ALTERNATIVE RISK-BASED CRITERIA FOR TRANSPORTATION OF RADIOACTIVE MATERIALS ON THE UNITED STATES DEPARTMENT OF ENERGY HANFORD SITE

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I. INTRODUCTION

Radioactive materials transportation safety is of significant interest at the U.S. Department of Energy (DOE) Hanford Site. The Site covers about 1,450 km^2 (560 mi^2) of desert. Radioactive waste sources are often widely separated from the facilities that characterize, treat, and dispose of the waste. The site layout, therefore, requires that radioactive materials be transported on roadways and railways for significant distances in areas remote from controlled facilities.

Onsite transportation within a DOE controlled site is generally safer than offsite transportation using public highways. Commercial transportation on public highways involves many unknowns, such as rapidly changing road conditions and weather, driver fatigue from long-distance operation, and highly variable traffic conditions. The effect of these variables is reflected in the significant differences in onsite and offsite traffic accident statistics and accident severity. The onsite transportation accidents at the Hanford Site have been demonstrated to be less severe than the offsite accidents, and the onsite accident rate is only a small fraction of that for public highways (Wang et al. 1991). The onsite controlled environment clearly provides an additional margin of transportation safety when compared to the public highways. It is, therefore, appropriate to rely on this additional margin of safety to justify the use of alternative packaging systems for selected onsite transportation operations.

It is the DOE Richland Field Office's (RL) policy to use packagings approved by the U.S. Department of Transportation (DOT)/DOE/U.S. Nuclear Regulatory Commission (NRC) whenever technically and economically practicable for onsite shipments. The RL also allows flexibility for onsite packagings and recognizes that an equivalent degree of safety shall be provided for alternative onsite shipments, as is afforded by the shipping regulations of the DOT. The equivalent safety concept provides flexibility for the DOE to apply acceptable economical alternatives for selected onsite transportation activities without compromising public safety.

The Westinghouse Hanford Company (Westinghouse Hanford) formed an Equivalent Safety Task Team in the spring of 1990. The charter of the task team was to establish a company position concerning the equivalent safety of packaging used for Hanford onsite transportation of radioactive materials. With the task team background information and risk assessment technique, this paper presents a proposed position on equivalent safety or alternative risk-based criteria for transportation

of radioactive materials on the DOE Hanford Site. The equivalent safety concept and its regulatory basis are delineated in Section II. This paper provides a general procedural application methodology and associated acceptance criteria and technical bases.

II. EQUIVALENT SAFETY

The equivalent safety concept is that alternative means of packaging yield an equivalent degree of safety (or equivalent level of risk) by achieving the same shipping results. The idea is similar to the concept stated in DOE Order 1540.2, "DOE Alternate and Equivalent Protection" (DOE 1986).

As stated in DOE Order 1540.2, a DOE alternative is an administrative relief from DOE regulations that meets and provides equivalent health and safety protection. Also in DOE Order 1540.2, equivalent protection is defined as those alternative measures that will achieve a level of safety at least equal to that specified in the regulations from which the alternative is sought, will be consistent with the public intent, and will provide adequate protection against the risks to life and property. Chapter IV, "Department of Energy Alternatives," of DOE Order 1540.2 (DOE 1986) provides procedures to be followed in granting alternatives to requirements set forth in DOE Order 5480.3 (DOE 1985) for shipments made via government-owned conveyances operated by DOE employees or authorized DOE contractor personnel.

According to RL Order 5480.1, Chapter III (RL 1982), an equivalent degree of safety shall be provided for onsite shipments as is afforded by the shipping regulations of DOT. It is RL's policy to use DOT/DOE/NRC approved containers whenever technically and economically practicable for onsite shipments and to keep the exposure to individuals during the normal transportation and handling of material packages as low as practicable.

Some reasonable assumptions and guidelines describe what constitutes equivalent safety and how safe is safe enough.

- Although DOE Order 1540.2 permits applications of equivalent safety for general transportation of hazardous materials, Westinghouse Hanford will only implement equivalent safety applications for onsite transportation.

- It is Westinghouse Hanford's policy to use DOT/DOE/NRC approved containers whenever technically and economically practicable for onsite shipments. Equivalent safety applications will only be used for selected packaging systems and transportation activities that do not meet the performance criteria of the regulations.

- For those onsite transportation activities and selected packaging systems feasible for equivalent safety applications, it is intended that DOT/DOE/NRC regulations for normal conditions of transport be met.

- For onsite packaging systems that do not meet the performance criteria of the regulations, alternative acceptance criteria are established to evaluate equivalent safety (see Section IV).

