U.S. NUCLEAR REGULATORY COMMISSION

Revision 1
June 1979

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.19

OCCUPATIONAL RADIATION DOSE ASSESSMENT IN LIGHT-WATER REACTOR POWER PLANTS DESIGN STAGE MAN-REM ESTIMATES

A. INTRODUCTION

Section 50.34, "Contents of Applications; Technical Information," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that each applicant for a permit to construct a nuclear power reactor provide a preliminary safety analysis report (PSAR) and that each applicant for a license to operate such a facility provide a final safety analysis report (FSAR). Section 50.34 specifies in general terms the information to be supplied in these reports.

A more detailed description of the information needed by the NRC staff in its evaluation of applications is given in Regulatory Guide 1.70, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants." Section 12.4, "Dose Assessment," of Regulatory Guide 1.70, Revision 3, states that the safety analysis report should provide the estimated annual radiation exposure to personnel at the proposed plant during normal operations. The man-rem estimate requirement is an important part of the overall, ongoing radiation protection design review. The purpose of this requirement is to provide that adequate detailed attention is given during the preliminary design stage (as described in the PSAR), as well as during construction after completion of design (as described in the FSAR), to dose-causing activities to ensure that personnel exposures will be as low as reasonably achievable (ALARA). The safety analysis report provides an opportunity for the applicant to demonstrate the adequacy of that attention and to describe whatever design and procedural changes have resulted from the dose assessment process.

The objective of this guide is to describe a method acceptable to the NRC staff for performing an assessment of collective occupational radiation dose as part of the ongoing design review process involved in designing a light-water-cooled power reactor (LWR) so that occupational radiation exposures will be ALARA.

B. DISCUSSION

The dose assessment process requires a good working knowledge of (1) the principal factors contributing to occupational radiation exposures that occur at a nuclear reactor power plant and (2) methods and techniques for ensuring that the occupational radiation exposure will be ALARA.

In assessing the collective occupational dose at a plant, the applicant evaluates each potentially significant dose-causing activity at that plant (i.e., activities that result in greater than one man-rem per year). The applicant specifically examines such things as design, shielding, plant layout, traffic patterns, expected maintenance, and radioactivity sources. This evaluation process is aimed at the consideration of eliminating unnecessary exposures, minimizing foreseen required doses (individual and collective), and examining the cost-effectiveness of each dose-reducing method and technique. This evaluation process and the dose reductions that may be expected to result are the principal objectives of the dose assessment. The dose assessments prepared in accordance with this guide are intended for use as an aid in what should be a continuing search for dose-reducing techniques and not for NRC regulatory enforcement purposes.

The principal benefits arising from this evaluation process occur during the period of preliminary design since many of the ALARA practices are part of the design process. On the

* Lines indicate substantive changes from previous issue.

other hand, additional benefits can also accrue during advanced design stages and even during early construction stages, as better evaluation of dose-causing operations are available and further design refinements can be identified. In addition, operations that will need special planning and careful dose control can be identified at the preoperational stage when the applicant can take advantage of all design options for reducing the occupational dose.

C. REGULATORY POSITION

This guide describes the format and content for assessments of the total annual occupational (man-rem) dose at an LWR--principally during the design stage. The dose assessment at this stage should include estimated annual personnel exposures during normal operation and during anticipated operational occurrences. It should include estimates of the frequency of occurrence, the existing or resulting radiation levels, the manpower requirements, and the duration of such activities. These estimates can be based on operating experience at similar plants. However, to the extent possible, estimates should include consideration of the design of the proposed plant, including radiation field intensities calculated on the basis of the plant-specific shielding design, taking into account the effect of any dose-reducing design changes.

The dose assessment process and the concomitant dose reduction analysis should involve individuals trained in plant system design, shield design, plant operation, and health physics. Knowledge from all these disciplines should be applied to the dose assessment and to the entire radiation protection design review in determining cost-effective dose reductions.

Plant experience provides useful information on the numbers of people needed for jobs, the duration of different jobs, and the frequency of the jobs as well as on actual occupational radiation exposure experience. The applicant should use personnel exposure data for specific kinds of work and job functions available from similar operating LWRs.* Useful reports on these data have been published by the Atomic Industrial Forum, Inc. and the Electric Power Research Institute, and a summary report on occupational radiation exposures at nuclear power plants is distributed annually by the Nuclear Regulatory Commission.

