ORNL-2562
Reactors – General
TID-4500 (14th ed.)

OPERATION OF THE ORNL GRAPHITE REACTOR AND OF THE LOW-INTENSITY TEST REACTOR AND PREOPERATIONAL WORK ON THE ORR

ANNUAL REPORT FOR 1957

J. A. Cox
W. R. Casto

OAK RIDGE NATIONAL LABORATORY
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

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OPERATIONS DIVISION

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OAK RIDGE RESEARCH REACTOR (ORR)

Summary

Since the ORR Building and associated facilities were not turned over to the Laboratory until July 15, 1957, the first six months of the year were spent in designing major additions and equipment, in fabricating and procuring equipment, and in preparing for testing and operation. A mockup of the reactor mechanical controls was assembled and then tested under conditions simulating operation conditions as closely as possible. After the ORR was transferred to the Laboratory, further activities included training of personnel, performing hydraulic tests on the reactor, and preparing for the neutron tests.

Proposed Lattice Arrangement

An operating lattice configuration (Fig. 1) has been proposed for the ORR. The arrangement shown provides two rows of beryllium between the beam holes and the fuel in order to reduce the fast flux. Fuel is loaded to the edges of the north, south, and west sides in order to provide high thermal and fast fluxes in these locations. Other advantages of this arrangement include good accessibility to lattice positions through the tank flanges (holes V-1 to V-10) so that the widest possible utilization of the reactor may be made. A rectangular 4 × 7 lattice will also be operated in critical tests to check the validity of calculated flux distributions.

Neutron and hydraulic tests will be performed on three lattices – the 4 × 7 without experiments, the operating lattice as shown in Fig. 1, and the operating lattice without the experiments. The tests will permit an evaluation of the effects of the experiments on water flow, neutron distribution, and reactivity.

Test Stand Mockup of ORR Mechanical Controls

The ORR mechanical controls were assembled in Building 3001 for the purpose of testing them under simulated operating conditions. The testing proved helpful in revealing abnormalities and malfunctions in the new bottom-drive system for shim rods.

The assembly included the complete installation of four shim rod drive assemblies and one fission chamber drive unit. One shim rod which could be shifted to any desired drive unit was available. The core was completely loaded with dummy fuel and reflector pieces.

The various tests which were conducted are listed below:

1. observance of normal drive tube movement,
2. observance of shim rod movement through the upper and lower bearings,
3. determination of the release spring constant,
4. determination of the magnet current vs load relationship,
5. determination of the friction factor of the release mechanism,
6. determination of operating characteristics of the magnets.

During these tests, which were carried out during the period 1-15-57 to 7-15-57, and immediately thereafter, the following changes and modifications were made in order to improve magnet workability and reliability:

1. The tolerances in the drive tube bearings were increased.

2. The shock absorbers were modified to include spiral grooves for automatic cleaning.

3. The clutch switch actuator was redesigned.

4. The magnets were redesigned to increase holding power.

5. The fission chamber takeup reel was redesigned.

6. A stainless steel wiper assembly was added, and an O-ring seal in the lower bearing of the drive unit was repositioned.

Following the completion of modifications, a shim rod was cycled 1000 times. Inspection indicated all parts to be in good working order and no excessive wear.

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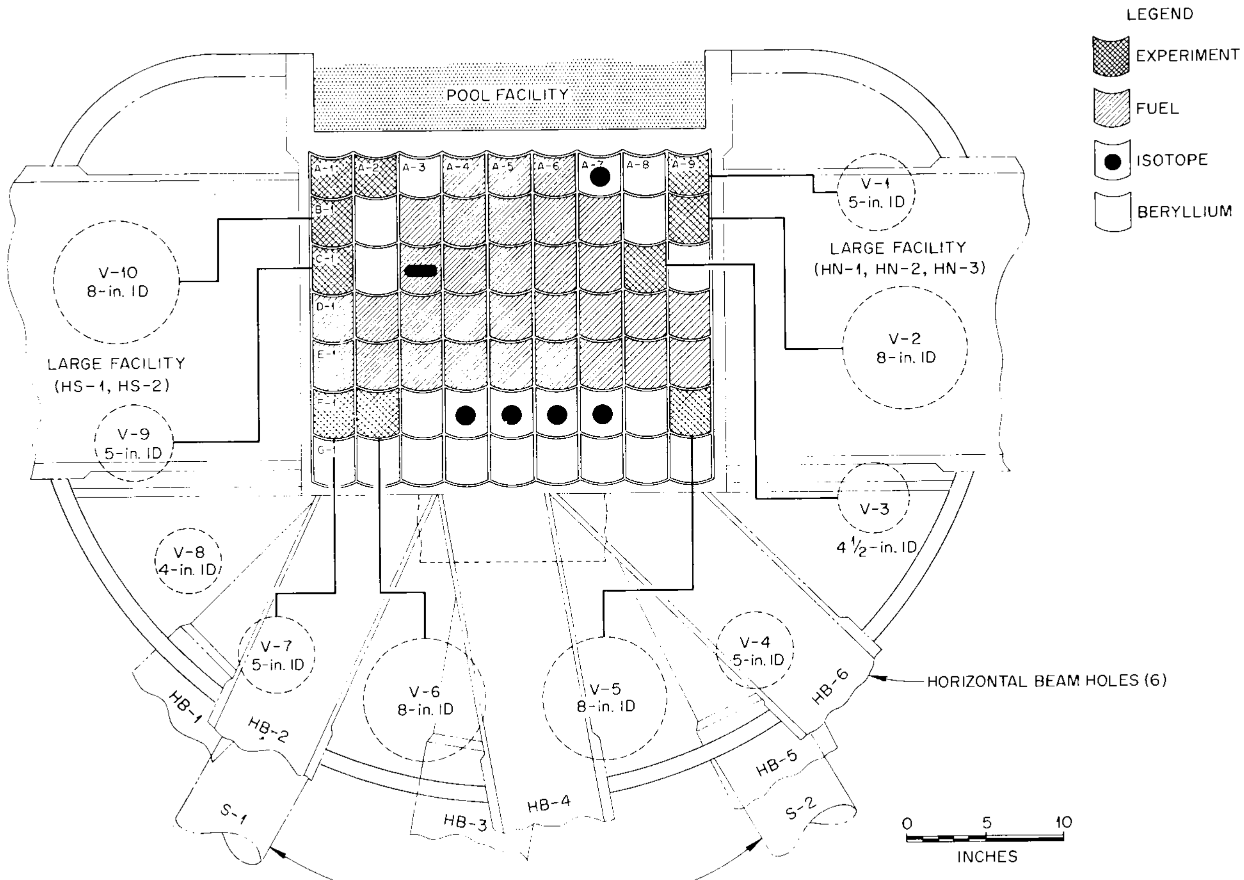

NOTE:
V-1 THRU V-10 ARE ACCESS HOLES IN TOP COVER OF REACTOR VESSEL.

Fig. 1. ORR Proposed Operating Lattice Configuration.

Training of Personnel

Operations personnel, under the direction of the ORR Project Group, performed flushing and cleaning operations on the reactor cooling system, the pool system, and the various bypass circuits of each main system. This enabled them to become familiar with the water systems. It became evident during these initial operations that several changes should be made in order to permit the fully remote operation of the reactor demineralizers and in order to utilize more efficiently the pool demineralizer. The revisions are being effected as listed below:

1. moving pressure gages to outside of cell,
2. moving sampling lines to outside of cell,
3. installing sight glass on the vent line outside the cell,
4. installing ball-float valve on off-gas line,
5. installing a "three-way valve" on regeneration solution line,
6. installing additional sampling lines between units,
7. relocating integrators,
8. relocating flow meters.

Hydraulic Test

The hydraulic testing of the ORR core was conducted by the Operations Division. A method of determining flow by injection of a potassium nitrate solution was developed, and its accuracy was proved in an out-of-reactor test stand. The installation of the hydraulic testing equipment inside the reactor vessel began on October 25, 1957. Testing began on November 24, 1957, and continued for approximately three weeks, on a 24-hr shift basis. When no tests were under way, reactor installation work was resumed. On December 11, 1957, the hydraulic testing was terminated in order to permit final installation work in the reactor vessel and related equipment. Following this work, a final test will be conducted, completing the hydraulic testing. This final test should require only a few days. A preliminary report is being prepared.[1]

Facility Assignments

Table 1 shows the presently proposed assignment of ORR research facilities. Most of the experimental work will begin within the next year.

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[1]F. T. Binford, *A Preliminary Report on the Results of the ORR Hydraulic Tests*, ORNL CF-58-2-11.

Table 1. Proposed Assignment of ORR Research Facilities

Facility	Access Flange	Nature of Experiment	Division	Requester
A-9	V-1	Thorium oxide slurry studies	Chemical Technology	J. P. McBride
B-9	V-2	Gas-cooled loop	Solid State	J. G. Morgan
C-8	V-3	HRP irradiation metallurgy	Solid State	R. G. Berggren
F-2	V-6	Hydraulic rabbit	Isotopes and Solid State	E. E. Beauchamp and C. M. Nelson
F-9	V-5	Vertical fused-salt loop	Solid State	W. E. Browning
F-1	V-7	Creep and stress corrosion	Solid State	J. C. Zukas
C-1	V-9	Fuel tests	Solid State	J. G. Morgan
B-1	V-10	Air-cooled loop	Solid State–GE	E. S. Collins
A-1, A-2	Special	Gas-cooled loop	APPR	H. C. McCurdy
Unassigned	V-4			
C-3		Fast-neutron facility	Solid State	M. C. Wittels
F-7		Isotope production	Isotopes	E. E. Beauchamp
A-7		Isotope production	Isotopes	E. E. Beauchamp
F-4		Isotope production	Isotopes	E. E. Beauchamp
F-5		Isotope production	Isotopes	E. E. Beauchamp
F-6		Isotope production	Isotopes	E. E. Beauchamp
Pool		Cryostat experiment	Solid State	T. H. Blewitt
Pool		ANP and HRP irradiation metallurgy	Solid State	R. G. Berggren
HN-1		HRP solution corrosion loop	REED	J. R. McWherter
HN-2		HRP autoclave irradiation studies	REED	R. A. Lorenz
HN-3		Pneumatic rabbit Activation analysis	Chemistry Analytical Chemistry	A. R. Brosi G. W. Leddicotte
HN-4		HRP slurry corrosion toroid	REED	D. T. Jones
HS-1, HS-2		PAR slurry loop program	Chemical Technology	T. A. Arehart
HB-1		Magnetic analysis of fission fragments with time-of-flight	Physics	H. W. Schmitt
HB-2		Neutron spectrometer	Physics	E. O. Wollan
HB-3		Neutron spectrometer	Physics	E. O. Wollan
HB-4		Neutron spectrometer	Chemistry	H. A. Levy
HB-5		Neutron spectrometer Neutron spectrometer	Physics Health Physics	L. D. Roberts H. P. Yockey
HB-6		Time-of-flight neutron spectrometer	Physics	J. A. Harvey

ORNL GRAPHITE REACTOR

Summary

The ORNL Graphite Reactor operated normally, with a downtime of 9.7%.

