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DRAFT REGULATORY GUIDE

Contact: N.L. Osgood (301)415-8513

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(Proposed Revision 2 of Regulatory Guide 7.9)

STANDARD FORMAT AND CONTENT OF PART 71 APPLICATIONS FOR APPROVAL OF PACKAGING FOR RADIOACTIVE MATERIAL

A. INTRODUCTION

This regulatory guide is being developed to provide guidance on the preparation of applications for approval of packaging to be used for the shipment of Type B and fissile radioactive material. It is not intended as an interpretation of the NRC's regulations, within the meaning of 10 CFR 71.2. Nothing contained in this guide is to be construed as having the force and effect of NRC regulations, or as indicating that applications supported by safety analyses and prepared in accordance with the recommendations of this regulatory guide necessarily will be approved, or as relieving any licensee from the requirements of 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," or any other pertinent regulations.

This regulatory guide should not be considered a substitute for 10 CFR Part 71. Its primary purpose is to assist the applicant in preparing an application that thoroughly and completely demonstrates the adequacy of the package in meeting the regulations. In addition to a package approval, the applicant must have an approved quality assurance program in accordance with the provisions of 10 CFR 71.101 through 71.137. Additional information may be requested in support of an application if the NRC believes that such information is necessary to provide reasonable assurance of the safety of the proposed shipment. In preparing an application for package approval, the applicant may find it useful to refer to other regulatory guides in Division 7, "Transportation."

Regulatory guides are issued to describe to the public methods acceptable to the NRC staff for implementing specific parts of the NRC's regulations, to explain techniques used by the staff in

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This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review or approval and does not represent an official NRC staff position.

Public comments are being solicited on this draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Rules and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. Comments may be submitted electronically or downloaded through the NRC's interactive web site at <WWW.NRC.GOV> through Rulemaking. Copies of comments received may be examined at the NRC Public Document Room, 11555 Rockville Pike, Rockville, MD. Comments will be most helpful if received by March 9, 2004.

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evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with regulatory guides is not required. Regulatory guides are issued in draft form for public comment to involve the public in developing the regulatory positions. Draft regulatory guides have not received complete staff review; they therefore do not represent official NRC staff positions.

The information collections contained in this draft regulatory guide are covered by the requirements of 10 CFR Part 71, which were approved by the Office of Management and Budget (OMB), approval number 3150-0008. The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

B. STANDARD FORMAT

Purpose of Standard Format

The purpose of this regulatory guide, "Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Material" (hereinafter called "Standard Format"), is to indicate the information to be provided in the application and to establish a uniform format for presenting the information. Use of this format will help ensure the completeness of the information provided, will assist the NRC staff and others in locating the information, and will aid in shortening the time needed for the review process. The application is the principal document in which the applicant provides the information and bases for the NRC staff to determine whether or not the package meets the requirements of 10 CFR Part 71.

Applicability of Standard Format

This Standard Format applies specifically to applications for approval of package designs of Type B and fissile radioactive material under 10 CFR Part 71. The Standard Format identifies general and detailed information required and will help ensure the completeness of the information provided.

Use of Standard Format

The Standard Format presents a format for applications for approval that is acceptable to the NRC staff. Conformance with the Standard Format, however, is not required. Applications for approval with different formats will be acceptable to the NRC staff if they provide an adequate basis for the findings requisite to the approval of packaging. However, because it may be more difficult to locate needed information, the staff review time for such applications may be longer.

Upon receipt of an application, the NRC staff will perform a preliminary review to determine whether the application provides a reasonably complete presentation of the information that is needed to form a basis for the findings required before approval of a package in accordance with 10 CFR Part 71. The Standard Format will be used by the staff as a guideline to identify the type of information needed. If the application does not provide a reasonably complete presentation of the necessary information, the application will not be reviewed further until a reasonably complete presentation is provided. The information provided in the application should be up to date with respect to the state of technology for transportation of radioactive materials and should take into account any recent changes in NRC regulations and guides, industry codes and standards, results of recent developments in transportation safety, and experience in the construction and use of radioactive material packaging.

Style and Composition

The applicant should strive for clear, concise presentation of the information provided in the application. Confusing or ambiguous statements and unnecessarily verbose descriptions do not contribute to expeditious technical review. Claims of adequacy of designs or design methods should be supported by technical bases (i.e., by an appropriate engineering evaluation or description of actual tests). Terms as defined in the packaging and transport regulations must be used.

The application should follow the numbering system and headings of the Standard Format at least to the headings with three digits (e.g., 2.1.2 Design Criteria). When a particular requirement does not apply to a package, the corresponding subsection should not be omitted but should be addressed with the term “Not Applicable.” A reason should be offered for not addressing a particular requirement when there is doubt as to its applicability.

Appendices to each section of the application should include detailed information omitted from the main text. A list of reports or other documents that are referenced in the text of the application should be included in the appendix at the end of the section in which they are referenced. When specific items are referenced, page numbers should be provided. If proprietary documents are referenced, the nonproprietary summary description of the document should also be referenced.

All physical tests of components and packages should be supported by photographs in the appendices of the appropriate section. Appendices to the application may also be used to provide supplemental information not explicitly identified in the Standard Format. Examples of such information are (1) summaries of the manner in which the applicant has treated matters addressed in NRC regulatory guides and (2) supplementary information regarding calculational methods or design approaches used by the applicant.

When numerical values are stated, the number of significant figures given should reflect the accuracy or precision to which the number is known. When possible, estimated limits of error or uncertainty should be given. Significant figures should not be dropped or rounded off if, by doing so, subsequent conclusions are inadequately supported.

Abbreviations should be consistent throughout the application and should be consistent with generally accepted usage. Any abbreviations, symbols, or special terms unique to the proposed packaging or not in general usage should be defined in each section of the application in which they are used.

Drawings, diagrams, sketches, and charts should be used when the information can be presented more accurately or conveniently by such means. Due concern should be taken to ensure that all information presented in drawings is legible, symbols are defined, and drawings are not reduced to the extent that visual aids are necessary to interpret pertinent items of information presented in the drawings.

Pages should be numbered by section and sequentially within each section. For example, the fourth page of Section 6 would be numbered 6-4.

Revisions

Data and text should be updated or revised by replacing pages. "Pen and ink" or "cut and paste" changes should not be used.

The changed or revised portion on each page should be highlighted by a "change indicator" mark consisting of a bold vertical line drawn in the margin opposite the binding margin. The line should be the same length as the portion actually changed.

All pages submitted to update, revise, or add pages to the application should show the date of change and a change or amendment number. A transmittal letter, including a guide page listing the pages to be inserted and the pages to be removed, should accompany the revised pages. When applicable, supplemental pages may follow the revised page.

All statements on a revised page should be accurate as of the date of the submittals.

Special care should be taken to ensure that the main sections of the application are revised to reflect any design changes reported in supplemental information (i.e., responses to NRC staff requests for information or responses to regulatory positions).

Physical Specifications

All material submitted as part of the application should conform to specific standards as to the physical dimensions of page size, quality of paper and inks, and numbering of pages, exhibits, and attachments. More specifically:

Paper Size (not to exceed)

Text pages:	8 ½ × 11 inches.
Drawings and graphics:	8 ½ × 11 inches preferred; however, a larger size is acceptable provided:

a. After reduction, the size does not exceed 11 × 17 inches, including a 2-inch margin at left for binding.
b. The finished copy when folded does not exceed 8 ½ × 11 inches.

All drawings should have a drawing number, sheet number, company name, title, revision number, date of revision, and signature or initials indicating approval of the drawing and each revision.

Paper Stock

Weight or substance:	20 pound for printing on both sides. 16 to 20 pound for printing on one side only.
Composition:	Wood chemical sulfite (no groundwood) and a pH of 5.5.
Color:	White is preferred, but pastel colors are acceptable provided the combination of paper stock and ink is suitable for microfilming.

Ink: Color sufficiently dense to record on microfilm or image-copying equipment.

