VOLUME 2: APPENDIX H

RISK INFORMING THE MATERIALS AND WASTE ARENAS:

A Case Study on the Transportation of the Trojan Reactor Vessel Package

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ABSTRACT

As a part of the effort to risk-inform regulation in the materials and waste arenas, the NRC staff identified candidate regulatory applications within NMSS to conduct case studies to test screening criteria and develop safety goals. A case study involving the transportation of radioactive material was identified to illustrate what has been done and what could be done in transportation to alter the regulatory approach in a risk-informed manner. The activity selected for the study is the transportation of the Trojan nuclear reactor vessel package which was completed in the late summer of 1999. The study follows the outline provided in the Case Study Plan ("Plan for Using Risk Information in the Materials and Waste Arenas") that was developed by the NMSS Risk Task Group. This report discusses the use of risk information in this particular case, and provides responses to standard questions on safety goals and screening criteria for risk-informing nuclear regulatory practice.

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1. INTRODUCTION

In SECY-99-100, the staff of the Office of Nuclear Materials Safety and Safeguards proposed a framework for risk-informed regulation in the materials and waste arenas. The Commission approved the proposal and directed the staff to develop appropriate materials and waste safety goals and to use an enhanced participatory process. This participatory process has included holding regular public meetings with all stakeholders involved in regulation of these arenas. At the first such meeting NRC staff suggested that screening criteria were needed to identify issues where risk-informing would be productive. It was suggested that development of safety goals and screening criteria would benefit from studying actual regulatory cases in the materials and waste arenas, to see how risk information was, or could have been, used. NMSS staff adopted this suggestion and, as part of the overall risk-informing effort, has conducted case studies on a spectrum of activities in the nuclear materials and waste arenas, including the transportation of radioactive materials. Shipment of the Trojan Reactor Vessel for disposal, the subject of this report, is one of these case studies.

1.1 Objectives and Approach

The results of this Trojan Reactor Vessel shipment case study will be consolidated with those from the other case studies in furtherance of the following objectives:

(1) Produce a final version of screening criteria for the materials and waste arenas.

(2) Illustrate how the application of risk information has improved or could improve a particular area of the regulatory process in the materials and waste arenas.

(3) Determine the feasibility of safety goals in the particular areas studied. If feasible, develop safety goal parameters, and a first draft of safety goals. If infeasible, document the reasons.

(4) Identify methods, data, and guidance needed to implement a risk-informed regulatory approach.

It is not an objective of this, or any other case study, to re-consider the regulatory actions that were taken by the NRC in the case being studied. The objectives are strictly those listed above.

The case studies are being conducted using a standardized approach. The case studies are largely retrospective, that is, they involve regulatory and physical actions already taken. Each case is studied by a member of the NMSS Risk Task Group, or a contractor with risk expertise. Subject matter experts from NRC staff with knowledge of the particular case act as advisors. Information is reviewed from NRC and licensee source documentation. Licensee and other stakeholders having knowledge of the particular case are consulted.

There is a list of standardized questions which are answered for each case studied. These questions address aspects of the four objectives listed above. After the investigative phase of the study, a preliminary set of answers to these questions is generated. These preliminary conclusions are presented at a public meeting with all stakeholders invited to participate.

Following the incorporation of information and ideas resulting from this meeting, a report documenting the case study is produced. This document is one such case study report. Results from all of the case studies will be consolidated in a final summary report.

1.2 Scope of Trojan Reactor Vessel Transport Case Study

The transportation of radioactive materials is one of the eight general areas from which case studies were selected. These eight areas were selected to represent the wide spectrum of activities, materials, and devices within the regulatory scope of NMSS. The scope of this case study is the regulatory decision to permit transportation of the Trojan reactor vessel package (TRVP) to its final disposal site in a specific manner. The Trojan reactor was being decommissioned, and disposal of the reactor vessel and various other reactor internals was part of this process. The licensee proposed to transport the vessel to its final disposal site by a method requiring exemption from certain regulatory requirements. The licensee, Portland General Electric (PGE), requested approval of this one-time shipment of the TRVP, with internals, in accordance with 10 CFR Part 71. The appendices provided as part of the Safety Analysis Report submitted with the request included a risk analysis of the proposed method of shipment.

This case study addressed the four general case study objectives (Section 1.1) by developing answers to a set of standardized questions concerning use of risk information in the staff decision to permit this transportation action. The scope of this case did not include consideration of the Trojan decommissioning in general. This was the scope of another of the case studies. The scope also did not include risk considerations involved in the final disposal of the vessel by burial at a designated waste site. It was noted during a public meeting on this case that the feasibility of disposing of reactor vessels, or other large single shipments, in the same manner is very dependent on very specific conditions that existed for this case; including:

(1) There was a licensed waste site that would accept such a large object for burial having the radioactivity inventory of a reactor vessel plus internals.

(2) The Trojan reactor site was on a navigable waterway.

(3) The navigable waterway ran from the reactor site to a point near the waste site.

Thus, the value of this case study lies not in the general applicability of the specific decision, but in the method of resolving a conflict with a prescriptive regulatory requirement by considering the risk of transporting the vessel by an alternative method compared to the risk using methods envisioned in the regulation.