The occupational dose assessment should include projected doses during normal operations, anticipated operational occurrences, and shutdowns and should be based on anticipated radiation conditions after at least 5 years of plant operation. Some of the exposure-causing activities that should be considered in this dose assessment include steam generator tube plugging and maintenance, repairs, inservice inspection, and replacement of pumps, valves, and gaskets. Doses from nonroutine activities that are anticipated operational occurrences should be included in the applicant's ALARA dose analysis. Radiation sources and personnel activities that contribute significantly to occupational radiation exposures should be clearly identified and analyzed with respect to similar exposures that have occurred under similar conditions at other operating facilities. In this manner, corrective measures can be incorporated in the design at an early stage.

Tables 1 through 8 are examples of worksheets for tabulation of data in the dose assessment process to indicate the factors considered. The actual numbers used in the tabulations will depend on plant-specific information developed in the course of the dose assessment review.

An objective of the dose assessment process should be to develop

1. A completed summary table of occupational radiation exposure estimates (such as Table 1),

2. Sufficient illustrative detail (such as that shown in Tables 2 through 8) to explain how the radiation exposure assessment process was performed,

3. A systematic process for considering and evaluating possible dose-reducing design changes and associated operating procedure changes as part of the comprehensive ongoing design review, and

4. A record of the review procedures, documentation requirements, and identification of principal ALARA-related changes resulting from the dose assessment. This record should be included in the assessment as a demonstration of the steps taken to ensure exposures will be ALARA.

During the final design stage, dose assessment should be updated to take into account any major design changes. In particular, completed shielding design and layout of equipment should permit better estimates of radiation field intensities in locations where work will be performed.

Analysis of the elements of the man-rem estimate (e.g., radiation levels, task duration, and frequency), treated qualitatively, can be of significant value in making engineering judgments regarding design changes for ALARA purposes. As a result of the dose assessment process described herein, it is to be expected that various dose-reducing design changes and innovations will be incorporated into the design.

*See Regulatory Guide 1.16, "Reporting of Operating Information--Appendix A Technical Specifications," for examples of work and job functions.

The precision of the man-rem estimate is of secondary importance. That estimate's relationship to actual man-rem doses received during subsequent plant operation will depend primarily on operating experience and maintenance and repair problems encountered rather than on design projections, however precise.

Entries in the tables should be identified and their basis explained in the text of the report, e.g., available data from similar plants, expected (reduced) values due to design, and engineering improvements. Such information will readily identify those areas in which ALARA efforts are to be made or have been made. Additionally, it would be of value to indicate whether the reduced values in applicable cases were derived on the basis of physical (or other) models. This would alert individuals concerned with the analysis of the occupational radiation dose assessment report in determining whether the well-intended improvements are productive or counterproductive.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals in connection with applications for construction permits or operating licenses until this guide is revised as a result of suggestions from the public or additional staff review. For construction permits, the review will focus principally on design considerations; for operating licenses, the review will focus principally on administrative and procedural considerations.

TABLE 1

TOTAL OCCUPATIONAL RADIATION EXPOSURE ESTIMATES

Activity	Dose* (man-rems/year)
Reactor operations and surveillance (see Tables 2 & 3)	-
Routine maintenance (see Table 4)	-
Waste processing (see Table 5)	-
Refueling (see Table 6)	-
Inservice inspection (see Table 7)	-
Special maintenance (see Table 8)	-
Total man-rems/year	-

*Occupational exposures from Tables 2 through 8 are entered in Table 1 and added to obtain the facility's estimated total yearly occupational dose.

TABLE 2

OCCUPATIONAL DOSE ESTIMATES DURING ROUTINE OPERATIONS AND SURVEILLANCE

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Walking in radiation zones	-	-	-	-	-	-	-
Checking systems and equipment:							
Containment cooling system	-	-	-	-	-	-	-
Boron acid (BA) makeup system	-	-	-	-	-	-	-
Fuel pool system	-	-	-	-	-	-	-
Control rod drive (CRD) system							
Other systems (specify):	-	-	-	-	-	-	-
Pumps:							
CRD	-	-	-	-	-	-	-
Residual heat removal	-	-	-	-	-	-	-
Accumulators	-	-	-	-	-	-	-
Pressurizer valves	-	-	-	-	-	-	-
Other equipment (specify):	-	-	-	-	-	-	-
Total	-	-	-	-	-	- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