Page Margins: A margin of no less than 1 inch should be maintained on the top, bottom, and binding side of all pages.

Printing

Composition: Text pages should be single spaced.

Type font and style: Must be suitable for microfilming.

Reproduction: May be mechanically or photographically reproduced. Text pages should preferably be printed on two sides with the image printed head to head.

Binding: Pages should be punched for standard 3-hole looseleaf binder and contained within a binder supplied by the applicant.

Separators: Separators should be provided between each section of the application.

Number of Copies: Ten copies of the application should be provided.

Proprietary Withholding

Proprietary information, such as specific design details shown on the engineering drawings, may be withheld from public disclosure subject to the provisions of 10 CFR 2.790. The request for withholding must be accompanied by an affidavit and must include information to support the claim that the material is proprietary. Requests for withholding are reviewed by the NRC's Office of the General Counsel for compliance with the requirements of 10 CFR 2.790.

C. APPLICATIONS

1. GENERAL INFORMATION

This section of the application should present an introduction and a description of the general package.

1.1 INTRODUCTION

This section should include the proposed use of the package, the model number, and, in the case of fissile packages, the proposed Criticality Safety Index (CSI).

1.2 PACKAGE DESCRIPTION

1.2.1 Packaging

The general packaging description should include:

- The overall dimensions, maximum weight (fully loaded), and minimum (empty) weight (if appropriate)
- Containment features
- Neutron and gamma shielding features, including personnel barriers

- Criticality control features, including neutron poisons, moderators, and spacers
- Structural features, including lifting and tie-down devices, impact limiters or other energy-absorbing features, internal supporting or positioning features, outer shell or outer packaging, and packaging closure devices
- Heat transfer features
- Packaging markings.

1.2.2 Containment System

The containment system components should be clearly identified. The exact boundary of the containment system should be defined; this may include the containment vessel, welds, drain or fill ports, valves, seals, test ports, pressure relief devices, lids, cover plates, and other closure devices. If multiple seals are used for a single closure, the seal defined as the containment-system seal should be clearly identified. A sketch of the containment system should be provided. All components should be shown on the engineering drawings in the appendix.

1.2.3 Contents

State the quantity of radionuclides to be transported. Describe the contents in the same detail as intended for the certificate of compliance. The description should include, if appropriate, the following information:

- Identification and maximum quantity (radioactivity or mass) of the radioactive material
- Identification and maximum quantity of fissile material
- Chemical and physical form, including density and moisture content, and the presence of any moderating constituents
- Location and configuration of contents within the packaging, including secondary containers, wrapping, shoring, and other material not defined as part of the packaging
- Identification and quantity of nonfissile materials used as neutron absorbers or moderators
- Any material subject to chemical, galvanic, or other reaction, including the generation of gases
- Maximum weight, and minimum weight if appropriate
- Maximum decay heat
- Any loading restrictions.

1.2.4 Operational Features

In the case of a complex package system, discuss the operational features of the package. This should include a schematic diagram showing all valves, connections, piping, openings, seals, containment boundaries, etc.

1.3 GENERAL REQUIREMENTS FOR ALL PACKAGES

The package description should address the requirements of 10 CFR 71.43, "General Standards for All Packages."

1.3.1 Minimum Package Size

The smallest overall dimension of the package should not be less than 10 cm (4 in).

1.3.2 Tamper-Indicating Feature

Describe and discuss the package closure system in sufficient detail to show that it incorporates a protective feature that, while intact, is evidence that the package has not been tampered with by unauthorized persons. This discussion should include covers, ports, or other access that must be closed during normal transportation. Describe tamper indicators and their locations.

1.4 APPENDIX

Drawings that clearly detail the safety features considered in the analysis should be included in Appendix 1.3. The drawings should include a materials list, dimensions, valves, fasteners, and welder and welding procedure qualification requirements. The drawings should specify, by appropriate weld symbol, the specifications for all packaging weld joints, including the method of nondestructive examination and the acceptance standard. Gasketed joints in the containment system should be sufficiently detailed to show, as a minimum, the surface finish and flatness requirements of the closure surfaces, the gasket or O-ring specification, and, if appropriate, the method of gasket or O-ring retention. Detailed construction drawings of large, complex packages should not be included. Packages authorized for shipment must conform to the approved design, that is, packages must conform to the drawings specified in the NRC approval.

The appendix should also include a list of references, a copy of any applicable reference not generally available, supporting information on special fabrication procedures, determination of the package category, and other appropriate supplemental information.

2. STRUCTURAL EVALUATION

This section of the application should identify, describe, discuss, and analyze the principal structural design of the packaging, components, and systems important to safety and describe how the package complies with the performance requirements of 10 CFR Part 71.

2.1 DESCRIPTION OF STRUCTURAL DESIGN

2.1.1 Discussion

Identify the principal structural members and systems such as the containment vessel, impact limiters, radiation shielding, closure devices, and ports that are important to the safe operation of the package. Reference the location of these items on drawings and discuss their structural design and performance.

Descriptive information important to structures includes:

- Dimensions, tolerances, and materials
- Maximum and minimum weights and centers of gravity of packaging and major subassemblies
- Maximum and minimum weight of contents, if appropriate
- Maximum normal operating pressure
- Description of closure system
- Description of handling requirements
- Fabrication methods, as appropriate.

2.1.2 Design Criteria

Describe the load combinations and factors that serve as design criteria. Design criteria may be used if judged acceptable by the NRC staff in meeting the structural requirements of 10 CFR 71.41 through 71.51. For each of these criteria, state the maximum allowable stresses and strains (as a percentage of the yield or ultimate values for ductile failure); describe how the other structural failure modes (e.g., brittle fracture, fatigue, buckling) are considered. If different design criteria are to be allowed in various parts of the packaging or for different conditions, the appropriate values for each case should be indicated. Include the criteria that will be used for impact evaluation. Identify all codes and standards that are used to determine material properties, design limits, or methods of combining loads and stresses. In cases of deviation from standard codes, or if certain components are not covered by such codes, provide a detailed description of the design criteria used as substitutes.

2.1.3 Weights and Centers of Gravity

List the total weight of the packaging and contents. Tabulate the weights of major individual subassemblies such that the sum of the parts equals the total of the package. Locate the center of gravity of the package and any other centers of gravity referred to in the application. It is not necessary to include the calculations made to determine these values, but a sketch or drawing that clearly shows the individual subassembly referred to and the reference point for locating its center of gravity should be included.

2.1.4 Identification of Codes and Standards for Package Design

Identify the established codes and standards proposed for use in package design, fabrication, assembly, testing, maintenance and use. Include an assessment of the applicability of the codes and standards. The codes or standards proposed should be appropriate for the package category (see Table 2-1).

Table 2-1 Category Designations for Type B Packages (from Regulatory Guide 7.11)

Contents Form/ Category	Category I	Category II	Category III
Special Form	Greater than 3,000 A_1* or greater than 1.11 PBq (30,000 Ci)	Between 3,000 A_1* and 30 A_1*, and not greater than 1.11 PBq (30,000 Ci)	Less than 30 A_1* and less than 1.11 PBq (30,000 Ci)
Normal Form	Greater than 3,000 A_2* or greater than 1.11 PBq (30,000 Ci)	Between 3,000 A_2* and 30 A_2*, and not greater than 1.11 PBq (30,000 Ci)	Less than 30 A_2* and less than 1.11 PBq (30,000 Ci)

* A_1 and A_2 are defined in 10 CFR 71.4.

2.2 MATERIALS

2.2.1 Material Properties and Specifications

List the material mechanical properties used in the structural evaluation. This may include yield stress, ultimate stress, modulus of elasticity, ultimate strain, Poisson’s ratio, density, and coefficient of thermal expansion. If impact limiters are used, include either a compression stress-strain curve for the material or the force-deformation relationship for the limiter, as appropriate. For materials subjected to elevated temperatures, the appropriate mechanical properties under these conditions should be specified. The source of all information in this section should be clearly and specifically referenced as to publication and page number. Where material properties are determined by testing, the test procedure, conditions, and measurements should be described in sufficient detail to allow the staff to conclude that the results are valid.

