Quality Assurance Program "NEDO-11209-04A" or the latest program as approved by the NRC. Currently the General Electric QA Program is approved by the NRC's Quality Assurance Program Approval for Radioactive Material Packages, approval number 0254, Docket 71-0254.

6.3.2 Inspection Prior to First Use *

6.3.2.1 The following represents the steps that are performed when purchasing new RA inner containers from a vendor or having a vendor perform refurbishment: *

Typical Characteristics to be Inspected	Typical Method of Inspection
1) Source inspection at vendor's facility	1) GE-Quality representative
2) Verification of container measurements	2) Based on dimensions on approved licensing drawing
3) Appearance integrity (i.e., painted surface, markings legibility and location)	3) Visual per drawing and inspection instructions
4) Weld integrity and weld dimensions	4) Visual per drawing / review welders qualifications

5) Cleanliness, finished appearance	5) Visual
6) Gasket	6) Per drawing / certification review / sample inspection
7) Pressure relief valve	7) Review certification for proper type. If installed at GE-Wilmington, see maintenance Section 6.3.
8) Certification of conformance	8) Review for completeness

Failures are rejected and dispositioned (e.g., reworked) based upon the discrepancy.

6.3.2.2 The following represents the steps that are performed when purchasing new RA outer containers from a vendor or having a vendor perform refurbishment: *

Typical Characteristics to be Inspected	Typical Method of Inspection
1) Source inspection (1st article)	1) GE-Quality representative
2) Verification of container characteristics (e.g., materials, dimensions, bolt holes, nail patterns, Ethafoam and honeycomb)	2) Based on notes and dimensions on approved licensing drawing
3) Appearance integrity (e.g., fit and finish, painted surfaces, finished appearance)	3) Visual per drawing and inspection instructions
4) Certification of conformance and dimensional data sheets	4) Visual for completeness

Failures are rejected and dispositioned based upon the discrepancy. *

6.4 Maintenance Program *

6.4.1 The metal RA inner container - All RA inners are inspected and/or refurbished prior to packaging for shipment as follows: * *

6.4.1.1 Container Exterior (RA inner) *

(1) No holes on surface.

(2) Dents not exceeding 1/2 inch in depth over a one square foot area allowable.

(3) Lifting handles on lid are securely fitted in brackets and brackets are welded per drawing. No cracks on weld.

(4) Body and lid lugs securely welded as per drawing. No cracks on weld.

(5) Lifting handles on body are securely fitted in brackets and brackets are welded per drawing. No cracks on weld. *

(6) No cracks on weld seams.

(7) Gasket must adhere to lid and end cap and have a clean sealing surface in good physical condition. Gasket is visually inspected and replaced if damaged.

(8) Pressure relief valve in place and in good working order.

6.4.1.2 Container Interior (RA inner) *

(1) Ethafoam lining visually clean, dry, and adherent to the container. Up to 2% of the total volume of the ethafoam may be removed for packing purposes.

(2) "Y" support blocks in place.

(3) Body and cover are visually clean and free of loose debris.

6.4.2 The RA Wooden Outer Container - All RA outers are inspected and/or refurbished at the GE-Wilmington facility prior to packing for shipment as follows: * * *

(1) Interior and exterior surfaces and bracing in good visual condition.

(2) Wooden skids properly located and firmly attached to container base.

(3) Bolts in good condition.

(4) Ethafoam material properly positioned, in good condition, clean, dry, and adhering properly.

(5) Interior must be clean and dry.

(6) Honeycomb that is deteriorated, cracking, or flaking material is replaced if the damaged (or missing) areas exceed 1% of the individual pieces cubic volume. *

In addition, honeycomb located in the ends of the box is replaced if after inspection (and removal if necessary) it is not within 1 inch of normal width or does not extend to at least the height of the top of the steel plate attached to the 1/2 inch plywood. The top portion of the end material is inspected and replaced as required.

The following exceptions do not count toward the 1% inspection criteria because they are viewed to be insignificant to the total performance of the container.

(a) Small areas of individual pieces where corners are rounded to approximately a radius of 3 inches.

(b) Minor crevices approximately 1/2 inch wide between butt joints of cushioning material, when due to small irregularities in edges of pieces of minor deviations in alignment during application of adhesive.

(c) In some, but not all boxes, there are four small areas of cushioning (approximately 8 inches x 8 inches) which have been removed to allow the engaging of lifting hooks with the body handles without damaging adjacent cushioning material. This is necessary because some handles vary slightly in location.

6.4.3 Five-Inch, Schedule 40 Stainless Steel Pipe *

6.4.3.1 Assure inside and outside of pipe is clean. *

6.4.3.2 Replace pressure relief valve with a certified valve before each shipment. * *

6.4.3.3 Assure gasket is in place on both ends of the pipe container and visually verify the condition of the gasket. * * *

6.4.3.4 Assure that the covers on both ends of the pipe are in good condition and are able to properly close. * *

FIGURE WITHHELD UNDER 10 CFR 2.390

REV.	DESCRIPTION	BY	CR#	APPROVAL	DATE
0	FIRST ISSUE FMA-324	BA		RES	6-3-98

REVISIONS

SIGNATURES		DATE
DRAWN	B. AYERS (IDD)	6/3/98
CHECKED		
ENGR:		
ENGR:		

SCALE 1/4 — ALL SURF. ✓

UNLESS OTHERWISE SPECIFIED
TOLERANCES ON :
2 PLACE DECIMALS ± FRACTIONS ±
3 PLACE DECIMALS ± ANGLES ±

GE NEP — GENERAL ELECTRIC COMPANY
NUCLEAR ENERGY PRODUCTION
WILMINGTON, N.C.