TABLE 3

OCCUPATIONAL DOSE ESTIMATES DURING NONROUTINE OPERATION AND SURVEILLANCE

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers Utility	Number of workers Contractor	Number of events per year	Dose (man-rems/year) Utility	Dose (man-rems/year) Contractor
Operation of systems equipment:							
Safety injection system	-	-	-	-	-	-	-
Feedwater pumps & turbine	-	-	-	-	-	-	-
Instrument calibration	-	-	-	-	-	-	-
Other (specify):	-	-	-	-	-	-	-
Collection of radioactive samples:							
Liquid	-	-	-	-	-	-	-
Gas	-	-	-	-	-	-	-
Solid	-	-	-	-	-	-	-
Radiochemistry	-	-	-	-	-	-	-
Radwaste operation	-	-	-	-	-	-	-
Health physics	-	-	-	-	-	-	-
Other (specify):	-	-	-	-	-	-	-
Total			-	-		- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

TABLE 4

OCCUPATIONAL DOSE ESTIMATES DURING ROUTINE MAINTENANCE

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Changing filters:							
Waste filter	-	-	-	-	-	-	-
Laundry filter	-	-	-	-	-	-	-
Boron acid filter	-	-	-	-	-	-	-
Pressure valves	-	-	-	-	-	-	-
BA makeup pump	-	-	-	-	-	-	-
BA holding pump	-	-	-	-	-	-	-
Instrumentation and controls:							
Transmitter inside containment	-	-	-	-	-	-	-
Transmitter outside containment	-	-	-	-	-	-	-
Radwaste processing system	-	-	-	-	-	-	-
Other (specify):	-	-	-	-	-	-	-
Total			-	-		- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

TABLE 5

OCCUPATIONAL DOSE ESTIMATES DURING WASTE PROCESSING

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Control room	-	-	-	-	-	-	-
Sampling and filter changing	-	-	-	-	-	-	-
Panel operation, inspection and testing	-	-	-	-	-	-	-
Operation of waste processing and packaging equipment	-	-	-	-	-	-	-
Other (Specify):	-	-	-	-	-	-	-
Total			-	-		- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

TABLE 6

OCCUPATIONAL DOSE ESTIMATES DURING REFUELING

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Reactor pressure vessel head and internals--removal and installation	-	-	-	-	-	-	-
Fuel preparation	-	-	-	-	-	-	-
Fuel handling	-	-	-	-	-	-	-
Fuel shipping	-	-	-	-	-	-	-
Other (specify):	-	-	-	-	-	-	-
Total			-	-		- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

Most work functions performed during refueling, and the associated occupational dose received, will vary depending on facility design (BWR or PWR), reactor pressure vessel size, and number of fuel assemblies in the reactor core. For a detailed description of pre-planned activities, time, and manpower schedule, refer to the "critical path for refueling tasks," which should be available from the Nuclear Steam Supply System (NSSS) supplier.

TABLE 7

OCCUPATIONAL DOSE ESTIMATES DURING INSERVICE INSPECTION

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Providing access: installation of platforms, ladders, etc., removal of thermal insulation	-	-	-	-	-	-	-
Inspection of welds	-	-	-	-	-	-	-
Follow up: installation of thermal insulation, platform removal, and cleanup	-	-	-	-	-	-	-
Total			-	-		- +	- = -

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary from plant to plant.

Estimates should be based on average yearly values over a 10-year period. Variations are expected as a consequence of reactor size, design, number of welds to be inspected yearly, and the degree of equipment automation available for remote examination of welds.

TABLE 8

OCCUPATIONAL DOSE ESTIMATES DURING SPECIAL MAINTENANCE

Activity*	Average dose rate (mrem/hr)	Exposure time per event (hr)	Number of workers		Number of events per year	Dose (man-rems/year)	
			Utility	Contractor		Utility	Contractor
Servicing of control rod drives	-	-	-	-	-	-	-
Servicing of in-core detectors	-	-	-	-	-	-	-
Replacement of control blades	-	-	-	-	-	-	-
Dechanneling of spent and channeling of new fuel assemblies	-	-	-	-	-	-	-
Steam generator repairs	-	-	-	-	-	-	-
Other (specify):	-	-	-	-	-	-	-
Total			-	-		- + - = -	

*The list of activities is for illustrative purposes only, is not all inclusive, and would be expected to vary significantly from plant to plant.

Most preplanned (or routine) maintenance activities during outage are described in the "critical path for refueling tasks," which should be available from the NSSS supplier, and are performed in parallel with the critical path refueling tasks to shorten reactor outage time.

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