Entergy

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Licensing
FAX Coversheet

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FAX:	
Phone:	
Date:	6/8/01
No. Sheets:	50

Message: As we discussed on the phone I have enclosed a DRAFT of the material we intend to present at the meeting scheduled for 6/18/01. This is a work in progress but will give the staff an opportunity to see the material we are developing before the meeting

John Kelly

DRAFT

EFFECTIVE DOSE EQUIVALENT

- 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

- John J. Kelly, Director - Licensing
- Entergy Nuclear Operations, Inc.
- X. George Xu, Ph.D., Associate Professor
- Nuclear Engineering and Health/Medical Physics
- Rensselaer Polytechnic Institute

- June 18, 2001

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Occupational Radiation Exposure

- Current Practice for Measuring and Reporting
- Changes in Technical and Regulatory Guidance
- Industry Activities to Address Changed Guidance

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Current Practice for Dosimetry

- Methodology Based on ICRP Guidance
- Conservative Measurement of Deep Dose Reported as EDE
- Reported Average Doses ARE Higher than EDE
- Present Methods Meet Regulatory Requirements

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Change in Guidance

- ICRP 26 - 1977
- 10 CFR 20 Changed - 1994
- NCRP 122 - 1995
- ANSI HPS N13.41 - 1997

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Industry Activities to Address Changed Guidance

- EPRI Research Initiated - 1988
- EPRI Phase I Report Issued - 1993
- Peer Review Journal Article - 1994
- EPRI Phase II Report Issued - 1995
- Peer Review Journal Article - 1995
- Peer Review Journal Article - 1996
- Peer Review Journal Article - 1997
- EPRI EDE Implementation Guide - 1998

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EXEMPTION REQUEST

- Use the analogous basis for deep-dose equivalent for external exposures [i.e., EDE] in meeting the 10 CFR 20.1201 (a) (1) annual occupational dose limits for adults
- No impact on the public or the worker's health and safety

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PERMISSION REQUEST

- Use the organ dose weighting factors in 10 CFR 20.1003 for the external whole body dose instead of the current single weighting factor of 1.0
- No impact on the public or the worker's health and safety

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ENTERGY APPPLICATION - THE OPTION

- 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 10 CFR 20.1003.
- No Technical Specification changes are required.

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ENTERGY APPPLICATION - THE OPTION (Cont'd)

- Individual licensees will evaluate the use of the EDE method and will modify applicable plant-specific radiation protection programs and procedures
- Compliance with 10 CFR 20 will be maintained at all times

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BWR Practical Example

ISI - Weld Inspections at JAF Refueling 2000

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

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PWR Practical Example

- See Separate Document entitled:
- "Analysis of EDE During Steam Generator Jumps Using the EPRI Methodology"
- Benjamin W. Morgan, CHP, Harris Nuclear Plant - CP&L
- Presented at EPRI EDE Workshop on August 13, 1997, in Atlanta, GA

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Conclusions

- Industry (EPRI) Theoretical and Measurement Work for New EDE Monitoring - COMPLETE
- Standards Setting Organizations (NCRP and ANSI/HPS) provide practical recommendations on the use of personal monitors to estimate the EDE (similar to EPRI's) - COMPLETE
- NRC needs to approve ENTERGY's application

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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 10CFR 20. It will be calculated as the sum of the DDE determined by use of the EPRI methodology for external and the committed effective dose equivalent for internal exposures.

(b) Organ dose from external emitters will 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 10CFR 20. The EPRI methodology will only be applied to determination of DDE as requested in Entergy's exemption[1].

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Question 2

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

Response:

Non-uniform (e.g., partial body) exposures will be handled using the DDE determined by use of the EPRI methodology as contribution to TEDE as defined in section 20.1003 of 10 CFR 20. In section 3.4 of reference 5.6 of Entergy's exemption[1] the EPRI methodology is described as requiring at least one of the two dosimeters to "see" the radiation source. Guidance in this and the other references will be utilized to assure validity of the dose determination in nonuniform or "partial body" exposures.

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Question 3

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

Response:

Entergy did not request an exemption from the requirements of 10CFR 20.1201(c) because 20.1201(c) already includes a provision that allows "...surveys or other radiation measurements" to be used in estimating DDE and SDE "if the individual monitoring device was not in the region of highest potential exposure..." Entergy considers the use of the EPRI EDE methodology as an alternate radiation measurement technique. Consequently, no exemption from 10CFR 20.1201(c) is necessary however, a request for permission to use a weighting factor other than 1.0 as discussed in footnote 2 to the table associated with the definition of "Weighting factor w_T" as defined in 10CFR20.1003 has been made. This is necessary to allow use of the EPRI methodology to calculate the DDE and its contribution to EDE.

