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Author(s): G.W.R. Endres, J.M. Aldrich and R.V. Griffith

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INTERIM REPORT

PRELIMINARY REPORT
NEUTRON DOSIMETRY AT SITE E - BWR*

G. W. R. Endres
Battelle, Pacific Northwest Laboratory
Richland, Washington 99352

Since this site is a BWR, containment could not be entered during operation due to the inert atmosphere. Consequently, the only neutron fields obtainable were those caused by streaming through pipe penetrations in the biological shield. Measurements were conducted at three different locations where the shielding and streaming conditions were similar. These were the only accessible locations where neutron exposure might be a problem. A diagram of pipe penetrations at Location X29 and the multisphere stand location at this site are shown in Figure 1.

Monitoring instruments and the multisphere spectrometer system were used for active dose equivalent measurements at each location. The measured dose equivalent rates were quite low, so passive dosimeters were exposed at only two locations due to exposure times required to accumulate response on the dosimeters. Multisphere spectrometer data were taken at all three locations. At location 1-X29 some difficulty was encountered with electronic noise interference. This was later traced to a problem with an electrical connector.

The three locations are designated 1-X29, 2-X29 and 3-X29 and pertinent data from portable survey instruments are given in Table 1.

TABLE 1. Portable Instruments - Site E

Location	Rascal 3/9" Ratio	Average Rascal mrem/hr	Average Snoopy mrem/hr	C.P. mR/hr
1-X29	4.6	1.4	0.08	0.8
2-X29	3.92	2.81	1.9	2.5
Gate	3.01			
3-X29	2.07	1.22	0.75	1.1

Dose equivalent rates vary from about 1 mR gamma and 1 mrem fast neutrons at location 1-X29 to 2.5 mR and about 3 mrem at location 2-X29. As an indication of average neutron energy, ratios of the neutron count rate of 3" and 9"

* Work performed for the U.S. Nuclear Regulatory Commission under DOE Contract EY-76-C-06-1830.

polyethylene spheres were taken at each location. These ratios varied from 2 to 4.5. According to data from Hankins,[1] these ratios indicate average neutron energies of about 80 keV at 1-X29, 100 keV at 2-X29 and 200 keV at 3-X29.

All the gamma instrument readings were taken with a standard Hanford C.P. instrument with no phantom present. As shown in Table 2, Vendor A, LLL, and PNL dosimeters were placed on two phantoms which were then placed in locations 1-X29 and 2-X29. The results of the dosimeters show a gamma exposure significantly higher than the instrument reading multiplied by the exposure time. Data from the licensee dosimeters placed on the phantoms are not available at this time so conclusions given here are preliminary.

TABLE 2. Personnel Dosimetry - Site E

Location	Time Calculated Dose	Dosimeters	mR γ	mrem n
1-X29	12.72 mR γ 11.13 - 15.9 mrem n	Site E-1		
		Site E-2		
		Vendor A - 1014	39	R*
		Vendor A - 1015	22	R
		LLL - EHF-1	20	21
		LLL - EHR-2	10	3
		PNL - E-1	24.7	9.3
		PNL - E-2	27.3	0
2-X29	41.33 mR γ 29.57 - 33.06 mrem n	Site E-3		
		Site E-4		
		Vendor A - 1012	57	R*
		Vendor A - 1013	61	R
		LLL - EHF-3	37	40
		LLL - EHR-4	8	5
		PNL - E-3	53.68	392.2
		PNL - E-4	43.08	187.4

* R = Data not reported.

Vendor A dosimeters show a response to the neutron spectrum at both locations. These dosimeters use the response of deep traps in LiF thermoluminescent material

(1) Dale E. Hankins, "Neutron Dosimetry Studies at the Lawrence Livermore Laboratory," presented at Sixth ERDA Workshop on Personnel Neutron Dosimetry, July 11-12, 1977, Oak Ridge, Tennessee (PNL-2449).

to show the presence of fast neutrons. The integrated neutron dose equivalent needs to be calibrated for each site location in order for the response to be meaningful. At location 1-X29 the integrated neutron dose equivalent from portable instruments is only 11 to 15 mrem depending on which instrument (Snoopy or Rascal) reading is used. One PNL dosimeter showed 9 mrem; the other "0". At location 2-X29, however, the PNL dosimeters show a high response to the fast neutrons. These data have not been corrected for spectral response. The correction for neutron energy will reduce these readings. The calibration of the PNL dosimeters is based on exposures to a bare Cf-252 neutron source at 1 meter distance.

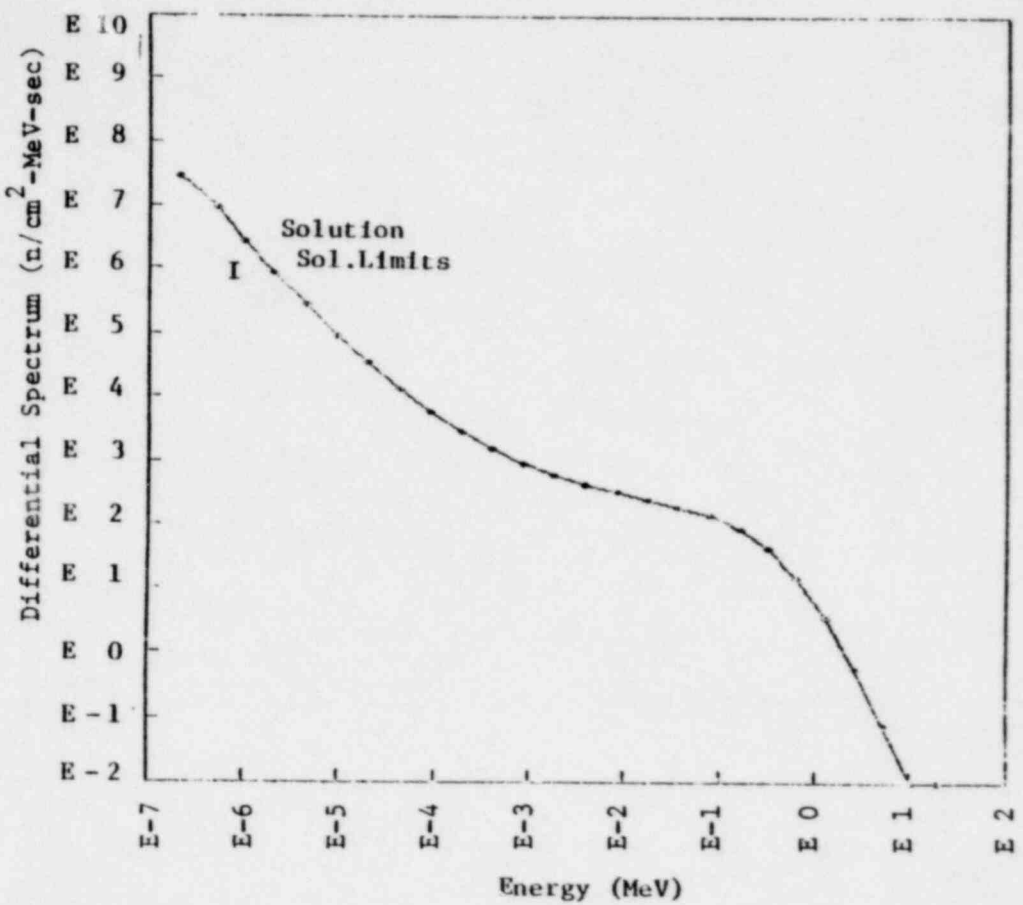
Multisphere data from locations 2-X29 and 3-X29 were analyzed at Lawrence Livermove Laboratory using the LOUHI unfolding code. These data are shown for the two locations in Tables 3 and 4. At location 2-X29 the dose equivalent rate as determined from multisphere data is 2.3 mrem/hr which is between the average Snoopy and Rascal readings. The average neutron energy interpreted by the unfolding code is 265 keV. At location 3-X29 the dose equivalent rate is 0.8 mrem/hr, which is again between the average instrument readings that are shown in Table 1. At location 3-X29, the average neutron energy determined by LOUHI is 167 keV. Plots of the differential flux spectra and the flux per unit lethargy are given in Tables 3 and 4. Figure 2 shows plots of flux vs. energy. These curves are quite similar to the flux per unit lethargy curves shown in Tables 3 and 4.

TABLE 3.

	E(I) MeV	Differential Flux (n/cm^2-MeV-sec)	Integral Flux	Integral Dose Equivalent	Energy Band MeV	Flux (n/cm^2-sec)
1	2.07E-07	2.90E+07	1.00E+00	1.00E+00	3.89E-07	1.13E+01
2	5.32E-07	8.79E+06	8.47E-01	9.79E-01	2.69E-07	2.37E+00
3	9.93E-07	2.67E+06	8.45E-01	9.75E-01	7.63E-07	2.04E+00
4	2.10E-06	8.29E+05	7.88E-01	9.71E-01	1.61E-06	1.34E+00
5	4.45E-06	2.68E+05	7.78E-01	9.68E-01	3.42E-06	9.17E-01
6	5.42E-06	9.14E+04	7.57E-01	9.66E-01	7.22E-06	6.60E-01
7	2.00E-05	3.38E+04	7.48E-01	9.65E-01	1.53E-05	5.14E-01
8	4.22E-05	1.35E+04	7.41E-01	9.64E-01	3.23E-05	4.36E-01
9	8.94E-05	5.91E+03	7.36E-01	9.64E-01	6.89E-05	4.07E-01
10	1.89E-04	2.87E+03	7.30E-01	9.63E-01	1.45E-04	4.16E-01
11	4.84E-04	1.54E+03	7.24E-01	9.62E-01	3.18E-04	4.90E-01
12	8.55E-04	9.14E+02	7.18E-01	9.61E-01	6.40E-04	5.85E-01
13	1.80E-03	5.95E+02	7.10E-01	9.60E-01	1.38E-03	8.21E-01
14	3.00E-03	4.20E+02	6.99E-01	9.59E-01	2.91E-03	1.22E+00
15	8.05E-03	3.17E+02	6.82E-01	9.57E-01	6.20E-03	1.97E+00
16	1.70E-02	2.48E+02	6.58E-01	9.54E-01	1.30E-02	3.22E+00
17	3.01E-02	1.93E+02	6.12E-01	9.46E-01	2.77E-02	5.35E+00
18	7.64E-02	1.42E+02	5.30E-01	9.24E-01	5.03E-02	7.19E+00
19	1.58E-01	8.95E+01	4.27E-01	8.62E-01	1.13E-01	10.1E+01
20	3.10E-01	4.38E+01	2.91E-01	7.33E-01	2.27E-01	9.94E+00
21	6.40E-01	1.50E+01	1.57E-01	5.18E-01	4.56E-01	6.84E+00
22	1.2 E+00	3.53E+00	6.41E-02	2.68E-01	9.20E-01	3.25E+00
23	2.59E+00	6.00E-01	2.82E-02	8.00E-02	1.05E+00	1.11E+00
24	5.22E+00	8.13E-02	5.72E-03	2.41E-02	3.73E+00	3.03E-01
25	1.05E+01	9.54E-02	1.12E-03	5.42E-03	7.50E+00	7.16E-02
26	1.0 E+01	1.84E-03	1.54E-04	7.75E-04	1.09E+01	1.13E-02

TABLE 3 (Cont'd)

Battelle Spectrum 1, 2/14/79
Location 2-X29



Detector	Measured Responses	Calculated Responses
Bare .5IN	3.75E+01	3.75E+01
CD .5IN	1.56E+01	1.56E+01
3 INCH CAD.	8.02E+01	8.06E+01
5 INCH CAD.	1.04E+02	1.05E+02
8 INCH LI.5	5.47E+01	5.45E+01
10 INCH LI.5	3.27E+01	3.17E+01
12 INCH LI.5	1.56E+01	1.59E+01

TABLE 3 (Cont'd)

Battelle Spectrum 1, 2/14/79
Lethargy Plot for Previous Differential Plot
Location 2-X29

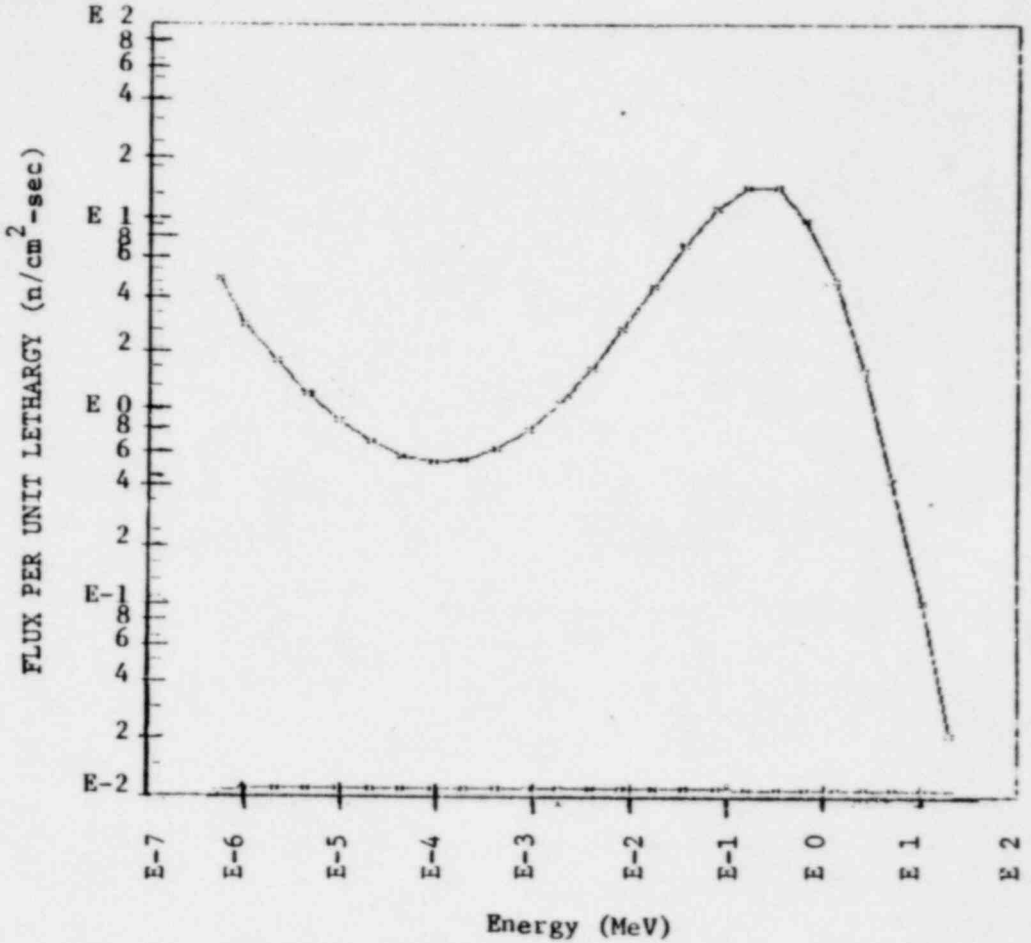
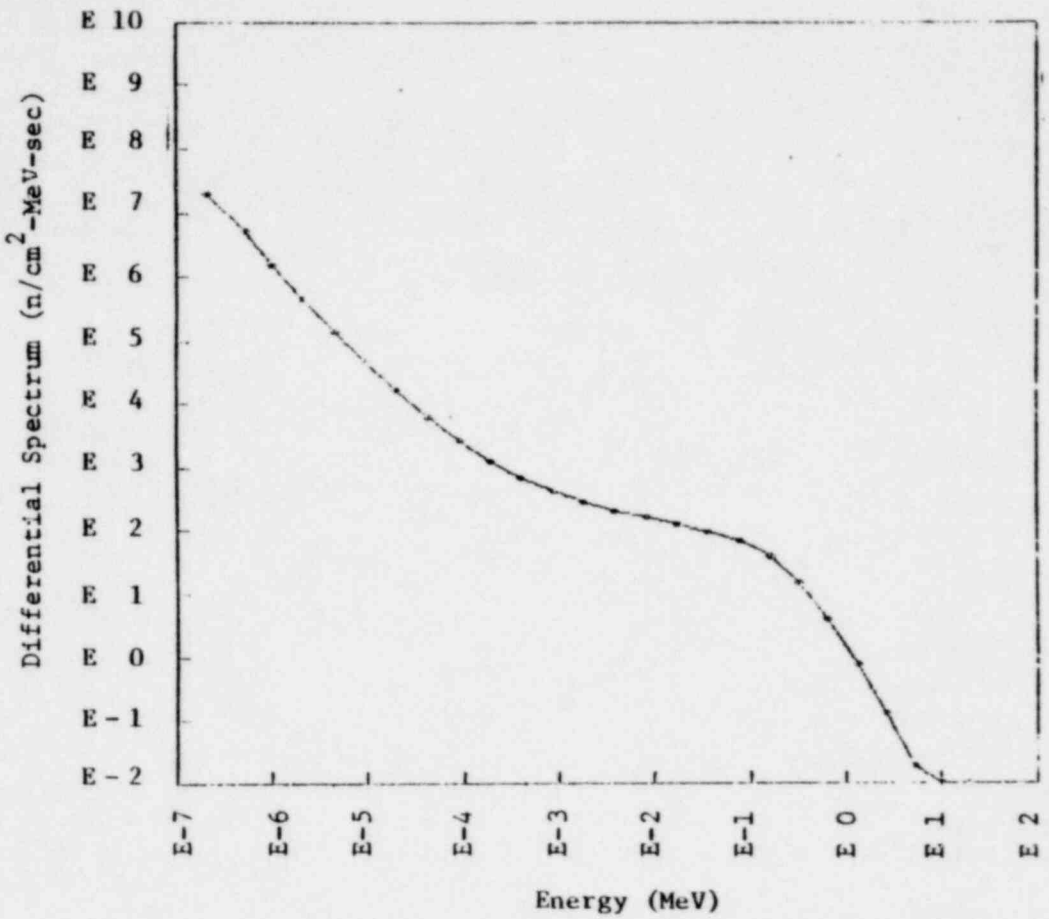


TABLE 4.