2.2.2 Chemical, Galvanic, or Other Reactions

Discuss possible chemical, galvanic, or other reactions in the packaging or between the packaging and the package contents, as well as methods used to prevent significant reactions. For each component material of the packaging, list all chemically or galvanically dissimilar materials with which it has contact. Coatings used on internal or external package surfaces should be considered. Consider reactions resulting from water inleakage or cask flooding and take into consideration the possible generation of hydrogen or other gases from chemical or radiolytic interactions. Galvanic interactions and the formation of a eutectic should be considered for components that are or may be in physical contact.

2.2.3 Effects of Radiation on Materials

Describe any aging or damaging effects of radiation on the packaging materials. These effects may include degradation of seals, sealing materials, coatings, adhesives, and structural materials.

2.3 FABRICATION AND EXAMINATION

2.3.1 Fabrication

Describe the fabrication processes used for the package, such as fitting, aligning, welding and brazing, heat treatment, and foam and lead pouring. For fabrication specifications prescribed by an acceptable code or standard (e.g., ASME, AWS), the code or standard should be identified on the engineering drawings. Unless the application justifies otherwise, specifications of the same code or standard used for design should also be used for fabrication. For components for which no code or standard is applicable, the application should identify the specifications on which the evaluation depends and describe the method of control to assure that these specifications are achieved. This description may reference a quality assurance or other appropriate specifications document, which should be specified on the engineering drawings.

2.3.2 Examination

Examination addresses the methods and criteria by which the fabrication is determined to be acceptable. Unless the application justifies otherwise, specifications of the same code or standard used for fabrication should also be used for examination. For components for which no fabrication code or standard is applicable, the application should summarize the examination methods and acceptance criteria in Section 8, "Acceptance Tests and Maintenance Program."

2.4 LIFTING AND TIE-DOWN STANDARDS FOR ALL PACKAGES

2.4.1 Lifting Devices

Identify all devices and attachments that can be used to lift the package or its lid. Show by testing or analysis that these devices comply with the requirements of 10 CFR 71.45(a). Provide drawings or sketches that show the location and construction of these items. Determine the effects of the forces imposed by lifting device and other packaging surfaces. Documented values of the yield stresses of the materials should be used as the criteria to demonstrate compliance with 10 CFR 71.45(a), including failure under excessive load.

2.4.2 Tie-Down Devices

Identify all devices that are a structural part of the package and can be used as tie-downs. Discuss the overall tie-down system. Show by testing or analysis that these devices comply with the requirements of 10 CFR 71.45(b). Provide drawings or sketches that show the location and construction of these devices and the overall tie-down system. Determine the effect of the imposed forces of vital package components, including the interfaces between the tie-down devices and other package surfaces. Documented values of the yield stresses of the materials should be used as the criteria to demonstrate compliance with 10 CFR 71.45(b), including failure under excessive load.

2.5 GENERAL CONSIDERATIONS

Package structural evaluation may be performed by analysis or test or a combination of both. In describing the structural evaluation of package, clearly show that the most limiting initial test conditions and most damaging orientations are considered, and the evaluation methods are appropriate and properly applied.

2.5.1 Evaluation by Test

Describe the test method, procedures, equipment, and facilities that were used. Describe the package orientations for free drop, puncture and immersion tests. If the package tested is not identical in all respects to the package described in the application, explain the differences and show that these differences would not affect the test results.

Describe the materials used as substitutes for the radioactive contents during the tests. Show that this substitution would not affect the test results. Consider the effects of internal decay heat and pressure buildup if these effects would have arisen with the actual loading.

Describe in a quantitative manner the damage caused by the tests and the results of any measurements that were made. Include both interior and exterior damage. Provide photographs of the damaged packaging.

For prototype and model testing, describe the test specimen completely and provide detailed drawings that show its dimensions and materials of construction. Specify the dimensional tolerances to which the prototype or model was fabricated and compare these to the tolerances that will be used for the package.

For scale models, state the scale factor that was used. Describe in detail the laws of similitude that were used for testing, considering time scale, material density, velocity at impact, and kinetic energy. Show that the model test will give conservative results for peak g-force, maximum deformation, and dissipated energy. Correlate the damage done to the model with damage to the package and show that the package would be adequate to meet the performance requirements of 10 CFR Part 71.

2.5.2 Evaluation by Analysis

Describe the methods and calculations used in the package evaluation in sufficient detail to allow the results to be verified. Clearly describe and justify all assumptions that are used in the analysis. Include adequate narration and use of sketches and free body force diagrams. For equations used in the analysis, either the source should be referenced or the derivation should be included.

For computer analyses, including finite element analyses, describe the computer program and show that it is well benchmarked, widely used for structural analyses, and applicable to the evaluation. Clearly describe any models and modeling details. The number of discrete finite elements used in the model should reflect the type of analysis being performed. For example, regions in the model of high stress or displacement should have a higher number of elements than regions that have a nearly equilibrated state of stress or are in a uniform stress field. Describe sensitivity studies used to determine the appropriate number of nodes or elements for a particular model. Describe in detail the modeling of bolted connections, including element types, modeling technique, and material properties.

The analysis should show how all the kinetic energy will be dissipated and what local deformation and dynamic forces occur during impact. The response of the package in terms of stress and strain to components and structural members should be shown. The structural stability of individual members, as applicable, should be investigated as well as stress that is due to impact combined with those stresses caused by temperature gradients, differential thermal expansions, pressure, and other loads. Provide a direct comparison of the results of the analysis with the acceptance criteria and show that the performance requirements of 10 CFR Part 71 are met.

2.6 NORMAL CONDITIONS OF TRANSPORT

In this section, show that the package, when subjected to the conditions and test (normal conditions of transport) specified in 10 CFR 71.71, meets the standards specified in 10 CFR 71.43 and 71.51, as demonstrated in the following paragraphs. The package should be assessed against each condition separately and a determination made that the applicable performance requirements specified in the regulations have been satisfied.

2.6.1 Heat

The thermal evaluation for the heat test should be described and reported in Section 3, "Thermal Evaluation."

2.6.1.1 Summary of Pressures and Temperatures. Summarize all pressures and temperatures determined in Section 3, "Thermal Evaluation," that will be used to perform the calculations required for Sections 2.6.1.2, 2.6.1.3, and 2.6.1.4.

2.6.1.2 Differential Thermal Expansion. Calculate the circumferential and axial deformations and stresses (if any) that result from differential thermal expansion. Consider steady-state and transient conditions. These calculations must be sufficiently comprehensive to demonstrate package integrity under normal transport conditions.

2.6.1.3 Stress Calculations. Calculate the stresses that are due to the combined effects of thermal gradients, pressure, and mechanical loads (including fabrication stresses from lead pour and lead cooldown). Provide sketches that show the configuration and dimensions of the members or systems being analyzed and locate the points at which the stresses are being calculated. The analysis should consider whether repeated cycles of thermal loadings, together with other loadings, will cause fatigue failure or extensive accumulations of deformation.

2.6.1.4 Comparison with Allowable Stresses. Make the appropriate stress combinations and compare the resulting stresses with the design criteria specified in the application. Show that all the performance requirements specified in the regulations have been satisfied.

2.6.2 Cold

The thermal evaluation under cold conditions should be described and reported in Section 3, "Thermal Evaluation." Assess the package for the effects of the cold condition, including material properties and possible freezing of liquids and lead shrinkage. Identify, for safety components, the resulting temperatures and their effect on operation of the package. Brittle fracture should be considered. Stresses should be within the limits for normal condition loads. For the sequential hypothetical accident test series, -29°C (-20°F) is the lowest service temperature that needs to be considered, as specified in 10 CFR 71.73(b).

