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MEASURED THERMAL AND FAST NEUTRON FLUENCE RATES FOR EPRI HOLDER DURING ATR CYCLE 168B

7/23/20 thru 10/29/20

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ATR CYCLE 168B EPRI
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This report contains the thermal (2200 m/s) and fast (E>1MeV) neutron fluence rate data for ATR Cycle 168B EPRI which were measured by the Radiation Measurements Laboratory (RML) as requested by the Power Reactor Programs (ATR Experiments) Radiation Measurements Work Order.

This report contains fluence rate values corresponding to the particular elevations (relative to the 80-ft. core elevation) where the measurements were taken. The data in this report consists of (1) a table of the ATR power history and distribution, (2) a hard copy listing of all thermal and fast neutron fluence rates, (3) plots of both the thermal and fast neutron fluence rates, and (4) an optical record (compact disk) containing a listing of the thermal and the fast neutron fluence rates, their assigned elevations and proper header identification of all monitor positions contained herein.

The fluence rates reported are for the average power levels given in the table of power history and distribution.

All "EPRI" holder monitor wires for this cycle were 23.875 inches long. This length allows measurements from 31.625 inches above core midplane to 12.125 inches above core midplane. The wires were counted from top to bottom at 1 inch intervals with the exception of the final count position which was 0.5 inches. The first count position was 4.25 inches from the top end, with the final count at 0.125 inches from the bottom end of the wire for a total of 19.5 inches of wire scanned in 21 positions. Note that the Center Line Fluence rate in this report corresponds to approximately 12 inches above core center line, since the monitor wires do not extend to core center.

The monitor was located at A-15. Due to the design of the experiment, monitor could not be designed to extend the full axial length of the ATR fuel.

DEFINITIONS OF REPORTED INFORMATION

ON PRINTED PAGES

1. CYCLE: The identification code given to a specific period of operation of the ATR for which the data in this report applies.

2. POSITION: The identification code given to a specific location in the ATR core area where neutron monitors were located and for which the data associated with the code apply. The letter code identifies the lobe and the number code identifies a monitor position.

3. MONITOR ID: The identification code given to a specific neutron monitor holder. The code is stamped on the holder. The letter code identifies the type of holder and the number is unique to allow tracking of the neutron monitors and their data.

4. EFPD: The acronym for, "Effective Full Power Days" which is the effective number of days the ATR operated at the average total core power level of the cycle. This value is obtained from the ATR power history and distribution.

5. AVERAGE MW: The average power level (in megawatts) at which the ATR lobe operated during the cycle. The values used for NW, NE, C, SW, and SE lobes are obtained from the ATR power history and distribution. The values used for the other lobes and core positions are determined as follows:

$$N = (NE + NW + C)/3$$
$$E = (NE + SE + C)/3$$
$$S = (SE + SW + C)/3$$
$$W = (NW + SW + C)/3$$

A1 through A8 = C
A9 = NE
A10 = SE
A11 = SW
A12 = NW

B1 or B2 = NE	I21 = NE	B 9 = N
B3 or B4 = SE	I22 = SE	B10 = E
B5 or B6 = SW	I23 = SW	B11 = S
B7 or B8 = NW	I24 = NW	B12 = W

6. DATE: The calendar dates corresponding to the outage and operating time of the cycle. These dates include the forced outage time associated with the cycle as well as the operating time.

7. ELEVATION: The vertical position associated with the neutron fluence rate measurement value relative to the 80 ft. elevation of the ATR core. The elevation values are in inches and negative values are below the 80 ft. elevation (commonly referred to as centerline). The elevation values are established reference elevation points specified as follows:

Holder Type	Reference Elevation	Drawing Numbers
H	77.948 ft.	424852
SR	77.768 ft.	417424
MICE	77.750 ft.	510528
EPRI	83.260ft.	601418
AGR-3/4	77.906ft.	602691

Using the dimensions of the monitor holders, the location of the monitor wire in the holder, the length of the wire and the distance between the measurements along the wire an elevation value for each fluence rate value is determined. An evaluation of the elevation tolerances is listed as follows:

	SR Holders	H or MICE Holders
Holder Fabrication	± 0.11 inch	± 0.11 inch
Cutting the Monitor Wire to Length	± 0.01 inch	± 0.01 inch
Wire Alignment in the Holder	± 0.13 inch	± 0.06 inch
Mounting the Wire to the Scanner	± 0.13 inch	± 0.13 inch
Scanning Control	± 0.01 inch	± 0.01 inch
Scanner Home Positioning	± 0.06 inch	± 0.06 inch
Stackup of the Safety Rod Components (estimated)	± 0.33 inch*	
Position of the Safety Rod Relative to 80 ft. (core centerline) during Operation	± 0.75 inch**	
95% Confidence Bound	± 0.78 inch	± 0.19 inch
Maximum Error	± 1.53 inch	± 0.38 inch

These elevation tolerances include only what are considered to be random errors. Systematic errors or biases may also occur due to information input. However, procedural controls are used to minimize this information input error.

*This estimate will be revised after an actual measurement is made.

**This estimate does not include variations due to thermal and hydraulic effects.

8. "THERMAL": The equivalent 2200 m/s (0.025 eV) neutron fluence rate assuming a Maxwellian distribution for the thermalized neutrons at 20.44C. The fluence rate is determined from the Co-59(n,γ)Co-60 reaction rate assuming a 37 barn 2200 m/s cross section for the reaction. Corrections for the epithermal reaction rate are made based on cadmium ratio measurements at each position of the fluence rate measurement. All fluence rate values are in units of neutrons per sqcm per second.

9. "FAST": The equivalent >1 MeV fission neutron energy fluence rate assuming a pure U-235 fission spectrum neutron energy distribution. The fluence rate is determined from the Ni-58(n,p)Co-58 reaction rate assuming a 0.092 barn fission spectrum averaged cross section for the reaction and a fission spectrum fraction of 0.692 for >1 MeV neutrons. Corrections for the burnout of the Co-58 isomers are made based on the measured 2200 m/s fluence rate, the exposure duration and the burnout cross sections of the isomers [1650 barns (71 days), 1.7 E+5 barns (9.1 hours)] at each position of the fluence rate measurement.

10. CENTERLINE FLU. RATE: The neutron fluence rate at the elevation assignment nearest to the ATR core centerline elevation (0.0).

11. AVG. MAX. FLU. RATE: The average of the highest three adjacent values.

12. MAX. FLU. RATE/MW (AVG.): The average maximum fluence rate divided by the average power level (MW) of the lobe or position.

13. K FACTOR: The conversion factor determined from the neutron monitor activity for converting the net count rate at each elevation to the absolute reaction product (^{60}Co or ^{58}Co) radioactivity per unit mass of the monitor material (d/s/mg).

14. RESONANCE CORRECTION: The fractional correction factor used to correct the Co-59(n,γ)Co-60 reaction rate for the epithermal neutron response at the position where the neutron monitor was located during irradiation. This correction factor was determined from cobalt "cadmium ratio" measurements at the same spatial location for the monitor geometry and atom density.

15. C/L BURNOUT CORRECTION: The correction factor for the burnout (transmutation) of the reaction products (Co-60, Co-58, Co-58m) of the neutron monitors during the cycle irradiation at the centerline fluence rate elevation. The burnout correction factors for other elevation assignments will vary (nonlinearly) depending on the "thermal" neutron fluence rates and cycle durations.

16. BACKGROUND (counts/sec.): The wire scanner detector background environment counting rate at the time the neutron monitor wires were scanned.

17. CHECK SOURCE (counts/sec.)
Date Hour: The wire scanner detector check source count rate on the day the neutron monitor wires were scanned. The check source is a radioactive (^{60}Co) cobalt-aluminum wire mounted in a fixture which reproducibly positions it over the detector collimator. This check source is used to test counting functions (gain and stability) of the scanner counting system. The count rate is corrected for background and decay corrected to 08/30/08, 12:00.