	E(I) (MeV)	Differential Flux (N/cm^2-MeV-sec)	Integral Flux	Integral Dose Equivalent	Energy Band (MeV)	Flux (n/cm^2-sec)
1	2.07E-07	1.89E+07	1.00E+00	1.00E+00	3.89E-07	7.35E+00
2	5.32E-07	5.36E+06	7.82E-01	5.59E-01	2.69E-07	1.44E+00
3	9.93E-07	1.53E+06	7.39E-01	9.51E-01	7.63E-07	1.17E+00
4	2.10E-06	4.47E+05	7.05E-01	9.44E-01	1.61E-06	7.20E-01
5	4.45E-06	1.37E+05	6.83E-01	9.39E-01	3.42E-06	4.69E-01
6	9.42E-06	4.49E+04	6.69E-01	9.37E-01	7.22E-06	3.24E-01
7	2.00E-05	1.60E+04	6.60E-01	9.35E-01	1.53E-05	2.45E-01
8	4.22E-05	6.26E+03	6.52E-01	9.34E-01	3.23E-05	2.02E-01
9	8.94E-05	2.72E+03	6.46E-01	9.33E-01	6.89E-05	1.87E-01
10	1.09E-04	1.32E+03	6.41E-01	9.32E-01	1.45E-04	1.91E-01
11	4.84E-04	7.13E+02	6.35E-01	9.31E-01	3.18E-04	2.27E-01
12	8.55E-04	4.29E+02	6.20E-01	9.29E-01	6.48E-04	2.75E-01
13	1.80E-03	2.85E+02	6.20E-01	9.28E-01	1.38E-03	3.93E-01
14	3.00E-03	2.06E+02	6.09E-01	9.26E-01	2.91E-03	6.00E-01
15	8.05E-03	1.59E+02	5.91E-01	9.23E-01	6.20E-03	9.86E-01
16	1.70E-02	1.26E+02	5.62E-01	9.19E-01	1.30E-02	1.64E+00
17	3.61E-02	5.70E+01	5.13E-01	9.07E-01	2.77E-02	2.69E+00
18	7.64E-02	6.74E+01	4.33E-01	8.72E-01	5.86E-02	3.95E+00
19	1.58E-01	3.70E+01	3.16E-01	7.83E-01	1.13E-01	4.27E+00
20	3.18E-01	1.52E+01	1.90E-01	6.17E-01	2.27E-01	3.45E+00
21	6.40E-01	4.10E+00	8.71E-02	3.91E-01	4.56E-01	1.87E+00
22	1.25E+00	7.94E-01	3.16E-02	1.83E-01	9.20E-01	7.31E-01
23	2.59E+00	1.28E-01	9.93E-03	6.05E-02	1.85E+00	2.37E-01
24	5.22E+00	1.92E-02	2.89E-03	1.85E-02	3.77E+00	7.16E-02
25	1.05E+01	2.82E-03	7.59E-04	5.09E-03	7.50E+00	2.12E-02
26	1.96E+01	4.09E-04	1.32E-04	9.24E-04	1.09E+01	4.46E-03

TABLE 4 (Cont'd)

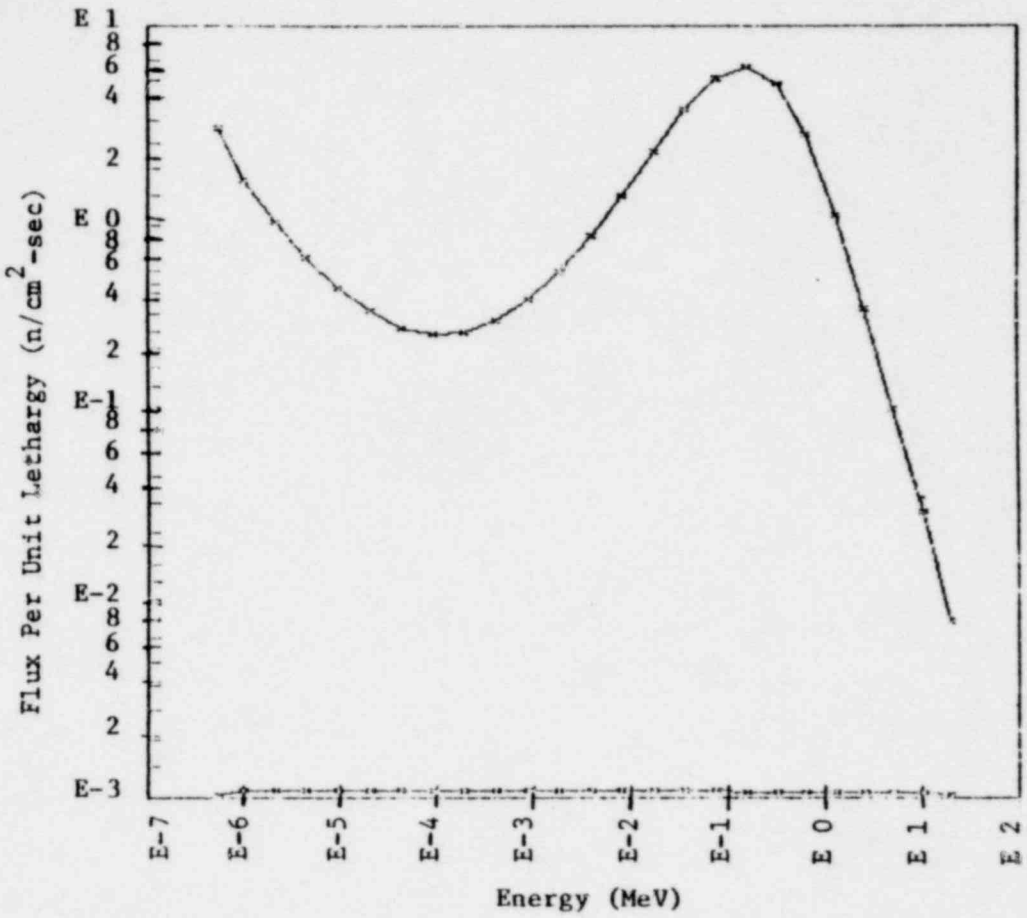
Battelle Spectrum 2, 2/14/79
Location 3-X29



Detector	Measured Responses	Calculated Responses
BARE .5IN	2.27E+01	2.27E+01
CD .5IN	8.56E+00	8.55E+00
3 INCH CAD.	3.61E+01	3.60E+01
5 INCH CAD.	4.39E+01	4.25E+01
8 INCH LI.5	2.11E+01	2.02E+01
10 INCH LI.5	1.16E+01	1.11E+01
12 INCH LI.5	4.99E+00	5.22E+00

TABLE 4 (Cont'd)

Battelle Spectrum 2, 2/14/79
Lethargy Plot for Previous Differential Plot
Location 3-X29



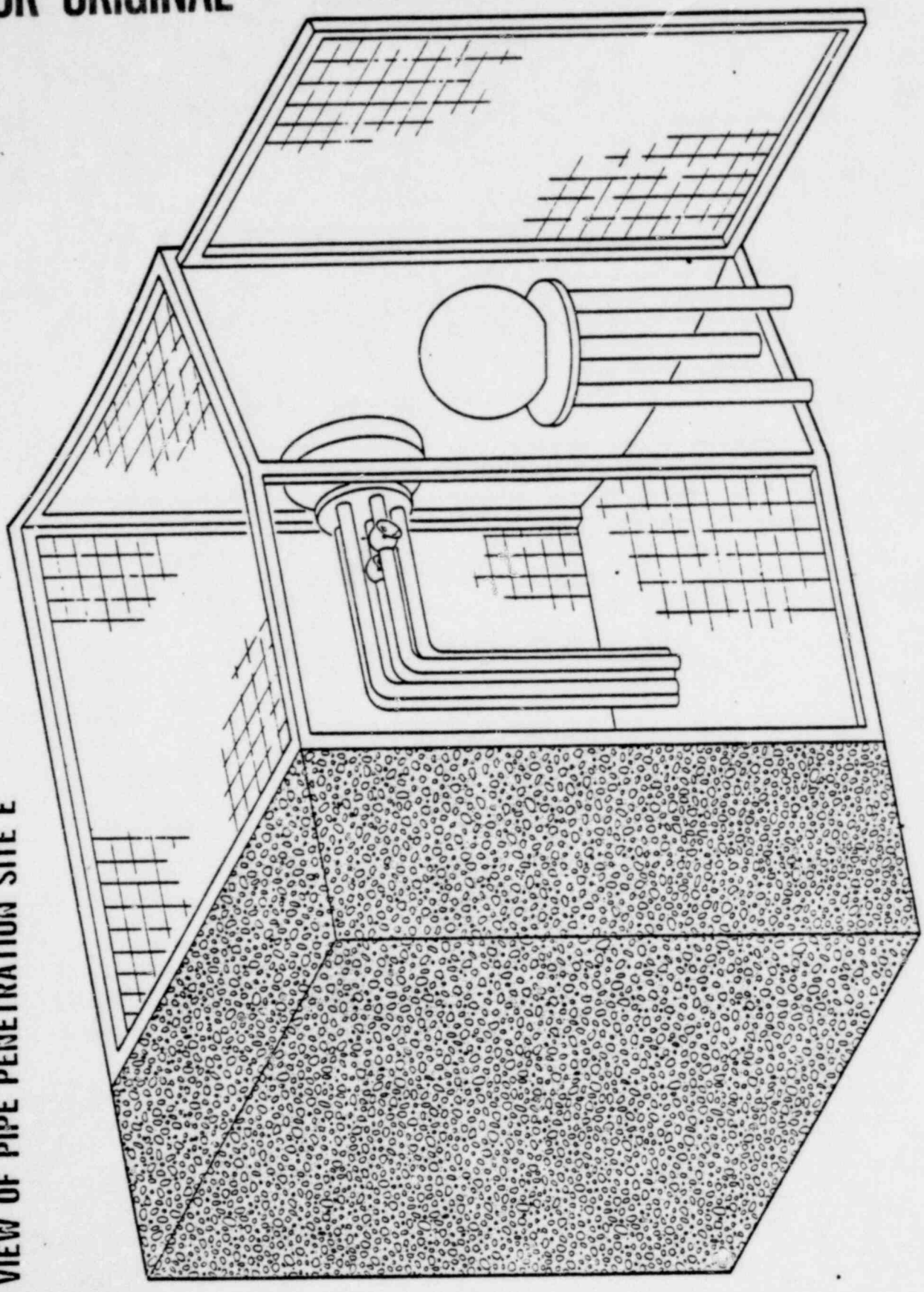
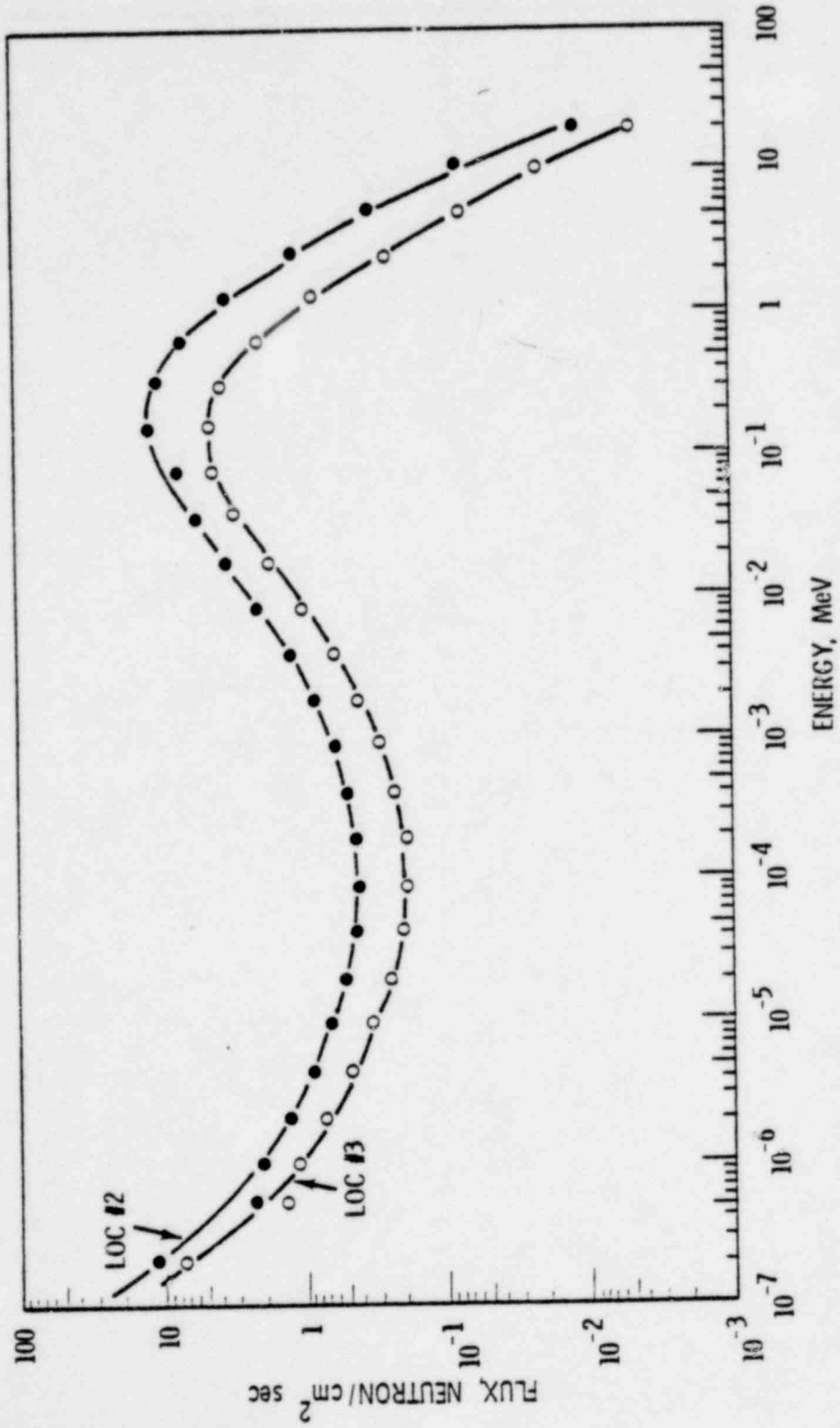


FIGURE 1. View of X29 Penetration

FIGURE 2. Flux vs. Energy - Site E



PRELIMINARY REPORT

NEUTRON DOSIMETRY AT SITE F - PWR*

G. W. R. Endres, J. M. Aldrich and R. V. Griffith†
Battelle, Pacific Northwest Laboratory
Richland, WAshington 99352

Site F was the first PWR site visited for this study. Containment entry was allowed during full power operation with reactor power at 98%. Once inside containment scattered and degraded neutron spectra were found at all points of interest.