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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[1]). A similar methodology was published by the National Council on Radiation Protection and Measurements (ref. 5.10 in the exemption request[1]). See attached presentation entitled: "Analysis of EDE During Steam Generator Jumps Using the EPRI Methodology", presented by Benjamin W. Morgan, CHP, Harris Nuclear Plant, CPL, at the EPRI EDE Workshop on August 13, 1997 in Atlanta, GA.

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Question 5

Present data that compares EDE with NRC approved methodology.

Response:

Data comparing the EPRI EDE methodology with NRC approved methodology are provided in references 5.4, 5.5, 5.6, 5.7 and 5.8 in the exemption request[1].
In particular, in section 4 of reference 5.6 of the exemption request[1] a comparison of the EPRI methodology to NRC approved methodology on a phantom in a laboratory environment and in a nuclear power plant environment is provided.
In addition, Entergy collected dosimetry 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 DDE using the EPRI EDE methodology (EPRI TR-109446, reference 5.8, section 3.2, equation 1) with the DDE using NRC approved methodology is as follows:

Worker	EPRI EDE	NRC EDE
	mRem	mRem
1	312	387
2	275	369
3	338	451
4	250	292

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Question 6

Provide criteria for use of 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[1]). A copy of this report was included as Attachment 3 to the exemption request.

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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[1].)

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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[1].)

See next Table for further discussion

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5. Results and Discussions (Cont.)

Evaluations of the Algorithms

Table 4.1.2. H'_E/H_E, ratio of the assessed effective dose equivalent[a], H'_E, to the actual effective dose equivalent received by a hermaphroditic individual, H_E, for different exposure geometries and photon energies.

Source Type	Source Geometry	1.0 MeV			0.3 MeV			0.08 MeV		
		A1	A2	A3	A1	A2	A3	A1	A2	A3
Parallel Beams	AP	1.23	0.87	1.05	1.25	0.79	1.02	1.14	0.63	0.89
	PA	0.56	0.97	1.17	0.39	0.96	1.25	0.17	0.76	1.05
	LAT	1.76	1.79	1.80	2.10	2.11	2.11	1.82	1.83	1.84
	Overhead[b]	2.04	2.03	2.04	2.49	2.47	2.48	2.25	2.24	2.24
	Underfoot	3.35	3.33	3.34	3.66	3.64	3.65	3.61	3.57	3.60
	Arbitrary[c]	1.49	0.99	1.24	1.71	0.99	1.35	1.64	0.86	1.25
Point Sources at Z=41 cm	X=0; Y= -44 cm	2.29	1.31	1.80	2.24	1.22	1.73	2.07	1.09	1.58
	X=44; Y= -44 cm	1.59	0.99	1.28	1.75	1.00	1.37	1.60	0.86	1.23
	X= 44 cm; Y= 0	1.30	1.30	1.30	1.33	1.31	1.32	0.99	0.95	0.97
	X= 44 cm; Y=44 cm	0.49	1.24	1.60	0.34	1.31	1.79	0.16	1.05	1.50
	X=0; Y= 44 cm	0.40	1.55	2.13	0.27	1.57	2.22	0.10	0.97	1.41
Point Sources at Z=06 cm	X=0; Y= -44 cm	1.23	0.72	0.98	1.28	0.70	0.99	1.14	0.60	0.87
	X=44; Y= -44 cm	1.34	0.83	1.08	1.45	0.81	1.12	1.31	0.69	1.00
	X= 44 cm; Y= 0	0.98	1.02	1.03	0.98	1.01	1.02	0.78	0.80	0.80
	X= 44 cm; Y=44 cm	0.40	1.07	1.41	0.23	1.11	1.55	0.11	0.97	1.39
	X=0; Y= 44 cm	0.31	1.01	1.36	0.20	1.15	1.63	0.08	0.85	1.24

[a] For A1, $H'_E = R_{Front}$. For A2, H'_E= Avg. (R_{Front}; R_{Back}). For A3, H'_E=[Max. (R_{Front}; R_{Back}) + Avg. (R_{Front}; R_{Back})]/2.
[b] Overhead beam source is realized by averaging over beams incident from polar angles within polar angle of 15°.
[c] Arbitrary geometry is realized by beams incident from both azimuthal and polar angles equal to 45°.