The fuel ruptured at the same high rate as last year. Approximately a year's supply of natural uranium slugs remains on hand. A preliminary safeguard report has been written for reloading the reactor with enriched fuel.

Rebuilding of the control system to incorporate modern control concepts has been partially completed. Fission and log *N* startup channels were installed.

Facility usage continued to be high. Graphite Reactor space was still in great demand.

New Fuel Loading

Calculations were completed for a cylindrical core, and a first draft of a report to the Advisory Committee on Reactor Safeguards has been prepared. A list of the characteristics of the proposed reactor compared with those of the present reactor is shown in Table 2. (A two-group, two-region claculation was made in order to provide estimates of the thermal and the fast neutron flux distributions in the new reactor.) The results are shown in Figs. 2 and 3. The fast and the slow fluxes in the present reactor have essentially the same spatial distribution in the core and are of the same magnitude. The higher fast flux in the new reactor is due both to the lower resonance absorption and to the increased power density caused by the smaller core. The fast flux plotted for the new reactor is the group I flux from the two-group calculation.

It is proposed to use simple, smooth-sided, hollow cylindrical fuel elements for the first charging. Changes may be made later in order to promote air turbulence, if necessary. In some work done on turbulators by the MIT Practice School, under the direction of the Operations Division, it was found that the gains were somewhat offset by the increased pressure drop for the models studied. The elements will contain 4 to 5 g of fuel per linear foot.

A study by the Reactor Controls Department has been started on design revisions to the present control system in order to allow operation with the new core at 4 Mw and to eventually completely redesign the control system for operation at higher power levels. Revisions of the present control system will be directed primarily to decreasing the shutdown lag time.

Downtime Analysis

An analysis of the downtime for the ORNL Graphite Reactor is presented in Table 3.

Performance of Reactor Fuel

During CY 1957 natural uranium slugs in the Graphite Reactor continued to rupture at a record rate. There were 41 ruptures in CY 1957, exactly the same number as in CY 1956. The number and type of slugs that have ruptured since 1944 are given in Table 4. Data for each rupture in CY 1957 are shown in Table 5, and a summary of slug ruptures, of nontransformed, partially transformed, and beta-transformed slugs is given in Table 6.

If the high slug-rupture rate of the last two years continues, the supply will be exhausted in about a year. At the end of CY 1957, 2431 fuel elements were on hand.

In order to conserve the limited supply of fuel, a shipment of 8-in. natural uranium slugs was obtained. The slugs were used for I^{131} production in the Graphite Reactor but are not suitable for general use because they are approximately 0.1 in. smaller in diameter than regular slugs. If loaded in large quantities, they would not provide sufficient uranium to operate the reactor.

The diameter of a normal slug is $1\frac{3}{16}$ in. Measurement of slug growth indicated that there were elongations up to 1.7 in., as shown in Table 5. The diameters of four slugs whose growth was

Table 2. Comparative Reactor Characteristics

Characteristics	Present Reactor	Proposed Reactor
Moderator	Graphite	Graphite
Reflector	Graphite	Graphite
Fuel	Natural uranium	Enriched uranium
Loading zone	Slab; $18 \times 18 \times 18\frac{2}{3}$ ft	Cylinder; h, 16 ft; R, 8.5 ft
Fuel channels in core	830	570
Critical loading (kg)		
U^{235}	193	$\sim$29.5
U^{238}	27,216	$\sim$3.0
Al	700	$\sim$634
Operating loading (kg)		
U^{235}	343	$\sim$32.8 (4 Mw loading)
U^{238}	47,630	$\sim$3.3 (4 Mw loading)
Al	1,240	$\sim$705 (4 Mw loading)
B^2 (cm^{-2})	92×10^{-6}	88.7×10^{-6}
f	0.890	0.563
p_{th}	0.886	0.999
k_∞	1.067	1.194
L^2_{core} (cm^2)	297	1101
$L^2_{reflector}$ (cm^2)	2400	2400
Prompt-neutron lifetime (sec)	0.001	0.0038
k_{eff} (typical, cold)	1.021	1.039 (4 Mw loading) 1.05 (7 Mw loading)
$\left(\frac{\Delta k/k}{\Delta T^\circ C}\right)_{total}$	-2.86×10^{-5}	-12.77×10^{-5}
$\left(\frac{\Delta k/k}{\Delta T^\circ C}\right)_{graphite}$	-2.08×10^{-5}	-12.60×10^{-5}
$\left(\frac{\Delta k/k}{\Delta T^\circ C}\right)_{fuel}$	-0.78×10^{-5}	-1.35×10^{-5}
$\left(\frac{\Delta k/k}{\Delta T^\circ C}\right)_{N_2}$	(Included in graphite)	$+1.18 \times 10^{-5}$
$\left(\frac{\Delta k/k}{\Delta M/M}\right)_{homogeneous}$		0.48
$\left(\frac{\Delta k/k}{\Delta M/M}\right)_{control}$		1.33

Table 2 (continued)

Characteristics	Present Reactor	Proposed Reactor
Operating reactivity requirements ($\Delta k/k$)		
Temperature and spare for control	0.004	$\sim$0.026
Xenon	0.002	0.008 (4 Mw loading) 0.0167 (7 Mw loading)
Experiments (nonpermanent)	$\sim$0.001	0.003
Burnup (four weeks)		0.002
Total	0.007	0.039
Reactivity in permanent experiments ($\Delta k/k$)	0.005	0.015
Reactivity used by rods (cold, critical reactor) ($\Delta k/k$)	0.007	0.039 (4 Mw loading)
Total excess reactivity (clean, cold reactor) ($\Delta k/k$)	0.01	0.054 (4 Mw loading)
Reactivity worth of shutdown rods ($\Delta k/k$)	0.027	0.077 (4 Mw loading) 0.10 (7 Mw loading)
Reactivity worth of regulating rods ($\Delta k/k$)	0.0107	0.03
Maximum allowable excess reactivity with present shutdown rods ($\Delta k/k$)	0.019	0.039
Number of average fuel channels to be left empty initially and loaded subsequently to make up for burnup		160
Number of channels to be fueled initially (before appreciable burnup)		410
Reactor power level (Mw)	3.5	4.0 7.0
Average thermal-neutron flux (n/cm^2/sec)	4.5×10^{11}	2.6×10^{12} (4 Mw loading)
Ratio of maximum neutron flux to average	2.24	2.28
Maximum fuel temperature (°C)	<280	<350
Typical cooling air flow per loaded fuel channel (lb/min)	6.5	8.6

about 1 in. or greater were measured, as shown below:

Slug	Longitudinal Growth (in.)	Transverse Growth (in.)
1	0.990	$1\frac{3}{32}$
2	1.014	$1\frac{1}{16}$
3	1.162	$1\frac{1}{16}-1\frac{3}{32}$
4	1.173	$1\frac{1}{16}-1\frac{3}{32}$

All these slugs were from channel 1972 and had been in the reactor for 1735 days. They were from lot 109.

Control System

The control system for the Graphite Reactor was modernized during CY 1957. Fission chamber and ion chamber channels, both with period and log indication, were installed. In order to make room for these new instruments on the main instrument panel, the inlet and outlet temperature recorders were moved. At this time, part of the

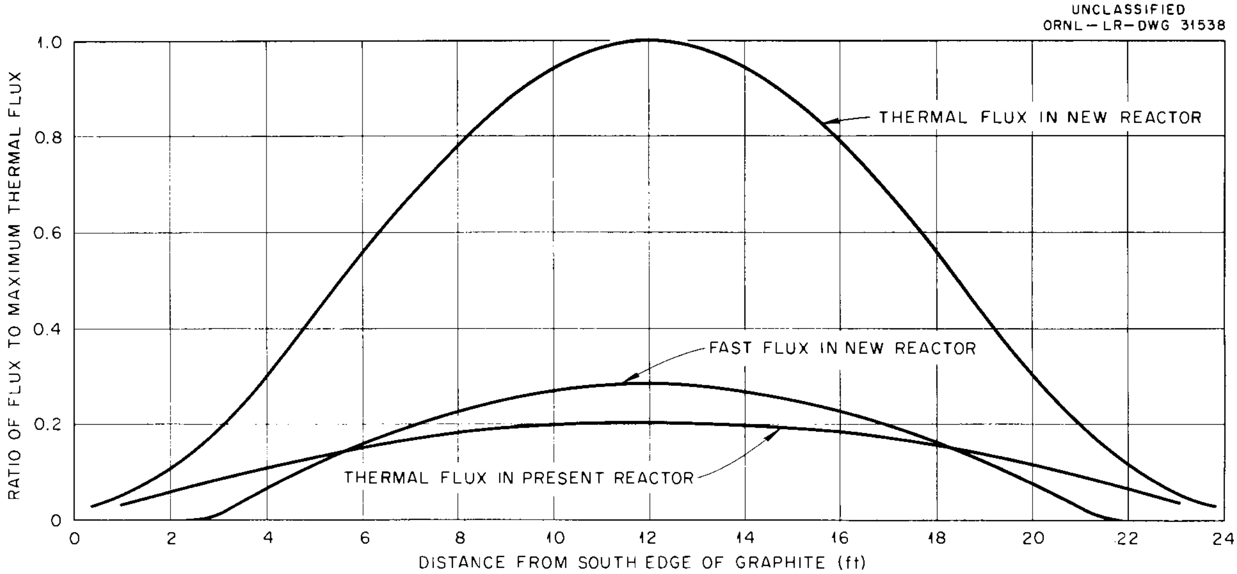

Fig. 2. Neutron Flux Distribution in Present and New Reactor for the Same Power Level – Starting at South Edge of Graphite.