TYPE OF DRAWING
SHIPPING CONTAINER
LOOSE FUEL RODS
FMF NRC LICENSING DRAWING

ISSUE DATE 6-3-98 | DWG NO. 0028B98 | REV. 0
CR NO. | FILE NAME 0028B98 | SH NO. 1 | CONT ON F

9806110345-01

FIGURE WITHHELD UNDER 10 CFR 2.390

9806110345-02

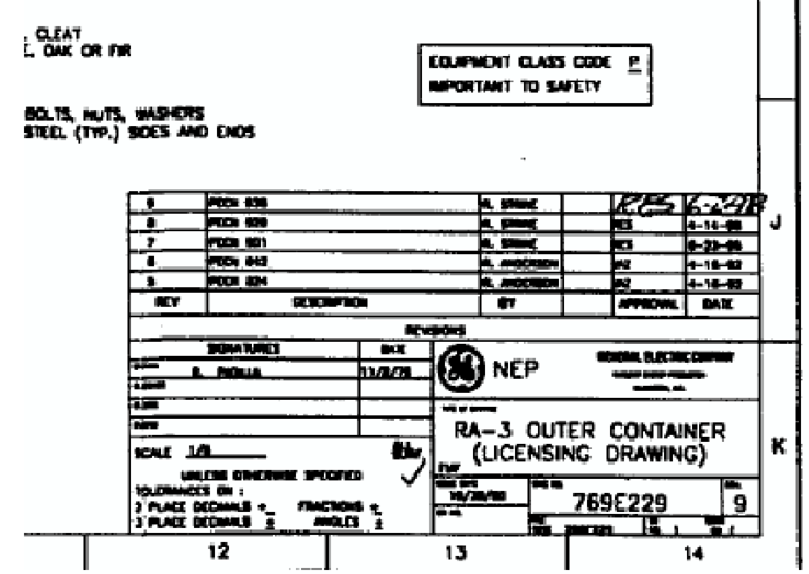

FIGURE WITHHELD UNDER 10 CFR 2.390

REV	DESCRIPTION	BY	CM	APPROVAL	DATE
6	[illegible]	[illegible]		KES	[illegible]
5	[illegible]	[illegible]		[illegible]	[illegible]
4	[illegible]			[illegible]	[illegible]
3	[illegible]	[illegible]		[illegible]	[illegible]
2	[illegible]	[illegible]		[illegible]	[illegible]
1	[illegible]	[illegible]		[illegible]	[illegible]

REVISIONS

NEP

GENERAL ELECTRIC COMPANY

SHIPPING CONTAINER

769E231

6

12 13 14

SECTION 7.0

APPENDIX L

Non-proprietary version of the "Criticality Safety Evaluation - RA-3 Fuel Bundle Contents"

CRITICALITY SAFETY EVALUATION
RA-3 FUEL BUNDLE CONTENTS

1. GENERAL DESCRIPTION

The RA-3 transport package consists of a wooden outer container surrounding a carbon steel inner container holding one or two fuel bundles. A fuel bundle may be either a nuclear fuel assembly or an accumulation of loose fuel rods. Loose fuel rods may be transported in accumulations of no more than 20 rods per bundle which may be held together by metal bands or other equivalent fasteners. Accumulations of more than 20 fuel rods per bundle must be shipped within 5 inch Schedule 40 304L stainless steel product containers as described in the following sections in this evaluation.

In this evaluation there is no requirement to fill the empty space in either the channel assembly or the product container, but quality requirements may dictate filling the empty space. It is important that anything used to fill the empty space is not a more effective moderator than water. The preferred method for filling the empty space is to use empty sealed rods.

The maximum pellet enrichment in loose rods covered by this evaluation is 5.00 wt % U-235. The RA-3 shipping container with loose rods is a Type A fissile package with the following restrictions:

Product container	not required	required
Maximum number of fuel rods per bundle	20	> 20
Allowable number of packages, N	infinite	12
Transport Index	0.0	4.2

2. PACKAGE DESCRIPTION

2.1 CONTENTS

The RA-3 may be used to transport up to two fuel bundles each containing unirradiated uranium dioxide pellets. The pellets have a nominal outside diameter between 0.340 and 0.515 inch. The maximum fuel pellet enrichment is 5.00 weight percent U-235. Typical fuel rod dimensions are shown in Table 1.

Table 1 Fuel rod dimensions

Rod type	Pellet outer diameter (inch)	Pellet-clad gap (inch)	Clad thickness (inch)
10 X 10	0.346	0.006	0.023
9 X 9	0.377	0.0065	0.025
8 X 8	0.411	0.007	0.029
7 X 7	0.508	0.0055	0.030

2.2 PACKAGING

The packaging consists of the zircaloy or stainless steel fuel rods that contain the fuel pellets, product container (DWG No. 0028B98), RA-3 inner shipping container (DWG No. 769E231), RA-3 outer shipping container (DWG No. 769E229).

2.2.1 Fuel Rods

Pellets and end plugs are contained in fuel rods up to 174 inches (441.96 cm) with dimensions in the range indicated in Table 1. The composition and atom densities of the tubes and other package materials is given in Table 6.2.

The fuel rods are sealed at both ends with zirconium or stainless steel plugs that are welded in place. The structural evaluation has shown that the fuel rods remain intact, and the pellets remain inside the fuel rod, under normal conditions of transport and hypothetical accident conditions.

For transport in the RA-3 container the fuel rods are sheathed in a 0.004 inch (0.010 mm) nominal thickness plastic sleeve and loaded directly into the inner container channel assembly or product container. Empty space in the channel assembly is filled with ethafoam, polyethylene, or wood packaging and empty space in the product container is usually filled with empty fuel tubes fitted with end plugs welded at both ends. A maximum of one bundle may be loaded into each channel in the channel assembly within the RA-3 inner container.