Portable monitoring instrument surveys were taken on three elevations. These data provided information as to the best location to set up spectrometer instrumentation and water phantoms. The active dose equivalent measurements were made with portable monitoring instruments (see Table 1) and the multisphere spectrometer (see Tables 3-6). The passive dose measurements were taken with several different types of dosimeters attached to six water phantoms inside containment (see Table 2).

The measured dose equivalent rates with portable instruments ranged from 0.1 mrem/hr to 60 mrem/hr (see Table 1). Four locations on the operating deck were identified for multisphere spectrometer and portable instrument measurements to be taken for comparison. When compared to the Snoopy, the multisphere is between 2 and 4 times lower and when compared to the Rascal the multisphere is between 2 and 9 times lower in dose equivalent rates. The gamma exposure at these same locations ranged from 3 to 12 mR/hr. One water phantom was positioned on a level above the operating deck by a steam generator. Four phantoms were placed on the operating deck about 8 feet down from the entry platform and one was on a third level by a primary coolant pump. The dose equivalent calculated from time spent at the location multiplied by the dose equivalent rate for gamma and neutron exposure is shown in Table 2. Some of the exposure times were quite short due to high rates of exposure.

Pertinent data from portable survey instruments are given in Table 1. Dose equivalent rates vary from about 3 mrem/hr gamma and 0.1 mrem/hr fast

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† R. V. Griffith employed at the University of California, Lawrence Livermore Laboratory.

* Work performed for the U.S. Nuclear Regulatory Commission under DOE Contract EY-76-C-06-1830.

neutrons to 12 mrem/hr gamma and 3.06 mrem/hr fast neutrons as interpreted from multisphere data. The multisphere interpretation of average neutron energies ranged from 0.3 to 35 keV. Location 4 showed an average energy of 0.3 keV, which is believed to be too low. An indication of the average neutron energy was obtained at four locations by the ratio of the count rates of BF_3 detectors inside 3-inch and 9-inch diameter polyethylene spheres. These ratios varied from 4 to 9. According to data from Hankins,(1) these ratios indicate average neutron energies of about 2 keV to 70 keV. These ratios are given only as a rough indicator of neutron energy. They may or may not be useful in correlating TLD albedo response and multisphere spectral data.

As shown in Table 2, the site, Vendor A, LLL, and PNL dosimeters placed on phantoms show gamma exposures slightly higher than the instrument readings at the same locations multiplied by the exposure time in locations 1-4. In locations 5 and 6 the dosimeter responses are significantly lower than the instrument readings. Two possible reasons for the discrepancy at locations 5 and 6 are that the instrument was misread in the higher dose rate areas or the exposure time in the area was not correct. Also, at location 5 the rear of the water phantom was facing a steam generator where a large contribution of gamma dose came from the ^{16}N-gamma in the steam generator.

Vendor A dosimeters use the response of deep traps in LiF thermoluminescent material to show a response to neutrons at each measurement location as shown in Table 2. Site F dosimeters use NTA film and registered minimal response to neutrons in each location. Vendor B dosimeters have four different measuring techniques incorporated in each package. The detection methods for neutrons in the Vendor B dosimeter include NTA film, TLD albedo, carbon recoil track etch and CR39 plastic track etch. In all six locations, the NTA film and both track etch type dosimeters showed almost no response. Values shown in Table 2 for Vendor B are derived from the TLD albedo dosimeter. PNL and LLL also use albedo dosimeters for neutron response. Both the PNL and LLL dosimeters show a response at each measurement location with the exception of dosimeters placed on the rear of the phantom at location 5.

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(1) Dale E. Hankins, "Neutron Dosimetry Studies at Lawrence Livermore Laboratory," presented at Sixth ERDA Workshop on Personnel Neutron Dosimetry, July 11-12, 1977, Oak Ridge, Tennessee (PNL-2449).

A calibration correction factor for Vendor B results has not been established. Therefore, the values shown in Table 2 for Vendor B albedo dosimeters are not corrected for neutron energy. The LLL albedo dosimeter results have been corrected for neutron energy response with the use of the 3-inch and 9-inch sphere ratios. PNL dosimeter data has not been corrected for neutron energy response. The proper corrections will be determined by special calibration at LLL and use of 3-inch and 9-inch sphere ratios. The present calibration of the PNL dosimeter is based on exposures to a bare ^{252}Cf neutron source at 1 meter distance.

Multisphere data from four locations were analyzed at Lawrence Livermore Laboratory using the LOUHI unfolding code. The average neutron energy interpreted by the unfolding code ranges from 0.3 keV to 35 keV. Plots of the differential spectrum versus energy are shown in Figures 1-4 and the flux per unit lethargy versus energy are shown in Figures 5-8. Figure 9 shows plots of flux versus energy for the four points measured. These curves are similar to the flux per unit lethargy curves shown in Figures 5-8. As can be seen in Figure 9, the curve for location 4 is shifted and the calculated neutron energy is very low for that point. The shifted spectrum may have been caused by a bad cable connector to the detector.

TABLE 1. Portable Instruments
Site F

Location	CP	Snoopy	Eberline
F-1	4.8 mR/hr	3-4 mrem/hr	3.4 mrem/hr Away from sphere
617' Containment			4.8 mrem/hr " " "
			3.7 mrem/hr " " "
			3.4 mrem/hr " " "
			5.3 mrem/hr Overhead
			5.6 mrem/hr On Multisphere Stand
			4.5 mrem/hr " " "
			4.7 mrem/hr " " "

Traverse Across	Distance from Containment	Snoopy	Eberline
Deck F-6	4'	3-3.5 mrem/hr	3.9,3.0,3.2 mrem/hr
	8'	3.0 mrem/hr	3.0,3.1,4.2 mrem/hr
	12'	3.0 mrem/hr	3.4,3.5,3.0 mrem/hr
	16'	3.0 mrem/hr	2.3,2.5,3.2 mrem/hr
	20'	2.0 mrem/hr	2.3,2.3,2.1 mrem/hr

Pump Deck Survey Location	CP	Snoopy	Eberline
560' (outside shielding)	6 mR/hr	0.1 mrem/hr	
Pump 1D	3.5 R/hr	50 mrem/hr	44.2 mrem/hr
Pump 1B	4.0 R/hr	60 mrem/hr	39.44 mrem/hr
Stairs	500 mR/hr	6 mrem/hr	4.88 mrem/hr 7.68 mrem/hr
Pump 1C	3.75 R/hr	45 mrem/hr	40.76 mrem/hr
Pump 1A	3.5 R/hr	45 mrem/hr	43.72 mrem/hr 34.52 mrem/hr 39.32 mrem/hr
Between Steam Generators A&B by Pump 1C	500 mR/hr	30 mrem/hr	28.0 mrem/hr

Table 1(cont'd) Portable Instruments - Site F

Survey CCW From Entry

Location	CP	Snoopy	Eberline
1	4.8 mR/hr	2-4 mrem/hr	2.2 mrem/hr
2	9 mR/hr	2-3 mrem/hr	3.5 mrem/hr
3	8.9 mR/hr	2-3 mrem/hr	2.5 mrem/hr
4	4 mR/hr	3 mrem/hr	2.8 mrem/hr
5	6-7 mR/hr	6-7 mrem/hr	7.6 mrem/hr 7.1 mrem/hr
6	3 mR/hr	2 mrem/hr	7.0 mrem/hr
7	12 mR/hr 6 mR/hr on floor	1.5 mrem/hr	2.3 mrem/hr
8	5 mR/hr	1.3 mrem/hr	1.7 mrem/hr
9	3 mR/hr	4 mrem/hr	5.2 mrem/hr
10	8 mR/hr	8 mrem/hr	9.1 mrem/hr
11	4 mR/hr	3 mrem/hr	5.7 mrem/hr

3/9" Eberline Rascal Ratios

Location	Ratio
1	8.5
2	8.43
3	8.9
4	4.18

TABLE 2. Personnel Dosimetry
Site F

Location	Time Calculated Dose Equivalent	Dosimeters	mR γ	mrem n
Jug #1	13.06 mR γ *	Site F-1	30	M
F-6, 617'	11.13 mrem n	Vendor A 1008F	20	R
		Vendor A 1009F	29	R
		Vendor B 010 F	-	330
		LLL-HFF-1	12	10
		LLL-HFR-2	12	7
		PNL-F-1	19.77	89.22
		PNL-R-2	20.03	51.38
Jug #2	17.53 mR γ	Site F-2	20	M
F-13, 617'	22.38-26.11 mrem n	Vendor A 1010F	20	R
		Vendor A 1011F	23	R
		Vendor B 011 F	-	600
		LLL-HFF-3	15	20
		LLL-HFR-4	12	12
		PNL-F-3	22.6	152.3
		PNL-R-4	20.03	31.68
Jug #3	16.79 mR γ	Site F-3	20	M
F-5, 617'	29.84-33.57 mrem n	Vendor A 1001F	46	R
below entry		Vendor A 1002F	27	R
		Vendor B 012 F	-	800
		LLL HFF-5	19	27
		LLL HFR-6	14	15
		PNL F-5	25.59	196.9
		PNL F-6	19.21	47.05
Jug #4	11.19 mR γ	Site F-4	M	M
on entry	11.19 mrem n	Vendor A 1003F	24	R
platform		Vendor A 1004F	15	R
		Vendor B 013 F	-	700
		LLL-HFF-7	11	23
		LLL-HFR-8	11	24
		PNL F-7	17.87	46.41
		PNL R-8	18.23	106.5
Jug #5	2,424.5 mR γ	Site F-5	1.[illegible]0	M
625', by	55.95-74.6 mrem n	Vendor A 1005F	9	R
steam generators		Vendor A 1006F	85[illegible]	R
A and B		Vendor B 014	-	1930
		LLL-HFF-9	687	22
		LLL-HFR-10	1,639	-
		PNL-F-9	1,042	606.9
		PNL-R-10	2,276	-

*γ is gamma
n is neutron

Table 2 (cont'd) Personnel Dosimetry - Site F

Location	Time Calculated Dose	Dosimeters	mR γ	mRem n
Jug #6 592', pump D	640 mR γ 2.75 mrem n	Site F-6	380	M
		Vendor A 001F	246	R
		Vendor A 1007F	166	R
		Vendor B 015 F	-	400
		LLL HFF-11	193	4
		LLL HFR-12	187	4
		PNL F-11	220.9	55.38
		PNL R-12	222.5	222.0

M = Minimal

R - a positive response was obtained. The dosimeter has not been calibrated to provide an interpretation of dose equivalent.

TABLE 3

Site F. Location 1 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	1.47E+08	1.00E+00	1.00E+00	3.39E-07	5.72E+01
2	5.32E-07	4.55E+07	7.46E-01	8.66E-01	2.69E-07	1.22E+01
3	9.93E-07	1.36E+07	6.92E-01	8.36E-01	7.63E-07	1.04E+01
4	2.10E-06	3.95E+06	6.46E-01	8.10E-01	1.61E-06	6.36E+00
5	4.45E-06	1.17E+06	6.17E-01	7.94E-01	3.42E-06	4.00E+00
6	9.42E-06	3.74E+05	6.00E-01	7.84E-01	7.22E-06	2.70E+00
7	2.00E-05	1.33E+05	5.88E-01	7.78E-01	1.53E-05	2.03E+00
8	4.22E-05	5.36E+04	5.79E-01	7.73E-01	3.23E-05	1.73E+00
9	8.94E-05	2.51E+04	5.71E-01	7.69E-01	6.89E-05	1.73E+00
10	1.89E-04	1.37E+04	5.63E-01	7.65E-01	1.45E-04	1.99E+00
11	4.04E-04	8.59E+03	5.54E-01	7.61E-01	3.18E-04	2.73E+00
12	8.55E-04	6.10E+03	5.42E-01	7.55E-01	6.40E-04	3.90E+00
13	1.80E-03	4.71E+03	5.25E-01	7.47E-01	1.38E-03	6.50E+00
14	3.80E-03	3.77E+03	4.96E-01	7.33E-01	2.91E-03	1.10E+01
15	8.05E-03	2.88E+03	4.47E-01	7.11E-01	6.20E-03	1.79E+01
16	1.70E-02	1.89E+03	3.68E-01	6.76E-01	1.30E-02	2.46E+01
17	3.61E-02	9.52E+02	2.59E-01	5.99E-01	2.77E-02	2.64E+01
18	7.64E-02	3.31E+02	1.41E-01	4.57E-01	5.86E-02	1.94E+01
19	1.58E-01	7.68E+01	5.55E-02	2.72E-01	1.13E-01	8.68E+00
20	3.18E-01	1.26E+01	1.71E-02	1.31E-01	2.27E-01	2.86E+00
21	6.40E-01	1.65E+00	4.34E-03	5.13E-02	4.56E-01	7.52E-01
22	1.29E+00	1.91E-01	9.92E-04	1.60E-02	9.20E-01	1.76E-01
23	2.59E+00	2.06E-02	2.14E-04	3.65E-03	1.85E+00	3.81E-02
24	5.22E+00	2.17E-03	4.44E-05	7.98E-04	3.73E+00	8.09E-03
25	1.05E+01	2.23E-04	8.54E-06	1.61E-04	7.50E+00	1.67E-03
26	1.96E+01	2.28E-05	1.10E-06	2.17E-05	1.09E+01	2.49E-04

Total Flux = 2.2522E+02 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 1.8030E+00 Mrem/Hour
Kerma Rate = 1.3282E-02 Ergs/Gm./Hour
Element 57 Dose Rate = 4.5246E-04 Rads/Hour
Average Energy = 2.7526E-02 Mev

TABLE 4

Site F. Location 2 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	2.19E+08	1.00E+00	1.00E+00	3.89E-07	8.52E+01
2	5.32E-07	7.90E+07	7.97E-01	8.81E-01	2.69E-07	2.13E+01
3	9.93E-07	2.67E+07	7.46E-01	8.50E-01	7.63E-07	2.04E+01
4	2.10E-06	8.46E+06	6.97E-01	8.20E-01	1.61E-06	2.89E+01
5	4.45E-06	2.63E+06	6.65E-01	8.00E-01	3.42E-06	8.99E+00
6	9.42E-06	8.54E+05	6.43E-01	7.87E-01	7.22E-06	6.17E+00
7	2.00E-05	3.04E+05	6.28E-01	7.78E-01	1.53E-05	4.65E+00
8	4.22E-05	1.22E+05	6.17E-01	7.71E-01	3.23E-05	3.94E+00
9	8.94E-05	5.73E+04	6.08E-01	7.66E-01	6.89E-05	3.95E+00
10	1.89E-04	3.13E+04	5.98E-01	7.61E-01	1.45E-04	4.54E+00
11	4.04E-04	1.99E+04	5.88E-01	7.55E-01	3.18E-04	6.33E+00
12	8.55E-04	1.43E+04	5.72E-01	7.47E-01	6.40E-04	9.15E+00
13	1.80E-03	1.12E+04	5.51E-01	7.35E-01	1.38E-03	1.55E+01
14	3.80E-03	8.90E+03	5.14E-01	7.16E-01	2.91E-03	2.59E+01
15	8.05E-03	6.58E+03	4.52E-01	6.85E-01	6.20E-03	4.08E+01
16	1.70E-02	4.00E+03	3.54E-01	6.37E-01	1.30E-02	5.20E+01
17	3.61E-02	1.77E+03	2.30E-01	5.41E-01	2.77E-02	4.90E+01
18	7.64E-02	5.23E+02	1.13E-01	3.83E-01	5.86E-02	3.06E+01
19	1.58E-01	1.05E+02	3.94E-02	2.10E-01	1.13E-01	1.19E+01
20	3.18E-01	1.55E+01	1.12E-02	9.49E-02	2.27E-01	3.52E+00
21	6.40E-01	1.96E+00	2.79E-03	3.67E-02	4.56E-01	8.94E-01
22	1.29E+00	2.30E-01	6.61E-04	1.18E-02	9.20E-01	2.12E-01
23	2.59E+00	2.69E-02	1.55E-04	2.93E-03	1.85E+00	4.98E-02
24	5.22E+00	3.17E-03	3.62E-05	7.21E-04	3.73E+00	1.18E-02
25	1.05E+01	3.78E-04	7.95E-06	1.66E-04	7.50E+00	2.84E-03
26	1.96E+01	4.52E-05	1.18E-06	2.56E-05	1.09E+01	4.93E-04

