Omaha Public Power District

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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Reference: Docket No. 50-285

Subject: Fort Calhoun Nuclear Station, "Request for Exemption from 10 CFR 20.1003 Definition of "Total Effective Dose Equivalent"

Pursuant to 10 CFR 20.2301, Omaha Public Power District (OPPD) requests an exemption from the requirements of 10 CFR 20.1003 of the definitions. OPPD is requesting that the definition of TEDE be revised to: "Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent or deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)."

Attachment 1 contains the Request For Exemption From 10 CFR 20.1003 Definition Of "Total Effective Dose Equivalent." Attachment 2 describes the Implementation Guidelines For Exemption From The 10 CFR 20.1003 Definition Of Total Effective Dose Equivalent (TEDE).

This request and its supporting information are consistent with requests from other licensees to apply nuclear industry sponsored research to enable more efficient utilization of personnel dosimetry.

If you have any questions or require additional information, please contact Dr. R. L. Jaworski at (402) 533-6833.

Sincerely,

R. T. Ridenoure
Division Manager
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A001

RTR/RLJ/rlj

Attachment 1 Request for Exemption from 10 CFR 20.1003 Definition of "Total Effective Dose Equivalent"

Attachment 2 Implementation Guidelines For Exemption From The 10 CFR 20.1003 Definition Of Total Effective Dose Equivalent (TEDE)

c: E. W. Merschoff, NRC Regional Administrator, Region IV
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J. G. Kramer, NRC Senior Resident Inspector
Winston & Strawn (w/o Attachment)

Attachment 1

REQUEST FOR EXEMPTION

FROM 10 CFR 20.1003

DEFINITION

OF

TOTAL EFFECTIVE DOSE EQUIVALENT

1.0 REGULATORY BACKGROUND

Commercial nuclear power plants are subject to the requirements of 10 CFR Part 20, "Standards for Protection Against Radiation." Section 20.4 of these requirements issued in 1960 (Ref. 5.1) stated that:

> For determining exposure to X or gamma rays up to 3 MeV, the dose limits specified in Section 20.101 to 20.104 inclusive, may be assumed to be equivalent to the air dose. For the purpose of this part, air dose means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of the highest dose rate.

On May 21, 1991 (Ref. 5.2), a final rule was published in the Federal Register that amended 10 CFR Part 20 to update the NRC's "Standards for the Protection Against Radiation." The purpose of that update

> ...puts into practice recommendations from [International Commission on Radiological Protection] ICRP Publication 26 and subsequent ICRP publications. The revision conforms the Commission's regulations to the Presidential Radiation Protection Guidance to Federal Agencies for Occupational Exposures signed by the President on January 20, 1987. The ICRP recommendations and Presidential guidance were based on the concept of the effective dose equivalent.

The final rule included definitions for *"deep-dose equivalent," "effective dose equivalent," "total effective dose equivalent,"* and *"weighting factor."* The final rule allowed using risk-weighted organ dose "effective dose" concept for internal doses without permitting a similar approach to be employed for external doses.

The NRC also noted (Ref. 5.2):

> The ICRP and 1987 Federal guidance on occupational radiation exposure in principle permit the use of external weighting factors. However, none of the principal standard-setting organizations has included specific recommendations for the use of weighting factors for external dose.
>
> The application of weighting factors also entails calculation of organ doses instead of whole-body doses from external radiation. One component of this calculation is estimation of the attenuation of the radiation as a function of the depth of the organ in the body. There are practical problems in the determination of the type and energies of the radiation involved and of the orientation of the

individual with respect to the source of the radiation that have to be considered in making such calculations. There, application of weighting factors for external exposures will be evaluated on a case-by-case basis until more guidance and additional weighting factors (such as for the head and the extremities) are recommended.

Final rule: ...For the purpose of weighting the external whole-body dose (for adding it to the internal dose), a single weighting factor, w* = 1.0, has been specified. The use of other weighting factors for external exposure may be approved on a case-by-case basis on request to the NRC.

