DOCKET NO. 50-39
File

CURTISS-WRIGHT CORPORATION
RESEARCH DIVISION
QUEHANNA, PENNSYLVANIA
U. S. A.

April 1, 1960

DOCKETED USAEC Division of Licensing & Regulation APR 4 1960 Docket Officer

U. S. Atomic Energy Commission
Division of Licensing and Regulation
1717 H. Street, NW
Washington 25, D. C.

Docket No. 50-39

Attention: Dr. Lyall Johnson
Chief, Licensing Branch
Division of Licensing and Regulation

Gentlemen:

Subject: Application to Amend Present Class 104 Reactor Operation License to 1.7 and 4 Mw Power Level

References:
a) Hazards Evaluation Report for Curtiss-Wright Research Reactor, CWR 4062, dated April 1959
b) AEC letter inquiry, L. Johnson to Wm. T Lake, dated July 6, 1959
c) Reactor site survey letter, G. R. Hill to H. L. Price, dated February 11, 1960
d) Telecon, C T. Edwards to J. A. McManemin, dated March 31, 1960
e) Telecon, S. H. Klein to C. T. Edwards, dated April 1, 1960

Application is hereby made to amend Curtiss-Wright Research Reactor Hazards Evaluation Report No. 4062 by adding the attached Appendix VII to our original license amendment request.

(See Reports File ... CWR 4062 A)

Report CWR 4062 forms an integral part of our application to amend our present Class 104 license to operate a nuclear reactor. It is our intention that the attached Appendix VII be considered a part of this Hazards Evaluation Report and, therefore, a part of our application to amend our present license. The information which follows is being supplied in answer to questions raised by personnel of the Hazards Evaluation Staff of the Division of Licensing and Regulation, U. S. Atomic Energy Commission, in references b, c, and d above.

It is noted that although we have answered all questions regarding interchanging of 10-plate and 19-plate fuel elements, our operational plans preclude accidental mixing of these elements. We have requested permission to operate at power levels up to 1.7 Mw with the present 10-plate elements. We shall continue to use the 10-plate element core until we have depleted

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its reactivity beyond a useful level or until we wish to dispose of it for other reasons. All the 10-plate elements will then be removed from the reactor and stored separately until ready for disposal. Only after this, will the 19-plate elements be introduced into the pool and the reactor core. There are no plans to return to operation with 10-plate fuel elements.

Since amending our license for 4 megawatt operation may be somewhat more involved than for 1.7 megawatt operation, it is hereby requested that an interim amendment be granted for operation at 1.7 megawatt, utilizing the present 10-plate elements.

In answer to Mr. C. T. Edward's telephone inquiry to Mr. J. A. McManemin questioning the size of our reactor site, as set forth in Mr. G. R. Hill's letter of February 11, 1960 to Mr. H. L. Price, please be advised that although the facility occupies approximately 2.7 acres, this reactor site location is a minimum of three miles from the boundary of any Curtiss-Wright controlled property. In fact, as specified on pages 52 through 54 or our original Hazards Evaluation Report (reference a above), the reactor is located on an eighty square mile tract of land owned and/or leased for ninety-nine years by Curtiss-Wright Corporation.

It is hoped that the above information will satisfactorily complete our application and that early action upon the license amendment can be taken.

Very truly yours,

CURTISS-WRIGHT CORPORATION
RESEARCH DIVISION

George R. Hill

PLG George R. Hill
Executive Vice President

State of New Jersey:
: ss.
County of Bergen :

George R. Hill, being duly sworn according to law, deposes and says that he is the Executive Vice President of the Curtiss-Wright Corporation mentioned in the foregoing application, that he has read the said application and knows the contents thereof and that the same is true to the best of his knowledge, information and belief.

George R Hill

Sworn to and subscribed before me this 1st day of April, 1960

W. James Hall
Notary Public
NOTARY PUBLIC OF NEW JERSEY
MY COMMISSION EXPIRES JULY 15, 1961

I, Roger W. Mullin, Jr., certify that I am the Secretary of the Corporation named, as applicant herein, that George R. Hill, who signed this application, was then Executive Vice President of said Corporation; that said application was duly signed for and in behalf of said Corporation by authority of its governing body, and is within the scope of its corporate powers.

