ORNL-TM-4010

THE ABSOLUTE NEUTRON SPECTRUM EMERGING THROUGH A 15-1/4-IN. COLLIMATOR FROM THE TSR-II REACTOR AT THE TOWER SHIELDING FACILITY

R. E. Maerker
F. J. Muckenthaler

OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE U.S. ATOMIC ENERGY COMMISSION

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22151
Price: Printed Copy $3.00; Microfiche $0.95

ORNL-TM-4010
UC-79d

Contract No. W-7405-eng-26

NEUTRON PHYSICS DIVISION

THE ABSOLUTE NEUTRON SPECTRUM EMERGING THROUGH A 15-1/4-IN. COLLIMATOR FROM THE TSR-II REACTOR AT THE TOWER SHIELDING FACILITY

R. E. Maerker and F. J. Muckenthaler

DECEMBER 1972

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
Operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

THE ABSOLUTE NEUTRON SPECTRUM EMERGING THROUGH A 15-1/4-IN. COLLIMATOR FROM THE TSR-II REACTOR AT THE TOWER SHIELDING FACILITY

R. E. Maerker and F. J. Muckenthaler

ABSTRACT

The neutron spectral intensities in a 100-group structure and the angular distribution emerging from the TSR-II reactor through the 15-1/4-in. tapered collimator at the Tower Shielding Facility are presented. These data may be used as free-field source terms in the calculations of experiments performed using this collimator, and were derived from many different measurements made at various positions along the beam centerline.

The geometry of the collimator arrangement to which the following data apply is shown in Fig. 1.

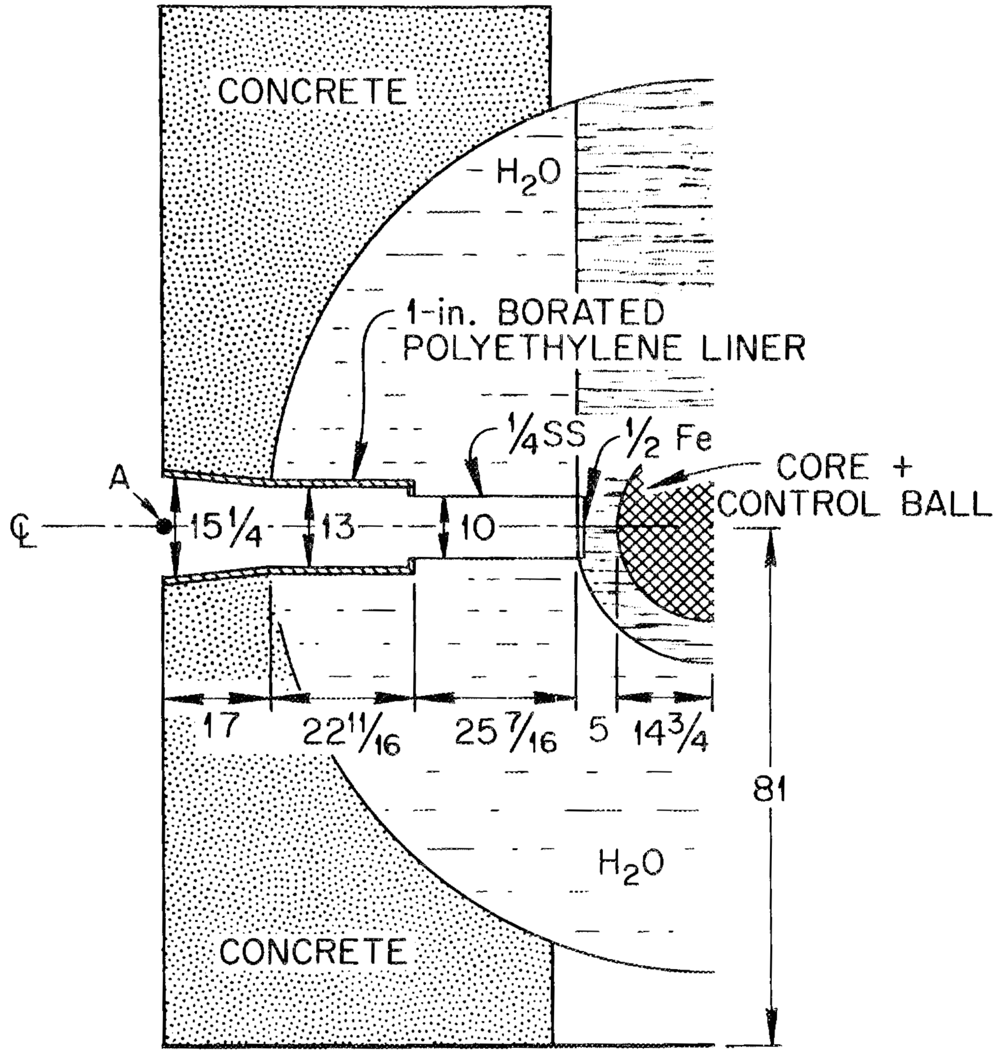
The neutron spectrum on the centerline in the plane of the outside concrete surface (i.e., point A in Fig. 1) is shown in Table I. The spectrum is presented in a 100-group structure, but it may be assumed to be smoothly varying and can thus be regrouped into any other desired structure. Note that the entries in the table are expressed in units of neutrons/cm^2/min/watt, i.e., the intensities have been integrated over the group.