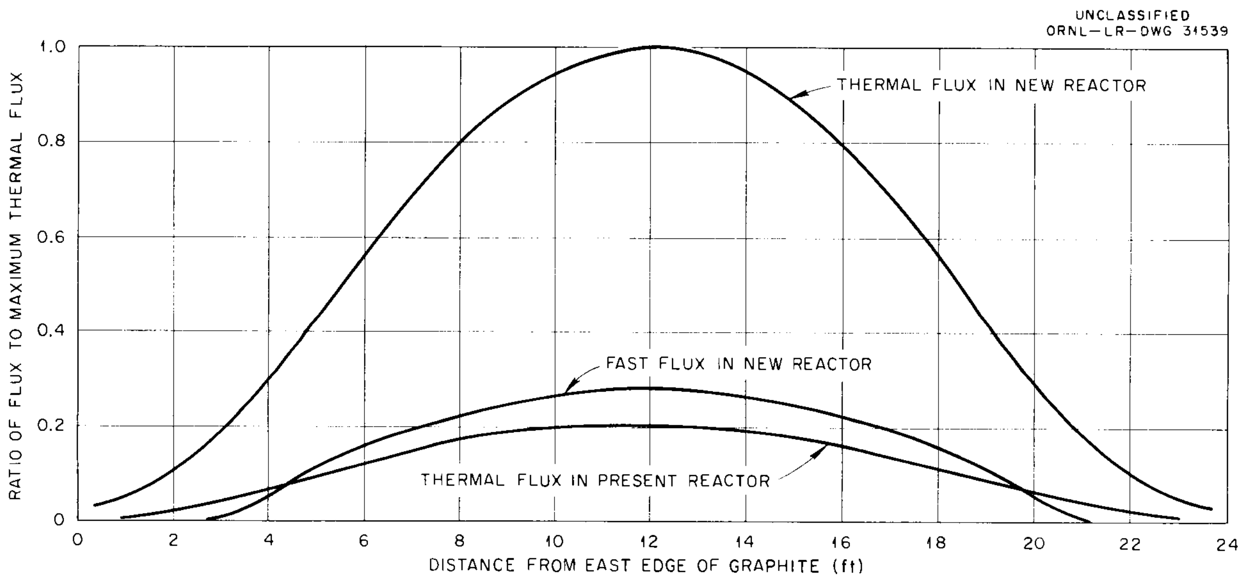

Fig. 3. Neutron Flux Distribution in Present and New Reactor for the Same Power Level – Starting at East Edge of Graphite.

old recorders installed in 1943 were replaced with modern instruments. It was necessary to use the reactor instrument hole formerly occupied by the No. 1 galvanometer chamber for the ion chamber. For this reason, only the No. 2 galvanometer is now in service. Scanner hole No. 5 was used for the fission chamber.

Standard annunciator units of the plug-in type have been installed to replace the original annunciation equipment. While this work was in progress, it became evident that the original 24-v safety circuits contained relays that were in need of replacement. To complete the standardization of the reactor controls, it was decided

Table 3. Downtime Analyses for the ORNL Graphite Reactor

	Number	Duration (hr)
Scheduled Shutdowns		
Regular	52	696.010
Special for Operations	3	14.616
Special for Isotopes Division	25	31.901
Special for Research	14	26.936
Subtotal		769.463
Unscheduled Shutdowns		
Equipment failure		
Operations	35	71.416
Research	3	2.750
Others	4	3.117
Human errors		
Operations	0	0
Research	0	0
Instrument Department	3	1.202
Maintenance	3	1.334
Subtotal		79.819
Total		849.282

Table 4. Slug Ruptures Since 1944

Calendar Year	Number of Ruptured Slugs
Bonded	
1957	41
1956	41
1955	19
1954	4
1953*	14
1952*	5
Unbonded	
1953*	4
1952*	8
1951	15
1950	13
1949	14
1948	14
1947	13
1946	6
1945	14
1944	4

*Most of the reactor was loaded with bonded slugs in 1952.

to replace the old system with 110-v equipment. By the end of the year this was practically complete.

All the chamber power supplies have been placed in suitable racks in the control room.

At the end of the year the Reactor Controls Department was revamping the wiring and developing the information necessary for a new and authentic wiring diagram for the Graphite Reactor.

Cooling System

The two 990-hp motors and fans operated well during the year, with only normal inspection and maintenance being necessary. Figure 4 shows the cooling air flow through the Graphite Reactor, the filter house, the fan house, and the stack. Pertinent operating data are shown at the appropriate places on the diagram.

Filters

In April the glass wool filters in cell 2 were changed. Although the pressure-drop measurements across the paper filters in cells 1 and 2 did not indicate that they were dirty, these filters were also changed because they had been in service for six years. During replacement it became evident that the wood frames had deteriorated in the hot, dry atmosphere of the filter house. The last filter changes occurred as follows:

Cell	Date Changed	
	Glass Wool Filter	Paper Filter
1	4-15-57	7-22-57
2	4-9-53	7-29-57
3	5-14-56	5-10-54
4	8-16-54	7-6-54

A comparison of the filter house pressure drops with those of a year ago is given in Table 7. Filter house pressure drops for CY 1957 are plotted in Fig. 5.

In October a decrease in the pressure drop across the paper filter in cell 4 occurred. An inspection on October 28 showed that one of the frames had been blown completely out of place. The filter was put back in place on that date. On this same day, the Hot Pilot Plant tied a 10-in. stainless steel off-gas line into

Table 5. Ruptured Slug Data for CY 1957

Lot No.	Rupture No.	Row No.	Number from West End of Row	Date	Days in Reactor	Temperature (°C)	Beta Transformed (%)	Growth of Slugs Measured (in.)	No. of Slugs Measured	Remarks
154	190	1762	Unknown	1-7-57	1701	210	75.0	0.010–0.482		
110	191	1470	15	1-14-57	1749	160	0.0	0.063–0.575	16	Located by visual inspection
113	192	2066	12	1-18-57	1753	195	0.0	0.010–0.825		Located by visual inspection
109	193	2270	12	2-3-57	1728	224	Unknown	0.090–0.637	12	Indicated by probe
114	194	2073	20	3-12-57	1800	195	25.0	0.135–0.840	20	
116	195	1367	13	3-18-57	1806	197	57.1	0.136–0.270	12	
113	196	2068	23	3-20-57	1815	135	0.0	0.125–1.101	24	
119	197	1861	10	3-25-57	1232	195	77.8	0.003–0.195	9	
113	198	1772	2	4-8-57	1833	193	0.0	0.004–0.590	39	
115	199	1973	Unknown	4-8-57	1827	200	27.3	0.066–0.413	41	
113	200	2166	24	4-15-57	1840	208	0.0	0.100–0.832	40	
114	201	1673	13	4-18-57	1837	201	25.0	0.028–0.791	43	
110	202	2070	12	4-20-57	1845	207	0.0	0.008–1.750	40	
111	203	1572	14	4-22-57	1847	188	0.0	0.002–0.355	44	Located by visual inspection
168	204	1062	13	5-13-57	1806	190	Unknown	0.000–0.113	53	Located by visual inspection
120	205	1374	12	5-20-57	1862	223	75.0	0.009–0.114	51	Located by visual inspection
154	206	2373	12	5-22-57	1836	247	75.0	0.008–0.413	51	Indicated by probe
116	207	1465	14	5-22-57	1871	195	57.1	0.003–0.293	48	Indicated by probe
215	208	1872	3	5-23-57	31	160	Unknown	0.000–0.760	40	Indicated by probe
154	209	2060	21	5-29-57	1843	210	75.0	0.034–0.465	54	Indicated by probe
116	210	1874	11	5-31-57	1880	175	57.1	0.012–0.289	49	Indicated by probe
114	211	1874	Unknown	5-31-57	683	175	25.0	0.012–0.289	49	Indicated by probe
120	212	1363	Unknown	6-10-57	1883	197	75.0	0.006–0.098	34	Located by visual inspection
186	213	1158	10	6-10-57	1771	197	82.4	0.004–0.030	53	Located by visual inspection
210	214	2378	9	6-10-57	1742	205	Unknown	0.004–0.036	53	Located by visual inspection
Unknown	215	1570	10	6-10-57	42	208	Iodine row			Located by visual inspection
154	216	1678	19	6-19-57	1864	215	75.0	0.002–0.428	51	Indicated by probe
155	217	1875	18	6-26-57	1871	220	66.7	0.002–0.060	50	Indicated by probe
115	218	1062	12	6-29-57	47	193	27.3	0.002–0.573	53	Indicated by probe
110	219	1670	1	7-1-57	1917	196	0.0			
170	220	1278	15	8-12-57	1890	205	100.0	0.010–0.578		
113	221	1567	16	9-11-57	1989	180	0.0	0.025–0.495	40	Located by visual inspection
118	222	1368	10	9-23-57	1995	212	87.8	0.017–0.319	43	Located by temperature of thermocouple slug
182	223	0862	16	10-21-57	1953	146	80.0	0.007–0.309	43	Located by visual inspection
178	224	1674	21	10-21-57	917	182	100.0			Located by visual inspection
215	225	1973	14	10-21-57	196	190	Unknown			Located by visual inspection
118	226	1573	25	11-[illegible]-57	2042	160	87.8			Indicated by probe
155	227	1578	16	11-16-57	2014	188	67.7			Indicated by probe
138	228	1473	14	12-2-57	2044	200	100.0			Located by visual inspection
117	229	1774	20	12-8-57	2071	138	27.3			Indicated by probe
154	230	1576	Unknown	12-20-57	2048	201	75.0			Indicated by probe
154	231	1576	24	12-20-57	2048	201	75.0			Indicated by probe

Table 6. Summary of Ruptures of Beta-, Partially-, and Nontransformed Slugs

Lot No.	Partially- and Nontransformed Slugs	Lot No.	Beta Transformed Slugs
109	1	138	1
110	3	168	1
111	1	170	1
113	5	178	1
114	3	210	1
115	2	215	3
116	2		8
117	1		
118	2		
119	1		
120	2		
154	6		
155	2		
182	1		
186	1		
	33		

the air duct between the reactor and the filter house. The following week the paper filter in cell 4 was replaced. A fraction of the Pa^{233} in the off-gas from the Hot Pilot Plant passed through both the glass wool and the paper filters.

Tables 8, 9, and 10 show that after the Hot Pilot Plant shut down the radioactivity decayed in a normal fashion. Also it was evident that the filter house could not retain all the Pa^{233}. Since the paper filters are rated at 99.5% removal of 0.3-μ particles, a portion of the Pa^{233} particles evolved from the chemical process apparently are smaller and are not removed.

Canal

The canal has been used at full capacity during CY 1957. Table 11 shows the canal inventory at the end of the year.

