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NEUTRON-EXPOSURE PARAMETERS FOR THE FOURTH HSST SERIES OF METALLURGICAL IRRADIATION CAPSULES*

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ABSTRACT

The neutron exposure parameters for the Heavy Section Steel Technology (HSST) Experiments performed at the Oak Ridge National Laboratory (ORNL) can be determined conservatively to ±10% (1σ) variance.

The neutron exposure parameters used for this study were fluence greater than 1 MeV, fluence greater than 0.1 MeV, and displacements per atom (dpa). Measured reaction rates, calculated neutron transport fluxes, and cross sections values were combined in the logarithmic least square adjustment code LSL.[1]

1. Introduction

The U.S. Nuclear Regulatory Commission (NRC) is conducting an extensive research program[2,3] to study fracture toughness of irradiated pressure vessel materials in the upper transition region and to investigate the applicability of small specimen test results to thick-section materials. This study has been extended to the study of upper-shelf behavior (plastic behavior). The first three irradiation experiments (nine capsules) contained fracture toughness specimens of four-inch (4T-CS) and a number of smaller specimens of low-shelf weldments.

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The fourth HSST irradiation series (four capsules) is primarily designed to obtain statistical data on the fracture toughness of "current practice" weldments. Each of the capsules contains one-inch-thick fracture toughness (1T-CS), Charpy V-notch, and tension test specimens (Figs. 1 and 2).

In support of the material irradiation experiments, a neutron characterization program was initiated to provide accurate exposure parameters for correlation with the property change rate data. The dosimetry results of the second and third HSST series have been reported in Refs. 4 and 5. The experience gained in these two experiments have led to modifications in the composition and distribution of the dosimeters which monitor the flux spectrun in the irradiated steel specimens. In addition, multiple foil sets were irradiated in simulated HSST irradiation capsules to obtain detailed neutron spectrum information. This dosimetry experiment was a joint effort between CEN/SCK, Mol, Belgium and ORNL. The methods and techniques of measurement, calculation, and analysis are the same as applied to the neutron spectral characterization of the PCA experiments and Blind Test.[6]

2. Results

The results reported in this paper are for capsules A and B of the fourth HSST irradiation series (Fig. 3). Tables 1 and 2 show the exposure parameters (fluence > 1 MeV, fluence > 0.1 MeV and dpa) for each specimen in capsule A. For the 1T-CT specimens, the exposure values represent values at the crack tip. For the charpy specimens, the values are given at the apex of the v-notch. Similarly Tables 3 and 4 represent the exposure values for capsule B. A 3-dimensional map for the exposure parameters has been determined. This map has the form

$$\Phi(x,y,z) = \Phi_o \cos B_x (x-x_o) \cos B_y (y-y_o) e^{-\lambda z} \quad . \qquad (1)$$

Preliminary estimates yield a ±10% (1σ) variance for the exposure parameters obtained from equation (1).

A technical report will be issued at a later date with a detailed uncertainty analysis and the methodology that was used to arrive at the