Finally, 10 CFR 20.1003 Definitions states that: "*Total Effective Dose Equivalent* means the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for Internal exposures)."

2.0 INDUSTRY BACKGROUND

The regulations in 10 CFR Part 20 were known to be appropriately conservative and within the capability of the technology and analytical methods at the time of its publication over 40 years ago. Nuclear utilities, in most cases, used film badges to demonstrate compliance with these regulations in the sixties and seventies and more recently started using thermoluminescent dosimeters (TLD) to measure occupational exposure to penetrating photon radiation.

Radiation dosimetry had advanced a great deal by the time of the original publication of 10 CFR Part 20. A significant advance was summarized in the publication of the ICRP 26 in 1977 (Ref. 5.3) which introduced the concept of risk-based radiation dose limits; i.e. Effective Dose Equivalent (EDE). This concept was based on the fact that human organs and tissues differ in their susceptibility to the effects of radiation. To account for these differences, the ICRP proposed specific organ radiation exposure weighting factors. As noted above, this concept was later incorporated into the revision to 10 CFR Part 20 in 1991 for internal doses, but not for external doses. The regulations required licensees to evaluate radiation exposures in terms of the EDE using the conservative assumption that the weighting factor for external exposure is one.

In 1988 a meeting of several radiation protection managers from nuclear power plants was held in Keystone, Colorado to identify important radiation protection issues that would benefit from EPRI research support. The attendees determined that dose assessment using the effective dose equivalent for external photon radiation was a high priority item that EPRI should support. The 10 CFR Part 20 regulations allowed licensees to propose alternative methods for evaluating the external radiation component of an EDE (Ref. 5.2).

In 1989, Batelle Northwest Laboratory was contracted by EPRI to conduct this research. In 1991, this research project moved to Texas A&M with the principal investigator. The EPRI Phase I Report was published in February 1993 (Ref. 5.4).

The research approach taken was to apply a validated and verified Monte Carlo computer code to calculate photon transport throughout the human body. The research used mathematical models for the human adult male and female and for a variety of external radiation sources, calculated energy deposition in a large number of human organs and tissues for a broad range of photon energies and radiation source geometries. Finally, given the published weighting factors, the researchers calculated the EDEs for these irradiations.

The results of the research showed the mathematical models of the human body and the computer code used to calculate external photon interactions within the body functioned correctly. This allowed the researchers to determine the dose equivalent to organs and tissues, which facilitated correct weighting and summing of doses to ascertain the EDEs.

The research described how the EDE varies with photon energy for various radiation beam source and point source geometries. The research discussed the relationship between an EDE and the location of dosimeters on the body and illustrated that dosimeter response to off-normal radiation beams (i.e., those that do not strike the body straight on) will not underestimate the EDE.

A paper based on this EPRI Phase 1 report was published in a peer-reviewed journal (Ref. 5.5).

The EPRI Phase 2 report was published in June 1995 (Ref. 5.6). This report presented calculations of photon energy fluence on the surface of the human body for a range of photon energies and source geometries. The researchers then derived algorithms from the energy fluence calculations and the Phase 1 results that can be applied to standard dosimeter readings to more accurately calculate effective dose equivalent. A comparison was then made of effective dose equivalent measurements using a physical model of the human torso with effective dose equivalent calculated by the algorithms under both laboratory and field conditions at a nuclear plant. Results from the laboratory and field trials yielded excellent agreement.

This research concluded that the widespread practice of supplementing a single front-worn dosimeter with additional dosimeters placed facing a radiation source can significantly overestimate effective dose equivalent. Using a single front-worn dosimeter is acceptable. Using the simple algorithms applied to two dosimeters (on the front and the back) yielded a more accurate and numerically lower effective dose equivalent under all radiation exposure situations.

A paper based on this EPRI Phase 2 report was published in a peer-reviewed journal (Ref. 5.7). Two other papers based on this research were also published in peer reviewed journals (Ref. 5.11 & 5.12). Another peer reviewed journal paper addressed the angular dependence of personnel dosimeters that are in current use at Omaha Public Power District (Ref. 5.13). Omaha Public Power District will continue to use dosimeters that have an angular response at least as good as that described in reference 5.13.

