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HIGH FLUX ISOTOPE REACTOR QUARTERLY REPORT

July, August, and September of 1970

R. V. McCord
B. L. Corbett

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SUMMARY

Additional cracked target rods, one requiring a 150-hour shutdown, were mainly responsible for reducing the operating time to 91.2% this quarter. A leak from the primary water system into the pool became apparent as the general radioactivity level of the pool water more than doubled. The leak was found at the HB-1 Marman flange, but its repair must await the development of various tools and repair techniques. The present leak-rate does not present a serious operational problem. This development process is under way and the leak will be repaired at the first opportunity. The semiannual reactor component inspection was completed without any component abnormalities being detected.

OPERATIONS

Basic operating data for the quarter are listed in Table 1.

Table 1. HFIR Basic Operating Data
(July 1 through September 30, 1970)

	This Quarter	Last Quarter	Year To Date
Total energy, MWd	8,366	8,679	24,429
Average power, MW/operating hr	99.7	99.9	99.8
Time operating, %	91.2	95.6	89.7
Reactor availability, %	91.2	95.6	89.7
Reactor water radioactivity, $\frac{c/min}{ml}$ (av)	233,000	249,000	
Pool water radioactivity, $\frac{c/min}{ml}$ (av)	333	140	
Reactor water resistivity, ohm-cm (av)	0.32×10^6	0.250×10^6	
Pool water resistivity, ohm-cm (av)	1.50×10^6	1.55×10^6	

The starting and ending dates for cycles 50, 51, 52, 53, and 54 are presented in Table 2. Cycle 54 was still in progress at the end of the quarter and 851 MWd had been accumulated.

Table 2. HFIR Cycles of Operation

Cycle No.	Date Started	Date Ended	Accumulated Power (MWd)
50	6-15-70	7-8-70	2331
51	7-9-70	8-2-70	2366
52	8-2-70	8-22-70	2000
53	8-29-70	9-21-70	2378
54	9-22-70	In progress	851

The status of the HFIR fuel and control-plate inventory is indicated in Table 3.

Table 3. HFIR Material Inventory

Item	This Quarter	Last Quarter
New fuel elements placed in service	4	4
New fuel elements available for use	44	44
Spent fuel elements on hand	12	13
Spent fuel elements shipped	5	1
New sets of shim plates placed in service	0	1
New sets of shim plates available for use	1	1

SHUTDOWNS

A summary of the HFIR shutdowns for the quarter is presented in Table 4. There were no unscheduled shutdowns. Table 5 gives further details of the shutdowns.

Table 4. Summary of HFIR Shutdowns

Type	Number	Downtime (hr)
	Scheduled	
End of cycle	4	193.633
Experiment	4	0.151
Training	1	0.050
		193.834

Table 5. Description of HFIR Shutdowns

Date	Downtime (hr)	Remarks
7-8-70	16.567	Fuel cycle 50 was completed at 5:30 p.m. A total power generation of 2331 MWd was obtained on fuel elements 40-0 and 40-I. The shutdown was extended to identify a leaking target rod and to complete routine maintenance items.
8-2-70	12.533	Fuel cycle 51 was completed at 2:24 a.m. A total power generation of 2366 MWd was obtained on fuel elements 41-0 and 41-I.
8-13-70	0.050	The reactor was shut down briefly for operator training.
8-22-70	150.333	Fuel cycle 52 was terminated at 6:00 p.m. because of high alpha activity in the primary system. A total power generation of 2000 MWd was obtained on fuel elements 42-0 and 42-I. The shutdown was extended to clean the system, identify a leaking target rod, and complete various maintenance items.
8-29-70	0.100	Shortly after the start of cycle 53 one safety plate was deliberately dropped twice to allow the computer to perform recovery tests.

Table 5. (continued)

Date	Downtime (hr)	Remarks
9-21-70	14.200	Fuel cycle 53 was completed at 8:20 p.m. A total power generation of 2378 MWd was obtained on fuel elements 43-0 and 43-I.
9-22-70	0.051	Shortly after the start of cycle 54 the reactor sagged below 10 MW twice during computer tests.

OPERATIONAL NOTES AND SPECIAL TESTS

Target Rod Cracks

Two additional target rods developed cracks this quarter. At the end of cycle 50 the level of alpha contamination in the primary water indicated a target rod had failed. Tests of the older rods showed that rod D63 was indeed leaking so it was removed. This was a plutonium-oxide rod which initially contained 8 g of ^{242}Pu pressed to 90% of its theoretical density. It had been irradiated for ~55,000 MWd.