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Question 9

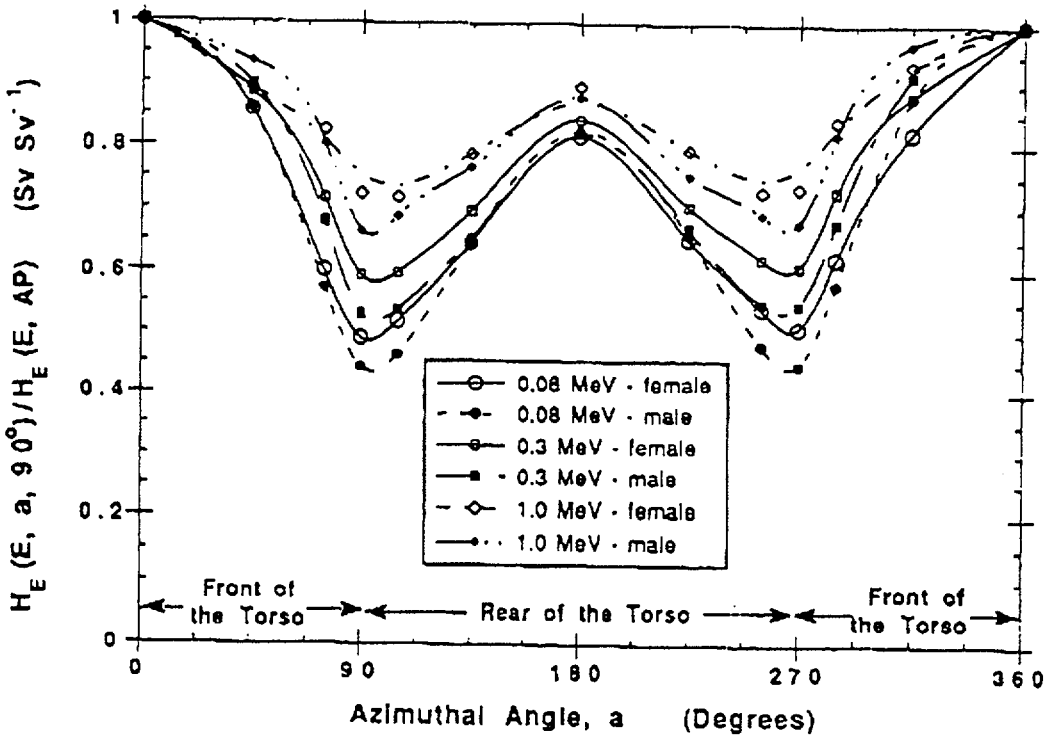
Provide the directional response summary of the dosimeters planned for use and how directional sensitivity will be accounted for.

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[1] describes the effect of directional response on the EPRI EDE methodology and on the NRC approved methodology.

See graph on next page for further discussion.

Optimum angular responses from our study



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$$R(E,\alpha) = \frac{H_E(E,\alpha)}{H_E(E,AP)} = 0.5 \times \{\cos[k(E) \times \alpha) + 1\}$$

E = photon energy (from 0.01 MeV to 10 MeV)

α = incident angle ($\leq 90°$);

k(E) = 0.66156-0.31814×$\log_{10}$E

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Question 10

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

Response:

The effect of different body positions on exposure for the EPRI EDE methodology are described in references 5.4, 5.5, 5.6, 5.7, and 5.8 of the exemption request[1].

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Question 11

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

Response:

TEDE for non-uniform whole body exposures resulting from narrow beam or partially shielded irradiations will be performed in the same manner as described in Entergy's answer to question 1and 2 of this summary response. Guidance is also provided in reference 5.7 of the exemption request[1].

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Analysis of EDE During Steam Generator Jumps Using the EPRI Methodology

Benjamin W. Morgan, CHP

Senior Analyst - HP Programs

Harris Nuclear Plant

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Presentation Outline

- The task
- The radiation environment
- Measuring the dose
  - dosimeter placement
  - dose results from past outages
  - analysis of ANSI and EPRI methodologies
  - selecting a method for calculating EDE

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The Task

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- HNP is a three-loop Westinghouse PWR
- Steam generators require eddy current testing and repair work each refueling
- Work is usually done with nozzle dams installed to minimize time that loops are drained

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The Task

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- Nozzle dams are installed and removed during steam generator "jumps"
- A "jump" is defined as a whole body entry into the steam generator channel head

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The Radiation Environment

- High levels of both radiation and contamination
- Radiation may vary by a factor of three between the manway and the tube sheet
- Continuous ventilation minimizes airborne contamination

