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

October 29, 1998

Mr. Stephen M. Quennoz
Trojan Site Executive
Trojan Nuclear Plant
71760 Columbia River Highway
Rainier, OR 97048

SUBJECT: AUTHORIZATION OF THE TROJAN REACTOR VESSEL PACKAGE FOR TRANSPORT

Dear Mr. Quennoz:

As requested in your letter dated March 31, 1997, the Commission has granted two specific exemptions, under 10 CFR 71.8, for approval of the Trojan Reactor Vessel Package (TRVP) for one-time shipment to the US Ecology disposal facility near Richland, Washington (TRVP Safety Evaluation Report, Enclosure 1). In making its decision, the Commission has determined that the exemptions are authorized by law and will not endanger life or property nor the common defense and security (63 FR 57713; October 28, 1998, Enclosure 2). The Commission has also determined that the TRVP shipment will not significantly affect the public health and safety or adversely impact the environment.

This letter constitutes authorization of the TRVP as an approved package for shipment under the General License issued in 10 CFR 71.12, subject to the following conditions:

1. The TRVP as configured for shipment must comply with the following Portland General Electric Company Drawings:

   M-9257, Sheet 1, Rev. 1; Sheet 2, Rev. 0
   M-9258, Sheets 1-8, Rev. 1
   M-9259, Sheets 1-2, Rev. 1; Sheet 3, Rev. 0; Sheets 4-5, Rev. 1
   M-9260, Sheets 1- 8, Rev. 1.

2. The TRVP must be transported in compliance with the specific exemption issued by the U.S. Department of Transportation (DOT).

3. The TRVP must be transported in accordance with Portland General Electric Company's Transportation Safety Plan for the Reactor Vessel and Internals Removal Project, PGE-1077, Rev. 0.

4. The TRVP must be prepared for shipment and operated in accordance with Sections 7.0 and 8.0 of the application dated March 31, 1997, as supplemented on August 8, August 13, and September 23, 1998.

Please note that this authorization does not relieve the shipper from compliance with any requirements in DOT's regulations in Title 49, unless those requirements are specifically waived by DOT exemption referenced in Condition 2. This authorization expires in December 2000.

Sincerely,

Susan F Shankman for

William F. Kane, Director
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Enclosures:
1. TRVP Safety Evaluation Report
2. 63 FR 57713

Docket Nos. 50-344; 71-9271

SAFETY EVALUATION REPORT
Trojan Reactor Vessel Package

SUMMARY

By application dated March 31, 1997, as supplemented, Portland General Electric Company (PGE or applicant) requested approval of the Trojan Reactor Vessel Package (TRVP) as a Type B transportation package. As part of its application, PGE requested exemptions, pursuant to 10 CFR 71.8, from the requirements of 10 CFR 71.71(c)(7) and 10 CFR 71.73(c)(1).

Subparagraph 10 CFR 71.71(c)(7) requires an evaluation of the package design under normal conditions of transport, and that includes a free drop of the specimen through a distance of 1 foot (for a package weighing more than 33,100 pounds) "...onto a flat, essentially unyielding, horizontal surface in a position for which maximum damage is expected."

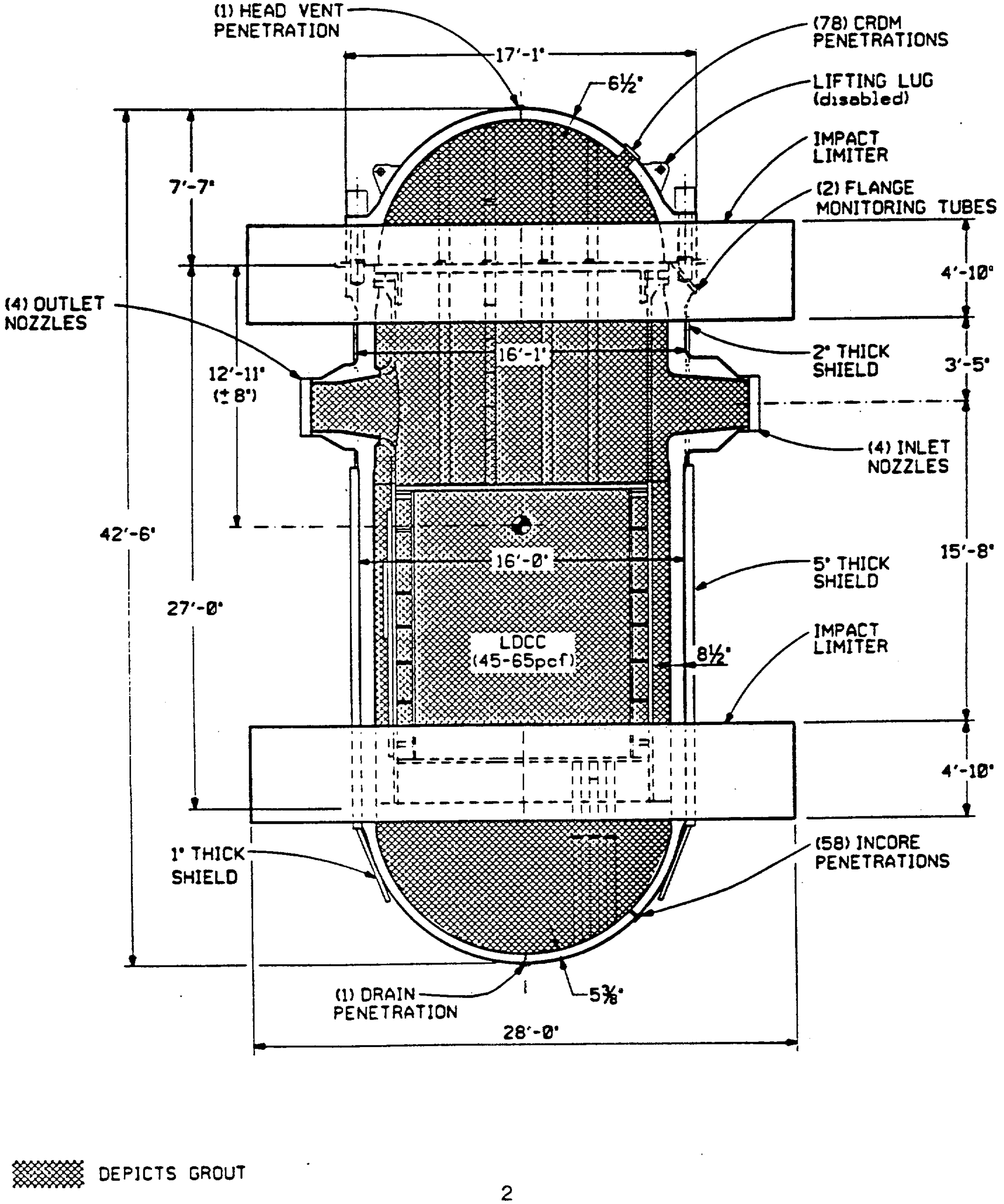
PGE has evaluated the ability of the TRVP with impact limiters to withstand a 1-foot horizontal drop. During transport, the TRVP will remain oriented in the horizontal position. PGE asserts, and staff agrees, that due to the unique size and mass of the package and the method of support of the package, no other orientation is reasonable for normal conditions during TRVP transport. Staff therefore agrees that the 1-foot drop test should not include orientations, other than horizontal, as normal conditions of transport for the one-time TRVP shipment. Accordingly, the TRVP has been exempted, under the provisions of 10 CFR 71.8, from the requirements of 10 CFR 71.71(c)(7) for orientations other than horizontal.

Subparagraph 10 CFR 71.73(c)(1) concerns tests for hypothetical accident conditions and requires: "A free drop of the specimen through a distance of 9 m (30-foot) onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected." Subparagraph 10 CFR 71.73(b) requires that the ambient air temperature must remain constant during testing at that value between -29 °C (-20 °F) and +38 °C (+100 °F) which is most unfavorable for the feature under consideration.

Based on the safety analysis report- (SAR-) specified transportation route, method of shipment, and operational and administrative controls, PGE determined that the maximum credible distance that the TRVP could drop on land during a hypothetical transport accident is 11 feet. This drop height and horizontal orientation were used as a design basis for the TRVP. PGE designed the TRVP and analyzed its performance under a hypothetical accident condition free drop test of 11 feet, rather than the 30-foot drop test specified in 10 CFR 71.73(c)(1), and therefore requested exemption from that requirement. Because the TRVP shipment is conditioned on a minimum initial TRVP temperature of 50 °F, and on a forecasted minimum daily low temperature during transport of 40 °F, the 11-foot drop and puncture were evaluated at 45 °F, rather than the required -20 °F.

Staff has concluded that the TRVP satisfies regulatory requirements under a hypothetical accident condition free drop of 11 feet. Further, staff has reviewed PGE's Probabilistic Safety Study for the TRVP shipment, and agrees that, due to the imposition of stringent operational and administrative controls identified in the Transportation Safety Plan, the probability that the TRVP will be involved in a transport event leading to accident conditions beyond that for which it has been analyzed is less than 1.0×10^{-6}. Accordingly, the TRVP has been exempted, under the provisions of 10 CFR 71.8, from the requirements of 10 CFR 71.73(c)(1) (30-foot drop test).

FIGURE 1. Trojan Reactor Vessel Package (TRVP)



Staff concludes that the operational and administrative controls that will be imposed on this shipment provide reasonable assurance that the TRVP will not encounter conditions beyond those for which it has been analyzed and demonstrated to provide protection. The staff believes that the risk to the public from this shipment is low, and comparable to that of other activities regulated by the Commission. Considering the statements and representations contained in the application, as supplemented, and the exemptions and conditions listed later in this report, staff has concluded that the TRVP, as exempted, meets the requirements of 10 CFR Part 71.

1.0 GENERAL INFORMATION REVIEW

1.1 Package Description

The TRVP consists of a reactor pressure vessel and its internal components, filled with concrete, with steel shielding installed on the exterior surface of the reactor vessel (Figure 1). The reactor vessel is a carbon steel cylindrical shell with an integral lower head and a removable upper head. The upper head is attached to the vessel by 54 tensioned head studs and sealed by dual metallic O-rings at the flange surface between the reactor vessel and the upper head. All reactor vessel penetrations are closed with welded plates. The overall length of the reactor vessel is 42 feet 6 inches and the diameter is 17 feet 1 inch (excluding the nozzles). The vessel thickness (excluding the stainless steel shielding) varies from 5⅜ inches at the lower head, to 6½ inches at the upper head, to 8½ inches at the core ring, to 10½ inches at the nozzle ring.

The reactor vessel contains upper and lower assemblies of internal components, and is filled with low-density concrete. The upper assembly consists of an upper instrumentation conduit and support assembly, an upper support plate, control rod guide tubes, and the upper core plate. The lower assembly consists of a core barrel, core baffle plates, core former plates, neutron shield pads, a lower core plate, lower core support columns, and the lower core support plate. The internal components are constructed of stainless steel. The package weighs approximately 2.04 million pounds.

1.2 Drawings

The package is constructed and assembled in accordance with the following PGE drawings:

- M-9257, Sheet 1, Rev. 1 and Sheet 2, Rev. 0
- M-9258, Sheets 1-8, Rev. 1
- M-9259, Sheets 1-2, Rev. 1; Sheet 3, Rev. 0; Sheets 4-5, Rev. 1
- M-9260, Sheets 1- 8, Rev. 1

1.3 Contents

1.3.1 Type and Form of Material

The irradiated steel reactor pressure vessel contains irradiated steel internal components and radioactive contamination in solidified concrete.

1.3.2 Quantity of Material

Approximately 74 petabequerels (2 million curies) of radioactive material are contained in an irradiated reactor pressure vessel and irradiated internal components, and approximately 5.7 terabequerels (155 curies) of radioactive material are contained as vessel and internal surface contamination.

1.4 References

Available under Docket 71-9271:

- PGE application dated March 31, 1997.
- Supplements dated August 8, August 13, and September 23, 1998.
- Reactor Vessel and Internals Removal Project, Transportation Safety Plan, PGE-1077, Rev. 0.

2.0 STRUCTURAL REVIEW

Structural Review Objective

The objective of this review is to verify that the structural performance of the TRVP, when based on the operational and administrative controls and transport conditions, has been adequately evaluated for normal conditions of transport and hypothetical accident conditions. PGE was granted exemption from the 1-foot normal-condition drop test, and the 30-foot drop test in considering hypothetical accident conditions. Further, a temperature of 45 °F was used for evaluating puncture and the 11-foot drop, under the exemption, because the TRVP shipment is conditioned on a minimum initial TRVP temperature of 50 °F, and on a forecasted minimum daily low temperature during transport of 40 °F.

2.1 Description of Structural Design

2.1.1 Descriptive Information, Including Weights and Center of Gravity

The applicant performed various structural analyses and engineering evaluations to show that the TRVP, under certain administrative controls and transport conditions, has adequate structural integrity to meet the requirements of 10 CFR Part 71, as exempted. The TRVP consists of the reactor vessel and its associated internal components. The internal volume of the reactor vessel, with the internal components in place, will be filled with low-density cellular concrete (LDCC). The reactor vessel's external attachments will be removed and all penetrations will be sealed with welded closures. Shielding will be installed on the external surface of the TRVP, as needed, to ensure compliance with the dose rate limits. Impact limiters are attached to the TRVP to lessen the effects of postulated drop impacts.

