February 24, 2009

Mr. David A. Christian
President and Chief Nuclear Officer
Virginia Electric and Power Company
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: KEWAUNEE POWER STATION, MILLSTONE POWER STATION, UNITS 1, 2 AND 3, NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2, AND SURRY POWER STATION, UNIT NOS. 1 AND 2 – APPLICATION TO USE WEIGHTING FACTORS FOR EXTERNAL EXPOSURE (TAC NOS. MD9472, MD9473, MD9474, MD9475, MD9476, MD9477, MD9478, MD9708)

Dear Mr. Christian:

By letter dated August 18, 2008, as superseded by letter dated September 22, 2008, Dominion Energy Kewaunee, Inc. (DEK), Dominion Nuclear Connecticut, Inc. (DNC), and Virginia Electric and Power Company (Dominion), submitted an application for Kewaunee Power Station, Millstone Power Station, Units 1, 2, and 3, North Anna Power Station, Unit Nos. 1 and 2, and Surry Power Station, Unit Nos. 1 and 2, respectively. Pursuant to Title 10 of the *Code of Federal Regulations,* Part 20, DEK, DNC, and Dominion requested approval by the Nuclear Regulatory Commission (NRC) to use weighting factors for calculating external whole body dose as specified in HPS N13.41, "Criteria for Performing Multiple Dosimetry."

On the basis of its review, the NRC staff finds the licensee's request acceptable. The enclosed safety evaluation documents the findings. Please contact Donna Wright at (301) 415-1864, if you have any questions on this matter.

Sincerely,

***/RA/***

Melanie Wong, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-305, 50-245, 50-336,
50-423, 50-338, 50-339, 50-280,
and 50-281

Enclosure:
Safety Evaluation

cc: Distribution via Listserv

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO APPROVAL TO USE EFFECTIVE DOSE EQUIVALENT

WEIGHTING FACTORS FOR EXTERNAL RADIATION EXPOSURE

DOMINION ENERGY KEWAUNEE, INC., DOMINION NUCLEAR CONNECTICUT, INC.,

VIRGINIA ELECTRIC AND POWER COMPANY

KEWAUNEE POWER STATION, MILLSTONE POWER STATION, UNITS 1, 2, AND 3,

NORTH ANNA POWER STATION, UNIT NOS. 1, AND 2

SURRY POWER STATION, UNIT NOS. 1, AND 2

DOCKET NOS. 50-305, 50-245/336/423, 50-338/339, AND 50-280/281

## 1.0 INTRODUCTION

By the letter dated August 18, 2008 (Agencywide Document Access and Management System (ADAMS) Accession No. ML082321198), as superseded by letter dated September 22, 2008 (ADAMS Accession No. ML082670295), Dominion Energy Kewaunee, Inc.; Dominion Nuclear Connecticut, Inc., and Virginia Electric and Power Company (the licensees) requested approval by the U.S. Nuclear Regulatory Commission (NRC) for the use of the weighting factors listed in Table 1 in the American National Standard Institute (ANSI) HPS N13.41-1997, "Criteria for Performing Multiple Dosimetry," for external radiation exposures when demonstrating compliance with total effective dose equivalent (TEDE), based on requirements in Title 10 of the *Code of Federal Regulations* (10 CFR), Part 20, for Kewaunee Power Station; Millstone Power Station, Units 1, 2, and 3; North Anna Power Station, Unit Nos. 1 and 2; and Surry Power Station, Unit Nos. 1 and 2. ANSI/HPS N13.41-1997 was approved December 1996.

The licensees stated that accurate assessment of occupational exposure of workers from external sources of radiation in highly non-uniform radiation fields requires a method for assessing the effective dose equivalent (EDE) and that the use of the proposed weighting factors will improve the accuracy of the licensees' assessment of occupational exposure. Therefore, the effect of granting this request would be to allow the licensees the option to control EDE 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

Section 20.1003 of 10 CFR defines EDE or $H_E$ as "the sum of the products of the dose equivalent to each tissue ($H_T$) and the weighting factors ($\omega_T$) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma_T \omega_T H_T$)." Each tissue weighting factor 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. For the purposes of implementing workplace controls, and due to the difference in dosimetry methods, 10 CFR 20.1003 breaks EDE into two components, 1) dose resulting from radioactive sources internal to the body, and 2) dose resulting from sources external to the body. The doses from external and internal exposures are then summed to obtain the total effective dose equivalent TEDE. Several dose limits (such as those in 10 CFR 20.1201(a)(1)(i) and 10 CFR 20.1301(a)) and other requirements in Part 20 are based on TEDE.

As of February 15, 2008, 10 CFR 20.1003 defines TEDE as the "sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)." The committed effective dose equivalent is the sum of the products of the dose equivalents to each tissue, from radioactive material taken into the body, integrated over 50 years, and the weighting factor applicable to that tissue.

In most relatively uniform exposure situations, a single dosimeter, calibrated to measure deep dose equivalent (DDE), worn on the whole body, provides a reasonably accurate estimate of the EDE from external exposures ($EDE_{ex}$). 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 $EDE_{ex}$. To ensure a conservative TEDE determination, 10 CFR 20.1201(c) requires that when external exposure is determined by measurement with an external monitoring device, the DDE, measured for the part of the body receiving the highest exposure, must be used in place of the $EDE_{ex}$, unless the $EDE_{ex}$ is determined by a dosimetry method approved by the NRC.

Using DDE in place of $EDE_{ex}$ can be overly conservative in extremely non-uniform irradiations (e.g., 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 Part 20.

## 3.0 TECHNICAL EVALUATION

The NRC staff has reviewed the technical approach for estimating $EDE_{ex}$ provided in ANSI/HPS N13.41-1997. This multiple dosimetry method divides the whole body into seven separate compartments. Each compartment, or combined compartment (since ANSI/HPS N13.41-1997 allows combining adjacent compartments), is monitored separately. Consistent with their current practice, the licensees have stated that the thorax and abdomen will be combined into a single combined compartment and will be monitored with a single dosimeter. The results of the dose measurement for each compartment, or composite 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 ANSI/HPS N13.41-1997. The factor for each compartment was developed by summing the stochastic weighting factors given in 10 CFR Part 20 for all the organs located within that compartment. For each tissue that reside in more than one compartment (i.e., 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 International Commission on Radiation Protection Publication 23.

Fundamental to this 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 ANSI/HPS N13.41-1997 are small enough so that under most 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 the compartment (particularly the thorax and abdomen compartments). In these cases, dosimeter placement, in each compartment becomes critical to ensuring that the $EDE_{ex}$ is not underestimated.

To ensure that the estimates of $EDE_{ex}$ are conservative, the licensees have committed to measuring the dose to each compartment (and/or combined 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 the licensees currently use for demonstrating compliance with 10 CFR 20.1201(c).

The licensees have stated that in uniform exposure situations, a single dosimeter placed on the wearer's chest, consistent with the licensees' current practice, will be used to monitor external exposure.

## 4.0 CONCLUSION

The NRC staff concludes that the licensees' proposed method for dose measurement using the multiple dosimetry method to determine $EDE_{ex}$ by applying the weighting factors listed in Table 1 of ANSI/HPS N13.41-1997, as discussed above in Section 3.0 of this report, is consistent with the ANSI/HPS standard and with the requirements of 10 CFR Part 20, and is therefore acceptable for the purposes of demonstrating compliance with the TEDE-based requirements in 10 CFR Part 20.

Principal Contributor: R. Pedersen, NRR

Date: February 24, 2009