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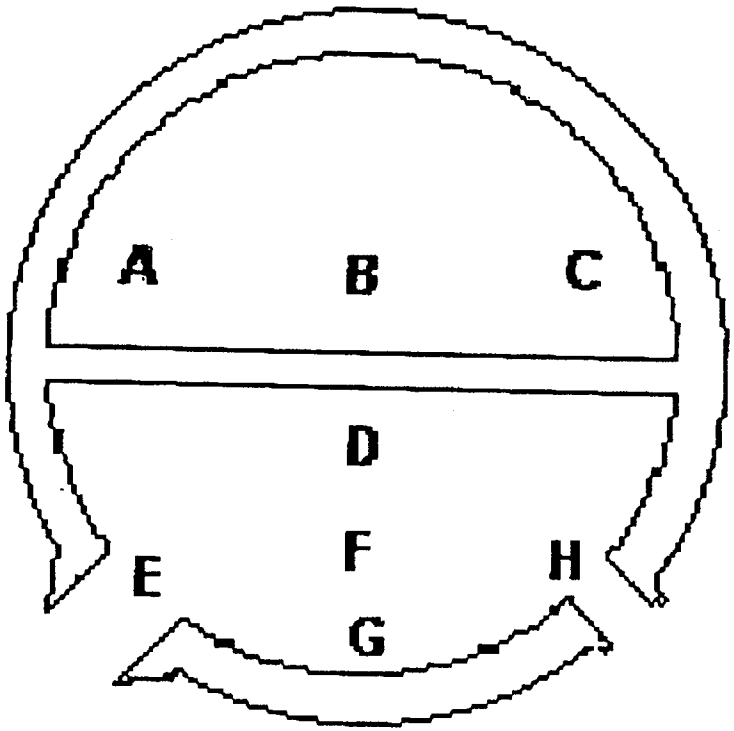
The Radiation Environment



- A - 7.8 - 17.3 R/h
- B - 8.3 - 12.7 R/h
- C - 9.0 - 17.3 R/h
- D - 9.4 - 15.1 R/h
- E - 5.8 - 15.2 R/h
- F - 6.6 - 15.1 R/h
- G - 7.4 - 12.7 R/h
- H - 1.7 - 4.0 R/h

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Measuring the Dose

- Dosimeter placement - multibadging required if:
  - nonuniform doses such that any part of the whole body exceeds the chest dose by 50%
  - exposure rates in the work area are greater than 100 mrem/h
  - TEDE will exceed 300 mrem for the task
  - it is not known what body location will receive the highest dose

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Measuring the Dose

- Dosimeter placement - multibadging discontinued if:
  - one location highest > 95% of the time
  - a body location is highest < 5% of the time
  - ratios to chest dosimeter is <1.5 for 95% or more for individuals for the same task
  - dose rates < 100 mrem/h
  - actual TEDE for the task < 300 mrem

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Measuring the Dose

- Dosimeter placement
  - for outages in 1989 and 1991 dosimeters were worn on the chest, head, back, left arm, right arm, left leg and right leg
  - using the criteria for discontinuing the use of multibadging, dosimeters were removed from the arms for the outage in 1995

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Measuring the Dose

- Dosimeter placement
  - In preparation for the 1997 outage the dose results from the three previous outages was reviewed.
  - This review also included NRC requirements, the newly issued ANSI Standard HPS N13.41-1997 and EPRI Report TR-101909.

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Measuring the Dose

- Dose Results
  - Data was available from 48 steam generator jumps
  - Of 260 non-chest TLDs, only nine exceeded the chest reading by more than 50%
  - Based on this, multibadging could be discontinued
  - 10CFR20.1201c requires that the assigned DDE be for the part of the body receiving the highest exposure