- The Safety Analysis Report for Packaging for an onsite package with fissile materials shall demonstrate that the package remains subcritical by meeting the DOT regulations or the criticality control requirements of the Westinghouse Hanford *Nuclear Criticality Safety* manual (WHC 1992).

The proposed alternative acceptance criteria based on the consideration of risk and regulations are described in Section IV. A procedural methodology regarding how to apply these criteria to an onsite transportation activity is described in Section III.

III. APPLICATION METHODOLOGY

This section describes a procedural methodology to apply the alternative acceptance criteria to onsite transportation activities. Similar methodology was previously used for many transportation and packaging applications (Wang et al. 1991). Procedural steps for onsite transportation and packaging alternative acceptance applications are as follows:

1. Identify the scope and purpose of a proposed onsite transportation activity.

2. Select suitable packagings, preferably DOE/DOT/NRC certified, for the onsite activity.

3. If certified packagings are not available, it is desirable to design a new packaging that meets all performance testing conditions as required by applicable regulations.

4. If time or cost become limiting factors, it is permitted to apply alternative risk acceptance criteria as described in Section IV to choose or design a suitable packaging and transportation arrangement, including specific operational controls to establish equivalent safety for the proposed or existing onsite activity. The regulatory requirements for normal conditions of transport shall be assessed.

5. When alternative acceptance criteria are applied, all the parameters and variables that affect the overall risk of the proposed transportation activity shall be evaluated concurrently to estimate the total risk. The parameters and variables of concern include the following: type of packaging, known performance capability, transport route, total mileage per year, road conditions, fire suppression capability, and operational controls such as escort requirements and restrictions under certain weather conditions.

6. The risk is evaluated from two quantitative assessments: the assessment of the release accident frequencies, and the assessment of the corresponding release consequences. If accidents yield different consequences, the corresponding frequencies should be evaluated separately. For example, fire release scenarios and non-fire release scenarios should have their corresponding accident frequencies evaluated separately.

7. For each set of accidents resulting in a particular type of release, the combined frequency and the associated consequence are used to determine the acceptability of the transportation operation by comparison with the criteria as graphed in Figures 1 and 2 and as discussed in Section IV.

Detailed methods and guidelines for determining best-estimate accident frequencies and expected consequences with predetermined, built-in conservatism are being developed.

IV. ACCEPTANCE CRITERIA AND TECHNICAL BASES

Westinghouse Hanford developed a set of alternative equivalent safety acceptance criteria to manage transportation-related risks. The acceptance criteria for the offsite public are much more conservative than those for the onsite workers because of the following reasons:

- For onsite workers, radiological risk is voluntary and generally accepted as an occupational hazard. In fact, the acceptance criteria for onsite workers are consistent with the regulatory occupational acceptance limits. Also, onsite emergency preparedness and procedures are more effective than offsite emergency preparedness and procedures in mitigating consequences.

- For offsite public, radiological risk is normally regarded as involuntary. The low acceptance criteria are consistent with the low U.S. Environmental Protection Agency (EPA), Code of Federal Regulations (CFR) criteria for the general public (EPA 1991).

Figures 1 and 2 depict the radiological risk acceptance guidelines for onsite workers and offsite public, respectively. The dose consequence acceptance criteria apply to the maximum exposed individual. The following are justifications for the quantitative limits.

Onsite Workers

Frequencies between 1.0×10^{-3}/yr to < 1.0/yr (up to one thousand-year accident)

The International Commission on Radiological Protection (ICRP) -60 (ICRP 1991) recommended an individual occupational exposure limit of 2 rem/yr. Westinghouse Hanford subsequently established a set of conservative limits of 1 rem/yr for radiation workers and 0.1 rem/yr for nonradiation workers. It is conservative to use a 0.1 rem/yr limit for nonradiation workers as the general radioactive release limit in this accident frequency range.

Frequencies between 1.0×10^{-6}/yr to $< 1.0 \times 10^{-3}$/yr (up to one million-year accident)

The ICRP-60 (ICRP 1991) recommended an occupational exposure limit of an effective dose of 2 rem/yr averaged over 5 years, providing the effective dose does not exceed 5 rem in a single year. The DOE Order 5480.11 (DOE 1991) and the International Atomic Energy Agency (IAEA 1990) also use a 5 rem/yr limit for occupational exposure. It is conservative to use 5 rem/yr as the accident release limit in this frequency range.