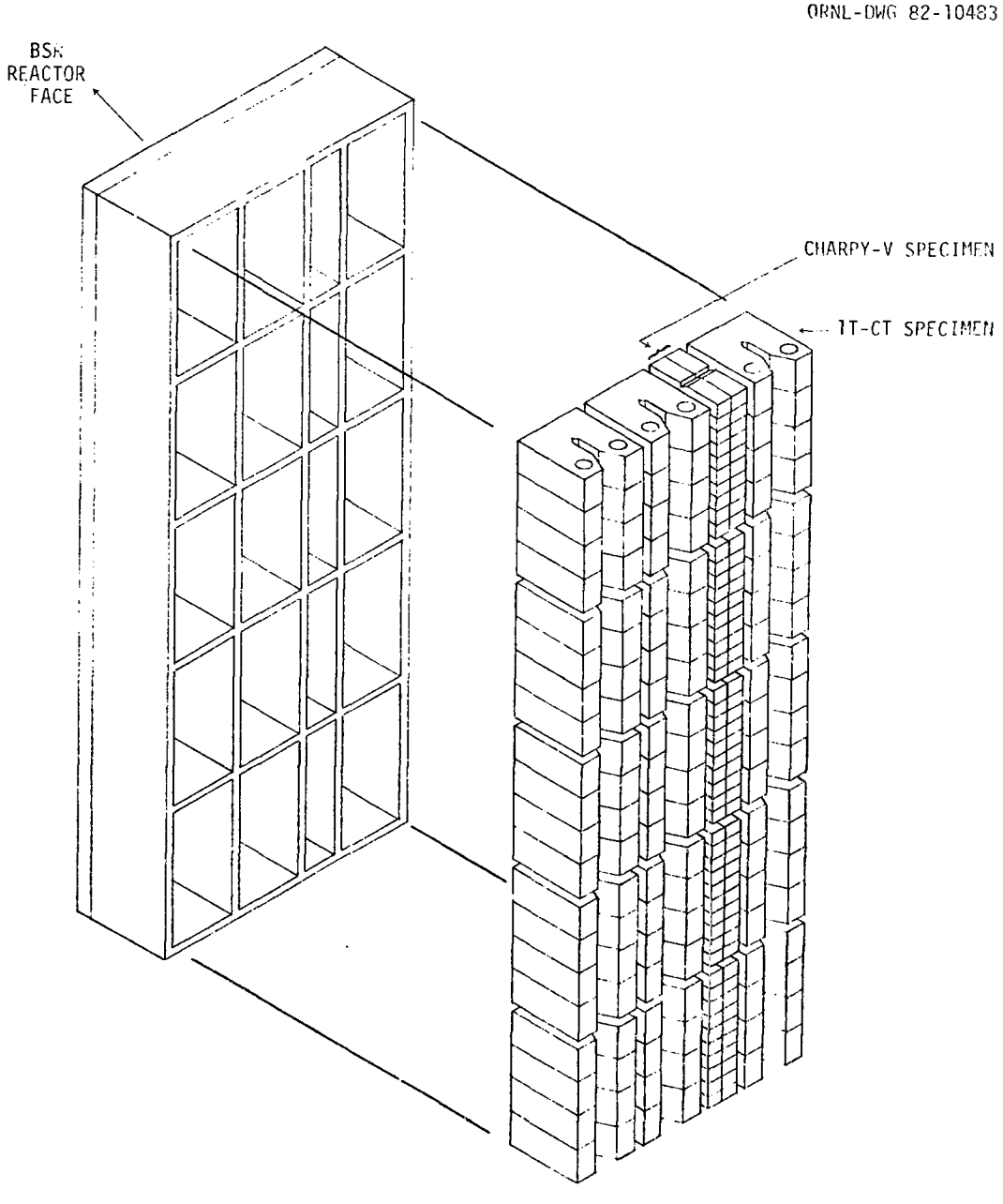

Fig. 1. Fourth HSST Series of Irradiation Capsules

1	21	41	42	141
		43	44	
		45	46	
2	22	47	48	142
		49	50	
3	23	51	52	143
		53	54	
		55	56	
4	24	57	58	144
		59	60	
5	25	61	62	145
		63	64	
		65	66	
6	26	67	68	146
		69	70	
7	27	71	72	147
		73	74	
		75	76	
8	28	77	78	148
		79	80	
9	29	81	82	149
		83	84	
		85	86	
10	30	87	88	150
		89	90	
11	31	91	92	151
		93	94	
		95	96	
12	32	97	98	152
		99	100	
13	33	101	102	153
		103	104	
		105	106	
14	34	107	108	154
		109	110	
15	35	111	112	155
		113	114	
		115	116	
16	36	117	118	156
		119	120	
17	37	121	122	157
		123	124	
		125	126	
18	38	127	128	158
		128	130	
19	39	131	132	159
		133	134	
		135	136	
20	40	137	138	160
		139	140	

Fig. 2. Specimen Position Numbers for Fourth HSST Series Irradiation Capsules.