Roger W. Mullin Jr.

APPENDIX VII

Amendment to CWR 4062

Answers to Questions of AEC Licensing Branch
Divisions of Licensing and Regulations

DOCKET NO. 50-39

March 24, 1960

File Cy.
(Trans. w/Ltr. 4-1-60)

CURTISS WRIGHT

CURTISS-WRIGHT CORPORATION
RESEARCH DIVISION
QUEHANNA, PA., U.S.A.

Classification review not required. [signature] 7/6/60

DOCKET NO. ____________

CWR 4062-A

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CURTISS WRIGHT

DOCKETED USAEC Division of Licensing & Regulation APR 4 1960 Docket Officer

CURTISS-WRIGHT CORPORATION
RESEARCH DIVISION
QUEHANNA, PENNSYLVANIA

APPENDIX VII
Amendment to CWR 4062

Answers to Questions of AEC Licensing Branch
Divisions of Licensing and Regulations

March 24, 1960

Prepared by

Research Reactor Personnel
Nuclear Sciences and Engineering

Approved for release by

C. F. Leyse

C. F. Leyse, Chief, Nuclear Sciences and Engineering

Contents

A. Fuel and Fuel Handling

Are these the present ones?

1. Describe the design and fabrication techniques used for the 10- and the 19-plate fuel elements. Is it planned to have both types of elements at the facility at the same time?

   The present 10-plate full fuel elements and 6-plate control elements are Curtiss-Wright design and are fabricated by Sylvania-Corning Nuclear Corporation. Each plate contains 17 grams of $U^{235} \pm 0.5$ grams U^{235} per core, 27.23 w/o aluminum 99.8 Alcoa grade 3A less than 10 ppm boron. The individual fuel plates are attached to the side plates by aluminum brazing using 12% silicon aluminum filler material. The nosepiece and handle are attached by aluminum fillet welds. (See CWR 4062; page 10, paragraph 1(a), and page 11.)

   The 19-plate full fuel elements and the 10-plate control elements are also Curtiss-Wright design and are fabricated by Sylvania-Corning Nuclear Corporation. Each plate contains 19 grams of $U^{235} \pm 0.5$ grams U^{235} per core, 90% enriched uranium. The individual fuel plates are attached to the side plates by a mechanical bond method. This bond technique produces a strength of 167 lb/linear in. of bond contact. The nosepiece and handle are attached to the element by aluminum fillet welds. (For description of these elements see; CWR 4062; page 12, paragraph 1(b), and page 13.)

   It is not planned to have both types of fuel elements at this facility after the 10-plate elements are disposed of because of fuel depletion or other reasons. Until use of the 10-plate element is discontinued, the 19-plate elements will be segregated, and will not be kept in the pool.

2. Give an analysis of the identification system of the 10- and 19-plate fuel assemblies.

   The identification system is described in detail in SOP 117, (see page 22 of this report).

   The following precautions are to be used to insure that the elements will not be interchanged:

   1) During loading operations, each element will be examined visually to determine if it is a 10- or 19-plate element.

2) The identification system described in SOP 117 will enable positive identification to be made.

3) Each time any element (fuel, reflector or experimental) is moved, the corresponding card for that element is transferred from the storage display board to the core display or vice versa.

4) In addition to the precautions in item 3, a complete record of all element movement is immediately made in the reactor operations log book.

3. What precautions are taken to prevent the interchange of fuel and reflector pieces in the reactor core?

When viewed from above fuel elements can be positively distinguished from reflector elements by the characteristic slotted appearance of the fuel plates; whereas, the reflector elements are solid in cross-section.