2.2.2 Product container

The product container is detailed in Drawing No. 0028B98. For the purpose of general discussion in this evaluation, the product container is a pipe that is fabricated from 5-inch, Schedule 40 304 stainless steel. The outside diameter of the pipe is 5.563 inches (141.30 mm) and the nominal wall thickness is 0.258 inches (6.55 mm) per ASTM Specification A 731/A 731M. The minimum wall thickness is 0.226 inches (5.74 mm) per ASTM Specification
A 530/A530M. Both ends of the pipe are fitted with a 6.50 inch square, 0.50 inch thick 304 stainless steel plate flange and cover. The pipe length is 167.00 inches from flange to flange. Covers are fastened to each flanged end with four 5/16-18 x 1.50 inch 304 stainless steel bolts and hex nuts. A collar for lifting is installed at two positions typically 6.00 from each end of the pipe. One of the covers is fitted with a breather valve .

2.2.3 RA-3 Inner Shipping Container

The product container is detailed in Drawing No. 769E231. For the purpose of general discussion in this evaluation, the inner container is fabricated from 1.5 mm (16 gauge) carbon steel. The inner container [18 1/8 inch (460 mm) by 11 7/16 inch (290 mm) by 182 15/16 inch (4647 mm)] is a welded construction. A channel assembly inside the inner container [6 7/8 inch (175 mm) by 6 7/8 inch (175 mm) by 179 1/4 inch (4553 mm)] retains up to two fuel bundles. The space between the fuel assembly and channel assembly is filled with 5/8 to ¾ inch (15.9 to 19.1 mm) ethafoam cushion and there is 1 inch (25.4 mm) ethafoam in the cover. There are ¾ inch (19 mm) diameter hole on 1 ¾ inch center-to-center spacing fabricated in each channel assembly side and top cover. The top cover and end cap are connected to the body through fourteen lugs on the cover and four lugs on each end cap using 3/8 - 16 UNC mild steel bolts, washers, and nuts. Gasket material that is either neoprene or isoprene 30-55 DURO seals the cover and end cap to the body and a breather plug is located in the end cap of the inner container.

2.2.4 RA-3 Outer Shipping Container

The product container is detailed in Drawing No. 769E229. For the purpose of general discussion in this evaluation, the transport package uses a wooden outer container (29 ¾ inch (756 mm) by 31inch (787 mm) by 206 ¾ inch (5251 mm). The RA-3 outer container exterior sides are constructed of ½ inch (13 mm) plywood and 2x4 inch (51x102 mm) thick pine or fir support beams. Honeycomb padding and ethafoam pads evenly spaced over the length of the container fill the space between the wooden over pack and inner container. A single inner shipping container is loaded into the outer shipping container.

Table 2. Material Specifications

Material	Density (g/cm3)	Constituent	Atomic density (atoms / b-cm)
U(5.00)O2	10.96	U235	1.237780E-03
		U238	2.322070E-02
		O	4.891270E-02
Water	1.000	H	6.686600E-02
		O	3.343300E-02
304 stainless steel	7.92	C	3.169100E-04
		Si	1.694000E-03
		Cr	1.647100E-02
		Fe	6.036000E-02
		Ni	6.483400E-03
		Mn	1.732100E-03
High density polyethylene	0.92	H	8.293800E-02
		C	4.146900E-02
Ethafoam	0.035	H	3.030000E-03
		C	1.515000E-03
Honeycomb	0.45	H	3.013100E-03
		C	2.092900E-03
		O	1.221970E-03
Wood	0.64	H	2.133400E-02
		C	1.185800E-02
		O	8.593300E-03
Zirconium	6.51	Zr	4.070910E-02
Carbon steel	7.82	C	3.921000E-03
		Fe	8.349100E-02

3. CRITICALITY SAFETY ANALYSIS MODELS

3.1.1 GENERAL MODEL

3.1.2 Dimensions

Figure 1a and 1b represent the vertical elevations of the RA-3 inner shipping container and Figure 2 represents the vertical elevations of the RA-3 outer shipping container both seen along vertical centerline of the package. A cross section of the package along A-A of Figure 2 is displayed in Figure 3. The figure's dimensions are used in the calculations.

CEMPLOT: bnd9uful 866/4/98 up: *Y across: *X units: NA slice:

FIGURE WITHHELD UNDER 10 CFR 2.390

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure **L**b Radial cross section of single-package inner container with rod bundle w/ product container

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 2. Radial cross section of single-package outer container

FIGURE WITHHELD UNDER 10 CFR 2.390

Figure 3. Axial cross section of single-package outer container

3.1.3 Materials

Figures 1a, 1b, 2 and 3 show the cross sections of the single-package models used for the calculations. Table 3a and 3b identify the regions and materials.

Table 3a Material specifications for Figures 1a and 1b - Inner shipping container

Material No.	Material	Density (g/cm3)	Model mass (kg)	Actual mass (kg)
1	UO2	10.96	2.9 - 640.5	2.8 - 506.6
2	High density polyethylene	0.92	.034 - 7.44	0.03 - 5.4
3	Carbon steel	7.82	191.1	198.1
4	Water	0.00 - 1.00	0.0 - 149	0.0
5	Wood	0.64	0.0	1.0
6	Carbon steel	0.85 x 7.82	50.1	49.9
7	Zr	6.51	0.5 - 111.4	.55 - 100.0
8	SS-304	7.92	84.5	102

Table 3b Material specifications for Figures 2 and 3 - Outer shipping container

Material No.	Material	Density (g/cm3)	Model mass (kg)	Actual mass (kg)
1	Ethafoam	0.5 x 0.035	4.65	6.94
2	Honeycomb	0.058	27.7	39.2
3	Wood	0.64	111.0	294.0
4	Carbon Steel	7.82	0	19.3

3.1.4 Models-Actual Package Differences

The contents evaluated were 20 loose fuel rods in each channel assembly and a variable number of fuel rods in 304L SS product container. The fuel rods evaluated have the minimum fuel pellet diameter which is conservative for 5.0 wt % enrichment in U-235. The number of loose fuel rods may actually be as few as one per shipping container, and approximately 90 fuel rods is the maximum that can actually be loaded in the 304L SS product container. Loose rods may actually be banded together using steel clamps, but the model does not assume the fuel rod spacing is constrained. Empty space in the 304L SS product container may be filled with sealed rods that contain no fuel pellets.