During cycle 52 the level of alpha contamination in the primary water rose to levels not previously encountered in normal operation. This cycle was therefore terminated after 2,000 MWd of operation. All target rods were checked; but only one, K23, was found to be leaking. The reason for the excessive release of contamination from this rod has not yet been determined. However, it was a relatively new rod containing 10 g of ^{242}Pu pressed to 80% of its theoretical density and had been irradiated for only ~42,000 MWd. Other target rods have been fabricated in this manner and irradiated for much longer periods without developing any leaks.

Demineralizer Resin

Some difficulty has been experienced with decomposition of the primary cation resins. Although the exchange capacity has not been affected much, mechanical breakage of the resins has occurred to such an extent that replacement has been necessary. Examination of the used resin has shown that the beads are extremely fragile and shatter into small pieces upon

application of a slight load. The resin damage has been tentatively attributed to radiation damage caused by alpha particles emitted from ^{244}Cm which is collected on the cation resin when target rods develop cracks.

Table 6 is a summary of the performance of the primary demineralizer resins.

Table 6. Performance of Primary Demineralizer Resins

Column	Resin Charge	Date Inserted	Date Removed	Throughput (gal)
West Cation	1	June 1965	10-15-68	113,200,000
	2	10-22-68	3-18-69	75,100,000
	3	3-18-69		
West Anion	1	June 1965		>190,000,000
East Cation	1	June 1965	1-31-69	95,500,000
	2	1-31-69	8-4-70	66,200,000
	3	8-12-70		
East Anion	1	June 1965		>170,000,000

Beam-Tube-Flange Leak

During cycle 53 an increase in the radioactivity level of the pool water made it apparent that a leak had developed from the primary water system. At the end of cycle 53 the pool water was lowered to the top of the reactor vessel while the primary system was pressurized in an unsuccessful attempt to locate the leak. After the start of cycle 54, water samples from various points in the pool indicated the leak was in the vicinity of the Marman clamp on HB-1. This was the clamp in which a flange coupling stud broke earlier this year.*

A temporary line and rotometer were installed between the primary and pool demineralizer systems to save the leaking water and to monitor the

*R. V. McCord and B. L. Corbett, High Flux Isotope Reactor Quarterly Report—January, February, and March of 1970, ORNL-TM-3000, May 14, 1970.

magnitude of the leak. The leak-rate appears to be ~0.75 gpm. It will be watched closely while procedures are developed and tools are fabricated to repair the defective Marman seal.

PLANT MAINTENANCE

Significant maintenance and changes in the various process systems are listed in Table 7.

INSTRUMENTATION AND CONTROLS

Significant maintenance and changes in the various instrumentation systems are listed in Table 8.

Table 7. Process System - Maintenance and Changes

Date	Component	Remarks
		Primary System
8-3-70	Primary pump	A 50-ohm resistor in the control circuit of primary pump PU-1C was replaced because of an open circuit.
8-24-70	Rod drives	The drive rod, gear box, upper O-ring seal, and Delrin seal housing were replaced on No. 4 rod drive. The No. 5 drive rod Delrin seal housing was replaced.
8-26-70	Strainer	A new model lenticular strainer was placed in the system.
8-27-70	Hot-water-injection system	A new automatic-valve manifold using ball valves was installed in the hot-water-injection system as described in mechanical change memorandum No. 28.
		Miscellaneous
8-7-70	Off-gas fan	Hot-off-gas fan FN-6 was removed from service to repair a faulty motor bearing.
8-12-70	Primary cleanup prefilter	When primary cleanup system prefilter FL 1-B was opened for inspection, some filter elements were found loose because of deteriorated gaskets. The gaskets were replaced and the filter elements were tightened.
8-12-70	Hydraulic tube	Water leakage into process flow transducer FT-5 caused a false low-flow signal and hydraulic-tube-sample ejection. The flow transducer was replaced.