Prior to loading a core configuration, a loading chart is prepared which designates fuel and reflector elements. This chart serves as a guide for loading operations. As each element is loaded, another loading chart is filled in with the code number of the fuel or reflector element. In addition, element type, code number, core position, and previous storage position are recorded in the Reactor Log. As a further check, a distinctive placard representing the element is hung on a core-simulating display board. As mentioned in SOP-117, the numbers and letters engraved on the sides of each element will provide positive identification.

4. What is the administrative system that will be used to insure proper and safe handling of fuel elements? Give other precautions to prevent unauthorized handling of the fuel elements.

Fuel elements will be handled only by persons holding valid AEC operators' licenses (or reactor operator trainees), as directed by the reactor engineer (shift supervisor) who holds a valid AEC operator's license. Handling tools are locked in a rack, with the key in the possession of the reactor engineer.

The loading procedures outlined in question 3 insure strict accounting control of all types of elements.

5. What are the heat distribution and heating values in both the 10- and 19-plate fuel elements at their planned maximum power levels?

Calculated heating values and heat distribution for the 10- and 19-plate fuel elements are tabulated below.

	Case I (10 Plate Core)	Case II (19 Plate Core)
Thermal Power	1.7 Mw	4 Mw
Core Loading	16-Full Elements	16-Full Elements
	4-Control Elements	4-Control Elements
	184-Total Plates	344-Total Plates
Thermal Power/Plate	9.24 kw/Plate	11.6 kw/Plate
Average Power Density	30 kw/Liter	72.5 kw/Liter
Max. to Average Heat Flux Ratio *radial*	1.8	1.8 *[illegible]*
Max. Surface Heat Flux	66,000 Btu/hr/ft^2	83,700 Btu/hr/ft^2
Burnout Heat Flux	890,000 Btu/hr/ft^2	820,000 Btu/hr/ft^2
Heat Transfer Coefficient	860 Btu/hr/ft^2/^{o}F	1155 Btu/hr/ft^2/^{o}F
Hot Channel Factor Used *axial*	1.67	1.67

[illegible] 3.0

B. Cooling System

1. Summarize the operational procedures followed in going to higher power levels.

   For power levels less than 100 kw, convection cooling is used and no system changes are necessary. For power levels in excess of 100 kw, forced circulation is required. The secondary cooling system is adequate for power levels up to and including 4 Mw. When the reactor is operating at power levels above 100 kw, and an increase in power is desired, it may be necessary to use the secondary cooling system. This system can be put into operation without shutting the reactor down. However, if it is desired to change the primary coolant flow rate (e.g., from 700 to 1200 gpm), the reactor will be shut down to accomplish this change. When the power level is less than 100 kw, and a power increase to more than 100 kw is necessary, the changeover to forced cooling must be accomplished during the reactor shutdown condition. The procedure required for preparing the system for forced cooling is given in detail in SOP 301, (see page 27).

2. Describe the procedure in changing from convection cooling to forced circulation. Are there any interlocks involved in this operation?

   Convection cooling can be used for power levels up to and including 100 kw and, if desired, forced cooling also may be used in the 0 - 100 kw range. For power levels greater than 100 kw, forced cooling is required. Assuming the reactor is operating on convection cooling, and it is desired to use forced cooling, the following steps in chronological order are taken.

   1) Announce over PA system that reactor is being shut down.

   2) If on "auto" control, switch to manual and insert all rods at their normal drive rates shutting down the reactor.

   3) Prepare cooling system for forced circulation as described under Cooling System, Question 1, above and as detailed in SOP 301.

With the forced cooling system in operation, the reactor is brought up to power according to normal start-up procedures.

There are two interlocks involved in changing from convection to forced circulation.

1) Attempting to go to forced circulation while the reactor is in operation would initiate a slow shutdown once the primary cooling pump was started. Therefore, the reactor should be shut down before the primary cooling pump is started.

2) If the plenum chamber door is closed while operating on convection cooling, an interlock initiates a slow shut down.

From the preceding, it is apparent that it is necessary to shut the reactor down in order to change from convection to forced circulation, since the interlocks mentioned above cannot be defeated.