1.3 Organization of the Report

In addition to this introduction, which is section 1, the report consists of five sections. Section 2 gives background information on the Trojan Reactor Vessel shipment, risks associated with it, and the regulatory context of this type of shipment of radioactive material. Section 3 discusses specific actions taken to develop this case study. Sections 4 and 5 provide the results in the form of answers to the standardized risk questions. Conclusions are summarized in section 6.

2. BACKGROUND

The Trojan Reactor Vessel Package (TRVP) consisted of the reactor vessel itself, plus various contaminated material contained inside it, and was filled with concrete. The TRVP materials contained approximately 2 million curies in the form of activated metal. When filled with low-density concrete, the package weighed approximately 1000 tons. The shipment included transporting the TRVP from the Trojan Nuclear Plant by barge on the Columbia River to Port of Benton of Washington, and by overland heavy-haul transporter to the Hanford site in Richland, Washington. Under current regulations, a large package, such as the TRVP, is required to be shipped in a Type B packaging. For various reasons, the Trojan Reactor Vessel Package could not meet the requirements for a Type B shipment, when transported as a single large unit. To conduct such a single shipment in a safe manner, the licensee proposed transport using a package and barge specifically designed for this purpose.

The case study analyzes how risk information was considered in the NRC approval process. Specifically, the case study identifies the risks involved with the removal and the transportation of the reactor vessel. The licensee used risk arguments to support its exemption request. The case study tests the draft screening criteria against this specific risk-informed activity. The case study also examines whether safety goals exist (either explicitly or implicitly) in the Commission's decision to grant the exemption.

General Situation

The Trojan Nuclear Plant in Rainier, Oregon was permanently shutdown in 1993 after approximately 17 years of service. As part of the decommissioning process, Portland General Electric (PGE) removed and disposed, off-site, the large components (removal and disposal of the four steam generators and pressurizer in 1995). Due to the size (1000 tons) and radiological content (2 million curies), of the reactor vessel, several options were considered:

(1) Ship the reactor vessel, with its internals intact, by barge up the Columbia river and transport it over land to the US Ecology site in Richland, Washington;

(2) Store the reactor vessel at the original site of the reactor;

(3) Dispose of the reactor vessel in one piece, with only those internals left inside which were Class C radioactive waste or less;

(4) Dispose of the reactor vessel and internals separately.

The application submitted to the NRC by the licensee, PGE, proposed to transport the vessel by Option 1. PGE developed a detailed plan to implement Option 1. The plan included removal of the reactor vessel from its containment, preparation of the vessel with shielding and impact limiters, a special purpose transporter and barge, and transport routing and timing that reduced specific risks.

Types of Risk Involved

There are risks associated with various phases of this process, and these risks differed in type and magnitude among the four alternatives above. The phases of the process include preparation of the vessel and other materials for transport, transport of the package, and final disposal. Risks included occupational radiation doses incurred by workers involved in each phase, exposure of the public during these processes, and in the future. Risks that needed consideration included those doses that likely would be incurred, as well as those that might be incurred in the case of a wide variety of unlikely accidents. Certain of the above alternatives involved considerable processing of equipment to remove radioactive contamination. Workers would incur occupational doses during this processing. Workers and some members of the public might be exposed to very low levels of radioactivity that penetrates the transport packages' shield during transport. Various transportation accidents could also occur. Transport might have involved breaking the vessel and internals up into multiple single truck shipments. In this case various truck accidents would be possible. For the barge shipment option, collisions, grounding, and sinking were among the accidents considered. Severe external events, such as volcanic eruptions, were also considered.

Applicable Regulatory Framework

10 CFR 71, Transportation and Packaging of Radioactive Material, is the principal regulation governing transport of the Trojan Reactor Vessel. The transportation requirements at issue were:

(1) 10 CFR 71.71 (c)(7), requiring a free drop test of the transport package of 1 foot under normal conditions of transport; and

(2) 10 CFR 71.73 (c)(1) and 71.73(b), requiring a free drop test of 30 feet under hypothetical accident conditions.

(3) 10 CFR 71.41(c) permitting an applicant to propose alternative test conditions adequate to provide equivalent safety; and 10 CFR 70.8 permitting exemptions.

However, the overall process of disposal of the vessel involved more than just transport. It included preparing the vessel and its contents for disposal, decommissioning of the site in general, and final burial. These other steps in disposal are the subject of several regulations. Specifically, the burial (land disposal) of radioactive waste is the subject of 10 CFR Part 61.

PGE submitted with their application a Safety Analysis Report (SAR) that included probabilistic safety studies for the transportation of the TRVP by barge and overland movement. PGE conducted the probabilistic safety studies as a basis for their request. These studies were Appendix 1 to the Safety Analysis Report (SAR).

The NRC conducted a review, by a multi-disciplinary staff, of the application. The review included corresponding with other government agencies. The NRC staff coordinated with the Department of Transportation (DOT) on the approval of the transportation of the TRVP. PGE also had to request an exemption from portions of the DOT regulations. The NRC staff also met with the US Coast Guard to discuss certain aspects of the TRVP shipment where the staff

had limited knowledge. The US Coast Guard reviewed PGE's transportation plan and found that the TRVP posed no safety concerns, from the modal perspective. Furthermore, local Oregon and Washington government agencies provided additional oversight of the TRVP transportation activity.

