May 29, 2001

MEMORANDUM TO: File

FROM: Thomas W. Alexion, Project Manager ***/RA/***
Project Directorate IV, Section 1
Division of Licensing Project Management

SUBJECT: ARKANSAS NUCLEAR ONE, UNITS 1& 2, JAMES A. FITZPATRICK NUCLEAR POWER PLANT, GRAND GULF NUCLEAR STATION, INDIAN POINT 3 NUCLEAR POWER PLANT, PILGRIM NUCLEAR POWER STATION, RIVER BEND STATION, AND WATERFORD 3 STEAM ELECTRIC STATION RE: PROPOSED EXEMPTION FROM 10 CFR 20.1003 DEFINITION OF DEEP-DOSE EQUIVALENT (TAC NOS. MB1869, MB1870, MB1876, MB1889, MB1881, MB1880, MB1878, MB1868)

The U. S. Nuclear Regulatory Commission (NRC) staff has had discussions with Entergy Operations, Inc., Entergy Nuclear Operations, Inc., and Entergy Nuclear Generation Company (Entergy, or the licensee), on its May 1, 2001, request for exemption from the 10 CFR 20.1003 definition of deep-dose equivalent.

In order to facilitate these discussions, the NRC provided the licensee with a "completeness and acceptance" review of what appears to be unclear, inadequate or missing information that the licensee needs to address in order for the NRC to continue its review. This "completeness and acceptance" review does not represent final NRC positions and it may get revised as a result of discussions with the licensee. The purpose of this memorandum is to place the attachment in the Public Document Room.

Docket Nos. 50-313, 50-368, 50-333, 50-416, 50-286, 50-293, 50-458, 50-382

Attachment: As stated

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Completeness and Acceptance Review of Entergy's
Request for Exemption from the 10 CFR 20.1003
Definition of Deep-Dose Equivalent (DDE)

The NRC has done a preliminary "completeness and acceptance" review of the licensee's request for exemption from the 10 CFR 20.1003 definition of DDE. What follows is a discussion of what appears to be unclear, inadequate or missing information that the licensee needs to address in order for the NRC to continue its review. This "completeness and acceptance" review does not represent final NRC positions and it may get revised as a result of discussions with the licensee.

Exemption Request

The licensee's exemption request is not clear in several areas, and the staff has to infer from other information what is being requested. Examples of this and other weaknesses are addressed below:

In Section 3.0, "Exemption Request," the second paragraph states that "Entergy is requesting to use the EPRI [Electric Power Research Institute] methodology as an acceptable alternative approach for accomplishing the Commission's objectives as specified in Part 20.1201(a)(1)." Assuming that "the Commission's objectives" means "meeting the intent of the dose limits," and "the EPRI methodology" is the effective dose equivalent (EDE) implementation guide in Reference 5.8 (EPRI TR-109446, "Criteria and Methods for Estimating External Effective Dose Equivalent from Personal Monitoring Results, EDE Implementation Guide, September 1998," referenced in the background section of the application), the request is still incomplete. Part 20.1201(a)(1) gives dose limits for the total effective dose equivalent (TEDE) to the whole body and the total organ dose to any individual organ. The EPRI methodology only addresses an alternate method of estimating one component of TEDE, and does not meet the referenced requirement alone. The licensee needs to address how they will calculate TEDE, and how they will determine the total organ dose, with the EPRI methodology.

The rest of the second paragraph in Section 3.0 states that Entergy is requesting the option to apply the 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," and gives the exposure to a non-uniform radiation source as an example. The staff has to assume that the licensee is only referring to EDE from external exposures, since inhalation (or other intakes) of radioactive materials will produce an expected, appropriate, difference between EDE and DDE. However, given that, this statement is still incomplete and inaccurate. The only non-uniform source exposure discussed in the EPRI documents is from an exposure to a point source (i.e., hot particle) in proximity to the body torso. The bulk of the EPRI guidelines discusses how EDE can be calculated from exposure to mono-directional uniform broad-parallel-beam sources. The apparent non-applicability to truly non-uniform exposures (e.g., partial body exposures) is a weakness of the methodology discussed below.

In the second item in the first paragraph in Section 3.0, the licensee requests permission to apply the organ weighting factors in Part 20.1003 to the whole body for external whole body dose. It is unclear why the licensee is making this request. Although the organ weighting factors are used in calculating the basis for the EPRI methodology, the method itself uses algorithms with one or two dose measurements to estimate the EDE from external exposures.

It does not apply a weighting factor(s) to the whole body dose. In addition, it is unclear to the staff why the licensee has not requested an exemption from 10 CFR 20.1201(c), particularly the requirement to measure DDE at the part of the whole body receiving the highest exposure.