EPRI subsequently published a concise summary (Ref. 5.8) of the EDE research, explaining the methodology for assessing effective dose equivalent and presenting some simple guidelines illustrating how the methodology can be implemented at nuclear power plants. Omaha Public Power District is proposing to follow these guidelines.

The National Council on Radiation Protection and Measurements (NCRP) supports these EPRI results as identified in their Report No. 122 (Ref. 5.9). The NCRP provides practical recommendations on the use of personal monitors to estimate the effective dose equivalent and effective dose for occupationally exposed individuals. These recommendations are similar to the results of the EPRI research and the algorithms presented therein.

NRC Inspection Procedure 83724 (Ref. 5.10) includes criteria for the placement of personal extremity dosimeters in non-uniform radiation fields. The procedure also includes a suggested dose gradient threshold for relocating or providing additional dosimetery.

3.0 EXEMPTION REQUEST

10 CFR 20.1201(a)(1) defines the annual occupational dose limits for adults "...which is the more limiting of: (i) The total effective dose equivalent... or (ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye..." Omaha Public Power District is requesting that the definition of TEDE be revised to: "Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent or deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)." Omaha Public Power District is requesting the option to use the analogous basis for deep-dose equivalent, i.e., effective dose equivalent and the EPRI methodology. (Note that 10 CFR 20.1201(c) already permits other radiation measurements to be used to assess the deep-dose equivalent, lens-dose equivalent and shallow-dose equivalent if the individual monitoring device was not in the region of highest potential exposure.) This change in definition would enhance the effectiveness of the final rule because it helps to accomplish the purpose of the original revision to Part 20 (Ref. 5.2) to put into practice the ICRP Publication 26 recommendations and to implement the 1987 Presidential guidance on occupational radiation exposure, both of which are based on the concept of effective dose equivalent.

Omaha Public Power District is requesting to use the EPRI methodology as an acceptable alternative approach for accomplishing the Commission's objectives as specified in Part 20.1201(a)(1). Omaha Public Power District would like the option to apply this EPRI approach where there is expected to be a significant difference between the deep-dose equivalent and the effective dose equivalent as defined in Part 20.1003. An example of this situation would be work in an area of high exposure where multiple dosimeters or placing of dosimeters on the part of the whole body receiving the highest dose are dictated. Procedures would specify when to use the current industry practice and when to use the alternative approach.

Omaha Public Power District would propose to use the option to monitor dose using the EDE_{EX} based on the following:

1. The EPRI weighted, two-dosimeter algorithm such that

$$EDE_{EX} = \frac{1}{2}\left[MAX + \frac{1}{2}\left(R_{front} + R_{back}\right)\right]$$

   where R_{front} is the reading of the dosimeter on the front of the body, R_{back} is the reading of the dosimeter on the back of the body, and MAX is the higher of the front or back dosimeter readings.

2. The radiological work will be conducted and the dosimeters worn in such away, that no shielding material is present between the source of radiation and the whole body, such that would cast a shadow on the dosimeter(s).

3. The dosimeters used to calculate EDE_{EX} will have demonstrated angular response at least as good as that specified in Health Physics Volume 68 No. 2, "A study of the Angular Dependence Problem in Effective Dose Equivalent Assessments." In addition, the dosimeters will be calibrated to indicate Deep Dose Equivalent at the monitored location to ensure their readings reflect electronic equilibrium conditions.

4. The Omaha Public Power District would not propose to use EDE_{EX} in situations where the sources of radiation are nearer than 12 inches (30 cm) from the surface of the whole body.

4.0 JUSTIFICATION FOR EXEMPTION

10 CFR 20.2301 states that the Nuclear Regulatory Commission may grant an exemption from the requirements of the regulations contained in 10 CFR Part 20 provided that:

- The exemption is authorized by law; and
- The exemption would not result in undue hazard to life and property.