The SAR probabilistic risk assessment identified a number of accidents, such as collision and sinking, that might, hypothetically, have resulted in breach of the vessel. The scenario with the highest estimated frequency was a collision with the vessel going overboard. The frequency of this event was estimated as 10^{-6} per year. Based on the risk analysis, the applicant determined that the maximum credible distance that the vessel could be dropped was 11 feet. Therefore the drop analysis in the SAR was conducted for 11 feet, rather than the 30 foot hypothetical drop specified in the regulation. Upon review by NRC staff, the staff concluded that the probabilistic safety studies and SAR analysis showed that occurrence of accident conditions beyond those for which the vessel had been analyzed as safe had a frequency less than 10^{-6} per year. This was evaluated as sufficiently safe, and in compliance with the regulations. After approximately 3 years of planning and implementation, the TRVP was safely shipped and disposed of in the late summer of 1999.

3. CASE STUDY APPROACH

To initiate this case study of the Trojan reactor vessel shipment, a review of all the applicable documents was conducted. References to these documents are given at the end of the report. The key documents were, of course, the applicant's safety analysis report (SAR), which included the risk analysis, and the NRC staff's Safety Evaluation Report (SER). A review was also conducted of local news articles and other documents related to the activity. A site visit was made; and interviews were held with licensee personnel familiar with the vessel transport action. Other selected stakeholders in the State of Oregon involved in this case were also consulted.

The NRC staff paper, SECY-98-231, "Authorization of the Trojan Reactor Vessel Package for One-time Shipment for Disposal", sought the Commission's approval, by negative consent, for the staff to grant two specific exemptions from package test requirements specified in 10 CFR Part 71 for the TRVP, as well as authorize the one-time shipment of the TRVP. The SECY paper included the Safety Evaluation Report prepared by the staff that resulted in acceptance of the probabilistic studies submitted by PGE.

The Safety Analysis Report (SAR) submitted by the licensee in support of the proposed vessel transport included three appendices that contained probabilistic information. The first was a probabilistic safety study of the barge transport leg, the second was a probabilistic safety evaluation of the overland movement leg, and the third was an assessment of external events. PGE also submitted a Transportation Safety Plan to describe the measures taken to ensure the safe transport of the TRVP from the Trojan site in Rainier, Oregon to the Hanford disposal site in Richland, Washington.

Additionally, it should be noted that the U.S. Navy uses the same route and mode of transportation to ship their submarine reactor compartments. The U.S. Navy documented their process in an internal report (Ref. 8).

Reports completed by other professional organizations were reviewed that contributed to the case study. EPRI published a technical report titled "Trojan Nuclear Power Plant Reactor Vessel and Internals Removal: Trojan Nuclear plant Decommissioning Experience". The report presented lessons learned during the progression of this activity. The activity was also acknowledged as the Project Management Institute (PMI) 2000 International Project of the Year. The publication "PM Network" covered the story.

NRC staff involved in the vessel shipment method approval were also consulted.

Following the above research, answers were prepared to the standard set of case study questions. These questions and the answers are given in Section 4 below. In order to test the draft screening criteria, the screening criteria questions were also applied as if the decision to risk-inform this decision were being proposed now. This is documented in Section 5 below.

These preliminary responses to the standard case study questions were then presented at a public meeting at NRC Headquarters May 11, 2001. This report has been modified so that responses to certain questions addressed input provided at the public meeting.

4. RESPONSES TO DRAFT CASE STUDY QUESTIONS

4.1 Screening Criteria Analysis/Risk Analysis Questions

(1) What risk information is currently available in this area? (Have any specific risk studies been done?)

Portland General Electric Company's Safety Analysis Report (SAR) reported results of the following three risk analyses. At the time that these studies were being contemplated (which is when screening would normally be done) there existed a considerable amount of risk information that was relevant to the proposed analyses. A list of these documents follows below.

PGE risk analyses:

1. Probabilistic Safety Study for the Transportation for the Trojan Reactor Vessel Package for Disposal (quantitative study of accident scenarios, developed by the Glosten Associates, Inc., the same company that prepared the safety analysis for the barge transportation of the Shippingport RVP in 1986)

2. Probabilistic Safety Evaluation of the Overland Movement of the Trojan Reactor Vessel Package for Disposal (a qualitative/quantitative study was prepared by Robert E. Jones, PE)

3. Assessment of external events

Pre-existing risk studies and information sources:

1. Shippingport Reactor Vessel Package Safety Analysis

2. Risk-Based Decision Making (RBDM) Guidelines (DOT & Coast Guard) -aids in identifying /evaluating hazards and determining how to cost-effectively respond to those hazards.

3. Barge Collisions, Rammings and Groundings-An Engineering Assessment of the Potential for Damage to Radioactive Material Transport Casks (SAND85-7165, TTC-05212) also known as "the Sandia report".

4. Regulatory Guide 7.12 -provides acceptance criteria to address brittle fracture concerns for transportation packages. It also provides for the use of alternative methods to assess material toughness.

5. The U.S. Navy performed analysis for the similar shipment of their reactor compartment transportation activity. (US Naval Nuclear Powered Submarine Inactivation, Disposal and Recycling, Sept. 1993)

6. Dose analysis completed by the State of Washington

(2) What is the quality of the study? (Is it of sufficient quality to support decision-making?)