The design weight of the TRVP, including reactor vessel internals, maximum shielding, LDCC (conservatively assumed 65 pounds/ft^3), and impact limiters is 2.04 million pounds. Itemized weights of the various components are listed in Table 2-4 of the safety analysis report (SAR). The TRVP center of gravity (CG) axial location is calculated to be 12 feet 11 inches, +/- 8 inches from the lower flange sealing surface. External shielding added to the package will not significantly change the design weight or the CG location.

2.1.2 Codes and Standards

The reactor vessel shell and upper head were constructed in accordance with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV)Code, Section III, Class 1 (1968 editions with Addenda through winter of 1968) and maintained in accordance with the ASME B&PV Code, Section XI. The reactor vessel was designed for a rated pressure and temperature of 2485 psig and 650 °F, respectively.

The structural analyses used in determining compliance with the requirements of 10 CFR Part 71 are performed in accordance with Regulatory Guide 7.6, "Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels." The load combinations used in these analyses are in accordance with Regulatory Guide 7.8, "Load Combinations for the Structural Analysis of Shipping Casks for Radioactive Material."

The reactor vessel shell, the closure plates, and the upper head closure studs are evaluated to meet the allowable stresses in ASME B&PV Code, Section III, Division 3. Allowable stress limits are specified in WB-3221 for normal operating condition, and WB-3224 for hypothetical accident conditions. These stress limits are consistent with the stress limits specified in ASME B&PV Code, Section III, NB-3000. The closure plates are field welded to the nozzles or penetrations by fillet welds. Allowable stress values for closure plate fillet welds are 0.49S according to Sections ND-3356.1© and ND-3359(b) (wherein "S" is the allowable base metal stress in tension). The applicant has relied on the reactor vessel and the LDCC to provide primary containment for the reactor's internal components and contaminants. The fillet welds, however, are designed to survive the normal transport and accident conditions to prevent any release of the LDCC material. Shielding components and welds are designed and constructed in accordance with ASME Section VIII, Division 2 requirements.

2.2 Material Properties

2.2.1 Materials and Material Specifications

Mechanical properties of steel components are listed in Table 2-5 of the SAR. The reactor vessel shells and top head material are SA-533 Grade B, Class 1; the inlet and outlet nozzles are SA-508 Class 2; the head studs are SA-540 Grade B24, Class 3. The closure plates for the nozzles are SA-240 Type 304L stainless steel and the penetration closures and the shielding materials are SA-516 Grade 70 steel. The design stress intensity values for steel materials are listed according to temperatures in Table 2-6 of the SAR. These stress intensity values are taken from ASME Code, Section II, Part D, Subpart 1, Tables 2A, and 4. Welding electrodes are selected according to American National Standards Institute/American Welding Society (ANSI/AWS) D1.1, and the allowable stress/stress intensities for welds are based on the lower allowable stress/stress intensity of the two metals welded.

The mechanical properties of impact limiter foam were used in the impact analysis of the TRVP. Table 2-7 of the SAR gives the bounding stress-strain curve values at the extreme ambient temperatures analyzed.

2.2.2 Prevention of Chemical, Galvanic, or Other Reactions

The TRVP is fabricated from similar ferrous materials; there is no potential for galvanic reaction through direct contact. The interior void space of the TRVP is completely filled with LDCC. The LDCC is a Portland cement-based mixture. There is no significant chemical reaction between Portland cement mixtures and ferrous steels. In addition, the LDCC should effectively preclude the in-leakage of water to the package interior. Since the TRVP is constructed of similar materials of low galvanic potential and its construction prevents environments conducive to corrosion, the TRVP will provide adequate assurance that there will be no significant chemical, galvanic, or other reactions in dry or wet environment conditions.

2.2.3 Effects of Radiation on Materials

On the basis of research and testing data, it was determined that Young's Modulus, yield strength, and tensile strength for the materials of construction irradiated during plant operation would increase during this period due to irradiation effects. The applicant has conservatively assumed the materials to be in the unirradiated state so that the allowable stress values, as derived from yield strengths and tensile strengths, were lower than would have been the case for irradiated materials.

The ductile-to-brittle transition temperature also increases for the materials of construction when they are subject to long-term exposure to radiation. However, this increase has a negative effect on the materials' capability to resist brittle fracture. Accordingly, in the brittle fracture analysis, the applicant used the adjusted material property values that account for the irradiation effects on ductility.

The ductile-to-brittle transition temperatures were measured previously for each of the Trojan reactor vessel beltline materials that could potentially be influenced by irradiation during the Trojan plant operating period. Surveillance capsules for monitoring the effects of neutron exposure on the material in the core region were inserted in the reactor vessel before initial plant startup. The applicant used data from analyses of the capsule specimens to adjust the ductile-to-brittle transition temperature based on the approach discussed in Regulatory Guide 1.99 to account for irradiation damage.

2.3 Lifting and Tie-Down Standards for All Packages

2.3.1 Lifting Devices

The reactor vessel will be lifted from its operating location by a system of lifting straps and lift fixtures. After the TRVP is assembled, the package will be lifted using a system of straps that encircle the vessel. Since the TRVP design has no lifting attachment as a structural part of the package, no analysis of lifting devices is required under 10 CFR Part 71.

2.3.2 Tie-Down Devices

An engineered tie-down system will be used to attach the TRVP to the transporter and barge. However, there will be no tie-down devices added as a structural part of the package and no lugs or other attachments will be welded to the outer surface of the package. Per Operating

Procedure 8.5.8, PGE has committed to rendering inoperable any attachments to the package that could be used to lift or tie down the package during transport.

2.3.2.1 Transporter Tie-Down System

The TRVP-to-transporter tie-down system consists of two shipping cradles mounted on a cradle support structure, a longitudinal restraint assembly, slings/straps, and attachment brackets. During transport, the TRVP will be restrained on the shipping cradles with slings/straps over the top of the package. The cradles and straps restrain the package against vertical and transverse tie-down forces. Two TRVP nozzles are used to restrain the package in the longitudinal direction. The two nozzles are captured in a longitudinal restraint assembly which is bolted to the cradle support structure. The cradle support structure is attached by brackets to the deck of the transporter to restrain transverse and vertical movements. The longitudinal movement is restrained by eight shear lugs on the support structure that engage slots in the deck of the transporter.

The applicant performed a detailed finite element analysis to calculate the stresses in the TRVP induced by the tie-down forces specified in 10 CFR 71.45(b)(1). The analysis is based on a static force applied to the CG of the package having a vertical component of 2 times the weight of the package, a horizontal component in the transverse direction of 5 times the weight of the package, and a horizontal component along the direction in which the transporter travels of 10 times the weight of the package. The finite element analysis is found in Appendix 2-2 of the SAR, and the stresses in the TRVP are shown to be less than the yield strength of any of its structural materials. However, 10 CFR 71.45(b)(3) requires that failure of any tie-down device that is a part of the package under excessive loads would not impair the ability of the package to meet the other requirements of 10 CFR Part 71. The only tie-down devices that are a part of the package are the two nozzles used for longitudinal restraint. The maximum nozzle stresses based on a tie-down force equal to 10 times the package weight are 43.5 ksi. Thus, the safety margin is 1.14 (50/43.5) for material yield strength and 1.84 (80/43.5) for the material ultimate strength. Since the transporter tie-down system is designed to meet the ANSI Standard 14.2 requirements, under excessive loads the bolts connecting the longitudinal restraint assembly to the cradle support structure will fail before the nozzles fail. As a result, the reactor vessel will remain intact and the TRVP containment function will not be affected. In light of the fact that the TRVP will be transported only once and the transporter will be limited to a maximum overland transport speed of 5 mph, staff concludes that the tie-down system analysis provides reasonable assurance of safety for tie-down loads during transport.

2.3.2.2 Barge Tie-Down System

During barge transport, the center two of four transverse beams in the cradle support structure will be connected to four bolsters that are welded to the barge. Through the connection of these beams to the bolsters, the vertical, transverse, and longitudinal movements are restrained. The tops of the bolsters are recessed so that the two cradle support beams are captured. The sides of this recessed area provide the longitudinal and transverse restraint of the cradle support beams. Vertical motion of the package is restrained by bolting the two cradle support beams to the top of the bolsters.

The TRVP to transporter tie-down system meets the requirements of the March 1993 draft of ANSI Standard N14.2. The transporter-to-barge tie-down system is designed to ANSI Standard

N14.24-1985, except that the transverse direction is designed to 1.6g based on the results of the PGE probabilistic safety study. In addition, a detailed tie-down analysis has been submitted to the National Cargo Bureau and the US Coast Guard for their review and approval.

2.4 General Considerations for Structural Evaluation of Packaging

2.4.1 Evaluation by Analysis

The steel components of the TRVP (i.e., reactor vessel, top head, head studs, and closure plates) are evaluated by hand calculations using well-developed theory or by finite element analysis using the ANSYS computer code. The SAR described clearly the assumptions, analytical models, and methods of analysis. Analytical results are presented clearly to demonstrate adequate margins of safety of the structural design.

The two impact limiters are constructed from polyurethane foam of a nominal density of 20 pounds/ft^3 and encased in 1/4-inch- thick steel shells of ASTM A516 Gr 70. The foam material crush properties are developed using the manufacturer's database and adjusted to values which represent the dynamic behavior at the bounding temperature extremes of -20 °F and 160 °F and a ±10% manufacturing variation. The impact limiters free-drop analysis is performed using the proprietary code CASKDROP by Package Technology, Inc. The CASKDROP computer code is specifically developed for impact limiter drop analysis based on the energy balance methodology. The code, however, neglects the thin steel shell, assuming it has insignificant energy-absorbing capability due to buckling in the drop impact analysis.

The load-carrying capability of the LDCC is conservatively neglected and the LDCC is included in the TRVP structural analysis by weight only. Similarly, the external shielding plates are shown to be adequately attached to the package but perform no structural functions.

2.4.2 Evaluation by Test

No components of the TRVP are evaluated by testing.

2.5 Normal Conditions of Transport

2.5.1 Heat

Calculations for maximum TRVP temperatures are presented in Section 3 of the SAR. The calculated maximum accessible surface temperature is 147 °F which is below the temperature limit of 185 °F specified in 10 CFR 71.43(g) for an exclusive use shipment. The water vapor and pressure increase caused by ambient temperature changes are small because of the average bulk temperature of the LDCC; consequently, it has been neglected. However, the design internal pressure of the TRVP has been conservatively assumed to be 100 psig.

The effects of temperature changes on the TRVP stresses are evaluated. Three types of thermally induced stresses are calculated. The first is caused by temperature gradients across the TRVP vessel wall. The second is the stress caused by differential thermal expansion between the steel shell and the LDCC. The third is the differential thermal expansion between various components of the package such as the closure plates covering the nozzle openings and closure head studs.

The thermal stresses are determined in Appendix 2-3 of the SAR. The thermal stress analysis results for various TRVP components are summarized in Table 2-10 of the SAR. The applicant calculated all stress/stress intensities as well below the allowable values of the design code.

2.5.2 Cold

The coefficient of thermal expansion for steel is greater than that of the LDCC. As required by §71.71(c)(3) for cold conditions, a -40 °F steady-state ambient temperature is assumed. Since the vessel shell will contract more than the LDCC, the vessel is loaded by the LDCC at the cold condition. The load is considered as a hydrostatic pressure acting on the entire inner surface of the vessel and has a magnitude of 43.3 psi. However, this pressure load is lower than the internal design pressure of 100 psig for the TRVP.

TRVP stresses induced by temperature changes are generally controlled by the hot condition discussed previously in Section 2.5.1. The stresses are determined in Appendix 2-3 of the SAR. The results are listed in Table 2-10 of the SAR and show that the thermal stresses are within the allowable stress limits of the design code.

2.5.3 Reduced External Pressure

The applicant has shown that a decrease in external pressure to 3.5 psia will result in a net internal pressure, including a 5 psi vapor pressure, of 16.2 psig. The TRVP design internal pressure is 100 psig. Therefore, the TRVP design meets the reduced external pressure condition.

2.5.4 Increased External Pressure

Staff has shown that an increase of external pressure to 20 psia will result in a small increase in net external pressure (0.3 psig over 160 days). Allowable external pressures for the vessel shell, spherical heads, and nozzles of the TRVP are determined in Appendix 2-5 of the SAR. The results are listed in Table 2-12 of the SAR and it can be seen that large margins exist for TRVP components for this loading condition.

2.5.5 Vibration

The applicant considered vibration loads of 2g vertical and 0.1g in both transverse and longitudinal directions. These vibration accelerations are taken from ANSI Standard 14.23, "Proposed American National Standard Tie-downs for Truck Transport of Radioactive Materials," March 5, 1993. These loads are applied simultaneously at the CG of the TRVP. The calculations and finite element analysis results are presented in Appendix 2-6 of the SAR. The highest stress in the vessel wall is 17.5 ksi at the cradle support location, which is less than the allowable primary membrane plus bending stress of 40 ksi permitted by the code. Thus, the TRVP meets the normal condition stress criteria for the vibration load condition.

2.5.6 Water Spray

All exterior surfaces of the TRVP are welded steel. The water spray will have no effect on the package performance.