2.6.3 Reduced External Pressure

Assess the package design for the effects of reduced external pressure specified in 10 CFR 71.71(c). Calculate the greatest possible pressure difference between the inside and outside of the package as well as the inside and outside of the containment system. Evaluate this condition in combination with the maximum normal operating pressure.

2.6.4 Increased External Pressure

Assess the package design for the effects of increased external pressure as specified in 10 CFR 71.71(c). Evaluate this condition in combination with minimum internal pressure. Calculate the greatest possible pressure difference between the inside and outside of the package as well as the inside and outside of the containment system. Calculate the possibility of buckling.

2.6.5 Vibration

Assess the package for the effects of vibrations normally incident to transport. Investigate the combined stresses due to vibration, temperature, and pressure loads and provide a fatigue analysis, if necessary. If closure bolts are reused, include bolt preload in the fatigue evaluation. Check packaging components for resonant vibration conditions that can cause rapid fatigue damage. The effect on package internals should also be considered.

2.6.6 Water Spray

Assess the package design for the effects of the water spray test. Ensure that this test has no significant effect on material properties.

2.6.7 Free Drop

Assess the package for the effects of the free drop test. The general comments in Section 2.7.1 also apply to this condition. Note that the free drop test follows the water spray test. Address such factors as drop orientation, effects of free drop in combination with pressure, heat, and cold temperatures, and other factors discussed in Section 2.5.

2.6.8 Corner Drop

If applicable, describe the effects of corner drops on the package.

2.6.9 Compression

For packages weighing up to 5,000 kg (11,000 lbs), describe the effects of compression on the package.

2.6.10 Penetration

Describe the effects of penetration on the package. Note that the point of impact could be at any location on the exterior surface of the package. Indicate which package location is most vulnerable.

2.7 HYPOTHETICAL ACCIDENT CONDITIONS

In this section, show that the package, when subjected to the tests (hypothetical accident conditions) as specified in 10 CFR 71.73, meets the standards specified in 10 CFR 71.51, 71.55(e) and 71.59(a)(2), as demonstrated in the following paragraphs.

Consider the hypothetical accident conditions specified by the regulations in 10 CFR 71.73, in the order indicated, to determine their cumulative effect on a package. Damage caused by each test is cumulative, and the evaluation of the ability of a package to withstand any one test must consider the damage that resulted from the previous tests. It should be noted that a determination must have been made in Section 2.6 that the effectiveness of the package has not been reduced as a result of the normal conditions of transport. Brittle fracture should be considered.

2.7.1 Free Drop

The performance and structural integrity of a package must be evaluated for the drop orientation that causes the most severe damage, including center-of-gravity-over-corner, oblique orientation with secondary impact (slap down), side drop, and drop onto the closure. An orientation that results in the most damage to one system or component may not be the most damaging for other systems and components. If a feature such as a tie-down component is a structural part of the package, it should be considered in the selection of the drop test configurations and the drop orientation. For these reasons, it is usually necessary to consider several drop orientations. Orientations for which the center of gravity is directly over the point of impact must be considered.

Assess a package with lead shielding for the effects of lead slump. The lead slump determined should be consistent with that used in the shielding evaluation.

Assess the closure lid bolt design for the combined effects of free drop impact force, internal pressures, thermal stress, O-ring compression force, and bolt preload.

Assess other package components, such as port covers, port cover plates, and shield enclosures, for the combined effects of package drop impact force, puncture, internal pressures, and thermal stress.

Consider the buckling of package components.

The assessment of the package may be by analysis, prototype testing, model testing, or comparison to a similar package.

2.7.1.1 End Drop. Describe the effects of the end drop test on the package.

2.7.1.2 Side Drop. Describe the effects of the side drop test on the package.

2.7.1.3 Corner Drop. Describe the effects of the corner drop test on the package.

2.7.1.4 Oblique Drops. Assess the package for the effects of oblique drops or provide information that shows that the end, side, and corner drops are more damaging to all systems and components vital to safety.

2.7.1.5 Summary of Results. Discuss the condition of the package after each drop test. Summarize the extent to which the packaging would be damaged in each orientation.

2.7.2 Crush

If applicable, describe the effects of the dynamic crush test on the package.

2.7.3 Puncture

Describe the effects of puncture on the package. Identify and justify that the position for which maximum damage would be expected has been evaluated. Any damage resulting from the free drop and crush tests must be considered. Consider both local damage near the point of impact of the puncture bar and the overall effect on the package. Note that the point of impact could be at any location on the exterior surface of the package. It is particularly important that all valves and fittings necessary for containment be considered. General comments provided in Sections 2.5 and 2.7.1 may also apply to this test condition.

Although analytical methods are available for predicting puncture, empirical formulas derived from puncture test results of laminated panels are usually used for the design of packages. The Nelm’s formula developed specifically for package design provides the minimum thickness needed for preventing the puncture of the steel surface layer of a typical steel-lead-steel laminated cask wall.

Consider punctures at oblique angles, near a support, at a valve, at the package closure, and at a penetration as appropriate.

2.7.4 Thermal

The thermal test should follow the free drop test and puncture tests and should be reported in Section 3, "Thermal Evaluation." Evaluate the structural design for the effects of a fully engulfing fire, as specified in 10 CFR 71.73(c)(4). Any damage resulting from the free drop, crush, and puncture conditions must be incorporated into the initial condition of the package for the fire test. Consider the temperatures resulting from the fire and any increase in gas inventory caused by combustion or decomposition processes when determining the maximum pressure in the package during or after the test. Assess the maximum thermal stresses, which can occur either during or after the fire.

2.7.4.1 Summary of Pressures and Temperatures. Summarize all the temperatures and pressures, as determined in Section 3, "Thermal Evaluation," of the application.

2.7.4.2 Differential Thermal Expansion. Calculate the circumferential and axial deformations and stresses (if any) that result from differential thermal expansion. Consider peak conditions, postfire steady-state conditions, and all transient conditions.

2.7.4.3 Stress Calculations. Calculate the stresses caused by thermal gradients, differential expansion, pressure, and other mechanical loads. Provide sketches showing configuration and dimensions of the members of systems under investigation, and locate the points at which the stresses are being calculated.

2.7.4.4 Comparison with Allowable Stresses. Make the appropriate stress combinations and compare the resulting stresses with the design criteria in Section 2.1.2 of the application. Show that all the performance requirements specified in the regulations have been satisfied.

2.7.5 Immersion – Fissile Material

If the contents include fissile material subject to the requirements of 10 CFR 71.55, and if water leakage has not been assumed for the criticality analysis, assess the effects and consequences of the water immersion test condition by immersing a damaged specimen under a head of water of at least 0.9 m (3 ft.) in the orientation for which maximum leakage is expected.

2.7.6 Immersion – All Packages

Evaluate an undamaged package for water pressure equivalent to immersion under a head of water of at least 15 m (50 ft.) for 8 hours. For test purposes, an external gauge pressure of water of 150 kPa (21.7 psi) gauge is considered to meet these conditions.

2.7.7 Deep Water Immersion Test (for Type B Packages Containing More than 10^5 A_2)

If applicable, evaluate the package for an external water pressure of 2 MPa (290 psi) for a period of no less than one hour, in accordance with 10 CFR 71.61.

2.7.8 Summary of Damage

Discuss the condition of the package after the accident test sequences. Summarize the extent to which safety systems and components have been damaged and relate the package condition to the acceptance standards.

2.8 ACCIDENT CONDITIONS FOR AIR TRANSPORT OF PLUTONIUM

If applicable, address the accident conditions specified in 10 CFR 71.74.

2.9 ACCIDENT CONDITIONS FOR FISSILE MATERIAL PACKAGES FOR AIR TRANSPORT

If applicable, address the accident conditions specified in 10 CFR 71.55(f).

2.10 SPECIAL FORM

As applicable when special form is claimed, state that the contents meet special form requirements given in 10 CFR 71.75 when subjected to the applicable test conditions of 10 CFR 71.77. Describe the chemical and physical form. If the source is not a doubly encapsulated right circular cylinder of welded construction, provide a detailed drawing of the encapsulation showing the dimensions, materials, manner of construction, and method of nondestructive examination.

