Entergy

Entergy Nuclear Northeast
Entergy Nuclear Operations, Inc.
440 Hamilton Avenue
P. O. Box 5029
White Plains, NY 10601-5029
Tel 914 272 3500

July 20, 2001
IPN-01-055
JPN-01-011
ENGC Ltr.-1.2.01.079
CNRO-2001-00030

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station PI-137
Washington, DC 20555-0001

SUBJECT: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
Pilgrim Nuclear Power Station
Docket No. 50-293
Arkansas Nuclear One, Units 1 & 2
Docket Nos. 50-313 & 50-368
James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
Waterford 3 Steam Electric Station
Docket No. 50-382
Grand Gulf Nuclear Station
Docket No. 50-416
River Bend Station
Docket No. 50-458
Supplement and Amendment to "Request for Exemption from 10 CFR 20.1003 Definition of "Deep-Dose Equivalent" and Permission to Use External Whole Body "Weighting Factors" Other than 1.0"

Reference: Letter from Michael R. Kansler (ENOI, ENGC) and Gary J. Taylor (EOI) dated May 1, 2001 [IPN-01-041, JPN-01-008, ENGC Ltr.-1.2.01.037, CNRO-2001-00023*] *Corrected May 9, 2001

Dear Sir:

Entergy is amending its May 1, 2001 exemption request to incorporate several changes and improvements suggested by the NRC staff. This revised exemption request supersedes and replaces the prior application in its entirety.

IE70
A001

In the referenced letter, Entergy Operations, Inc. (EOI), Entergy Nuclear Operations, Inc. (ENOI) and Entergy Nuclear Generating Company (ENGC) *[Entergy]* submitted a request pursuant to 10 CFR 20.2301 for an exemption from the requirements of 10 CFR 20.1003, Definitions, for "*deep-dose equivalent*" and permission to use external whole body "*weighting factors*" other than 1.0 in calculating the "*effective dose equivalent*" for external exposures within the scope of 10 CFR 20.1202 and other applicable sections. In this letter Entergy asked for a meeting to discuss the request.

Subsequent to Entergy's submittal, the NRC staff performed a "Completeness and Acceptance Review of Entergy's Request for Exemption from the 10 CFR 20.1003 Definition of Deep-Dose Equivalent (DDE)" in an internal memorandum to file, dated May 29, 2001, and transmitted to Entergy via facsimile the same day. The NRC staff raised eleven (11) questions. The meeting with the NRC staff requested by Entergy in its May 1, 2001 letter occurred at the NRC offices in Rockville, MD on June 18, 2001. At the meeting, Entergy provided a response to the NRC staff questions of May 29, 2001 as well as amplified on other aspects of the submittal, and answered additional questions.

Entergy also had a conference call with the NRC staff on June 27, 2001 to discuss details of this revised submittal. Based on this conversation and the recommendations from the NRC's Office of General Counsel, Entergy is revising its submittal.

Entergy is modifying its exemption submittal to request only a change in the definition of "*total effective dose equivalent*" as defined in 10 CFR 20.1003. Entergy is requesting that: "*Total Effective Dose Equivalent* (TEDE) means the sum of the effective dose equivalent or the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)." The original exemption request has been revised; bars in the margin indicate changes (See Attachment 1). Additional references discussed at the June 18, 2001 meeting and the June 27, 2001 phone call have been added for completeness.

Entergy is also supplementing its original exemption request with additional information; namely the responses to the staff's questions based on the discussions which took place at the meeting on June 18, 2001(See Attachment 2) and the phone conversation on June 27, 2001.

If you have any questions, please contact Mr. J. Kelly at (914) 272-3370.