The requested exemption satisfies the 10 CFR 20.2301 criteria as stated below:

A. The requested exemption is authorized by law.

10 CFR 20.2301 authorizes the Nuclear Regulatory Commission to grant this exemption.

B. The requested exemption does not present an undue hazard to life or property.

The requested exemption will allow use of a well-founded and more accurate means of estimating worker radiation exposure and does not impact public health and safety or present an undue hazard to life or property.

5.0 REFERENCES

5.1 Federal Register (25 FR 10914), November 17, 1960
5.2 Federal Register (56 FR 23360), May 21, 1991
5.3 ICRP Publication 26, Recommendations of the ICRP Annals of the ICRP, 1977
5.4 EPRI TR-101909, Volume 1; Assessment of the Effective Dose Equivalent for External Photon Radiation, Volume 1: Calculational Results for Beam and Point Source Geometries, Final Report, February, 1993
5.5 Reece, W. D.; Poston, J. W.; Xu, X.G. Determining the effective dose equivalent for external photon radiation: Calculational results for beam and point source geometries. Radiation Protection Dosimetry Volume 55, No. 1, 1994, pp. 5-21.
5.6 EPRI TR-101909, Volume 2; Assessment of the Effective Dose Equivalent for External Photon Radiation, Volume 2: Calculational Techniques for Estimating External Effective Dose Equivalent from Dosimeter Readings. Final Report, June, 1995
5.7 Xu, X. G.; Reece, W. D.; Poston, J. W. A study of the angular dependence problem in effective dose equivalent. Health Physics Volume 68, No. 2, February 1995, pp. 214-224.
5.8 EPRI TR-109446, Criteria and Methods for Estimating External Dose Equivalent from Personnel Monitoring Results: EDE Implementation Guide, Final Report, September, 1998
5.9 NCRP Report No. 122, Use of Personal Monitors to Estimate Effective Dose Equivalent and Effective Dose to Workers for External Exposure to Low-LET Radiation, December 27, 1995
5.10 NRC Inspection Manual, Inspection Procedure 83724, External Occupational Exposure Control and Personnel Dosimetery, April 17, 2000
5.11 Xu, X. G.; Reece, W. D. Sex-Specific Tissue Weighting Factors for Effective Dose Equivalent Calculations. Health Physics Volume 70, No. 1, January 1996, pp. 81-86
5.12 Reece, W. D.; Xu, X. G. Determining Effective Dose Equivalent for External Photon Radiation: Assessing Effective Dose Equivalent from Personal Dosimeter Readings. Radiation Protection Dosimetry, Volume 69, No. 3, 1997, pp. 167-178.

5.13 Plato, P.; Leib, R.; Miklos, J. Two Methods for Examining Angular Response of Personnel Dosimeters. Health Physics Volume 54, No. 6, June 1988, pp. 597-606.

ATTACHMENT 2

IMPLEMENTATION GUIDELINES FOR EXEMPTION

FROM THE 10CFR 20.1003

DEFINITION OF TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)

1) TEDE will be calculated as defined in section 20.1003 of 10 CFR 20. It will be calculated as the sum of the deep-dose equivalent (for external exposures) determined by use of the EPRI EDE methodology and the committed effective dose equivalent (for internal exposures).

2) Total organ dose will not be calculated using the EPRI methodology. The organ dose will be calculated as a Committed Dose Equivalent (CDE) as defined in section 20.1003 of 10 CFR 20. The EPRI methodology will only be applied to determination of TEDE for external whole body exposures.

3) For routine tasks and known radiation environment, the single-dosimeter method will be used. This method is the same as current NRC approved method.
   a) For potential high-level whole-body exposures where multiple dosimeters would normally be assigned, the EPRI two-dosimeter methodology will be used.
   b) Partial body exposures are rare in nuclear power plants. The EPRI methods are not intended for partial body exposures.