2.5.7 Free Drop

The TRVP is transported solely in a horizontal orientation by a transporter or barge. Because of the weight and size, once the package is secured on the transporter, it will not be moved or lifted again during transport. Consequently, the TRVP is only analyzed for a 1-foot drop in the horizontal orientation. The maximum impact resulting from a 1-foot free drop based on maximum impact limiter stiffness under the -20 °F temperature condition is 8g (Appendix 2-7a of the SAR). The TRVP is analyzed to show that when exposed to a 9g impact load and 100 psig internal pressure, the combined stresses in the containment boundary will meet the allowable stress limits specified by the ASME B&PV Division 3 Code and Regulatory Guide 7.6 for normal conditions of transport. Stresses in the TRVP shell caused by to the free drop are determined by finite element analysis. The resulting maximum stress intensity in the vessel shell from 9g free drop impacts and design internal pressure (100 psig) is calculated to be 10,396 psi. The allowable design stress intensity is 1.5 S_m= 1.5 x 26,700 psi = 40,000 psi. Thus, the vessel shell has a design factor of 40,000/10,396 = 3.85. The upper head closure studs are evaluated to show the stresses induced by the 9g impact and 100 psig internal pressure loads are less than the stresses from the preload (the closure stud preload force is 720,000 pounds). Therefore, there is no added tensile load on the studs from the free drop event and the flange seal compression is not affected.

The nozzle cover plates are loaded by the internal pressure of 100 psig, their self-weight, and a portion of the LDCC material located directly above the plate. In a side drop event, the amount of LDCC supported by the cover plate is conservatively assumed to be a cylinder of 36 inches in diameter and 62.5 inches in length. The volume of this cylinder is 36.8 ft^3. Thus, the maximum weight of concrete is 2,392 pounds. The weight of the cover plate is 570 pounds. The total inertia force under a 9g impact load and the internal pressure are combined to get a total pressure load of 133.9 psi acting uniformly on the cover plate. The maximum stress in the plate is calculated by hand to be 6,631 psi. For the Type 304L stainless steel at 175 °F, S_m = 16,700 psi. The margin of safety, based on 1.5 S_m for primary membrane plus bending stress intensity, is 2.78. The applicant evaluated the cover plate attachment weld and found that the margin of safety is 2.31 for the attachment weld.

The external shielding installed around the reactor vessel is necessary for the TRVP to meet dose rate limits specified in 10 CFR Part 71. The main shielding must remain in place during both normal and accident conditions. Since the accident condition is bounding, the adequacy of the external shielding is evaluated under the hypothetical accident conditions.

2.5.8 Corner Drop

The corner drop test is not applicable because the package weight exceeds 220 pounds and neither wood nor fiberboard are used as materials of construction.

2.5.9 Compression

The compression test is not applicable because the weight of the TRVP exceeds 11,000 pounds.

2.5.10 Penetration

The exterior shells and surfaces of the TRVP can withstand the impact forces imposed by the normal-condition penetration test. There are no valves or relief devices that could be impacted.

2.6 Hypothetical Accident Conditions

2.6.1 Free Drop

The applicant stated that because of the extraordinary controls placed on the transport of the TRVP (Section 7 of the SAR), 30-foot free drops should not be considered as credible accident events for the TRVP. The applicant also believes that end drops, or steep-angle vertical drops are not applicable to the TRVP because of the very large size and weight of the package. Consequently, the TRVP is analyzed for a side drop and a shallow angle oblique drop with a maximum drop height of 11.0 feet. For the reasons described next, the applicant concluded and the staff concurs that the postulated 11.0-foot free drops should provide reasonable assurance for the safe transport of the TRVP:

- Because of the very large overall size and weight of the TRVP, it is not credible to assume an impact surface which is "essentially unyielding." Nevertheless, the applicant has performed impact analyses for the postulated free drops based on the assumption that the ground (i.e., the impact surface) is an unyielding surface and all impact energy will be absorbed by the TRVP.

- The TRVP will be only shipped one time as an exclusive-use DOT Exempt shipping package. The shipment is estimated to take about 72 hours. The TRVP is transported first on a barge on the Columbia River, and then by a transporter over land (approximately 30 miles) to the disposal site. The land transport route has no bridges or overpasses and the road is in good condition with no hazardous conditions.

- The transporter, specially designed for transporting large, heavy loads, will be limited to a maximum transport speed of 5 mph (7.33 ft/sec). At this speed, the equivalent free drop height is less than 1 foot (0.83 ft.) based on the kinetic energy. The assumed 11-foot drop height is obtained by considering the maximum height from the top surface of the shipping cradle top surface to the ground minus the depth of the impact limiter. The crush distance of the impact limiter during impact is added to the impact energy calculations.

- The material properties are conservatively based on the unirradiated materials so that the allowable stress intensity values are derived from lower yield strength and tensile strength than those of the irradiated materials. To preclude brittle fracture, the applicant has proposed that the TRVP will be transported only if the initial temperature of the vessel exceeds 50 °F and if a minimum daily low temperature of 40 °F is forecast each day along the transportation route for the expected shipping duration.

The free-drop analysis is performed using the proprietary code CASKDROP by Package Technology, Inc. The CASKDROP code uses a quasi-static energy balance approach, in which the energy consumed is the cumulative sum of crush force multiplied by the deformation increments. When the total energy absorbed equals the total potential energy of the drop (including the crush distance of the impact limiter), the solution is complete and the quasi-static impact deceleration in terms of the gravity "g" is equal to the total maximum crush force divided by the package weight.

The results of the free-drop impact analyses are given in Table 2-15 of the SAR. All impact values are given for the package CG, defined in units of "g," and are normal to the ground. The resulting maximum impact for a side drop is 20.1g for the cold, -20 °F case, and the minimum clearance (over the inlet nozzle) is 6.4 inches for the warm, 160 °F case. The maximum impact for a shallow angle (approximately 19°to the horizontal surface) is 16.3g for the cold-temperature case. Thus, the side-drop event is the governing free-drop event for the TRVP. The applicant performed a stress analysis for a side-drop event assuming the impact deceleration force is 22g. The stresses in the reactor vessel are determined by the finite element model and methodology as described in Appendix 2-9 of the SAR. The maximum stress intensity in the vessel shell is determined to be 26,438 psi near the bottom of the vessel, on the outside surface, beneath the lower impact limiter. For the vessel shell material of SA-533 Grade B, Class 1, and at 200 °F temperature, the allowable stress intensity is 80,000 psi based on ASME Section III, Division 3 Code and NRC Regulatory Guide 7.6. Therefore, the vessel shell meets the design stress criteria for the postulated free drop accident conditions. The vessel shell is also evaluated using the ASME Code Case N-284, and shown not to buckle under the 11-foot side drop condition.

The upper vessel head attachment studs are evaluated by hand calculations for the combined stresses due to the design internal pressure and the free-drop impact loads. The resulting stresses in the head studs are less than the preload force and thus, there will be no adverse effect on the sealing capability of the vessel.

The nozzle cover plate and its attachment welds are evaluated for the worst side-drop condition. The governing side-drop condition is for the nozzle pointing directly toward the ground. The cover plate is loaded by the internal pressure, its own weight, and the LDCC material located directly above the plate. The results of the analysis show that the nozzle cover plate and the attachment welds have a minimum safety margin of 5 against the allowable stresses specified by the design code.

External shielding plates have been installed around the reactor vessel to meet external dose rate limits of 10 CFR Part 71. The shielding plates are welded to each other but not to the reactor vessel. The applicant submitted an analysis of the shielding plate welds in SAR Appendix 2-10 showing that the welds are adequate to ensure the shielding plates will remain in place during the postulated 11-foot side drop accident condition.

Linear elastic fracture mechanics methods are used to evaluate brittle fracture in the reactor vessel during normal operating and accident conditions. The fracture evaluations are presented in SAR Appendix 2-12 based on the approach defined in Section XI of the ASME Code. The material fracture toughness is assumed to be the lower bound dynamic toughness using the Section XI, K_{Ia} reference toughness curve. This curve is indexed to the reference temperature (T-RT_{NDT}). The nil-ductility transition temperature (RT_{NDT}) is measured and recorded for the vessel material at the time of fabrication. The RT_{NDT} of the vessel materials are adjusted for the effects of neutron bombardment using Regulatory Guide 1.99. For the TRVP, only the core beltline region received a significant neutron dose during the reactor's service life. Given the adjusted RT_{NDT} value, and the service temperature value T (assumed to be -20°F), the lower bound material fracture toughness is then obtained from the reference toughness curve. The analysis conservatively assumed a full circumference crack geometry in a region of maximum tensile stress. The maximum hypothetical flaw size is taken from Table IWB-3510-1 of ASME Section XI, IWB-3000. The linear elastic fracture mechanics evaluation results showed that the minimum factor of safety on crack initiation is 2.0 for the TRVP at the nozzle region. However, since the evaluation is based on material temperature equal to 45 °F, the minimum factor of safety for the TRVP against fracture initiation will be increased to 2.8.

2.6.2 Crush

Because this package has a mass greater than 500 kg (1100 pounds), and a density greater than water, this test is not applicable.

2.6.3 Puncture

The TRVP is evaluated for the 40-inch puncture test under the hypothetical accident conditions. The puncture pin was conservatively assumed to impinge directly on: (1) reactor vessel shell in the region below the nozzles, (2) reactor lower head, (3) reactor upper head, (4) nozzle cover plate, and (5) upper or lower penetration covers. The reactor vessel puncture analyses are performed by the finite element method using the ANSYS computer code. The puncture load is applied as a pressure load over the area of the puncture bar and the dynamic flow stress of 50,000 psi for the A36 steel puncture bar has been assumed. The finite element puncture analyses are presented in SAR Appendix 2-11. The puncture analyses for the nozzle cover plate and the penetration covers were performed using hand calculations. These puncture analyses have shown that the stresses in the TRVP are within the ASME Code stress allowables for level D service limits and that the TRVP will not be penetrated by a puncture event.

The fracture evaluation for the case of a hypothetical accident condition puncture is presented in SAR Appendix 2-12. Similar to the fracture analysis performed for the free-drop condition, the evaluation is based on a linear elastic fracture mechanics approach to preclude crack initiation as given in Section XI of the ASME Code. A quarter-circular crack is assumed to exist in the upper and lower heads and an aspect ratio of a/l=0.5 is used. The maximum hypothetical crack size is obtained from Table IWB-3501-1 of the ASME Section XI Code. Based on the most critical stress and a material temperature of -20 °F, the minimum factor of safety on flaw initiation is 1.0, for the upper head. However, if the fracture evaluation is based on a material temperature of 45 °F, the minimum factor of safety against crack initiation will be increased to 1.4, essentially meeting the ASME Section XI safety factor (i.e., $\sqrt{2}$) specified for emergency and faulted conditions.

Therefore, to preclude fracture initiation for the hypothetical accident puncture event, the applicant has proposed that the TRVP will be transported only if the initial temperature of the vessel is greater than 50 °F and if a minimum daily low temperature of 40 °F and a minimum average daily temperature of 50 °F are forecast each day for the transportation route and the expected shipping duration. The applicant has shown, based on the very large thermal inertia of the reactor vessel filled with the LDCC, that these conditions assure that the shell temperature of the vessel will remain above 45 °F for the duration of the shipment.

2.6.4 Thermal

The temperatures in the components of the TRVP, as a result of the fire test specified in 10 CFR Part 71, are calculated in Section 3 of the SAR. The maximum temperature of the vessel containment boundary increases from a steady-state pre-fire temperature of 196 °F to a fire peak temperature of 844 °F. However, the bulk average temperature of the LDCC material inside the reactor vessel changes only slightly from a steady-state pre-fire value of 289 °F to a fire peak temperature of 310 °F. Consequently, the internal pressure of the TRVP will not be increased significantly and is much lower than the TRVP design internal pressure of 100 psig. In addition, during the fire test the vessel shell will expand more than the LDCC, and no thermal stresses are induced due to differential thermal expansion. It is concluded that the TRVP meets the fire test condition specified in 10 CFR Part 71.

2.6.5 Immersion - All Material

Immersion under a head of water of 50 feet is equivalent to subjecting the package to an external pressure of 21.7 psig. Allowable external pressures for the cylindrical shell, spherical heads, and cylindrical nozzles of the reactor vessel are evaluated in accordance with ASME Section III, Division 1, Article NB-3133. The evaluation has conservatively neglected the support provided by the LDCC materials. Details of these calculations are given in SAR Appendix 2-5 and the results are summarized in SAR Table 2-12. The minimum allowable external pressure is for the main body of the cylindrical shell located between the nozzles and the lower head; it is 1,327 psi. Assuming the temperature is at cold condition, -20 °F, and the minimum pressure within the TRVP is reduced to 11.1 psia, the maximum differential pressure in the immersion case is:

$$P = 21.7 \text{ psig} + 14.7 \text{ psia} - 11.1 \text{ psia} = 25.3 \text{ psig}$$

Based on the NB-3133 allowable external pressures, for an applied external pressure of 25.3 psi, the margin of safety is very large. Thus, immersion of the TRVP under 50 feet of water will have no consequence.

2.6.6 Internal Pressure Test

The reactor shell and upper heads were constructed in accordance with ASME Section III, Subsection NB, and maintained in accordance with Section XI of the ASME Code. The reactor vessel was designed for a rated pressure and temperature of 2485 psig and 650 °F respectively. The maximum normal operating temperature (MNOP) of the TRVP is only 6.9 psig as calculated by the applicant based on an average vessel wall temperature of 125 °F and ambient temperature of 100 °F. The TRVP design pressure is conservatively assumed to be 100 psig. Thus, staff concludes that the TRVP containment structure will not yield under the pressure test at 150% of the MNOP, and that the stresses are within the allowable stress limits set by the design code.

2.7 Evaluation Findings

2.7.1 Description of Structural Design

The staff has reviewed the package design description and concludes that the contents of the application meet the requirement of 10 CFR 71.31. The staff reviewed the codes and standards used in the package design and finds that they are acceptable.