Very truly yours,

Michael R. Kansler
Senior Vice President and
Chief Operating Officer
ENOI, ENGC

Gary J. Taylor
Senior Vice President &
Chief Operating Officer
EOI

Attachments: cc: See next pages

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

Attachment 2 Entergy's Response to NRC Completeness and Acceptance Review Dated 5/29/01 of Entergy's Request for Exemption from the 10 CFR 20.1003 Definition of Deep-Dose Equivalent (DDE) cc:

ENOI, ENGC

Mr. Hubert J. Miller
Regional Administrator, Region I
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

PILGRIM

Mr. Douglas Starkey, Project Manager
Project Directorate I
Office of Nuclear Reactor Regulation
Mail Stop: O-8B-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Senior Resident Inspector
Pilgrim Nuclear Power Station
600 Rocky Hill Road
Plymouth, MA 02360

Mr. Robert Hallisey
Radiation Control Program
Center for Communicable Diseases
Mass. Dept. of Public Health
305 South Street
Jamaica Plain, MA 02130

INDIAN POINT 3

Mr. Patrick Milano, Project Manager
Project Directorate I-1
Office of Nuclear Reactor Regulation
Mail Stop: O-8-E20
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Resident Inspector's Office
Indian Point 3 Nuclear Power Plant
U. S. Nuclear Regulatory Commission
P. O. Box 337
Buchanan, NY 10511

JAMES A FITZPATRICK

Mr. Guy Vissing, Project Manager
Project Directorate I
Office of Nuclear Reactor Regulation
Mail Stop: OWFN 8C2
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Resident Inspector's Office
James A. FitzPatrick Nuclear Power Plant
U. S. Nuclear Regulatory Commission
P. O. Box 136
Lycoming, NY 13093

ENOI

Mr. William M. Flynn, President
New York State Energy, Research,
And Development Authority
Corporate Plaza West
286 Washington Avenue Extension
Albany, NY 12203-6399

EOI

Mr. Ellis W. Merschoff
Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, TX 70611-8064

ANO Units 1 & 2

Mr. R. L. Bywater
NRC Senior Resident Inspector
P. O. Box 310
London, AR 72847

Mr. William Reckley
NRR Project Manager Region IV/ANO-1
U. S. Nuclear Regulatory Commission
Mail Stop 7-D-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Mr. Thomas W. Alexion
NRR Project Manager Region IV/ANO-2
U. S. Nuclear Regulatory Commission
Mail Stop 7-D-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Mr. David D. Snellings
Director Division of Radiation
Control and Emergency Management
Arkansas Department of Health
4815 West Markham Street
Little Rock, AR 72205

GGNS

Mr. T. L. Hoeg,
NRC Senior Resident Inspector
P. O. Box 399
Port Gibson, MS 39150

Mr. S. P. Sekerak
NRR Project Manager Region IV/GGNS
U. S. Nuclear Regulatory Commission
Mail Stop 7-D-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Dr. D. F. Thompson
State Health Officer
State Board of Health
P. O. Box 1700
Jackson, MS 39205

RBS

Mr. P. J. Alter
NRC Senior Resident Inspector
P. O. Box 1051
St. Francisville, LA 70775

Mr. R. E. Moody
NRR Project Manager Region IV/RBS
U. S. Nuclear Regulatory Commission
Mail Stop 7-D-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

WF3

Mr. T. R. Farnholtz
NRC Senior Resident Inspector
P. O. Box 822
Killona, LA 70066

Mr. N. Kalyanam
NRR Project Manager Region IV/WF3
U. S. Nuclear Regulatory Commission
Mail Stop 7-D-1
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

RBS & WF3

Mr. Prosanta Chowdhury
Radiation Emergency Response Supervisor
Louisiana Department of Environmental Quality
P. O. Box 82215
Baton Rouge, LA 70884-2215

ATTACHMENT 1~~to~~
IPN-01-~~044~~ 055
JPN-01-~~008~~ 011
ENGC Ltr.-1.2.01.~~037~~ 079
CNRO-2001-~~00023~~ 00030

REQUEST FOR EXEMPTION FROM 10 CFR 20.1003
DEFINITION OF ~~"DEEP DOSE EQUIVALENT" AND PERMISSION TO USE EXTERNAL WHOLE BODY "WEIGHTING FACTORS" OTHER THAN 1.0~~
TOTAL EFFECTIVE DOSE EQUIVALENT

