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UNITED STATES OF AMERICA 6 February 1984

NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD
Glenn O. Bright
Dr. James H. Carpenter
James L. Kelley, Chairman

In the Matter of CAROLINA POWER AND LIGHT CO. et al. (Shearon Harris Nuclear Power Plant, Units 1 and 2)	Docket 50-400 OL ASLBP No. 82-468-01 OL

Joint Intervenors' Response to Summary Disposition on Joint Contention IV - Thermoluminescent Dosimeters and Update to Discovery of J.I. on Joint IV

This response is filed under an extension of time agreed to by Applicants' attorney Baxter. When not reached, Judge Kelley was left a message about this agreement. For the convenience of the Board and parties, we address herein the Staff's "Response" (which in our opinion is just another motion for summary disposition) received II-6-84, insofar as possible; further response to it will be filed within the time allowed by the NRC rules.

We would resp ectfully call the attention of the Board, the Applicants and the Staff to the proposed rules on "improved personnel dosimetry processing" 49 FR 1205-1211, January 10, 1984. Please consider these responses to be updates of discovery on Joint IV.

First, contrary to both Applicants' and Staff affidavits, the Commission states that "... the NRC recognizes that some licensees use pocket ionization chambers for the purposes of recording the official whole body dose of individual employees and that this ia an acceptable method of providing dosimetry services in accordance with (section) 20.202 of the NRC regulations" (49 FR 1209) (Update to Staff Interrogatory 19 on Joint IV: such personal ionization monitors exist and are available and NRC says they comply with its rules)

IV(2)(a)&(b) +IV(3)(a)&(b)

(Update to Applicants' Interrogatory IV-1(a) and (b): If accurately calibrated, the Commission says that pocket ionization chambers can be used for officially recording whole body doses to individuals. See 49 FR 1209; These instruments are n_ecessary because of the unreliability of data from TLDs which require lab processing to be read. NRC states, 49 FR 1208, that in their most recent tests, "Six percent of all models of dosimeters failed every category attempted and 44% passed every category attempted ... 50% of all models submitted for testing did not successfully pass all categories for which they were tested. The highest overall passing ratex ... was 94% for high-energy photons in the protection dose range, and the lowest passing rate of 55% was achieved for low-energy photons in the protection dose range.

"An alternative method of examining the overall performance of dosimetry processors would be to examine the performance index, P, of each of the dosimeters irradiated without regard to S. When the reported dose estimate is compared with the delivered dose, 78% of the dosimeters tested during the third round were within ± 30% of the correct delivered dose. When the individual results are evaluated using criteria of ± 50% of the correct delivered dose, 89% of all processed dosimeters meet this criterion ... NRC considers that improvement on the part of most dosimetry processors is needed ..." We reconfirm our response to Joint IV-2(b) that ± 30% is not accurate enough to ensure ALARA (how can you know the dose is as low as can be achieved if you don't know what the dose is? The range of plus or minus 30% is a span of 60% of the reported dose. Notice that NRC, 49 FR 1208, confirms that most dosimeters don't meet all criteria for acceptance (56% don't); and that 11% of processed dosimeters don't come within 50% of delivered dose and 22% are outside the plus or minus 30% range in the 3d round

see Tables 4, 5 + 7 + pp 40 - 42 of NUREG/CR 2891

of NRC tests. Joint Intervenors also note Table 8 of NUREG/CR 2891 which shows that In test #3, 4% of dosimeters were not within ±90% tolerance limits (5% in test #2 and 9% in test #1); 6% in test 3 were not within ± 70% ~~in~~ (8% in test 2 and 14% in Test 1). Page 24 of NUREG/CR 2891 + other cites there from showing this entire table is appended to this response/discovery update for The Board + NRC Docketing + Service. This performance is ridiculously bad. You can obviously be off more than 90% above an actual dose, but it's hard to get more than 90% below the actual dose, 100% below being the limit beyond which common sense indicates the result must be in error (i.e. showing a negative radiation dose). We assume Staff + Apps have the documents NUREG/CR 2891 + 2892

CP&L states (affidavit in support of summary disposition at 9) that they are processor number 187 in NUREG/CR 2891. On page 18 thereof, the |P| + S ("performance", see p. vii of NUREG/CR 2891 defining Table 3 thereof, which p.18 is part of) for processor 187 in category V Beta is shown to be 0.3063, i.e. over 30% error. Moreover, this was with a less stringest error-measuring criterion, |P| + S less than or equal to L, instead of the criterion |P| + 2S less than or equal to L that was used in previous tests (see p.4 of NUREG /CR 2891). Examining pages D.24 and D.25 of NUREG/CR 2891, we find (line 1432, p. D24) that in the accident category 1D, |P| + 2S is above 30% (.3701: 0,111plus 2 x .1295), the L or limit criterion. Thus CP&L passed this category because the test criterion had been made less stringent, allowing them to take |P| + S, below the Limit. Moreover, (line 1433) the dosimeter with the highest P, .2844, is the highest dose (337.90 mrem). that's nearly 30% error by itself.

Further, NUREG/CR 2891 says L is 0.2 for low doses, e.g. 30 mrem (p.4). p. D-24 Line 1433, col. 4 thereof, shows P of 0.2048 for a dosimeter with a dose reading 17.85 mrem. It also shows a P of -.3057 (more than 30% error on minus side), column 11) on a dose of 105 mrem

These errors violate the criterion given in CP&L's affidavit of S.A. Browne at p.11 (error limit of 30% for doses between 10 and 500 mrem) also. Similar violations of that limit are found in line 1448, p.D-25, with a P of .43419 in col 2 for a dose of 155 mrem, and a P of .3517 in col. 5 for a dose of 250 mrem. P is the percent error in reported dose vs. actual (p.4 N/CR 2891) → Equation 1, p.4 Surely CP&L has not been forthcoming or accurate in its response to discovery, and in its affidavit, by saying there is no evidence of errors that violate applicable standards, or so it would appear to Joint Intervenors. Compare answer to 16(c)(i) and (ii), 8/1/83 by Apps. p.10 We believe these errors violate ALARA and show a "we do only what the rules make us do" attitude by CP&L for low-level radiation. Otherwise, they'd seek more accuracy Joint Intervenors believe that accurate measurement of low-level radiation doses is essential to protect the health and safety of nuclear workers, not only under current rules (cf. NRC at 49 FR 1208 supra) especially if low-level radiation is found to have more serious effects than NRC and CP&L now believe.

END of this discovery update.

We note that NRC is proposing (49 FR 1209) to require processors of dosimeters to pass a qualification for National Bureau of Standards accreditation (NVLAP procedures of 15 CFR 7b). At page 1210, NRC goes on to say that testing for this will begin in January 1984. Joint Intervenors believe that this contention is not a collateral attack on this rule proposal (since the proposed rule came out about a year and a half after the contention was given to the Board, the proposed rule may attack the contention), but is in fact consistent with it. Given that this rule is to be considered within the next few months and that CP&L has not yet met its requirements (they've applied: Browne affidavit at p.5, item 5), it would be premature to rule out this contention until this rule is acted upon. We would also cite the points from the NUREG/CR 2891 and NRC notice of proposed rule (laid out above)

as reasons why CP&L's motion for summary disposition should be denied. NRC has found, 49 FR 1206, that "there is a need to evaluate the performance of personnel dosimetry processors ..." and that there is a need for "improvement on the part of most dosimetry processors ... (including) competency requirements" 49 FR 1209.