2.7.2 Material Properties

To the maximum credible extent, there are no known chemical, galvanic, or other reactions among the packaging components, among package contents, or between the packaging components and the contents in dry or wet environment conditions. The effects of radiation on materials are considered in the linear elastic fracture mechanics evaluation of the containment components for preventing brittle fracture.

2.7.3 Lifting and Tie-Down Standards for All Packages

The staff has reviewed the lifting and tie-down systems for the package and concludes that they meet the 10 CFR 71.45 standards.

2.7.4 General Considerations for Structural Evaluation of Packaging

The staff has reviewed the packaging structural evaluations and concludes that they meet 10 CFR 71.35 requirements.

2.7.5 Normal Conditions of Transport

The staff has reviewed the packaging structural performance under the normal conditions of transport (as described earlier) and concludes that there will be no substantial reduction in the effectiveness of the packaging, and, therefore, no loss or dispersal of radioactive contents, and no significant increase in external surface radiation levels.

2.7.6 Hypothetical Accident Conditions

The applicant did not evaluate the package for the 30-foot free-drop tests under the hypothetical accident conditions as specified in 10 CFR 71.73(c)(1). Instead, the applicant has requested to evaluate alternative drop tests based on the extraordinary administrative controls to be placed on the transport of the TRVP. The alternative test conditions are 11-foot maximum height free drops for a side (package axis horizontal) or a shallow angle (~ 19 degrees with respect to horizontal) orientations. However, except for the free-drop tests, the applicant did perform evaluations for all other tests for hypothetical accident conditions specified in 10 CFR 71.73(c).

The staff has reviewed the packaging structural performance under the alternative 11-foot free drop and other tests for hypothetical accident conditions and concludes that the packaging has adequate structural integrity to satisfy the containment, shielding, and temperature requirements of 10 CFR Part 71.

2.7.7 Internal Pressure Test

The staff has reviewed the containment structure and concludes that it will meet the 10 CFR 71.85(b) requirement for a pressure test without yielding.

3.0 THERMAL REVIEW

The thermal evaluation for the TRVP was conducted for normal and hypothetical accident conditions using the HEATING7.2I computer code. A decay heat source of 60,635 Btu/hr (17,766 watts) was assumed, based on the activity present on November 1, 1997. This heat source is conservative in that it does not account for the decay in source strength from November 1, 1997, to August 1999, the date of the proposed shipment.

3.1 Normal Conditions of Transport

In analyzing the TRVP for normal conditions, the applicant conducted a series of seven thermal evaluations. The results of these evaluations are summarized below:

Component	100°F, Max Solar	70 °F, No Solar	-20 °F, No Solar	-40 °F, No Solar
LDCC Max	595 °F	557 °F	482 °F	465 °F
LDCC Bulk	289 °F	244 °F	163 °F	144 °F
Vessel Seal	125 °F	98 °F	-9 °F	-29 °F
Accessible Surface	160 °F (147 °F Maximum without insolation)	119 °F	35 °F	15 °F
Impact Foam Bulk	131 °F	88 °F	0 °F	-20 °F
Vessel ID Average	149 °F	104 °F	-	1 °F
Vessel Max	196 °F	156 °F	74 °F	55 °F
Vessel Min	120 °F	71 °F	-16 °F	-36 °F

The major acceptance criteria for normal conditions are that the maximum accessible surface temperature for the package when shipped as exclusive use does not exceed 185 °F, and that the metallic O-ring containment seal does not exceed its design temperature of 650 °F.

The maximum temperatures calculated for the TRVP occurred in the applicant's analysis for 100 °F ambient temperature with full solar insolation. Under these conditions, the maximum temperature experienced in the region of the metallic O-ring seal was determined to be approximately 125 °F, significantly less than the rated seal operating temperature of 650° F. In addition, the results of the applicant's analysis show that the maximum temperature for any accessible surface was calculated to be 147 °F, assuming a 100 °F ambient temperature without solar insolation. This is well below the 185 °F limit specified in 10 CFR 71.43(g) for packages shipped as exclusive use.

The maximum normal operating pressure (MNOP) was calculated to be approximately 21.6 psia (6.86 psig), assuming a 100 °F ambient temperature with solar insolation over a period of one year. This pressure considered the effects of vapor pressure (2.0 psig) resulting from any residual water remaining in the LDCC and the effects of radiolytically generated gases. The maximum operating pressure based on 160 days was determined to be less than 5 psig - the threshold for requiring a physical pressure test under 10 CFR 71.85(b).

However, the requirement for testing in 10 CFR 71.85(b) is based on the assumption that a package in unrestricted commerce could be lost or undelivered for a period of up to one year. Since the TRVP shipment will be under observation and escorted at all times, the staff believes that the maximum operating pressure is bounded by the 160-day calculation.

In either case, the maximum operating pressure (i.e., 6.86 psig or 5 psig) is much less than the TRVP design pressure of 100 psi. On the basis of these considerations, the staff has concluded that the physical test described in 10 CFR 71.85(b) is not required.

The thermal stresses in the TRVP resulting during normal transport conditions are discussed in Sections 2.5.1 and 2.5.2.

3.2 Accident Conditions

The TRVP was evaluated for hypothetical accident conditions, i.e., a 30-minute 1475 °F fire, no solar insolation, and an internal heat load of 60,635 Btu/hr. The following table gives the initial (pre-fire) and maximum temperatures reached at various locations within the TRVP:

Location	Initial temperature	Maximum Temperature
TRVP Surface	160 °F	864 °F
O-Ring Seal	125 °F	197 °F
LDCC Max.	595 °F	601 °F
LDCC Avg.	289 °F	310 °F
Vessel	196 °F	844 °F

During the fire test, the maximum temperature of the containment boundary increased from 196 °F to a peak temperature of 844 °F. However, the average LDCC temperature increased only slightly from 289 to 310 °F. Consequently, the internal pressure would not increase significantly as a result of the fire test, and would remain much lower than the internal design pressure of 100 psig. The maximum temperature experienced in the region of the metallic O-ring seal was determined to be approximately 197° F, significantly less than the rated seal operating temperature of 650° F. In addition, there are no significant problems with either material properties or thermal stresses (see Section 2.6.4) within the temperature ranges given within the table.

The fire test was analyzed on a TRVP subjected to an 11-foot drop test (in lieu of the standard 30-foot drop test). On the basis of the damage determined for the 11-foot drop test, the staff has concluded that the TRVP meets the thermal requirements of 10 CFR Part 71. In addition, the staff has concluded that the probability of a fire environment such as that mandated by the regulations in 10 CFR 71.73 is less than 1 x 10^{-6}.

4.0 CONTAINMENT EVALUATION

4.1 Description of Containment System

The containment boundary of the package consists of the reactor vessel shell, reactor vessel upper head, metallic O-rings in the vessel flange, and the penetration closure plates. The upper head is attached to the reactor vessel by 54 pre-tensioned 7-inch-diameter studs. The reactor vessel is constructed of SA-533 carbon steel and the nozzles are made of SA-508 carbon steel. The O-rings are made of silver-plated Inconel alloy 718. The reactor vessel has approximately 150 penetrations. Among the major penetrations are 4 reactor inlet nozzles, which are approximately 32-1/2 inches in diameter, and 4 reactor outlet nozzles, which are approximately 34 inches in diameter. Among the smaller penetrations are 58 in-core instrument penetrations, 78 control-rod-drive mechanism penetrations, a lower head drain hole, a head vent, and 2 flange monitoring tube penetrations. Each penetration is closed by a steel cover plate. The plate thickness is 2-1/2 inches for the large penetrations, and 5/8-inch for the smaller penetrations. The cover plates are welded to the vessel with continuous fillet welds.

The radioactive material in the package is present primarily as large activated metal components, and is not available for release from the package. The quantity of radioactivity that is present in the form of contamination is estimated as 5.742 terabequerels (155.2 curies), with 0.788 terabequerels (21.3 curies) on the surfaces of the reactor vessel itself, and the remainder on the surfaces of the reactor's internal components. The predominant radionuclides are cobalt-60 [3.67 terabequerels (99.2 curies)], iron-55 [1.006 terabequerels (27.7 curies)], and nickel-63 [0.74 terabequerels (20 curies)]. On the basis of the mixture of radionuclides, the applicant calculated the effective A_2 value [64.38 gigabequerels (1.74 curies)] for the surface contamination. The predominant contributors on an A_2 basis are cobalt-60 (approximately 10%) plutonium isotopes (approximately 57 %), and americium-241 (approximately 25 %). The radioactivity is based on decay to November 1, 1997.

The quantity and distribution of the radionuclides in the surface contamination were determined using information from a sample taken from a steam generator tube, and from the measured dose rates from reactor coolant system piping. The applicant assumed that the isotopic distribution of radioactivity in the reactor vessel was the same as that previously determined for a section of a steam generator tube. The assumption regarding isotopic uniformity was based on information in a Westinghouse topical report (January 1992), that is referenced in the application. The magnitude of the source in the reactor vessel was based on the dose rate measurements taken for a section of reactor coolant piping. The magnitude was determined by modeling the piping using the Microshield computer code, and then normalizing the calculated-to-measured dose rate value. The activity per unit surface area was then determined. This areal concentration was multiplied by the total surface area of the internal components and the internal surface area of the reactor vessel. For a total surface area of 14,875.8 ft^2, and a total activity of 5.742 terabequerels (155.2 curies), the areal concentration is about 407 kilobequerels (11 microcuries) per square centimeter.

The containment system of the package is welded completely closed, except for the reactor vessel head closure, which is closed by 54, 7-inch diameter studs pre-tensioned to

720,000 pounds force. The reactor vessel head closure was designed for containment under the high temperatures and pressures of an operating reactor. The applicant evaluated the containment boundary (e.g., closure devices, including vessel studs, and closure plate welds) under normal conditions of transport (as described earlier). The applicant concluded that the design of the closure devices was adequate to ensure that they would remain intact, and that the containment system would not be breached under normal conditions of transport. In addition, the void spaces within the reactor vessel are filled with solidified low-density concrete that is intended to fix the radioactive material in place.

The applicant did not evaluate the package under all the hypothetical accident conditions in 10 CFR 71.73. Instead the applicant requested an exemption and proposed evaluating the package under alternative tests and conditions. These alternative tests and conditions consisted of a hypothetical drop from a reduced height at a specific orientation that does not necessarily represent the most damaging orientation, and at alternative initial conditions (e.g., temperature). The applicant concluded that the package containment system would not be breached under those alternative conditions.

4.2 Hydrogen Generation

The applicant evaluated the generation of flammable gases within the package during transport. The applicant used guidance from Electric Power Research Institute (EPRI) Publication NP-4938, "Methodology for Calculating Combustible Gas Concentration in Radwaste Containers," and GEND-052, "Hydrogen Control in the Handling, Shipping, and Storage of Wet Radioactive Waste." The applicant calculated the rate of hydrogen generation within the vessel. Hydrogen is generated by radiolysis of the water that is present in the concrete, and the rate of generation is based on the characteristics of the material and the energy absorbed in the material. The quantity of hydrogen generated from the low-density concrete per unit of absorbed energy from the radiation was based on experiments performed for resin bead-grout mixtures. The concentration of the hydrogen was then calculated on the basis of the ability of the hydrogen to migrate throughout the vessel, and on the estimated void volume within the concrete (~ 50%). A 5% concentration of hydrogen was used as the lower limit for flammability and detonation.

The applicant calculated that the hydrogen concentration within the reactor vessel may reach 5 percent by volume approximately 98 days after the vessel is sealed. The applicant stated that the shipment time is expected to be less than 45 days, including the time period from sealing the package until the actual transportation is completed.

The containment system has a flange closure designed to be leak-tight to water under high temperatures and pressures, and has penetrations that are welded completely closed. In addition, the radioactivity present as surface contamination is fixed by solidified low-density concrete.

Provided that the package containment system would not be breached under normal or off-normal conditions, the staff agrees that the package would not exceed 10 CFR 71.51(a)(2) material release limits, i.e., it would not release more than 1×10^{-6} A_2/hr under normal conditions and would not release more than an A_2 quantity in 1 week, under off-normal conditions.

5.0 SHIELDING EVALUATION

The radiation shielding for the TRVP consists of the reactor vessel itself, the low-density concrete that will be used to fill the voids within the vessel, and steel shield plates that will be welded together onto the reactor vessel before transport. The wall of the reactor vessel is constructed of carbon steel and its thickness ranges from 5-1/2 to 8-1/2 inches. The low-density concrete has a bulk density of between 45 and 65 pounds/ft^3. The steel plates that will be welded together onto the vessel are 5 inches thick around the core region and are 2 inches thick above the core region. Steel shield plates will be welded onto the vessel nozzles to close and shield vessel penetrations. Supplemental shield plates may be welded onto the primary shield plates to shield localized areas, or "hot spots." The applicant concluded that the shield plates would remain in place and that the shielding effectiveness would not be reduced under normal conditions of transport.

The radioactive material present in the package is in the form of the irradiated reactor vessel, irradiated vessel internal components, and a layer of contamination on the surfaces of the vessel and internal components. Dose rate measurements, isotopic analysis of surface contamination, and activation analysis were used to determine the magnitude and isotopic distribution of the radioactive material present in the package. The total radioactivity estimated to be present in the reactor vessel package in the form of activation products is 74.4 petabequerels (2.01 x 10^6 curies). The predominant radionuclides are cobalt-60 [42.5 petabequerels (1.15 x 10^6 curies)], iron-55 [2.58 petabequerels (6.97 x 10^5 curies)], and nickel-63 [5.81 petabequerels (1.57 x 10^5 curies)]. The radioactivity estimated to be present in the form of loose surface contamination is 5.74 terabequerels (155.2 curies), including 3.76 terabequerels (99.2 curies) of cobalt-60, 1.02 terabequerels (27.7 curies) of iron-55, and 0.74 terabequerels (20 curies)of nickel-63. The radioactivity is based on decay to November 1, 1997. For the shielding analysis, the applicant concluded that only cobalt-60 would contribute to the external dose rates.