Comparative radiation levels are as follows:

	Activity (mr/hr)	
	December 1956	December 1957
Average in walkway	20	27
Over water at walls	85	77

Table 12 shows the major radioactive constituents of the canal water at the beginning and at the end of the year.

The radiation over the water and at the walls comes largely from radioactive materials that have penetrated the bare concrete as deeply as ¼ in. In order to lower the radiation from this source, it is planned to raise the walls of the canal 18 in. with concrete blocks clad with stainless steel on the water side. This will allow the water level to be raised to the new level and will prevent radioactive particles from adhering to the walls near the surface of the water. The extra depth of the canal will permit longer pieces of radioactive equipment to be handled.

Another addition being planned is a canal demineralizer. This will reduce the amount of dissolved radioactive materials in the water which will slowly leach radioactive materials from the bare concrete.

Facility Usage

Holes 3, 16, and 21 were used for the production of P^{32} from sulfur and were occupied 100% of the time.

Holes 4, 18, and 61 were used to irradiate various items such as automobile piston rings and Sb-Be sources. Holes 4 and 18 were in use 100% of the time. Hole 61 was used by the Isotopes Division 40% of the time, and the remaining 60% was assigned to Solid State Division–GE for electronic component testing.

Hole 10 was used for short-term exposures of miscellaneous materials for research and for radioisotope production, at a controlled temperature of 50°C, in use 100% of the time.

Hole 11 was used 85% of the time by the Chemical Technology Division for thorium slurry studies.

Hole 12 was used by the Solid State Division as a cryostat for studies of radiation damage at extremely low temperatures and was occupied 100% of the time.

Holes 13 and 14 were used by the Isotopes Division for making "unit and service irradiations" for the radioisotope program and were in use 100% of the time.

Hole 15S was used by Solid State Division–GE 96% of the time for component testing; the north section, 15N, was unassigned.

Hole 17N was used by the Physics Division during the first third of the year for study of fission-fragment energies by magnetic analysis;

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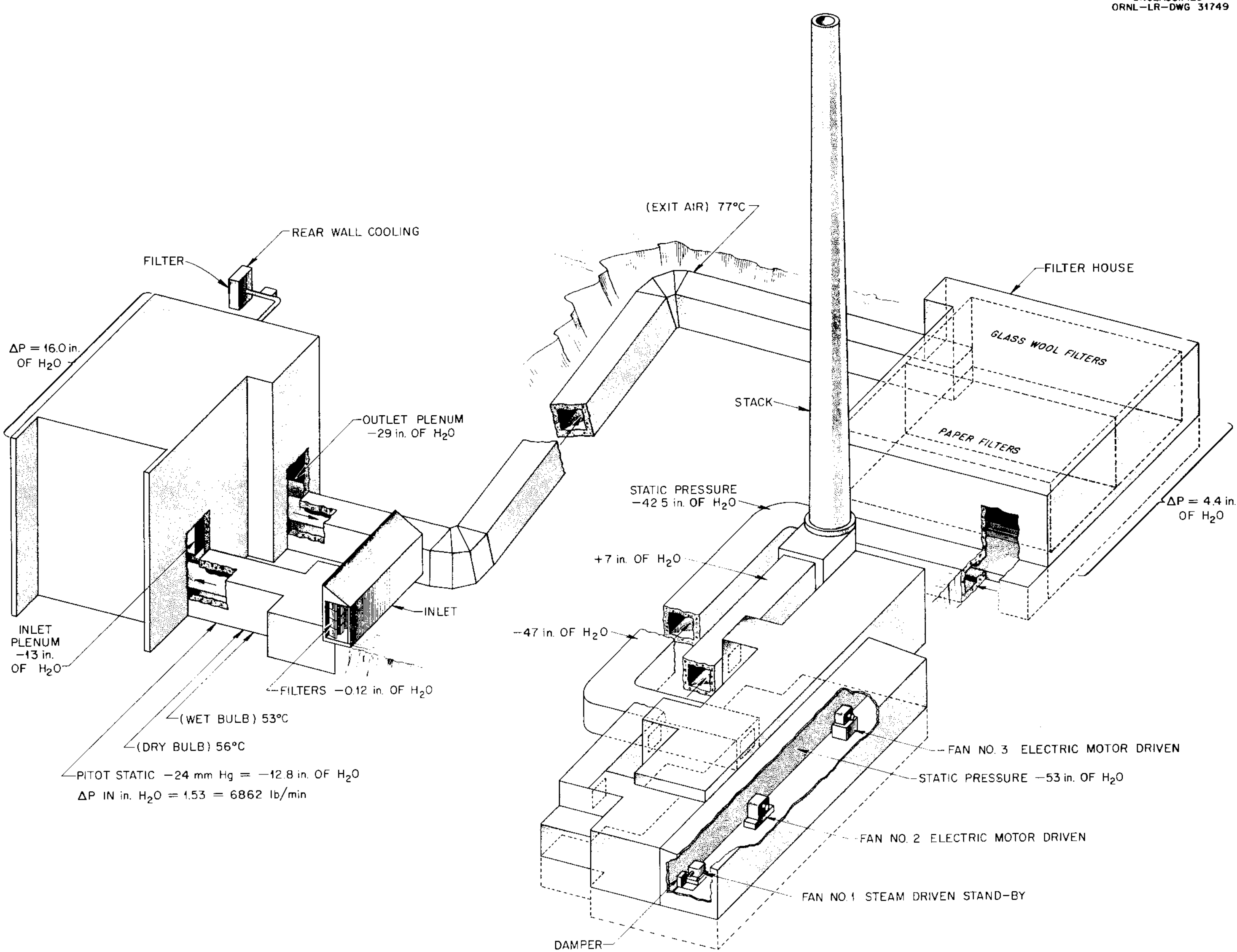

Fig. 4. Graphite Reactor Cooling System Air Flow.

on May 16 this facility was assigned to the Solid State Division for copper-crystal experiments.

Holes 18N, 54N, and 55N were used 25% of the time by the General Electric Company, working under an AEC contract to test proportional counters and ion chambers.

Hole 19, a water-cooled tube, was used 100% of the time by the Solid State Division to study radiation effects on plastic.

Hole 20N, which contains a stringer of solid graphite equipped with thermocouples, was used by the Reactor Operations Department to measure the temperature of the reactor graphite. Hole 20S was used by the Solid State Division–GE 86% of the time for component testing.

Hole 22, containing two pneumatic tubes, was used by the Reactor Operations Department 100% of the time.

Table 7. Comparative Pressure-Drop Data for Graphite Reactor Filter House

	Pressure Drop (in. H_2O)		
	Glass Wool	Paper	Total Across Filter House
12-31-57	1.8	1.0	3.3
12-31-56	2.3	2.1	5.6

Table 8. Decline in Radiation Readings for Cell 2 (Paper Filter) After Hot Pilot Plant Shutdown

Date	Radiation Reading (mr/hr)*
11-18-57	240
11-25-57	170
12-2-57	150
12-9-57	140
12-16-57	120
12-23-57	85

*Radiation readings were made with a portable ion chamber at 3 ft.

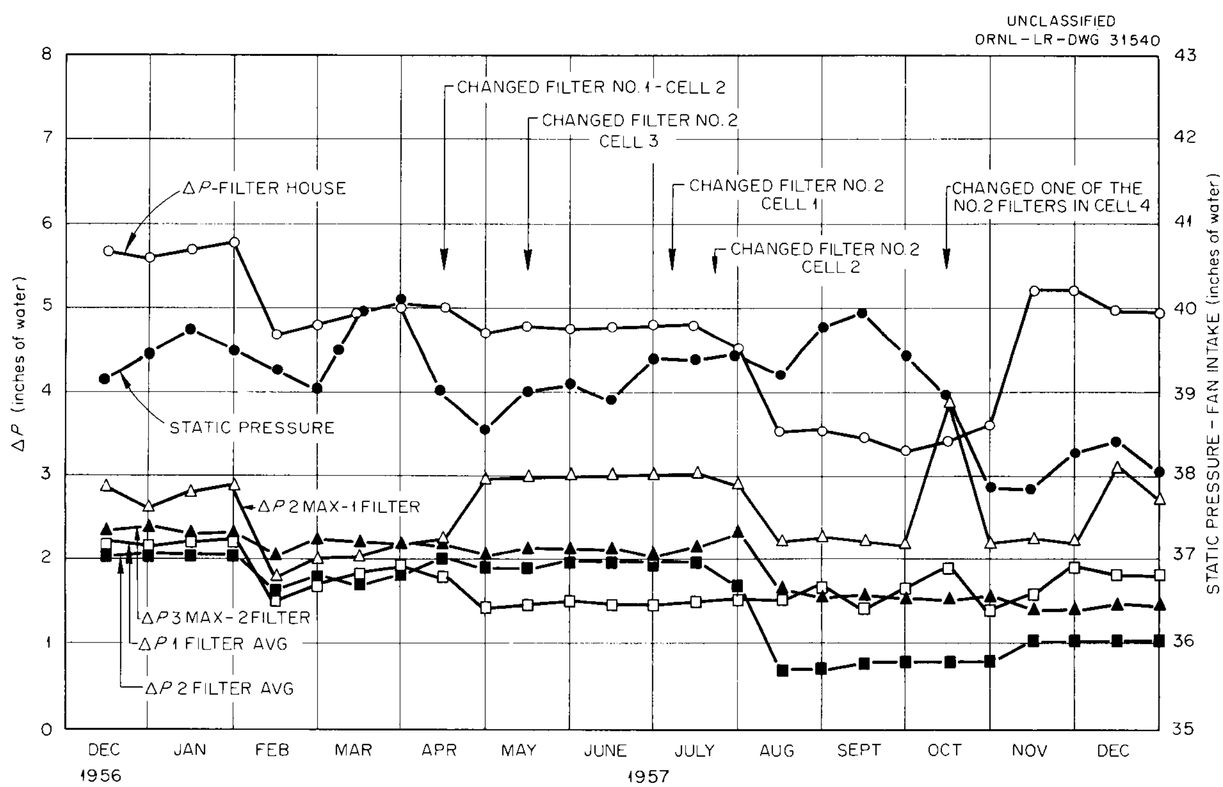

Fig. 5. Filter House Pressure Drops.

Hole 50N was used 50% of the time by the Solid State Division to study radiation effects on electrical insulating materials. Hole 50S was occupied 100% of the time by a neutron collimator for neutron diffraction studies.