ENTERGY OPERATIONS, INC.
ENTERGY NUCLEAR OPERATIONS, INC.
ENTERGY NUCLEAR GENERATING COMPANY

~~May 9~~ July 20, 2001

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_T = 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 yeas 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. ~~6.3~~ 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 ~~accepted for publication~~ 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 ~~trails~~ 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 ~~accepted for publication~~ 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 Entergy (Ref. 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. Entergy is proposing to follow these guidelines at its nuclear facilities.

These EPRI Phase 1 and Phase 2 research reports address the NRC's concerns raised in the Statements of Consideration identified above.

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. Changes to this and other NRC guidance documents may be appropriate if this exemption is approved.

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..." Entergy 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)." Entergy is requesting the option: (1) to use the analogous basis for deep-dose equivalent, i.e., effective dose equivalent, and the EPRI methodology (2) to use the organ dose weighting factors as specified in Part 20.1003 for the external whole body dose instead of the current single weighting factor of 1.0. (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.

Entergy 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). Entergy 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 examples of this situation would be work in an area of high exposure received from a non-uniform radiation source where multiple dosimeters or placing of dosimeters on the part of the whole body receiving the highest dose are dictated. Individual facility procedures would specify when to use the current industry practice and when to use the alternative approach.

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
IPN-01-055
JPN-01-011
ENGC Ltr.-1.2.01.079
CNRO-2001-00030

ENTERGY'S RESPONSE TO NRC COMPLETENESS AND ACCEPTANCE REVIEW DATED 5/29/01 OF ENTERGY'S REQUEST FOR EXEMPTION FROM THE 10CFR 20.1003 DEFINITION OF DEEP-DOSE EQUIVALENT (DDE)

July 20, 2001

Question 1

(a) Address how TEDE will be calculated, and (b) how total organ dose will be calculated using EPRI methodology.

Response

(a) 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 using algorithm A3 (Ref. 5.8 in the exemption request) and the committed effective dose equivalent (for internal exposures).

(b) 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 exposure as requested in Entergy's exemption.

Question 2

Explain how non-uniform exposures (e.g. partial body exposures) will be handled.

Response

1. For routine tasks and known radiation environment, the single-dosimeter method will be used. This method is the same as current NRC approved method.
2. For potential high-level whole-body exposures where multiple dosimeters would normally be assigned, the EPRI two-dosimeter methodology will be used. In section 3.4 of reference 5.6 of Entergy's exemption request, the EPRI methodology is described as requiring at least one of the two dosimeters to "see" the radiation source. Peer-reviewed papers have shown that at least one of the two dosimeters will "see" (i.e., there is nothing between the dosimeter and the radiation source such that the radiation will be incident on the dosimeter) the whole- body irradiation, thereby allowing for accurate readings. Job-specific Radiation Work Permits will require the worker to move about to ensure this requirement is met and the use of the EPRI methodology is applicable.
3. Partial body exposures are rare in nuclear power plants. The above methods are not intended for partial body exposures.

Question 3

Explain why an exemption from 10CFR 20.1201(c) is not requested.

Response

Entergy did not request an exemption from the requirements of 10 CFR 20.1201(c) because section 20.1201(c) already includes a provision that "The deep-dose equivalent ... may be assessed from surveys or *other radiation measurements* for the purpose of demonstrating compliance with the occupational dose limits, if the individual monitoring device was not in the region of highest potential exposure..." Entergy considers the use of the EPRI EDE methodology as another radiation measurement.

Question 4
Compare the EPRI methodology to any independent work that validates it.

Response
The EPRI methodology has been published in peer-reviewed journals (references 5.5 and 5.7, in the exemption request). The National Council on Radiation Protection and Measurements (ref. 5.10 in the exemption request) published a similar methodology. Angular response of dosimeters is addressed in the response to Question 9.