For the activation source term, the applicant performed neutron transport calculations using the ANISN computer code to determine neutron flux levels throughout the reactor vessel and internal components. The calculations used the operating history of the Trojan plant, which included 14 cycles over the period between December 1975 and November 1992. Thermal neutron flux levels in the vessel ranged from 1.87 x 10^{13} n/cm^2-s in the core-former plates to 1.9 x 10^9 n/cm^2-s in the reactor vessel wall. The source regions considered in the analysis were: core baffles, core formers, core barrel, thermal shields, upper core plate, lower core plate, reactor vessel wall, and the stainless steel vessel cladding. The neutron fluxes were used as input to the ORIGEN2 computer code which calculated activation products in the various components.

In April 1996, the applicant performed in-place radiation surveys of the unshielded reactor vessel. Measurements were taken at 6 radial locations around the reactor vessel and at 25 axial locations at most radial locations. The measurements were taken in the space between the reactor vessel and the concrete biological shield, at a distance of about 8-1/2 inches from the vessel wall. The maximum measured dose rate was 43 mSv/hour (4,300 millirem/hour) at a vessel elevation corresponding to the core centerline.

The applicant then performed shielding analyses using the calculated source term to compare with the measurements. For these analyses, no supplemental shielding was modeled. The reactor vessel was assumed to be filled with water, consistent with the conditions during the radiation measurements. The maximum dose rate based on the calculated source term was 56.4 mSv/hour (5,640 millirem/hour). The calculated activation source terms were then normalized to the measured values. The ratio of the calculated to measured value was 0.78. The calculated source terms were then reduced by this fraction. The activation source term represented decay to November 1, 1997.

Using these reduced source terms and the QAD-CGGP point kernel computer code, the applicant performed shielding analyses to determine the external dose rates from the reactor vessel package and to determine the supplemental shielding needed to meet external radiation standards. The various internal components were modeled separately. The reactor vessel wall and cladding were also modeled separately. Since the source concentration in the reactor vessel wall varies significantly across the wall thickness, and since the reactor vessel is the most important contributor to external dose, the distribution of radioactivity in the vessel wall was also considered. The low-density concrete was assumed to fill all voids, and was assumed to have a bulk density of 0.7208 g/cm^3. The external shield plates were modeled.

The applicant assessed the dose rates from the nozzles; this analysis considered separate source terms for the surface contamination on the upper internal components and the activated lower internal components.

The maximum dose rates calculated by the applicant are shown below.

EXTERNAL DOSE RATES (mrem/hr)

Location	Calculated	Allowable
Package Surface		
Side	95	200
Nozzle	5	200
End (lower head)	35	200
Two Meters from Conveyance		
Side	5.5	10
Nozzle	4.2	10
End	<0.1	10

The applicant did not evaluate the package under all the hypothetical accident conditions in 10 CFR 71.73. Instead the applicant requested an exemption and proposed evaluating the package under alternative tests and conditions. These alternative tests and conditions consisted of a drop from a reduced height at a specific orientation that does not necessarily represent the most damaging orientation, and at alternative initial conditions (e.g., temperature). The applicant concluded that the package shielding would remain intact under those alternative conditions. For this case, the applicant evaluated the dose rates at a distance of 1 meter from the package. The dose rates calculated were made assuming that the geometry of the containment system and the contents was the same, that the primary shield plates welded together onto the vessel remained in place, and that the concrete would not fissure, crack or otherwise be degraded. The maximum dose rate at 1 meter was calculated as 0.142 mSv/hour (14.2 millirem/hour).

The results of the applicant's calculations are within the limits for external radiation specified in 10 CFR 71.47 and 71.51. In addition, the operating procedures and acceptance tests for the package specify that the radiation dose rates will be measured before shipment to ensure that they meet the requirements of 10 CFR 71.47. Supplemental shield plates may be used, if needed, to reduce dose rates to those levels.

The applicant has concluded, and the staff agrees, that the package shielding, together with the radiation survey performed before shipment, are adequate to assure that the external dose rates are within the limits of 10 CFR 71.47. Provided that the package containment system and shielding would remain intact and undamaged under normal and off-normal conditions of transport, the staff agrees that the package provides adequate shielding to meet the dose rate requirements of 10 CFR 71.47, that the dose would not significantly increase under normal conditions of transport, and that the dose rate would not exceed the 10 CFR 71.51(a)(2) external radiation dose rate limit, i.e., it would not exceed 0.01 Sv/hour (1 rem/hour) at a distance of 1 meter from the package surface under those off-normal conditions.

6.0 CRITICALITY REVIEW

Trace amounts of fissile materials may be present in the package, however, the quantity is less than the exempt quantities defined in 10 CFR 71.53. Therefore, criticality is not a concern.

7.0 OPERATING PROCEDURES REVIEW

The operating procedures consist of the planning and safety that will be exercised for the transport of the TRVP. These special controls that will be in place provide the means of attaining adequate safety for the shipment of the TRVP.

A Transportation Safety Plan (TSP) has been prepared, which addresses the operating controls and procedures, radiological controls, and contingency actions. The Operating Procedures section states that the requirements of the TSP will be implemented by detailed procedures.

The staff reviewed Section 7, "Operating Procedures," and the separate Reactor Vessel and Internals Removal Project Transportation Safety Plan. The staff agrees that all of the measures stated in Section 7 and the TSP (e.g., barge and transporter speed restrictions, weather condition restrictions, inspections, classification, and certification of the barge) should be implemented.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM REVIEW

Chapter 8 of the application described acceptance tests that will be performed before the TRVP is transported. The acceptance tests include inspection of the package closure devices and radiation and contamination surveys of the package before shipment. The containment system of the package is welded completely closed, except for the vessel flange O-rings. The metallic O-rings are procured from an approved supplier and are inspected visually before use. The O-rings are installed following established procedures to ensure proper sealing. The closure devices, including the studs, O-rings, and sealing surfaces will be inspected visually for defects will be repaired as necessary. The package will be inspected visually and the penetration cover plate welds will be examined nondestructively before transport. The staff agrees with the applicant's conclusion that these acceptance tests are adequate to ensure that the package is properly closed for transport, and that leak testing of the package is not necessary. This conclusion is not based on the analysis submitted by the applicant, but is based on the design of the containment system, the non-destructive examination that will be performed before shipment, and the form of the radioactive contents.

After the package is prepared, and before it is shipped, it will be surveyed for loose surface contamination and for external radiation levels to ensure that it meets the applicable limits for removable surface contamination and external radiation.

CONDITIONS

Authorization of the TRVP for transport is subject to the following conditions:

1. The TRVP as configured for shipment must comply with the following Portland General Electric Company Drawings:

   M-9257, Sheet 1, Rev. 1; Sheet 2, Rev. 0
   M-9258, Sheets 1-8, Rev. 1
   M-9259, Sheets 1-2, Rev. 1; Sheet 3, Rev. 0; Sheets 4-5, Rev. 1
   M-9260, Sheets 1- 8, Rev. 1.

2. The TRVP must be transported in compliance with the specific exemption issued by the U.S. Department of Transportation.

3. The TRVP must be transported in accordance with Portland General Electric Company's Transportation Safety Plan for the Reactor Vessel and Internals Removal Project, PGE-1077, Rev. 0.

4. The TRVP must be prepared for shipment and operated in accordance with Sections 7.0 and 8.0 of the application dated March 31, 1997, as supplemented on August 8, August 13, and September 23, 1998.

EXEMPTIONS

1. The TRVP has been exempted, under the provisions of 10 CFR 71.8, from the requirements of 10 CFR 71.71(c)(7) for orientations other than horizontal.

2. The TRVP has been exempted, under the provisions of 10 CFR 71.8, from the requirements of 10 CFR 71.73(c)(1) (30-foot drop test) and 10 CFR 71.73(b) (i.e., temperature).

CONCLUSION

Considering the statements and representations contained in the application, as supplemented, and the exemptions and conditions listed above, the staff has concluded that the Trojan Reactor Vessel Package (TRVP), as exempted, meets the requirements of 10 CFR Part 71. An NRC authorization for the TRVP has been issued for the one-time shipment of the TRVP, subject to specified conditions, including that the TRVP is approved, marked, and transported as an Exempt package under applicable U.S. Department of Transportation regulations.

ACRONYMS

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
B&PV	boiler and pressure vessel
CDRM	control rod drive mechanism
CG	center of gravity
COI	certificate of inspection
DOT	U.S. Department of Transportation
EPRI	Electric Power Research Institute
LDCC	low-density cellular concrete
LLNL	Lawrence Livermore National Laboratory
MNOP	maximum normal operating temperature
NCB	National Cargo Bureau
NRC	U.S. Nuclear Regulatory Commission
PGE	Portland General Electric Company
PSE	probabilistic safety evaluation (overland mode)
PSS	probabilistic safety study (river mode)
RAI	request for additional information
SAR	safety analysis report
TRVP	Trojan Reactor Vessel Package
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey

SAFETY EVALUATION REPORT
Trojan Reactor Vessel Package

APPENDIX A
PROBABILISTIC SAFETY STUDY

Description of the Probabilistic Safety Study for the Transportation of the Trojan Reactor Vessel Package

The safety analysis report submitted by the Portland General Electric Company contained (1) the "Probabilistic Safety Study (PSS) for the Transportation of the Trojan Reactor Vessel Package (TRVP) by Barge on the Columbia River from the Trojan Site to the Port of Benton" and (2) the "Probabilistic Safety Evaluation of the Overland Movement of the Trojan Reactor Vessel Package for Disposal". The PSS for the barge transport, which was a quantitative study of accident scenarios, was developed by the Glosten Associates, Inc., the same company that prepared the safety analysis for the barge transportation of the Shippingport RVP in 1986. The land transport evaluation, a qualitative/quantitative study, was prepared by Robert H. Jones, P.E.

Neither the barge transport nor the land transport study contained an assessment of external events. In a request for additional information (RAI), the staff asked about the consideration of external events. In response to the RAI, the licensee submitted a separate assessment of external events. A specific section is provided for the review and evaluation of each submittal.

Section A: Evaluation of the Probabilistic Safety Study (PSS) for the Transportation of the Trojan Reactor Vessel Package (TRVP) by Barge on the Columbia River from the Trojan Site to the Port of Benton

A.1.0 Adequacy of the Data Used in the Barge Shipment PSS

Accident Frequency Data

Statistical data on the frequency of accidents that occur on the Columbia River were obtained from "Operational Plan for Barging the Shippingport RVP/NST Package to Port of Benton, Washington" (referred to as the "Shippingport study" in this report). The data in the Shippingport study was in turn based on the U.S. Coast Guard's (USCG's) Automated File of Commercial Vessel Casualty Database (magnetic tape) for years 1976-1980. This database contained the number of accidents according to specific categories (e.g., collision, ramming) for each year.

In order to place accident rates on a per mile basis, the Shippingport study used data on the volume of barge obtained from the U.S. Army Corps of Engineers, "Waterborne Commerce of the United States, years 1976 - 1980." These data included the number of trips by freight barges on specific rivers and the average number of miles per trip, form which annual barge miles can be calculated. Because tugboats can push flotillas made up of several barges lashed together into one floating unit, the average number of barges per flotilla for the Columbia River was used to convert the annual barge miles to floating unit miles. The number of accidents per category from the USCG database were then divided by the average floating unit miles on the Columbia River for the years 1976 - 1980 to obtain the accidents per barge floating unit per mile.

The sorting and binning of the USCG records to arrive at the number of accidents under a given category involving at least one freight barge on the Columbia River was not explained in the PSS, but it was explained in Chapter 11 ("Safety Analysis") of the Shippingport study. According to the Shippingport study, the 1976 - 1980 database was structured by primary accident type as opposed to initiating events. The primary accident types were (1) collision, (2) ramming, (3) grounding, (4) fire/explosion, (5) foundering, (6) capsize, (7) flooding/swamping, and (8) all other. As an example of a primary accident type, "capsize" refers only to those capsize events that were caused by severe weather, poor maintenance, or low stability. Those capsize events that resulted from other causes, such as collision or ramming, are not counted in the capsize primary accident type.

All of the primary accident types were analyzed in the PSS accident scenarios except for "flooding/swamping" and "all other." "Flooding/swamping" involves the uncontrolled entry of water into the hull of the vessel. With respect to the database, "flooding/swamping" was specifically defined by the USCG as being without sinking or capsize. In response to an RAI, the licensee effectively showed that "flooding/swamping" is not a threat to the TRVP. The "all other" category included minor accidents that were evaluated and dismissed, such as cargo damage with no vessel damage, and material failure, such as failure of machinery, cargo gear, and propeller shaft.