Frequencies $< 1.0 \times 10^{-6}$/yr (incredible accidents)

Any traffic accident associated with a frequency less than 10^{-6}/yr is considered incredible. The resulting risk is generally considered acceptable if the accident consequence is less than the dose value corresponding to the iso-risk line, as shown in Figure 1, with reasonable uncertainty consideration. For an iso-risk line, the risk (i.e., frequency x consequence) is the

same at any point along the line. Since low-frequency events generally have relatively high distribution uncertainty, an uncertainty study is being conducted by Westinghouse Hanford. An uncertainty study will determine a generic conservative limit for this frequency range.

Offsite Public

Frequencies between 1.0×10^{-3}/yr to < 1.0/yr (up to one thousand-year accident)

The DOE Order 5400.5 (DOE 1990) and 40 CFR 61 (EPA 1991) placed an allowable airborne pollutant release limit of 10 mrem/yr for offsite public members. This low quantitative value (3% of background radiation) is insignificant and very conservative as the accident release limit at this frequency range.

Frequencies between 1.0×10^{-6}/yr to $< 1.0 \times 10^{-3}$/yr (up to one million-year accident)

The DOE Order 5400.5 (DOE 1990) allows an effective dose equivalent of 0.5 rem/yr to the public in special cases if the average lifetime dose is less than 0.1 rem/yr. The IAEA safety guides (IAEA 1990) also support the same limit. It is conservative to use 0.5 rem/yr as the accident release limit in this frequency range.

Frequencies $< 1.0 \times 10^{-6}$/yr (incredible accidents)

Any traffic accident associated with a frequency less than 10^{-6}/yr is considered incredible. The resulting risk is generally considered acceptable if the accident consequence is less than the dose value corresponding to the iso-risk line, as shown in Figure 2, with reasonable uncertainty consideration. An uncertainty study will determine a generic conservative limit for this frequency range.

V. EXAMPLES OF CRITERIA APPLICATION

As standards and regulations governing the transport of radioactive materials continue to develop, many packaging systems require re-evaluation. In some cases where packagings do not meet the regulatory performance requirements, it is possible to apply alternative criteria to show that use of the packagings poses an acceptable risk. Examples of payloads that require packagings of this description include large contaminated nuclear facility equipment from waste processing operations, retrieved waste drums containing Type B quantities of radioactive materials, and decommissioned reactor components.

In another application, a cask used to transport waste tank samples onsite was evaluated to demonstrate that the dose consequences associated with releasing the contents are acceptable if the accident frequency is limited to less than 10^{-3} per year. This limitation is accomplished by placing an annual mileage limit on cask transport.

Structural evaluation of another container determined that the waste box would not survive any accident conditions. It was assumed that the dose consequences of an accident would be unacceptable, so a highly restrictive annual mileage limit was imposed to maintain the accident frequency at lower than 10^{-6} per year.

VI. SUMMARY

The Westinghouse Hanford position on equivalent safety for onsite transportation is based on a regulation-based risk acceptance approach. The acceptance criteria based on conservative regulatory individual dose limits have been verified to be less than the iso-risk lines corresponding to the operational risk at normal conditions of transport.

An uncertainty study is being initiated within Westinghouse Hanford to estimate the magnitude of the uncertainty, especially for low-probability events at frequencies less than 10^{-6}/yr. It is expected that even with a conservative adjustment of uncertainty, the acceptance criteria are still much lower than the adjusted iso-risk line.

This paper documents a Westinghouse Hanford approach to deal with equivalent safety for onsite transportation. Also included are the relevant technical bases, which will be reviewed and revised, if necessary, as soon as the radioactive health effect study is updated by the authoritative national or international agencies. A procedural methodology for applications to onsite transportation activities is also discussed.

This technical position not only provides Westinghouse Hanford Transportation and Packaging staff with working guidelines for onsite transportation of radioactive materials, but also serves as a risk management tool to ensure safe operation of the onsite transportation. The same philosophy and technique may be used for transporting other hazardous materials or substances at the Hanford Site.

VII. REFERENCES

DOE, 1985, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes*, DOE Order 5480.3, U.S. Department of Energy, Washington, D.C.

DOE, 1986, *Hazardous Materials Packaging for Transport - Administrative Procedures*, DOE Order 1540.2, U.S. Department of Energy, Washington, D.C.

DOE, 1990, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE, 1991, *Radiation Protection for Occupational Workers*, U.S. Department of Energy Order 5480.11, U.S. Department of Energy, Washington, D.C.

EPA, 1991, "National Emission Standards for Hazardous Air Pollutants," Title 40, *Code of Federal Regulations*, Part 61, as amended, U.S. Environmental Protection Agency, Washington, D.C.

IAEA, 1990, *Safety Series No. 7 - Regulations for the Safe Transport of Radioactive Material*, ISSN 0074-1892, International Atomic Energy Agency, Vienna, Austria.

