February 28, 2007

Mr. J. A. Stall
Senior Vice President, Nuclear and
Chief Nuclear Officer
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SUBJECT: DUANE ARNOLD ENERGY CENTER, ST. LUCIE NUCLEAR PLANT, UNITS 1 AND 2, SEABROOK STATION, AND TURKEY POINT NUCLEAR PLANT, UNITS 3 AND 4 - APPLICATION TO USE EFFECTIVE DOSE EQUIVALENT WEIGHTING FACTORS FOR EXTERNAL EXPOSURE (TAC NOS. MD3821, MD3822, MD3823, MD3824, MD3825, MD3826)

Dear Mr. Stall:

By letter dated December 11, 2006, you requested the U.S. Nuclear Regulatory Commission's (NRC's) approval for the use of the weighting factors provided in the American National Standard Institute HPS N13.41-1997 (the Standard) for external radiation exposures when demonstrating compliance with total effective dose equivalent, based on requirements in Part 20 of Title 10 to the *Code of Federal Regulations* (10 CFR) for Duane Arnold Energy Center, St. Lucie Nuclear Plant, Units 1 and 2, Seabrook Station, and Turkey Point Nuclear Plant, Units 3 and 4.

On the basis of its review, the NRC staff finds your request acceptable. The enclosed safety evaluation documents the staff's findings.

If you have any questions, please contact Karl Feintuch 301-415-3079.

Sincerely,

/RA/

L. Raghavan, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-331, 50-335, 50-389, 50-443,
50-250, and 50-251

cc: See next page

Florida Power and Light Company

ST. LUCIE PLANT
TURKEY POINT PLANT
SEABROOK STATION, UNIT NO. 1
DUANE ARNOLD ENERGY CENTER

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Florida Power and Light Company

ST. LUCIE PLANT
TURKEY POINT PLANT
SEABROOK STATION, UNIT NO. 1
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On the basis of its review, the NRC staff finds your request acceptable. The enclosed safety evaluation documents the staff's findings.

If you have any questions, please contact Karl Feintuch 301-415-3079.

Sincerely,
/RA/
L. Raghavan, Chief
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
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Docket Nos. 50-331, 50-335, 50-389, 50-443,
50-250, and 50-251

cc: See next page

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NAME	KFeintuch	THarris	TFrye		LRaghavan
DATE	02/23/07	02/23/07	02/26/07	02/27/07	02/28/07

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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

FOR FLORIDA POWER & LIGHT COMPANY, FLORIDA POWER & LIGHT ENERGY

SEABROOK, AND FLORIDA POWER & LIGHT ENERGY DUANE ARNOLD

DOCKET NOS. 50-335, 50-389, 50-250, 50-251, 50-443, AND 50-331

1.0 INTRODUCTION

By letter to the Nuclear Regulatory commission (NRC) dated December 11, 2006 (Agencywide Documents Access and Management System (ADAMS) Accession no. ML063480330), Florida Power & Light Company (FPL); FPL Energy Seabrook, LLC (FPL Energy Seabrook); and FPL Energy Duane Arnold, LLC, (the licensees) requested an approval to use weighting factors provided in the American National Standards Institute (ANSI) HPS N13.41-1997 (the "Standard," Reference 1), for external radiation exposures when demonstrating compliance with total effective dose equivalent (TEDE), based requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20 (Reference 2), for Duane Arnold Energy Center, St. Lucie Nuclear Plant, Units 1 and 2, Seabrook Station, and Turkey Point Nuclear Plant, Units 3 and 4. The effect of granting this request would be to allow the licensees 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 their 1977 Publication No. 26 (Reference 3). 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.

Section 20.1003 of 10 CFR defines effective dose equivalent (EDE or H_E) as "the sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma \omega_T H_T$)."

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

ENCLOSURE

sources internal to the body, and (2) dose resulting from sources external to the body. Dose limits and other requirements in 10 CFR 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 20.1003 as the "sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)."

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

The organ dose weighting factor (W_T) for an organ or tissue is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. There are eight weighting factors defined in 10 CFR 20.1003. 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 20.1003, states that, "[f]or 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 weighting factors) 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 (Reference 4).

The NRC staff's review of the Standard determined that the Standard's criteria for monitoring each compartment are not sufficiently clear to ensure that a conservative estimate of EDE_{ex} will result. Although not stated in the Standard, fundamental to this compartment method of determining EDE_{ex} are the following assumptions: (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 body compartments defined in the Standard are such 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.

In response to this concern, the licensees have 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. This composite compartment will be called the "chest compartment." 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 at the highest exposed part 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). In addition, the dosimeters will be calibrated to measure DDE.

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:

$$TEDE = EDE_{ex} + CEDE$$

is consistent with the basis for the dose limits, and footnote 2 to the "Organ Dose Weighting Factors" table in 10 CFR Part 20.1003.

Additionally, the NRC staff concludes that the multiple dosimetry method to estimate EDE_{ex} using the weighting factors listed in Table 1 of ANSI/HPS 13.41-1997, as proposed by the licensees, is technically sound and is acceptable for the purposes of demonstrating compliance with the TEDE-based requirements in 10 CFR Part 20.

5.0 REFERENCES

1. ANSI-HPS N13.41-1997, "An American National Standard – Criteria for Performing Multiple Dosimetry," Health Physics Society, December 1996.

2. Title 10 of the *Code of Federal Regulations* (10 CFR) Part 20, "Title 10 Code of Federal Regulations Part 20 – Standards for Protection Against Radiation."

3. ICRP 26, "ICRP Publication 26 – Recommendations of the International commission on Radiation Protection," January 17, 1977, Pergamon Press.

4. ICRP 23, "ICRP Publication 23 – Reference Man: Anatomical, Physiological and Metabolic Characteristics," April 18, 1975, Pergamon Press.

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Date: February 28, 2007