Loose rods are modeled at a variable pitch to determine the water-to-fuel ratio that results in a maximum package reactivity. Empty space in the model is filled with water at density varying from void condition to full density water to determine the optimum moderation. None of the packaging material actually used to fill space in the channel assembly or shipping container for loose rods is a more effective moderator than water, with the exception of polyethylene plastic sheath used to package individual rods. The 0.004 inch thick polyethylene sheath is modeled as a 0.010 inch thickness of high density polyethylene material in direct contact with the fuel rods. All fuel rods are modeled to contain uranium dioxide enriched to 5.00 wt % U-235, but any fuel rod containing fuel pellets up to an enrichment of 5.00 wt % may be loaded in the RA-3 package.

3.2 CONTENTS MODEL

Figures 1a and 1b show the package contents consisting of pellets in fuel rods as configured for both the single-package and package-array calculations. Each fuel rod is modeled as 174 inches long. Partial-loading configurations are allowed, as are variation in pellet enrichment up to 5.00 wt % U235. Partial loadings do not require further analysis because they are bounded by the more reactive configuration of full loading.

Fuel rod spacing is variable from about 1.08 cm to 3.83 cm depending on either the constraint of the inner container channel dimensions or the product container inner diameter for both normal conditions of transport and accident conditions. The space available for fuel rods in the channel assembly is approximately 6- 7/8 inches (175 mm x 175 mm). The maximum pitch for 20 fuel rods in a triangular lattice arrangement in the channel assembly is 3.83 cm. The fuel rod spacing for a triangular lattice in the product container is restricted to 2.33 cm. The product container has a nominal inside diameter of 5.047 inches (128 mm). Each fuel rod is encased in 0.010 inch (0.254 mm) thick polyethylene and the remaining space between the fuel rods is filled water. Water may leak into the product container, and the interstitial water density is varied to determine the most reactive condition.

3.3 SINGLE PACKAGES

The single package model is used to determine the most reactive configuration of contents material and optimum moderation. Water is a more effective reflector than the wood, honeycomb, and ethafoam materials in the outer shipping container; therefore, only close reflection by water on all sides of a single package consisting of the RA-3 inner shipping container is modeled. The only difference between the normal transport condition and hypothetical condition is the presence of the RA-3 outer container; therefore, the model for a single package for normal transport conditions and hypothetical accident conditions is the same.

The RA-3 package was subjected to the tests specified in 10 CFR 71.55, General requirements for all fissile material packages, with a fuel assembly contents, and the geometric form of the package was not substantially altered. No differences between the RA-3 package containing the fuel assembly and the RA-3 package containing loose fuel rods have been identified that invalidate application of RA-3 test conclusions to the RA-3 with the loose rods content.

3.4 PACKAGE ARRAYS

Rectangular parallelepiped packages such as the RA-3 may be shipped in a tightly packed square pitch configuration or shift to that configuration because of hypothetical accident conditions.

Two array model types are included in this evaluation. The first model type consists of an infinite array of close packed, square-pitch, undamaged inner and outer container consistent with the normal condition of transport. The second model type consists of a variable array size of close-packed damaged packages consisting of the inner container only. The array size is dimensioned for the second model to minimize surface-to-volume ratio. This results in the most reactive configuration because the overall dimensions minimize neutron leakage at the boundary. As required by 10 CFR 71.59, the damaged packages are evaluated with optimum interspersed hydrogenous moderation consistent with tests specified in 10 CFR 71.73, Hypothetical Accident Conditions.

4. METHOD OF ANALYSIS

GEMER, a proprietary General Electric company standard criticality analysis computer codes was used in the analysis of these computational models. All calculations were performed using Pentium processors running under Windows 95 or Windows NT.

4.1 COMPUTER CODE SYSTEM

GEMER is a Monte Carlo program which solves the neutron transport equation as an eigenvalue or a fixed source problem including the neutron shielding problem. GEMER adds an advanced geometry input package to the problem solving capability of the Monte Carlo code which is very similar to KENO.

4.2 CROSS SECTIONS AND CROSS-SECTION PROCESSING

GEMER uses cross sections processed from the ENDF/B-IV library tapes. These cross section are prepared in 190 group format and those in the resonance region may have the form of the resonance parameters or Doppler broadened multigroup cross section. Thermal scattering of hydrogen in water is represented by the $S(\alpha,\beta)$ data in the ENDF/B-IV library. The types of reactions considered in the Monte Carlo calculation are fission, elastic, inelastic, and (n,2n) reactions; the absorption is implicitly treated by reducing the neutron weight by the non-absorption probability on each collision.

4.3 CODE INPUT

All problems were started with a flat neutron distribution over the system, in the fissile material only. All problems were run for at least 110 generations of 1000 neutrons per generation, skipping the first five generations, for a total of 110,000 histories. Mirror reflection was applied to the orthogonal-plane boundaries of the single package model to simulate infinite array-package models. Close, full-density, 30.48 cm (12 inch) thick water reflector was modeled explicitly.

Figures 3a through 3d are sample input files. The files correspond to single packages and package arrays typically used in the calculation of k_{eff}.