Table 8. Instrumentation - Maintenance and Changes

Date	Component	Remarks
		Safety System
8-12-70	Channel 2 flux signal	The dual signal converter for the channel 2 reset flux and flux-to-flow signal was replaced when the signal to the flux-to-flow recorder went off-scale.
8-31-70	Temperature transmitter	Channel 3 safety temperature outlet transmitter, TT-100-3B, was replaced because of a 4-MW error in computed heat power.
9-21-70	Channel 3 flow signal	Changes required to increase the range of the main flow measurement from 0-17,000 gpm to 0-20,000 gpm were made in channel 3 according to instrumentation change memorandum No. 67.
		Servo System
7-8-70	Multiplier	The servo multiplier in channel 2 (XwM-100-5A) was replaced because of a faulty output.
7-9-70	Operational amplifier	A battery-charger failure caused the channel 1-x/y gain operational amplifier to fail, which, in turn, called for a full insert on this channel. The amplifier was replaced.
7-15-70	Control action	All three servo channels were adjusted to increase the gain and decrease the response time of the control system.
8-3-70	Drawer R-1, channel 2	Circuit modifications were made in drawer R-1 of channel 2 to provide access to the demand signal for rod oscillation reactivity measurements in accordance with instrumentation change memorandum 66.
8-3-70	Channel 3	Servo channel 3 became noticeably sluggish in responding to a demand change. A partially shorted capacitor was found and replaced in the gain circuit.

Table 8. (continued)

Date	Component	Remarks
		Wide-Range Counting Channels
8-31-70	Gearbox	The gearbox on channel 2 failed and was replaced.
9-8-70	Operational amplifier	Noisy log-power and reactor-period signals on channel 1 were corrected by the replacement of the dual operational amplifier module serving the function generator and the power pile network.
		Miscellaneous
7-9-70	Battery charger	A transformer failed in instrument battery charger A-2 on channel 1. A spare charger was placed in service.

SYSTEM SURVEILLANCE TESTS AND RESULTS

Stack Filters

All absolute filters in the special building hot exhaust (SBHE) and hot-off-gas (HOG) systems were tested for particulate removal efficiency on September 21, 1970. The results of the test are tabulated in Table 9.

Table 9. Particulate Removal Efficiency Tests

Filter Bank	Filter Position	Efficiency, %
SBHE, east	South	99.993
SBHE, east	North	99.991
SBHE, center	South	99.996
SBHE, center	North	99.996
SBHE, west	South	99.967
SBHE, west	North	99.980
HOG, east	South	99.909
HOG, east	North	99.981
HOG, center	South	99.925
HOG, center	North	99.81
HOG, west	South	97.00
HOG, west	North	99.68

Semiannual Reactor-Component Inspection

At the end of cycle 52 the semiannual reactor-component inspection was made. The shroud flange, fuel grid, and control plates were removed from the reactor vessel. The components which remained in the vessel--upper and lower tracks, beryllium, beam tubes, and support pedestals--were inspected with periscopes and telescopes. No component abnormalities were detected.

Vessel Head Studs

The accumulated number of tensioning cycles on the reactor vessel head studs is presented in Table 10. These studs were designed for a fatigue life of 40 cycles loading due to tensioning of the bolts and 730 full pressure (1000 psig) cycles.

Table 10. Vessel Head Stud-Tensioning Cycles

	This Quarter	Last Quarter	Total To Date
Head bolts tensioned			10
1500 psig			10
950 psig			199
650 psig	6	4	343
			562

Water Analyses

Results of various analyses performed by the analytical laboratories are tabulated in Table 11.

Table 11. Water Analyses Results

Date	Total Solids (ppm)	Non-Volatile Material (ppm)	Si (ppm)	Cl (ppm)	Cu (ppm)	Hg (ppm)	Na (ppm)	Ca (ppm)	Al (ppm)	Conductivity (mhos)	pH	$CaCO_3$ (ppm)	CrO_4 (ppm)	O_2 (ppm)	H_2O_2 (ppm)	NO_3 (ppm)	H_2 (ppm)	NO_2 (ppm)	H^3 (dis $min^{-1}ml^{-1}$)
										Primary Water									
7-14-70	1.20	1.00	<0.01	<1	<0.005	<1	0.008		<0.02	3.63×10^{-6}				41.4	10.6	0.11	2.77	0.12	3.04×10^{5}
8-17-70	1.60	0.40	<0.01	0.15	<0.005	<0.002	<0.002		0.01	3.82×10^{-6}				44	5.2	0.26	3.8	0.17	3.00×10^{5}
9-15-70	1.20	0.40	<0.01	0.1	<0.005	<0.002	<0.002		0.008	2.54×10^{-6}				27	2.3	0.13	1.6	0.10	1.80×10^{5}
										Pool Water									
7-14-70	1.00	0.80	<0.01	<1	<0.005		<0.002	<0.002		6.74×10^{-7}									1.54×10^{5}
8-17-70	1.20	0.60	<0.01	<0.14	<0.005	<0.002	<0.002	<0.002		6.58×10^{-7}									1.41×10^{5}
9-15-70	1.16	0.46	<0.01	0.04	<0.005	<0.002	<0.002	<0.002		7.71×10^{-7}									1.80×10^{5}
										Secondary Water									
7-14-70				20							7.0	363	20						
8-17-70				21		0.002					6.8	363	19						
9-15-70				21		0.004					6.2	342	21						