The PSS compared the annual total traffic volume on the Columbia River for the years 1976-1979 with the annual total traffic volume on the Columbia River for the years 1992-1995, to justify using the earlier data. This comparison demonstrated that the volume of traffic volume remained relatively constant in the two periods. However, the PSS did not compare the data on the frequency of accidents on the cargo deck of barges from 1976 - 1980 with recent data. In an RAI, the staff requested justification for using these older data without comparing them to more recent data. In response to the RAI, the licensee obtained additional data on the frequency of such accidents from the Coast Guard for 1993 - 1997. The licensee then sorted the data to be as consistent as possible with the 1976 - 1980 data binning definitions. Taking into account that the volume of traffic has remained relatively constant on the Columbia River during these two periods, the USCG data on accident frequency data were shown to be comparable between years 1976 - 1980 and 1993 - 1997. Therefore, the staff finds it acceptable to use the 1976 - 1980 data for this application. However, the staff advises that any future studies involving marine accident data should use the more recent data because of the dynamic nature of transportation traffic and the increased credibility of using more recent data. In addition, the recent data are reproducible and easily accessible, whereas data on magnetic tape from 1976 - 1980 are not.

Accident Consequence Data and Distributions

Probability data and distributions for the consequences of barge accidents (e.g., collision penetration distance, peak transverse acceleration) were obtained from "Barge Collisions, Rammings and Groundings - An Engineering Assessment of the Potential for Damage to Radioactive Material Transport Casks" (SAND85-7165, TTC-05212). (This study will be referred to as "the Sandia report"). The Sandia report used Monte Carlo simulation studies to develop the probability distributions. The Sandia report divided domestic waters into five navigable domains (western rivers, the Mississippi River system, other inland rivers and waterways, the Gulf intracoastal waterway, and offshore seas). The Columbia River is classified under inland rivers and waterways (referred to as "inland waters") in the Sandia report. Inland waters comprise those U.S. navigable waters subject to inland rules of navigation.

The PSS assumed that the collision consequence probability distributions given in the Sandia report for inland waters best characterized the TRVP barge exposure below the Bonneville Lock and Dam (where large ships may be encountered). However, the Columbia River's classification notwithstanding, the PSS assumed that above the Bonneville Lock and Dam (where traffic is almost entirely other towboats and barge tows), collision consequence probability distributions for western rivers were best suited. The category "western rivers" is considered to be all waters covered by Western Rivers Rules. The staff finds this assumption acceptable.

A.2.0 TRVP Barge Accident Scenarios

In response to an RAI, event trees depicting barge accident scenarios and the conditional probabilities for each event on the trees were provided. These figures made it easier to evaluate the PSS.

A.2.1 Collision - Sinking Scenario

The probability of a barge collision for the 270.8 miles of transit up the Columbia River was given in Table 1 of the PSS as 4.3E-4. Collisions, as classified in the data for this study, involve accidents between two or more vessels that are both under command and underway. The conditional probability of sinking following a collision as taken from the Sandia report was 0.016. Therefore, the scenario probability -- barge collision and consequent sinking-- is 6.9E-6.

The conditional probability of sinking following a collision was based on typical inland barges, which have no longitudinal subdivisions and are transversely subdivided into 6 to 8 watertight compartments with minimal freeboard and buoyancy. The barge transporting the Trojan TRVP will have 17 watertight compartments. The PSS included a sinking analysis for the Trojan barge which demonstrated that, at a minimum, 9 watertight compartments would have to be damaged in order for the Trojan barge to sink. Using the Sandia report to determine the relationship between collision penetration distance into a struck freight barge and the cumulative probability of having such a damaging collision, the PSS showed that a penetration distance of 33.65 feet was estimated to occur in 1E-6 collisions. This distribution of penetration consequences of barge collisions does not consider how often a collision occurs. In other words, the collision occurrence frequency for this distribution of consequences is assumed to be 1. The penetration distance may occur at any point along the length of the barge. (This collision penetration relationship is for inland waters which, in the PSS, includes the portion of the Columbia River below the Bonneville Dam, where exposure to deep draft shipping with wedge-like bows is possible).

The PSS determined that no more than 6 watertight compartments could be damaged in a collision with a 33.64-foot penetration distance, measured in any direction from any contact point. Therefore, the information inferred from the PSS is that the discrete probability of a collision on the Columbia River resulting in the sinking of the Trojan barge is less than (4.3E-4)(1E-6), or 4.3E-10, on the basis of its unusual subdivisional design. The staff finds this reasoning acceptable.

A.2.2 Ramming - Sinking Scenario

The probability of a barge ramming accident for the 270.8 miles of transit up the Columbia River was given in Table 1 as 1.1E-3. Rammings, as classified in the data for this study, involve accidents between vessels and fixed objects or vessels moored or otherwise not underway. The conditional probability of sinking following a ramming accident as taken from the Sandia report (for a typical barge) was 0.006. Therefore, the scenario probability --barge ramming and consequent sinking-- is 6.6E-6. *The PSS assumes that the tow is proceeding at a speed of 10 knots when it strikes a fixed object (sailing instructions for the TRVP shipment are to be issued restricting the speed of the tow to no more than 10 knots).* Using this speed, the PSS calculated the worst ramming penetration distance to be approximately 47.4 feet, measured from the bow of the barge. This penetration distance, from the bow of the barge, would cause a maximum of 4 watertight compartments of the Trojan barge to be damaged during a ramming. Therefore, the PSS concluded that the Trojan barge would remain afloat during a ramming event, on the basis of its unusual subdivisional design and the speed restriction of 10 knots. The staff agrees with the analysis and assumptions for this scenario.

A.2.3 Collision - TRVP Overboard Scenario from Lateral Acceleration

ANSI standard N14.24 specifies that cargo seafastenings must resist a lateral acceleration of 0.5g without exceeding 90% of (shear) yield stress. The PSS calculated the ultimate shear force capacity of the seafastenings (assuming that the seafastenings will be constructed of steel with a 36 ksi tensile yield stress) and the acceleration associated with this ultimate force (assuming the TRVP weighs 1533 S.T.) Using the Sandia report to calculate the relationship between maximum transverse acceleration during a collision on the western rivers[1] and cumulative probability, the PSS determined that there is a 5.32% probability that the transverse acceleration associated with a collision will result in transverse shear loads exceeding the ultimate shear capacity of seafastenings designed to meet the ANSI N14.24 standard for lateral acceleration. Therefore, the probability of a collision resulting in a seafastening failure (causing the TRVP to go overboard) is (4.3E-4)(5.32E-2) = 2.3E-5.

In order to reduce this probability (of the TRVP overboard as a result of a collision), the PSS states that the licensee is going to increase the transverse acceleration design standard for the seafastenings to 1.60g. The PSS shows that a seafastening design of 1.60g for the peak transverse acceleration reduces the probability of a collision resulting in a seafastening failure from 2.3E-5 to 1.0E-6.

Therefore, the PSS states that the arrangement for securing the cargo should be designed to maintain control of the TRVP package under exposure to a peak transverse acceleration of 1.60g. The staff agrees with the analysis and design change for this scenario. Therefore, as long as the licensee designs the seafastenings for a 1.60g peak transverse acceleration, the staff finds the level of safety provided to protect against this scenario to be acceptable.

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[1] This is more conservative than using the Inland Waters relationship because the conditional probability for a given transverse acceleration in a collision event occurring below the Bonneville Dam is less than that above Bonneville because of the greater likelihood that a collision below Bonneville will involve a striking vessel with a wedge-like bow. These bows penetrate more deeply than the blunt bows of barges, but result in lower peak accelerations.

A.2.4 Collision or Ramming - TRVP Overboard from Longitudinal Acceleration

The ANSI standard N14.24 specifies that cargo seafastenings must resist a longitudinal acceleration of 1.5g for a collision environment. Considering that the barge deck will be made of ½-inch-thick steel plate, the bottom shell of the barge will be made of 7/16-inch-steel plate, the bow rake angle will be 32 degrees, and the barge beam will be 55 feet, and taking into account the total virtual mass of the loaded barge, the PSS calculated the peak longitudinal acceleration to be 1.09 g. The PSS concluded that because this value is a lot less than the ANSI N14.24 standard for longitudinal acceleration, the probability of a collision or ramming of the Trojan barge resulting in a longitudinal acceleration that would cause the TRVP to go overboard is effectively zero. The staff finds the evaluation of this scenario to be acceptable. It is important to note that this result is based on the barge specifications and mass stated above and in the PSS.

A.2.5 Collision - Impact with the TRVP

The PSS states that the TRVP package is inset 16.5 feet from each side of the barge. On the basis of the Sandia report's conditional probability of collision penetration for barges operating on inland waters and western rivers, the conditional probability of a collision penetration equaling or exceeding 16.5 feet is 1.3E-2 and 5.8E-4, respectively.

The probability of collision contact between the TRVP and the striking vessel must also take into account the conditional probability that a randomly located collision with a uniform probability distribution along the length of the barge is located on that portion of the length occupied by the TRVP. This has been called the "longitudinal stowage factor" and is the TRVP length as a fraction of the total barge length (42.25/240 = 0.18).

As shown in the PSS, the probability of a collision contacting the TRVP in the segment of travel below Bonneville is (1.2E-4)(1.3E-2)(0.18) = 2.8E-7 and above Bonneville is (3.2E-4)(5.8E-4)(0.18) = 3.3E-8. The total probability of a collision contacting the TRVP during the barge trip is the sum, 3.2E-7. The staff finds the analysis and assumptions for this scenario to be acceptable.

A.2.6 Ramming - Impact with TRVP

The PSS assumes that the tow is proceeding at a speed of 10 knots when it strikes a fixed object (sailing instructions for the TRVP shipment are to be issued restricting the speed of the tow to no more than 10 knots). Using this speed, the PSS calculated the worst ramming penetration distance to be approximately 47.4 feet, measured from the bow of the barge. The forward end of the TRVP is set back from the bow by approximately 98 feet. Therefore, the maximum ramming penetration would stop short of the TRVP by approximately 50.6 feet. On this basis, the PSS concluded that the probability of a ramming impact contact with the TRVP package is effectively zero. The staff agrees with this assessment.

A.2.7 Foundering Scenario

The probability of a typical barge foundering event for the 270.8 miles of transit up the Columbia River was given in Table 1 as 2.1E-5. According to the data classification scheme used in this analysis (the USCG 1976 - 1980 data), founderings include vessel sinkings, for instance due to leakage through sea valves or piping, or through hull seams that have cracked open, and other major failures, such as primary hull girder failure, which culminate in sinking. Using this definition, all founderings are presumed to end in sinking. Therefore, the probability of a typical barge foundering and subsequently sinking on the 270.8 miles of travel along the Columbia River is (2.1E-5)(1) = 2.1E-5. It should be noted that sinkings that are the consequences of accidents such as collisions, rammings, groundings, fire or explosion, or capsizing are not counted as foundering incidents.

The PSS states that foundering is usually the result of either weather-related damage or poor maintenance, or both. Because the Trojan barge will be classed, certificated, and inspected by a marine surveyor before use, poor maintenance was dismissed as a probable cause of foundering. The PSS also asserts that weather forecasts will be consulted and sailing instructions issued restricting the voyage to a time when where relatively benign wind and sea conditions are predicted. In addition, should wave heights on any of the Columbia River pools exceed 6.5 feet, the barge will be instructed to hold below the dam until the conditions abate. On the basis of these assumptions, the PSS dismissed heavy weather as a probable cause of foundering. Therefore, the PSS concluded that the probability of the Trojan barge foundering/sinking is effectively zero.

The staff did not agree that the licensee adequately justified its conclusion that the typical barge probability of foundering of 2.1E-5 would be reduced to not credible for the Trojan barge on the basis of the information and assumptions provided in the PSS. The staff requested further information in an RAI on (1) tug boat inspection and maintenance, (2) the inspection and certification process of the barge by a marine surveyor, (3) a comparison of the inspection and maintenance practices of a typical barge to those of the Trojan barge, (4) the accuracy of weather predictions, and 5) locations for holding the barge in the event of severe wave conditions. In response to the RAI, the licensee provided adequate information that tends to support its conclusion.

The following information was given in the PSS. The Trojan barge does not have a piping system, so that the barge cannot founder as a result of leakage through valves or piping. The structural design and watertight integrity of the barge are reviewed by the American Bureau of Shipping (ABS) for classification. ABS and the USCG inspect at regular intervals to support Classification, Loadline Certificate, and Certificate of Inspection (COI) renewals. The National Cargo Bureau will inspect the loading and seafastenings to ensure compliance with the engineered plans, and also will review the stability of the loaded barge. A marine surveyor (using prepared checklists) inspects the barge at the slip before and after loading the TRVP. The marine surveyor inspects for structural integrity, including denting, bending, cracking, or wastage, and checks manways to ensure that they are properly secured. The marine surveyor documents his findings in a Trip and Tow Report. For comparison, typical river barges are not classed or inspected. A marine surveyor will inspect the tugs for PGE immediately before the trip, which includes inspection of the winch wires.

Extreme wave conditions can only be reached if there are sustained winds over long straight open stretches of water. Local thunderstorms, which can have high winds and may not be absolutely predictable, do not last long enough to develop the severe wave conditions. In the event of severe weather conditions, the barge would be held on the lee of dams by either the tugs or moorage, which is available at some locks and at additional points of refuge along the route. On the basis of the information provided, the staff believes that the probability of a typical barge sinking along this route of 2.1E-5 would not apply to the Trojan barge. The staff believes that, although foundering may be credible for the Trojan barge, the probability would be less than 1E-6, on the basis of the preceding information.