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3a. Single-package with bundle of rods, accident condition, file bnd9uful.in

*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*
*

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3b Single-package with product container, accident condition, file ra10p000.in

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3b Single-package with product container, accident condition, file ra10p000.in (continued)

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3c Package Array with product container, normal condition, file ra10su7.in

CONTAINS
GE COMPANY PROPRIETARY INFORMATION
WITHHELD FROM PUBLIC DISCLOSURE

Figure 3d Package Array with product container, accident condition, file ra10-s7e.in

4.4 CONVERGENCE OF CALCULATIONS

Problem convergence was determined by examining plots of k_{eff} by generation run and skipped, as well as the final k_{eff} edit tables. No trends were observed either in k_{eff} by generation run over the last half of total generations or, correspondingly in k_{eff} by generation skipped over the first half of total generation. No sudden changes of greater than one standard deviation in k_{eff} by generation run or skipped, resulting from an abnormal k_{eff} generation, were found. Frequency distribution bar graphs appear to approximate normal distributions with single peaks and no significant outlying values.

5. VALIDATION OF CALCULATION METHOD

Validation of GEMER consists of performing calculation of benchmark experiments including the area of applicable to the low enriched fuel rod lattice. Bias for GEMER and the ENDF/B-IV library has been established for the area of applicability for the RA-3 package. The bias determined using a set of 79 critical benchmark experiments specific to UO2 rod lattices is no greater than 0.012 ($\Delta k_u + \beta$) at a 99% confidence level. The area of applicability for the benchmark calculations are enrichment ranges from 1.29 to 9.83 weight percent U-235 and H/U-235 ratio 41 to 866.

Using a general equation for the upper safety limit (USL) and requirements of 10 CFR 71, calculations are considered subcritical, if the following condition is satisfied:

$$k_{eff} + 2\sigma \leq 0.95 - \Delta k_u + \beta$$
$$k_{eff} + 2\sigma \leq 0.938$$

6. CRITICALITY CALCULATIONS AND RESULTS

This evaluation demonstrates the subcriticality of a single package (Section 6.1) and an array of packages (Section 6.2) during normal conditions of transport and hypothetical accident conditions. The transport index (TI) is determined for criticality control (Section 6.3).

6.1 SINGLE PACKAGE

Calculations show that a single package remains subcritical under general requirements for fissile material packages for both normal conditions of transport and hypothetical accident conditions. The effect of increasing fuel rod pitch is evaluated to determine the most reactive contents for a single damaged package for two configurations of rod bundles. The first configuration is loose fuel rods in the channel assembly, and the second configuration is loose fuel rods in a product container. Full-density water is optimum for both content configurations.

Fuel rod pitch is directly related to water-to-fuel ratio within the contents. Optimum moderation for fuel rods occurs at a fuel rod pitch intermediate between a close packed lattice and the maximum lattice spacing possible within the constraint of the channel assembly or product container. The number of fuel rods in the product container is reduced to less than the actual capacity to obtain a maximum reactive contents.

The mass limit of 20 fuel rods determines the pitch at which the maximum reactivity occurs for rod bundles in the channel assembly without the product container. The geometry limit of the stainless steel pipe determines the pitch at which the maximum reactivity occurs for fuel rods loaded in a product container. The effect of moderation on reactivity of a single damaged package is displayed in Figure 4 for both content configurations. Table 4 summarizes the most reactive condition for a single package.

Table 4. Single-package calculation

Case	Description	$k_{eff} \pm \sigma$
bnd9uful	Optimally moderated, damaged package w/o product container (20 fuel rods)	0.55817 ± 0.00236
rasu7ful	Optimally moderated, damaged package w/ product container	0.57146 ± 0.00211

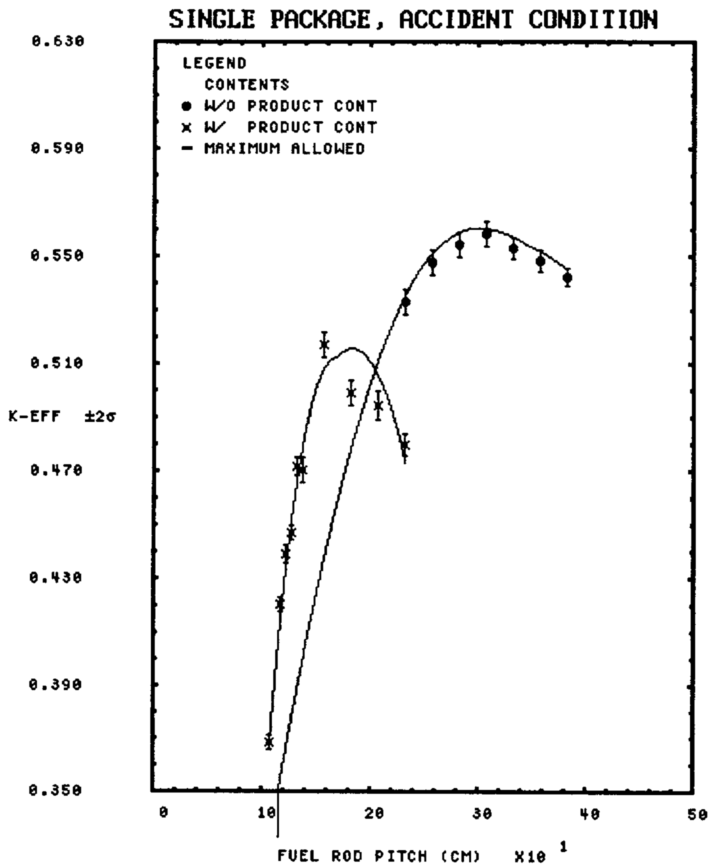

Figure 4 Typical reactivity, k_{eff}, vs contents moderation for single package

6.2 PACKAGE ARRAYS

The calculation results displayed in Table 5 demonstrate that an infinite array of packages is adequately subcritical under normal conditions of transport. The package arrays evaluated using the damaged single package are more reactive than those arrays using the undamaged single package. The accident condition array assumes the hypothetical accident condition for all packages.