According to the Safety Evaluation Report (SER) conducted by the NRC, the staff found the probabilistic safety studies and their results to be acceptable. During the review process, the staff requested additional information prior to finding the analysis acceptable. The other studies mentioned in question 1 appear to be of sufficient quality to support decision-making.

(3) What additional studies would be needed to support decision-making and at what cost?

Originally, neither the barge nor land transport studies contained an assessment of external events other than normal transportation accidents. The NRC staff inquired about the possible effects of such external events. In response, the licensee submitted a supplementary analysis of external events as an additional appendix to the SAR.

(4) How is/was risk information used and considered by the NRC and licensee in this area?

NRC: The staff used the risk analysis in the SAR which listed the probability of all accidents identified. This analysis showed that of accidents, beyond those specifically demonstrated in the SAR to be accommodated by the design features without failure, none had a probability of greater than one in a million. Staff concluded that this probability was sufficiently low. Thus staff found that the risk analysis submitted by PGE, in addition to other representations in the application, demonstrated that the TRVP met the requirements of 10 CFR Part 71.

Licensee: In performing the probabilistic safety studies, the licensee self-identified an accident scenario with an elevated risk. The scenario was a barge collision sufficiently severe to cause failure of the seafastenings from lateral acceleration, resulting in the TRVP going overboard. Therefore, the licensee made design changes that made this result less likely. Thus risk information directly resulted in a risk reduction.

(5) What is the societal benefit of this regulated activity?

GENERAL BENEFITS

The transport of the Trojan Reactor Vessel Package (TRVP) from the power plant site to the disposal facility is part of the process of disposal, which is a part of the overall decommissioning process. This overall decommissioning process has the societal benefits of reducing or eliminating future exposures to residual radioactivity of the nuclear power plant components and site, as well as the benefit of making the site available for general use. These processes involved in decommissioning, including transport, have some risk for workers and the public due to occupational or incidental radiation exposures. There is also the possibility of radiological risk due to accidents.

Thus the transport and disposal process involves achieving the general benefits to society at the cost of these occupational and incidental risks.

As was pointed out in the public meetings, decommissioning is only necessary because the reactor existed in the first place. Thus consideration of societal benefits for decommissioning and waste disposal really involves the whole life cycle of the system. That is, the major benefit associated with the various risks of this disposal is actually the generation of electricity from nuclear power. This consideration will apply when developing societal safety goals that relate to societal benefits from an application.

RISK REDUCTION BENEFIT OF BARGE TRANSPORT

In disposing of the Trojan reactor vessel, there were, in principle, several alternatives. The major ones were listed in the licensee submittal and were evaluated as far as their regulated impacts. The principal alternatives were transport of the vessel and other components to the disposal site a) by cutting up the vessel and conducting 44 individual truck shipments, or b) a single barge shipment with the vessel intact. The following table shows that one of the societal benefits weighing in favor of the barge transport was the fact that this alternative had lower risks in several categories, as noted in the table below. There is also a benefit in avoiding the potential for ordinary highway accidents resulting in non-radiological injuries.

type of risk	truck transport	barge transport
worker occupational dose- in package preparation	< 154 person-rem	67 person-rem
worker occupational dose - during transport	< 1.19 person-rem	0.09 person-rem
public incidental dose	0.56 person-rem	0.02 person-rem

(6) What is the public perception/acceptance of risk in this area?

Through the review of past local news articles, staff and licensee interviews, the public perception of risk in this activity was low. While PGE previously shipped the steam generators and pressurizer by the same mode and received some adverse stakeholder reaction, it helped to assuage public concern regarding the TRVP shipment. It can be assumed that PGE's success in these areas paved the way for the TRVP shipment.

According to SECY 98-231, the US Coast Guard stated from the modal safety perspective, the TRVP shipment was similar to the previous shipments of Trojan steam generators and pressurizer and Navy reactor compartments, and raised no significant or unique safety issue.

A comment was made at the public meeting May 11, 2001on this case study that the lack of public opposition to this shipment may have been a result of the fact that the reactor vessel was being removed from its site near them. That is, the shipment was accepted because it was part of the process of removing and decommissioning a nuclear power plant, not because all persons approved of this particular shipment, or of radioactive material shipments in general.

(7) What was the outcome when this application was put through the draft screening criteria? Did this application pass any of the screening criteria? Does the outcome seem reasonable? Why or why not?

The activity passed all of the Draft Screening Criteria. That is, if these criteria had been used to decide whether a risk-informed approach was appropriate with respect to this regulatory situation, it would have passed. In fact, due to the large burden reduction and reduced total risk, the risk-informed approach turned out to be very beneficial. The cost of the risk analysis was likely modest compared to these benefits.

4.2 Safety Goal Analysis Questions

(1) What is the basis for the current regulations in this area (e.g., legislative requirements, international compatibility, historical events, public confidence, undetermined, etc.)?

The current 10 CFR Part 71, section 71.71 can be viewed as a prescriptive regulation, yet it appears that it was developed in a risk-informed manner. The staff has made a proposal to amend the one-time exemption for nonstandard packages in Part 71 using the TRVP shipment as an example. One of the proposed changes to 10 CFR Part 71, with respect to large component shipments, considers IAEA requirement TS-R-1 with respect to “Special Arrangements”.