2.11 FUEL RODS

In Section 4, “Containment,” where fuel rod cladding is considered to provide containment of radioactive material under normal or accident test conditions, provide an analysis or test results showing that the cladding will maintain sufficient mechanical integrity to provide the degree of containment claimed.

2.12 APPENDIX

The appendix should include a list of references, copies of applicable references if not generally available, computer code descriptions, input and output files, test results, test reports, and other appropriate supplemental information.

3. THERMAL EVALUATION

This section of the application should identify, describe, discuss, and analyze the principal thermal engineering design of the packaging, components, and systems important to safety and describe how the package complies with the performance requirements of 10 CFR Part 71.

3.1 DESCRIPTION OF THERMAL DESIGN

Describe the significant thermal design features and operating characteristics of the package. The operation of all subsystems should be discussed. Identify any thermal criteria that will be applied directly to thermal results (e.g., maximum fuel temperature, shield temperature not to exceed melt). Also identify properties evaluated here but used to support other evaluations (e.g., pressure, temperature, distributions relative to thermal stress). Summarize the significant results of the thermal analysis or tests and the implication of these results on the overall package. State the minimum and maximum decay heat loads assumed in thermal evaluation. The maximum decay heat load assumed should be consistent with the source terms assumed in the shielding and containment analyses.

3.1.1 Design Features

Design features important to thermal performance include:

- Package geometry and materials of construction.
- The structural and mechanical features that may affect heat transfer, such as cooling fins, insulating materials, surface conditions of the package components, and gaps or physical contacts between internal components.

3.1.2 Content's Decay Heat

The maximum decay heat and the radioactivity of the contents should be specified. Show that the decay heat is consistent with the maximum quantity of radioactive contents.

3.1.3 Summary Tables of Temperatures

Present summary tables of the maximum or minimum temperatures that affect structural integrity, containment, shielding, and criticality for both normal conditions of transport and hypothetical accident conditions. For the fire test condition, the tables should also include:

- The maximum temperatures of various package components and the time at which they occur after fire initiation.
- The maximum temperatures of the post-fire steady-state condition.

3.1.4 Summary Tables of Maximum Pressures

Include the maximum normal operating pressure and maximum pressure under hypothetical accident conditions in the summary tables.

3.2 MATERIAL PROPERTIES AND COMPONENT SPECIFICATIONS

3.2.1 Material Properties

Specify the appropriate thermal properties for materials that affect heat transfer both within the package and from the package to the environment. Include any liquids or gases within the package and gases external to the package for hypothetical accident conditions. The thermal absorptivities and emissivities should be appropriate for the package surface conditions and each thermal condition. When reporting a property as a single value, ensure that this value bounds the equivalent temperature-dependent property. References for the data cited should be provided.

3.2.2 Component Specifications

Include the technical specifications of package components, as appropriate. For example, in the case of valves or seals, the operating pressure range and temperature limits should be included. The properties of fabricated insulation and coatings should be tabulated. Test data should be supplied in support of performance specifications and should be presented in detail in the appendix. Specify the maximum allowable service temperatures or pressures for each package component, as appropriate. The minimum allowable service temperature of all components should be less than or equal to -40°C (-40 °F).

3.3 GENERAL CONSIDERATIONS

Thermal evaluations of the package design can be performed by analysis or test or by a combination of both.

3.3.1 Evaluation by Analysis

Describe the methods and calculations used in the package thermal evaluation in sufficient detail to allow the results to be verified. Clearly describe and justify all assumptions that are used in the analysis. For computer analyses, including finite element analyses, describe the computer program and show that it is well benchmarked and widely used for thermal analyses and is applicable to the evaluation. Clearly describe any models and modeling details.

3.3.2 Evaluation by Test

Describe the test method, procedures, equipment, and facilities that were used. If the package tested is not identical in all respects to the package described in the application, explain the differences and show that these differences would not affect the test results. Temperature data should be taken at gaskets, valves, and other containment boundaries, as well as for the overall package, especially temperature-sensitive materials.

Some conditions, such as ambient temperature, decay heat of the contents, or package emissivity or absorptivity, may not be exactly represented in a thermal test. Include appropriate corrections or evaluations to account for these differences.

Describe in a quantitative manner the damage caused by the tests and the results of any measurements that were made. Include both interior and exterior temperatures. Provide photographs of the testing and the test specimen.

3.3.3 Margins of Safety

Appropriately address the margins of safety for package temperatures, pressures, and thermal stresses. Include the effects of uncertainties in thermal properties, test conditions and diagnostics, and analytical methods. Show that the analysis or test results are reliable and repeatable.

3.4 THERMAL EVALUATION UNDER NORMAL CONDITIONS OF TRANSPORT

Evaluate the package performance, including system and subsystem operation, for normal conditions of transport with respect to the results of the thermal analysis or tests performed. Take into account significant conditions to be found in the ranges bounded by the minimum and maximum ambient temperatures and minimum and maximum decay heat loads. Compare the results with allowable limits of temperature, pressure, etc., for the package components. Designate the information that is to be used in other sections of the review. Present the information in summary tables along with statements and appropriate comments.

3.4.1 Heat and Cold

Demonstrate that the tests for normal conditions of transport do not result in significant reduction in packaging effectiveness, including:

- Degradation of the heat-transfer capability of the packaging (such as creation of new gaps between components),
- Changes in material conditions or properties (e.g., expansion, contraction, gas generation, and thermal stresses) that affect the structural performance,
- Changes in the packaging that affect containment, shielding, or criticality such as thermal decomposition or melting of materials,
- Ability of the packaging to withstand the tests under hypothetical accident conditions.

Verify that the component temperatures and pressures do not exceed their allowable values. Show that the package meets the maximum surface temperature requirements specified in 10 CFR 71.43(g).

3.4.2 Maximum Normal Operating Pressure

Determine the maximum normal operating pressure when the package has been subjected to the heat condition for one year. In regard to the maximum normal operating pressure calculation, consider all possible sources of gases such as:

- Gases initially present in package
- Saturated vapor, including water vapor from the contents or packaging.
- Helium from the radioactive decay of the contents
- Hydrogen or other gases resulting from thermal- or radiation-induced decomposition of materials such as water or plastics
- Fuel rod failure.

Demonstrate that hydrogen and other flammable gases will not result in a flammable mixture within any confined volume.

3.4.3 Maximum Thermal Stresses

Determine the most severe thermal stress conditions that result during the fire test and subsequent cool-down. Report the temperatures corresponding to the maximum thermal stresses.

3.5 THERMAL EVALUATION UNDER HYPOTHETICAL ACCIDENT CONDITIONS

Evaluate the package performance under hypothetical accident thermal conditions. The hypothetical accident conditions as defined in 10 CFR 71.73, are applied sequentially.

3.5.1 Initial Conditions

Prior to the fire test, consider the effects of the drop, crush (if applicable), and puncture tests on the package design. Identify and justify the initial conditions that are most unfavorable, including initial ambient temperature, internal pressure, decay heat, etc.

3.5.2 Fire Test Conditions

Describe in detail the test or analyses used to evaluate the package under the fire test conditions. Show that the evaluation addresses the requirements in 10 CFR 71.73(c).

3.5.3 Maximum Temperatures and Pressure

Determine the transient peak temperatures of package components, as a function of time both during and after the fire. Determine the maximum temperatures from the post-fire, steady-state condition. The transient results of the thermal analysis or test should be presented. The temperatures reported should include those temperatures at locations in the package that are significant to the safety analysis and review. Report the temperatures for such items as contents, gaskets, valves, and shielding. The calculations of transient temperatures should trace the temperature-time history up to and past the time at which temperature maximums are achieved and begin to fall.