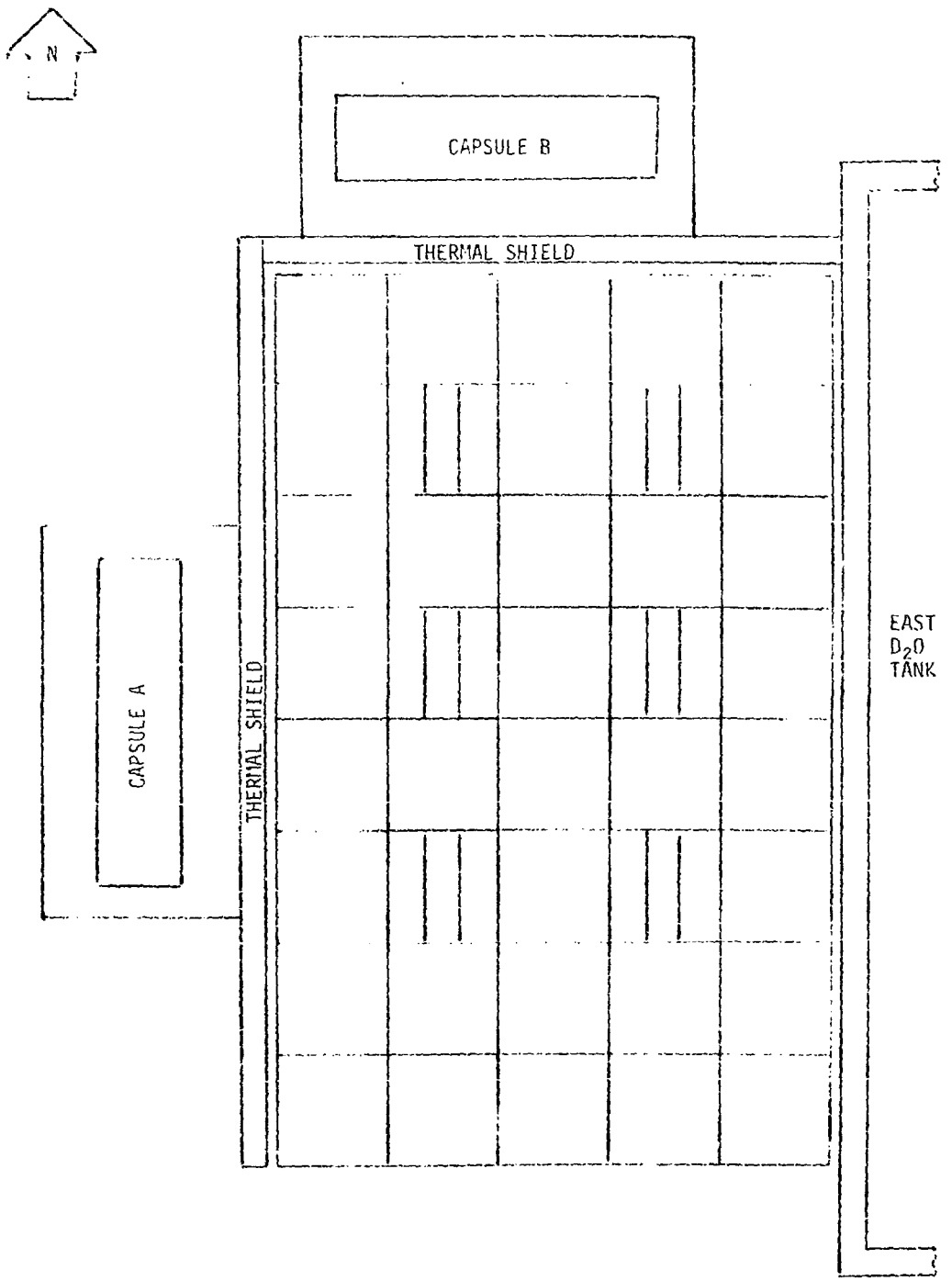

Fig. 3. Fourth HSST Experimental Configuration.