Total Flux = 4.1868E+02 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 3.0307E+00 Mrem/Hour
Kerma Rate = 2.1696E-02 Ergs/Gm./Hour
Element 57 Dose Rate = 8.1176E-04 Rads/Hour
Average Energy = 2.2729E-02 Mev

TABLE 5

Site F. Location 3 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	2.23E+08	1.00E+00	1.00E+00	3.89E-07	8.67E+01
2	5.32E-07	3.63E+07	7.67E-01	7.57E-01	2.69E-07	9.76E+00
3	9.93E-07	7.73E+06	7.41E-01	7.29E-01	7.63E-07	5.90E+00
4	2.10E-06	2.40E+06	7.25E-01	7.11E-01	1.61E-06	3.86E+00
5	4.45E-06	1.08E+06	7.15E-01	7.00E-01	3.42E-06	3.69E+00
6	9.42E-06	6.75E+05	7.05E-01	6.89E-01	7.22E-06	4.87E+00
7	2.00E-05	5.40E+05	6.92E-01	6.75E-01	1.53E-05	8.26E+00
8	4.22E-05	4.93E+05	6.70E-01	6.52E-01	3.23E-05	1.59E+01
9	8.94E-05	4.46E+05	6.27E-01	6.09E-01	6.89E-05	3.07E+01
10	1.89E-04	3.40E+05	5.45E-01	5.27E-01	1.45E-04	4.93E+01
11	4.04E-04	1.90E+05	4.13E-01	3.98E-01	3.18E-04	6.04E+01
12	8.55E-04	7.27E+04	2.51E-01	2.43E-01	6.40E-04	4.65E+01
13	1.80E-03	1.98E+04	1.27E-01	1.27E-01	1.38E-03	2.73E+01
14	3.80E-03	4.22E+03	5.33E-02	5.93E-02	2.91E-03	1.23E+01
15	8.05E-03	7.80E+02	2.04E-02	2.96E-02	6.20E-03	4.84E+00
16	1.70E-02	1.35E+02	7.47E-03	1.82E-02	1.30E-02	1.76E+00
17	3.61E-02	2.31E+01	2.75E-03	1.17E-02	2.77E-02	6.40E-01
18	7.64E-02	4.07E+00	1.03E-03	7.57E-03	5.86E-02	2.39E-01
19	1.58E-01	7.53E-01	3.96E-04	4.88E-03	1.13E-01	8.51E-02
20	3.18E-01	1.50E-01	1.69E-04	3.22E-03	2.27E-01	3.41E-02
21	6.40E-01	3.23E-02	7.81E-05	2.10E-03	4.56E-01	1.47E-02
22	1.29E+00	7.64E-03	3.87E-05	1.28E-03	9.20E-01	7.03E-03
23	2.59E+00	1.97E-03	1.99E-05	6.90E-04	1.85E+00	3.64E-03
24	5.22E+00	5.47E-04	1.01E-05	3.66E-04	3.73E+00	2.04E-03
25	1.05E+01	1.61E-04	4.64E-06	1.74E-04	7.50E+00	1.21E-03
26	1.96E+01	4.85E-05	1.41E-06	5.49E-05	1.09E+01	5.29E-04

Total Flux = 3.7361E+02 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 1.5149E+00 Mrem/Hour
Kerma Rate = 1.3053E-03 Ergs/Gm./Hour
Element 57 Dose Rate = 6.1362E-04 Rads/Hour
Average Energy = 9.8808E-04 Mev

TABLE 6

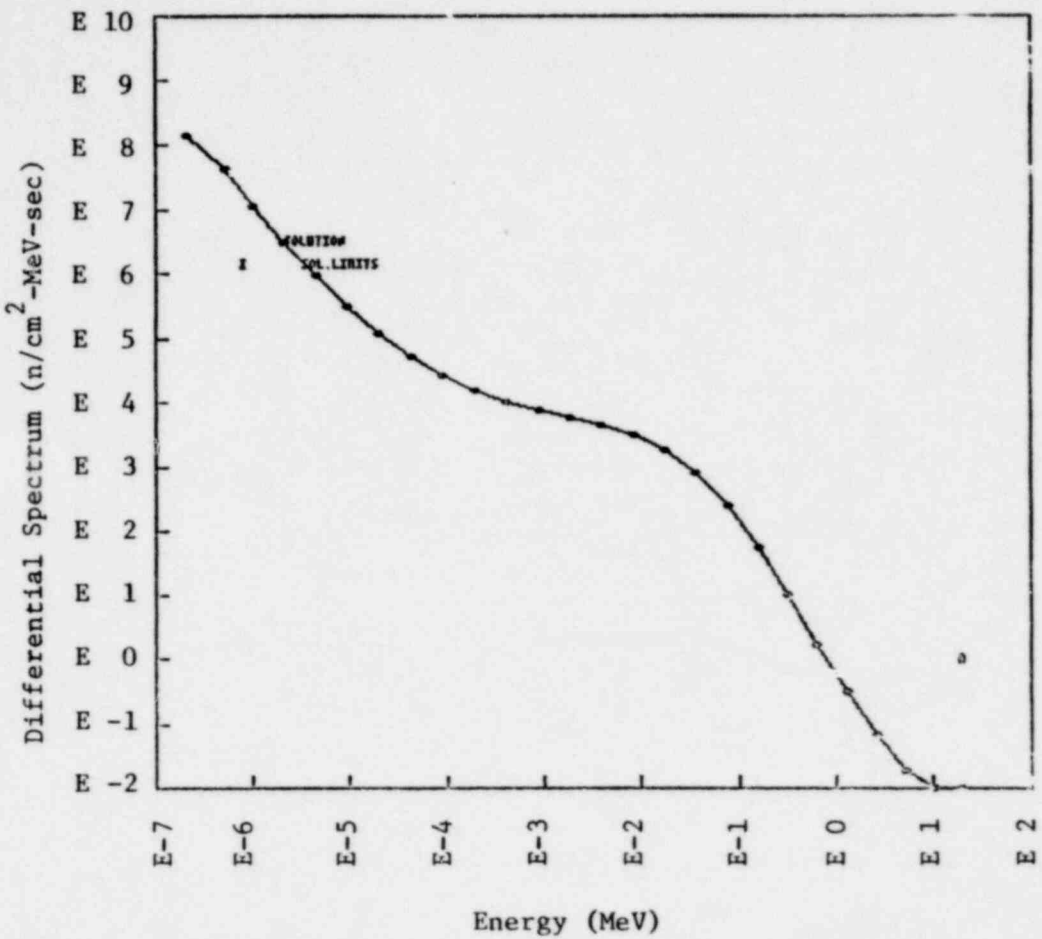
Site F. Location 4 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	1.44E+08	1.00E+00	1.00E+00	3.89E-07	5.60E+01
2	5.32E-07	1.54E+07	6.88E-01	6.79E-01	2.69E-07	4.14E+00
3	9.93E-07	2.74E+06	6.66E-01	6.55E-01	7.63E-07	2.09E+00
4	2.10E-06	9.20E+05	6.54E-01	6.42E-01	1.61E-06	1.48E+00
5	4.45E-06	5.48E+05	6.46E-01	6.33E-01	3.42E-06	1.87E+00
6	9.42E-06	5.02E+05	6.35E-01	6.22E-01	7.22E-06	3.62E+00
7	2.00E-05	5.71E+05	6.15E-01	6.01E-01	1.53E-05	8.74E+00
8	4.22E-05	6.12E+05	5.67E-01	5.51E-01	3.23E-05	1.98E+01
9	8.94E-05	4.55E+05	4.57E-01	4.41E-01	6.89E-05	3.13E+01
10	1.89E-04	1.91E+05	2.83E-01	2.70E-01	1.45E-04	2.77E+01
11	4.04E-04	4.73E+04	1.29E-01	1.23E-01	3.18E-04	1.50E+01
12	8.55E-04	8.53E+03	4.59E-02	4.41E-02	6.40E-04	5.46E+00
13	1.80E-03	1.35E+03	1.56E-02	1.60E-02	1.38E-03	1.86E+00
14	3.80E-03	2.09E+02	5.29E-03	6.65E-03	2.91E-03	6.08E-01
15	8.05E-03	3.37E+01	1.92E-03	3.64E-03	6.20E-03	2.09E-01
16	1.70E-02	5.87E+00	7.56E-04	2.63E-03	1.30E-02	7.63E-02
17	3.61E-02	1.12E+00	3.31E-04	2.06E-03	2.77E-02	3.10E-02
18	7.64E-02	2.36E-01	1.59E-04	1.65E-03	5.86E-02	1.38E-02
19	1.58E-01	5.51E-02	8.23E-05	1.33E-03	1.13E-01	6.23E-03
20	3.18E-01	1.43E-02	4.78E-05	1.08E-03	2.27E-01	3.25E-03
21	6.40E-01	4.12E-03	2.98E-05	8.62E-04	4.56E-01	1.88E-03
22	1.29E+00	1.31E-03	1.93E-05	6.48E-04	9.20E-01	1.21E-03
23	2.59E+00	4.55E-04	1.27E-05	4.40E-04	1.85E+00	8.42E-04
24	5.22E+00	1.70E-04	7.98E-06	2.87E-04	3.73E+00	6.34E-04
25	1.05E+01	6.72E-05	4.45E-06	1.66E-04	7.50E+00	5.04E-04
26	1.96E+01	2.73E-05	1.65E-06	6.34E-05	1.09E+01	2.98E-04

Total Flux = 1.8014E+02 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 7.4038E-01 Mrem/Hour
Kerma Rate = 2.8292E-04 Ergs/Gm./Hour
Element 57 Dose Rate = 3.0401E-04 Rads/Hour
Average Energy = 2.8905E-04 Mev

FIGURE 1

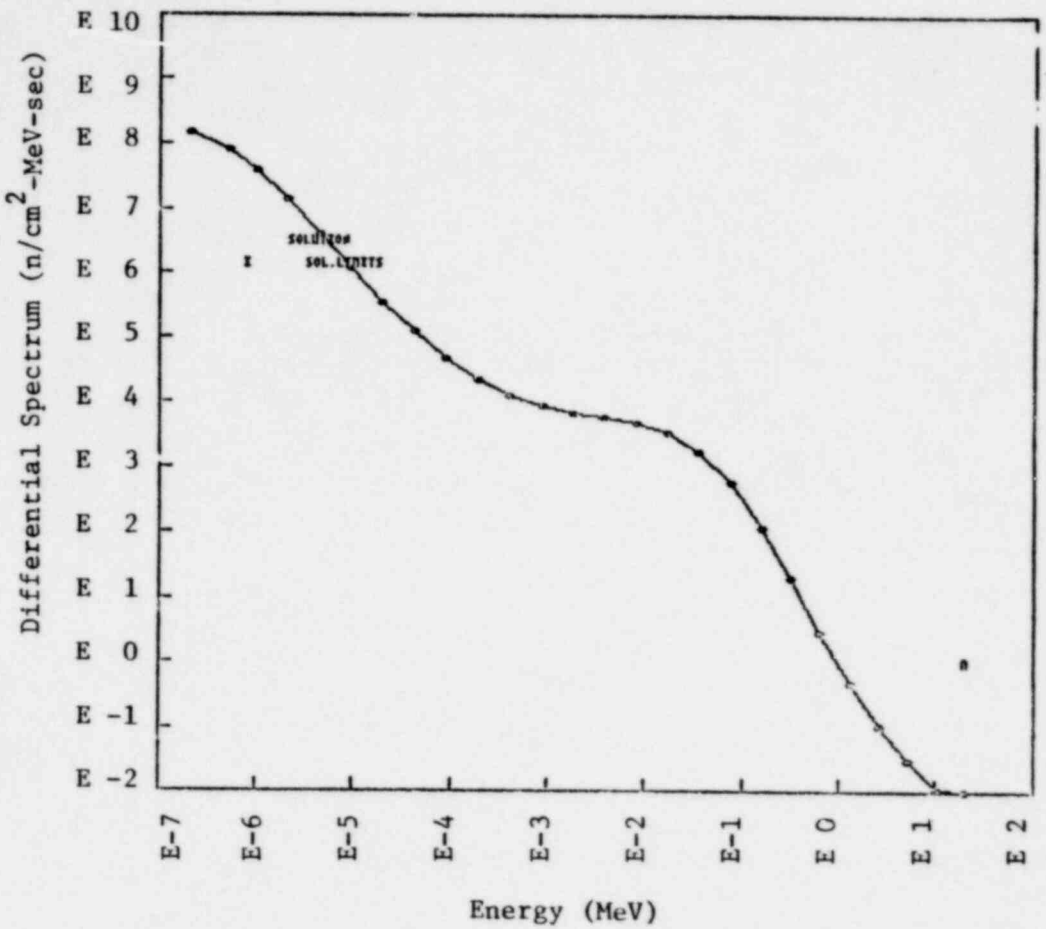
Battelle Multisphere Measurement No. 1
Site F



Detector	Measured Responses	Calculated Responses
Bare .5 in.	1.71E+02	1.71E+02
CD .5 in	6.34E+01	6.31E+01
3 inch Cad	2.44E+02	2.51E+02
5 inch Cad	2.28E+02	2.27E+02
8 inch LI .5	8.83E+01	8.14E+01
10 inch LI .5	4.22E+01	3.92E+01
12 inch LI .5	1.44E+01	1.59E+01

FIGURE 2

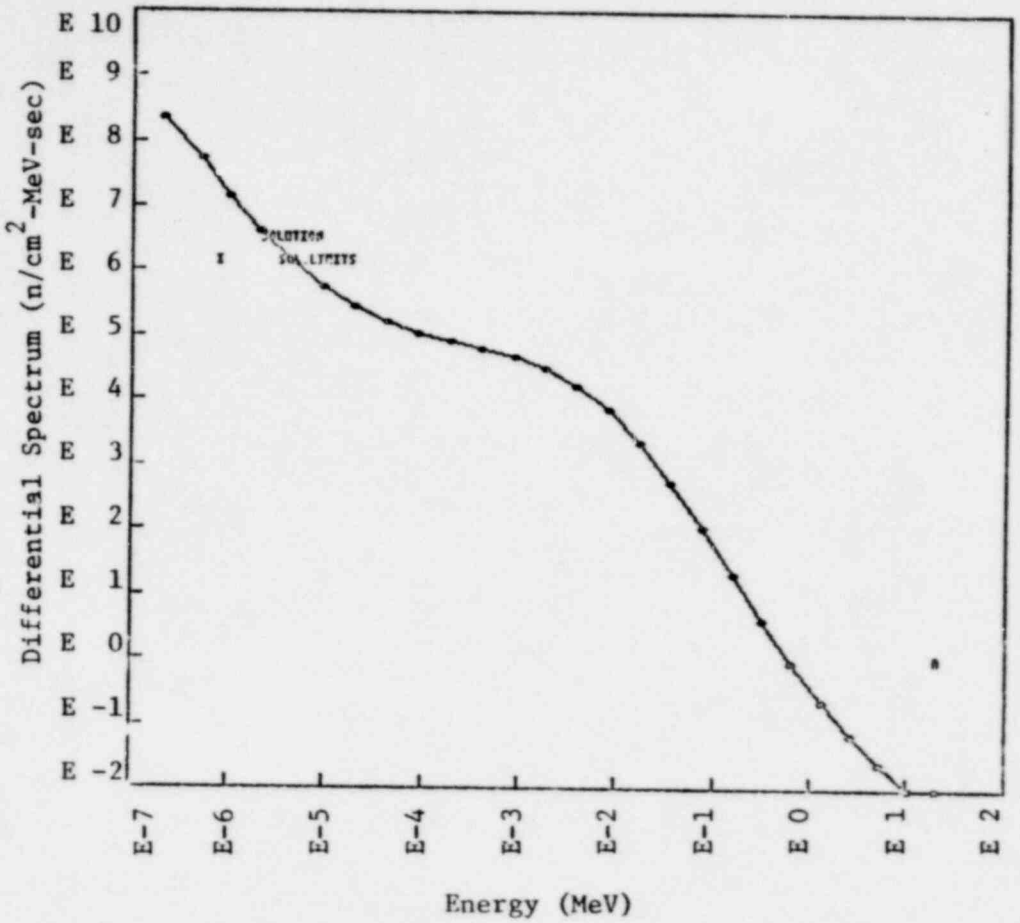
Battelle Multisphere Measurement No. 2
Site F