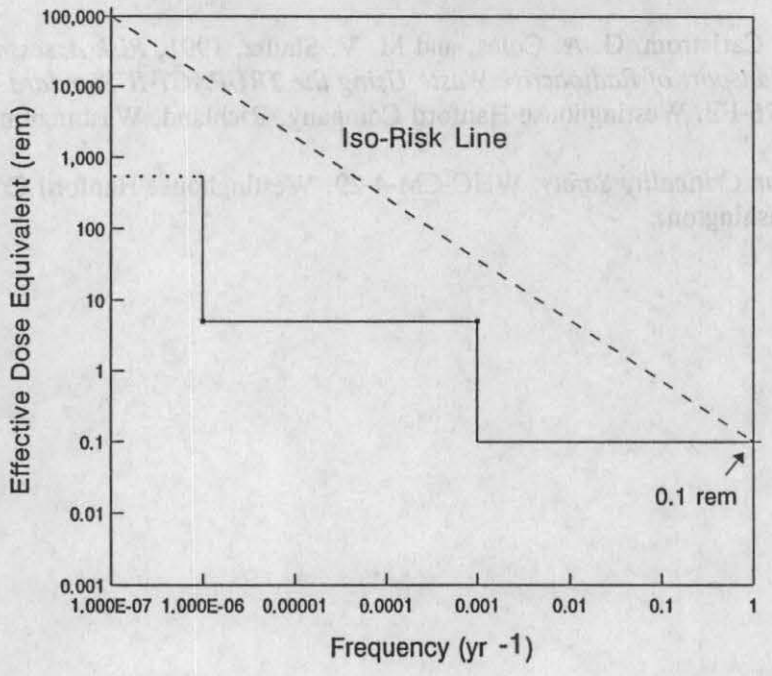
ICRP, 1991, *1990 Recommendations of the International Commission on Radiological Protection*, ISSN 0146-6453, ICRP Publication 60, International Commission on Radiological Protection, Pergamon Press, Oxford, England.

RL, 1982, *Environmental Protection, Safety, and Health Protection Programs for Richland Operations*, RL Order 5480.1, U.S. Department of Energy, Richland Field Office, Richland, Washington.

Wang, O. S., R. F. Carlstrom, G. A. Coles, and M. V. Shultz, 1991, *Risk Assessment of Intra-Area Transport of Radioactive Waste Using the TRUPACT-II Standard Waste Box*, WHC-SA-1276-FP, Westinghouse Hanford Company, Richland, Washington.

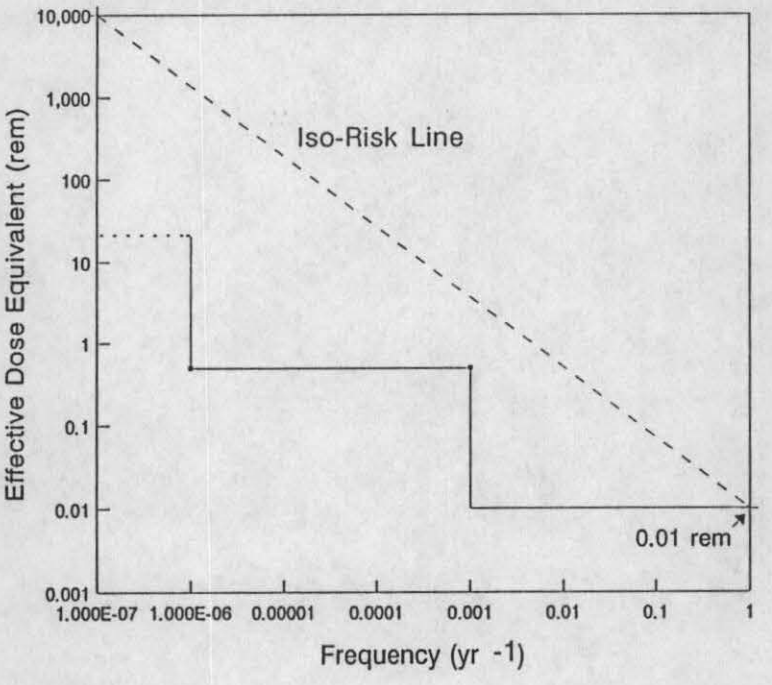
WHC, 1992, *Nuclear Criticality Safety*, WHC-CM-4-29, Westinghouse Hanford Company, Richland, Washington.

Figure 1. Radiological Risk Acceptance Guidelines (Onsite Workers)



..... To be determined via uncertainty study

Figure 2. Radiological Risk Acceptance Guidelines (Offsite Public)



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