Update to discovery: Joint Intervenors note, re IV*4(a) and (b), that Applicants' own affiant Browne says (p.4 of affidavit in support of motion for summary disposition) that "SRPDs are knocked off-scale very easily by dropping or bumping them and are insensitive to beta radiation." That's clearly a problem with the self-reading personal dosimeters (SRPDs) that can make them completely unsuitable to check the TLD readings with, that makes them very error prone, etc. Re Applicants' interrogatory IV-5(a) we reconfirm, see above answer and former answer to IV-4(a). Applicants' affiant Browne, affidavit at p. 6, item 8, says that SRPDs can be used to estimate dose to a worker who lost a TLD "with only slightly less accuracy". (We believe SRPDs are significantly less accurate than TLDs.) Yet he's also said that the SRPDs are not sensitive to beta radiation, which can be a substantial component of the dose to a worker in a nuclear plant. This applies to Interrogatory IV-7(a) also, as an update. (end of update)

Argument vs. summary disposition: Applicants' own affiant says SRPDs are not sensitive to beta radiation and are error-prone. Thus, the lack of real-time monitoring from TLDs is a problem. Browne's affidavit says (pp 7-8) that the individuals working in the plant have a current dose reading that depends on the SRPD between times the TLDs are read. But he admits the SRPDs are insensitive to beta radiation and can be thrown off-scale by being bumped. (p.5) Is it reasonable to believe all workers will always know when their

SRPDs get bumped? Browne's statements about beta surveys when SRPDs are used are only vague generalities. There is no reason to believe SRPDs will give an accurate real time dose, and TLDs do not, ams the contention states.

p.10 item 12

Browne asserts that Joint Intervenors have not specified conditions of exposure, radiation type, energy, dosimeter design, and irradiation geometry. (We do address error levels and inaccuracies above, citing the Commission itself as well as NUREG CR 2891). But Joint Intervenors think that that's CP&L's problem: to maintain ALARA, under all exposure conditions, geometries etc. accurate records are needed. Inaccuracies of plus or minus 50% are just not acceptable. Minus 50% means the dose is only half recorded.

Bro_wne fails to address the Commission's observation (49 FR 1205) that "Personnel dosimeters appear to be capable of providing consistently accurate information on the amount of radiation received, provided the dose recorded by the dosimeter is above the detection threshold, e.g. about 20 mrems for photons." Thus, exposures of up to 20 mrem could go undetected multiple times , even if dosimeters wer processed accurately and consistently and interpreted correctly (as the NRC notes is required for adequate dose estimates, 49 FR 1205).

In sum, there are two kinds of errors that are important even if every condition Browne claims is met, were met: doses under 20 mrem not being recorded, and errors on individual dosimeters which are either large negative values, or fall outside the ± 20% or ± 30% or ± 50% the rules require. We have a case of a whole class of CP&L dosimeters with errors or plus or minus 30% (see above re NUREG/CR 2891 Appendix D). The kinds of errors we allege, and the percentages, are real, Browne and the NRC give the perdentages: NUREG/CR 2891 shows errors. An individual dosed beyond safe limits, or unknowingly

dosed, is in trouble. With errors of ± 50% as Applicants assume is OK, the cumulative dose of an individual is a blur, not an accurate number. We believe ALARA means what it says: As Low As Reasonably Achievable. To lower the exposure, you've got to know the exposure. We have pointed out above instances of CP&L's violating the criteria for exposure recording accuracy Browne himself quotes or states, (see e.g. end of page 3 and beginning of p.4 above). Staff's argument ("response" of II-3-84 at 2-3) is defeated by this data.

Finally, Joint Intervenors protest that Applicants and Staff misinterpret our position on pressurized ionization monitoring. The contention says "Applicants should be required to use portable pressurized ionization monitors in radiation hazard areas to corroborate the exposures indicated by TLDs." We believe that the use of area monitoring to back up personal dosimetry is standard health physics practice; and that pressurized ionization monitoring is appropriate because it identifies specific radionuclides present, reads fairly fast, and is portable and can record data. Pressurized ionization monitors for high dose rates, e.g. at plant effluent stacks (radiological effluent release points) do exist, contrary to Staff's statements at p.5 of II-3-84 "~~Response~~ Block affidavit". The P.I. monitor picks up the contaminants in the air which can contribute to internal dose, and which are (by disintegrating) delivering external dose by beta and gamma radiation. The use of a PI monitor thus strengthens radiation protection for workers. (see Staff "ResP"p.5) If they only weigh 23 pounds and can be put where workers are working, they can back up the TLDs. Staff seems to say (p.5 ibid) they can measure up to 100 megarads an hour, which is consistent with what we understand of plant stack P.I. monitors. However, the 100 MR number may be a typo. We submit that Staff admits 100 megarads unless they correct any error in this number.

Exx
For the above reasons, summary disposition should fail on Joint IV.

Wells Eddleman, pro JI

Further discovery update to Staff: Interrogatory 14: See 49 FR 1205-11 as cited above; see also NUREG/CR 2891, e.g. Table_s 4,5 & 7, and as cited above. Int 15 See NUREG/CR 2891. Int 16: See NUREG/CR 2891, though it doesn't appear to deal with manufacturers explicitly. Check also NUREG/CR 2892 & citations by Applicants' affiant Browne, p.9, his affidavit re summary disp.; Interrogatory 17: We still don't know what "generation" means. but see above e.g. pp 3-4 re Harris dosimeter test errors and failures to meet, e.g. 30% error between 10 and 500 mrem, etc. We also note that "A performance testing program, by itself, will not determine whether the processor actually treats its routine client's dosimeters with the same competency accorded to dosimeters received from the PTL"(NRC's test contractor)(49 FR 1208) *see also recommendation 3, p. 41, NUREG/CR 2891* i.e. the tests CP&L had, they evidently knew were a test. A blind test of an outfit that processes its own dosimeters is basically impossible. Thus, CP&L's results may be extra-careful so far, but still had plenty of errors, e.g. those cited above from NUREG/CR 2891.

Interrogatory 18: Staff cited a 23 lb, portable, up to 100 MR/hr device, Block affidavit of II-3-84, p.5, but didn't identify it. We believe it could do the job. You must know its identity, he's your employee. Interrogatory 21: see above updates. Interrogatory 22: See above updates, here & elsewhere in this response/discovery update, to Apps and/or to Staff. Interrogatory 23: see discussion of Applicants' affiant Browne's statements re this re SRPDs, pp 5-6 supra.

2-6-84 WE for JI

SHORT LIST of FACTS IN DISPUTE on JOINT IV

1. The contention speaks for itself as to what it says.
2. Panasonic TLDs wouldn't meet the |P| + 2S ≤ L criterion in NUREG/CR/2891 (e.g. line 14&32 p.D-24 thereof, cited on p. 3 above) in accident conditions.
3. Harris TLDs are shown to violate the 30% error criterion for radiation between 10 mrem and 500 mrem, see pp 3-4 above, and the criterion of 0.2 for below 20 mrem, see p.3 above.
4. SRPDs aren't sensitive to beta and can be made useless by bumping. There is no assurance every bump will be detected. Yet workers will work based on exposure levels "allowed" by SRPD readings between TLD readings.

5. Applicants' computer-based dosimetry system incorporates the problem stated in item 4 above.

6. Personal ionization monitors can be carried at all times. (see 49 FR 1209, last column, bottom). They're pocket meters.