Table 1. Exposure Parameters for Capsule A 1T-CT Specimens

Specimen Position No.	Fluence >1 MeV	Fluence >.1 MeV	DPA	Specimen Position No.	Fluence >1 MeV	Fluence >.1 MeV	DPA	Specimen Position No.	Fluence >1 MeV	Fluence >.1 MeV	DPA
1	7.9485E+18	2.6420E+19	1.2545E-02	21	1.0480E+19	3.6404E+19	1.6890E-02	141	8.8131E+18	3.0132E+19	1.4112E-02
2	1.0668E+19	3.5955E+19	1.6933E-02	22	1.3109E+19	4.6066E+19	2.1232E-02	142	1.0917E+19	3.7778E+19	1.7570E-02
3	1.3254E 19	4.5022E+19	2.1107E-02	23	1.5589E+19	5.5174E+19	2.1232E-02	143	1.2899E+19	4.4977E+19	2.0826E-02
4	1.5676E+19	5.3500E+19	2.5012E-02	24	1.7891E+19	6.3618E+19	2.9125E-02	144	1.4737E+19	5.1645E+19	2.3842E-02
5	1.8467E+19	6.3250E+19	2.9508E-02	25	2.0517E+19	7.3227E+19	3.3452E-02	145	1.6830E+19	5.9224E+19	2.7275E-02
6	2.0406E+19	7.0000E+19	3.2627E-02	26	2.2321E+19	7.9801E+19	3.6419E-02	146	1.8266E+19	6.4404E+19	2.9626E-02
7	2.2092E+19	7.5836E+19	3.5331E-02	27	2.3871E+19	8.5414E+19	3.8960E-02	147	1.9497E+19	6.8822E+19	3.1636E-02
8	2.3502E+19	8.0684E+19	3.7587E-02	28	2.5148E+19	9.0000E+19	4.1045E-02	148	2.0510E+19	7.2428E+19	3.3284E-02
9	2.4875E+19	8.5332E+19	3.9767E-02	29	2.6358E+19	9.4272E+19	4.3006E-02	149	2.1467E+19	7.5780E+19	3.4829E-02
10	2.5600E+19	8.7715E+19	4.0904E-02	30	2.5966E+19	9.6334E+19	4.3972E-02	150	2.1945E+19	7.7392E+19	3.5586E-02
11	2.6007E+19	8.8953E+19	4.1521E-02	31	2.7266E+19	9.7237E+19	4.4424E-02	151	2.2177E+19	7.8090E+19	3.5935E-02
12	2.6090E+19	8.9031E+19	4.1611E-02	32	2.7255E+19	9.6969E+19	4.4357E-02	152	2.2160E+19	7.7864E+19	3.5872E-02
13	2.5728E+19	8.7457E+19	4.0963E-02	33	2.6793E+19	9.4949E+19	4.3524E-02	153	2.1781E+19	7.7864E+19	3.5195E-02
14	2.5079E+19	8.4921E+19	3.9862E-02	34	2.6982E+19	9.2060E+19	4.2289E-02	154	2.1206E+19	7.3960E+19	3.4209E-02
15	2.4118E+19	8.1277E+19	3.8254E-02	35	2.5073E+19	8.8062E+19	4.0560E-02	155	2.0393E+19	7.0792E+19	3 2826E-02
16	2.2857E+19	7.6573E+19	3.6160E-02	36	2.3777E+19	8.3005E+19	3.8356E-02	156	1.9351E+19	6.6788E+19	3.1067E-02
17	2.0848E+19	6.9168E+19	3.2842E-02	37	2.1743E+19	7.5151E+19	3.4914E-02	157	1.7717E+19	6/0572E+19	2.8322E-02
18	1.8969E+19	6.2305E+19	2.9752E-02	38	1.9858E+19	6.7933E+19	3.1737E-02	158	1.6204E+19	5.4859E+19	2.5789E-02
19	1.6854E+19	5.4629E+19	2.6285E-02	39	1.7746E+19	5.9897E+19	2.8189E-02	159	1.4510E+19	4.8498E+19	2.2960E-02
20	1.4530E+19	4.6241E+19	2.2483E-02	40	1.5432E+19	5.1141E+19	2.4311E-02	160	1.2652E+19	4.1563E+19	1.9867E-02