REACTOR DESIGN CHANGES

Mechanical change memoranda, which describe design changes completed this quarter, are tabulated in Table 12.

Table 12. Mechanical Change Memoranda

Memo No.	Subject	General Description
28	Hot-water-injection system	To replace automatic valves rendered useless by erosion and to prevent erosion of the new valves this memorandum authorizes the following changes in the hot-water-injection system: replace all air-operated plug-type valves with air-operated ball valves; add autoclave-type isolation valves in series to expedite replacement in event of failure; operate the hot-water-injection system pressurized during nontesting periods to eliminate the high differential pressure across these valves; and prefabricate the new valve manifold so it can be pressure-tested on the bench to meet code requirements without subjecting the reactor system to test procedures.

Instrumentation change memoranda, which describes work completed this quarter, are tabulated in Table 13.

Table 13. Instrumentation Change Memoranda

Memo No.	Subject	General Description
66	Servo demand oscillation	To investigate the frequency response of the control system, circuit modifications will be made in the channel 2 servo demand to permit switching this demand between 97 and 100 MW by an external oscillator. This memorandum authorizes the necessary circuit modifications and subsequent tests of system frequency response.
67	Range change of flow transmitters	When fuel elements without combs are used, the primary flow rate is >17,000 gpm. To permit use of these elements it is necessary to change the range of the primary flow monitors from 0-17,000 gpm to 0-20,000 gpm.

REVISIONS TO THE HFIR OPERATING MANUAL

The revisions and additions to the HFIR operating manual which have been published this quarter are tabulated in Table 14.

Table 14. HFIR Manual Revisions

Date	Section	Title	General Description
7-20-70	10.3	Acid and caustic	Procedures for handling caustic and acid were revised to reflect improved safety methods which have been developed.
8-24-70	1	Temporary procedure changes	Documentation of the existing procedure for handling special operating instructions was added to the manual.

REACTOR EXPERIMENTS

Experimental Facilities

Usage of the various HFIR experimental facilities is tabulated in Table 15.

Table 15. Experiment Facility Usage

Facility	Description	Division
RB-1	Isotope production	Isotopes
RB-2	Isotope production	Isotopes
RB-3	Isotope production	Isotopes
RB-4	HFIR tensile specimens	Operations
RB-5	HTGR fuel irradiation*	Reactor
RB-6	Isotope production	Isotopes
RB-7	Isotope production	Isotopes
RB-8	Isotope production	Isotopes
CR-3	Thermocouple irradiation	Reactor
CR-5	Startup source	Operations

*Facility assigned but not currently in use.

Table 15. (continued)