Base the evaluation of the maximum pressure in the package design on the maximum normal operating pressure as it is affected by fire-caused increases in package component temperatures. Account for possible increases in pressure caused by fire-induced thermal combustion or decomposition processes, fuel rod failure, phase changes, etc.

Compare the results with allowable limits of temperature, pressure, etc., for the package components. Consider any damage to the package either from interpretation of the analysis or from test observation. This assessment should include structural damage, breach of containment, and loss of shielding.

3.5.4 Accident Conditions for Fissile Material Packages for Air Transport

If applicable, address the expanded fire test conditions specified in 10 CFR 71.55(f).

3.6 APPENDIX

The appendix should include information such as justification of assumption or analytical procedures, test results, photographs, computer program descriptions and input and output files, specifications of O-rings and other components, and applicable pages from referenced documents.

4. CONTAINMENT

This section of the application should identify and discuss the package containment system and describe how the package complies with the performance requirements of 10 CFR Part 71.

4.1 DESCRIPTION OF THE CONTAINMENT SYSTEM

4.1.1 Containment Boundary

Define and describe the containment system, including components such as the containment vessel, welds, seals, lids, cover plates, valves, and other closure devices. The description should include materials of construction and applicable codes and standards. Identify the containment boundary of the package.

Describe the containment penetrations and their method of closure. Identify performance specifications for components such as valves and pressure relief devices. Show that the package does not allow continuous venting. Identify the method used to protect any valve or similar device on the package against unauthorized operation and, except for a pressure relief valve, describe the enclosure used to retain any leakage.

Show that the containment system can be securely closed with a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

4.1.2 Special Requirements for Plutonium

Plutonium in excess of 0.74 Tbq (20 Ci) is required to be shipped as a solid.

4.2 GENERAL CONSIDERATIONS

4.2.1 Type A Fissile Packages

For Type A fissile packages, no loss or dispersal of radioactive material is permitted under normal conditions of transport, as specified in 10 CFR 71.43(f). Although 10 CFR Part 71 does not provide numerical release limits for Type A packages, the package must retain fissile contents to ensure subcriticality under both normal conditions of transport and hypothetical accident conditions.

4.2.2 Type B Packages

Type B packages must satisfy the quantified release rates of 10 CFR 71.51. The application should describe in detail the method used to demonstrate that these release rates are met.

4.3 CONTAINMENT UNDER NORMAL CONDITIONS OF TRANSPORT (TYPE B PACKAGES)

The evaluation of the containment system should be performed for the most limiting chemical and physical forms of the contents. Include any significant daughter products. Identify the constituents of the releasable source term, including radioactive gases, liquids, and powder aerosols. Consider the maximum internal pressures.

Demonstrate that the package meets the containment requirements of 10 CFR 71.51(a)(l) under normal conditions of transport. The structural performance of the containment system, including seals, closure bolts, and penetrations, and leakage testing of the containment system should be addressed.

4.4 CONTAINMENT UNDER HYPOTHETICAL ACCIDENT CONDITIONS (TYPE B PACKAGES)

The evaluation of the containment system should be performed for the most limiting chemical and physical forms of the contents. Include any significant daughter products. Identify the constituents of the releasable source term, including radioactive gases, liquids, and powder aerosols. Consider the maximum internal pressures. The releasable contents and internal pressures may be different from those considered under normal conditions of transport.

Demonstrate that the package meets the containment requirements of 10 CFR 71.51(a)(2) under hypothetical accident conditions. The structural performance of the containment system, including seals, closure bolts, and penetrations, and leakage testing of the containment system should be addressed.

4.5 LEAKAGE RATE TESTS FOR TYPE B PACKAGES

Describe leakage tests that are used to show that the package meets the containment requirements of 10 CFR 71.51. These may include leakage tests of test units, newly fabricated packagings, periodic tests, and pre-shipment tests.

4.6 APPENDIX

The appendix should include supporting information and analysis, including a list of references, copies of applicable references if not generally available to the reviewer, test results, and other appropriate supplemental information.

5. SHIELDING EVALUATION

This section of the application should identify, describe, discuss, and analyze the principal shielding design of the packaging, components, and systems important to safety and describe how the package complies with the performance requirements of 10 CFR Part 71.

5.1 DESCRIPTION OF SHIELDING DESIGN

5.1.1 Design Features

Describe the radiation shielding design features of the package, including dimensions, tolerances, materials of construction, and densities of material for neutron and gamma shielding.

5.1.2 Summary Table of Maximum Radiation Levels

Present the maximum dose rates for both normal conditions of transport and hypothetical accident conditions at the appropriate locations for non-exclusive or exclusive use (or both), as applicable. See Table 5-1.

Table 5-1 Example for Summary Table of External Radiation Levels (Non-Exclusive Use)

Normal Conditions of Transport	**Package Surface mSv/h (mrem/h)**			**1 Meter from Package Surface mSv/h (mrem/h)**		
Radiation	Top	Side	Bottom	Top	Side	Bottom
Gamma						
Neutron						
Total						
10 CFR 71.47(a) Limit	2 (200)	2 (200)	2 (200)	0.1(10)*	0.1 (10)*	0.1 (10)*

* Transport index may not exceed 10.

Hypothetical Accident Conditions	**1 Meter from Package Surface mSv/h (mrem/h)**		
Radiation	Top	Side	Bottom
Gamma			
Neutron			
Total			
10 CFR 71.51(a)(2) Limit	10 (1000)	10 (1000)	10 (1000)

5.2 SOURCE SPECIFICATION

In this section, describe the contents and the gamma and neutron source terms used in the shielding analysis. Address any increase in source terms with time. For packages designed for spent fuel transport, assumed fuel burnup, power density, and cooling times should be stated.

5.2.1 Gamma Source

State the quantity of radioactive material included as contents and tabulate the gamma decay source strength (MeV/sec and photons/sec) as a function of photon energy. Describe in detail the method used to determine the gamma source strength and distribution.

5.2.2 Neutron Source

State the quantity of radioactive material included as contents and tabulate the neutron source strength (neutron/sec) as a function of energy. Describe in detail the method used to determine the neutron source strength and distribution.

5.3 SHIELDING MODEL

5.3.1 Configuration of Source and Shielding

Describe in detail the model that was used in the shielding evaluation. Evaluate the effects of the tests for normal conditions of transport and hypothetical accident conditions on the packaging and its contents. The models used in the shielding calculation should be consistent with these effects.

Include sketches, to scale, and dimensions of the radial and axial shielding materials. Include the dimensions of the transport vehicle and package location for exclusive-use shipments in which the analysis is based on the radiation levels of 10 CFR 71.47(b), as appropriate.

Include all dose point locations in the shielding model, including all locations prescribed in 10 CFR 71.47(a) or 71.47(b) and 10 CFR 71.5 l(a)(2). Choose these points to identify the location of the maximum radiation levels. Include voids, streaming paths, and irregular geometries in the model or otherwise treat in an adequate manner.

5.3.2 Material Properties

Describe the material properties (e.g., mass densities and atom densities) in the shielding models of the packaging and contents. The source of the data for uncommon materials should be referenced. Include any changes resulting under normal conditions of transport or hypothetical accident conditions, as appropriate.

5.4 SHIELDING EVALUATION

5.4.1 Methods

Provide a general description of the basic method used to determine the gamma and neutron dose rates at the selected points outside the package for both the normal and accident conditions of transport. This should include a description of the spatial source distribution and any computer program used with its referenced documentation. The basic input parameters should be discussed in detail. The basis for selecting the program, attenuation and removal cross-sections, and buildup factors should be provided.

5.4.2 Input and Output Data

Identify the key input data for the shielding calculations. These depend on the type of code (e.g., deterministic or Monte Carlo), as well as the code itself. Show that information from the shielding models is properly input into the code. Include at least one representative input file and output file (or key sections of the file). Show that the code achieved proper convergence and calculate dose rates. Show that the results agree with those reported in the text.

5.4.3 Flux-to-Dose-Rate Conversion

Include a tabulation of the flux-to-dose-rate conversion factors as a function of energy. Data should be supported by appropriate references.

