

external sources (EDE_{ex}). However, in non-uniform exposure situations, such as from a directional source, DDE measured at the part of the whole body with the highest exposure can be an overly conservative estimate.

The NRC recently published RIS 2003-04 to encourage licensees to use the EDE_{ex} for determining TEDE whenever the dose from external sources is calculated instead of measured with personnel dosimetry. The RIS discusses the limitations on, and the regulatory basis for, substituting the EDE_{ex} for DDE in determining compliance with TEDE based regulatory requirements. Estimating EDE_{ex} from dosimeter readings is very dependent on exposure geometry. Therefore, RIS 2003-04 also noted that methods for estimating TEDE from an EDE_{ex} determined from dosimeter readings, must be approved by the NRC. The 2003-04 RIS also noted that NRC approved the use of a two dosimeter method for estimating effective dose equivalent at Entergy sites (Reference 1).

This RIS describes the exposure situations in which NRC would regard the use of a monitoring method to estimate EDE_{ex} as appropriate and acceptable for estimating TEDE. This RIS does not affect the definition of other non-TEDE limits or criteria in part 20.

Summary of Issues

Use of Effective Dose Equivalent

The NRC has approved a method for estimating EDE_{ex} from external photon exposure situations. The guidance in this RIS is based on the review and approval of the exemption for Entergy (Reference 1).

This method uses two dosimeter readings and is based on research conducted by the Electric Power Research Institute (EPRI). The EPRI work (References 2, 3, and 4) indicates that a single dosimeter, calibrated to read DDE and worn on the chest, provides a reasonably accurate estimate of EDE_{ex} when the individual is exposed to a number of randomly distributed radiation sources during the monitoring period. This is consistent with current allowable dosimetry practices and requires no special approval. However, for nonuniform exposures, such as from directional radiation fields or point sources, EDE_{ex} can be estimated from a reading of a dosimeter worn on the front (R_{front}) of the trunk of the body, combined with the reading of a dosimeter worn on the back (R_{back}) of the trunk of the body.

Two algorithms are given by EPRI for combining the dosimeter results:

9. Mean Method:

The first algorithm is a simple, un-weighted, average (MEAN) of the two dosimeter readings. The MEAN is equal to $\frac{1}{2}(R_{front} + R_{back})$.

The EPRI technical reports state that the non-weighted average does not always give a conservative result. Since no method is provided to identify when the simple average gives non-conservative results, *this algorithm is not approved for use at this time.*

10. Weighted Method:

The second algorithm, which was the subject of the Entergy exemption, is a weighted average algorithm such that:

$$EDE_{ex} = \frac{1}{2}(H_i + MEAN)$$

Where H_i is the higher of R_{front} or R_{back} .

A mathematically simpler form of this weighted algorithm is:

$$EDE_{ex} = \frac{3}{4}H_i + \frac{1}{4}L_o$$

Where H_i is the higher of R_{front} or R_{back} and L_o is the lower of R_{front} or R_{back} .

The data presented in the EPRI technical reports (references 1 and 2) indicate that this weighted two-dosimeter algorithm provides a reasonably conservative estimate of EDE_{ex} . Therefore, only the weighted two-dosimeter algorithm is approved for use at this time for exposures in a non-uniform field.

As a result of NRC approving the above weighted method, monitoring the DDE at the part of the body receiving the highest exposure as provided in 10 CFR 20.1201(c) is not needed for determining compliance with TEDE based requirements when the weighted method is used subject to the limitations which are set out below. This is because Footnote 2 in the "Organ Dose Weighting Factors" table in 10 CFR 20.1003, permits the use of weighting factors to determine external exposures without case-by-case approvals when specific NRC guidance has been issued. This RIS constitutes such guidance for using the above weighted method for determining the external exposure from weighted dosimeters measuring direct DDE. An exemption from part 20 is not needed if the guidance in this RIS is followed for determining external exposures. However, 10 CFR 20.1201(c) still applies to the DDE required to be used in complying with the organ dose limit in 10 CFR 20.1201(a)(1)(ii).

Additional Issues and Limitations

Licensees may, subject to the following limitations, use this weighted two-dosimeter method for determining EDE_{ex} , and estimating TEDE, from external photon exposures without applying for further approval from the NRC.

Partial-body irradiations (*i.e.*, exposure geometries that preferentially shield the dosimeters) could bias the EPRI method results in the non-conservative direction. Licensees must ensure that dosimeters are worn so that at least one of the two dosimeters "sees" the major source, or sources, of radiation (one dosimeter will normally be shielded from a source by the body). In other words, the radiological work will be conducted and the dosimeters worn in such a way, so that no shielding material is present between the radioactive source(s) and the whole body, that would cast a shadow on the dosimeter(s) and not over other portions of the whole body.

This method for estimating EDE_{ex} from dosimeter readings, is not valid for exposure situations where the individual is immersed in a shielding material (*i.e.*, diving operations). Large dose-rate gradients resulting from such immersions over the space occupied by the body can bias the two dosimeter results.

Only dosimeters that have demonstrated angular response characteristics at least as good as those specified in Reference 5, are to be used. If the dosimeter's response decreases more rapidly than EDE_{ex} , as the angle of incident radiation increases, the resulting EDE_{ex} estimate will be biased in the non-conservative direction. In addition, the dosimeters should be calibrated to indicate DDE at the monitored location to ensure their readings reflect electronic equilibrium conditions.

This method for estimating EDE_{ex} from two dosimeter readings is not applicable to exposure situations where the sources of radiation are nearer than 12 inches (30 cm) from the surface of the body. This is the closest distance that the two-dosimeter algorithm has been demonstrated to provide conservative results for discrete (point) radiation sources.

The use of monitoring methods for estimating EDE_{ex} , from exposure to point sources (*i.e.*, hot particles) on, or near the surface of the body, is outside the scope of this approval. Tables 5 through 7, in Reference 3, provide some calculated EDE_{ex} values resulting from exposure to point sources in contact with the torso of the body. However, the information provided in these tables does not bound all of the pertinent point source exposure situations.

Licensees using the weighted methodology need to maintain sufficient records to demonstrate the above limitations were satisfied.