Detector	Measured Responses	Calculated Responses
Bare .5 in	2.86E+02	2.89E+02
CD .5 in	1.71E+02	1.67E+02
3 inch Cad.	4.73E+02	5.05E+02
5 inch Cad.	4.52E+02	4.36E+02
8 inch LI.5	1.74E+02	1.53E+02
10 inch LI.5	8.15E+01	7.35E+01
12 inch LI .5	2.58E+01	2.97E+01

FIGURE 3

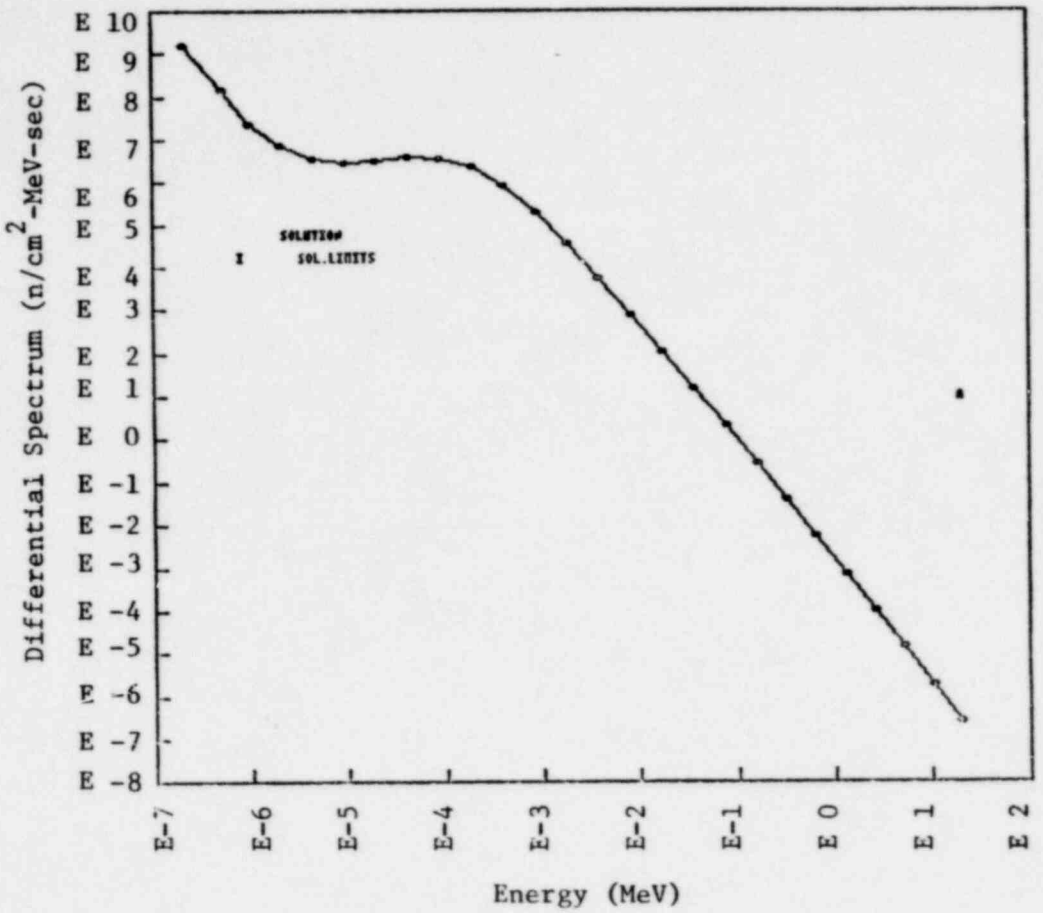
Battelle Multisphere Measurement No. 3
Site F



Detector	Measured Responses	Calculated Responses
Bare .5 in	2.79E+02	2.78E+02
CD .5 in	1.06E+02	1.06E+02
3 inch Cad.	5.05E+02	5.32E+02
5 inch Cad.	4.85E+02	4.33E+02
8 inch LI .5	1.74E+02	1.41E+02
10 inch LI .5	5.66E+01	6.62E+01

FIGURE 4

Battelle Multisphere Measurement No. 4
Site F



Detector	Measured Responses	Calculated Responses
Bare .5 in	1.83E+02	1.72E+02
CD .5 in	5.90E+01	6.30E+01
3 inch Cad.	3.02E+02	2.64E+02
5 inch Cad.	2.76E+02	1.75E+02
8 inch LI .5	8.01E+01	5.24E+01
10 inch LI .5	1.73E+01	2.41E+01

FIGURE 5

Battelle Multisphere Measurement no. 1, Site F
Lethargy Plot for Previous Differential Plot.

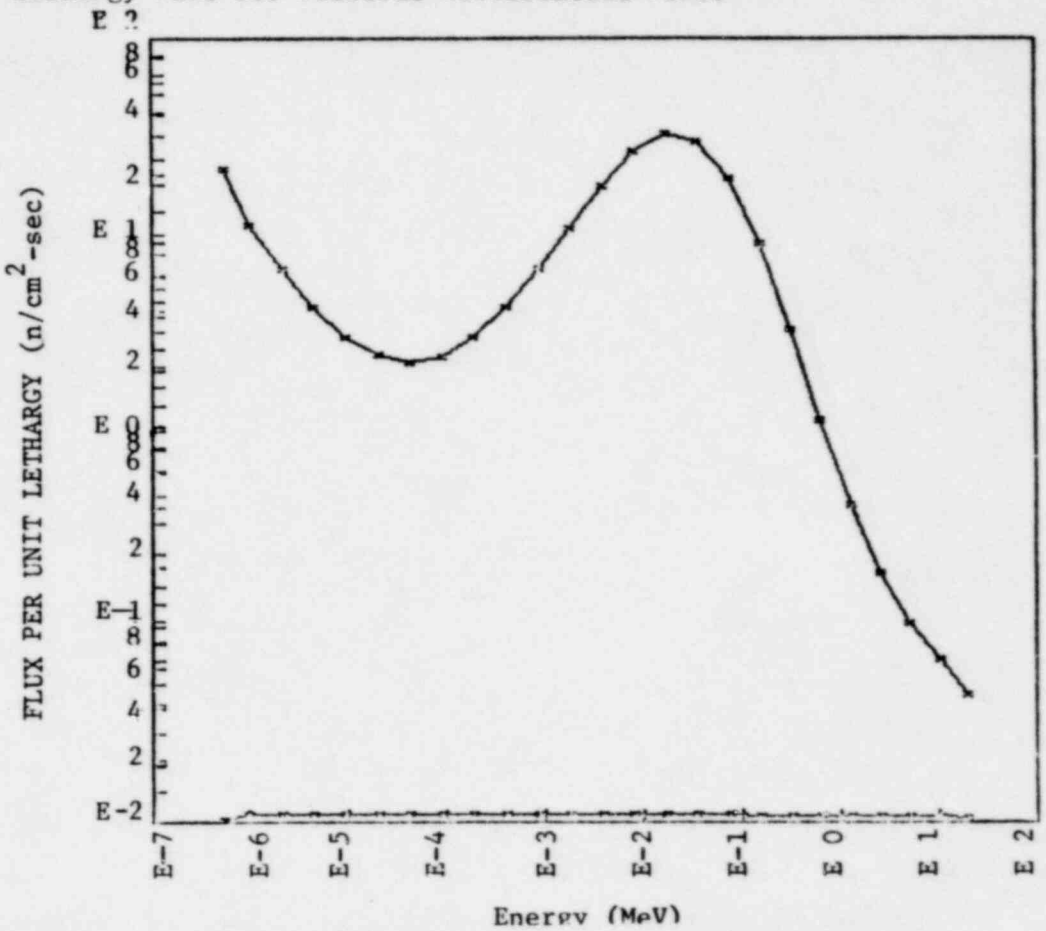


FIGURE 6

Battelle Multisphere Measurement no. 2, Site F
Lethargy Plot for Previous Differential Plot.

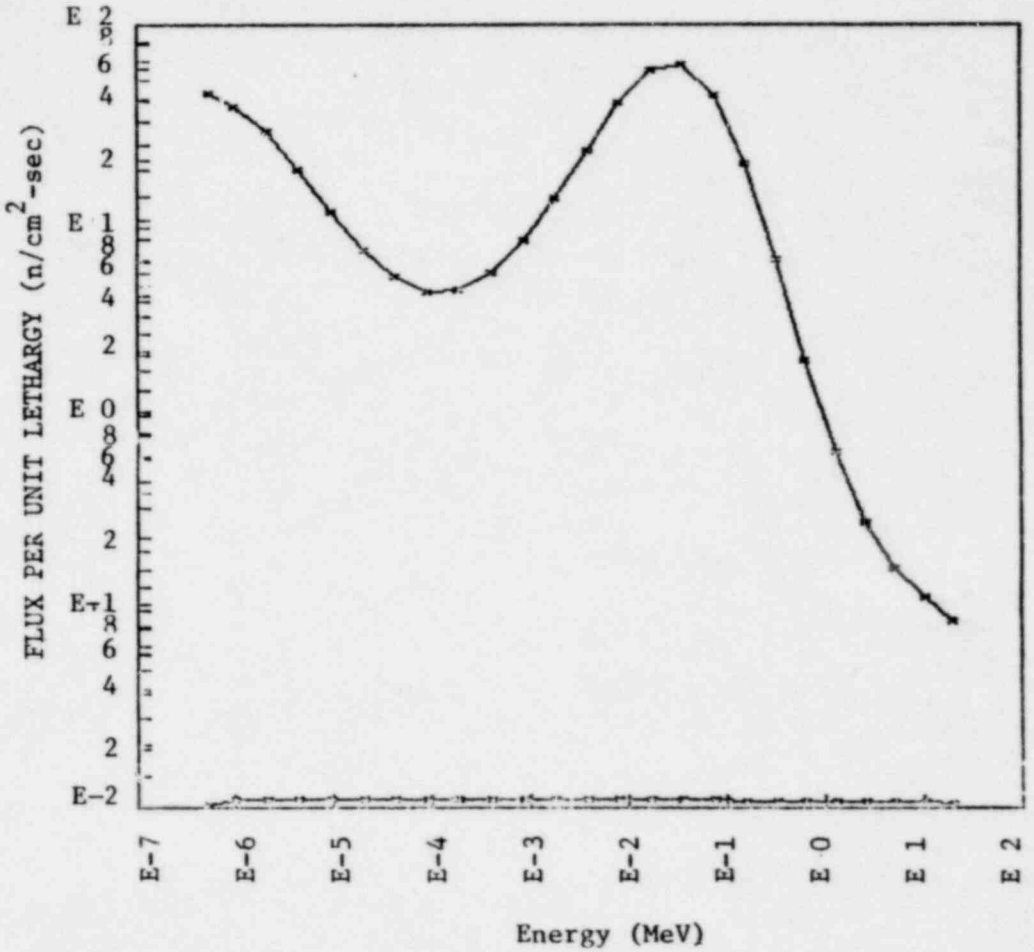


FIGURE 7

Battelle Multisphere Measurement no. 3, Site F

Lethargy Plot for Previous Differential Plot.

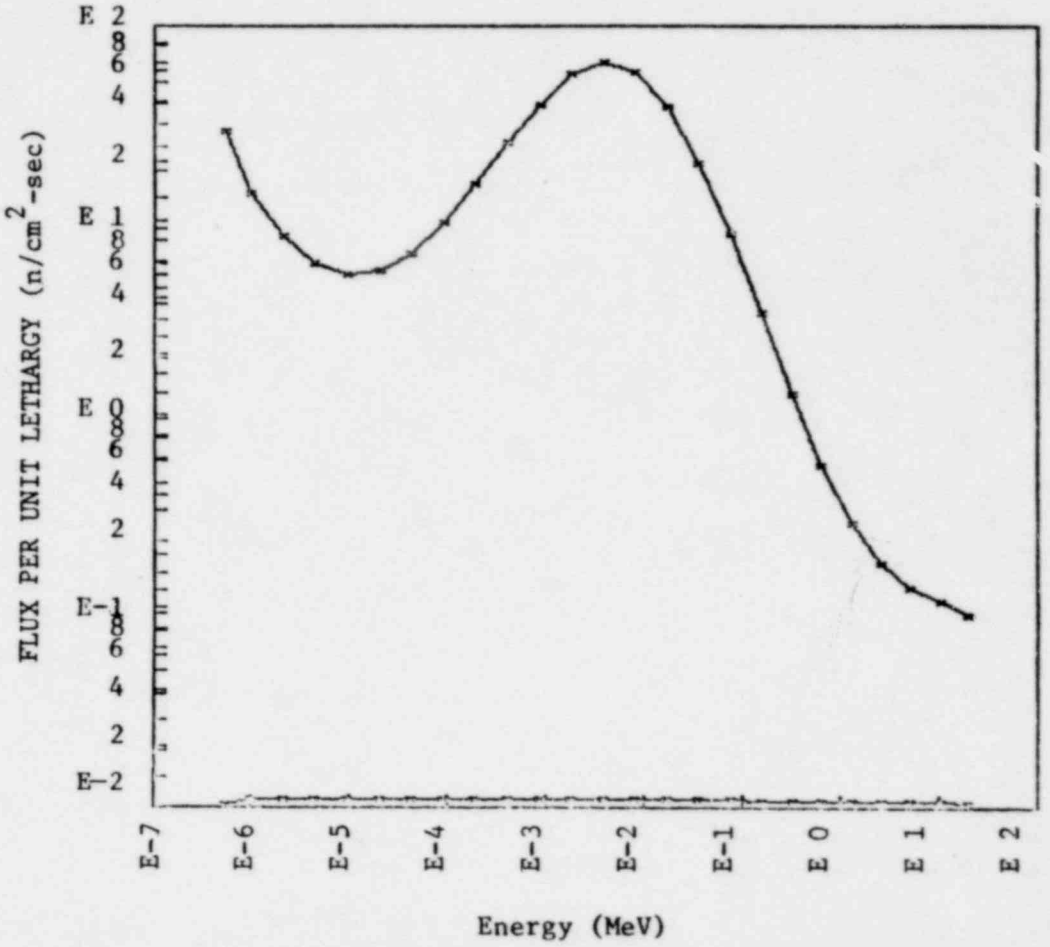
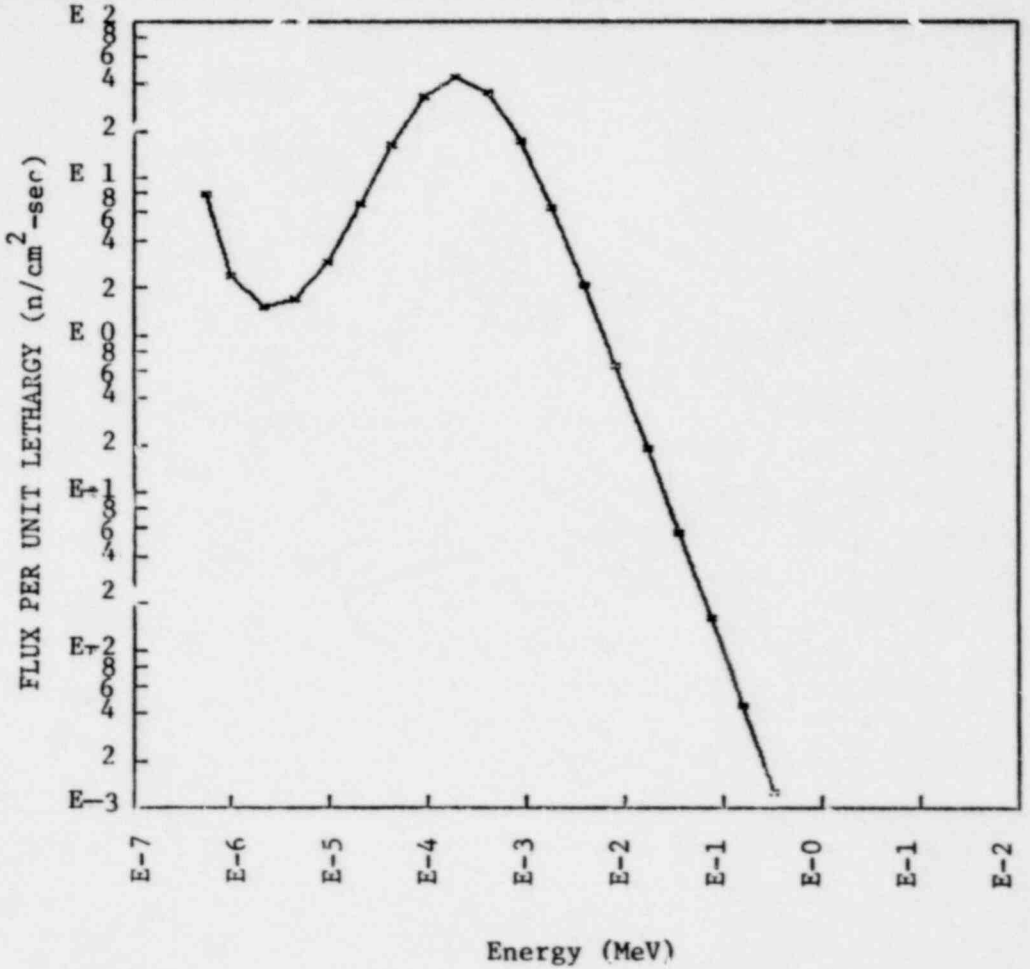


FIGURE 8

Battelle Multisphere Measurement no. 4, Site F

Lethargy Plot for Previous Differential Plot.