5.4.4 External Radiation Levels

Describe the results of the radiation analysis. These should agree with the summary tables. Select locations of maximum dose rates for the analysis and provide sufficient data to show that the radiation levels are reasonable and their variations with location are consistent with the geometry and shielding characteristics of the package. Provide information for normal and accident conditions.

5.5 APPENDIX

Include information such as justification of assumptions or analytical procedures, test results, photographs, computer program descriptions and input and output files, references, applicable pages from referenced documents, and other supplemental information.

6. CRITICALITY EVALUATION

This section of the application should identify, describe, discuss, and analyze the principal criticality engineering-physics design of the packaging, components, and systems important to safety and describe how the package complies with the performance requirements of 10 CFR 71.55 and 71.59.

6.1 DESCRIPTION OF CRITICALITY DESIGN

6.1.1 Design Features

Describe the design features of the package that are important for criticality. These should include such information as the confinement system for the fissile material, neutron absorbing and moderating materials, flux traps, spacers, etc.

6.1.2 Summary Table of Criticality Evaluation

Provide a summary table of criticality analysis results for the package for the following cases, as described in Sections 6.4, 6.5, and 6.6:

- A single package, under the conditions of 10 CFR 71.55(b), (d), and (e)
- An array of undamaged packages, under the conditions of 10 CFR 71.59(a)(1)
- An array of damaged packages, under the conditions of 10 CFR 71.59(a)(2).

In the table, include the maximum value of the effective neutron multiplication factor (k_{eff}), the uncertainty, the bias, and the number of packages evaluated in the arrays.

6.1.3 Criticality Safety Index

Provide the Criticality Safety Index (CSI) based on the number of packages evaluated in the arrays, and show how it was calculated.

6.2 FISSILE MATERIAL CONTENTS

Provide a description of the fissile materials in the package. Include mass, dimensions, enrichment, physical and chemical composition, density, moisture, and other characteristics dependent on the specific contents.

6.3 GENERAL CONSIDERATIONS

The considerations discussed below are applicable to the criticality evaluations of a single package and arrays of packages under normal conditions of transport and hypothetical accident conditions.

6.3.1 Model Configuration

Describe and provide sketches of the calculation model used in the calculations. The sketches should identify the materials used in all regions of the model. Differences between the actual package configuration and the model should be identified, and the model should be shown to be conservative. Differences between the models for the normal conditions of transport and accident conditions should be clearly identified.

6.3.2 Material Properties

Provide the appropriate mass densities and atomic number densities for materials used in the models of the packaging and contents. Material properties should be consistent with the condition of the package under the tests of 10 CFR 71.71 and 71.73. Address any differences between normal conditions of transport and hypothetical accident conditions. Specifically address materials relevant to the criticality design such as poisons, foams, plastics, and other hydrocarbons.

6.3.3 Computer Codes and Cross-Section Libraries

Provide a complete description of the basic calculational methods used to calculate the effective multiplication constant of the package to demonstrate compliance with the fissile material package standards. This should include a description of the computer program and neutron cross-sections used with their referenced documentation. The basis for selecting the program and cross-sections should be discussed. Identify key input data for the criticality calculations, such as neutrons per generation, number of generations, convergence criteria, mesh selection, etc., depending on the code used.

6.3.4 Demonstration of Maximum Reactivity

The analyses should demonstrate the most reactive configuration of each case listed in Sections 6.4, 6.5, and 6.6 (single package, arrays of undamaged packages, and arrays of damaged packages). Clearly identify and justify assumptions and approximations.

The analysis should determine the optimum combination of internal moderation (within the package) and interspersed moderation (between packages), as applicable. Consider the preferential flooding of different regions within the package as appropriate. Note that the maximum allowable fissile material mass is not necessarily the most reactive contents.

6.4 SINGLE PACKAGE EVALUATION

6.4.1 Configuration

Demonstrate that a single package is subcritical under both normal conditions of transport and hypothetical accident conditions. Consider:

- Fissile material in its most reactive credible configuration consistent with the condition of the package and the chemical and physical form of the contents.
- Water moderation to the most reactive credible extent, including water inleakage to the containment system as specified in 10 CFR 71.55(b).
- Full water reflection on all sides of the containment system as specified in 10 CFR 71.55(b)(3), or reflection by the package materials, whichever results in the maximum reactivity.

6.4.2 Results

The package should also meet the additional specifications of 10 CFR 71.55(d)(2) through 71.55(d)(4) under normal conditions of transport.

6.5 EVALUATION OF PACKAGE ARRAYS UNDER NORMAL CONDITIONS OF TRANSPORT

6.5.1 Configuration

An array of 5N packages should be subcritical under normal conditions of transport. Consider:

- The most reactive configuration of the array (e.g., pitch and package orientation) with nothing between the packages,

- The most reactive credible configuration of the packaging and its contents under normal conditions of transport. If the water spray test has demonstrated that water would not leak into the package, water inleakage need not be assumed,
- Full water reflection on all sides of a finite array.

6.5.2 Results

Present the results of the analyses for arrays and identify the most reactive array conditions.

6.6 PACKAGE ARRAYS UNDER HYPOTHETICAL ACCIDENT CONDITIONS

6.6.1 Configuration

An array of 2N packages should be subcritical under hypothetical accident conditions. Consider:

- The most reactive configuration of the array (e.g., pitch, package orientation, and internal moderation),
- Optimum interspersed hydrogenous moderation,
- The most reactive credible configuration of the packaging and its contents under hypothetical accident conditions, including inleakage of water,
- Full water reflection on all sides of a finite array.

6.6.2 Results

Present the results of the analyses for arrays and identify the most reactive array conditions.

6.7 FISSILE MATERIAL PACKAGES FOR AIR TRANSPORT

6.7.1 Configuration

A single package should be subcritical under the expanded accident conditions specified in 10 CFR 71.55(f). Consider:

- The most reactive configuration of the contents and packaging under the expanded accident conditions,
- Full water reflection,
- No water inleakage.

6.7.2 Results

Present the results of the analyses for the single package and identify the most reactive contents and packaging conditions.

6.8 BENCHMARK EVALUATIONS

Benchmark the computer codes for criticality calculations against critical experiments. Use the same computer code, hardware, and cross-section library as those used to calculate the effective multiplication factor values for the package in the benchmark experiments.

Provide a justification for the validity of the calculational method and neutron cross-section values used in the analysis by presenting the results of calculations for selected critical benchmark experiments.

6.8.1 Applicability of Benchmark Experiments

Provide a description of selected critical benchmark experiments that are to be analyzed using the method and cross-sections given in Section 6.3. The applicability of the benchmarks in relation to the package and its contents should be shown. All similarities and differences should be noted and resolved respectively. References giving full documentation on these experiments should be provided. Address the overall quality of the benchmark experiments and the uncertainties in experimental data.

Actual nuclear and geometric input parameters used for benchmark calculations should be provided. Provide the results of the benchmark calculations.

6.8.2 Bias Determination

Present the results of the calculations for the benchmark experiments and the method used to account for biases, including the contribution from uncertainties in experimental data.

Analyze a sufficient number of appropriate benchmark experiments and use the results of these benchmark calculations to determine an appropriate bias for the package calculations, considering parameters such as pitch-to-rod diameter, assembly separation, neutron absorber material, etc. Address statistical and convergence uncertainties.

6.9 APPENDIX

This appendix should include information such as justification of assumption or analytical procedures, test results, photographs, and a list of references and applicable pages from referenced documents, if not generally available, and other supplemental information. Include computer code descriptions and input and output files. Input files for representative or most limiting cases for a single package and arrays of damaged and undamaged packages should be included.

7. PACKAGE OPERATIONS

Describe the package operations used to load a package and prepare it for transport. The operations steps should be presented sequentially in the actual order of performance. The operations should describe the fundamental steps needed to assure that the package is properly prepared for transport consistent with the package evaluation in Sections 2 through 6 of the application.