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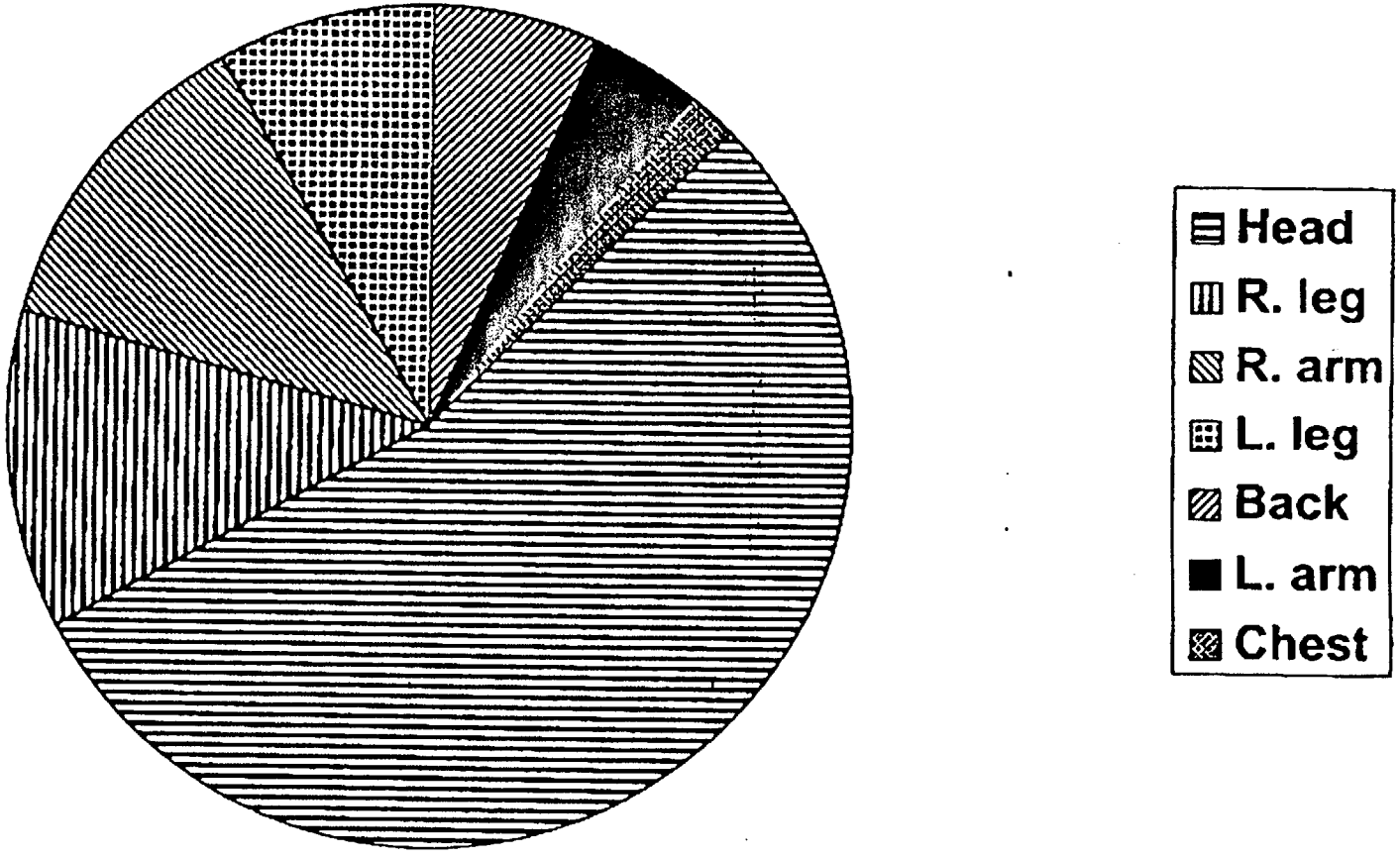
Measuring the Dose - Highest Dose Locations



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Measuring the Dose

- ANSI Standard HPS N13.41-1997
  - Recommends multibadging if the reference dosimeter reading will be exceeded by 30% and the dose will exceed 10% of the limiting value (47 of 206)
  - Recommends the use of dosimeters in at least two locations
  - Provides compartment weighting factors for determining the EDE

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Measuring the Dose

- ANSI Compartment Weighting Factors
  - Head and neck - 0.10
  - Thorax, above the diaphragm - 0.38
  - Abdomen, including the pelvis- 0.50
  - Upper right arm - 0.005
  - Upper left arm - 0.005
  - Right thigh - 0.005
  - Left thigh - 0.005

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Measuring the Dose

- EPRI Report TR-101909
  - Developed three algorithms for computing EDE using one or two dosimeters
  - Discouraged the use of the highest result from a multibadge set as the dose
  - Discouraged placing a dosimeter at the highest dose location

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Measuring the Dose

- Comparison of the ANSI and EPRI methodologies
  - Data from the 48 steam generator jumps were used with the ANSI weighting factors and the three EPRI algorithms to calculate doses
  - Results for each EPRI algorithm were compared to the ANSI results