Hole 51N, containing a water-cooled enriched uranium converter, was used 100% of the time by the Solid State Division to study the effects of fast neutrons upon materials. Hole 51S was used 100% of the time by a collimator for neutron diffraction work under the Physics Division.

Hole 52N was used 100% of the time by the Solid State Division for low-temperature studies of semiconductors and metals. In Hole 52S, the Physics Division conducted experiments to determine the effects of extremely low temperature upon the angular distributions of fission products emitted from thin layers of fissionable material. The experiment occupied the hole 100% of the time.

Hole 57N was occupied 100% of the time by a collimator used by ORSORT for training students. Hole 57S, reserved by the Solid State Division, was released to Applied Nuclear Physics for a collimator experiment.

Table 9. Decline in Radiation Readings for Fan Housing 2 After Hot Pilot Plant Shutdown

Date	Radiation Reading (mr/hr)*
10-27-57	0.7**
11-4-57	7.0
11-11-57	6.0
11-18-57	3.5
11-25-57	3.2
12-2-57	1.5
12-9-57	1.3
12-16-57	1.1
12-23-57	1.0
12-30-57	0.8

*Radiation readings were made with a G-M survey meter through the walls of the housing.

**Hot Pilot Plant connected to Graphite Reactor exhaust system on 10-28-58.

Table 10. Decline of Pa^{233} in Filter House Exhaust After Hot Pilot Plant Shutdown

Date	Sample Volume (ft^3)	Pa^{233} ($\mu c/ft^3$)
10-29-57		6×10^{-2}*
10-31-57	57.3	1.6×10^{-2}
11-1-57	969.7	1.0×10^{-2}
11-1-57	165.4	5.0×10^{-3}
12-5-57	4329	3.6×10^{-6}
12-9-57	4450	2.8×10^{-6}
12-30-57	6172	5.2×10^{-7}

*This analysis was made on a gas sample; all the others were taken on filters through which known amounts of filter house exhaust air had passed. In the first sample, other minor components, detected by gamma spectrometry, were I^{131}, I^{132}, and Zr^{95}-Nb^{95}. By the end of November, the activity had changed from predominantly Pa^{233} to I^{131}.

Table 11. Canal Inventory at End of CY 1957

Items	Number
4-in. bonded uranium slugs	3,944
8-in. bonded uranium slugs	2
Thorium slugs	13,140
Enriched uranium slugs	82
Enriched LITR fuel elements	21
Enriched BSF fuel elements	3
Enriched SIWI fuel elements	4
Enriched Mark II fuel elements	32
Miscellaneous pieces	253
Empty containers	
Bins	4
Buckets	4
Pails	5

Table 12. Comparative Gamma Activity in Canal Water

	Radioactivity			
	December 1956		December 1957	
	Counts/min/ml	Per Cent	Counts/min/ml	Per Cent
Gross	912	100	705	100
Cs^{137}	139	15	68	9.6
Co^{60}	185	20	95	13.0
Ba^{140}	15	2	10	1.4

Hole 59 contained a neutron collimator used by the Physics Division 40% of the time.

Holes 60 and 61 were used 85% of the time by the Solid State Division–GE for component testing.

The Animal Tunnels and the Slant Thermal Tunnel were used about 50% of the time by various research groups for studies of radiation damage.

The Thermal Column was reserved 70% of the time by ORSORT, the Applied Nuclear Physics Division, and the Biology Division.

Holes A, C, and D were used 100% of the time by the Solid State Division for determining radiation effects on crystals and to study the electrical properties of conduction.

Hole B was used 100% of the time by the Isotopes Division for production.

Holes 1768, 1867, and 1968 are charged with donut slugs and have been used 75% of the time by the Solid State Division and the Isotopes Division for fast neutron irradiations.

Eleven metal channels have been used 100% of the time for I^{131} production by the Isotopes Division.

Radioisotope Production

Radioisotope production in the Graphite Reactor for CY 1957 is shown in Table 13.

Table 13. Radioisotope Production in Graphite Reactor for CY 1957

Hole No.	Number of Samples	Type of Sample	Remarks
3	83	Sulfur, 4½ lb	P^{32} production
4	34	Service irradiations	
10	78	Short-term irradiations	
13	42	Short-term irradiations	
14	1637	Short-term irradiations	
16	81	Sulfur, 4½ lb	P^{32} production
18	14	Service irradiations	
21	83	Sulfur, 4½ lb	P^{32} production
22	65	Short-term irradiations	
A	3	Service irradiations	
61	5	Service irradiations	
2069	20	Service irradiations	
1867	3	Service irradiations	
Tunnel	0		
Tunnel	0		
1468	153	Bonded slugs	Iodine production
1566	164	Bonded slugs	Iodine production
1570	171	Bonded slugs	Iodine production
1668	151	Bonded slugs	Iodine production
1671	151	Bonded slugs	Iodine production
1765	152	Bonded slugs	Iodine production
1767	137	Bonded slugs	Iodine production
1769	136	Bonded slugs	Iodine production
1772	89	Bonded slugs	Iodine production
1869	126	Bonded slugs	Iodine production
2071	18	Bonded slugs	Iodine production

LOW INTENSITY TEST REACTOR (LITR)

Summary

The LITR operated satisfactorily in CY 1957. Shutdowns from reactor controls were slightly less than half of the CY 1956 record.

Permission was received from the AEC to operate from the remote control desk in Building 3001, and remote operation was begun on March 27. The system has been very successful.

Demineralizer performance has been good; the purity of the water was kept high and radioactivity in the water was kept low. Fission products in the water apparently came from uranium contamination on the fuel plates.

Three minor radiation incidents occurred. Each involved the release of fission gas from experiments during their removal from the reactor. No overexposure of personnel or contamination of the building resulted.

New experimental facilities were added at core positions C-39, C-43, C-52, and HB-5, increasing the number of facilities by 18%.

Use of the facilities remained high, and future plans indicate that demand for the LITR research facilities will continue even after ORR operation begins.

Downtime Analysis

Downtime at the LITR during CY 1957 was about 18%; an analysis is given in Table 14.

Fuel Usage in the LITR

In CY 1957, 19 fuel elements were added to the core and 19 were removed. At the end of the year there were 28 fuel elements in the core, including four partial elements and three shim rods (see Fig. 6). Table 15 shows the initial weights of U^{235} in the fuel elements when added and the depleted weights of U^{235} in the fuel elements when removed. The burnup, calculated at 1.26 g/Mwd, includes the fission loss and the conversion of U^{235} to U^{236}.

Fuel Recovery

No fuel elements were shipped for recovery processing during CY 1957. Three shim rods, fourteen fuel elements, and four partial fuel elements are stored in the canal of Building 3001. When the LITR shipping container has been repaired, this stored fuel will be sent to the recovery plant at Arco, Idaho. (The container became unusable when contamination leaked between the jacket and the lead filling.)

Reactor Controls

There were 26 accidental shutdowns of the LITR during CY 1957 as a result of reactor equipment failure (see Table 13). The cause of the shutdowns was attributed to several major components of the reactor control system. Since the number of shutdowns resulting from control instrument failures dropped from 59 in CY 1956 to 26 during CY 1957, it can be concluded that maintenance is improving.

The cooling-water flow blockout was redesigned so that it will be ineffective when the power is greater than N_L. Also, the blockout on the exit and bypass valve limit switches was removed.

An alarm which is actuated by failure of recorder power was added to the annunciator system.

In an effort to achieve a higher degree of safety from the recorder safety switches, the balance motor has been transferred from the chart-drive power switch to the amplifier power switch on the following recorders: No. 1 safety, No. 2 safety, pile period, log N, count rate, and T. This change will prevent the safety switches from being blocked out by the stoppage of the recorder-chart drive.

Remote Control System

Since March 27, the LITR has been operated remotely from the Graphite Reactor Building control desk. Formerly, an operator was always at the original LITR control desk while the reactor was operating. There has been no incident to indicate inadequacies in the remote control system. Prior to completely remote operation, the remote system had been tested in actual

Table 14. Analysis of LITR Downtime

	Number	Downtime (hr)
Scheduled Shutdowns		
Regular	54	655.169 (Operations) 312.600 (Research)
Research		
REED	47	154.033
Solid State Division	3	7.050
Solid State Division (G.E.)	25	39.451
Chemical Technology	15	35.934
Physics Division	1	2.500
Subtotal	145	1206.737
Unscheduled Shutdowns		
Human error		
Operations	3	1.133
Research	8	3.332
Other	6	5.299
Equipment failures		
Operations	26	25.384
Research	85	309.888
Other	8	5.133
Subtotal	136	350.169
Total	281	1556.906

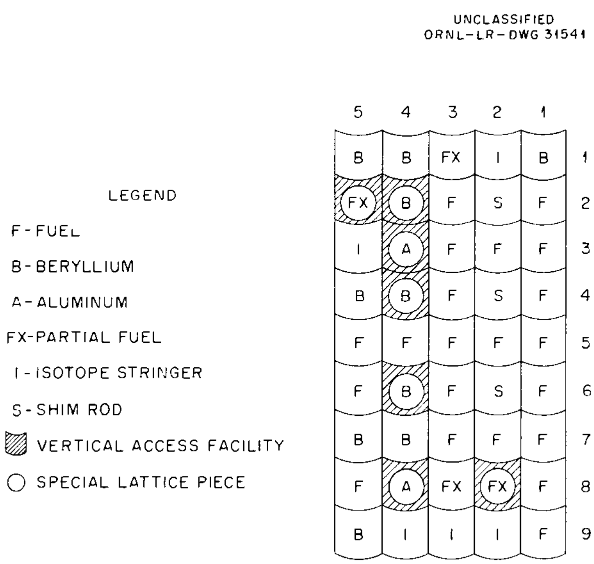

Fig. 6. LITR Lattice Configuration.

operation for about 18 months, but with an operator in attendance.

Demineralizer System

All the LITR demineralizer operating data, since the first installation in 1953, have been assembled in Tables 16, 17, 18, 19, and 20. The water activity measurements were made with a gamma scintillation counter employing a well-type NaI crystal. The water samples were allowed to decay for 20 min before counting in order to permit short-lived activities to decay.

Table 21 is a chronological listing of the different demineralizer systems.