A.2.8 Bottom Raking - Sinking Scenario

The PSS stated that a bottom raking over the entire length of the Trojan barge could cause as many as 12 watertight compartments to be violated, a quantity of flooding water that could sink the Trojan barge. However, credit was not taken in the sinking analysis for the air in the unvented compartments. Using a program that determines hydrostatic equilibrium when bubbles form in damaged tanks [the General Hydrostatics program (GHS)], an equilibrium analysis was performed of the barge loaded with the TRVP and subject to bottom damage to 12 compartments. The analysis concluded that the event results in a stable situation in which the barge remains floating on bubbles of air in each compartment. As long as the air is trapped, the barge would float upright indefinitely. In response to an RAI, the licensee stated that time would be available to move the barge into shallow water where it cannot sink or capsize.

It should be noted that for a bottom raking to occur, the barge most likely will have entered shallow water so that it will ground without actually sinking. The staff agrees that this scenario does not pose a risk to the TRVP.

A.2.9 Side Raking - Capsize Scenario

Side raking could occur during either a collision or a ramming event. If the barge is raked by some protrusion so that most of one side is opened, it could capsize. However, the PSS asserts that with the seafastenings designed to meet (and actually exceed, see Section A.2.3) the ANSI N14.24 standard (which utilizes design loads greater than the TRVP's weight in water), the TRVP will remain attached to the barge in the event of a capsize. Using the GHS program to determine the submergence depth of the TRVP in the event of this capsize scenario, the deepest point of submergence of any part of the TRVP in this capsized state was determined to be 41.5 feet. The TRVP has been demonstrated to meet the provisions of 10 CFR 71.73(c)(6) which is immersion under a head of water of at least 50 feet. Therefore, a side raking with subsequent capsize of the barge will not result in either the TRVP sinking or damage to the TRVP. The staff agrees with this assessment.

A.2.10 Poor Maintenance or Low Stability and Severe Weather- Capsize

The probability of a typical barge capsizing as a result of poor maintenance or low stability and severe weather for the 270.8 miles of travel along the Columbia River was reported in Table 1 of the PSS as 8.1E-6. For the same reasons as presented in the section on foundering, the licensee concluded that a capsize resulting from poor maintenance or low stability and severe weather is not credible for the Trojan barge. The PSS also asserts that the evaluation of collision and ramming events envelope all credible capsize events (which result in no damage to the TRVP). The staff agrees with this conclusion.

A.2.11 Barge Breakaway from Tug Scenario

The scenario of the Trojan barge breaking away from the tug was not specifically addressed in the PSS. The licensee's response to an RAI addressed this scenario qualitatively. The response stated that most barge breakaways occur when unattended barges are improperly moored.

The Trojan barge will be pushed by two tugboats. Each tug is fully equipped and capable of pushing the barge by itself. Both tugs will be winched onto the stern of the barge with two cables. As an added precaution, an emergency line with a float will be installed on the barge, so that it can be controlled by being taken under tow. Breakaway events of pushed barges are due to poorly maintained equipment, inadequate inspection, neglect, or extreme weather. The condition of the cables will be inspected by the marine surveyor immediately before the TRVP barge leaves the slip. The TRVP barge will not leave the slip or any intermediate point of refuge (locks) if extreme weather conditions are forecast.

The response acknowledged that a breakaway event is conceivable, but the consequences would not be considered to pose a hazard in this transport because two independent tugs are immediately available to control the barge and reconnect. Breakaways from large flotillas have resulted in accidents because the pushing tug is not immediately free to control the breakaway barge(s). The staff agrees with this qualitative assessment.

A.2.12 Collision, Ramming or Grounding leading to TRVP Fire Exposure

The Fire/Explosion probability of a typical barge traveling along the 270.8 miles of the Columbia river was given in Table 1 as 5.4E-5. This value includes general cargo barges that routinely carry flammable material among their cargo consignments. Therefore, this value overestimates the probability of fire for the Trojan barge. The probability of a collision with, or ramming into, a tank barge carrying flammable liquid is the only fire scenario of concern for this shipment. On the basis of conditional probabilities inferred from the Sandia report, the PSS estimated a probability of the scenario--collision with a tank ship or barge and resulting fire of any duration along the Trojan route of travel--to be 6.0E-7. The licensee has demonstrated that the TRVP complies with 10 CFR 71.73(c)(4) (a 1475 °F fire lasting 30 minutes). The PSS cited a Swedish study on spent fuel transportation accidents, which estimated the probability of a collision followed by a fire of long duration to be 1.1E-7 per ship year. The PSS applied this value to the Trojan barge travel time to calculate a discrete probability for the Trojan shipment of 6.0E-10. Although the staff has not reviewed or verified the Swedish study, the staff believes that the probability of the Trojan barge colliding with or ramming into a tank barge carrying flammable liquid leading to a long duration fire is, at most, a small fraction of 6.0E-7.

A.3.0 Additional Information

A summary of the estimated discrete accident probabilities for the transportation of 270.8 miles on the Columbia River is presented in Table A-1. The second column represents the discrete accident probability estimate of each scenario in the first column for a typical barge. The third column presents the estimated discrete accident probabilities for the trip using the specific barge that has been designed for the Trojan shipment. The fourth column presents the justification for the changes in the accident probabilities.

A study by the USCG concluded that the majority of accidents occurred on downriver passages, with accidents at bridges occurring during high water conditions. The one-time TRVP transport occurs on an upriver passage and will not be attempted during high water conditions. Accident data provided by the USCG have not been separated for upriver vs. downriver, or high water vs.

low water, etc., categories. These are additional reasons why the USCG numbers for accident data may be too large in reference to this particular shipment.

Finally, the deepest point in the Columbia River between the Trojan site and the Port of Benton is approximately 191 feet (at normal pool elevation) at mile 219.5, located in Lake Umatilla above the John Day Dam. The applicant's emergency response plan details the availability of recovery craft with the capability to raise the TRVP from such depths. Therefore, in the unlikely event that the TRVP barge were to sink to the bottom at any location along the route, it could be recovered.

Section B: Evaluation of the Probabilistic Safety Evaluation (PSE) of the Overland Movement of the TRVP for Disposal

This study (the PSE) evaluated the safety of two alternate overland routes from the Port of Benton to the U.S. Ecology facility on public roads and Hanford Reservation highways. One of the routes is 20 miles long and the other route is 30 miles long. To date, all large shipments of radioactive components have been made using the 30-mile overland route.

B.1.0 Description of Data used in the Study

The PSE used the accident frequency data that Lawrence Livermore National Laboratory (LLNL) had chosen for NUREG/CR-4829, "Shipping Container Response to Severe Highway and Railway Accident Conditions." The source of the data was the American Petroleum Institute (API) files for shipping petroleum products nationally, which was a large database of hazardous commodities shipped in large and heavy trucks. The accident frequency, 6.4E-6 accidents/vehicle-mile, was about 2.5 times greater than the national average based on data from the Bureau of Motor Carrier Safety.

Because the speed of the TRVP transporter will be limited by procedure to 5 mph, the PSE reviewed two data sets that contained estimates of the fractions of accidents that occur in segmented velocity ranges. The first was "Severities of Transportation Accidents Volume III - Motor Carriers", prepared by Sandia, which estimated that the fraction of accidents that occur in the 0 - 10 mph range is 0.19. The second data set was LLNL data for California, which estimated the fraction of accidents in the 0 - 10 mph range to be 0.2137. The PSE chose to use 0.20 as the fraction of accidents that occur at 10 mph or less. In a response to an RAI, the licensee clarified that this fraction is a function of a given truck's speed preceding the accident, without consideration of the speed of the other traffic. Therefore, even though other traffic is not limited to 5 mph, the use of these data is appropriate based solely on the speed of the TRVP transporter.

B.2.0 Accident Scenarios

The PSE used the truck accident event tree from the LLNL study. The LLNL event tree subdivides all accidents into collision and non-collision categories. The "collision" category represents impacts with other vehicles or with fixed roadside objects, such as bridge abutments or overpass structures. The "non-collision" category represents jackknifings, overturns (i.e., loss-of-control accidents), and off-road incidents.

The collision tree is further subdivided into fixed objects and non-fixed objects. Surveys of both the 20 and 30 mile routes (which are included as attachments to the PSE), showed that the terrains of both routes are void of bridges, overpasses, or other fixed objects that would match those in the event tree. On the basis of the results of the surveys, the PSE dismissed collisions with fixed objects. The staff agrees with this assessment. The PSE also dismissed collisions with non-fixed objects (i.e., cars, trucks, trains, pedestrians) on the basis that (1) the route will be along low traffic-density highways, (2) any conflicting traffic will be controlled by escorting and speed/passing restrictions, or by prohibition during TRVP transit times, (3) no trains will be operated during the TRVP shipment, and (4) the majority of vehicles are automobiles that belong to Hanford employees, which are "soft" relative to the TRVP and its transporter. The staff does not agree that the traffic controls for the shipment completely eliminate the possibility of a collision type accident and this is discussed further in Section B.2.2.

B.2.1 Non-collision Accident Scenarios

In order to quantitatively analyze the non-collision accidents, the PSE referred to two studies that provided estimates of the fraction of accidents that are collisions and the fraction that are non-collisions. One study was the LLNL study, which estimated that the fraction of collision accidents is approximately 74% with the remaining 26% being non-collision accidents. The other study was a study sponsored by the Environmental Protection Agency (EPA), "Transportation Accident Risks in the Nuclear Power Industry, 1975 -2020." The EPA study examined the collision/non-collision split on a velocity distribution basis and estimated that a 96.5% - 3.5% split between collision and non-collision accidents, respectively. The explanation was that the lower speeds do not often produce the forces which result in jackknifing, or overturning or both. On the basis of these two studies, the PSE used a 95% - 5% split between collision and non-collision accidents, respectively.

For the non-collision events, the PSE dismissed overturning and jackknifing because of the low speed and the powering arrangement. Two prime movers are used for most of the transport, one in the front and one in the back. Three prime movers are used for some short sections where the road grade is more than 6%. The basis of this assumption appears to be acceptable. By dismissing the accident scenarios mentioned previously, the only scenario left for quantification in the PSE was an off-road, non-collision excursion. For simplification, the PSE assumed that the conditional probability that a non-collision accident will be off-road (as opposed to roadbed) was assumed to be 1.

On the basis of a survey of terrain features for the 30-mile route, the PSE determined that less than 1 mile (or 3.3%) had damage potential terrain features (e.g., dropoffs). For the 20-mile route, less than 2 miles (or 10%) had damage potential terrain features.

Using these fractional probabilities, the PSE calculated the probability of a low-speed, non-collision, off-road accident on the 30 mile route to be 6.4E-8 and on the 20 mile route to be 1.3E-7. The consequences of having this accident occur were not quantitatively analyzed in the PSE. The PSE qualitatively addressed this issue by stating that the consequences of these accidents are most likely to be low because of the lack of "hard" targets or surfaces and because the TRVP is protected from impact forces with impact limiting structures. The staff agrees with the quantitative/qualitative assessment of this scenario.

B.2.2 Collision Accident Scenarios

As stated earlier in the evaluation, the staff does not believe that the controls for the shipment completely eliminate the possibility of a collision-type accident. Therefore, the probability of a collision type accident at low speed with consideration of the controls associated with this shipment were roughly calculated by the staff. The staff used the 6.4E-6 accidents per vehicle-mile, the fraction of all accidents at low speeds as 0.2, the fraction of accidents that are collision accidents (as opposed to non-collision accidents) as 0.74 (from the LLNL study), and the fraction of collisions with non-fixed objects as 0.88 (from the LLNL study). The controls associated with this shipment were conservatively estimated to reduce the accident rate by 90%. Therefore, the probability of a collision accident with a non-fixed object for the 30-mile route is was calculated to be:

(6.4E-6 accidents/mile)(0.74)(0.88)(0.2)(0.1)(30 miles) = 2.5E-6

Since the most of these accidents involve an automobile, the consequences to the TRVP and transporter are anticipated to be quite minor. With all of the conservatism in the calculation and consideration of the consequences, the staff considers this risk of the overland movement of the TRVP acceptable.

Section C: Evaluation of the Assessment of External Events

In response to an RAI, the licensee briefly assessed external events, including earthquakes, volcanic activity, weather-related or pollution-related reduced visibility, tornadoes, and external flooding. Scenarios were quantified for those external events with initiating event frequencies that were estimated to be greater than 1E-7. External events that were justifiably shown to have initiating event frequencies of less than 1E-7 were dismissed.

C.1.0 Earthquakes

The seismic data used for this evaluation were taken from " Seismic Design Mapping State of Oregon," January 1995, by Geometrix Consultants. These data were supplemented for the Port of Benton to U.S. Ecology facility area by the seismic motions described in the "Individual Plant Examination of External Events for Washington Nuclear Plant 2," June 1995. The seismically induced risks that were evaluated were (1) land transporter with TRVP restraint and stability under hypothetical seismic ground motions and (2) seismically induced landslide mass movements and seiches during barge transport.

C.1.1 Land Transporter Restraint and Stability

The duration of land transport from the Port of Benton to the US Ecology site is planned to be 6 hours. Ground motions corresponding to a 2500-year recurrence interval were used for this evaluation. When combined with the transport time, the probability of exceedance of these ground motions is 2.7E-7. From the WNP-2 data, the horizontal and vertical response accelerations at the 2500-year recurrence interval were well below ANSI Standard N14.2, "Proposed American National Standard Tie-downs for Truck Transport of Radioactive Materials." Therefore, the TRVP will remain restrained during the 2500-year recurrence interval seismic event, with large margins available.

Overturning stability was also evaluated; the TRVP will remain stable during a 2500-year-recurrence-interval seismic event. The study also determined that the risk of seismically induced soil liquefaction and soil settlement is not considered to be significant at this level of ground motion. The staff agrees with this assessment.

