May 10, 2005

Mr. Harold B. Ray
Executive Vice President
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SUBJECT: SAN ONOFRE NUCLEAR GENERATING STATION (SONGS), UNITS 1, 2, AND 3 - REQUEST TO USE WEIGHTING FACTORS FOR THE WHOLE BODY FOR DETERMINING EFFECTIVE DOSE EQUIVALENT FROM EXTERNAL EXPOSURES (TAC NOS. MC5476, MC5477, AND MC5478)

Dear Mr. Ray:

By letter dated December 20, 2004, as supplemented by letter dated February 23, 2005, Southern California Edison (the licensee) requested approval for the use of weighting factors other than 1.0 for the whole body to determine the effective dose equivalent (EDE) from external exposures. In accordance with footnote 2 to the table of weighting factors in Section 1003 of Part 20 of Title 10 to the *Code of Federal Regulations* (10 CFR), this EDE will be added to the committed effective dose equivalent from internal exposures when demonstrating compliance with the total effective dose equivalent requirements in 10 CFR Part 20.

Enclosed is the NRC staff's Safety Evaluation. Please contact me at (301) 415-8450 if you have any questions on this matter.

Sincerely,

/RA/

Bo M. Pham, Project Manager, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-361, 50-362, 50-206

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE APPROVAL TO USE WEIGHTING FACTORS

FOR EXTERNAL RADIATION EXPOSURES

SOUTHERN CALIFORNIA EDISON COMPANY

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS), UNITS 1, 2, AND 3

DOCKET NOS. 50-361, 50-362, 50-206

1.0 INTRODUCTION

By letter dated December 20, 2004 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML043630036), as supplemented by letter dated February 23, 2005 (ADAMS Accession No. ML050590054), Southern California Edison (the licensee) requested an approval to use weighting factors provided in the American National Standard Institute (ANSI) HPS N13.41-1997 (the Standard) for external radiation exposures when demonstrating compliance with total effective dose equivalent (TEDE), based on requirements in Part 20 to Title 10 of the *Code of Federal Regulations* (10 CFR) for the SONGS, Units 1, 2, and 3. The effect of granting this request would be to allow the licensee the option to control TEDE using the weighted external exposure measurements in those cases where it is a more accurate predictor of the risk from occupational radiation exposure.

2.0 REGULATORY EVALUATION

The radiation protection approach and dose limits contained in 10 CFR Part 20 are based on the recommendations of the International Commission on Radiation Protection (ICRP) in its 1977 Publication No. 26 (ICRP 26). For stochastic effects, the ICRP's recommended dose limitation is based on the principle that the risk should be equal, whether the whole body is irradiated uniformly or there is non-uniform irradiation (such as when radioactive materials are taken into the body and, depending on their physical and chemical properties, concentrate in certain tissues and organs). Therefore, the ICRP 26 recommendations are based on controlling the sum of the risk weighted doses to selected organs.

Effective dose equivalent (EDE or H_E) is defined in 10 CFR 20.1004 as "the sum of the products of the dose equivalent to each tissue (H_T) and the weighting factors (ω_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma_T \omega_T H_T$)."

For the purposes of implementing workplace controls, and due to the difference in dosimetry, 10 CFR Part 20 breaks this EDE into two components: (1) dose resulting from radioactive sources internal to the body, and (2) dose resulting from sources external to the body. Dose limits and other requirements in Part 20 are based on the sum of these external and internal

exposures. For radioactive material taken into the body, the occupational dose limit is based on the resulting dose equivalent integrated over 50 years, or committed effective dose equivalent (CEDE).