It was noted at the public meeting of May 11, 2001, that one should be wary of drawing general conclusions about vessel disposal from this Trojan case, since there were two unique facts that made it possible. The first was that there existed a final disposal site, in Richland, Washington, that was licensed to dispose of a shipment of this size and composition. The second fact was that intact shipment by barge was feasible due to the existence of the Columbia river route directly from the reactor to the disposal site.

(2) Are there any explicit safety goals or implicit safety goals embedded in the regulations, statements of consideration, or other documents (an example would be the acceptance of a regulatory exemption based in part on a risk analysis and the outcome)?

In 10 CFR Part 71, it states that the package design has to meet hypothetical accident conditions and the release rate can be no more than the occupational dose limit (ALARA).

In the review of PGE’s probabilistic safety studies, the estimated probability of any accident that exceeded the conditions for which the package was designed was one in a

million (10^{-6}). This value of 10^{-6} was considered acceptable by the staff for this one-time shipment. The acceptance language in the SER did not use exceptionally strong terms such as trivial or negligible. The actual consequences of the accidents in the risk studies were not explicitly evaluated. The risk metric considered would appear to be accident risks to individuals, perhaps both the general public and workers. On balance, the decision in this case seems to imply that the safety goal level of risk to individuals from single special shipments may be about 10^{-6} or less.

(3) What was the basis for the development of the strategic goals, performance goals, measures and metrics? How are they relevant/applicable to the area being studied and how do they relate/compare with the regulatory requirements? How would they relate to safety goals in this area?

The first four of the factors considered in the screening criteria, are the performance measures in the NRC Strategic Plan for the Materials Arena. These are: maintain safety, improve efficiency, reduce burden, and increase public confidence. The Trojan RV shipment decision approach had a positive effect on all of these.

(4) Are there any safety goals, limits, or other criteria implied by decisions or evaluations that have been made that are relevant to this area?

There was a bounding probability that was used as an acceptance criteria in the NRC's review of PGE's Safety Analysis Report. The probabilistic safety study showed that the most likely of the accident scenarios was a TRVP barge collision with the TRVP lost overboard. PGE developed a recovery plan for this scenario. Consequently the staff concluded "Since the probability of accidents that could damage the package and lead to potential health impacts is less than 10^{-6}, these accidents were not evaluated by the staff." In addition, the potential consequences associated with the scenarios were anticipated to be low. Therefore, the staff found the probabilistic studies and results to be acceptable. This tends to imply that a 10^{-6} probability of health impact to an individual is at or below the safety goal level of risk.

(5) If safety goals were to be developed in this area, would tools/data be available for measurement?

Yes. The risk information mentioned previously in question 1 of the Screening Criteria Analysis/Risk Analysis Questions as well as the data used in the licensee's SAR would be available for measurement for a similar activity. However, it remains to be determined how applicable this is for other transportation activities. Furthermore, there have been general radioactive material transportation risk studies. These studies evaluated both frequencies and consequences of transportation accidents. Thus these tools exist for application to future special cases.

(6) Who are/were the populations at risk?

As far as the principal risk at issue in the decision to grant an exemption, namely the risk of a transportation accident, the populations at risk were the transport workers and the

public along the transport route. Limitation of the population dose to workers, and to members of the public that would likely occur incident to transport were also considered in the choice of the barge transport alternative. Thus both public and worker populations were considered with respect to both high and low probability events.

(7) What are/were, and what could be/have been, the various consequences to the populations at risk?

As noted above, the radiological consequences that might result from the postulated barge accident scenarios were not estimated. Even in the case of accidents exceeding design capabilities, some shielding would likely remain effective in limiting direct shine. The radioactive materials involved with the vessel shipment are relatively insoluble. Individual doses resulting from an accident would thus be limited by these factors.

The non-accident consequences expected from the barge shipment were calculated. Worker radiation exposure was estimated to be 67 person-rem for preparation of the transport package. Worker doses during actual transport were estimated to be 0.09 person-rem. Exposures to members of the general public were estimated to be 0.02 person-rem.

(8) What parameters should be considered for the safety goals (e.g., workers vs. public, individual vs. societal, accidents vs. normal operations, acute vs. latent fatality or serious injury, environmental and property damage)?

Except for acute fatalities, all of the above parameters appear to have been considered in the various evaluations. Different risk metrics and populations were considered with respect to different decisions. The package exemption decision was driven by consideration of the low probability of accidents. Limitation of population doses was considered in the basic choice of the barge alternative. Even property damage during transport was considered.

(9) On the basis of the answers to the questions above, would it be feasible to develop safety goals in this regulatory area?

For this case, the populations and risks seem well characterized and amenable to being formulated in safety goal statements. The probabilistic safety studies performed in this case show that quantification of the risks for comparison to goals is also feasible.

(10) What methods, data results, safety goals, or regulatory requirements would be necessary to make it possible to risk-inform similar cases?

Depending on the mode of transportation for a similar activity, the same methods, data results and regulatory requirements could be applicable. Although, this study did not consider whether the same methods could be employed in other transportation activities. Further evaluation of the methods and data is required. As stated earlier, considerations are being made for the amendment of 10 CFR Part 71 with regard to large component shipments.