ON PLOTS

18. REACTOR: Identification of the reactor with which the data are associated (normally ATR).

19. CYCLE POWER: The total megawatt days of power produced during the reactor cycle. This value is normally obtained from the ATR power history and distribution information supplied by PRP.

20. MATERIAL: The element name of the neutron monitor material. The "thermal" neutron monitor material is normally an alloy (CoAl) of cobalt (Co) and aluminum (Al) where the weight percent is given preceding the percent (%) symbol.

21. EXPERIMENT: The identification code given to the experiment located in the loop. This information is provided by PRP.

POWER HISTORY AND DISTRIBUTION
CYCLE 168B

7/23/20

To

10/29/20

	NW	NE	C	SW	SE	TOTAL MWD
MWD	1042.38	1136.63	1266.06	1355.81	1312.14	6113.02
EFPD	57.50					
MWD/44 = EFF. TE.	23.69	25.83	28.77	30.81	29.82	
EFF. TE. / EFPD = PF	.412	.449	.500	.536	.519	
MWD/EFPD = AVG. POWER (MW)	18.13	19.76	22.02	23.58	22.82	
TOTAL MWD/EFPD = AVERAGE FULL POWER (MW)	106.31					

The following power history was used for fluence rate determinations

Days	Power (MW)	Power Factor (P.F.)
43.48	106.31	1.00
4.72	0	0
0.25	35.08	0.33
1.25	0	0
13.87	106.31	1.00
132.00	0	0

CYCLE: 168BEPRI POSITION: A-15 MONITOR ID: EPRI-41
EFPD: 57.5 AVERAGE MW: 22.0 DATE: 07/23/20 to 10/29/20

ELEVATION from core CL (inches)	"THERMAL" 2200 m/s CO (n/cm**2/sec)	"FAST" >1 MeV NI (n/cm**2/sec)
31.60	4.27E+12	1.20E+12
30.62	5.45E+12	2.07E+12
29.62	7.70E+12	3.00E+12
28.62	1.23E+13	4.58E+12
27.62	1.62E+13	6.82E+12
26.62	1.93E+13	9.76E+12
25.62	2.47E+13	1.51E+13
24.62	2.76E+13	2.28E+13
23.62	2.85E+13	3.56E+13
22.62	3.14E+13	4.80E+13
21.62	3.89E+13	6.13E+13
20.62	5.05E+13	7.28E+13
19.62	6.09E+13	8.39E+13
18.62	7.32E+13	9.95E+13
17.62	8.16E+13	1.11E+14
16.62	9.14E+13	1.20E+14
15.62	1.02E+14	1.31E+14
14.62	1.09E+14	1.43E+14
13.62	1.16E+14	1.43E+14
12.62	1.27E+14	1.55E+14
12.12	5.58E+13	2.21E+11

CENTER LINE FLU. RATE	1.16E+14	1.43E+14
AVG. MAX. FLU. RATE	1.17E+14	1.47E+14
MAX. FLU. RATE/MW (AVG.)	5.32E+12	6.68E+12
K FACTOR	1588.87	1369.26
RESONANCE CORRECTION	0.75	NA
C/L. BURNOUT CORRECTION	1.001	1.756
BACKGROUND (COUNTS/SEC.)	8.29	8.29
CHECK SOURCE (COUNTS/SEC.)		
02/17/21 08:03	3245.	3245.