The TEDE is defined in 10 CFR 20.1004 as the "sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)."

$$\text{TEDE} = \text{deep-dose equivalent (DDE)} + \Sigma_T \omega_T H_{50,T} \text{ (CEDE)}$$

The organ ω_T is the proportion of the risk of stochastic effects resulting from the dose to that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. The weighting factors are applicable to the organs and tissues whether the dose results from radiation sources internal or external to the body. However, measuring the dose to the various organs and tissues with a dosimeter worn outside the body, presents some practical difficulties. If the body is irradiated uniformly, the external component of TEDE can be determined with a single DDE measurement on any part of the whole body. However, if the body is not irradiated uniformly, a single dose measurement can not determine the dose to the various organs and tissues for an accurate determination of the external EDE (EDE_{ex}). To ensure a conservative determination of TEDE, 10 CFR 20.1201(c) requires that the DDE component be determined from the part of the whole body receiving the highest exposure.

In addition, footnote 2 to the "Organ Dose Weighting Factors" table in 10 CFR 20.1004 states that "for the purpose of weighting the external whole body dose (for adding to the internal dose), a single weighting factor, of $\omega_T = 1.0$, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued."

This conservative approach to determining TEDE can be overly conservative for extremely non-uniform-irradiations (i.e., when only a small portion of the whole body is irradiated). As discussed in NRC Regulatory Issue Summaries 2002-06, 2003-04, and 2004-01, the NRC has approved several methods for determining EDE_{ex}, and has encouraged the use of EDE_{ex} in place of DDE for demonstrating compliance with the TEDE requirements in 10 CFR Part 20.

3.0 TECHNICAL EVALUATION

The NRC staff has reviewed the technical approach for estimating EDE_{ex} provided in the Standard. This multiple dosimetry method divides the whole body into seven separate compartments. Each compartment, or composite compartment (since the Standard allows combining adjacent compartments), is monitored separately. The results of the dose measurement for each compartment are weighted with an associated "compartment factor." The resulting weighted doses are then summed to determine the EDE_{ex} for the whole body.

The compartment factors are listed in Table 1 of the Standard. The factor for each compartment was developed by summing the stochastic weighting factors given in ICRP 26 (Part 20 organ ω_T) for all the organs located within that compartment. For each tissue that resides in more than one compartment (e.g., red bone marrow), the weighting factor was apportioned between the compartments based on the fraction of the total mass of the tissue residing in each, using the information in ICRP 23.

Fundamental in the ANSI/HPS 13.41 multiple dosimeter method of determining EDE_{ex} are the

assumptions that (1) the average dose to the tissues in each compartment can be reasonably measured (with one or more dosimeters), and (2) that the dose distribution across the compartment is sufficiently constant so that this average dose can be applied to each tissue in the compartment. The compartments defined in the Standard are small enough so that under most normal exposure situations these assumptions are met and a single determination of DDE in each compartment is sufficient. However, this may not be the case in those unusual situations where a significant dose gradient exists across one or more compartments (particularly the thorax and abdomen compartments). In these cases, the number and placement of dosimeters in each compartment become critical to ensuring that the EDE_{ex} is not underestimated.

To ensure that the estimates of EDE_{ex} are conservative, the licensee has committed to measuring the dose to each compartment (or composite compartment) by locating the dosimeter, calibrated to DDE, at the highest exposed portion of that compartment. The dosimeter location for each compartment will be subject to the same criteria currently used for demonstrating compliance with 10 CFR 20.1201(c).

The licensee has stated that in most normal exposure situations they intend to provide one dosimeter for a combined thorax-abdomen composite compartment, consistent with the Standard and their current multi-badging practice.

4.0 CONCLUSIONS

The NRC staff concludes that calculating TEDE using EDE_{ex} in place of DDE provides a more accurate estimate of the risk associated with the radiation exposures experienced by radiation workers at a nuclear power plant. The NRC staff finds that limiting TEDE such that

$$EDE_{ex} + CEDE < 5 \text{ rem}$$

is consistent with the basis for the dose limits, and footnote 2 to the “Organ Dose Weighting Factors” table in 10 CFR Part 20.1004.

Additionally, the NRC staff concludes that the multiple dosimetry method to estimate EDE_{ex} using the weighting factors listed in Table 1 of the Standard, as proposed by the licensee, is technically sound and is acceptable for the purposes of demonstrating compliance with the TEDE-based requirements in 10 CFR Part 20.

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Date: May 10, 2005

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