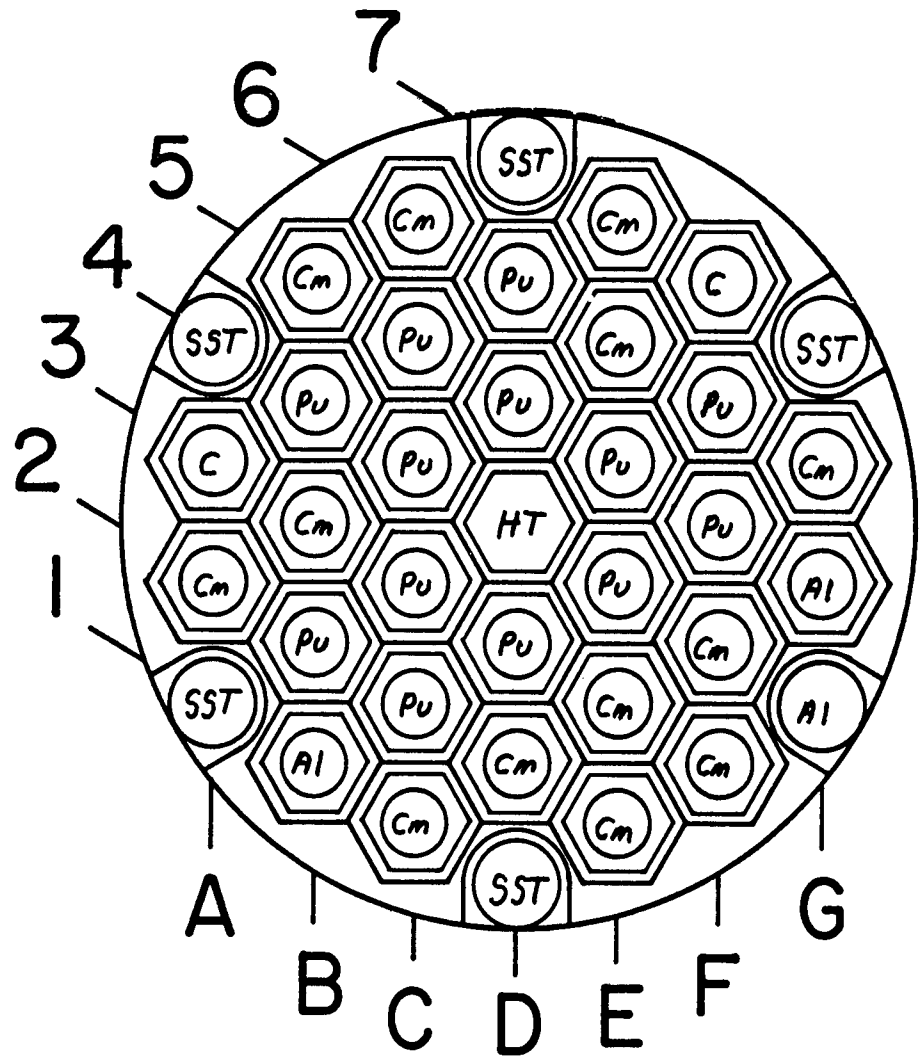
Facility	Description	Division
VXF-1	HFIR corrosion specimen	Operations
VXF-7	Pneumatic tube*	Analytical Chemistry
VXF-17	Fuel tests*	Metals and Ceramics
EF-2	Noise analysis studies	Instrumentation and Controls and Operations
HB-1	Neutron diffractometer	Solid State
HB-2	Neutron diffractometer	Chemistry
HB-3	Neutron diffractometer	Solid State
HB-4	Neutron diffractometer*	Solid State

*Facility assigned but not currently in use.

HFIR Target Loading

A description of the HFIR target loading for each of the operating cycles this quarter is presented in Figures 1, 2, 3, 4, and 5.

