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YUCCA MOUNTAIN PROJECT

Repository ALARA Goal Compliance

INFORMAL STUDY

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TABLES

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ACRONYMS

ALARA	as low as is reasonably achievable
HPT	health physics technician
LLWF	low-level waste facility
PCSA	preclosure safety analysis
NRC	Nuclear Regulatory Commission
SNF	spent nuclear fuel
TEDE	Total Effective Dose Equivalent
YMP	Yucca Mountain Project

1. INTRODUCTION

1.1 PURPOSE

The purpose of this informal study is to demonstrate that annual radiological worker doses of 0.5 rem per year or less are achievable for repository facility handling operations as presented in the license application and in the environmental impact statement for the Yucca Mountain Project (YMP).

1.2 SCOPE

The scope of this informal study includes all surface nuclear facilities worker doses for nominal site throughputs with design basis source terms.

1.3 PROCESS

This document is an informal study prepared in accordance with procedure EG-PRO-3DP-G04B-00016, *Engineering Studies* (Reference 5.7).

2. REQUIREMENTS, RESULTS AND CONCLUSIONS

2.1 REPOSITORY ALARA GOAL

The Nuclear Regulatory Commission (NRC) annual limit for Total Effective Dose Equivalent or TEDE for occupationally exposed radiological workers is 5 rem per year (Reference 5.2). The Repository's stated as low as is reasonably achievable (ALARA) design goal for individual worker doses is to minimize the number of individuals that have the potential of receiving more than 0.5 rem per year (Reference 5.1, Section 4.10.3.3.1).

2.2 WORKER DOSE ESTIMATES

For compliance purposes, initial conservative calculations of worker doses were developed based on minimum operating staffing levels using maximized individual handling facility annual throughputs and maximum source terms. See Reference 5.6 for additional information.

The ability to successfully meet the Repository ALARA goal is demonstrated by using best estimates of more realistic worker doses which were calculated based on design basis source terms and expected nominal throughputs and are tabulated in Table 1.0, Worker Doses Using Nominal Throughput of 500 Casks per Year with Design Basis Source Terms. This Table takes into account the reasonable expectation that the majority of commercial nuclear plants will send a mix of old and young fuel. Consequently, the dose rates on transportation casks will be much lower than maximum regulatory limits allowed for transport. The table illustrates the combined effect on individual and collective doses for the various facilities based on the nominal throughput of 500 casks per year and a design basis source term resulting in an expected annual collective dose for the site of 106 person-rem. This value is well in line with typical individual site collective doses experienced throughout the nuclear power industry, as described in NUREG-0713 (Reference 5.5, Vol. 27, Appendix B).Table 1.0 also presents average annual

worker doses accounting for rotation of individual workers and crews to the other handling facilities.

The average worker doses for the functional worker categories are demonstrated to be below the 0.5 rem per year repository ALARA goal.

Table 1.0 Worker Doses Using Nominal Throughput of 500 Casks per Year with Design Basis Source Terms

Facility	Total Number of Work Crews per Facility	Nominal Number of Casks per Facility (A)	Individual Dose (rem/year) (B)	Collective Annual Dose (person-rem) (C)	Basis
Receipt Facility	5 Crews 5 Operators 1 HPT	210	Operator – 1.3 HPT – 0.8	36	Assumption 3.2.1, 3.2.2.
Canister Receipt and Closure Facility 1	5 Crews 5 Operators 1 HPT	72	Operator – 0.3 HPT – 0.2	9	Assumption 3.2.1, 3.2.2.
Canister Receipt and Closure Facility 2	5 Crews 5 Operators 1 HPT	72	Operator – 0.3 HPT – 0.2	9	Assumption 3.2.1, 3.2.2.
Canister Receipt and Closure Facility 3	5 Crews 5 Operators 1 HPT	72	Operator – 0.3 HPT – 0.2	9	Assumption 3.2.1, 3.2.2.
Wet Handling Facility	6 Crews 5 Operators 1 HPT	50	Operator – 0.4 HPT – 0.3	13	Assumption 3.2.1, 3.2.2.
Initial Handling Facility	1 Crew 5 Operators 1 HPT	24	Operator – 0.8 HPT – 0.5	5	Assumption 3.2.1, 3.2.2.
Aging Facility	6 Crews 4 Operators 1 HPT	135	Operator – 0.2 HPT – 0.3	6	Assumption 3.2.1, 3.2.2.
Low Level Waste Facility	2 Crews 5 Operators 1 HPT	NA	Operator – 0.7 HPT – 0.6	9	Assumption 3.2.3.
Cask Receipt Security Station	5 Crews 4 Operators 1 HPT 1 Security	365	Operator – 0.4 HPT – 0.4 Security – 0.2	10	Assumption 3.2.1, 3.2.2.
			TOTAL COLLECTIVE	**106**	
			AVERAGE OPERATOR	**0.480**	
			AVERAGE HPT	**0.358**	
			AVERAGE SECURITY	**0.200**	

TABLE NOTES:

- The column A throughput values are carried over from the nominal throughputs presented in Table 4.0-2 column A of Reference 5.6
- The column B and C values are based on values presented in columns B and C of Table 4.0-2 of Reference 5.6 with a dose reduction factor of 2.7 applied with the exception of the low level waste facility (LLWF) which is based on assumption 3.2.3.
- HPT = health physics technician.
- Average Operator, HPT and Security individual doses assume rotation of workers in the category.
- Average Operator, HPT and Security individual doses assume similar tasks for worker category in each facility.
- Subsurface maintenance worker doses are not included because their tasks are not related to cask handling.