Table 2. Exposure Parameters for Capsule A Charpy Specimens

Specimen Position No.	Fluence >1 MeV	Fluence >.1 MeV	DPA	Specimen Position No.	Fluence >1 MeV	Fluence >.1 MeV	DPA
41	7.6558E+18	2.7335E+19	1.2598E-02	42	7.5128E+18	2.6789E+19	1.2372E-02
43	8.5618E+18	3.0795E+19	1.4133E-02	44	8.4019E+18	3.0179E+19	1.3880E-02
45	9.4528E+18	3.4196E+19	1.5643E-02	46	9.2762E+18	3.3513E+19	1.5362E-02
47	1.0327E+19	3.7534E+19	1.7124E-02	48	1.0134E+19	3.6784E+19	1.6816E-02
49	1.1183E+19	4.0802E+19	1.8574E-02	50	1.0974E+19	3.9987E+19	1.8240E-02
51	1.2019E+19	4.3993E+19	1.9990E-02	52	1.1795E+19	4.3114E+19	1.9631E-02
53	1.2834E+19	4.7102E+19	2.1370E-02	54	1.2594E+19	4.6161E+19	2.0986E-02
55	1.3626E+19	5.0123E+19	2.2711E-02	56	1.3372E+19	4.9122E+19	2.2303E-02
57	1.4394E+19	5.3050E+19	2.4011E-02	58	1.4125E+19	5.1990E+19	2.3580E-02
59	1.5137E+19	5.5878E+19	2.5268E-02	60	1.4854E+19	5.4762E+19	2.4814E-02
61	1.6437E+19	6.0820E+19	2.7465E-02	62	1.6129E+19	5.9605E+19	2.6971E-02
63	1.7100E+19	6.3337E+19	2.8585E-02	64	1.6780E+19	6.2072E+19	2.8071E-02
65	1.7733E+19	6.5736E+19	2.9653E-02	66	1.7401E+19	6.4423E+19	2.9121E-02
67	1.8334E+19	6.8012E+19	3.0667E-02	68	1.7992E+19	6.6654E+19	3.0117E-02
69	1.8903E+19	7.0161E+19	3.1626E-02	70	1.8550E+19	6.8759E+19	3.1058E-02
71	1.9439E+19	7.2178E+19	3.2527E-02	72	1.9076E+19	7.0736E+19	3.1943E-02
73	1.9940E+19	7.4061E+19	3.3370E-02	74	1.9568E+19	7.2581E+19	3.2770E-02
75	2.0406E+19	7.5805E+19	3.4151E-02	76	2.0025E+19	7.4290E+19	3.3538E-02
77	2.0836E+19	7.7407E+19	3.4871E-02	78	2.0447E+19	7.5861E+19	3.4245E-02
79	2.1229E+19	7.8864E+19	3.5527E-02	80	2.0833E+19	7.7289E+19	3.4889E-02
81	2.1860E+19	8.1181E+19	3.6576E-02	82	2.1452E+19	7.9559E+19	3.5919E-02
83	2.2144E+19	8.2210E+19	3.7045E-02	84	2.1730E+19	8.0568E+19	3.6380E-02
85	2.2389E+19	8.3086E+19	3.7447E-02	86	2.1971E+19	8.1426E+19	3.6774E-02
87	2.2594E+19	8.3806E+19	3.7781E-02	88	2.2172E+19	8.2132E+19	3.7102E-02
89	2.2760E+19	8.4569E+19	3.8046E-02	90	2.2334E+19	8.2684E+19	3.7363E-02
91	2.2885E+19	8.4775E+19	3.8242E-02	92	2.2457E+19	8.3081E+19	3.7556E-02
93	2.2969E+19	8.5022E+19	3.8369E-02	94	2.2540E+19	8.3324E+19	3.7680E-02
95	2.3013E+19	8.5110E+19	3.8426E-02	96	2.2583E+19	8.3410E+19	3.7736E-02
97	2.3016E+19	8.5039E+19	3.8414E-02	98	2.2586E+19	8.3340E+19	3.7724E-02
99	2.2979E+19	8.4808E+19	3.8332E-02	100	2.2550E+19	8.3114E+19	3.7643E-02
101	2.2903E+19	8.3967E+19	3.7997E-02	102	2.2377E+19	8.2290E+19	3.7315E-02
103	2.2650E+19	8.3288E+19	3.7718E-02	104	2.2227E+19	8.1624E+19	3.7040E-02
105	2.2458E+19	8.2453E+19	3.7370E-02	106	2.2038E+19	8.0806E+19	3.6699E-02
107	2.2225E+19	8.1463E+19	3.6954E-02	108	2.1810E+19	7.9836E+19	3.6290E-02
109	2.1953E+19	8.0321E+19	3.6471E-02	110	2.1543E+19	7.8717E+19	3.5816E-02
111	2.1643E+19	7.9029E+19	3.5922E-02	112	2.1238E+19	7.7451E+19	3.5277E-02
113	2.1294E+19	7.7589E+19	3.5307E-02	114	2.0896E+19	7.6040E+19	3.4673E-02
115	2.0907E+19	7.6004E+19	3.4629E-02	116	2.0517E+19	7.4486E+19	3.4007E-02
117	2.0484E+19	7.4277E+19	3.3888E-02	118	2.0101E+19	7.2794E+19	3.3279E-02
119	2.0024E+19	7.2411E+19	3.3085E-02	120	1.9650E+19	7.0965E+19	3.2491E-02
121	1.9083E+19	6.8614E+19	3.1446E-02	122	1.8726E+19	6.7243E+19	3.0882E-02
123	1.8524E+19	6.6372E+19	3.0477E-02	124	1.8178E+19	6.5046E+19	2.9930E-02
125	1.7933E+19	6.4007E+19	2.9452E-02	126	1.7598E+19	6.2728E+19	2.8923E-02
127	1.7311E+19	6.1521E+19	2.8374E-02	128	1.6987E+19	6.0292E+19	2.7864E-02
129	1.6657E+19	5.8921E+19	2.7244E-02	130	1.6346E+19	5.7744E+19	2.6755E-02
131	1.5974E+19	5.6210E+19	2.6064E-02	132	1.5676E+19	5.5088E+19	2.5597E-02
133	1.5974E+19	5.3395E+19	2.4838E-02	134	1.4978E+19	5.2328E+19	2.4392E-02
135	1.4525E+19	5.0479E+19	2.3566E-02	136	1.4254E+19	4.9471E+19	2.3143E-02
137	1.3762E+19	4.7469E+19	2.2252E-02	138	1.3505E+19	4.6521E+19	2.1852E-02
139	1.2973E+19	4.4370E+19	2.0897E-02	140	1.2731E+19	4.3484E+19	2.0522E-02