4) The criteria for use of dosimetry are provided in section 4 of EPRI TR-109446 (reference 5.8). The NRC approved dosimetry method (EPRI algorithm [A1]) will be used for all routine dosimetry. Where procedures and guidance specify multiple dosimetry, Omaha Public Power District will use methodology and algorithm [A3], with one badge on the chest and one badge on the back of the torso. The EPRI algorithm [A3] is the more conservative of the two EPRI algorithms for multi-badging situations while still providing a realistic estimate of the dose to the worker.

5) The dosimeters to be used in the EPRI EDE methodology are the same dosimeters used for compliance with the NRC approved methodology and have the same directional response. A February 1995 article in "Health Physics" describes the effect of directional response on the EPRI EDE methodology and on the NRC approved methodology.

   In a paper published in 1988, the Panasonic UD-802 dosimeter (the dosimeter currently used by Omaha Public Power District) was tested for angular dependence from 0° to 90° polar and azimuthal angles of incidence. The discussion section of the paper concluded that the Panasonic UD-802 dosimeter can pass the 0.5 tolerance limit at 90° for high-energy gamma rays (662 keV, Cs-137). The data demonstrated that the measured exposure at angles from 0° to 90° for these high-energy gamma rays characteristic of a nuclear power plant environment are well within the NVLAP tolerance limit for dosimetry and conservative compared to the calculated EDE.

6) The EPRI methodology will not be used in a water environment such as experienced by divers.

Supporting Information

1) Data comparing the EPRI EDE methodology with NRC approved methodology for various workers in high exposure jobs such as steam generator worker and work performed in the lower reactor cavity is summarized in Table 1. The information in Table 1 is for multi-badged people randomly selected from 1993 through 2002. The doses listed in Table 1 were calculated using the EPRI A3 method for individuals who had multi-badges that included the chest and back, and then compared to the highest whole body dosimeter reading from the set of dosimeters for the individuals.

   Results from the comparison show an average percent difference of –16% when using the EPRI EDE methodology to assign TEDE with that using the NRC approved methodology.

Table 1: Comparison of Multibadged Radiation Workers

Worker No.	NRC Maximum mrem	EPRI Method Option (3) mrem	% Difference	EDE/Chest
1	182	85	-53%	0.853
2	484	417	-14%	0.873
3	274	116	-58%	0.895
4	383	153	-60%	0.897
5	416	374	-10%	0.898
6	107	99	-8%	0.923
7	205	97	-53%	0.930
8	150	140	-7%	0.933
9	63	47	-25%	0.945
10	600	575	-4%	0.958
11	870	564	-35%	0.960
12	164	142	-14%	0.971
13	120	114	-5%	0.972
14	500	414	-17%	0.974
15	237	222	-6%	0.978
16	205	197	-4%	0.983
17	92	82	-11%	0.985
18	225	223	-1%	0.989
19	545	474	-13%	0.996
20	92	90	-2%	0.997
21	800	575	-28%	1.000
22	250	200	-20%	1.000
23	950	600	-37%	1.000
24	235	165	-30%	1.019
25	200	195	-3%	1.083
26	453	431	-5%	1.183
27	625	588	-6%	1.237
28	120	93	-23%	1.321
29	133	121	-9%	1.424
30	400	355	-11%	1.614
31	600	165	-73%	1.833
Avearge Difference			-16%	
Range				
Minimum			-73%	
Maximum			-1%	
Total Magitude			71%	

2) EPRI methodology requires at least one of the two dosimeters (one on the chest and one in the center region of the back) to "see" the radiation source. Peer-reviewed papers have shown that at least one of the two dosimeters will "see" the whole-body irradiation, thereby allowing for accurate readings. Easy-to-use dosimeter holders will keep the dosimeters close to the torso in a desirable orientation. Peer-reviewed papers also show that, as the worker moves around, the chance for each dosimeter to "see" the radiation will increase, and the weighted average reading gives realistic dose to the worker. Multi-badge historical data shows that the chest badge or back badges are always exposed to the sources of radiation.