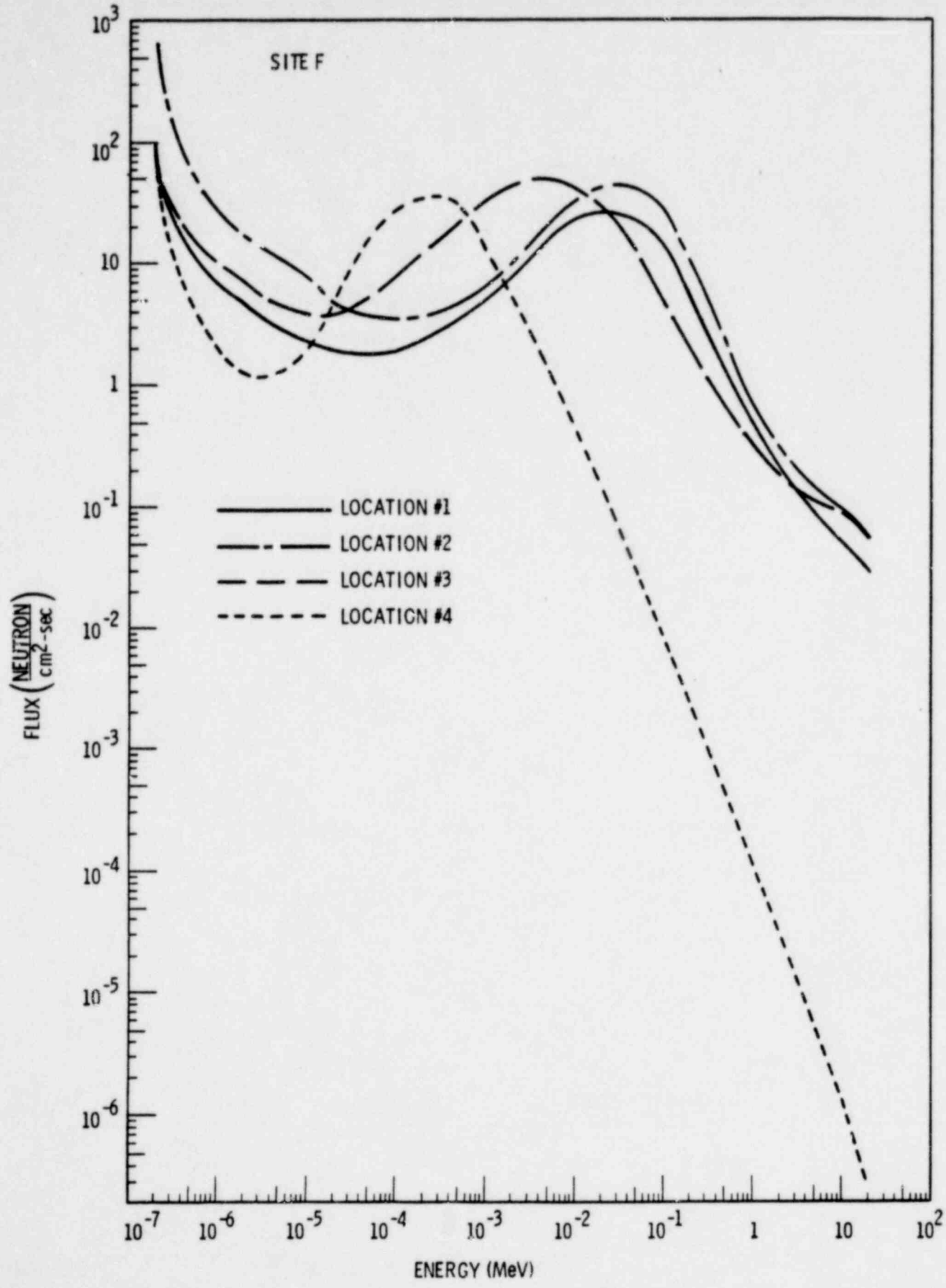


FIGURE 9

PRELIMINARY REPORT
NEUTRON DOSIMETRY AT SITE G - PWR*

G. W. R. Endres, J. M. Aldrich and R. V. Griffith†
Battelle, Pacific Northwest Laboratory
Richland, Washington 99352

Site G was the second PWR site visited in this study. Inside containment well-moderated neutron spectra were found at all points of interest. Because of time and exposure limitations, not all of the instruments were used at every location. Reactor power level during entries remained nearly constant at 98-100%.

Portable monitoring instruments, the multisphere spectrometer system, and the tissue equivalent proportional system (TEPC) were used for active dose equivalent measurements at several locations. In as many cases as possible, these measurements were taken at the same location for comparison purposes. The measured dose equivalent rates ranged from 4.6 mrem/hr to 850 mrem/hr as measured with multisphere and TEPC systems. The personnel dosimeters were placed on water phantoms at predetermined locations. Some of the passive dosimeter exposure times were quite short due to high exposure rates. The TEPC and multisphere spectrometer data were taken at two and three locations, respectively.

Pertinent data from portable survey instruments are given in Table 1. Dose equivalent rates vary from about 5 mrem/hr gamma and 0.2 mrem/hr neutron to 400 mR/hr gamma and 500 mrem/hr neutron. Preliminary analysis on the three sets of multisphere data indicates 4.6, 10.1, and 54 mrem/hr with average neutron energies of 1, 21, and 7 keV, respectively. Another indicator of neutron energy is derived from the ratio of measurements taken with 3" and 9" polyethylene spheres with a BF-3 detector. These ratios ranged from

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* Work performed for the U.S. Nuclear Regulatory Commission under DOE Contract EY-76-C-06-1830.

† Mr. Griffith is employed by the University of California, Lawrence Livermore Laboratory, Livermore, CA.

8.3 to 18. According to data from Hankins,[1] these ratios indicate average neutron energies of about 2 keV and below. The lower the 3" to 9" ratio the higher the average neutron energy. All of the gamma instrument readings were taken with a standard Hanford CP instrument with no phantom present. Site G employees tested three different types of dosimeters in conjuction with those used in this study. For clarification their dosimeters have been identified as Site G-J, Site G-K, and Site G-L.

As shown in Table 2, Site G types J and K, Vendor A, LLL, and PNL dosimeters placed on phantoms at the same locations show gamma exposures lower than the instrument reading multiplied by the exposure time at respective locations. The Site G-L type dosimeters seem to give doses which are high by factors ranging from 2 to 16 when compared to the average gamma responses of the other dosimeters. Discrepancies between the total dose calculated by timekeeping and that shown on dosimeters, except Site G-L types, can be caused by three major contributing factors: 1) in high dose rate areas the instrument is misread, 2) the stay time in the area was not correct, or 3) the instrument reading shows the highest dose rate in the area and not the best average. The LLL-type dosimeters were used on both the front and back of the phantoms and indicate the front is receiving more exposure than the rear of the phantom. The front of the phantom was always directed toward the reactor cavity.

Vendor A dosimeters show a response to the neutron spectrum at most of the locations. These dosimeters use the response of deep traps in LiF thermoluminescent material to show the presence of fast neutrons. The neutron energy spectrum must be known for each site or point of measurement in order for the responses of the dosimeters to be properly interpreted to give the correct dose equivalent. The Site G-J dosimeter was only a gamma dosimeter, and the Site G-L dosimeter showed no response to the neutrons. The Site G-K dosimeter

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(1) Dale E. Hankins, "Neutron Dosimetry Studies at Lawrence Livermore Laboratory," presented at Sixth ERDA Workshop on Personnel Neutron Dosimetry, July 11-12, 1977, Oak Ridge, Tennessee (PNL-2449).

data shows a high response to neutrons. Calibration correction factors for these varying neutron spectra are not available at this time. Vendor B dosimeters have four different dosimetry techniques incorporated in each package: NTA film, TLD albedo and two track etch detectors using carbon recoil and proton recoils. A new track etch technique uses CR-39 plastic in which proton recoil tracks are observed. In six of the seven locations, NTA, carbon recoil track etch, and CR-39 respond; but the indicated dose was much smaller than the actual neutron dose. Values shown in Table 2 for Vendor B albedo dosimeters are derived from the response of the TLD chips with no corrections applied for the variation in response with neutron energy. Values for the LLL dosimeters have been corrected for neutron energy using the 3" and 9" sphere measurement. The PNL dosimeters indicate dose equivalents which are higher than actually received because the calibration of the PNL dosimeters is based on exposures to a bare ^{252}Cf neutron source. The PNL dosimeter data in Table 2 have not been corrected for spectral response.

The multisphere data were analyzed at Lawrence Livermore Laboratory using the LOUHI unfolding code. Tables 3-5 show the data that are derived in the program and the resultant dose equivalents determined by this technique are usually somewhat less than those measured by the "Snoopy" or "Rascal" portable survey instruments. The average neutron energy interpreted by the unfolding code is 6.7, 1.0, and 21 keV. Plots of the differential spectrum versus energy are shown in Figures 1-3 and flux per unit lethargy versus energy is shown in Figures 4-6. The final plot, flux versus energy - Figure 7, is quite similar to the flux per unit lethargy curve shown in Figure 4.

TABLE 1. Portable Survey Instruments
Site G

Eberline Rascal Ratios

Location	Ratio	Location	Ratio
9	8.343	15, at 93'	8.379
3	9.838	A ∿2' from cavity	8.683
3, on Multisphere stand	9.655	17, at swithchboard	8.983
4, at Analyzer	8.873	2, on 2/28	9.712
2, at entry on 3/1	9.99	18, at equipment hatch, outside containment	18.681
22, at 77'	10.783		

Location	Instrument	Reading	
9	CR	44 mR/hr γ	
	PNR-4	140 mrem/hr n	
3	CP	7 mR/hr γ	
	Snoopy	20 mrem/hr n	
	Eberline	@ Jug	@ Multisphere
		18.6 mrem/hr n	23.8 mrem/hr n
		16.7 mrem/hr n	22.1 mrem/hr n
		20.2 mrem/hr n	24.8 mrem/hr n
4, at analyzer	CP	10 mR/hr γ	
	Snoopy	30 mrem/hr n	
	Eberline	31.2 mrem/hr n	(100 cts)
		30.8 mrem/hr n	
		26.5 mrem/hr n	
2, at entry on 2/28	CP	13 mR/hr γ	
	Snoopy	∿ 16 mrem/hr n	
2, at entry on 3/1	CP	12 mR/hr γ	
	Snoopy	12.13 mrem/hr n	
	Eberline	14.0 mrem/hr n	(100 cts)
		16.1 mrem/hr n	
		14.4 mrem/hr n	
		15.7 mrem/hr n	
22, 77'	CP	6-7 mR/hr γ	
	PNR-4	2 mrem/hr n	

Table 1 continued. Portable Survey Instruments - Site G

Location	Instruments	Readings
15, 93'	CP	35 mR/hr γ
	PNR-4	200 mrem/hr n @ hoist
		175 mrem/hr n @ Jug
~6' from cavity on grating	CP	400 mR/hr γ
	PNR-4	275 mrem/hr n
	Eberline	22.1 mrem/hr n @ analyzer
		26.5 mrem/hr n
		19.4 mrem/hr n
22, at 77'	CP	5-6 mR/hr γ
	Eberline	.3 mrem/hr n (10 cts)
		.2 mrem/hr n
15, at 93'	Eberline	162.1 mrem/hr n
		124.7 mrem/hr n
		154.7 mrem/hr n
		154.3 mrem/hr n
		144.2 mrem/hr n
A, ~2' from cavity on concrete	CP	200 mR/hr γ
	PNR-4	500 mrem/hr n
17, at swithchboard	CP	14 mR/hr γ
	Snoopy	30 mrem/hr n

TABLE 2. Personnel Dosimetry Results
Site G

Location	Time Calculated Dose	Dosimeters	mR γ	mRem n
2	272.78 mR γ 209.83 mRem n	Site GJ-1-27920	190	---
		Site GK-1-01001	180	930
		Site GK-2-00009	180	50
		Site GL-1-1645	743	0
		Vendor A 0002	206	R
		Vendor A 0003	205	R
		Vendor B 004	—	6,380
		LLL HGR-1	130	229
		LLL HGF-2	164	250.67
		PNL G-1	205.3	552.9
3	209.83 mR γ 209.83 mRem n	Site GJ-2-28073	110	---
		Site GK-3-01002	110	2,540
		Site GL-2-1647	915	0
		Vendor A 0004	108	R
		Vendor A 0005	0	R
		Vendor B 005	—	9.910 Rem
		LLL HGR-3	88	215.33
		LLL HGF-4	102	308.67
		PNL G-2	133.8	3,049
41	104 mR γ 138.66 mRem n	Site GH-3-27938	80	n/a
		Site GK-4-01003	80	940
		Site GL-3-1648	757	0
		Vendor A 0006	97	R
		Vendor A 0007	102	R
		Vendor B 006	---	6,580
		LLL HGR-5	49	56
		LLL HGF-6	68	196.67
		PNL G-3	98.19	1,707
9	62.25 mR γ 193.66 mRem n	Site GH-4-28041	40	n/a
		Site GK-5-01004	40	710
		Site GL-4-1622	574	0

Table 2 continued. Personnel Dosimetry Results - Site G

Location	Time Calculated Dose	Dosimeters	mR γ	mRem η
9, (continued)		Vendor A 0008	57	R
		Vendor A 0009	12	R
		Vendor B 007	---	5,790
		LLL HGR-7	27	76
		LLL HGF-8	43	196
		PNL G-4	57.56	1,098
		PNL G-5	57.82	1,821
A 93'	346.66 mR γ	Site GJ-5-27941	260	n/a
	238.33 mRem η	Site GK-6-01005	240	1,320
		Site GL-5-1591	1,345	0
		Vendor A 3001	222	R
		Vendor A 0014	218	R
		Vendor B 008	---	9,840
		LLL HGR-9	154	184.33
		LLL HGF-10	201	339.33
		PNL G-6	262.9	342.4
		PNL G-7	236.1	5,173
15 @ 93'	752.5 mR γ	Site GJ-6-28106	470	n/a
	3,762.5 mRem η	Site GK-7-01007	500	4,070
		Site GL-6-1593	9,515	0
		Vendor A 0012	258	R
		Vendor A 0013	71	R
		Vendor B 003	---	73,200
		LLL HGR-11	327	1,310
		LLL HGF-12	515	2,658
		PNL G-8	548.8	19,180
		PNL G-9	597.9	20,480
22 @ 77'	149.92 mR γ	Site GJ-7-27772	80	n/a
	42.83 mRem η	Site GK-8-01006	60	90
		Site GL-7-1592	162	0
		Vendor A 0010	73	R
		Vendor A 0011	79	R
		Vendor B 002	---	470
		LLL HGR-13	31	10
		LLL HGF-A	59	20.33
		PNL G-10	87.68	186.9
		PNL G-11	87.38	312.6