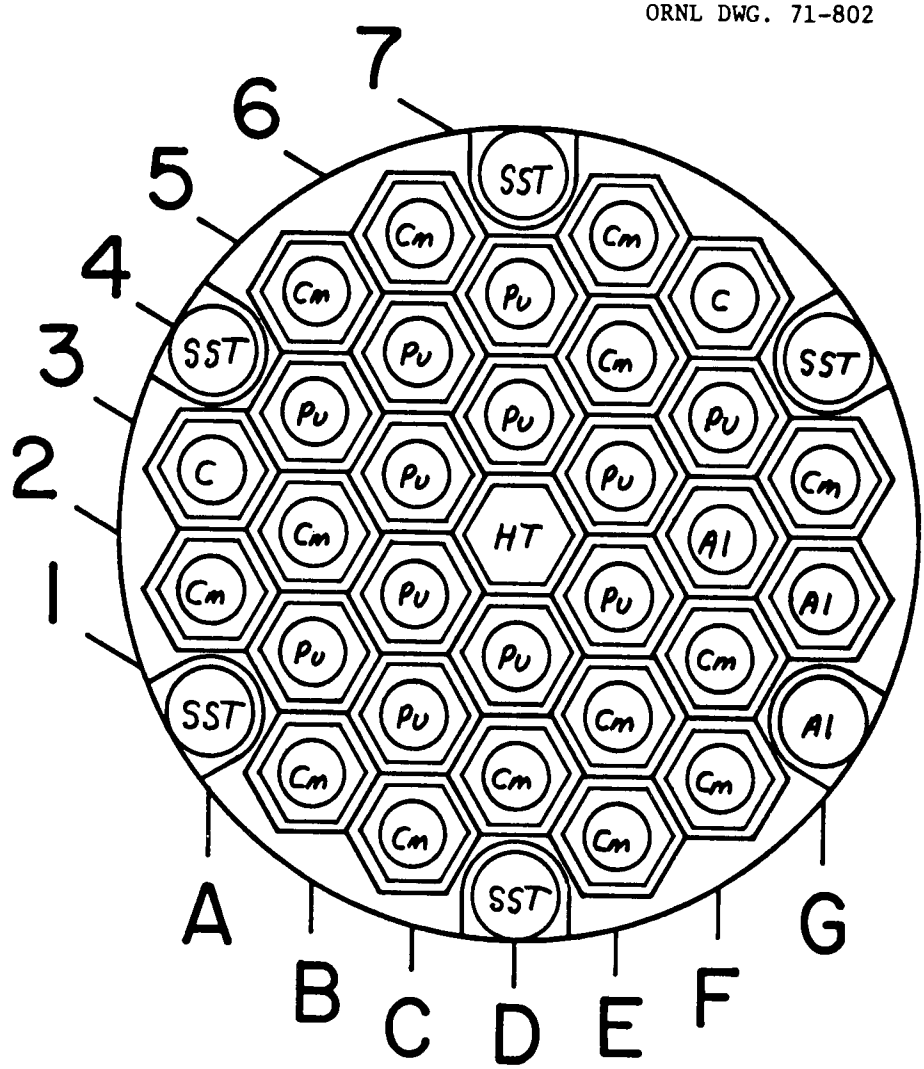
ORNL DWG. 71-801



TARGET TYPE	NUMBER
PLUTONIUM (Pu)	13
CURIUM (Cm)	13
STAINLESS STEEL (SST)	5
GRAPHITE (C)	2
ALUMINUM (Al)	3
HYDRAULIC TUBE (HT)	1