To integrate over the plane of the collimator exit surface, the above spectrum should be multiplied by 1200 cm^2, so that

$$\int dA \int j(E,r)\, dE = 3.24 \times 10^8 \text{ neutrons/min/watt.} \quad (1)$$

The angular distribution of this source may be assumed to arise from an anisotropic point source located 59.5 inches inside the collimator measured from the outside concrete surface. The anisotropy is defined by

ORNL-DWG 72-7405R2



DIMENSIONS IN INCHES

Fig. Diagram of the 15-1/4-in. Collimator Arrangement for the TSR-II Reactor at the Tower Shielding Facility.

Table I. Source Spectrum on the Centerline at the End of the Collimator

Group	Energy Interval	Intensity ($n/cm^2/min/watt$)	Group	Energy Interval	Intensity ($n/cm^2/min/watt$)
1	13.5-14.9 MeV	14	51	67.4-86.5	1790
2	12.2-13.5	32	52	52.5-67.4	1730
3	11.05-12.2	73	53	40.9-52.5	1650
4	10.0-11.05	199	54	31.8-40.9	1590
5	9.04-10.0	312	55	24.8-31.8	1530
6	8.19-9.04	545	56	19.3-24.8	1490
7	7.41-8.19	846	57	15.0-19.3	1440
8	6.70-7.41	1375	58	11.7-15.0	1370
9	6.07-6.70	2070	59	9.12-11.7	1340
10	5.49-6.07	2585	60	7.10-9.12	1310
11	4.97-5.49	3180	61	5.53-7.10	1260
12	4.49-4.97	3665	62	4.31-5.53	1220
13	4.07-4.49	4420	63	3.35-4.31	1200
14	3.68-4.07	4880	64	2.61-3.35	1180
15	3.33-3.68	4825	65	2.03-2.61	1150
16	3.01-3.33	5315	66	1.58-2.03	1120
17	2.73-3.01	6570	67	1.23-1.58	1100
18	2.47-2.73	7075	68	961-1230 eV	1030
19	2.23-2.47	6955	69	749-961	1020
20	2.02-2.23	6190	70	583-749	1010
21	1.83-2.02	5570	71	454-583	990
22	1.65-1.83	5175	72	354-454	970
23	1.50-1.65	4200	73	275-354	960
24	1.35-1.50	4000	74	214-275	940
25	1.22-1.35	3170	75	167-214	920
26	1.11-1.22	2485	76	130-167	900
27	1.00-1.11	2350	77	101-130	900
28	0.907-1.00	2135	78	78.9-101	900
29	0.821-0.907	2215	79	61.4-78.9	900
30	0.743-0.821	2345	80	47.9-61.4	900
31	0.672-0.743	2320	81	37.3-47.9	900
32	0.608-0.672	1990	82	29.0-37.3	900
33	0.550-0.608	1700	83	22.6-29.0	900
34	0.497-0.550	1425	84	17.6-22.6	900
35	0.450-0.497	1210	85	13.7-17.6	900
36	0.408-0.450	1130	86	10.7-13.7	930
37	0.369-0.408	1170	87	8.32-10.7	960
38	0.334-0.369	1175	88	6.48-8.32	990
39	0.302-0.334	1130	89	5.04-6.48	1035
40	0.273-0.302	1055	90	3.93-5.04	1035
41	0.247-0.273	955	91	3.06-3.93	1035
42	0.224-0.247	837	92	2.38-3.06	1035
43	0.202-0.224	777	93	1.86-2.38	1060
44	0.183-0.202	926	94	1.44-1.86	1100
45	0.166-0.183	845	95	1.13-1.44	1170
46	0.150-0.166	827	96	0.876-1.13	1250
47	0.136-0.150	785	97	0.683-0.876	1350
48	0.123-0.136	798	98	0.532-0.683	1565
49	0.111-0.123	799	99	0.414-0.532	1900
50	86.5-111 keV	1870	100	0.000-0.414	9.50×10^4
			Totals 1-100	0.000-14.9 MeV	2.702×10^5