Table 3. Exposure Parameters for Capsule B 1T-CT Specimens

Specimen Position No.	Fluence 1 MeV	Fluence .1 MeV	DPA	Specimen Position No.	Fluence 1 MeV	Fluence .1 MeV	DPA	Specimen Position No.	Fluence 1 MeV	Fluence .1 MeV	DPA
1	5.5006E+18	1.8511E+19	8.7261E-03	21	6.9316E+18	2.4142E+19	1.1131E-02	141	5.6745E+18	1.9113E+19	9.0076E-03
2	7.1566E+18	2.4418E+19	1.1410E-02	22	8.8069E+18	3.0995E+19	1.4212E-02	142	7.1586E+18	2.4395E+19	1.1409E-02
3	8.7272E+18	3.0017E+19	1.3955E-02	23	1.0579E+19	3.7464E+19	1.7121E-02	143	8.5609E+18	2.9382E+19	1.3677E-02
4	1.0194E+19	3.5238E+19	1.6330E-02	24	1.2226E+19	4.3471E+19	1.9824E-02	144	9.8654E+18	3.4015E+19	1.5785E-02
5	1.1879E+19	4.1222E+19	1.9055E-02	25	1.4109E+19	5.0315E+19	2.2909E-02	145	1.1358E+19	3.9299E+19	1.8193E-02
6	1.3047E+19	4.5350E+19	2.0939E-02	26	1.5405E+19	5.5005E+19	2.5028E-02	146	1.2387E+19	4.2925E+19	1.8193E-02
7	1.4060E+19	4.8907E+19	2.2567E-02	27	1.6521E+19	5.9014E+19	2.6844E-02	147	1.3275E+19	4.6033E+19	2.1273E-02
8	1.4905E+19	5.1849E+19	2.3919E-02	28	1.7442E+19	6.2294E+19	2.8338E-02	148	1.4011E+19	4.8584E+19	2.2448E-02
9	1.5724E+19	5.4649E+19	2.5219E-02	29	1.8318E+19	6.5355E+19	2.9745E-02	149	1.4717E+19	5.0984E+19	2.3565E-02
10	1.6153E+19	5.6064E+19	2.5888E-02	30	1.8760E+19	6.6839E+19	3.0442E-02	150	1.5079E+19	5.2166E+19	2.4127E-02
11	1.6390E+19	5.6773E+19	2.6242E-02	31	1.8982E+19	6.7495E+19	3.0772E-02	151	1.5270E+19	5.2717E+19	2.4407E-02
12	1.6432E+19	5.6768E+19	2.6275E-02	32	1.8982E+19	6.7318E+19	3.0737E-02	152	1.5285E+19	5.2632E+19	2.4401E-02
13	1.6203E+19	5.5731E+19	2.5854E-02	33	1.8659E+19	6.5894E+19	3.0146E-02	153	1.5054E+19	5.1608E+19	2.3983E-02
14	1.5803E+19	5.4117E+19	2.5164E-02	34	1.8156E+19	6.3846E+19	2.9272E-02	154	1.4676E+19	5.0092E+19	2.3334E-02
15	1.5215E+19	5.1822E+19	2.4167E-02	35	1.7440E+19	6.1009E+19	2.8045E-02	155	1.4131E+19	4.7971E+19	2.2413E-02
16	1.4445E+19	4.8874E+19	2.2875E-02	36	1.6518E+19	5.7418E+19	2.6481E-02	156	1.3424E+19	4.5270E+19	2.1229E-02
17	1.3221E+19	4.4249E+19	2.0833E-02	37	1.5070E+19	5.1839E+19	2.4036E-02	157	1.2307E+19	4.1057E+19	1.9369E-02
18	1.2077E+19	3.9969E+19	1.8934E-02	38	1.3727E+19	4.6714E+19	2.1780E-02	158	1.1266E+19	3.7172E+19	1.7646E-02
19	1.0789E+19	3.5187E+19	1.6805E-02	39	1.2223E+19	4.1011E+19	1.9262E-02	159	1.0097E+19	3.2838E+19	1.5716E-02
20	9.3728E+18	2.9962E+19	1.4470E-02	40	1.0575E+19	3.4801E+19	1.6512E-02	160	8.8122E+18	2.8107E+19	1.3603E-02