4.3 Questions upon Developing Draft Safety Goals

The following are draft qualitative safety goals under consideration for regulation of nuclear materials at the time of this report:

> *Individual: Nuclear materials use and disposal do not pose significant additional risks to the life and health of individual members of the public, and to workers associated with these activities.*
>
> *Society: Societal risks to life and health from nuclear materials use and disposal are not significant additions to other societal risks, and the benefits of the use greatly outweigh the risks.*
>
> *Environment and Property: Nuclear materials use and disposal do not result in environmental or property damage in excess of other means of achieving a similar end objective that is deemed beneficial to society.*

In conducting these case studies, a set of standard questions concerning safety goals was developed. These questions specifically address the draft safety goals above. The purpose of these questions is to use the draft safety goals to gain insights into the area and issues regulated in the case study. These questions and their answers for the Trojan Reactor Vessel Transport case study follow.

(1) Are the current regulations sufficient in that they reflect the objectives of the draft goals? Would major changes be required?

The current NRC transportation regulations appear to reduce the likelihood of accidental release of transport package contents to a probability much lower than for other hazardous materials by requiring demonstrated survivability of the transport package when subject to specified severe events. Unless the radioactive material were quite volatile, no such accident would seem to lead to large doses, nor small doses to large numbers of persons. Thus these regulations appear to address adequately the accident component of the objectives of the draft safety goals above. Since the environmental and property would be unaffected by such transport except as a result of an accident, these qualitative safety goals would appear to be addressed as well.

In addition to requirements limiting accident consequences, sections 71.47, 71.51 and other sections specify limits on external dose rates and leakage under normal conditions that are quite stringent, for example 0.1 mSv/hour at 2 meters from the vehicle surface. It would take 10 hours exposure at 0.1 mSv/hr to reach the public dose limit of 1 mSv/year. Thus these regulations appear to be sufficient, in general, to address the “normal conditions” objectives of the draft individual safety goals above. Societal risk is also limited by both the accident requirements and the normal dose rate limits. Note that the societal safety goal has two parts: 1) “not significant additions to other societal risks, and”, 2) “ the benefits of the use greatly outweigh the risks”. With respect to the first, the societal risk of radioactive materials transport would seem to be quite low relative to other societal highway transport risks. With respect to the second, the benefit to risk comparison, it is difficult to judge non-quantitatively. Furthermore, it may be that for transport related to waste disposal, this societal goal should be

evaluated as the total benefit of the whole nuclear power life cycle compared to its total risk. Also, there are clearly risk tradeoffs involved in waste transport. The transport risk is presumably incurred in order to place the material in a condition of lower long term risk. Another trade off is the vehicle collision risk imposed by transport compared to this risk reduction due to relocating the waste. This trade off is explicitly mentioned in the regulation relating to decommissioning of sites. These considerations seem to indicate that use of societal risk information in decision-making is a broader question than a simple comparison to a safety goal.

(2) Would the regulations need to be tightened?

As a general rule, safety goals are only aspirations, so they do not force regulations to be tightened. However, if actual risk levels are well above the safety goal levels, there may be an opportunity for cost-effective risk reduction. As discussed under question (1) above, the doses and risks for Type B packages conforming to Part 71 and DOT regulations appear to limit doses and accident risks for individuals to levels that are quite low for typical transport cases. Thus there does not appear to be a need for more stringent dose limits or package robustness. A quantitative evaluation of the limits on doses and leak rates in the regulation against draft QHO's would provided a clearer answer to this question. It would appear that the only sense in which the regulations might need to be tightened, would be to cover cases where the current prescriptive package design criteria did not adequately address some unique vulnerability of a particular type of shipment. Such vulnerabilities might be revealed by a case-specific risk assessment. Such a risk assessment would be unlikely to pass the screening consideration review unless at least one such unaddressed vulnerability had already been identified.

(3) Are the regulations overly conservative and/or too prescriptive with respect to the goals?

The dose rate and leakage limits of the regulations do not seem overly conservative, although quantitative evaluation of risk metrics would be informative here. The case study itself pointed out that the Type B package accident requirements are overly prescriptive, at least when non-highway transport options are available. However, if such alternative situations are rare, modification of the regulations may not be the cost effective way to deal with this situation.

(4) If these were the safety goals, what decisions would be made?

The draft safety goals address societal, environmental, and property damage risks. As pointed out above, minimization of societal risks involve trade offs that point toward the need to consider all risks in the decision-making. That is, all sources of risk of the whole waste disposal operation need to be considered together with the radiological and collision transport risk in order to reach a rationale decision. In the case of the Trojan Reactor Vessel transport, the reduction in the societal risk was cited as a benefit to permitting barge shipment. Thus, in general, a risk informed decision process which includes all safety goal risk metrics is capable of reaching a more logical decision. This does not mean that quantitative risk assessment will always provide such a benefit. The section of this report on "Screening Considerations" addresses this question of when is it beneficial to risk-inform.

(5) Would these goals be acceptable to the public?