The allowed number of damaged packages for the 20 fuel rod bundle without the product container is unlimited. The maximum allowed number of damaged packages with the product container contents is determined for a range fuel rod pitches within the product container. The number of rods in the product container decreases as the fuel rod pitch increases. Optimum moderation of the contents is full density water as demonstrated by the most single package calculations. But, void in the inner shipping package outside the product container results in maximum interaction between the contents of the single packages. Therefore, the package arrays are most reactive with no interstitial moderation outside the product container.

Table 5 summarizes the cases used to determine the maximum allowed number of damaged packages, 2N, for a range of fuel rod pitches. Fuel rod pitch corresponds to a specific number of rods that fit into the product container. The maximum allowed k_{eff} is the USL specified in Section 5.

Table 5. Results for array calculations

Case	Description		$k_{eff} \pm \sigma$
ra10b000	Infinite array, optimum moderation, undamaged package w/ product container		0.85872 ± 0.00255
bn12i125	Infinite array, optimum moderation, damaged package w/o product container		0.85271 ± 0.00179
ra10-s1	Damaged package,	10 x 15 x 1	0.92429 ± 0.00139
ra10-s1a	finite array,	8 x 12 x 1	0.90051 ± 0.00133
ra10-s1b	full water reflection,	6 x 9 x 1	0.85031 ± 0.00127
ra10-s1c	optimum moderation,	5 x 7 x 1	0.80441 ± 0.00154
ra10-s1d	w/ product container,	4 x 8 x 1	0.79575 ± 0.00148
ra10-s1e	fuel rod pitch 1.077 cm,	4 x 6 x 1	0.75885 ± 0.00200
ra10-s1f	no. fuel rods 109	4 x 5 x 1	0.72779 ± 0.00194
ra10-s2	Damaged package,	10 x 15 x 1	0.99215 ± 0.00152
ra10-s2a	finite array,	8 x 12 x 1	0.96575 ± 0.00153
ra10-s2b	full water reflection,	6 x 9 x 1	0.92001 ± 0.00152
ra10-s2c	optimum moderation,	5 x 7 x 1	0.87514 ± 0.00158
ra10-s2d	w/ product container,	4 x 8 x 1	0.86290 ± 0.00158
ra10-s2e	fuel rod pitch 1.177 cm,	4 x 6 x 1	0.82827 ± 0.00153
ra10-s2f	no. fuel rods 92	4 x 5 x 1	0.80381 ± 0.00231
ra10-s3	Damaged package,	10 x 15 x 1	1.01564 ± 0.00149
ra10-s3a	finite array,	8 x 12 x 1	0.99079 ± 0.00157
ra10-s3b	full water reflection,	6 x 9 x 1	0.94598 ± 0.00164
ra10-s3c	optimum moderation,	5 x 7 x 1	0.89884 ± 0.00159
ra10-s3d	w/ product container,	4 x 8 x 1	0.88773 ± 0.00151
ra10-s3e	fuel rod pitch 1.227 cm,	4 x 6 x 1	0.85655 ± 0.00163
ra10-s3f	no. fuel rods 84	4 x 5 x 1	0.83091 ± 0.00217

Table 5. Results for array calculations (continued)

ra10-s4	Damaged package,	10 x 15 x 1	1.02236 ± 0.00177
ra10-s4a	finite array,	8 x 12 x 1	0.99758 ± 0.00162
ra10-s4b	full water reflection,	6 x 9 x 1	0.95600 ± 0.00164
ra10-s4c	optimum moderation,	5 x 7 x 1	0.91137 ± 0.00162
ra10-s4d	w/ product container,	4 x 8 x 1	0.90418 ± 0.00176
ra10-s4e	fuel rod pitch 1.277 cm,	4 x 6 x 1	0.86651 ± 0.00161
ra10-s4f	no. fuel rods 76	4 x 5 x 1	0.84094 ± 0.00199
ra10-s5	Damaged package,	10 x 15 x 1	1.04891 ± 0.00155
ra10-s5a	finite array,	8 x 12 x 1	1.02520 ± 0.00164
ra10-s5b	full water reflection,	6 x 9 x 1	0.97702 ± 0.00157
ra10-s5c	optimum moderation,	5 x 7 x 1	0.93548 ± 0.00159
ra10-s5d	w/ product container,	4 x 8 x 1	0.93070 ± 0.00162
ra10-s5e	fuel rod pitch 1.327 cm,	4 x 6 x 1	0.89639 ± 0.00182
ra10-s5f	no. fuel rods 73	4 x 5 x 1	0.87062 ± 0.00199
ra10-s6	Damaged package,	10 x 15 x 1	1.08883 ± 0.00160
ra10-s6a	finite array,	8 x 12 x 1	1.06036 ± 0.00159
ra10-s6b	full water reflection,	6 x 9 x 1	1.01781 ± 0.00143
ra10-s6c	optimum moderation,	5 x 7 x 1	0.97167 ± 0.00155
ra10-s6d	w/ product container,	4 x 8 x 1	0.95890 ± 0.00186
ra10-s6e	fuel rod pitch 1.377 cm,	4 x 6 x 1	0.92932 ± 0.00223
ra10-s6f	no. fuel rods 75	4 x 5 x 1	0.90121 ± 0.00215
ra10-s7	Damaged package,	10 x 15 x 1	1.07766 ± 0.00193
ra10-s7a	finite array,	8 x 12 x 1	1.05544 ± 0.00230
ra10-s7b	full water reflection,	6 x 9 x 1	1.00542 ± 0.00213
ra10-s7c	optimum moderation,	5 x 7 x 1	0.96973 ± 0.00211
ra10-s7d	w/ product container,	4 x 8 x 1	0.95861 ± 0.00268
ra10-s7e	fuel rod pitch 1.477 cm,	4 x 6 x 1	0.92410 ± 0.00261
ra10-s7	no. fuel rods 55	4 x 5 x 1	0.89870 ± 0.00211
ra10-s8	Damaged package,	10 x 15 x 1	1.08508 ± 0.00147
ra10-s8a	finite array,	8 x 12 x 1	1.06262 ± 0.00146
ra10-s8b	full water reflection,	6 x 9 x 1	1.02191 ± 0.00167
ra10-s8c	optimum moderation,	5 x 7 x 1	0.98169 ± 0.00162
ra10-s8d	w/ product container,	4 x 8 x 1	0.96797 ± 0.00161
ra10-s8e	fuel rod pitch 1.577 cm,	4 x 6 x 1	0.93445 ± 0.00174
ra10-s8f	no. fuel rods 37	4 x 5 x 1	0.91320 ± 0.00159