Fig. 1. HFIR Target Loading for Cycle No. 50 - June 15, 1970

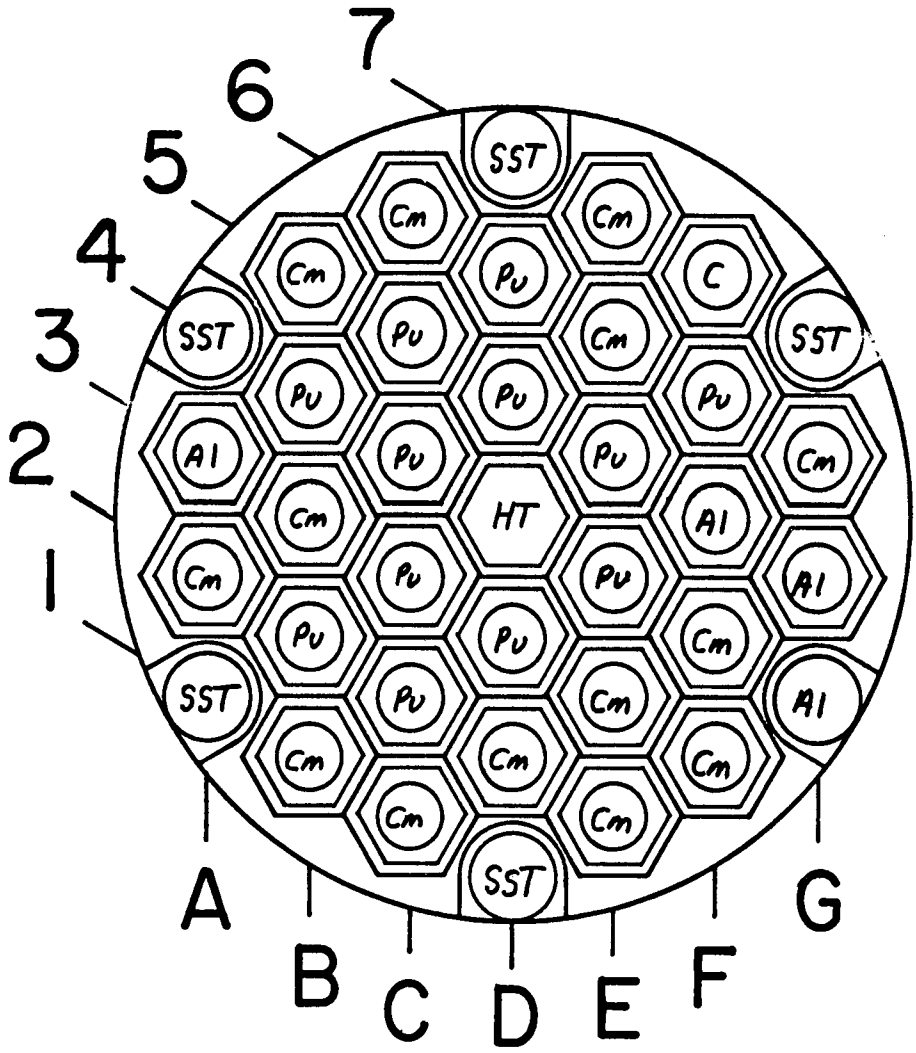
ORNL DWG. 71-802



TARGET TYPE	NUMBER
PLUTONIUM (Pu)	12
CURIUM (Cm)	14
STAINLESS STEEL (SST)	5
GRAPHITE (C)	2
ALUMINUM (Al)	3
HYDRAULIC TUBE (HT)	1

Fig. 2. HFIR Target Loading for Cycle No. 51 - July 9, 1970

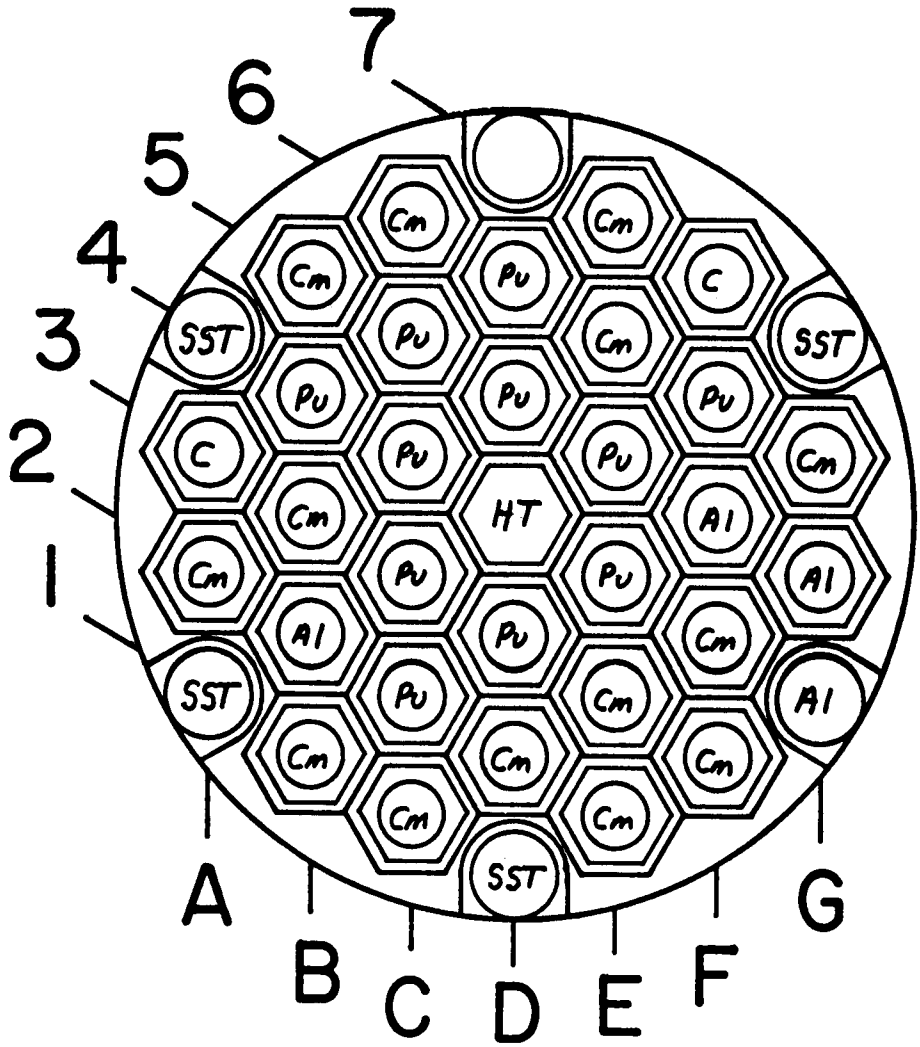
ORNL DWG. 71-803



TARGET TYPE	NUMBER
PLUTONIUM (Pu)	12
CURIUM (Cm)	14
STAINLESS STEEL (SST)	5
GRAPHITE (C)	1
ALUMINUM (Al)	4
HYDRAULIC TUBE (HT)	1