Table 4. Exposure Parameters for Capsule B Charpy Specimens

SPECIMEN POSITION No.	FLUENCE >1 MeV	FLUENCE >.1 MeV	DPA	SPECIMEN POSITION No.	FLUENCE >1 MeV	FLUENCE >.1 MeV	DPA
41	5.5840E+18	1.9859E+19	9.1671E-03	42	5.4686E+18	1.9381E+19	8.9778E-03
43	6.2505E+18	2.2376E+19	1.0289E-02	44	6.1213E+18	2.1838E+19	1.0076E-02
45	6.9059E+18	2.4851E+19	1.1392E-02	46	6.7631E+18	2.4253E+19	1.1157E-02
47	7.5491E+18	2.7280E+19	1.2474E-02	48	7.3931E+18	2.6623E+19	1.2217E-02
49	8.1790E+18	2.9657E+19	1.3534E-02	50	8.0100E+18	2.8944E+19	1.3254E-02
51	8.7945E+18	3.1980E+19	1.4569E-02	52	8.6127E+18	3.1210E+19	1.4268E-02
53	9.3945E+18	3.4242E+19	1.5578E-02	54	9.2002E+18	3.3419E+19	1.5256E-02
55	9.9778E+18	3.6441E+19	1.6559E-02	56	9.7715E+18	3.5564E+19	1.6217E-02
57	1.0544E+19	3.8571E+19	1.7509E-02	58	1.0326E+19	3.7644E+19	1.7148E-02
59	1.1091E+19	4.0630E+19	1.8428E-02	60	1.0861E+19	3.9652E+19	1.8048E-02
61	1.2049E+19	4.4228E+19	2.0036E-02	62	1.1799E+19	4.3164E+19	1.9622E-02
63	1.2538E+19	4.6060E+19	2.0855E-02	64	1.2278E+19	4.4952E+19	2.0425E-02
65	1.3004E+19	4.7807E+19	2.1637E-02	66	1.2736E+19	4.6657E+19	2.1191E-02
67	1.3448E+19	4.9464E+19	2.2380E-02	68	1.3170E+19	4.8274E+19	2.1918E-02
69	1.3868E+19	5.1029E+19	2.3082E-02	70	1.3582E+19	4.9802E+19	2.2606E-02
71	1.4264E+19	5.2499E+19	2.3743E-02	72	1.3969E+19	5.1236E+19	2.3252E-02
73	1.4635E+19	5.3870E+19	2.4360E-02	74	1.4332E+19	5.2574E+19	2.3857E-02
75	1.4979E+19	5.5141E+19	2.4933E-02	76	1.4670E+19	5.3815E+19	2.4418E-02
77	1.5297E+19	5.6309E+19	2.5461E-02	78	1.4981E+19	5.4954E+19	2.4935E-02
79	1.5589E+19	5.7371E+19	2.5943E-02	80	1.5266E+19	5.5991E+19	2.5407E-02
81	1.6057E+19	5.9061E+19	2.6714E-02	82	1.5725E+19	5.7641E+19	2.6162E-02
83	1.6268E+19	5.9813E+19	2.7059E-02	84	1.5932E+19	5.8374E+19	2.6500E-02
85	1.6451E+19	6.0452E+19	2.7355E-02	86	1.6110E+19	5.8998E+19	2.6791E-02
87	1.6604E+19	6.0979E+19	2.7602E-02	88	1.6261E+19	5.9512E+19	2.7032E-02
89	1.6728E+19	6.1392E+19	2.7799E-02	90	1.6382E+19	5.9915E+19	2.7225E-02
91	1.6823E+19	6.1690E+19	2.7945E-02	92	1.6475E+19	6.0206E+19	2.7368E-02
93	1.6888E+19	6.1873E+19	2.8041E-02	94	1.6539E+19	6.0384E+19	2.7462E-02
95	1.6923E+19	6.1940E+19	2.8086E-02	96	1.6573E+19	6.0450E+19	2.7506E-02
97	1.6928E+19	6.1891E+19	2.8080E-02	98	1.6578E+19	6.0402E+19	2.7501E-02
99	1.6904E+19	6.1727E+19	2.8024E-02	100	1.6554E+19	6.0242E+19	2.7445E-02
101	1.6780E+19	6.1121E+19	2.7785E-02	102	1.6433E+19	5.9651E+19	2.7212E-02
103	1.6671E+19	6.0630E+19	2.7585E-02	104	1.6326E+19	5.9171E+19	2.7015E-02