The package should be operated in accordance with detailed written procedures that are based on and consistent with the operations described in this section of the application. The package operations should be consistent with maintaining occupational radiation exposures as low as reasonably achievable (ALARA) as required by 10 CFR 20.1101(b) of 10 CFR Part 20, “Standards for Protection Against Radiation.”

7.1 PACKAGE LOADING

The operations should include inspections, tests, and preparations of the package for loading. This should include the inspections made prior to loading the package to determine that the package is not damaged and radiation and surface contamination levels are within allowable limits of the regulations.

7.1.1 Preparation for Loading

At a minimum, the operations for preparing the package for loading should specify that the package is loaded and closed in accordance with detailed written procedures, that the contents are authorized in the package approval, that the package is in unimpaired physical condition, that any required moderator or neutron absorber is present and in proper condition. Special controls and precautions for handling should be included. The operations should discuss the inspection of gaskets, criteria for replacement, and if applicable, processes for repair. The inspection of each closure device and criteria for replacement should also be discussed.

7.1.2 Loading of Contents

At a minimum, the operations for loading the contents should describe how the contents are loaded and how the package is closed.

7.1.3 Preparation for Transport

The operations for preparing the package for transport should address radiation and contamination surveys of the package, leakage testing of the package, measurement of the package surface temperature, package tie-down, and the application of tamper-indicating devices.

7.2 PACKAGE UNLOADING

This section should include inspections, tests, and special preparations of the package for unloading. As applicable, the operations used to ensure safe removal of fission gases, contaminated coolant, and solid contaminants should be discussed.

7.2.1 Receipt of Package from Carrier

The process for receiving the package should address radiation and contamination surveys and inspection of the tamper-indicating device. Describe any proposed special controls and precautions for handling and unloading. Address the appropriate requirements of 10 CFR 20.1906, “Procedures for Receiving and Opening Packages.”

7.2.2 Removal of Contents

Operations should include the appropriate method for opening and removing contents from the package.

7.3 PREPARATION OF EMPTY PACKAGE FOR TRANSPORT

Describe the inspections, tests, and special preparations of the packaging necessary to ensure that the packaging is verified to be empty and is properly closed, and the radiation and contamination levels are within allowable limits. Address the appropriate requirements of 49 CFR 173.428 (Empty Class 7 (radioactive) materials packaging).

7.4 OTHER OPERATIONS

Include the provisions for any special operational controls (e.g., route, weather, shipping time restrictions, etc.).

7.5 APPENDIX

This appendix should include supporting documentation, detailed discussions and analysis of processes or protocols, and graphic presentations. Include a list of references, copies of applicable references if not generally available, test results, and other appropriate supplemental information.

8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

This section of the application should discuss the acceptance tests and maintenance program to be used for the packaging in compliance with Subpart G of 10 CFR Part 71.

8.1 ACCEPTANCE TESTS

Discuss the tests to be performed prior to the first use of each packaging. The information should include a description of the test and its acceptance criteria. The acceptance tests must confirm that each packaging is fabricated in accordance with the drawings referenced in the package approval.

8.1.1 Visual Inspections and Measurements

The visual inspections to be performed and the intended purpose behind each inspection should be discussed. State the criteria for acceptance of each of these inspections as well as the action to be taken if noncompliance is encountered. The inspections should verify that the packaging has been fabricated and assembled in accordance with the drawings. Dimensions and tolerances specified on the drawings should be confirmed by measurement.

8.1.2 Weld Examinations

Describe welding examinations to verify fabrication in accordance with the drawings, codes, and standards specified in the application. Location, type, and size of the welds should be confirmed by measurement. Other specifications for weld performance, nondestructive examination, and acceptance should be verified as appropriate.

8.1.3 Structural and Pressure Tests

Identify and describe the structural or pressure tests. Such tests should comply with 10 CFR 71.85(b), as well as applicable codes or standards specified. Describe the action taken when the prescribed criteria are not met. An estimate of the sensitivity of the tests should be provided.

8.1.4 Leakage Tests

Describe the leak tests to be performed. Leak tests should be performed on the containment vessel as well as on auxiliary equipment. Describe the criteria for acceptance and the action to be taken if the criteria are not met. Specify the sensitivity of the test and give the basis for the estimate.

8.1.5 Component and Material Tests

Specify the appropriate tests and acceptance criteria for components that affect package performance. Provide acceptance criteria and discuss the action to be taken if the criteria are not met. Specify test sensitivity, as applicable.

Specify the appropriate tests and acceptance criteria for packaging materials. Components such as gaskets should be tested under conditions simulating the most severe service conditions under which the gaskets are to perform, including performance at pressure and at high and low temperatures. Tests for neutron absorbers (e.g., boron) and insulating materials (e.g., foams, fiberboard) should assure that minimum specifications for density and isotopic content are achieved. Test the materials to meet the performance specifications shown on the engineering drawings.

8.1.6 Shielding Tests

Specify the appropriate shielding tests for both neutron and gamma radiation. The tests and acceptance criteria should be sufficient to assure that no defects, voids, or streaming paths exist in the shielding.

8.1.7 Thermal Tests

Specify the appropriate tests to demonstrate the heat transfer capability of the packaging. These tests should confirm that the heat transfer performance determined in the thermal evaluation is achieved in the fabrication process.

8.1.8 Miscellaneous Tests

Describe any additional tests to be performed prior to use of the packaging.

8.2 MAINTENANCE PROGRAM

Describe the maintenance program used to ensure continued performance of the packaging. The program should include periodic testing, inspection, and replacement schedules, as well as criteria for replacement and repair of components and subsystems on an as-needed basis.

8.2.1 Structural and Pressure Tests

Identify and describe any periodic structural or pressure tests. Such tests would generally be applicable to codes, standards, or other procedures specified in the application.

8.2.2 Leakage Tests

Describe the tests to be performed and the frequency of performance. Specify the sensitivity of these tests. For most systems, this would include a test of each package before each shipment and an annual test of each packaging. In general, elastomeric seals are replaced and leak tested within the 12-month period prior to shipment. Metallic seals are generally replaced and tested prior to each shipment.

8.2.3 Component and Material Tests

Describe, as appropriate, the periodic tests and replacement schedules for components. Identify any process that could result in deterioration of packaging materials, including loss of neutron absorbers, reduction in hydrogen content of shields, and density changes of insulating materials. Ensure packaging effectiveness for each shipment through the appropriate tests and acceptance criteria. Specify replacement intervals for components susceptible to fatigue, such as bolts.

8.2.4 Thermal Tests

Describe the periodic tests to assure the heat-transfer capability during the service life of the packaging. Tests similar to the acceptance tests discussed in Section 8.1.7 may be applicable. The typical interval for periodic thermal tests is 5 years.

8.2.5 Miscellaneous Tests

Describe any additional tests to be performed periodically on the package or its components.

8.3 APPENDIX

Include a list of references, copies of applicable references if not generally available, and other appropriate supplemental information.

DRAFT VALUE/IMPACT STATEMENT

A separate regulatory analysis was not prepared for this regulatory guide. Revision of this regulatory guide was necessary to make the guide consistent with the 10 CFR Part 71 final rule that brings Part 71 into harmony with the 1996 Edition of the International Atomic Energy Agency Regulations for Safe Transport of Radioactive Material (TS-R-1). NUREG/CR-6713, “Draft Regulatory Analysis of Major Revision of 10 CFR Part 71," provides the regulatory analysis for this regulatory guide. A copy of NUREG/CR-6713 is available for inspection and copying for a fee at the U.S. Nuclear Regulatory Commission Public Document Room, 11555 Rockville Pike, Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or (800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>. Copies are available at current rates from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20402-9328 (telephone (202)512-1800); or from the National Technical Information Service by writing NTIS at 5285 Port Royal Road, Springfield, VA 22161; <http://www.ntis.gov/ordernow>; telephone (703)487-4650.