7. Portable pressurized ionization monitors weighing no more than 23 lbs, with a range up to 100 MR/hr, are available.

8. Such monitors can be put almost anywhere people are working.

9. Such PI monitors can identify individual nuclides present in a work area.

10. Portable ionization monitors can have recording equipment attached to them to measure integrated dose.

11. Applicants' pencil dosimeters (see 8/1/83 response to J.I.'s discovery at p.16) are accurate within ± 10%, which is better than the TLDS limit (as claimed by Applicants) of ± 50% in most cases and ± 30% in accidents or high dose conditions.

12. ALARA requires accurate information on exposures. ± 50% errors in exposure data would prevent effective action to reduce exposures in many cases.

13. NRC has found (49 FR 1206) that personnel dosimetry measurements are important and that test "Results also indicated that the whole body or whole body and skin dose received by occupationally exposed personnel may often be considerably different from that recorded."(ibid)

14. NRC has proposed tightening the rules for dosimeter processing performance beyond that of ANSI N13.11 by requiring National Bureau of Standards accreditation of processors. (49 FR 1205-1211, esp at1209)

15. SRPDs are not sensitive to beta radiation, which means that when they are used to back up TLDs, no beta record would be available, without PI monitoring or other added backup, leading to the problem of beta dose being different from that recorded (cited by NRC 49 FR 1206).

16. The requirements of 10 CFR 20.202(a)(1) and(2) cannot be met effectively without dose assessment more accurate than ± 50% as to the amount actually received, unless the recorded exposure is set as measured exposure plus maximum error range, as Joint Intervenors propose.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of CAROLINA POWER & LIGHT CO. Et al.) Docket 50-400
Shearon Harris Nuclear Power Plant, Units 1 and 2) O.L.

CERTIFICATEOF SERVICE

I hereby certify that copies of "Joint Intervenors Response to Board Order served Jan 30 1984; and of WB Requests for Clarifidation of, and Objections to, Bd. Order of 1-27-84 and of Joint Intervenors' Response to Summary Disposition on Joint IV. + Discovery update on Joint IV (in Response document)
HAVE been served this 6 day of February 1984, by deposit in the US Mail, first-class postage prepaid, upon all parties whose names are listed below, except those whose names are marked with an asterisk, for whom service was accomplished by including letter of Bruno Uryc Jr NRC to Wells Eddleman, re pipe hangers, previously served to Applicants and to Judge Kelley for the Board.

Judges James Kelley, Glenn Bright and James Carpenter (1 copy each)
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TO 50-400 Board re Joint Intervenors' Response to Summ Disp ON Joint IV, II-6-84

NUREG/CR 2891

LIST OF TABLES

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NUREG/CR 2891

Table 3 continued.

Radiation Categories	I X ray Accident	II Gamma Accident	III X ray Shallow	III X ray Deep	IV Gamma	V Beta	VI Gamma + X ray Shallow	VI Gamma + X ray Deep	VII Gamma + Beta Shallow	VII Gamma + Beta Deep	VIII Gamma + Neutron
Dosimeter Code Number											
182			0.5024	0.1335	0.1005	0.5300	0.3693	0.0891	0.1902	0.0526	1.7145
183					0.0627	0.8957			0.8006	0.0931	
184					0.5416						1.2909
185	0.1297	0.0919	0.1631	0.1881	0.1196	0.0831	0.1723	0.2052	0.1710	0.0843	0.1908
186*											
187	0.2406	0.1052	0.1041	0.1228	0.0614	0.3053	0.0583	0.1594	0.1640	0.1060	
188	0.9237	0.6027	1.0567	0.6499	0.2434	0.3791	0.8830	0.6737	0.5767	0.3368	0.9632
189	0.2355	0.1608	0.3993	0.6199	0.2607	0.3423	0.3385	0.2740	0.4060	0.3176	0.2812
190			0.5470	0.5344	0.1708	0.5538	0.3569	0.3696	0.4432	0.3985	0.1453
191*											
192	0.3187	0.1155	1.4558	0.5534	0.2076	1.4166	0.6948	0.3518	0.7508	0.4031	0.6550
193	1.9733	0.7837	3.0410	0.0966	0.0499	0.1220	3.3129	0.1167	0.1235	0.1860	0.3201
194	1.0326	0.5363	1.4322	1.0703	0.0652	0.2885	1.6137	0.3667	0.1670	0.0818	0.1844
195*											
196					0.2982	0.2348			0.3628	0.4340	
197	0.3867	0.1307	0.4789	0.4493	0.1022	0.1111	0.3294	0.2391	0.1173	0.1225	0.0939
198*											

 NUREG/CR 2891

Table 4. Summary of the number of dosimeter types that participated in each category and the passing rate for all three tests of the pilot study.

		Test #1* 5/78 to 10/78		Test #2* 11/78 to 4/79		Test #3 11/81 to 4/82	
	Radiation Test Categories	Number	Passing	Number	Passing	Number	Passing
I.	Accident, low-energy photons	44	23%	37	39%	42	55%
II.	Accident, high-energy photons	61	46%	53	62%	51	82%
III.	Low-energy photons	35	14%	34	53%	53	55%
IV.	High-energy photons	62	77%	54	87%	64	94%
V.	Beta particles	42	60%	39	69%	57	86%
VI.	Photon mixtures (III&IV)	42	56%	36	65%	54	59%
VII.	Photons (IV) plus beta particles (V)	40	45%	39	47%	56	84%
VIII.	Photons (IV) plus neutrons	30	48%	29	66%	47	72%
Average weighted by number of dosimeter types			48%		62%		75%

*Note: The test categories for Tests #1 and #2 were defined differently than for Test #3. The results from Tests #1 and #2 have been regrouped to be as compatible as possible with the categories defined for Test #3.

 NUREG/CR-2891

F&B

Table 5. Summary of the number of dosimeter types that participated in Categories III through VII of Test #3 and the passing rate among this group of five beta-photon categories in the protection dose range.

Dosimeter Types That:	Number of Dosimeter Types	Percent
passed all categories attempted*	34	49%
failed at least one category attempted*	36	51%
	70	100%
attempted and passed all five categories	17	39%
attempted but did not pass all five categories	27	61%
	44	100%

*Note: Some processors chose to participate in a few, but not all, of the five beta-photon categories.

Table 6. Average bias, $|\bar{P}|$, and precision, S, terms at each depth of each category for Test #3.

	Radiation Test Category	Depth	Number of Dosimeter Types	Average $|\bar{P}|$	Average S
I.	Accident, low-energy photons	Deep	42	0.2327	0.1879
II.	Accident, high-energy photons	Deep	51	0.0872	0.1217
III.	Low-energy photons	Shallow	53	0.3342	0.2825
III.	Low-energy photons	Deep	53	0.2352	0.2218
IV.	High-energy photons	Deep	64	0.0741	0.1321
V.	Beta particles	Shallow	57	0.1890	0.1431
VI.	Photon mixtures (III&IV)	Shallow	54	0.3065	0.2963
VI.	Photon mixtures (III&IV)	Deep	54	0.2104	0.1889
VII.	Photons (IV) plus beta particles (V)	Shallow	56	0.1699	0.1418
VII.	Photons (IV) plus beta particles (V)	Deep	56	0.1172	0.1992
VIII.	Photons (IV) plus neutrons	Deep	47	0.1457*	0.2326*
	Average weighted by number of dosimeter types			0.1887	0.1936

*Note: The average bias for Category VIII changes to 0.1388 and the average precision changes to 0.2257 when 0.18 is used for the ratio of photon to neutron dose equivalent rates for moderated californium-252 (see Table 11). The average bias and precision terms shown above are based on the ratio of 0.30 actually used for Test #3.