The present LITR demineralizer system has functioned very well. Table 18 shows the operating data of the present system through CY 1957. The system consists of two cation columns, each containing 7 ft^3 of IR-120 cation

Table 15. Fuel Usage in the LITR in 1957

	Weight of U^{235} (g) Original	Depleted	Burnup		Weight of Original U^{235} (g)
Fuel Elements Removed				**Fuel Elements Added**	
Fuel Piece				Fuel Piece	
L-66	200.010	110.826	89.184	L-100	200.230
L-72	199.980	113.064	86.916	L-99	200.000
L-57	194.990	114.505	80.405	L-104*	94.910
L-73	199.980	139.124	60.856	L-98	200.000
L-65	200.460	108.568	91.892	L-97	200.000
L-60	195.940	113.251	82.689	L-92	200.000
L-58	195.550	107.962	87.588	L-93	200.000
L-78*	94.740	66.768	27.972	L-95*	94.660
L-71*	84.760	45.368	39.392	L-94*	94.660
L-72*	147.480	123.231	24.249	L-91	199.510
L-52	200.070	111.842	88.228	L-51*	136.870
L-77*	94.740	68.663	26.077	L-90	198.430
L-55	194.990	110.643	84.347	L-85	198.180
L-56	194.990	110.040	84.950	L-86	198.180
L-53	199.790	116.905	82.885	L-68	173.764
L-64	200.460	131.553	68.907	L-83	198.570
L-50	199.770	98.645	101.125	L-82	199.130
L-49	199.770	94.068	105.702	L-80	199.700
L-54	194.480	118.042	76.438	L-81	199.130
Total	3392.950	2003.068	1389.802	Total	3385.924
Average	178.576	105.425	73.147	Average	178.207
Shim rod L-27-S	130.380	23.929	106.451	Shim rod L-70-S	131.780

*Partial fuel element.

resin, two anion columns, each containing 3 ft^3 of IRA-401 anion resin, and one mixed-bed column containing 14 ft^3 of IR-120 cation resin and 20 ft^3 of IRA-401 anion resin. The water flows through a single-bed cation column, a single-bed anion column, and the mixed-bed column, in that order. The extra set of cation-anion columns is held in reserve. This system has been in use since November 2, 1956, and operates at a flow rate of 40–60 gpm.

In Table 19, routine radiochemical and ionic analyses of reactor water are presented. Activation analyses of scrapings from new LITR fuel elements have indicated that the fuel plates were contaminated with uranium during fabrication. This appears to account for the Np^{239} and fission products identified in the cooling water of the LITR.

Radioisotope Production

The production of radioisotopes in the LITR has become quite important. Table 22 shows a breakdown of the various types produced. Pneumatic tubes are now being used for the production of isotopes having high specific activity and short half life. These isotopes are produced by a weekend irradiation and picked up early each Monday morning. By mid-morning they have been processed, analyzed, divided into portions, packaged, and shipped to the airport.

Unusual Incidents

In July, about 3 lb of 0.1-in. lead shot was inadvertently dumped into the reactor vessel. This required the reactor shutdown period to be extended by about 63 hr so that the shot could

Table 16. Operating Data for the First Demineralizer System in the LITR

Activity*

In: average, 200,000–300,000 counts/min/ml

Out: average, 40,000–70,000 counts/min/ml

Run No.	Starting Date	Depletion Date	Amount Through (gal)	Reactor H_2O Inlet		Remarks
				pH	Resistance (ohm-cm)	
1	1-14-53	2-14-53	172,800	6.2	500,000	Mixed bed, 0.83 ft^3 IR-120 Column, 1.66 ft^3 IRA-410
2	2-21-53	3-27-53	252,000	6.0	600,000	
3	3-27-53	4-21-53	172,000	6.0	700,000	
4	4-21-53	6-5-53	316,800	6.3	750,000	
5	6-5-53	7-4-53	216,000	6.3	400,000	Separate anion and cation columns
6	7-9-53	7-28-53	122,400	6.3	375,000	
7	7-31-53	8-5-53	36,000	6.2	250,000	
8	8-9-53	8-28-53	136,800	5.9	330,000	
9	8-28-53	9-7-53	129,600	6.0	330,000	Mixed-bed column
10	9-24-53	10-11-53	244,800	6.0	375,000	
11	10-11-53	10-21-53	144,000	6.1	275,000	
12	10-24-53	11-9-53	230,000	6.0	250,000	
13	11-13-53	12-16-53	475,000	6.2	240,000	New resins – cation and anion
14	12-16-53	1-18-54	460,400	6.3	260,000	
15	1-20-54	1-29-54	115,600	6.0	180,000	3 ft^3 mixed resins in each of 2 columns
16	1-29-54	2-8-54	144,000	6.2	190,000	
17	2-8-54	2-15-54	100,400	6.2	190,000	
18	2-17-54	3-8-54	301,200	6.1	275,000	
19	3-9-54	4-12-54	475,600	6.2	425,000	New resins
20	4-12-54	5-11-54	432,000	6.0	325,000	
21	5-11-54	6-8-54	388,400	6.0	325,000	
22	6-11-54	7-8-54	388,400	6.1	325,000	
23	7-8-54	7-31-54	330,600	6.1	325,000	
24	7-3-54	8-16-54	230,200	6.1	225,000	
25	8-19-54	9-3-54	302,400	6.2	200,000	

*No water activity available; counts estimated.

be removed from the fuel elements and from the reactor tank. Table 23 shows all the known items that have fallen into the LITR tank and that have not been retrieved.

Three times during November parts of the LITR Building had to be evacuated because of the release of radioactive gas from experiments. No excessive exposures of workers occurred and no extensive contamination of the rooms or equipment was found.

New Facilities

A 1-in.-ID aluminum tube for sample irradiation was installed through a packing gland in the south manhole cover and extends to a beryllium core piece in C-39. Another facility, installed by the Chemical Technology Division, is a vertical experimental tube that enters the reactor vessel through a special fitting in the north wall of tank A. It terminates in a magnesium core piece in position C-43.

Table 17. Operoting Data for Cation Column in the LITR Demineralizer System

Run No.	Starting Date	Depletion Date	Amount Through (gal)	Gamma Activity (counts/min/ml)		Decontamination Factor	Reactor Water		Remarks
				Influent (av)	Effluent (av)		pH (av)	Resistance (ohm-cm, av)	
				First Modification*					
1	9-18-54	10-11-54	496,800	53,280	3,383	15.7	5.9	450,000	North unit
2	10-4-54	12-9-54	1,144,800	53,280	3,383	15.7	5.8	600,000	North unit
3	10-22-54	1-24-55	691,200	52,283	7,960	6.6	5.8	572,500	South unit
4	12-9-54	2-16-55	799,200	49,800	5,900	8.4	5.9	695,000	North unit
5	1-25-55	4-22-55	1,837,600	62,400	6,782	9.2	5.8	446,600	South unit
6	2-16-55	4-26-55	1,512,000	66,200	8,835	7.5	5.8	425,000	North unit
				Second Modification					
7	4-26-55	7-19-55	1,792,800	47,100	4,167	11.3	6.1	500,000	South unit
8	7-19-55	8-11-55	475,200	46,250	4,110	11.2	6.1	600,000	North unit – replaced resin
9	8-11-55	10-13-55	1,339,200	44,650	3,495	12.8	6.1	616,667	South unit – replaced resin
10	10-13-55	11-17-55	734,400	39,025	3,495	11.2	6.0	550,000	North unit
11	11-17-55	11-22-55	108,000	35,400	3,495	10.1	6.0	700,000	South unit – replaced resin
12	11-22-55	12-13-55	453,000	38,000	3,495	10.8	6.0	700,000	North unit
13	12-13-55	12-18-55	108,000	46,000	4,985	9.2	6.4	950,000	South unit
14	12-18-55	4-27-56	3,002,400	35,000	4,985	7.0	6.1	775,000	North unit
15	4-27-56	5-12-56	324,000	39,000	4,985	7.8	5.9	600,000	South unit
16	5-12-56	5-28-56	345,600	37,000	4,985	7.4	6.1	350,000	North unit – replaced resin IR-120
17	5-28-56	5-29-56	18,000	35,400	4,985	7.1	5.9	450,000	South unit – replaced resin
18	5-29-56	6-17-56	1,015,000	38,000	4,985	7.6	5.9	450,000	North unit
19	6-17-56	6-24-56	151,200	36,000	4,985	7.2	5.9	450,000	South unit
20	6-24-56	6-30-56	129,600	42,000	4,985	8.4	5,9	450,000	North unit
21	6-30-56	7-1-56	21,600	43,000	4,985	8.6	5.9	450,000	South unit
22	7-1-56	8-9-56	820,800	44,000	4,985	8.8	6.0	400,000	North unit
23	8-9-56	9-9-56	648,000	40,000	4,985	8.0	6.1	350,000	South unit – replaced resin
24	9-9-56	10-29-56	1,080,000	39,000	4,985	7.8	5.9	400,000	North unit
				Third Modification					
1	11-2-56	5-14-57	11,059,000	21,564	14,500	1.5	5.9	611,818	North unit
2	5-14-57	8-11-57	5,010,200	19,318	11,700	1.6	6.0	853,000	South unit
3	8-11-57	9-2-57	1,209,600	26,952	15,000	1.8	6.0	667,500	North unit
4	9-2-57	9-23-57	1,564,750	26,202	12,500	2.1	6.1	710,000	South unit
5	9-23-57	11-26-57	3,541,975	27,878	14,900	1.9	5.9	668,333	North unit
6	11-26-57	Still in service	1,559,180	32,255	15,300	2.1	5.8	662,500	South unit

*See Table 21 for description of each modification.

Table 18. Operating Data for the Anion Column in the LITR Demineralizer System

Run No.	Starting Date	Depletion Date	Amount Through (gal)	Gamma Activity (counts/min/ml) Influent (av)	Gamma Activity (counts/min/ml) Effluent (av)	Decontamination Factor	Reactor Water pH (av)	Reactor Water Resistance (ohm-cm, av)	Remarks
				Second Modification*					
1	3-24-55	4-29-55	734,400	8,835	2,984	2.9	5.8	450,000	
2	4-30-55	5-25-55	540,000	3,735	2,760	1.3	5.8	450,000	
3	5-26-55	6-23-55	842,000	3,525	3,369	1.04	6.1	500,000	
4	6-24-55	7-20-55	626,400	5,241	3,880	1.3	6.2	500,000	
5	7-21-55	9-20-55	1,296,000	4,110	2,138	1.9	6.0	725,000	Old resin replaced with new resin 7-20-55
6	9-21-55	9-26-55	43,200	7,087	1,027	6.9	6.1	400,000	Old resin replaced with new resin 9-20-55
7	9-27-55	12-12-55	1,641,600	3,495	2,804	1.2	6.2	825,000	
8	12-12-55	10-29-56	7,495,200	4,985	2,128	2.3	5.9	672,000	
				Third Modification					
1	11-2-56	8-24-57	16,934,400	13,100	2,780	4.7	5.9	718,846	North anion column
2	8-24-57	9-23-57	1,564,750	13,752	2,650	5.2	6.0	667,500	South anion column
3	9-23-57	Still in service	5,043,495	15,100	4,060	3.7	5.8	666,000	North anion column

*See Table 21 for description of each modification.