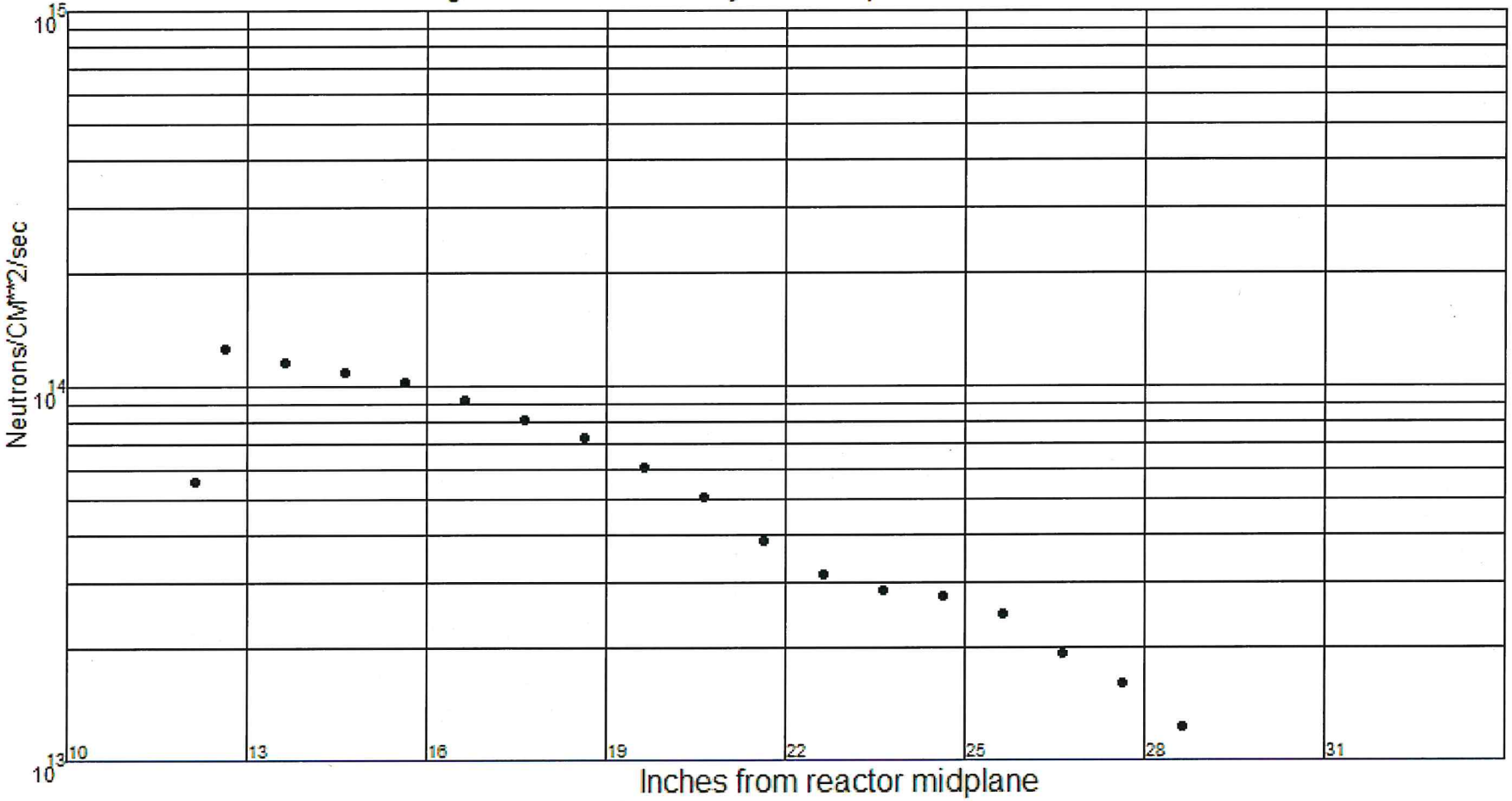
Thermal Neutron Fluence Rate (2200 M/S)

Reactor: ATR | Cycle: 168BEPRI | Cycle Power: 6112.8 Mwd | Date: 07/23/20-10/29/20

Monitor No.:EPRI-41 | Position: A-15 | Material:0.0956 %CoAl | Experiment: ZRRI-ZG-C

Average Maximum Fluence Rate: 1.17E+14

Averaged values over 57.5 Days reactor operations at 106.3 MW



Fast Neutron Fluence Rate (> 1 MeV)

Reactor: ATR | Cycle: 168BEPRI | Cycle Power: 6112.8 Mwd | Date: 07/23/20-10/29/20

Monitor No.:EPRI-41 | Position: A-15 | Material: Nickel | Experiment: ZRRI-ZG-C

Average Maximum Fluence Rate: 1.47E+14

Averaged values over 57.5 Days reactor operations at 106.3 MW