 NUREG/CR 2891 F+B

Table 8. Performance of individual dosimeters irradiated during the three tests of the pilot study.

Tolerance Limit	Dosimeters Within the Indicated Tolerance Limit for P (Eq. 1)		
	Test #1	Test #2	Test #3
± 10%	27%	37%	42%
± 30%	62%	73%	78%
± 50%	78%	86%	89%
± 70%	86%	92%	94%
± 90%	91%	95%	96%

Table 7. Dosimeter types that showed the worst test results in each category for Test #3.

Category	Dosimeter Code No.	$\lvert\bar{P}\rvert + S$	$\bar{P}$	S	No. of Dosimeters With $P \leq L$ [1]
I	193	1.9733	0.7988	1.1745	0
	154	1.2386	0.6042	0.6344	0
	194	1.0326	0.6406	0.3920	3
II	193	0.7837	0.0928	0.6909	0
	188	0.6027	-0.4337	0.1691 [2]	2
	194	0.5363	0.4706	0.0658 [2]	0
III	123	3.2830	1.3097	1.9733	2
	193	3.0410	2.1249	0.9162	1
	105	3.0338	1.7315	1.3023	4
IV	169	0.8551	-0.0729	0.7822	14
	115	0.6632	0.0497	0.6135	14
	126	0.6625	0.4259	0.2366 [2]	7
V	192	1.4166	0.8700	0.5466	0
	203	0.9154	0.7884	0.1270 [2]	1
	183	0.8957	0.7901	0.1057 [2]	0
VI	193	3.3129	2.8667	0.4463	0
	139	3.1979	0.6938	2.5401	14
	115	3.0229	0.8099	2.2131	8
VII	168	3.3777	0.7165	2.6613	14
	161	1.5481	0.8661	0.6820	5
	158	0.9984	0.6419	0.3565	5
VIII	182	1.7145	0.6919	1.0226	10 [3]
	173	1.6222	0.0965	1.5257	14
	184	1.2909	0.1686	1.1223	14

[1] The pass/fail criterion is $\lvert\bar{P}\rvert + S \leq L$ where L = 0.3 for Categories I and II and L = 0.5 for Categories III through VIII.

[2] These dosimeter types show small precision terms (S < 0.25) and large, but correctable, biases.

[3] This dosimeter type showed excellent test results for the first two test months but a large bias for the third test month.

 NUREG/CR 2891

Category VIII. The six calibration dosimeters were irradiated simultaneously to 500 mrem of neutrons and to a corresponding dose equivalent from the photons from californium-252 assumed* to be 0.30(500 mrem) = 150 mrem. Once a processor determines the correct response factor for their dosimeter to the moderated californium-252 source using the six calibration dosimeters, determination of the dose delivered to the 15 test dosimeters should be trivial.

3. Pass Fail Criterion

The Standard has always required (see Page 4 of the Standard) that a performance index be calculated for each dosimeter by:

$$P = \frac{H' - H}{H} \qquad \text{(Eq. 1)}$$

where: P = performance index

H'= reported dose

H = delivered dose

For each group of test dosimeters, the average performance index, $\bar{P}$, and its associated standard devciation, S, are calculated.

The pass/fail criterion for the draft of the Standard used for Tests #1 and #2 required that:

$$|\bar{P}| + 2S \leq L \qquad \text{(Eq.2)}$$

where the tolerance limit, L, varied from about 2.0 for low doses (30 mrem) to 0.5 for high doses (10,000 mrem) in the protection range and was a constant 0.3 for accident doses above 10,000 mrem. Between Tests #2 and #3, the pass/fail criterior was changed to:

$$|\bar{P}| + S \leq L \qquad \text{(Eq. 3)}$$

*In Appendix B (page 23) of the Standard, the photon to neutron dose equivalent ratio was stated to be 0.30. At the conclusicn of Test #3, this ratio was found to be 0.18. The effects of this ratio are shown in the RESULTS section of this report.

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APPENDIX D

Test #3 data for all processors that reported doses before the end of the pilot study.

Each depth of each category requires three lines (example shown):

Line 1: Processor code number (101)
Category number (1)
Depth (D = deep, S = Shallow)
Type of dosimeter (TLD)
$\bar{P}$ (-0.2313)
S (0.0909)
$|\bar{P}|$ + S (0.3222)
L (0.3000)

see p. D.1 line 1

Line 2: Values of P for 15 test dosimeters. A P value of 99.9999 is the code for a voided dosimeter. (-0.3102 -0.2791 - 0.3937...)

Line 3: Values of the delivered dose for 15 test dosimeters. (24.28 122.08 21.19...)