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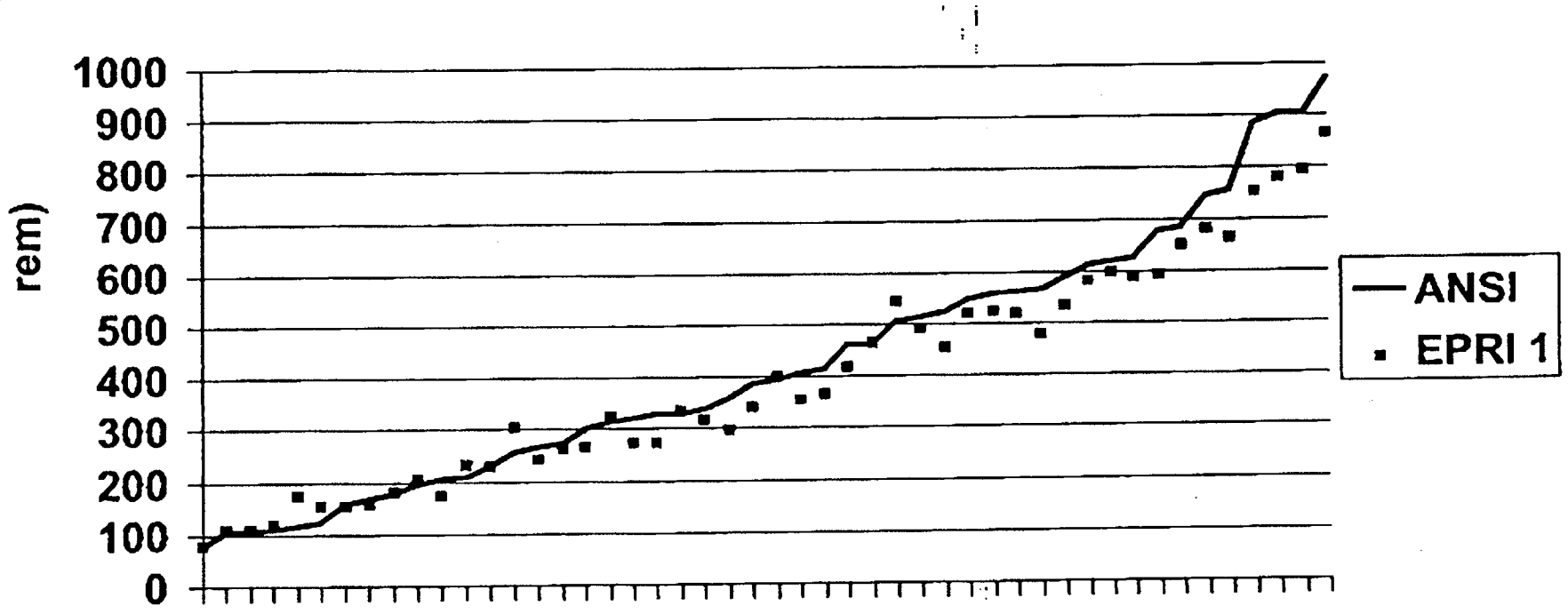
ANSI vs EPRI Algorithm 1



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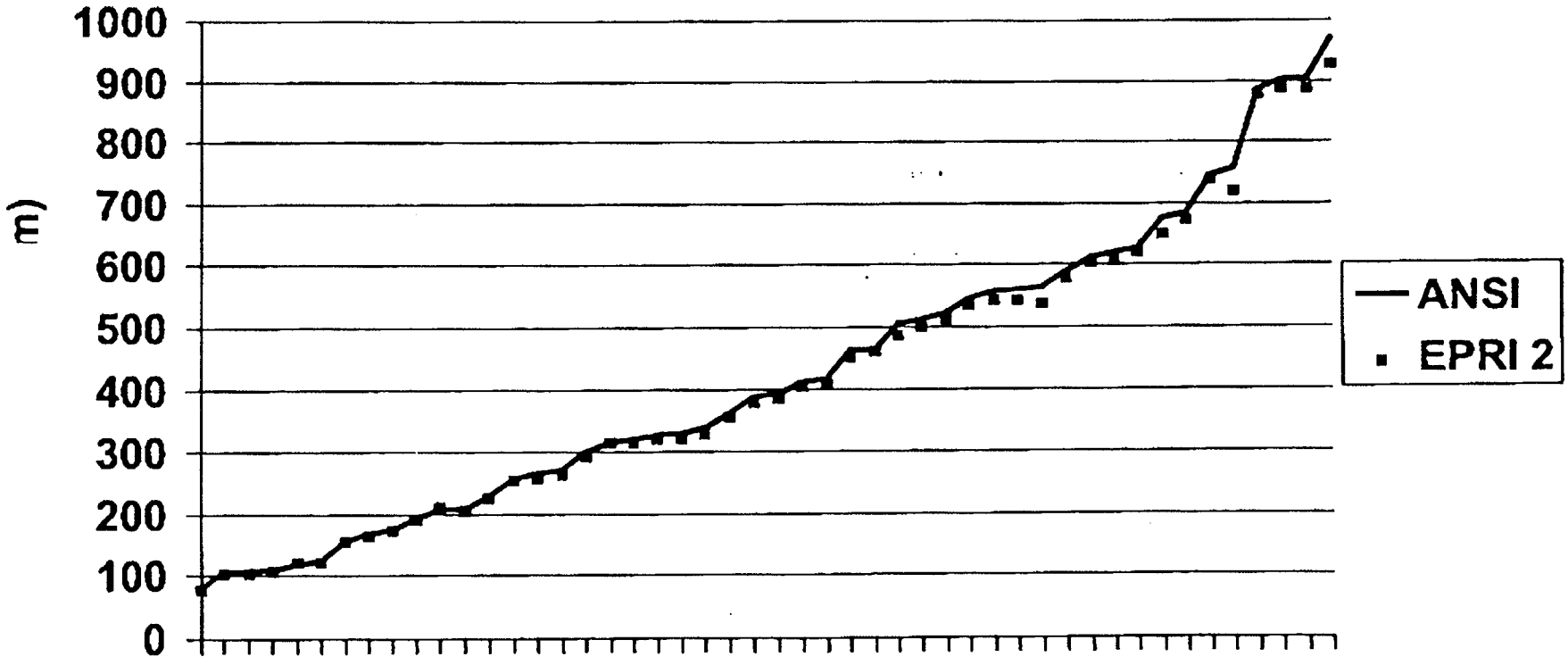
ANSI vs EPRI Algorithm 2