The draft individual safety goal above is very similar to the reactor individual safety goal, thus it is expected that it would meet the same acceptance. The first part of the draft societal safety goal, “not a significant addition to other societal risks”, is the same as the the reactor goal, hence acceptable. The second element of the draft societal risk raises the fact that the benefit/risk trade offs of materials applications differ from reactors. The acceptability of this goal is unclear. It seems reasonable that an application where the benefits greatly outweigh the risks, would be acceptable. It should be remembered that this is a societal goal, not individual. Thus the controversial issue of who gets the benefit versus who gets the risk do not arise directly. This is an individual risk issue, to be considered under the individual risk goal. Most societal beneficial applications of technology have very low risk, but a few, like automobiles and drugs result in considerable risk.

5. RESPONSES TO DRAFT SCREENING CRITERIA

The draft screening criteria were developed by the staff and revised on the basis of comments received at a public workshop, the public meeting, and discussions with the NMSS Risk Steering Group. The criteria were posed in the form of questions in an implicit flow chart for determining whether to proceed with an attempt to risk-inform a particular regulatory situation. These screening criteria questions were applied to the regulatory decisions involved in the transportation of the Trojan reactor vessel package, and were answered as follows.

(1) Would a risk-informed regulatory approach help to resolve a question with respect to maintaining or improving the activity's safety?

Yes. The TRVP could not meet the 10 CFR 71.73(c)(1) which requires transport packages to be capable of surviving a 30-foot drop, with subparagraph 10 CFR 71.73(b) which requires that the ambient air temperature must remain constant during testing at that value between -29 ^{o}C (-20 ^{o}F) and 38 ^{o}C (100 ^{o}F), and 71.71(c)(7) which requires the integrity of transport packages to be tested by a one-foot drop onto a flat, unyielding surface prior to shipment. PGE devised a special mode of package protection and transport by barge. The safety question was: Was this alternative transport equivalent in safety to a transport conforming to the specific regulatory requirement? PGE submitted a probabilistic safety study for this special transportation by barge, and a probabilistic safety evaluation for the overland shipment. A risk analysis for external events was also included. PGE concluded that it could conduct the transport in a manner that was safer than transport conforming to the prescriptive requirements. The NRC staff reviewed the risk assessments and agreed that the risk was low enough.

(2) Could a risk-informed regulatory approach improve the efficiency or the effectiveness of the NRC regulatory process?

Yes. Without a risk analysis to support the low probability of certain accidents identified for this shipment method, the NRC staff review might have been protracted by such considerations as determining the consequences of ramming or sinking, or whether 30 foot drops could occur. Resolving such technical issues would have been inefficient, and might have been ineffective in reaching timely resolution.

Currently, a proposal for the revision of 10 CFR Part 71 has been submitted. One of the issues identified in the revision is whether the NRC should propose Part 71 amendments to provide a standard for review of large-object packages, such as the Trojan Reactor Vessel, versus the current exemption process. As stated in SECY-01-0035, "...The proposed action would result in enhanced regulatory efficiency by standardizing the requirements to provide greater regulatory certainty and clarity, and would ensure consistent treatment among licensees requesting authorization for special packages."

(3) Could a risk-informed regulatory approach reduce unnecessary regulatory burden for the applicant or licensee or the NRC?

Yes. The current regulations under 10 CFR Part 71, requires an exemption for large objects as packages and requires Commission approval. The licensee viewed the regulatory process as a challenge. In addition, the alternatives to shipment of the vessel intact, appeared to be substantially more costly as well as involving the burden of higher occupational doses to its workers.

(4) Would a risk-informed approach help to effectively communicate a regulatory decision or situation?

Yes. The risk assessment provided a clear and understandable technical basis for the staff's decision that the alternative mode of transport was equivalently safe. In performing the risk assessment, PGE self-identified an elevated risk and made a design change to lower the risk. The NRC and the licensee conducted public meetings that addressed safety and regulatory concerns involved with the shipment in which the risk information showed that a wide spectrum of accidents had been considered and accommodated by the design.

(5) Does information (data) and analytical models exist that are of sufficient quality or could they be reasonably developed to support risk-informing a regulatory activity?

Yes. The identification of potential accidents used standard techniques. Statistical data on the frequency of various maritime and inland waterway accidents was available from government sources. The adequacy was demonstrated by PGE's analysis that included:

(1) "Probabilistic Safety Study for the Transportation of the Trojan Reactor Vessel Package by Barge on the Columbia River from the Trojan Site to the Port of Benton"

(2) Probabilistic Safety Evaluation of the Overland Movement of the Trojan Reactor Vessel Package for Disposal

(3) Assessment of external events

The State of Washington also conducted a dose analysis that was available to support risk-informing this activity.

(6) Can startup and implementation of a risk-informed approach be realized at a reasonable cost to the NRC, applicant or licensee, and/or the public, and provide a net benefit? The net benefit will be considered to apply to the public, the applicant or licensee, and the NRC[1]. The benefit to be considered can be improvement of public health and safety, improved protection of the environment, improved regulatory efficiency and effectiveness, improved communication to the public, and/or reduced regulatory burden (which translates to reduced cost to the public.)

Yes. There was a large potential for saving costs in this case. These reductions in burden on the applicant and the NRC staff easily offset the added cost of the risk assessment and associated activities. Net benefits are identified below by stakeholder.