The ALARA design objective is to pursue, through an iterative process, a continuous reduction in individual and collective worker doses. Further reduction in estimated worker doses will result from application of lower source dose rates accomplished through additional refinements in designed shielding and through an aggressive continued application of operational ALARA considerations in handling activities. This includes rotation of entire work crews and crew members to the other handling facilities, optimization of crew sizing, rotation of functional tasking within a crew as well as applications of remoting more operations and development of refined handling tools. During the operations phase, Repository management's commitment to the ALARA Program and commitment to policies that foster vigilance against departures from good practice will also result in further reduction in worker doses through continued application of experienced-based improvements in handling operations through good radiation protection planning and practice, and the application of lessons learned.

2.3 CONCLUSION

The results of worker dose estimates based on preliminary design indicate that average individual worker doses of 0.5 rem per year or less are achievable for repository facility handling operations in compliance with the ALARA goal.

3. STUDY BASIS

3.1 REQUIREMENTS

The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 0.5 rem per year (Reference 5.1, Section 4.10.3.3).

Paragraph 20.1101 (c) of 10 CFR 20, "Standards for Protection Against Radiation" states that licensees should make every reasonable effort to maintain exposures to radiation as far below the limits specified in Part 20 as is reasonably achievable. Reasonably achievable is judged by considering the state of technology and the economics of improvements in relation to all the benefits from these improvements (Reference 5.2).

Regulatory Guide 8.8 states in part that merely controlling the maximum dose to the individuals is not sufficient; the collective dose to the group also must be kept as low as is reasonably achievable (Reference 5.3, Section B).

Regulatory Guide 8.10 states in part that, even though the current occupational exposure limits provide a very low risk of injury, it is prudent to avoid unnecessary exposure to radiation. Reducing occupational exposures as far below the specified regulatory limits as is reasonably achievable is the objective for licensees using good radiation planning and practice, as well as by management commitment to policies that foster vigilance against departures from good practice. Personnel responsible for radiation protection should be continually vigilant for means to reduce exposure (Reference 5.4, Sections B and C).

3.2 ASSUMPTIONS

3.2.1 **Assumption**–The maximum spent nuclear fuel (SNF) source term dose rates are 2.7 times higher than design basis SNF source term dose rates.

Rationale–This assumed factor of 2.7 is comparable (+/-10%) with project issued calculations for a factor increase in dose rate through the same shielding medium when changing from a design basis source term to a maximum source term (Reference 5.8, Tables 6.1-8 and 6.3-3). The 2.7 factor is deemed conservative because it is expected that YMP will typically be receiving fuel closer to the average source term. It is not, however, expected that every transportation cask that is received at YMP will be at the regulatory limit for transportation casks; thus, there would be lower doses expected on the transportation casks and a factor is needed to be applied to the maximized dose rates calculated in the worker dose assessments to make the dose rates more appropriate for the expected nominal conditions of the casks received at YMP.

Use–This assumption is used in Table 1.0.

3.2.2 **Assumption**–It is expected that most utilities will send the oldest SNF for disposal first.

Rationale–This is consistent with 10 CFR Part 961.11, Subpart B (1) (a) (Reference 5.9) which states in part that "it is expected that most utilities will send the oldest SNF for disposal first."

Use–This assumption is used in Table 1.0.

3.2.3 **Assumption**–Worker doses from processing contaminated materials in the LLW facility are not based on the SNF source term.

Rationale–Transportation casks loaded with SNF are not processed in this facility. Worker doses in the LLW facility are mainly based on the amount of radioactive material processed.

Use–This assumption is used in Table 1.0 for the LLW facility.

4. EVALUATION OF ALTERNATIVES

The worker doses shown in Table 4.0-2 of Reference 5.6 for a nominal throughput were adjusted to the design basis source term per Assumption 3.2.1 and are tabulated in Table 1.0. The dose reduction factor used in Table 1.0 takes into account the expectation that the majority of

commercial nuclear plants will send a mix of old and young fuel and, consequently, the dose rates on transportation casks will be much lower than maximum levels used in the worker dose calculations. Thus, the 2.7 reduction factor (Assumption 3.2.1) was applied to the nominal doses from Table 4.0-2 of Reference 5.6 to produce the worker doses shown in Table 1.0. Average worker doses in rem per year were calculated in Table 1.0 by multiplying the number of workers in a crew by the number of work crews per facility to determine the total number of workers in each worker category. The total number of workers per worker category was multiplied by the individual dose in rem per year for each worker category in each facility to determine the total collective dose for each worker category. This value, in turn, was divided by the total number of workers in each worker category to determine the average annual worker dose for each worker category as well as the collective annual dose in each facility.

Table 1.0 and Table 4.0-2 of Reference 5.6 present two alternatives to the maximized worker doses presented in Table 4.0-1 of Reference 5.6. Table 4.0-2 (Reference 5.6) is shown to demonstrate the effect of nominal throughput on maximum source term. Best estimates of worker doses based on expected source terms and throughputs are tabulated in Table 1.0.

As shown in Table 1.0, the resultant collective dose for the site has been reduced to **106** person-rem. Average annual worker doses in rem for each worker category are: **Operator – 0.480; Health Physics Technician – 0.358;** and **Security – 0.200.**

5. REFERENCES

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5.9 10 CFR 961. 2007. *Energy: Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste.* Internet Accessible.