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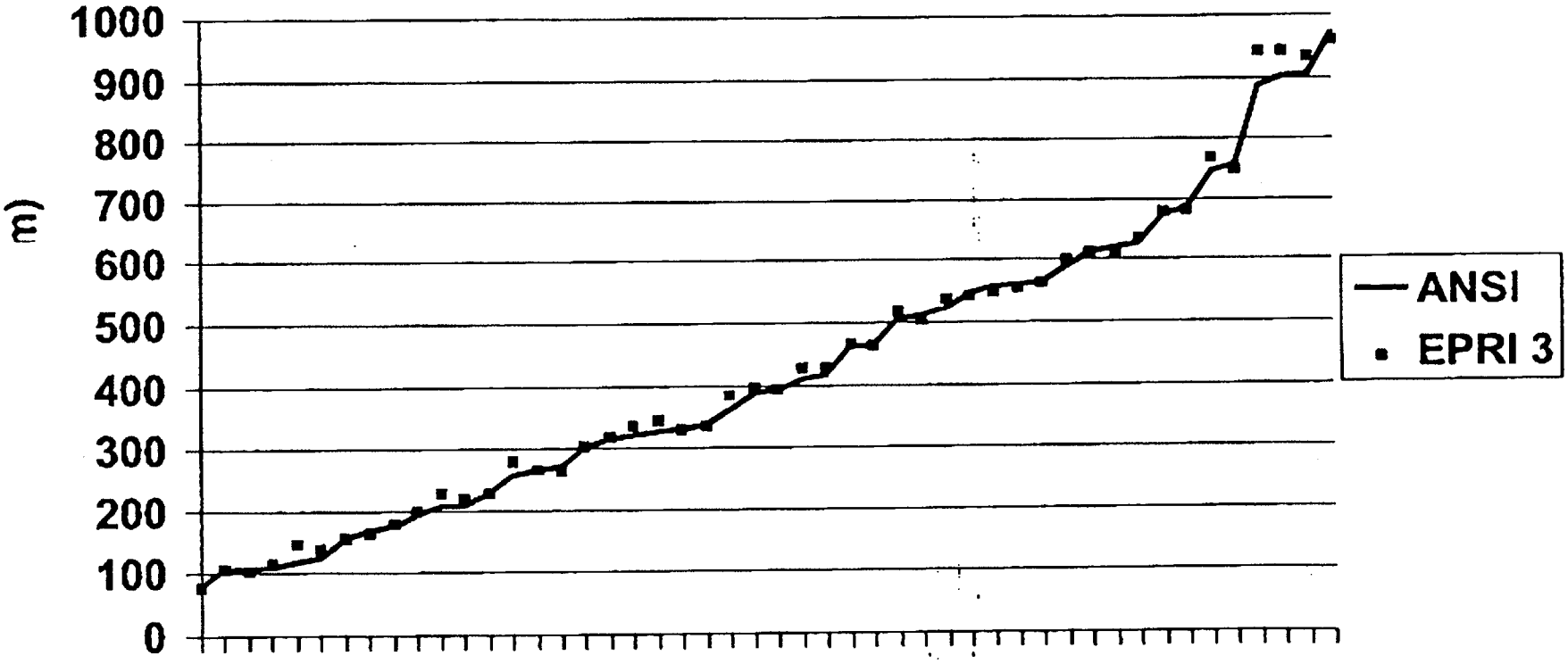
ANSI vs EPRI Algorithm 3