specifying that the beam is uniform over the 15-1/4-in. diameter of the open collimator and zero elsewhere. Penetration through the concrete surrounding the collimator is relatively small, the contribution from the wings of the profile beyond the open collimator adding about 5% to the integral appearing in Eq. (1).

The centerline intensity of this source at any point beyond the collimator may be calculated from the following equation:

$$\phi(E,z) = \phi(E) \times \left(\frac{151.1}{151.1+z} \right)^2 \times e^{-\Sigma_T(E)z} \times \text{factor }(E), \qquad (2)$$

where z is the distance in centimeters from point A in Fig. 1, $\phi(E)$ is the spectrum appearing in Table I, $\Sigma_T(E)$ is the total cross section in cm^{-1} for air at a density of 1.18 mg/cm^3, and

factor (E) = 1 for groups 1-86
= 0.85 for groups 87-99
= 0.90 for group 100.

The factor (E) is inserted to account for the effect of collimator scattering which tends to increase the flux near the collimator. Equation (2) applies best for z >10 cm beyond which the collimator scattering component is negligible.

The above spectrum and angular distribution were deduced from bare beam measurements using hydrogen counters, NE-213 spectrometers, Blosser spectrometers, and integral counting rates of a group of Bonner balls, all at various locations in front of the collimator[1]. The estimated accuracy of the absolute spectrum is ±10% from 14.9 MeV down to 200 keV, and ±20% below 200 keV.

[1] F. R. Mynatt, M. L. Gritzner, R. E. Maerker, and B. J. McGregor, "Fast Reactor Shielding Monthly Progress Reports for July 1971 through November 1971," ORNL-TM-3538, 3573, 3606, 3639, and 3666 (1971). The entries in Table I include the results of a more recent centerline traverse using a bare and cadmium-covered BF_3 detector.

For calculations of neutron intensities behind a shield placed over the collimator and concrete, source enhancement effects due to multiple reflection between the shield, collimator, and concrete must be calculated and included, and in general will vary with the geometry and composition of the shield.

INTERNAL DISTRIBUTION

1-3. L. S. Abbott
4. J. L. Anderson
5. A. R. Buhl
6. G. T. Chapman
7-11. C. E. Clifford
12. G. F. Flanagan
13. M. L. Gritzner
14. W. O. Harms
15. K. M. Henry
16. L. B. Holland
17. W. E. Kinney
18. R. E. Maerker
19-20. F. C. Maienschein
21. B. J. McGregor
22. F. J. Muckenthaler
23. F. R. Mynatt
24. E. M. Oblow
25. F. G. Perey
26. V. Rado
27. W. A. Rhoades
28. R. T. Santoro
29. H. E. Seagren
30. A. H. Snell
31. P. N. Stevens
32. D. B. Trauger
33. D. K. Trubey
34. G. E. Whitesides
35. H. Feshbach (consultant)
36. P. F. Fox (consultant)
37. C. R. Mehl (consultant)
38. H. T. Motz (consultant)
39-40. Central Research Library
41. ORNL Y-12 Technical Library Document Reference Section
42-44. Laboratory Records
45. Laboratory Records ORNL RC
46. ORNL Patent Office

EXTERNAL DISTRIBUTION

47-48. USAEC Division of Reactor Development and Technology, Washington, D. C. 20545: Director.

49. USAEC-RDT Senior Site Representative, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 37830.

50. USAEC Oak Ridge Operations Office, P.O. Box E, Oak Ridge, TN 37830: Research and Technical Support Division.

51. USAEC Technical Information Center, Office of Information Services, P.O. Box 62, Oak Ridge, TN 37830.

52-247. For distribution as shown in TID-4500 Distribution Category, UC-79d, Liquid Metal Fast Breeder Reactors (Physics).