101	1D TLD	-0.2313	0.0909	0.3222	0.3000									
-0.3102	-0.2791	-0.2537	-0.2765	-0.3588	-0.0813	-0.2324	-0.1970	-0.1891	-0.3264	-0.1809	-0.1844	-0.1772	-0.0957	-0.1862
24.28	122.08	21.15	102.21	19.57	10.88	16.54	275.23	286.12	32.36	163.59	126.74	75.35	414.67	329.32
101	2C TLD	0.0415	0.0596	0.1612	0.3000									
-0.0183	0.0012	0.1380	-0.0357	0.0186	0.0237	-0.0296	0.1475	0.0904	-0.0298	0.0387	0.0524	0.0911	0.0832	0.0573
10.33	13.28	215.64	110.55	64.40	92.80	26.02	222.13	119.68	36.33	53.63	301.20	21.63	146.60	34.43
101	3S TLD	0.3634	0.2785	0.5816	0.5000									
0.9332	0.9144	0.0026	0.2653	0.0544	0.5921	0.5665	0.1422	0.0349	0.1434	0.3661	0.5352	0.3463	0.0591	-0.0044
85.35	390.50	643.70	260.80	1754.47	5213.27	159.59	1444.64	550.77	12593.51	51.24	4396.73	6239.18	122.74	70.31
101	3C TLD	0.2537	0.2882	0.5820	0.5000									
0.9917	0.4854	-0.0096	0.2222	0.0497	0.5761	0.5534	0.0787	0.0289	0.0968	0.3823	0.5144	0.3283	0.0965	0.0075
60.25	282.00	454.38	184.09	1238.45	3679.96	112.65	1019.75	388.78	8889.54	36.17	3103.58	4404.13	86.64	49.63
101	4C TLD	0.0258	0.0446	0.0704	0.5000									
0.0222	0.0247	0.0050	0.0011	0.0235	0.0415	-0.0048	0.0328	0.0867	0.0931	0.0220	-0.0719	0.0387	0.0969	-0.0249
58.70	63.43	232.84	2247.54	1221.28	1680.24	5426.11	3098.43	492.31	2790.13	78.28	393.28	370.65	136.75	1999.83
101	5S TLD	-0.1589	0.1055	0.3045	0.5000									
-0.2227	-0.3260	-0.3231	-0.3521	-0.3573	-0.2574	-0.1433	-0.1282	-0.1462	-0.0211	-0.1127	-0.2255	-0.1686	-0.0814	-0.1182
192.96	5564.02	2142.23	980.05	847.98	276.04	712.06	8545.31	732.04	332.01	896.00	225.95	2225.28	5007.57	1065.97
101	6S TLD	0.2187	0.1038	0.3225	0.5000									
0.1581	0.3209	0.1467	0.2436	0.2180	0.2381	0.2993	0.1564	0.1018	0.2106	0.2717	0.4314	0.3195	0.1564	0.0078
155.43	177.91	279.07	422.35	336.61	2140.42	6272.54	631.26	235.98	1115.15	271.28	223.56	5001.73	203.21	625.10
101	6C TLD	0.2354	0.1274	0.3625	0.5000									
0.2767	0.3651	0.1367	0.2358	0.1521	0.2650	0.4063	0.1359	0.1727	0.1545	0.3381	0.4706	0.2751	0.1342	-0.0274
171.41	142.84	228.73	356.05	285.40	1057.73	5013.26	537.03	191.87	952.80	209.25	183.60	4313.37	158.70	565.52
101	7S TLD	-0.0870	0.0636	0.1506	0.5000									
-0.1950	-0.1735	0.0336	-0.1039	-0.1501	-0.0470	-0.0413	0.0040	-0.0486	-0.1034	-0.0846	-0.1692	-0.0762	-0.0746	-0.0856
245.41	405.32	4015.05	2176.04	1029.57	3148.05	808.40	453.14	851.36	1388.58	218.47	1384.23	427.56	859.07	382.78
101	7C TLD	0.0399	0.0500	0.0855	0.5000									
0.1203	0.0493	0.0329	-0.0278	0.0160	0.0732	0.1265	0.1090	0.0600	0.0329	-0.0091	-0.0193	0.0088	0.0363	-0.0100
93.73	142.96	3001.13	1459.58	497.63	2096.45	337.34	315.61	566.01	551.84	100.91	892.23	232.95	458.36	156.56
101	8C TLD	-0.0644	0.0929	0.1573	0.5000									
0.0461	0.1165	-0.0084	-0.0023	0.0600	-0.2091	-0.0756	-0.0463	-0.1317	-0.0447	-0.1417	-0.1377	-0.1154	-0.1002	-0.1714
1672.84	219.36	555.69	1002.32	301.96	2022.95	292.09	1467.93	4203.44	1674.88	396.13	2725.33	323.65	333.39	3620.75
102	5S TLD	0.0158	0.0631	0.0789	0.5000									
0.0365	0.0047	0.0176	-0.0715	0.0142	0.0143	0.0673	-0.0404	0.1338	0.1445	0.0045	-0.0266	-0.0066	-0.0775	0.0226
192.96	5564.02	2142.23	980.05	847.98	276.04	712.06	8545.31	732.04	332.01	896.01	226.02	2224.67	5007.89	1065.90
103	1C TLD	-0.0453	0.2470	0.2563	0.3000									
0.0720	-0.5567	0.6444	0.0326	-0.1467	-0.1231	-0.1093	-0.1377	0.0318	-0.1029	0.0344	-0.0341	-0.1059	-0.0777	-0.1266
96.84	220.74	127.62	17.85	225.73	342.64	37.45	50.30	16.30	207.33	105.14	15.18	54.06	337.90	32.59
103	2C TLD	-0.2578	0.1979	0.4556	0.3000									
-0.2375	-0.2202	-0.3306	-0.3273	-0.2448	-0.1505	-0.1134	-0.1250	-0.0974	-0.9236	-0.2414	-0.2907	-0.2347	-0.1781	-0.1407
100.26	60.93	56.16	43.90	63.63	62.88	162.26	87.67	17.12	49.91	78.88	105.57	37.60	20.03	153.49
103	3S TLD	0.0368	0.1067	0.1435	0.5000									
0.0375	0.1623	0.0441	-0.2163	0.0047	0.0413	-0.0127	0.1556	0.0066	0.1404	-0.1298	0.1134	0.1180	-0.0270	0.1138
213.98	263.94	693.43	48.49	7976.35	689.54	4488.91	1013.33	71.53	318.31	309.11	7229.96	75.13	206.58	9187.99
103	3C TLD	0.0862	0.0872	0.1734	0.5000									
0.3304	0.1678	0.0501	-0.0650	0.0659	0.2286	-0.0078	0.1618	0.1883	0.1438	0.0266	0.1188	0.1314	-0.0193	0.1192
151.05	266.50	485.48	34.23	5630.35	487.74	3168.64	715.30	50.49	224.69	218.20	5103.50	53.03	145.82	6485.64
103	4C TLD	-0.0510	0.0901	0.1461	0.5000									
-0.1151	-0.0329	-0.1133	-0.0526	0.0324	-0.1305	0.0247	0.0408	0.1633	-0.0169	-0.0140	-0.1225	-0.1355	-0.1651	-0.1086
368.41	214.04	6857.73	138.27	42.62	1388.16	120.04	5830.29	2976.84	1881.73	4432.91	8758.08	4325.17	104.71	41.51
103	5S TLD	0.1356	0.2998	0.4346	0.5000									
0.1152	0.0580	1.0306	-0.4661	0.0038	0.2832	0.1595	0.1356	0.1393	0.1544	-0.0328	0.0332	0.1872	0.1673	0.0573
741.02	155.40	654.07	1376.55	256.05	246.62	401.02	327.59	4998.86	660.08	1251.08	181.00	2687.09	520.01	401.98
103	6S TLD	0.0360	0.0794	0.1154	0.5000									
0.0673	0.1113	0.0516	0.0035	-0.0554	0.0463	-0.0172	-0.0183	0.1861	0.0234	-0.0837	-0.0078	0.1710	0.0591	-0.0328
502.34	79.18	299.56	2899.92	2262.46	4787.30	124.14	370.80	485.61	320.51	485.62	3637.45	145.18	1528.73	270.88
103	6C TLD	0.0425	0.1500	0.1925	0.5000									
-0.0283	0.2492	0.1122	-0.1336	-0.1566	-0.6554	0.0673	0.0602	0.3823	0.0296	0.0301	-0.1252	0.1565	-0.0853	0.1337