The Solid State Division installed a 1-in.-ID tube through the spare regulating-rod hole. The tube terminates in a partial fuel element in C-52.

Horizontal beam hole HB-5 has been modified by REED so that three rocking-bomb (pressure capsule) experiments can be conducted simultaneously.

Experimental Usage of Facilities

A brief discussion of each experimental facility is given in the following sections, and a summary of the shutdowns is given in Table 24. Some of the planned shutdowns were for several experiments and are shown in the table for each of the experiments involved. The trouble shutdowns are counted only once.

Horizontal Beam Hole HB-1. – This facility was used for time-of-flight neutron spectrometer studies (chopper type). Extensive modifications to the system were made this year, and the installation will be tested before it is transferred to the ORR.

Horizontal Beam Hole HB-2. – Two HRP circulating fuel-loop runs were made in this facility.

Horizontal Beam Hole HB-3. – The Solid State Division used this facility for stress-corrosion tube-burst experiments, for thermocouple tests, and for metallurgical-sample irradiations.

Horizontal Beam Hole HB-4. – Two HRP circulating fuel-loop runs were made in this facility.

Horizontal Beam Hole HB-5. – This facility accommodated rocking-capsule HRP fuel corrosion tests. The experimental apparatus was modified during the year so that three rocking-capsule experiments can be performed simultaneously. Formerly, this facility could accommodate only one capsule.

Horizontal Beam Hole HB-6. – This hole was used for single HRP rocking-bomb fuel-corrosion tests. The last two experiments of the year were on thorium oxide slurry instead of the usual sulfate solutions.

Slant Experiment Hole V-2. – This hole was used for moderator tests, but for the most part was not in demand, because of the low neutron flux. However, a series of runs in this position are planned for 1958. These runs will be air-cooled fuel studies by the Solid State Division–GE.

Core Position C-21. – This is an aluminum container of the same external dimensions as a fuel element. It was in continuous use during the year for exposure of isotope target material.

Core Position C-28. – This is a wet-tube sample irradiator and consists of a perforated aluminum

Table 19. Operating Data for the Mixed-Bed Column in the LITR Demineralizer System

Run No.	Starting Date	Depletion Date	Amount Through (gal)	Gamma Activity (counts/min/ml) Influent (av)	Gamma Activity (counts/min/ml) Effluent (av)	Decontamination Factor	Reactor Water pH (av)	Reactor Water Resistance (ohm-cm, av)	Remarks
				First Modification*					
1	9-18-54	11-2-54	1,504,000	3383	2000	1.7	5.9	450,000	
2	11-5-54	11-23-54	388,000	3383	2000	1.7	5.5	450,000	
3	12-2-54	1-13-54	648,000	7960			6.1	900,000	
4	1-16-55	2-7-55	475,000	5900			5.8	490,000	
5	2-11-55	3-10-55	464,000	5400			5.7	400,000	
				Second Modification					
6	3-15-55	5-3-55	836,522	2972	1560	1.9	5.8	450,000	
7	5-6-55	6-14-55	606,020	3625	1475	2.4	6.1	500,000	
8	6-16-55	8-5-55	871,308	3009	1400	2.1	6.2	500,000	
9	8-6-55	8-25-55	410,400	2138	1350	1.6	5.9	700,000	
10	8-26-55	9-21-55	397,461	2138	1375	1.5	6.1	750,000	
11	9-25-55	10-19-55	331,195	2804	1450	1.9	6.1	400,000	
12	10-27-55	12-14-55	727,024	2804	1265	2.2	6.0	700,000	10-19-55, replaced DA with 18 ft^3 of new resin, IRA-401
13	12-15-55	3-7-56	1,207,764	2804	1320	2.1	6.4	950,000	
14	3-8-56	5-8-56	821,954	2128	1240	1.7	5.9	600,000	
15	5-8-56	5-25-56	179,600	2128	980	2.2	6.1	350,000	
16	5-27-56	7-20-56	625,967	2128	1220	1.7	5.9	450,000	
17	7-22-56	9-6-56	606,332	2128	1310	1.6	6.1	350,000	
18	9-8-56	11-6-56	588,806	2128	1607	1.3	5.9	400,000	
				Third Modification					
19	11-6-56	12-12-56	1,755,000	2780	1290	2.1	5.9	860,000	
20	12-13-56	1-17-57	1,864,270	2780	1500	1.8	5.9	740,000	
21	1-19-57	2-3-57	651,213	2780	1420	1.9	5.6	540,000	Cation resin replaced
22	2-4-57	2-17-57	551,318	2780	1500	1.8	5.3	450,000	
23	2-18-57	3-11-57	1,146,200	2780	1610	1.7	6.1	710,000	
24	3-13-57	4-4-57	1,158,800	2780	1450	1.9	6.1	620,000	
25	4-5-57	4-20-57	913,920	2780	1235	2.2	6.0	760,000	
26	4-24-57	5-25-57	1,655,100	2780	1190	2.3	6.1	850,000	
27	5-26-57	6-20-57	1,238,640	2780	1215	2.3	6.0	760,000	
28	6-22-57	7-15-57	856,000	2780	1020	2.7	6.1	710,000	
29	7-16-57	8-4-57	1,003,980	2780	990	2.8	6.0	1,320,000	
30	8-5-57	8-20-57	792,330	2780	960	2.9	5.9	625,000	
31	8-21-57	8-23-57	3,200	Unsuccessful regeneration					
32	8-24-57	9-20-57	1,403,750	2650	1900	1.4	6.1	710,000	
33	9-21-57	10-2-57	584,800	4060	1850	2.2	6.1	685,000	
34	10-5-57	10-25-57	1,212,245	4060	1980	2.0	5.8	750,000	
35	10-28-57	11-12-57	746,400	4060	2150	1.9	5.7	570,000	
36	11-13-57	12-6-57	1,246,000	4060	2300	1.8	5.9	615,000	
37	12-8-57	Still in service	1,852,800	4060	2290	1.8	5.7	710,000	

*See Table 21 for description of each modification.

Table 20. Results of Routine Analyses for Principal Constituents in LITR Cooling Water

Month	Radioactive Constituents (counts/min/ml)			Nonradioactive Constituents (ppm)								
	Na^{24}	Np^{239}	I^{131}	Al + Be	Cl	CO_2	Cu	H_2O_2	NO_3	SO_4	Dissolved O_2	Total Solids
Jan.	6×10^3	1.47×10^3	32	<0.05	<0.05	<0.03	<0.05	5.50	<0.05	<0.05		2.10
Feb.	1.33×10^4	1.13×10^3	25									
March	5.35×10^4	8.13×10^3	31									
April	1.13×10^4	9.19×10^2	28									
May	1.13×10^4	5.62×10^2	25									
June	3.22×10^3	9.07×10^2	26									
July	2.56×10^4	8.24×10^2	32	<0.05	<0.002	1.30	<0.05	4.20	<0.05	<0.05	5.40	3.20
Aug.	3.31×10^4	7.34×10^2	115									
Sept.	2.30×10^4	9.31×10^2	22									
Oct.	1.53×10^4	1.08×10^3	106									
Nov.	5.0×10^3	1.75×10^3	730									
Dec.	2.64×10^4	1.0×10^3	89									
Av for year	1.88×10^4	1.62×10^3	105									

Table 21. Chronology of the LITR Demineralizer Systems

	Date of Installation	Date Out of Service	Description
First system	January 1953	August 1954	Two alternately used, 2.5-ft^3 mixed-bed columns, each containing 0.83 ft^3 of Amberlite IR-120 cation resin and 0.67 ft^3 of Amberlite IRA-401 anion resin; flow rate, 3 gpm; operation data in Table 16.
First modification	September 1954	March 1955	Two alternately used, 2.5-ft^3 cation pre-columns, and one 30-ft^3 mixed-bed column; each cation pre-column contained 2.5 ft^3 of Amberlite IR-120 resin; the mixed-bed unit contained 18 ft^3 of Amberlite IR-120 resin; flow rate, 15 gpm; operation data in Table 17.
Second modification	March 1955	November 1955	In addition to the above, a 3-ft^3 anion pre-column containing Amberlite IRA-401 was installed between the cation pre-columns and the mixed-bed column; flow rate, 15 gpm; operation data in Tables 17 and 18.
Third modification	November 1956	In service	(*1*) Two alternately used cation pre-columns, each containing 7 ft^3 of Amberlite IR-120 resin; (*2*) two alternately used anion pre-columns, one containing 3.5 ft^3 of Amberlite IRA-401 resin and the other containing 6 ft^3 of Amberlite IRA-401 resin; and (*3*) one 30-ft^3 mixed-bed column containing 18 ft^3 of Amberlite IRA-401 anion resin and 12 ft^3 of Amberlite IR-120 cation resin; flow rate, 40–60 gpm; operation data in Table 18.

tube which runs through a spare shim rod position in the top plug to a partial fuel element. It was in continuous use during the year by the Solid State Division for the irradiation of various crystals in high fast-flux fields.

Core Position C-29. – This position was occupied full time by an isotope stringer and was in use full time for radioisotope production.

Core Position C-31. – This is a sulfur irradiation facility for production of P^{32}. It is a partial fuel element and was in continuous use during the year.

Core Position C-38. – This position contained a partial fuel element used as a high fast-flux facility for the irradiation of various crystals by the Solid State Division and was in use full time.

Core Position C-39. – This facility contained an isotope stringer with four vertical holes and was in use full time. One of these holes will accommodate a tube which extends outside the tank reactor through the south manhole cover. Such a dry tube facility was used for three months by the Physics Division for irradiations.

Core Position C-41. – This position contained a partial fuel element as a CaO irradiation source for the Physics Division. It was in use through June, at which time the program was completed, and the original beryllium reflector piece was replaced.

Core Position C-42. – This position provides access to the reactor through an unused shim rod hole in the top plug. The Solid State Division has used this facility since February for fuel and moderator studies. Mechanical positioning of the test capsules in the flux zone made additional cooling of the experiment unnecessary, but the facility is being changed so that it can accept air-cooled experiments.