Table 5. Results for array calculations (continued)

ra10-s9	Damaged package,	10 x 15 x 1	1.01056 ± 0.00202
ra10-s9a	finite array,	8 x 12 x 1	0.99237 ± 0.00205
ra10-s9b	full water reflection,	6 x 9 x 1	0.91668 ± 0.00192
ra10-s9c	optimum moderation,	5 x 7 x 1	0.91459 ± 0.00213
ra10-s9d	w/ product container,	4 x 8 x 1	0.90652 ± 0.00245
ra10-s9e	fuel rod pitch 1.827 cm,	4 x 6 x 1	0.88407 ± 0.00229
ra10-s9f	no. fuel rods 30	4 x 5 x 1	0.86219 ± 0.00214
ra10s10	Damaged package,	10 x 15 x 1	0.97282 ± 0.00225
ra10s10a	finite array,	8 x 12 x 1	0.95380 ± 0.00228
ra10s10b	full water reflection,	6 x 9 x 1	0.91668 ± 0.00192
ra10s10c	optimum moderation,	5 x 7 x 1	0.88515 ± 0.00225
ra10s10d	w/ product container,	4 x 8 x 1	0.87633 ± 0.00251
ra10s10e	fuel rod pitch 2.077 cm,	4 x 6 x 1	0.85097 ± 0.00253
ra10s10f	no. fuel rods 26	4 x 5 x 1	0.83855 ± 0.00223

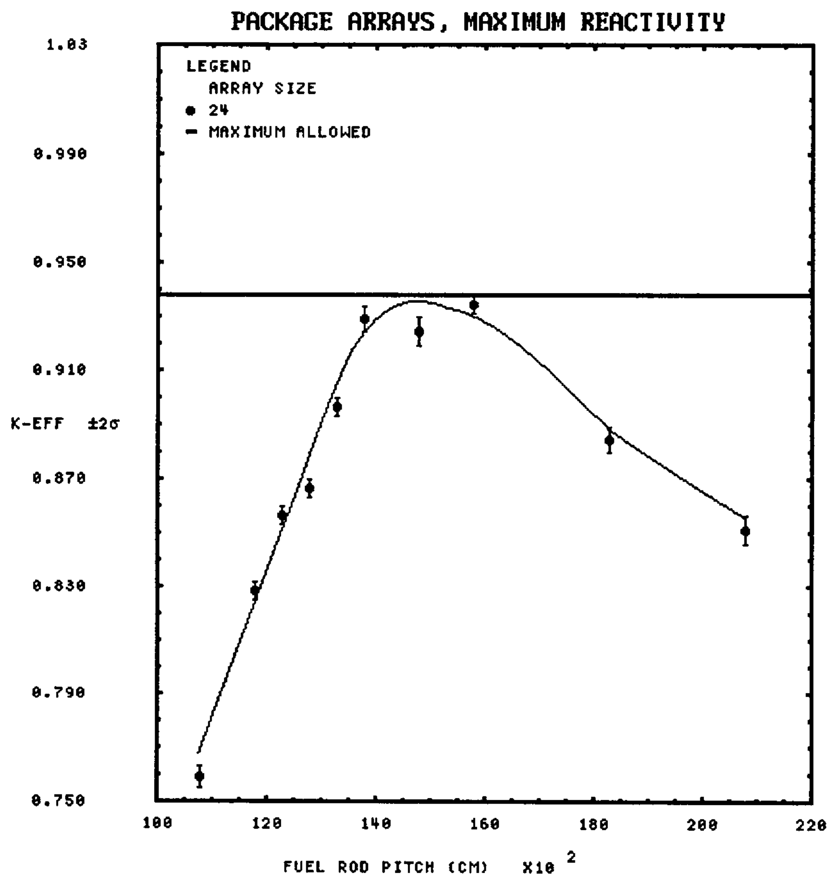

Figure 5a Typical reactivity, k_{eff}, vs moderation of product container for package array (4 x 6 x 1)

The k_{eff} results may be plotted for a specific array size to determine the optimum fuel rod pitch. Figure 5a displays a the relationship between k_{eff} and moderation typical for the package array with the product container. The optimum moderation occurs in at a fuel rod pitch 1.4 cm to 1.6 cm for any array size. This is consistent with the most reactive condition for a single package with the product container and typical of k_{eff} calculations or infinite fuel rod lattices.