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401.53	166.16	1715.50	4761.19	2056.86	2203.15	1487.76	403.23	778.33	4472.30	3372.67	375.79	172.73	309.92	560.14
183	4C FILM	0.0067	0.0560	0.0627	0.5000									
-0.1137	0.0181	0.0194	0.0363	-0.0545	-0.0042	-0.0033	0.0415	-0.0714	-0.0005	0.1196	-0.0048	0.0157	0.0560	0.0458
2256.68	58.94	1226.25	63.69	234.79	1687.08	5548.19	3111.04	494.31	2801.49	78.60	394.38	372.16	137.31	2007.97
183	5S FILM	0.7501	0.1057	0.8557	0.5000									
0.7620	0.9015	0.6618	0.7142	0.6352	0.8367	0.7835	0.6851	0.8715	0.8403	0.7410	0.8317	0.7306	1.0508	0.8013
192.96	5564.02	2142.23	980.05	847.98	276.04	712.06	8545.31	732.04	332.01	896.01	226.02	2224.67	5007.89	1065.90
183	7S FILM	0.7287	0.0618	[illegible]	0.5000									
0.8023	0.7615	0.7119	0.6454	0.7147	0.8184	0.8153	0.7035	0.6517	0.7759	0.7998	0.7508	0.7526	0.6262	0.7471
245.79	405.90	1512.98	2181.90	3645.85	3156.59	809.77	464.42	853.66	1390.82	218.91	1387.91	428.51	660.91	383.49
183	7C FILM	0.0390	0.0542	0.0931	0.5000									
0.0676	0.0590	0.1121	0.0859	0.0719	0.0451	0.0038	-0.0438	-0.0551	-0.0453	0.0560	0.1162	0.0389	0.0147	0.0624
94.11	143.54	459.06	1445.84	3013.95	2104.98	338.71	316.89	568.32	554.08	101.33	895.86	333.90	460.23	157.20
184	4C TLD	-0.1690	0.3526	0.5416	0.5000									
-0.1075	-0.1095	-0.1717	-0.0960	0.1286	-0.1314	0.3371	-0.1533	-0.1678	-0.1210	-0.9923	-0.1653	-0.9915	-0.0708	-0.0219
368.41	214.04	6857.73	138.27	42.62	1381.53	120.04	5822.57	2979.93	1877.11	4432.91	8758.08	4325.17	104.71	41.51
184	8C TLD	0.1686	1.1223	1.2909	0.5000									
-0.1051	-0.0109	-0.1948	-0.1699	-0.1136	-0.1479	-0.1017	-0.0888	-0.1400	-0.1766	-0.1470	-0.1066	-0.0995	-0.0907	4.2221
402.72	166.62	1720.44	4772.96	2126.48	2210.20	1491.03	403.76	780.55	4487.95	3383.44	377.19	173.35	310.77	561.85
185	1C TLD	0.0203	0.1054	0.1257	0.3000									
-0.0271	-0.0107	0.0287	-0.1676	0.0200	0.0230	0.0618	0.0626	0.0374	0.1240	-0.2639	0.0797	0.0849	0.1682	0.0834
96.80	270.66	127.54	17.89	225.62	341.25	37.30	50.09	16.23	206.49	104.72	15.12	53.84	336.53	32.45
185	2C TLD	-0.0421	0.0499	0.0919	0.3000									
-0.0436	-0.0620	-0.1060	-0.1420	-0.0478	0.0155	-0.0247	-0.0658	-0.0634	-0.0440	-0.0063	-0.0145	-0.0003	-0.0844	0.0584
99.85	63.68	55.53	43.72	63.38	62.63	161.30	87.31	17.05	49.71	78.56	105.15	37.45	19.94	152.87
185	3S TLD	-0.0495	0.1136	0.1631	0.5000									
0.0637	0.0243	-0.0140	0.1483	-0.2583	-0.2055	-0.0015	-0.0168	-0.0646	-0.1330	-0.2220	0.0056	-0.0931	-0.0105	0.0346
215.29	366.09	697.74	68.77	7960.91	690.07	4479.86	1014.01	71.63	318.34	308.49	7215.39	74.98	206.16	9169.47
185	3C TLD	0.0467	0.1414	0.1881	0.5000									
0.0594	0.0177	-0.0173	0.3654	-0.2613	0.1250	-0.0055	-0.0206	0.1867	0.2283	-0.0310	0.0017	0.0392	-0.0174	0.0305
151.97	258.42	492.52	34.42	5615.64	487.11	3162.26	715.77	50.56	224.71	217.76	5093.21	52.93	145.53	6472.57
185	4D TLD	-0.0156	0.1040	0.1196	0.5000									
-0.0107	0.0414	-0.2430	0.0384	0.2251	-0.0043	-0.0130	-0.0748	-0.0387	-0.0820	-0.1017	-0.0088	-0.0048	-0.0699	0.1128
366.92	213.17	6829.92	137.71	42.45	1375.53	119.55	5798.55	2967.84	3063.08	4414.93	8722.55	4307.62	104.29	41.34
185	5S TLD	0.0042	0.0789	0.0831	0.5000									
-0.0090	0.0639	0.0581	-0.2415	-0.0203	0.1124	0.0074	-0.0171	0.0126	-0.0198	0.0472	0.0386	0.0581	-0.0231	-0.0048
781.00	155.08	654.94	1376.39	250.07	240.02	401.02	327.59	4998.86	660.08	1250.99	181.02	2686.79	519.99	401.93
185	6S TLD	0.0371	0.1352	0.1723	0.5000									
0.0662	0.1779	0.0208	-0.1389	-0.1023	0.1666	0.2089	0.0234	-0.0150	-0.2320	0.0904	0.1423	0.1886	0.0799	-0.1191
500.85	78.96	298.78	2891.55	1999.48	4768.58	124.08	405.52	484.29	319.02	484.21	3626.03	144.70	1524.27	270.19
185	6C TLD	0.0898	0.1154	0.2052	0.5000									
0.1050	0.2530	0.1280	-0.0943	-0.0363	0.1344	0.2279	0.1345	0.0476	-0.1544	0.1421	0.1521	0.1761	0.1320	0.0
422.62	65.44	236.70	2405.89	1803.40	4289.67	106.69	354.36	380.89	254.26	404.52	3145.68	128.39	1272.98	212.00
185	7S TLD	-0.0871	0.0889	0.1710	0.5000									
-0.0095	0.0647	-0.2389	-0.0150	-0.2189	-0.0531	-0.0882	-0.0832	-0.1272	-0.1881	-0.0756	0.0267	-0.1315	0.0041	-0.0971
359.42	242.33	5003.60	741.14	1787.23	360.10	641.60	5062.25	482.34	394.16	324.55	4299.15	2842.83	2170.09	996.84
185	7C TLD	-0.0318	0.0525	0.0843	0.5000									
0.0146	0.0732	0.0182	-0.0360	-0.0130	-0.0698	-0.0936	0.0440	-0.0964	-0.0563	-0.0805	-0.0335	-0.0177	-0.0327	-0.0966
175.44	153.75	2096.82	426.34	1325.25	237.59	393.85	3063.08	277.79	243.71	209.12	2989.28	1578.95	809.12	590.02
185	8C TLD	-0.0571	0.0936	0.1908	0.5000									
-0.1226	0.0629	-0.2787	-0.1682	-0.3542	-0.0458	-0.0681	0.0264	-0.0856	-0.1391	-0.0523	-0.1373	-0.1054	-0.0002	-0.0885
400.04	165.59	1709.45	4707.90	2050.19	2196.67	1681.97	401.41	775.36	4457.16	3361.96	374.41	172.14	309.06	558.45
187	1C TLD	0.1111	0.1295	0.2406	0.3000									
0.1049	0.1371	0.1205	0.2048	0.6765	0.1566	0.1002	0.0935	0.1289	0.2106	-0.3057	0.0872	0.0858	0.2844	0.1416
96.84	220.74	127.62	17.85	225.73	342.64	37.45	50.30	16.30	207.33	105.14	15.18	54.06	337.90	32.59
187	2C TLD	-0.0641	0.0411	0.1052	0.3000									
-0.0165	-0.0612	-0.0580	-0.0341	-0.0681	-0.1126	0.0250	-0.0825	-0.0304	-0.1405	-0.0454	-0.0926	-0.1011	-0.0612	-0.0814
100.26	60.93	56.16	43.90	63.63	62.88	161.95	87.67	17.12	49.91	78.88	105.57	37.60	20.03	153.49
187	3S TLD	0.0561	0.0480	0.1041	0.5000									
0.0436	0.0005	-0.0231	0.0846	0.0584	0.0890	0.1074	-0.0109	0.0032	0.1349	0.0417	0.0455	0.0648	0.0892	0.1130