TABLE 3

Site G. Location 2 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	9.81E+08	1.00E+00	1.00E+00	3.89E-07	3.82E+02
2	5.32E-07	1.82E+08	6.54E-01	6.46E-01	2.69E-07	4.90E+01
3	9.93E-07	4.19E+07	6.10E-01	5.99E-01	7.63E-07	3.20E+01
4	2.10E-06	1.29E+07	5.81E-01	5.67E-01	1.61E-06	2.08E+01
5	4.45E-06	5.33E+06	5.62E-01	5.46E-01	3.42E-06	1.82E+01
6	9.42E-06	2.85E+06	5.46E-01	5.29E-01	7.22E-06	2.06E+01
7	2.00E-05	1.86E+06	5.27E-01	5.10E-01	1.53E-05	2.85E+01
8	4.22E-05	1.36E+06	5.01E-01	4.83E-01	3.23E-05	4.39E+01
9	8.94E-05	1.00E+06	4.61E-01	4.44E-01	6.89E-05	6.89E+01
10	1.89E-04	6.70E+05	3.99E-01	3.83E-01	1.45E-04	9.72E+01
11	4.04E-04	3.66E+05	3.11E-01	2.99E-01	3.18E-04	1.16E+02
12	8.55E-04	1.53E+05	2.06E-01	2.00E-01	6.40E-04	9.79E+01
13	1.80E-03	4.85E+04	1.17E-01	1.19E-01	1.38E-03	6.69E+01
14	3.80E-03	1.22E+04	5.63E-02	6.37E-02	2.91E-03	3.55E+01
15	8.05E-03	2.60E+03	2.41E-02	3.52E-02	6.20E-03	1.61E+01
16	1.70E-02	4.98E+02	9.50E-03	2.26E-02	1.30E-02	6.47E+00
17	3.61E-02	9.02E+01	3.62E-03	1.47E-02	2.77E-02	2.50E+00
18	7.64E-02	1.61E+01	1.36E-03	9.31E-03	5.86E-02	9.43E-01
19	1.58E-01	2.94E+00	5.02E-04	5.76E-03	1.13E-01	3.32E-01
20	3.18E-01	5.61E-01	2.02E-04	3.62E-03	2.27E-01	1.27E-01
21	6.40E-01	1.14E-01	8.61E-05	2.22E-03	4.56E-01	5.20E-02
22	1.29E+00	2.49E-02	3.91E-05	1.26E-03	9.20E-01	2.29E-02
23	2.59E+00	5.85E-03	1.84E-05	6.25E-04	1.85E+00	1.08E-02
24	5.22E+00	1.47E-03	8.63E-06	3.05E-04	3.73E+00	5.48E-03
25	1.05E+01	3.87E-04	3.66E-06	1.35E-04	7.50E+00	2.90E-03
26	1.96E+01	1.05E-04	1.03E-06	3.93E-05	1.09E+01	1.14E-03

Total Flux = 1.1040E+03 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 4.5636E+00 Mrem/Hour
Kerma Rate = 4.1392E-03 Ergs/Gm./Hour
Element 57 Dose Rate = 1.8668E-03 Rads/Hour
Average Energy = 9.7937E-04 Mev

TABLE 4

Site G. Location 3 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	1.08E+09	1.00E+00	1.00E+00	3.89E-07	4.20E+02
2	5.32E-07	2.95E+08	7.11E-01	8.23E-01	2.69E-07	7.94E+01
3	9.93E-07	8.33E+07	6.56E-01	7.88E-01	7.63E-07	6.36E+01
4	2.10E-06	2.51E+07	6.13E-01	7.60E-01	1.61E-06	4.04E+01
5	4.45E-06	8.33E+06	5.85E-01	7.42E-01	3.42E-06	2.85E+01
6	9.42E-06	3.07E+06	5.66E-01	7.30E-01	7.22E-06	2.22E+01
7	2.00E-05	1.28E+06	5.50E-01	7.20E-01	1.53E-05	1.96E+01
8	4.22E-05	5.96E+05	5.37E-01	7.12E-01	3.23E-05	1.93E+01
9	8.94E-05	3.11E+05	5.24E-01	7.04E-01	6.89E-05	2.14E+01
10	1.89E-04	1.79E+05	5.09E-01	6.96E-01	1.45E-04	2.60E+01
11	4.04E-04	1.11E+05	4.91E-01	6.86E-01	3.18E-04	3.53E+01
12	8.55E-04	7.24E+04	4.67E-01	6.72E-01	6.40E-04	4.63E+01
13	1.80E-03	4.79E+04	4.35E-01	6.55E-01	1.38E-03	6.61E+01
14	3.80E-03	3.06E+04	3.90E-01	6.30E-01	2.91E-03	8.90E+01
15	8.05E-03	1.81E+04	3.29E-01	5.98E-01	6.20E-03	1.12E+07
16	1.70E-02	9.25E+03	2.52E-01	5.58E-01	1.30E-02	1.20E+02
17	3.61E-02	3.91E+03	1.69E-01	4.91E-01	2.77E-02	1.08E+02
18	7.64E-02	1.31E+03	9.47E-02	3.86E-01	5.86E-02	7.68E+01
19	1.58E-01	3.42E+02	4.19E-02	2.56E-01	1.13E-01	3.86E+01
20	3.18E-01	6.94E+01	1.55E-02	1.43E-01	2.27E-01	1.58E+01
21	6.40E-01	1.12E+01	4.72E-03	6.53E-02	4.56E-01	5.11E+00
22	1.29E+00	1.49E+00	1.21E-03	2.25E-02	9.20E-01	1.37E+00
23	2.59E+00	1.68E-01	2.66E-04	5.23E-03	1.85E+00	3.11E-01
24	5.22E+00	1.68E-02	5.21E-05	1.08E-03	3.73E+00	6.27E-02
25	1.05E+01	1.55E-03	9.01E-06	1.96E-04	7.50E+00	1.16E-02
26	1.96E+01	1.37E-04	1.03E-06	2.33E-05	1.09E+01	1.49E-03

Total Flux = 1.4580E+03 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 1.0093E+01 Mrem/Hour
Kerma Rate = 6.2784E-02 Ergs/Gm./Hour
Element 57 Dose Rate = 2.8045E-03 Rads/Hour
Average Energy = 2.1031E-02 Mev

TABLE 5

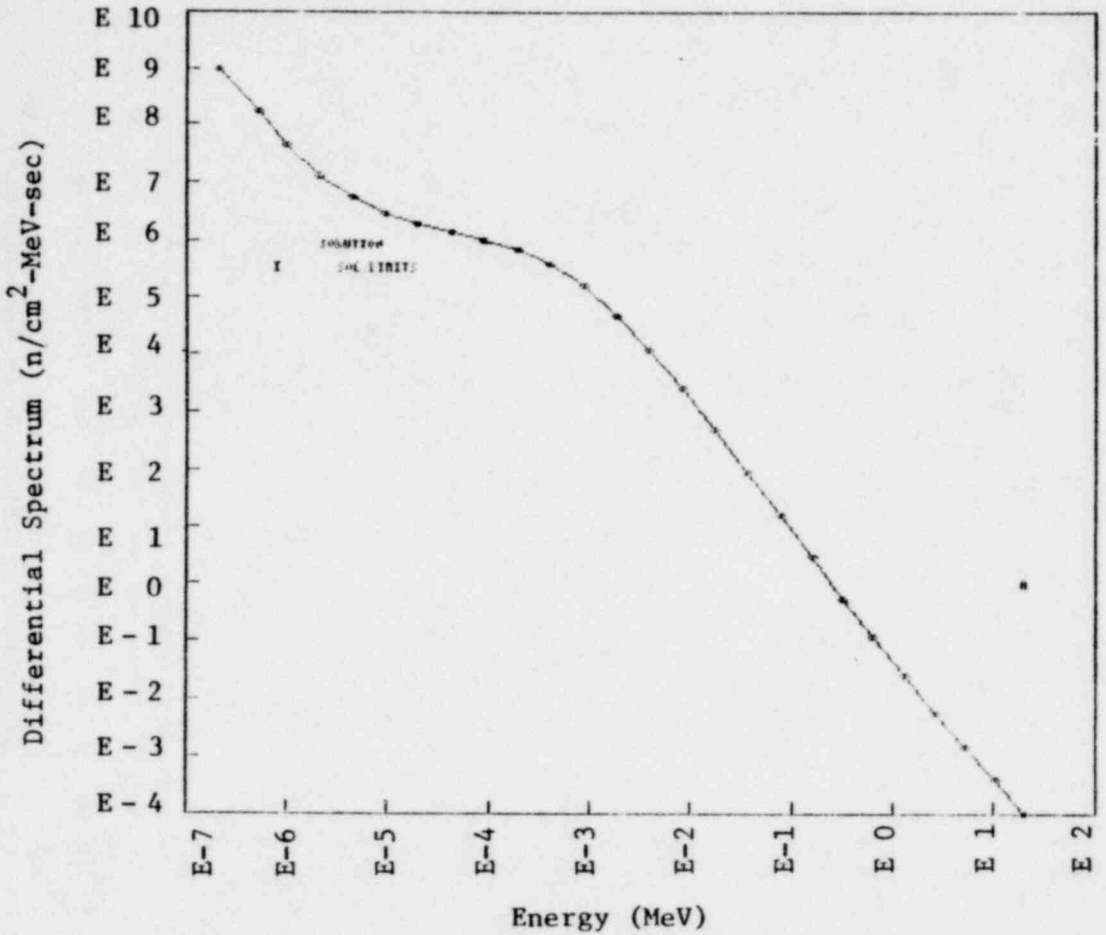
Site G. Location 9 (Linear Detector Background)

	E(I) MeV	DIFFERENTIAL FLUX (n/cm^2-MeV-sec)	INTEGRAL FLUX	INTEGRAL DOSE EQUIVALENT	EN. BAND MeV	FLUX (n/cm^2-sec)
1	2.07E-07	9.77E+09	1.00E+00	1.00E+00	3.89E-07	3.80E+03
2	5.32E-07	2.49E+09	6.58E-01	7.01E-01	2.69E-07	6.70E+02
3	9.93E-07	6.59E+08	5.98E-01	6.46E-01	7.63E-07	5.03E+02
4	2.10E-06	1.88E+08	5.53E-01	6.04E-01	1.61E-06	3.03E+02
5	4.45E-06	6.01E+07	5.26E-01	5.79E-01	3.42E-06	2.06E+02
6	9.42E-06	2.21E+07	5.07E-01	5.62E-01	7.22E-06	1.60E+02
7	2.00E-05	9.44E+06	4.93E-01	5.50E-01	1.53E-05	1.44E+02
8	4.22E-05	4.70E+06	4.80E-01	5.38E-01	3.23E-05	1.52E+02
9	8.94E-05	2.69E+06	4.66E-01	5.27E-01	6.89E-05	1.85E+02
10	1.89E-04	1.72E+06	4.50E-01	5.13E-01	1.45E-04	2.49E+02
11	4.04E-04	1.18E+06	4.27E-01	4.95E-01	3.18E-04	3.75E+02
12	8.55E-04	8.19E+05	3.93E-01	4.68E-01	6.40E-04	5.24E+02
13	1.80E-03	5.39E+05	3.46E-01	4.31E-01	1.38E-03	7.44E+02
14	3.80E-03	3.10E+05	2.79E-01	3.79E-01	2.91E-03	9.02E+02
15	8.05E-03	1.44E+05	1.98E-01	3.18E-01	6.20E-03	8.93E+02
16	1.70E-02	5.14E+04	1.18E-01	2.59E-01	1.30E-02	6.68E+02
17	3.61E-02	1.39E+04	5.81E-02	1.90E-01	2.77E-02	3.85E+02
18	7.64E-02	2.97E+03	2.33E-02	1.19E-01	5.86E-02	1.74E+02
19	1.58E-01	5.25E+02	7.71E-03	6.42E-02	1.13E-01	5.93E+01
20	3.18E-01	8.26E+01	2.40E-03	3.19E-02	2.27E-01	1.88E+01
21	6.40E-01	1.23E+01	7.14E-04	1.45E-02	4.56E-01	5.61E+00
22	1.29E+00	1.80E+00	2.12E-04	5.71E-03	9.20E-01	1.66E+00
23	2.59E+00	2.67E-01	6.32E-05	1.79E-03	1.85E+00	4.94E-01
24	5.22E+00	4.05E-02	1.87E-05	5.59E-04	3.73E+00	1.51E-01
25	1.05E+01	6.22E-03	5.14E-06	1.61E-04	7.50E+00	4.67E-02
26	1.96E+01	9.65E-04	9.46E-07	3.07E-05	1.09E+01	1.05E-02

Total Flux = 1.1125E+04 Neutrons/Sq.Cm./Sec.
Dose Equivalent Rate = 5.3884E+01 Mrem/Hour
Kerma Rate = 1.9909E-01 Ergs/Gm./Hour
Element 57 Dose Rate = 1.9542E-02 Rads/Hour
Average Energy = 6.7404E-03 Mev

FIGURE 1

Site G, Location 2
Linear Detector Background



Detector	Measured Responses	Calculated Responses
Bare .5 In	1.10E+03	1.08E+03
CD .5 In	3.64E+02	3.69E+02
3 Inch Cad.	1.21E+03	1.27E+03
5 Inch Cad.	1.05E+03	8.62E+02
8 Inch LI .5	4.48E+02	2.70E+02
10 Inch LI .5	1.46E+02	1.24E+02
12 Inch LI .5	3.60E+01	4.86E+01

FIGURE 2

Site G, Location 2 (Linear Detector Background)