Fig. 3. HFIR Target Loading for Cycle No. 52 - August 2, 1970

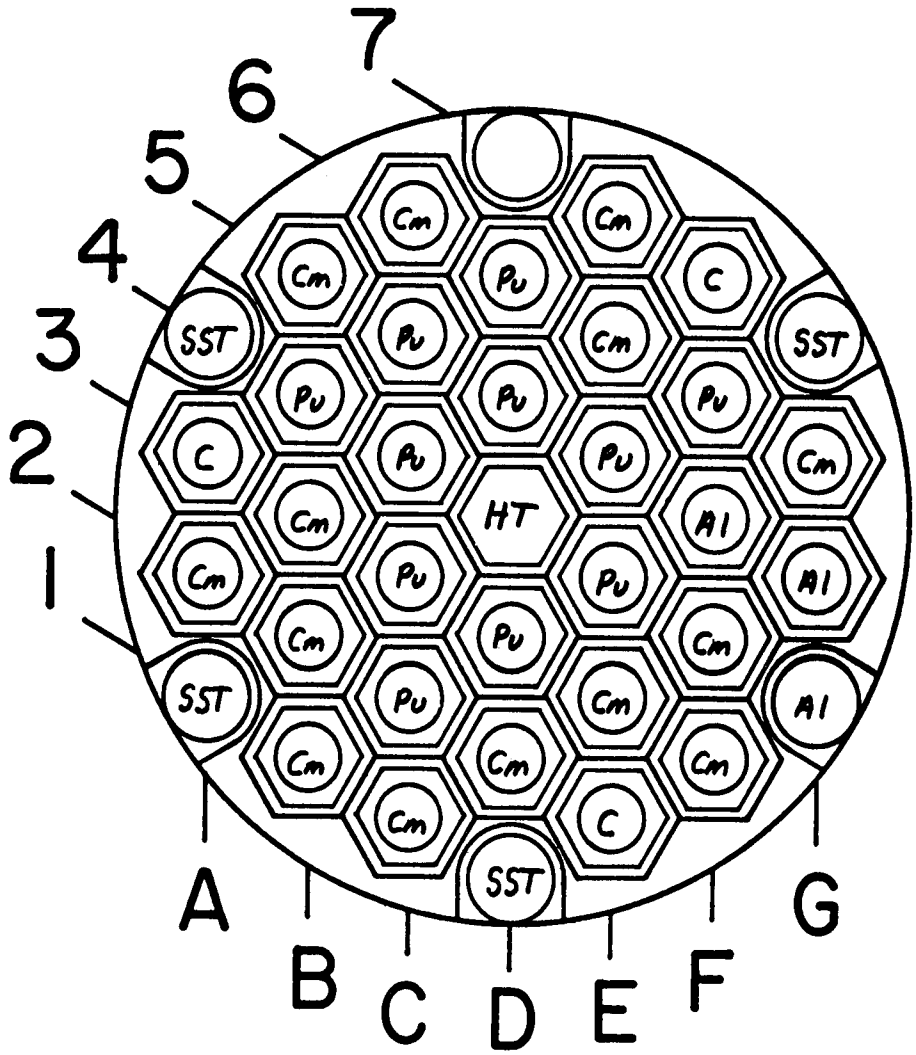
ORNL DWG. 71-804



TARGET TYPE	NUMBER
PLUTONIUM (Pu)	11
CURIUM (Cm)	14
STAINLESS STEEL (SST)	4
GRAPHITE (C)	2
ALUMINUM (Al)	4
HYDRAULIC TUBE (HT)	1

Fig. 4. HFIR Target Loading for Cycle No. 53 - August 29, 1970

ORNL DWG. 71-805



TARGET TYPE	NUMBER
PLUTONIUM (Pu)	11
CURIUM (Cm)	14
STAINLESS STEEL (SST)	4
GRAPHITE (C)	3
ALUMINUM (Al)	3
HYDRAULIC TUBE (HT)	1

Fig. 5. HFIR Target Loading for Cycle No. 54 - September 22, 1970

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