3. Is there sufficient instrumentation and interlocks on the forced coolant exit plenum to detect coolant by-pass of the flexible hose? If not, how is one assured that sufficient coolant is flowing through the reactor core?

The system is currently being modified to include a core flow measuring device preceding the flexible hose. This device will consist of a standard grid plug, and will be fitted with a tube extending above the surface of the pool. Under normal flow through the core, the head of water in the tube will be depressed several inches. In the event flow through the core is by-passed, the water level in the tube approaches the pool surface. At a set point of 75% normal flow, the water makes contact between two electrodes, and a slow shutdown results.

C. Shielding

1. What are the dose rates for areas around the faces of the tank of the reactor at 4 Mw operation? Experience with the present facility at 1 Mw operation would be informative.

   Radiation measurements made by the Health Physics Group with the reactor operating at 1 Mw give the following dose-rates at the faces:

   a. Beam Tube Room (Shield Face)

   Dose-rate at contact

   1) Thermal neutron flux 1 n/cm^2-sec
   2) Fast neutron flux 1 n/cm^2-sec
   3) Gamma ray dose-rate 0.05 mr/hr

   b. Beam Ports (Flooded)

   Dose-rate at contact

   1) Thermal neutron flux 1 n/cm^2-sec
   2) Fast neutron flux 1 n/cm^2-sec
   3) Gamma ray dose-rate 0.05 mr/hr

   c. Beam Ports (Dry)

   Dose-rate at contact

   1) Thermal neutron flux 177 n/cm^2-sec
   2) Fast neutron flux 465 n/cm^2-sec
   3) Gamma ray dose-rate 1.3 mr/hr

   Dose rate at one meter

   1) Thermal neutron flux 12 n/cm^2-sec
   2) Fast neutron flux 25 n/cm^2-sec more than MPC

   At all other positions, there was no noticeable neutron flux.

Other gamma ray dose-rate measurements consist of:

Position	Dose Rate (mr/hr)
Pool surface above core	2.1
Console bridge at console	0.6
Console bridge above control rod drive guide tubes	0.6
Console bridge above ion chamber tubes	1.5

2. The activation of the pool water due to oxygen-16 activation is described in the report. It is also of interest to know the activation of the pool water due to longer life of the activated oxygen-17. What is the increase in dose-rate at the surface of the water during an operating cycle?

   The pool water activation by the formation of C^{14} from the reaction O^{17} (n, α) C^{14} has been computed assuming a 60% neutron absorption in water. This leads to a formation rate of 4.86×10^{-3} μc/sec or approximately 2.5 millicuries in a 144-hour operation period. Because of the type of emission (0.155 Mev β -), there will be no visible increase in dose rate at the water surface from this emitter.

   The increase in dose rate at the surface of the water during an operating cycle with steady state operation at 1 Mw is shown in Figure 1. The equilibrium dose rate is 2.1 mr/hr for continuous operation at 1 Mw of power.

   The dose rate at 4 Mw will be somewhat more than 4 times this value; however, it is expected to be in the range of 10 to 15 mr/hr. Only actual operation will give the actual dose rate at 4 Mw.