Core Position C-43. – In February the beryllium core piece in C-43 was replaced with a special magnesium piece by the Chemical Technology Division to establish a new facility for studies on thorium oxide. Access to the outside of the

Table 22. LITR Radioisotope Production

Position	Number of Irradiations		
	Unit[a]	Service[b]	Process[c]
C-29	51		
C-49	62		
C-53	194		
C-49	3	1	
Regulating rod facility		1	
C-31			19
Pneumatic tube		119	200

[a]A specified amount of a target chemical irradiated to the radiation level advertised in the Radioisotope Catalog and shipped without chemical processing.

[b]An irradiation of a special type as directed by the customer. Usually the material is supplied by the customer and is shipped without chemical processing.

[c]An irradiation of a chemical compound which is processed chemically and sold in solution.

Table 23. Items Dropped into the LITR

Item	Resting Position in Reactor Vessel	Approximate Date
Fe^{59} sample	Unknown	1952
Pencil meter	Unknown	1955
Rb_2CO_3 sample	Between beryllium and upper grid support casting on west side of core	1956
Magnifying glass	Between beryllium and upper grid support casting on west side of core	1956
3 lb 0.1-in. lead shot	Tank A flange and core – 90% recovered	July 1957
Rubber stopper, 2 in.	Tank E below core pieces	July 1957
2 Cd-wrapped Au foils	Unknown	Oct. 1957

Table 24. Analyses of LITR Shutdowns Due to Experiments

Facility	Number of Experiments	Days in Use	Time Used (%)	Special Planned Shutdowns	Average Duration of Planned Shutdowns (hr)	Trouble Shutdowns	Average Duration of Trouble Shutdowns (hr)
HB-1	1	365	100.0	1	2.500	1	0.333
HB-2	3	106	29.0	7	6.005	9	14.524
HB-3	13	323	88.5	0	0	9	1.987
HB-4	2	75	20.5	0	0	3	20.167
HB-5	9	86	23.6	12	3.756	32	0.820
HB-6	10	175	47.9	35	2.648	4	3.946
C-28	*	250	68.5	0	0	0	0
C-42	10	221	60.5	2	1.058	4	0.796
C-43	2	154	42.2	0	0	7	0.657
C-44	14	210	57.5	14	1.561	4	0.667
C-46	1	21	5.8	0	0	15	2.453
C-48	29	211	57.8	23	1.572	12	1.150
C-52	*	28	7.7	0	0	0	0
V-2	0	0	0	0	0	0	0
V-1	0	0	0	0	0	0	0

*Experimenters exposed samples intermittently.

reactor vessel was made through an existing side opening so that the air-cooling, electrical, and other necessary connections could be made.

Core Position C-44. – The Chemical Technology Division used this facility for capsule experiments on agitated, air-cooled thorium oxide slurries; C-44 is another unused shim rod position and has access to the outside through the shim rod drive-shaft hole in the top plug.

Core Position C-46. – The Solid State Division used this position (unused shim rod) for a wet-tube sample irradiation facility. During May it was used for a fused-salt circulating-fuel loop, which required that another opening be used through the side of tank A for leads to the north midriff section.

Core Position C-48. – The Solid State Division–GE used this position for air-cooled fuel and moderator tests and for general radiation damage studies. A large, flexible tube through a special flange in the side of tank A gives access to the facility.

Core Position C-49. – This position was occupied by an isotope stringer and was in use full time for radioisotope production.

Core Position C-52. – This position was occupied by a partial fuel element and was used by the Solid State Division for studies of fast neutron flux determination.

Core Position C-53. – This position was occupied by an isotope stringer and was in use full time for radioisotope production.

Reactor Water System

Figure 7 shows the equipment and flow of water at the LITR. The following paragraphs describe the sections indicated by the numbered circles, while the radiation readings are given in Table 25 for the points indicated by the numbered squares in the figure.

1. *Reactor Vessel.* – capacity, 4000 gal; mild steel; Amercoat-painted inside.

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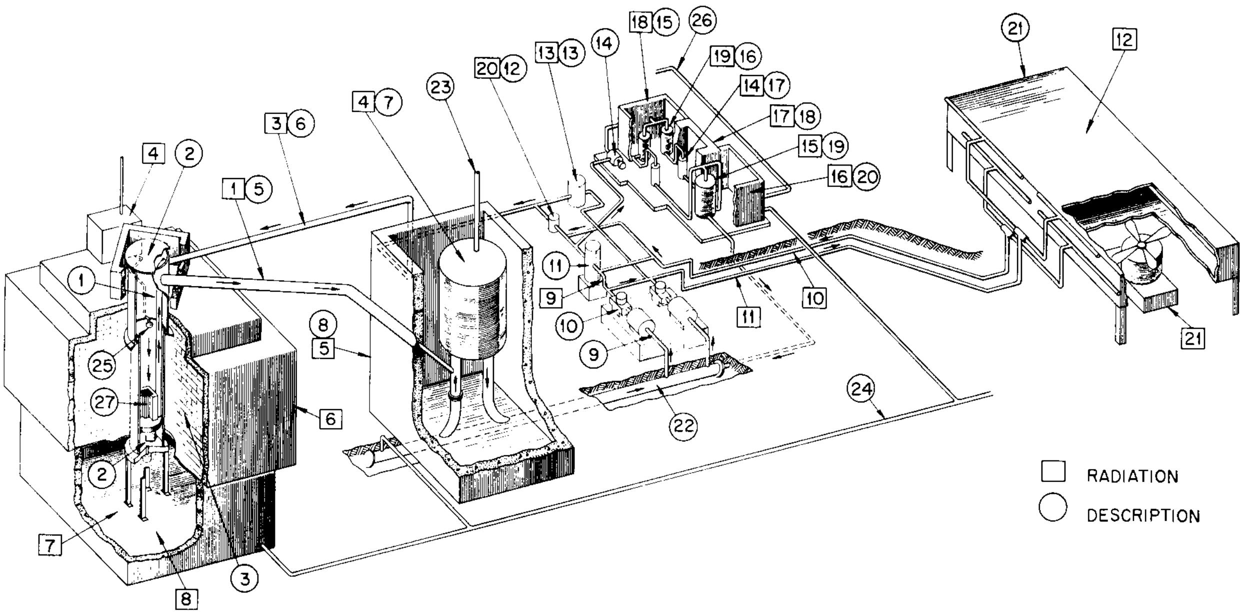

Fig. 7. LITR Cooling Water System.

2. *Exit Water Lines.* – eight 2-in.-dia aluminum pipes which converge to an 8-in.-dia aluminum line before leaving the reactor vessel.

3. *Reactor Shield.* – standard concrete blocks, unmortared, 9 ft, 7 in.; standard concrete blocks, mortared, 1 ft, 0 in.; total shield thickness, 10 ft, 7 in.

4. *Spray Tank.* – capacity, 600 gal; filled automatically by the reactor water system; drained automatically through sprays if the water is lost from the reactor tank; material, aluminum.

5. *Exit Reactor Water Line.* – 8-in.-dia aluminum pipe, shielded by 3½ in. of lead.

6. *Inlet Reactor Water Line.* – 8-in.-dia aluminum pipe, shielded by 1 in. of lead.

7. *Seal Tank.* – capacity, 7000 gal; mild steel, Amercoat-painted.

8. *Shield for Seal Tank.* – 18 in. thick; 12 in. of standard-mortared concrete, 6 in. of barytes-mortared concrete.

9. *Motor for Circulating Pump.* – 440 v, 75 hp.

10. *Water Circulation Pump.* – capacity, 1300 gpm (estimated); cast steel housing, stainless steel impeller.

11. *Shell and Tube Heat Exchanger.* – Monel tubes, channel, and tube sheets; steel shell and baffles; hairpin bundle; 480 ft^2 of heat transfer surface; one pass on shell side, two passes on tube side.

12. *Strainer.* – hole size in basket, ¼ in.; cast steel body, stainless steel basket.

13. *Bypass Filter.* – capacity, 400 gpm (estimated); filter medium, cotton-cord wound cylinders; 72 filter cartridges; steel.

14. *Demineralizer Pump.* – capacity, 60 gpm; stainless steel.

15. *Shield for Cation Columns.* – 12-in. thickness of mortared barytes concrete block.

Table 25. LITR Radiation Readings

Numbered Square	Radiation* (mr/hr)	Remarks
1	45	
2	20	2 ft above the top plug
3	15	
4	430	
5	22	
6	4.5	
7	600	2 ft under bottom of tank E of the reactor vessel, 28 hr after shutdown
8	5000	Headlevel 10 ft west of the reactor tank, 28 hr after shutdown
9	70	
10	45	
11	75	
12	100	1 ft over the fluid cooler
13	130	
14	1800	
15	60	
16	10	
17	260	
18	33	
19	200	
20	45	
21	30	6 ft below water tubes

*Readings taken with a cutie-pie at 4 in. during operation at 3 Mw, unless otherwise indicated.

16. *Pre-Cation Columns.* – IR-120 resin, 7 ft^3; stainless steel; 60-gpm flow.

17. *Pre-Anion Columns.* – IRA-401 resin, 3 ft^3; stainless steel; 60-gpm flow.

18. *Anion Demineralizer Shield.* – 6-in. thickness of mortared barytes concrete block.

19. *Mixed-Bed Demineralizer.* – IR-120, 14 ft^3 and IRA-401, 20 ft^3; stainless steel; 60-gpm flow.

20. *Shield for Mixed Bed Column.* – 6 in. thick; first four courses are standard-mortared concrete block, next seven courses are mortared barytes concrete block, last seven courses are normal-mortared concrete block.

21. *Fluid Cooler.* – capacity, 2.0 Mw when outside air is 90°F; aluminum tubes in aluminum fins; 2 fans, 2-speed fan motors, 5 and 40 hp; volume of 125 gal.

22. *Reactor Water Line.* – 20-in. pipe; Amercoat-painted steel.

23. *Vent to Off-Gas.* – 3-in.-dia steel pipe.

24. *Contaminated Drain to LITR Retention Ponds.* – 4-in.-dia terra cotta pipes.

25. *Spray Nozzle for Spray Tank.* – fed by 1-in. stainless steel lines in order to spray-cool the reactor core for two hours after loss of water from the reactor vessel.

26. *Hot Drain Line to Tank Farm.* – 2-in. stainless steel pipe for disposal of radioactive regenerant effluents from the ion exchange columns.

27. *LITR Core.*

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