215.72	368.83	695.15	48.86	7976.35	651.46	4488.91	1016.05	71.77	318.98	309.11	7229.96	75.13	206.58	9187.95
187	3C TLD	0.0217	0.1911	0.1228	0.5000									
0.0639	0.0080	-0.0355	-0.1302	0.0635	0.0941	0.1128	-0.1871	0.0066	0.1414	-0.1338	0.0505	0.0559	0.0972	0.1183
152.27	259.94	492.52	34.49	5630.35	488.05	3168.64	717.22	50.66	225.16	218.20	5103.50	53.03	145.82	6485.64
187	4C TLD	-0.0282	0.0332	0.0614	0.5000									
-0.0554	-0.0516	-0.0573	-0.0526	-0.0645	-0.0055	-0.0170	0.0391	0.0101	0.0069	-0.0322	-0.0443	-0.0451	0.0028	-0.0363
366.41	214.04	6857.73	138.27	42.62	1381.53	120.04	5822.57	2979.93	1877.11	4432.91	8758.08	4325.17	104.71	41.51
187	5S TLD	0.2372	0.0681	0.3053	0.5000									
0.1395	0.3419	0.2692	0.2545	0.3517	0.2416	0.2553	0.1325	0.2411	0.3195	0.2398	0.2651	0.1423	0.2289	0.1917
781.02	155.00	654.97	1376.59	250.05	240.02	401.02	327.59	4998.86	660.08	1250.99	181.02	2686.79	519.99	401.93
187	6S TLD	0.0026	0.0557	0.0583	0.5000									
0.0595	0.0948	0.0668	0.0290	-0.0204	-0.0060	-0.0519	-0.0231	0.0092	0.0723	0.0172	-0.0700	-0.1045	-0.0162	-0.0180
504.00	79.46	300.90	2910.50	2005.93	4784.66	124.46	370.55	485.54	319.87	485.62	3637.45	145.18	1528.73	270.88
187	6C TLD	-0.0524	0.0670	0.1554	0.5000									
-0.0897	0.0935	-0.0894	-0.1019	-0.1232	-0.1038	-0.0377	-0.0271	-0.1412	-0.0587	-0.1054	-0.1753	-0.1074	-0.1652	-0.1532
425.12	65.84	238.31	2420.77	1812.37	4304.78	107.04	329.95	381.93	254.98	405.78	3156.13	128.84	1276.93	212.58
187	7S TLD	0.6593	0.0647	0.1640	0.5000									
0.0865	0.0337	0.0667	0.2000	0.0262	0.1185	0.0463	0.1270	0.1004	0.1287	0.0696	0.0920	0.2136	0.1874	-0.0012
359.86	242.82	5005.32	742.47	1791.81	361.07	643.21	5074.73	483.47	395.15	325.37	4311.33	2849.26	2173.72	999.24
187	7C TLD	-0.0457	0.0603	0.1060	0.5000									
0.0388	-0.0089	-0.0690	-0.0095	-0.1012	-0.0988	-0.0163	0.0210	-0.0176	-0.0029	-0.0693	0.0262	-0.1548	-0.1263	-0.0969
176.16	154.37	2105.36	428.08	1330.65	238.56	395.46	3075.56	278.92	244.70	200.93	3001.45	1585.38	892.74	592.42
188	1C FILM	-0.2398	0.0839	0.9237	0.3000									
-0.8993	-0.8181	-0.8666	-0.7653	-0.8399	-0.9537	-0.8459	-0.8500	-0.8227	-0.9272	-0.8883	-0.6527	-0.7753	-0.9453	-0.7227
96.45	219.84	127.11	17.77	224.81	326.02	35.63	47.65	15.51	197.25	104.72	15.12	53.84	336.53	32.45
188	2D FILM	-0.4337	0.1590	0.6027	0.3000									
-0.5655	-0.4766	-0.4570	-0.4510	-0.4320	-0.5403	-0.6684	-0.5797	-0.4077	-0.5136	-0.3254	-0.4218	-0.1055	-0.0373	-0.5238
99.85	60.68	55.93	43.72	63.36	62.63	161.30	87.21	17.05	49.71	78.56	105.15	37.45	19.94	152.87
188	3S FILM	-0.5066	0.5501	1.0567	0.5000									
-1.0000	-1.0000	-1.0000	1.0506	-1.0000	-0.5653	-0.8146	-0.3590	-0.3020	-0.5602	-0.1248	-0.8406	-0.0664	-0.1754	-0.8419
215.29	366.09	657.74	48.77	7960.31	690.07	4476.50	1014.01	71.63	318.34	308.49	7215.39	74.98	206.16	9169.47
188	3D FILM	-0.2329	0.4165	0.6455	0.5000									
-0.2104	-0.4965	0.0558	0.4525	-0.7366	-0.3841	-0.7373	-0.0919	-0.0111	-0.3770	0.2395	-0.7742	0.3226	0.0307	-0.7760
151.97	258.42	492.52	34.42	5615.04	487.11	3159.88	715.77	50.56	224.71	217.76	5093.21	52.93	145.53	6472.57
188	4C FILM	-0.0514	0.1970	0.2434	0.5000									
-0.0189	0.0320	-0.1689	0.0166	0.1780	-0.1715	-0.0799	-0.3102	-0.3733	-0.3438	-0.0306	0.0364	0.2188	0.0548	0.2095
366.92	213.17	6829.92	137.71	42.45	1375.93	119.55	5798.95	2967.84	3063.08	4414.93	8722.55	4307.62	104.29	41.34
188	5S FILM	-0.0884	0.2908	0.3751	0.5000									
-0.1147	-0.0949	-0.0820	-0.1264	-0.6782	-0.1251	-0.1522	-0.1453	-0.1998	-1.0000	0.1991	0.1601	0.2543	0.1346	0.0450
779.36	154.67	653.58	1373.67	249.52	240.02	401.02	327.59	4998.86	660.08	1250.99	181.02	2686.79	519.99	401.93
188	6S FILM	-0.6611	0.2220	0.8830	0.5000									
-0.5622	-1.0000	-1.0000	-1.0000	-0.8253	-0.3856	-0.5970	-0.6751	-0.6696	-0.5925	-0.4045	-0.6565	-0.4505	-0.7584	-0.3387
502.50	79.24	300.17	2902.09	2003.15	4768.58	124.08	369.33	484.29	319.02	486.58	3638.63	145.58	1531.58	272.21
188	6C FILM	-0.4556	0.1781	0.6737	0.5000									
-0.7168	-0.3906	-0.2005	-0.6644	-0.6788	-0.3170	-0.5313	-0.6350	-0.5799	-0.4887	-0.2866	-0.6038	-0.3799	-0.7105	-0.2503
423.78	65.64	237.65	2413.35	1805.99	4289.67	106.69	328.81	380.89	254.26	406.48	3154.58	129.02	1278.14	213.42
188	7S FILM	-0.2985	0.2781	0.5767	0.5000									
-0.5823	-0.7523	-0.4703	-0.4600	-0.7761	-0.1669	-0.2207	-0.2908	-0.1914	-0.1376	-0.0140	-0.0134	-0.0219	0.1180	-0.4984
359.14	242.19	5002.95	740.73	1786.41	360.11	641.62	5062.08	482.31	394.25	324.55	2888.83	4253.15	2173.52	996.84
188	7D FILM	-0.0542	0.2426	0.2368	0.5000									
0.0260	0.0407	-0.1892	-0.0383	-0.0452	-0.0740	-0.0860	-0.2850	-0.0280	-0.0152	0.1493	-0.0500	0.0069	-0.8891	0.0678
175.44	153.75	2696.82	426.34	1325.25	237.59	393.85	3063.08	277.79	243.71	200.12	1578.95	2989.28	892.55	590.02
188	8C FILM	0.0725	0.8907	0.9632	0.5000									
0.1245	0.3286	-0.1635	99.9999	-0.1655	-0.2316	-0.1349	3.0357	0.0937	-0.2325	-0.3813	-0.3340	0.0279	-0.7476	-0.2049
400.04	165.59	1709.45	4747.82	2050.19	2196.67	1481.97	401.41	775.36	4457.16	3361.96	321.34	169.27	309.06	558.45
189	1C TLD	-0.1531	0.0824	0.2355	0.3000									
-0.1305	-0.2746	-0.2761	-0.1683	-0.1324	-0.1662	-0.1795	-0.2104	-0.2812	-0.1555	-0.1058	-0.0813	-0.0354	-0.0289	-0.0703
96.84	229.74	127.62	17.85	225.73	342.64	37.45	50.30	16.30	207.33	105.16	15.19	44.20	338.02	32.60
189	2C TLD	-0.0742	0.0866	0.1608	0.3000									
0.0047	-0.0538	-0.0940	-0.1350	-0.1572	-0.2584	-0.0397	-0.1264	-0.1118	-0.1483	-0.0823	-0.0246	0.0077	0.0309	0.0749