Supporting EPRI Documents

The licensee provided copies of the EPRI Technical Reports TR-101909, Volumes 1 and 2 (Assessment of the Effective Dose Equivalent for External Photon Radiation, Volume 1: Calculational Results for Beam and Point Source Geometries, February 1993, and Volume 2: Calculational Techniques for Estimating External Effective Dose Equivalent from Dosimeter Readings, June 1995) and TR-109446 that document the EPRI methodology for estimating external EDE, with their May 1, 2001, request. A preliminary review of these documents revealed the following weaknesses in the methodology and/or proposed request:

No comparison is provided of the EPRI methodology to any independent work that validates the methodology. The licensee does state that the EPRI recommendations are similar to those in National Council on Radiation Protection and Measurements (NCRP) Publication 122; however, these NCRP recommendations have not been adopted by the NRC.

The data presented in the tables and figures in the EPRI technical reports compare (or normalize) dose values or dosimeter responses to the value at the center of the chest. The reports do not include the estimated EDE that would be obtained from the current NRC approved method (e.g., the DDE at the whole body location receiving the highest dose). This is a shortcoming in that the licensee contends that the requested method is a significant improvement over the currently required method.

The EPRI methodology provides three ways to estimate EDE. The implementation recommendations in Section 4 of TR-109446 provide no clear criteria for when each should be used or how dosimetry is to be worn. The first method recommends a single badge worn on the front of the torso. Although the earlier discussion indicates this should be at waist level for males and chest level for females, no recommendation is made. Also, there is a discussion of using the data in TR-101909, Volume 2, to adjust this dosimeter reading “if necessary” with no guidance on when it is necessary or appropriate. The second method, that averages the readings of one dosimeter worn on the front of the torso and one worn on the back (again, no specifics on location), is to be used when the first method results in doses that are too conservative. For exposure situations where the second method results in doses that are not conservative, a second two-badge algorithm is provided. This algorithm weights the highest reading of the front or back badge by averaging it with the average used in the first method [e.g., (((a+b)/2)+a)/2, where a is the highest reading and b is the lowest reading of the two badges]. The licensee needs to clarify how they will determine which method is appropriate for each exposure situation.

Page 3-6 of TR-101909, Volume 2, states that the calculational methods that form the basis of the EPRI work, assume that dosimeters are isotropic and respond the same, regardless of the incident radiation direction. It goes on to acknowledge that real dosimeters are not usually isotropic, but then intimates that this is “advantageous.” However, in addressing this issue on page 4-18 of TR-101909, Volume 2, the report gives a reference to an earlier paper by the authors with some vague conclusions that this work can be used to improve the EDE estimates

and/or redesign dosimeters. There is no clear discussion of the impact that the directional sensitivity/response function, of commercially available dosimeters, will have on implementing the EPRI recommendations. The staff notes that in the discussion, in Section 3.3 of TR-109446, on adjusting single dosimeter readings with the tabulated factors from TR-101909 Volume 2, EPRI notes that real dosimeters have a directional dependent response that needs to be factored in, and then warns that the "two-badge algorithms must use uncorrected readings." No rational is given for why the directional dependence of the badge sensitivity is a factor with one badge but not two badge algorithms. Many real dosimeters have very poor sensitivity to (and are not generally considered calibrated for) radiation incident on the badge at more than 60 degrees off normal to the badge face. The licensee needs to provide the directional response function of the dosimeters they intend to use with this EPRI methodology and how this directional sensitivity will be accounted for. The licensee needs to discuss situations where the source is generally in the same plane as the face of the dosimeter (i.e., a point source on the front of the body with one badge), as well as the impact of badge directional sensitivity on the application of the methodology in general.

The EPRI methodology is based on calculations that model a hermaphrodita human, standing erect with arms hanging to the sides. The computer code was "validated" with actual thermoluminescent dosimeter (TLD) measurements, again on an erect armless human torso. There is no discussion on the applicability of this EDE estimating methodology for differing exposure geometries (e.g., a squatting figure with legs shielding an anterior-posterior (A-P) exposure, a squatting figure with a source under foot, or an erect figure with arms extended, shielding the chest badge from an off center A-P exposure). It appears that these body positions, commonly assumed when working on mechanical equipment, would result in significantly different self-shielding results than those factored into the EPRI methodology. The licensee needs to demonstrate that the proposed dosimetry method is bounding for all reasonably foreseeable exposure situations.

Contrary to general statements made in both the EPRI documents and the licensee's request, the EPRI methodology is not applicable to all non-uniform exposure situations. The licensee needs to describe how they intend to calculate TEDE from non-uniform whole body exposures resulting from narrow beam, or partially shielded, irradiations.