C.1.2 Seismically Induced Landslide Mass Movements and Seiches During Barge Transport

Because the seismicity and landslide susceptibility change significantly from Prescott to the Hanford Reservation, geologic terrain was broken into three segments: (1) Prescott to West End of Columbia River Gorge, (2) Columbia River Gorge, and (3) East End of Gorge to Hanford. The evaluation used the 1000-year-recurrence-interval earthquake and calculated that the probability of this level earthquake occurring over the 3 days of barge travel was 8E-6. Peak ground accelerations for an earthquake with a 1,000-year return period range from 0.27g at Trojan to 0.13g at Hanford. A review of case histories regarding earthquake-induced landslides indicated that large, rapid landslides or rock avalanches have typically occurred in earthquakes with peak accelerations of 0.5g. The segment of the trip that has the highest peak accelerations (Segment 1) where postulated peak accelerations are 0.27g for the 1000-year recurrence interval, is more vulnerable to lateral spread than to rapid landslide. The magnitude of lateral-spread-generated waves would not exceed wind-generated waves. For these reasons, the licensee stated that the risk of a seismically induced large landslide and resulting seiche, with the barge in proximity to the seiche, would be less than 1E-7. The staff agrees with this assessment.

C.2.0 Volcanic Activity

Mount St. Helens, Mount Adams, and Mount Hood are considered by the USGS to be active or potentially active, and are considered in the scope of the USGS Volcanic Hazards Program. A primary goal of the Volcano Hazards Program is forecasting and predicting eruptions. *Included in the Reactor Vessel Package Transportation Plan checklist will be a requirement to contact the USGS or Oregon State Geologist to obtain assurance that there is no eruption forecast for these three mountains before the barge leaves the Trojan site.*

Mount Hood is the closest to the transportation route, being approximately 22 miles south of the Columbia River. Because of its proximity, the licensee's evaluation focused on Mount Hood. Hazard zones and probability data for eruptions of volcanoes in the Cascade range were taken from the USGS report, "Volcanic Hazards with Regard to Siting Nuclear Power Plants in the Pacific Northwest." The proximal-hazard zone for Mount Hood encompasses approximately 56 miles of the Columbia River. The transit time through this zone at 10 knots, allowing 30 minutes each for the Bonneville Dam and the Dalles Dam locks, is approximately 6.6 hours. Combining the transit time with Mount Hood data results in the following probabilities, which are greater than 1E-7:

- P(Lahars) =2.3E-6
- P(Pyroclastic flows) = 1.53E-6
- P(Explosive eruption<0.10km^3) = 3.87E-7

A lahar generated by a Mount Hood eruption would likely deposit large amounts of sediment and debris in the river. The evaluation states that it is doubtful that sediment would have any immediate effect on the shallow draft barge (7-ft. draft). The barge would be docked if large quantities of debris were encountered, and would remain docked until debris that could hamper navigation is naturally flushed away or removed by other means. Therefore, the evaluation states that a lahar generated by a volcanic eruption should not result in a hazard to the TRVP barge.

On the basis of a graph of the number and minimum distance traveled for late-glacial and postglacial pyroclastic flows at Mount Hood, the joint probability of the occurrence of a volcanic eruption-initiated pyroclastic flow and that of its reaching the barge in transit was considered to be less than 1E-7. The staff agrees with the assessment of volcanic hazards.

C.3.0 Weather-related or Pollution-related Reduced Visibility

The probability of reduced visibility was not quantified. The evaluation states that in the event that visibility threatens the ability of the land haul or tugboat crew to safely transport the TRVP, operational controls will be initiated (e.g., hold barge in a benign location).

C.4.0 Tornado

EPRI report NP-768, "Tornado Missile Risk Analysis" and Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," were used to determine a tornado's annual strike probabilities during transport. These data were then combined with the respective durations of TRVP transport in each tornado region and conservative estimates of the target area envelope. The resulting probability of a tornado strike on the TRVP transport was less than 1E-7. The staff agrees with the assessment of the tornado strike probability.

C.5.0 External Flooding

The Columbia River dams reduce the likelihood of flooding along the river transport route. Large floods that may affect navigation in the Columbia River are caused by very abnormal weather patterns and can be predicted well in advance. No potential for flooding along the land route was identified. The staff agrees with the assessment of flooding.

APPENDIX A
CONCLUSION

The probabilistic safety studies that were submitted as appendices to the SAR consisted of three separate reports: (1) a PSS for the transportation of the TRVP by barge on the Columbia River, (2) a PSE of the overland movement, and (3) an assessment of external events. These reports utilized event tree methodology for providing a systematic assessment of accident scenarios. The results of these reports show that the accident scenario with the highest probability of occurrence is a barge collision of enough magnitude to cause failure of the seafastenings from lateral acceleration resulting in the TRVP going overboard. The discrete accident probability for this scenario was estimated to be 1.0E-6. This result is contingent upon designing the cargo seafastenings to a transverse acceleration of 1.6g (which is above the ANSI N14.24 standard). Uncertainty analysis was not included in the submittals. However, because the probability of occurrence of accidents is low, and the potential consequences associated with the scenarios are also anticipated to be low, the staff finds the probabilistic analyses and results to be acceptable. It should be noted that these results are dependent upon the operational controls placed on the shipment that are specified in Sections 7.0 and 8.0 of the application, and in Portland General Electric Company's Transportation Safety Plan for the Reactor Vessel and Internals Removal Project.

ACCIDENT SCENARIOS	PROBABILITY TYPICAL BARGE	PROBABILITY TROJAN BARGE	JUSTIFICATION
Collision - Sinking	6.9E-6	<4.3E-10	Sinking analysis performed for barge w/17 watertight compartments.
Ramming - Sinking	6.6E-6	~ 0	Speed restriction of 10 knots. Sinking analysis for barge w/ 17 watertight compartments.
Collision - TRVP Overboard (due to lateral acceleration)	2.3E-5	1.0E-6	Designing cargo seafastenings to maintain control of TRVP under transverse acceleration of 1.60g.
Collision or Ramming - TRVP Overboard (longitudinal accel.)	Not specifically calculated	~ 0	Designing cargo seafastenings to ANSI standard is much greater than peak longitudinal acceleration.
Foundering/Sinking	2.1E-5	<<1E-6	Based on barge design, classification, certification, and inspection. Also based on restricting transport to benign weather conditions.
Bottom Raking - Sinking	Data not available	~ 0	Based on barge w/17 watertight, unvented compartments and shallow water conditions.
Side Raking - Capsize	Data not available	Data not available	Seafastenings designed to ANSI standard for vertical acceleration will keep TRVP attached to barge in event of capsize. No damage to TRVP.
Poor Maintenance or Low Stability and Severe Weather - Capsize	8.1E-6	~ 0	Based on barge design, classification, certification, and inspection. Also based on restricting transport to benign weather conditions.
Collision - Impact w/TRVP	Specific to location of cargo	3.2E-7	Based on dimensions of barge and TRVP and location of TRVP on barge.
Ramming - Impact w/TRVP	Specific to location of cargo	~ 0	Based on 10 knot speed restriction and location of TRVP on barge w.r.t. bow of barge.
Fire/Explosion	5.4E-5	<<6.0E-7	General cargo barges routinely carry flammable material among their cargo consignments. TRVP only susceptible to long duration fire (>30 min).

Table A-1:Summary of estimated discrete accident probabilities during transportation on 270.8 miles of Columbia River for typical barge versus barge carrying Trojan TRVP

the issue of law or fact to be raised or controverted. In addition, the petitioner shall provide a brief explanation of the bases of the contention and a concise statement of the alleged facts or expert opinion which support the contention and on which the petitioner intends to rely in proving the contention at the hearing. The petitioner must also provide references to those specific sources and documents of which the petitioner is aware and on which the petitioner intends to rely to establish those facts or expert opinion. Petitioner must provide sufficient information to show that a genuine dispute exists with the applicant on a material issue of law or fact. Contentions shall be limited to matters within the scope of the amendment under consideration. The contention must be one which, if proven, would entitle the petitioner to relief. A petitioner who fails to file such a supplement which satisfies these requirements with respect to at least one contention will not be permitted to participate as a party.

Those permitted to intervene become parties to the proceeding, subject to any limitations in the order granting leave to intervene, and have the opportunity to participate fully in the conduct of the hearing, including the opportunity to present evidence and cross-examine witnesses.

If a hearing is requested, the Commission will make a final determination on the issue of no significant hazards consideration. The final determination will serve to decide when the hearing is held.

If the final determination is that the amendment request involves no significant hazards consideration, the Commission may issue the amendment and make it immediately effective, notwithstanding the request for a hearing. Any hearing held would take place after issuance of the amendment.

If the final determination is that the amendment request involves a significant hazards consideration, any hearing held would take place before the issuance of any amendment.

A request for a hearing or a petition for leave to intervene must be filed with the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, Attention: Rulemakings and Adjudications Staff, or may be delivered to the Commission's Public Document Room, the Gelman Building, 2120 L Street, NW., Washington, DC, by the above date. A copy of the petition should also be sent to the Office of the General Counsel, U.S. Nuclear Regulatory Commission, Washington, DC 20555–0001, and to Michael I. Miller, Esquire; Sidley and Austin, One First National Plaza, Chicago, Illinois 60603, attorney for ComEd.

Non-timely filings of petitions for leave to intervene, amended petitions, supplemental petitions and/or requests for hearing will not be entertained absent a determination by the Commission, the presiding officer or the presiding Atomic Safety and Licensing Board that the petition and/or request should be granted based upon a balancing of the factors specified in 10 CFR 2.714(a)(1)(i)–(v) and 2.714(d).

For further details with respect to this action, see the application for amendment dated December 13, 1996, as supplemented on October 10, 1997, February 13, 1998, April 13, 1998, June 2, 1998, July 8, 1998, September 25, 1998, and October 1, 1998, which are available for public inspection at the Commission's Public Document Room, the Gelman Building, 2120 L Street, NW., Washington, DC, and at the local public document room located at: for Byron, the Byron Public Library District, 109 N. Franklin, P.O. Box 434, Byron, Illinois 61010; for Braidwood, the Wilmington Public Library, 201 S. Kankakee Street, Wilmington, Illinois 60481.

Dated at Rockville, Maryland, this 21st day of October 1998.

For the Nuclear Regulatory Commission.

Ramin R. Assa,

Project Manager, Project Directorate III-2, Division of Reactor Projects—III/IV, Office of Nuclear Reactor Regulation.

[FR Doc. 98–28816 Filed 10–27–98; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

[Docket No.: 71–9271]

Portland General Electric Co.; Issuance of Environmental Assessment and Finding of No Significant Impact Regarding the Proposed Exemptions From Requirements of 10 CFR Part 71

Portland General Electric Company (PGE or applicant) has applied for a package approval from the U.S. Nuclear Regulatory Commission (NRC) for the one-time shipment of the Trojan Reactor Vessel Package (TRVP), with internals intact, from the Trojan Nuclear Plant site at Rainier, Oregon, to the US Ecology radioactive waste disposal facility near Richland, Washington. As part of its application, PGE has requested exemptions, pursuant to 10 CFR 71.8, from requirements 10 CFR 71.71(c)(7) and 10 CFR 71.73(c)(1). This Environmental Assessment (EA) was prepared to assess the potential environmental impacts of granting these exemptions as well as an exemption from 10 CFR 71.73(b) to the extent it is needed to grant an exemption from 10 CFR 71.73(c)(1).

Identification of Proposed Action

By letter dated March 31, 1997, PGE requested, in part, approval for the one-time shipment of the TRVP by means of two specific exemptions, under 10 CFR 71.8, from the requirements of 10 CFR 71.71(c)(7) and 71.73(c)(1), in the 10 CFR part 71 regulations governing the packaging and transportation of licensed materials.

The TRVP is the Trojan reactor vessel prepared for transport as a shipping package. The reactor vessel is a large, thick-walled, steel structure measuring approximately 13 m (42 feet, 6 inches) in length and 5.2 m (17 feet, 1 inch) in outside diameter. The reactor vessel void space, with internals installed and intact, will be filled with low-density cellular concrete, to prevent movement of radioactive material within the reactor vessel. The vessel will be sealed and shielded as necessary to meet the dose limit requirements of 10 CFR 71.47 and 10 CFR 71.51. Impact limiters will be installed to minimize reactor vessel stresses associated with the analyzed TRVP drops. The impact limiters are each approximately 1.5 m (4 feet, 10 inches) in width and 7.6 m (28 feet) in outside diameter. The maximum gross weight of the TRVP is conservatively 925 metric tons (2.04 million pounds).

The TRVP will be shipped approximately 482 km (300 miles) as a one-time, exclusive use, radioactive material transportation package for the purpose of disposal at the US Ecology low-level radioactive waste facility on the Hanford Nuclear Reservation near Richland, Washington. During the shipment, the TRVP is expected to be outside the Trojan Nuclear Plant site and US Ecology facility boundaries less than 72 hours.

Section 71.71(c)(7) requires an evaluation of the package design under normal conditions of transport and must include a determination of the effect, on that design, of a free drop of the specimen through a distance of 0.3 m (1 foot) [for a package weighing more than 15000 kg (33,100 pounds)] "* * * onto a flat, essentially unyielding, horizontal surface in a position for which maximum damage is expected."

Before shipment, the TRVP will be prepared as a shipping package and will be loaded and tied down onto a specially designed transporter. The loaded transporter will be moved onto

ENCLOSURE 2