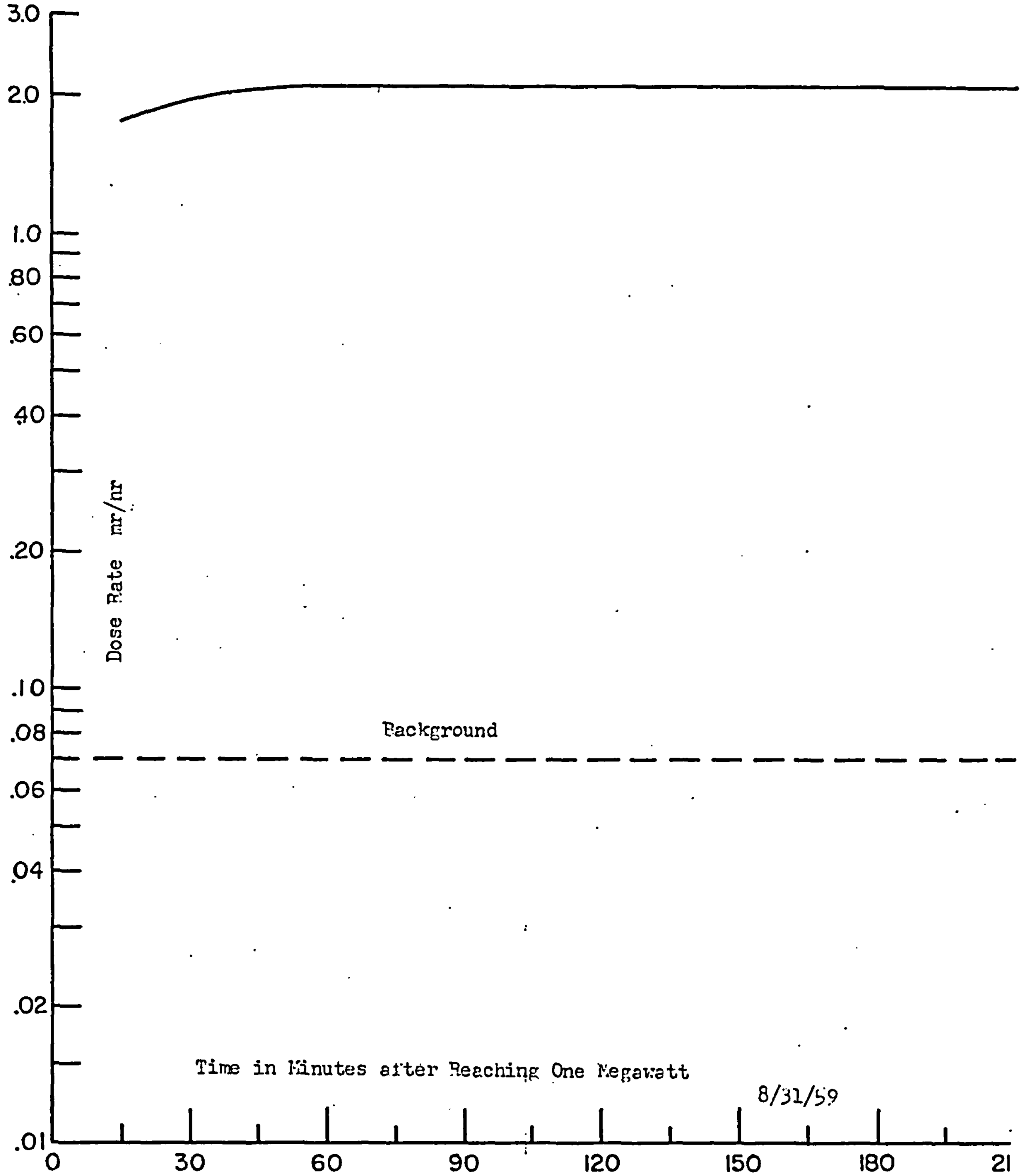


Figure 1. Dose Rate at Pool Surface vs.
Operating Time at One Megawatt

D. Safety Considerations

1. What is the method used to check out instrumentation prior to nuclear startup?

The general method used to check out instrumentation prior to nuclear startup is based on special observations of equipment under simulated operating conditions. Instruments that are used for giving indication and/or reactor shutdown due to abnormal situations are checked by simulating abnormal situations electronically at, or as near as possible to, the primary detecting device (the device which initially detects abnormal situations). The following items are parts of the reactor start-up checkout procedure as listed on pages 130 through 132 of the Hazards Evaluation Report (CWR 4062). They will be dealt with by number where method and basic instrument calibration functions are not obvious from the checkout procedure.

#3. Check Fission Product Delayed Neutron Monitor, as follows: observe the predetermined high voltage to the BF_3 probe; calibrate the ratemeter by inserting 60 cycle per second shaped pulses from line voltage into input circuit of the count ratemeter; calibrate the meter scale and recorders. The detector and amplifier are checked by placing a small radium beryllium neutron source near the detector assembly.