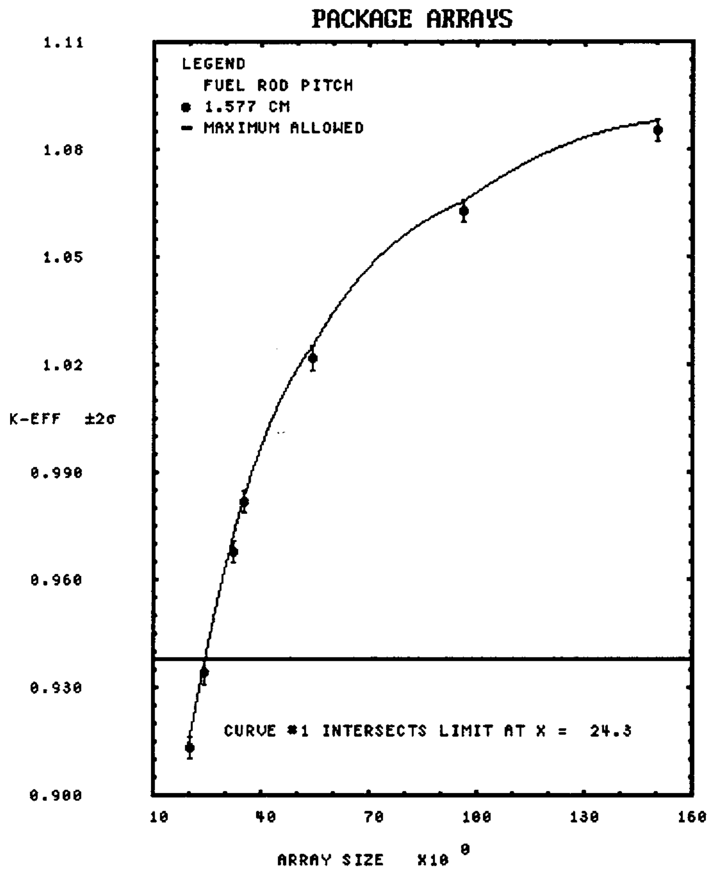

Figure 5b Typical reactivity, k_{eff}, vs array size for a product container moderation (fuel rod pitch 1.577 cm , 55 fuel rods)

The k_{eff} results for each array size are plotted to determine a maximum allowed value for 2N for a range of fuel rod pitches. Figure 5b displays a typical relationship between k_{eff} and array size for specific fuel rod pitch. The maximum allowed number of damaged packages, 2N, is about 26 for optimum moderation of the product container that occurs at a fuel rod pitch of 1.577 cm.

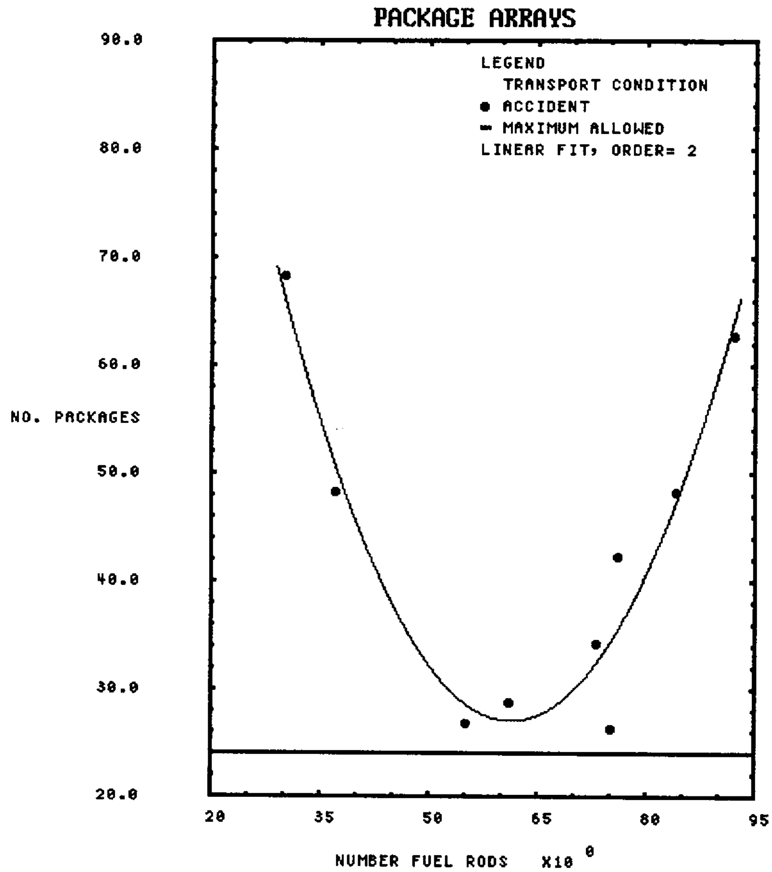

Figure 5c Maximum allowed number of damaged packages, 2N, with product container contents

Each value for 2N is plotted versus the number of fuel rods that corresponds to the value determined for a specific array size as shown in Figure 5b. This demonstrates that there is a maximum number of packages allowed for which the damaged array is subcritical independent of the number of fuel rods loaded in the product container. This maximum value for 2N is no less than 24 as shown in Figure 5c.

6.3 CRITICALITY SAFETY INDEX

The criticality safety index. (TI) for criticality control is determined by the number of packages that remain below the upper safety limit (USL). For normal conditions of transport, and infinite array of packages with either the rod bundle contents is subcritical. Therefore, the maximum allowed number of undamaged packages that may be in any arrangement is unlimited, and 5N is equal to infinity.

Under hypothetical accident conditions, an infinite number of packages with a bundle of 20 fuel rods loaded directly in the channel assembly is subcritical. Therefore, 2N is equal to infinity when the product container is not used. A maximum of only 24 damaged packages remain subcritical when the product container is used, and 2N is equal to 24 when the product container is used.

The transport indexes assigned to the RA-3 package with a rod bundle contents depends on the packaging used for the fuel rods. A TI = 0.0 may be assigned when the number of fuel rods is limited to 20 per side of the channel assembly for a total of 40 fuel rods per RA-3 package. However, a TI = 4.2 must be assigned when the product container is used, but there is no limit on the number of fuel rods loaded in the product container.