105	1.6532E+19	6.0026E+19	2.7334E-02	106	1.6190E+19	5.8582E+19	2.6770E-02
107	1.6364E+19	5.9309E+19	2.7034E-02	108	1.6026E+19	5.7883E+19	2.6476E-02
109	1.6168E+19	5.8482E+19	2.6685E-02	110	1.5833E+19	5.7075E+19	2.6.34E-02
111	1.5942E+19	5.7545E+19	2.6287E-02	112	1.5613E+19	5.6161E+19	2.5744E-02
113	1.5689E+19	5.6501E+19	2.5842E-02	114	1.5365E+19	5.5142E+19	2.5308E-02
115	1.5408E+19	5.5352E+19	2.5350E-02	116	1.5089E+19	5.4020E+19	2.4826E-02
117	1.5099E+19	5.4099E+19	2.4812E-02	118	1.4787E+19	5.2797E+19	2.4300E-02
119	1.4764E+19	5.2745E+19	2.4229E-02	120	1.4459E+19	5.1476E+19	2.3729E-02
121	1.4078E+19	4.9988E+19	2.3039E-02	122	1.3787E+19	4.7875E+19	2.2563E-02
123	1.3671E+19	4.8361E+19	2.2334E-02	124	1.3388E+19	4.7197E+19	2.1873E-02
125	1.3239E+19	4.6643E+19	2.1588E-02	126	1.2965E+19	4.5521E+19	2.1143E-02
127	1.2784E+19	4.4838E+19	2.0804E-02	128	1.2520E+19	4.3759E+19	2.0374E-02
129	1.2307E+19	4.2949E+19	1.9982E-02	130	1.2052E+19	4.1916E+19	1.9569E-02
131	1.1807E+19	4.0980E+19	1.9124E-02	132	1.1563E+19	3.9995E+19	1.8729E-02
133	1.1287E+19	3.8935E+19	1.8231E-02	134	1.1054E+19	3.7998E+19	1.7854E-02
135	1.0747E+19	3.6817E+19	1.7305E-02	136	1.0525E+19	3.5931E+19	1.6947E-02
137	1.0188E+19	3.4630E+19	1.6347E-02	138	9.9775E+18	3.3797E+19	1.6010E-02
139	9.6111E+18	3.2378E+19	1.5360E-02	140	9.4124E+18	3.1599E+19	1.5043E-02

values. Preliminary results of the uncertainty analysis can be found in Ref. 7.

3. Conclusions and Recommendations

The results achieved in the analysis of the fourth HSST experiments indicate that for a reasonable amount of time and funds, a considerable improvement in accuracy is attainable. The following steps are suggested for the analysis of exposure parameters from test reactor experiments.

1. ^{237}Np (n,f) and ^{238}U (n,f) sensors with gadolinium or CdO covers be included in the dosimetry multiple foil sets at select locations.
2. Single wire sensors should be placed at as many locations as feasible to obtain a complete and accurate spatial distribution of fast fluxes.
3. Good calculations for the source term in the core and the transport of neutrons from the core to the experiment.
4. A cross section data base for the reaction rate cross section and their variances and covariances.
5. A least square adjustment method to combine the reaction rate data, the calculated fluxes, and cross section values and arrive at an overall uncertainty for the exposure parameter of interest.

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