Lethargy Plot for Previous Differential Plot

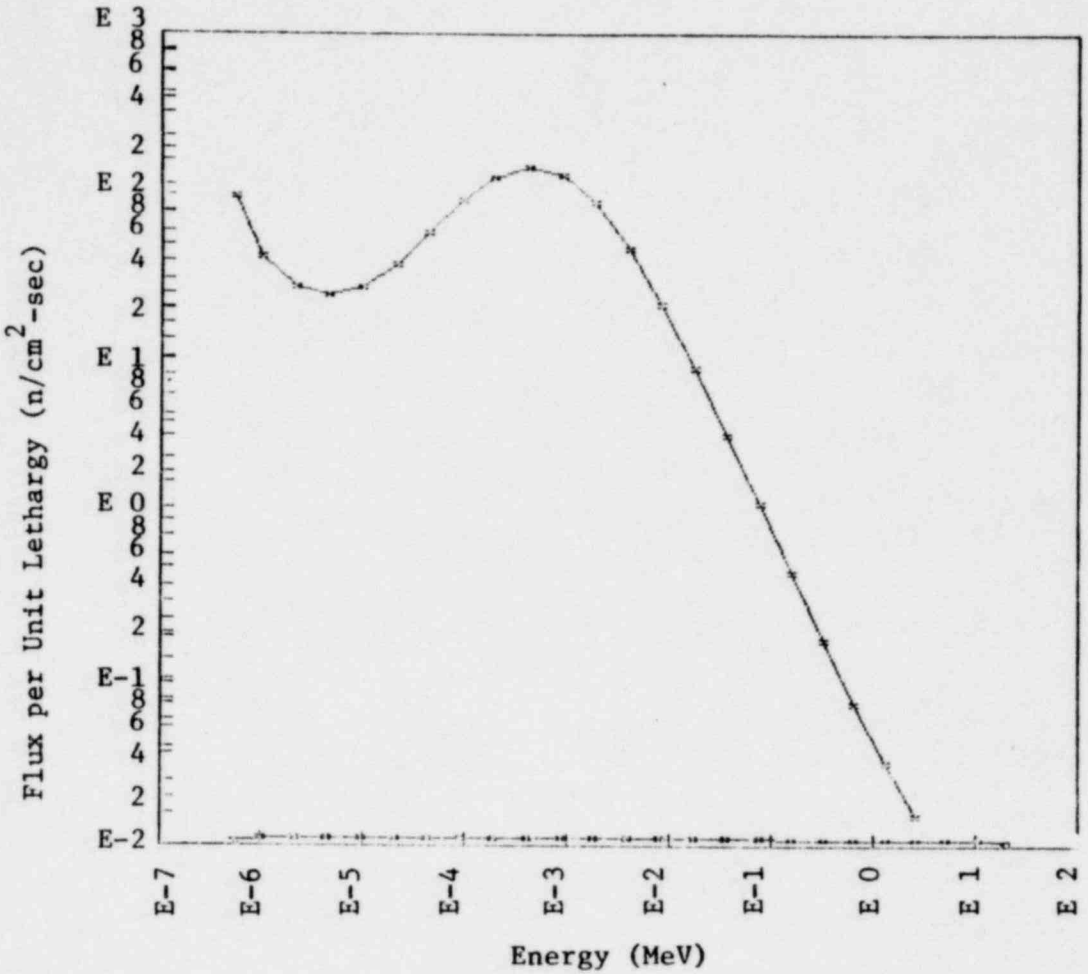
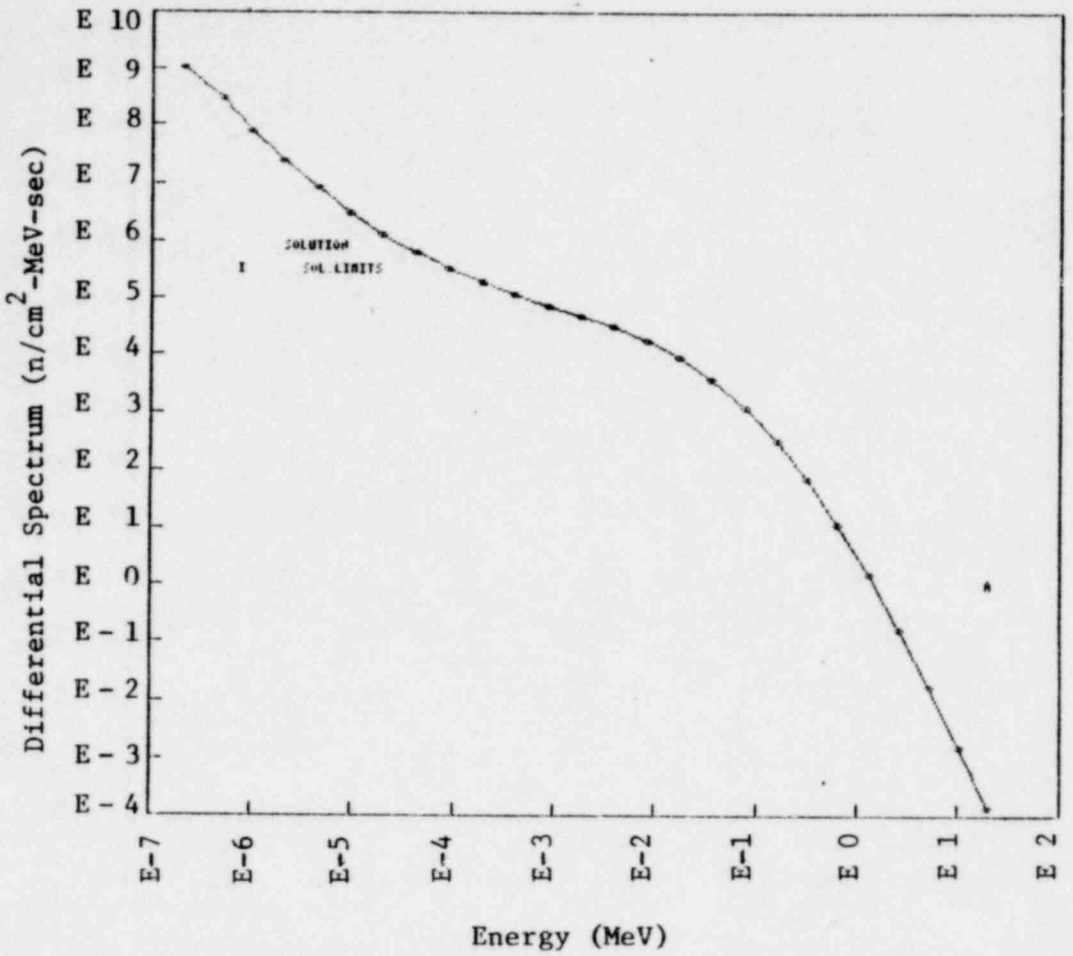


FIGURE 3

Site G, Location 3
Linear Detector Background



Detector	Measured Responses	Calculated Responses
Bare .5 In	1.23E+03	1.23E+03
CD .5 In	4.36E+02	4.36E+02
3 Inch Cad.	1.56E+03	
5 Inch Cad.	1.37E+03	1.35E+03
8 Inch LI .5	4.76E+02	4.78E+02
10 Inch LI .5	2.27E+02	2.29E+02
12 Inch LI .5	9.23E+01	9.17E+01

FIGURE 4

Site G, Location 3 (Linear Detector Background)

Lethargy Plot for Previous Differential Plot

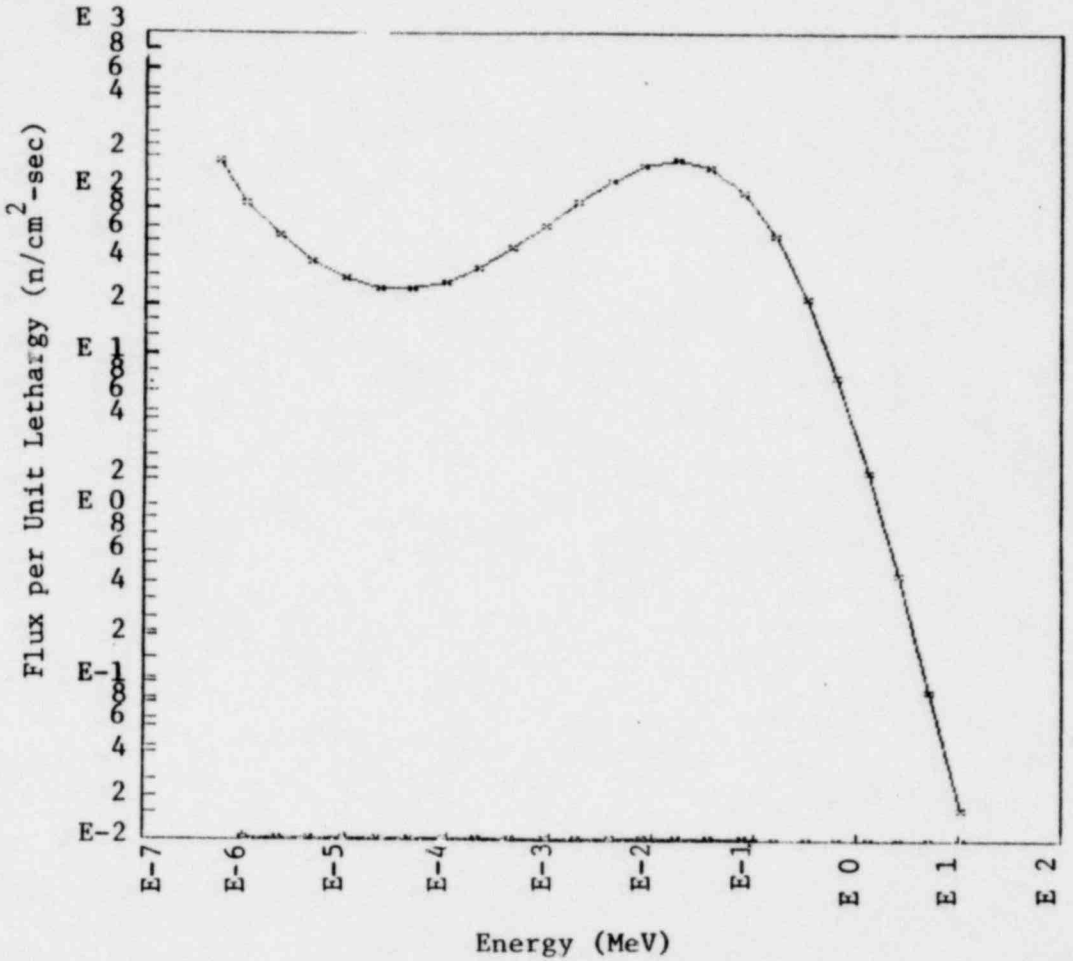
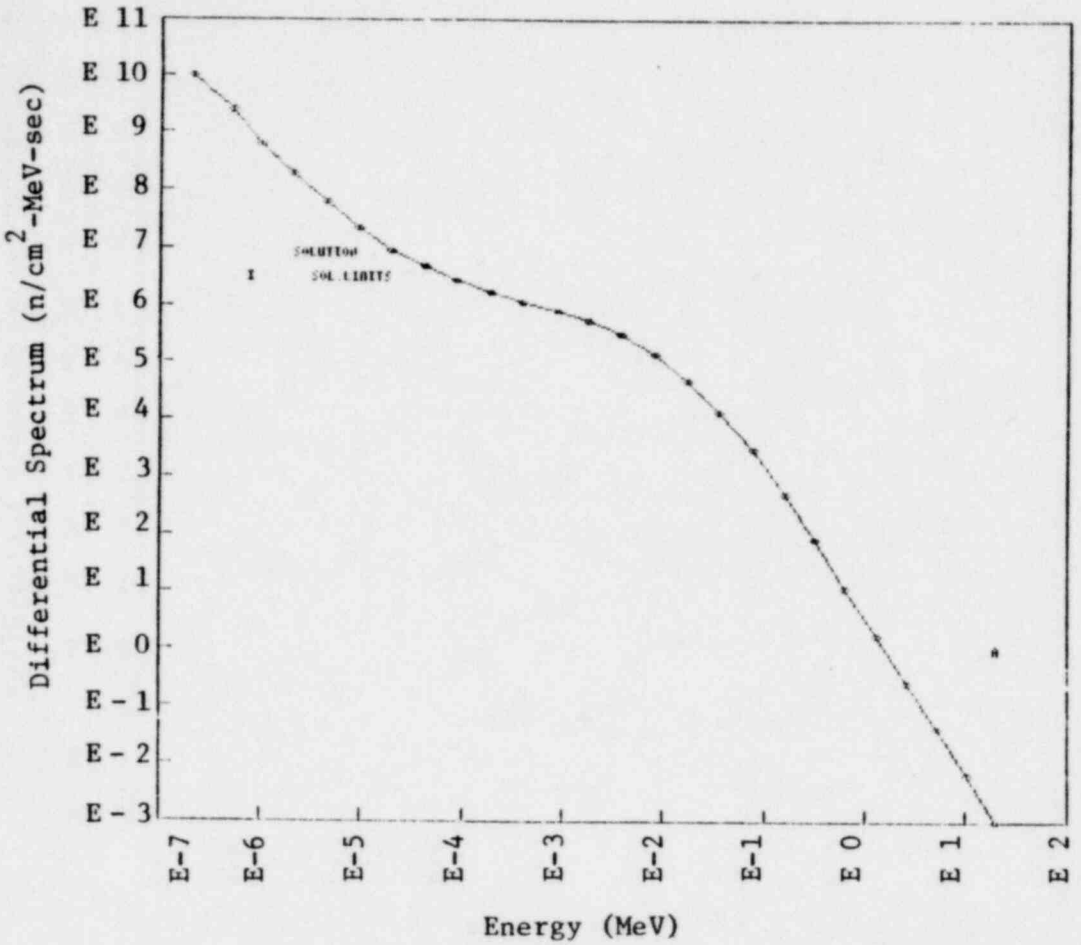


FIGURE 5

Site G, Location 9
Linear Detector Background



Detector	Measured Responses	Calculated Responses
Bare .5 Inch	1.07E+04	1.07E+04
CD .5 Inch	3.53E+03	3.52E+03
3 Inch Cad.	1.12E+04	1.16E+04
5 Inch Cad.	9.65E+03	9.04E+03
10 Inch Li .5	1.79E+03	1.43E+03
12 Inch Li .5	4.82E+02	5.60E+02

FIGURE 6

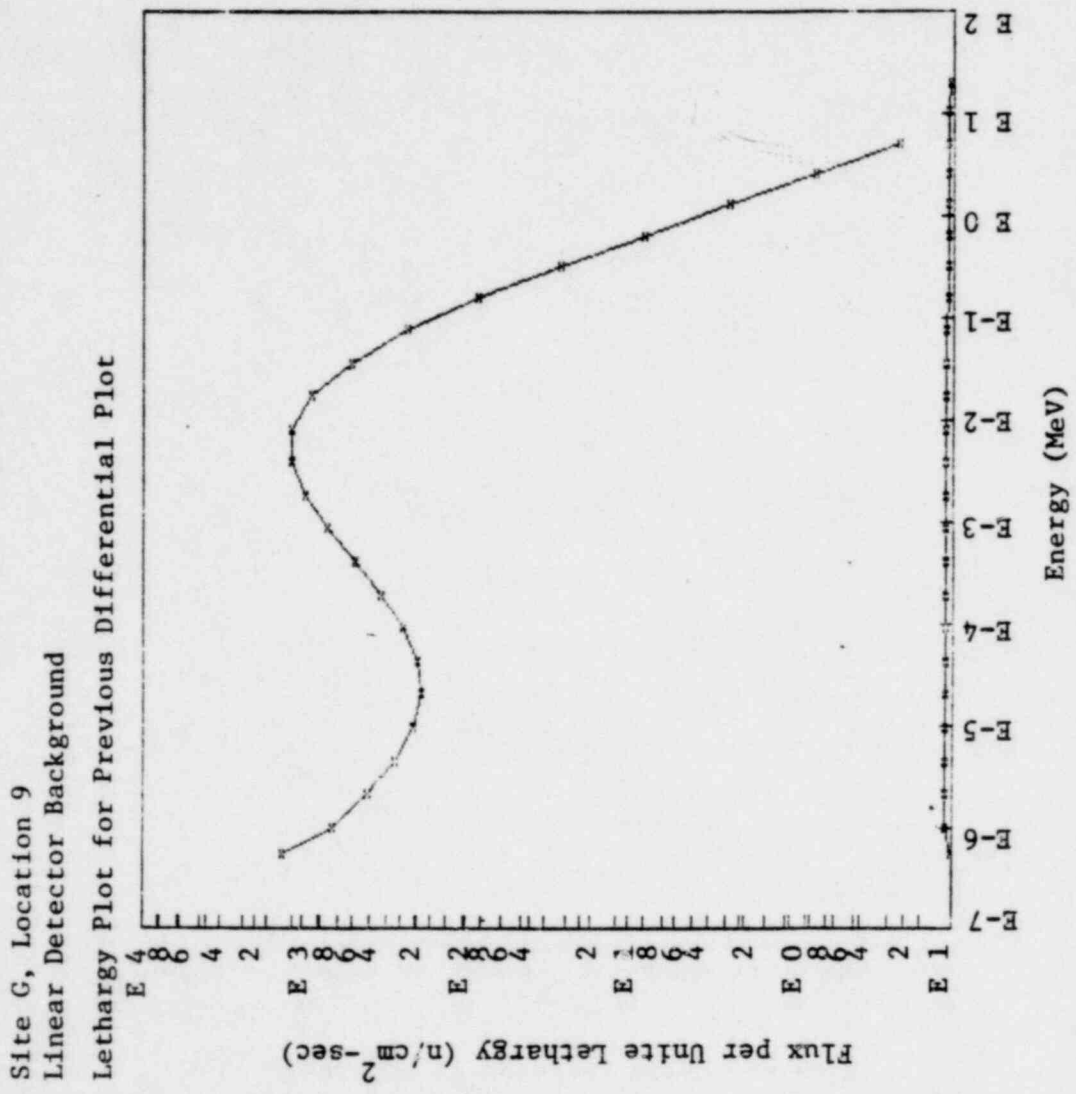


FIGURE 7