#4. Check Ion Exchange Fission Product Monitor. The procedure is identical to number 3, with the exception of observing normal counter background to check the detector.

#6. Check Compensation of Linear and Log N, C.I.C. Chambers. A visual inspection is made to determine if the Log N is slightly up scale from the lower limit pin and if the linear is slightly above zero on the most sensitive range (compatible with residual power). If these conditions are not met, the compensating voltages are changed to correct values by instrument maintenance personnel.

#9. Check Jordan Ram System. The radiation monitor system is checked for high voltage. Master meter readings are compared with station unit meter relay readings. The meters are also observed to make sure that readings are characteristic of normal gamma background levels. Meter relay alarm points are also checked. Each unit is calibrated monthly by Health Physics personnel.

#11. Calibrate Log Count Ratemeter. This is done by inserting a shaped 60 cycle per second signal on the input. The meter and recorder are observed for proper indication, and adjustment is made if necessary.

#13. Magnet Current Calibrations. These calibrations are made weekly by the Instrument Maintenance Group. The operator determines if the magnet currents are set according to the most recent calibration. The bus protect circuit is checked by decreasing the bias on the #1 tube of the magnet current amplifier. This normally should drop the magnet current by approximately 1 milliamp, if properly adjusted.

#14. Check Safety Amplifier #2. This amplifier is checked by inserting a d.c. level on the input of its Sigma preamp. The d.c. level is compatible with the signal at this point due to 140% of the neutron flux. If all rods drop reliably from the 3 in. position, the test is considered successful.

#15. Check Safety Amplifiers #3 and #4. These amplifiers are checked using the same procedure as used for safety amplifier #2.

#18. Calibrate Log N - Period Amplifier.

A. through D. The d.c. amplifier is checked by inserting two different voltages on the input and also by grounding the input. When the input is grounded, zero current should flow through the meter. The two voltages applied are reference voltages designed to give a set meter reading. These three different meter readings are checked and adjusted to read properly.

E. through H. The period fast scram is checked by switching from operate to low calibrate. With this condition the input to the electrometer goes from zero to a predetermined value in a short period of time introducing a rate of change of current indicative of a short period (always less than five seconds). Safety amplifier #1 detects the short period and feeds a scram signal to the sigma bus dropping all rods. Periodically the 5-second scram set point is checked by the instrument maintenance group using the "Pile Period Simulator." This instrument supplies a predetermined ramp signal which simulates a desired period signal.

#22-B. Flow rates are noted to make sure that the instruments are working properly. Core effluent, differential, and heat exchanger temperatures are observed to make sure that the temperature measuring equipment is working satisfactorily. Proper readings on both flow and temperature equipment under the conditions that are standard, serve as checks on the instrumentation.

2. Describe the location of the detectors, particularly in reference to the startup source.

The detectors are located to the rear of the grid plate and above the core. The source is fixed in a source holder which places it on the horizontal midplane of the reactor. It is normally placed in the front edge of the core diagonally opposite the fission counter.

3. What is the core configuration to be used with each type of reflector? Discuss the excess reactivity available for each core geometry and the reactivity control available in the control rods for each case.

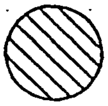
The Curtiss-Wright Research Reactor design affords a high degree of flexibility in core configuration; hence, figures depicting typical graphite-reflected cores are attached (Figures 2, 3, 4, and 5). Figure 2 represents a water-reflected core; whereas, the other figures are representative of graphite-reflected cores.

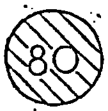
The following tabulates the total excess reactivity present in each of the representative loadings, and the reactivity control obtainable for each loading.

Loading #	Total Excess Reactivity % Δ k/k	Total Rod Worth % Δ k/k
5	1.67	8.34
24 D	0.87	6.69
27 H	1.36	4.89
29	2.81	7.76

Future loadings utilizing beryllium oxide reflectors generally will be similar to the graphite-reflected loadings shown on the enclosed figures. Four safety rods will be available for control of cores reflected with beryllium oxide rather than the three presently on hand.