Question 5
Present data that compares EDE with NRC approved methodology.

Response
Data comparing the EPRI EDE methodology with NRC approved methodology is provided in references 5.4, 5.5, 5.6, 5.7 and 5.8 in the exemption request. In particular, in section 4 of reference 5.6 of the exemption request a comparison of the EPRI methodology to NRC approved methodology on a phantom in a laboratory environment and in a nuclear power plant environment are provided.

In addition, Entergy collected dosimeter data using the EPRI methodology described in EPRI TR-109446 (reference 5.8) and compared the results with that obtained using NRC approved methodology. The data were collected for four workers performing In-service Inspections of welds at a BWR during a refueling outage in the fall of 2000. A comparison of the TEDE using the EPRI EDE methodology (EPRI TR-109446, reference 5.8, section 3.2) with that using NRC approved methodology is as follows:

Worker	NRC EDE [A1] mRem	EPRI EDE [A2] mRem	EPRI EDE [A3] mRem
1	387	312	349
2	369	275	322
3	451	338	394
4	292	250	271

Question 6
Provide criteria for how dosimetry should be used and worn.

Response
The criteria for use of dosimetry are provided in section 4 of EPRI TR-109446 (reference 5.8 of the exemption request). The NRC approved dosimetry method (EPRI algorithm [A1]) will be used for all routine dosimetry. Where procedures and guidance specify multiple dosimetry, Entergy is seeking the option to use the EPRI 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.

Question 7
Provide guidance regarding how and when dosimetry reading should be "adjusted."

Response
The guidance regarding how and when dosimetry reading should be "adjusted" are provided in section 4 of EPRI TR-109446 (reference 5.8 of the exemption request). Single badge doses will not be "adjusted." When procedures and guidance recommend multi-badging, the EPRI methodology using algorithm A3, the weighted-average method, will be used as described in the answer to Question 6.

Question 8
Describe when each of the three EPRI methods will be used to estimate EDE.

Response
The EPRI method to be used to estimate EDE is described in section 4 of EPRI TR-109446 (reference 5.8 of the exemption request). The response to Question 6 provides specific commitments on the use of the method. The EPRI two-badge methodology using algorithm [A2], the simple average method, will not be used.

Question 9
Provide the directional response summary of the dosimeters planned for use and how directional sensitivity will be accounted for.

Response
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," (reference 5.7 of the exemption request) describes the effect of directional response on the EPRI EDE methodology and on the NRC approved methodology. See attached graph comparing ANSI standard and EPRI EDE results with dosimeter response from 0° to 60° which was derived from reference 5.7 of the exemption request.

In a paper published in 1988 (reference 5.13 of the exemption request), the Panasonic UD-802 dosimeter (the dosimeter currently used by Entergy) 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 in the attached graph.

Question 10
Describe how the methodology will account for different body positions during exposure.

Response
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. Job-specific Radiation Work Permits will require the worker to move about such that the EPRI methodology is satisfied. The computation of the two-dosimeter readings is detailed in the response to Question 6.

Question 11
Describe how TEDE will be calculated from non-uniform whole body exposures resulting from narrow-beam or partially shielded irradiations.

Response
The dosimetry placement for non-uniform exposures was described in response to question 2 and the method of calculation of TEDE was provided in the response to question 1.

Although partial body exposures are common in medical settings where narrow-beams or internal injection of radionuclides is involved, they are rare in nuclear power plants. The EPRI methodology is intended only for external whole-body exposure.

Graph plotted using data in Table 3 of ANSI N13.11-1993 "Personnel Dosimetry Performance – Criteria for Testing" and data in Reference 5.7 of the exemption request. For Cs-137 source E=662 keV.

The comparison shows that all dosimeters are required to have a conservative angular response curve compared to EDE for up to 60 degrees.