Licensee: The shipment of the entire reactor with its internals provided a benefit over the alternative recommendations of indefinite on-site storage and/or segmentation of the reactor vessel package. With the latter, portions of the internals with the highest activation levels would no longer qualify for disposal under 10 CFR 61 regulations. It would substantially increase occupational radiation exposure at least 100% (i.e. 134 to 154 person-rem vs 67 person-rem) It would result in approximately 44 individual cask shipments to the US Ecology facility. It would increase radiation exposure to the transportation workers at least 1000% (i.e. 1.06 to 1.19 person-rem vs 0.09 person-rem). By shipping the reactor vessel as a whole, with internals, the decommissioning schedule was also shortened.

Public: There was a net safety benefit for the public. The alternative of segmenting the reactor vessel into 44 individual cask shipments by truck would have increased the public exposure to radiation at least 2300% (i.e. from 0.48 to 0.56 person-rem vs 0.02 person-rem), although the levels still would have been low. From the modal safety perspective, 44 truck shipments would have had greater risk of a transportation accident than the single barge shipment.

NRC: The NRC staff benefitted from a relatively clear safety argument for the exemption. NRC also recognized, as a result of this activity, that the regulatory framework may be altered to improve efficiency and effectiveness. Consequently, the NRC staff has made a proposal to amend the one-time exemption for nonstandard packages in Part 71 using the TRVP shipment as an example. The proposal is currently under consideration by the Commission.

(7) Do other factors exist (e.g., legislative, judicial, adverse stakeholder reaction) which would preclude changing the regulatory approach in an area, and therefore, limit the utility of implementing a risk-informed approach?

No. The exemption was granted and the shipment was made in accordance with all applicable regulatory rules and regulations. In this particular case, according to the public response at the public meetings and local newspaper articles, no adverse stakeholder reaction existed to impede the risk-informed approach taken. However, as was pointed out at the public meeting of May 11, 2001 on this case study, the Oregon

public in this case appeared to favor removal of the reactor from a site in their state, which would tend to offset any concerns over transport. In general, transport of radioactive materials always has the potential for adverse reaction from public along the transport route. Example public reactions follow:

- "The reactor's departure marks a major milestone in a contentious, if overly optimistic, era of nuclear power and anti-nuclear activism in Oregon.....It isn't expected to draw protestors, whose acts of civil disobedience colored Trojan's history since it opened in 1976(The Oregonian newspaper-*"A new chapter opens for Trojan"*, by Brent Hunsberger, Aug. 4, 1999)

- "Today, activists claim the shipment of the reactor vessel to Hanford as a victory, though not a perfect solution..."It means we won," said Greg Kafoury, a Portland lawyer whose group, Don't Waste Oregon, led three initiative campaigns against the plant, all of which failed" 1976(The Oregonian newspaper-*"A new chapter opens for Trojan*", by Brent Hunsberger, Aug. 4, 1999)

- No demonstrators or security problems were encountered during transport. (Trojan Nuclear Power Plant Reactor Vessel and Internals Removal: Trojan Nuclear Plan Decommissioning Experience, EPRI report #10000920, Ch. 14 Transportation p.14-7).

6. SUMMARY AND CONCLUSIONS

The conclusions are organized to address the four objectives of the case studies as numbered below.

1. What did the case study say about the effectiveness of the screening criteria?

The draft screening criteria appear to contain all the relevant considerations for making decisions as to whether to pursue risk-informing a proposed regulatory action. However, some clarifying guidance is needed to make their use practical for the staff, and to make their intent clear to stakeholders. The screening criteria would have identified this case as one which would benefit from risk information.

2. What insights did the case study provide about the current and potential value of using risk-information? What process improvements could be made to facilitate applying risk information in similar situations?

This case study showed the potential of risk information to provide for substantial burden reduction and improved staff efficiency in making decisions, at no increase in risk. In fact, as illustrated by this case, the alternative shipment method (intact by barge) that was justified by the risk analysis, was actually a substantial reduction in risk. Regulations often prescribe just one way to provide and demonstrate safety, but risk analysis can open the path to many more options with equivalent or better safety, along with other benefits such as efficiency.

3. What did the case study say about the feasibility and utility of safety goals? What were the implicit/explicit safety goals or elements?

There were several risk metrics involved in the process of preparing, shipping, and disposing of the reactor vessel from the Trojan reactor, including occupational exposure of workers and accident risks. There appears to be no reason why safety goals could not be developed for these risk metrics. The primary metric that was considered in the decision to permit the shipment was the 10^{-6} probability for the most likely accident. Thus the staff decision that this was an acceptable risk is a reference point for a safety goal on accidental risks with consequence levels similar to these.

The important insight is that licensee uncertainty and staff decision making would have been alleviated if a clear set of safety goals existed. The licensee was able to calculate the 10^{-6} probability, but there was no guidance saying what would be acceptable. That is, safety goals are needed.

4. What insights did the case study provide on the information, tools, methods, guidance needed for a risk-informed regulatory approach in this specific case study area and (if possible) in other similar regulatory areas?

The risk studies in this case identified a considerable number of sources for estimating the probabilities of transportation accidents. Statistical data exists from several sources (see references). Quantitative consequences of the transport accidents identified in the

risk studies were not calculated. Thus, there was little information available for evaluating applicable consequence methods. More realistic evaluation of consequences of transportation accidents was a major objective of the study reported in Reference 14. Although developing realistic source terms appears difficult for some scenarios, in general, consequence evaluation methods are available for transportation risk assessment.

7. REFERENCES

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