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Selecting a Method

- Multibadging not required by plant procedure
- 10CFR20 requires measuring dose at the highest location
- ANSI recommends multibadging for this type of task using at least two dosimeters
- EPRI algorithm 3 provides the best result without underestimating ANSI

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Recent Results

- For the most recent outage, dosimeters were placed on the chest, back and head
- Fifteen jumps were performed
- Doses from EPRI 3 compared to highest reading

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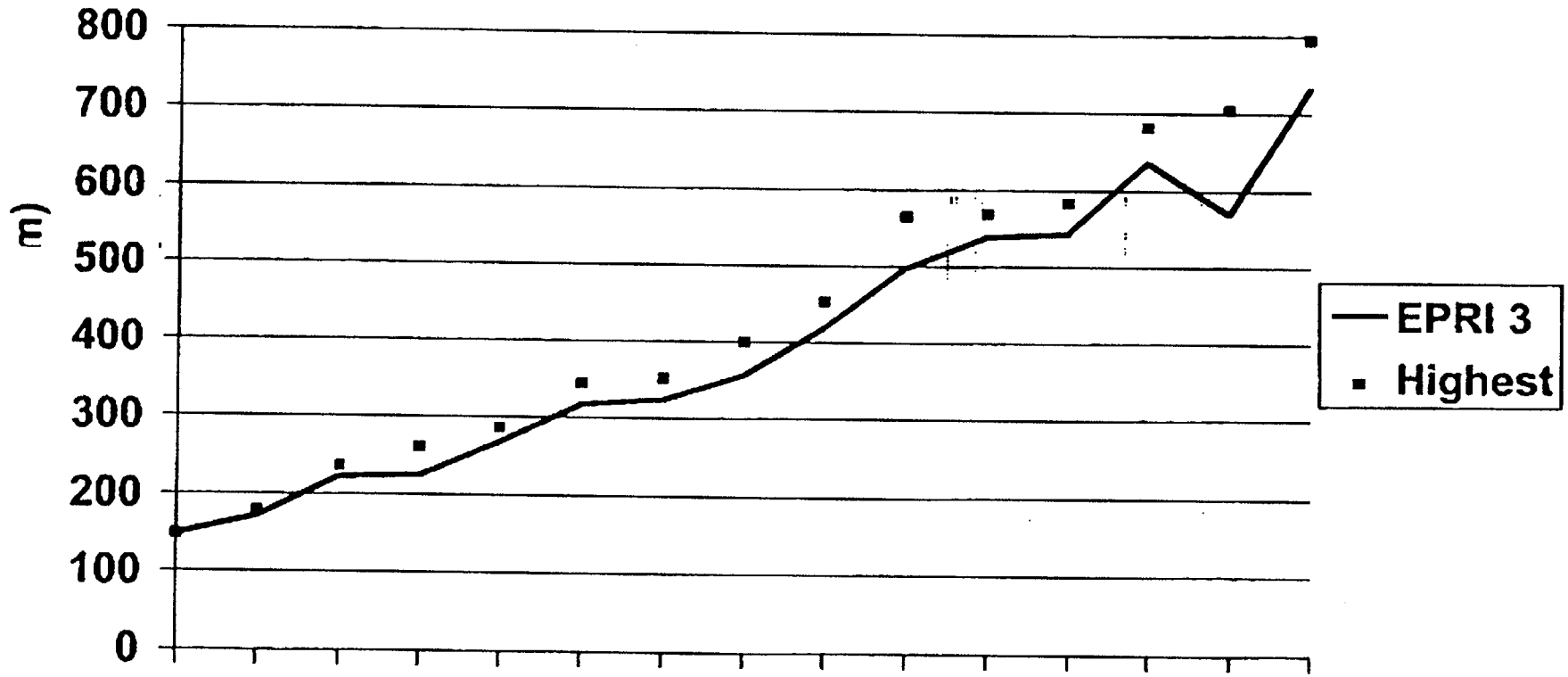
Measuring the Dose



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Summary

- Multibadging has gone from 7 dosimeters to 3
- With acceptance of EDE methodology this can decrease to 2
- The use of EPRI algorithm 3 meets the intent of the ANSI standard

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