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Table 1. Alphabetical listing of the 56 processors that participated in Test #3 and that reported their doses before the end of the pilot study.

Argonne National Laboratory
Arkansas Power and Light
Atomic Energy Industrial Laboratories
Battelle Pacific Northwest Laboratory
Bethlehem Steel Corporation
Bettis Atomic Power Laboratory
Bureau of Medicine and Surgery
→ Carolina Power and Light Company
Charleston Naval Shipyard
Consumers Power Company
Duke Power Company
Eberline Instrument Corporation
Florida Power and Light Company
Harvard University
Health Physics Northwest, Inc.
Houston Lighting and Power Company
ICN Pharmaceuticals, Inc.
Kansas Gas and Electric Company
Knolls Atomic Power Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Mason & Hanger, Inc.
Monsanto Research Corporation
Naval Research Laboratory
New England Nuclear Corporation
NLO, Inc.
Northeast Utilities Service Company
Nuclear Sources and Services, Inc.
Oak Ridge National Laboratory
Omaha Public Power District
Pacific Gas and Electric Company
Pacific Radiation Corporation
Portland General Electric Company
Portsmouth Naval Shipyard
Power Authority of the State of New York
Public Service Electric and Gas Company
Radiation Detection Company
Reynolds Electrical and Engineering Co.
Rochester Gas and Electric Corporation
Rockwell International
R.S. Landauer Jr. and Company
Sandia National Laboratories
Southern California Edison
Teledyne Isotopes
Tennessee Valley Authority
Texas Utilities Generating Company
Three Mile Island Nuclear Station
Union Electric Company
United States Air Force
United States Army
Idaho National Engineering Laboratory
United States Testing Company
Virginia Electric Power Company
Washington Public Power System
Welex
Yankee Atomic Electric Co.

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RECOMMENDATIONS

The following recommendations are offered to help the NRC and other interested organizations to continue the momentum begun in 1975 to develop a nationally recognized testing program for personnel dosimetry processors.

1. A dosimetry testing program needs the backing of one or more regulatory agencies. The management that ultimately controls the funding of a dosimetry processing unit within an organization responds favorably to requests to improve quality when regulatory pressures are exerted. We recommend that a mandatory testing program be established based on the experiences gained during the pilot study.

2. Many processors participated in more categories than they actually thought necessary (e.g., the two accident categories and the categories involving low-energy photons). This was done partly in the belief that their regulatory agency will eventually require such participation. We recommend that guidelines be developed for the test categories required of generic types of processors (e.g., nuclear power plants, commercial processors, etc.).

3. The spirit of the development of the HPSSC Standard and the subsequent pilot study would be violated if the primary goal of processors was to pass a testing program with little or no regard for the relationship between test results and the needs of radiation workers being served. We recommend that processors and regulators accept that different algorithms may be required for testing and for routine use.

4. The HPSSC Standard was not intended to be used to test direct-reading dosimeters.* However, it seems reasonable not to exclude these important dosimeters from testing and accreditation. An increase in the testing fees for direct-reading dosimeters would compensate the testing laboratory for the additional work required to prepare the dosimeters for irradiation and to read them after irradiation. We recommend that the testing laboratory be permitted to process (by following written procedures supplied by the processor) as well as to irradiate direct-reading dosimeters.

5. The HPSSC Standard was not intended to be used to test extremity dosimeters.* However, the comments made above concerning direct-

*New standards are currently in an early development stage for direct-reading and extremity dosimeters. Until the standards are completed (circa 1986), the procedures in the current Standard could be modified to permit testing of these two types of dosimeters. This would provide a valuable data base for the development of the standards for these two types of dosimeters.

reading dosimeters apply to extremity dosimeters as well. We recommend that the testing laboratory be permitted to accept extremity dosimeters for testing and accreditation.

6. Categories III through VII represent a substantial test of a processor's ability since the type of radiation used for each dosimeter is not reported to the processor when the dosimeters are returned by the testing laboratory. A processor could defeat the significance of the Standard by passing one of these categories at a time (the type of radiation would then be known), or by retesting only in those categories failed. We recommend that, for Categories III through VII, a processor be accredited only in those categories that were passed simultaneously.

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5. The four primary reasons for the poor performance of some processors in Tests #1 and #2 are still evident in Test #3. These are incorrect calibration factors, dosimeter variability, clerical errors, and poor calibration for accident doses.

6. The best processor performance is observed in Category IV, high-energy photons in the protection dose range.

7. The worst processor performance is observed in Categories I, III, and VI which use low-energy photons. This is probably due to the fact that low-energy photons have large conversion factors from exposure to dose equivalent, and that many processors have not yet developed or adjusted algorithms to deal with the response of their dosimeters to low-energy photons.

15. The results obtained from some processors (military and private industry) were slightly better than the results obtained from other processors when comparing the performance of individual dosimeters (see Table 10).

16. Measurements made late in the pilot study showed the ratio of photon to neutron dose equivalent rates from the moderated californium-252 source is actually 0.18 instead of the value of 0.30 used during Test #3. This correction in the ratio affected the pass/fail results of only one out of the 47 processors that participated in Category VIII (see Table 11).

CONCLUSIONS

The following conclusions are derived from the data produced from Tests #1, #2, and #3 of the pilot study, and from five years of discussions with dosimetry processors.

1. The HPSSC Standard shown in Appendix A is generally not a difficult standard to pass for a competent processor. It represents an acceptable measure of minimum performance, and is an appropriate basis for a regulatory program to accredit dosimetry processors.

2. The five-year pilot study of the HPSSC Standard has encouraged processors to devote considerable attention to proper calibration and quality control procedures. It has also developed a commonly accepted terminology (e.g., shallow and deep depths and the use of dose equivalent instead of exposure) which has helped standardize personnel dosimetry among most of the processors.

3. Much of the success of the pilot study and the improvements seen from Test #1 to Test #2 to Test #3 are due to the increased perception by most processors that a mandatory testing program is imminent. Many processors responded to the mounting pressures of a pending mandatory testing program by making significant improvements in their dosimetry system. Without the implementation of a mandatory program, further improvements are doubtful.

4. Although the tolerance limits in the HPSSC Standard represent a minimum level of performance, the results of Test #3 suggest that many processors can achieve bias, $|\overline{P}|$, and precision, S, terms of less than 0.1 each for test dosimeters.

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