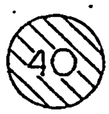
<u>Description of Loading Diagram</u>


- Full (100%) fuel element (Approximately 170 grams of U-235)



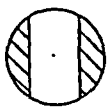
- 80% fuel element (Approximately 136 grams of U-235)

- 60% fuel element (Approximately 102 grams of U-235)

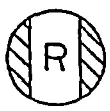


- 40% fuel element (Approximately 68 grams of U-235)

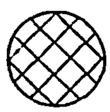
- 20% fuel element (Approximately 34 grams of U-235)

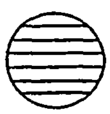

- Control Rod fuel element without rod (Approximately 102 grams of U-235

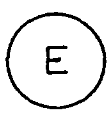
- Control Rod fuel element with safety rod.



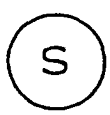
- Control Rod fuel element with regulating rod.


- Graphite reflector element (Approximately 7,470 grams per element)


- Beryllium reflector element



- Experimental element (Isotope production element, core access element, etc.)



- Po-Be Source

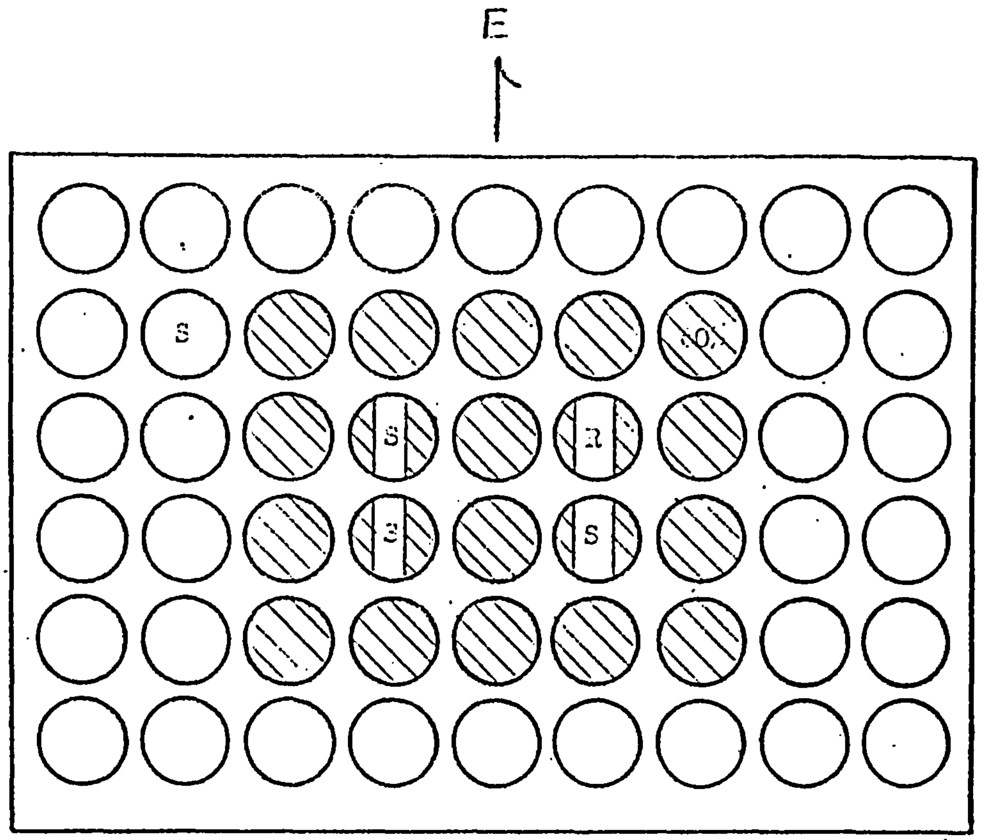


FIGURE 2

ROD POSITIONS: SR-1 11.6" SR-2 23" SR-3 23" RR 13"

LOADING NO. 5 TOTAL FUEL (U-235)= 2650 gms

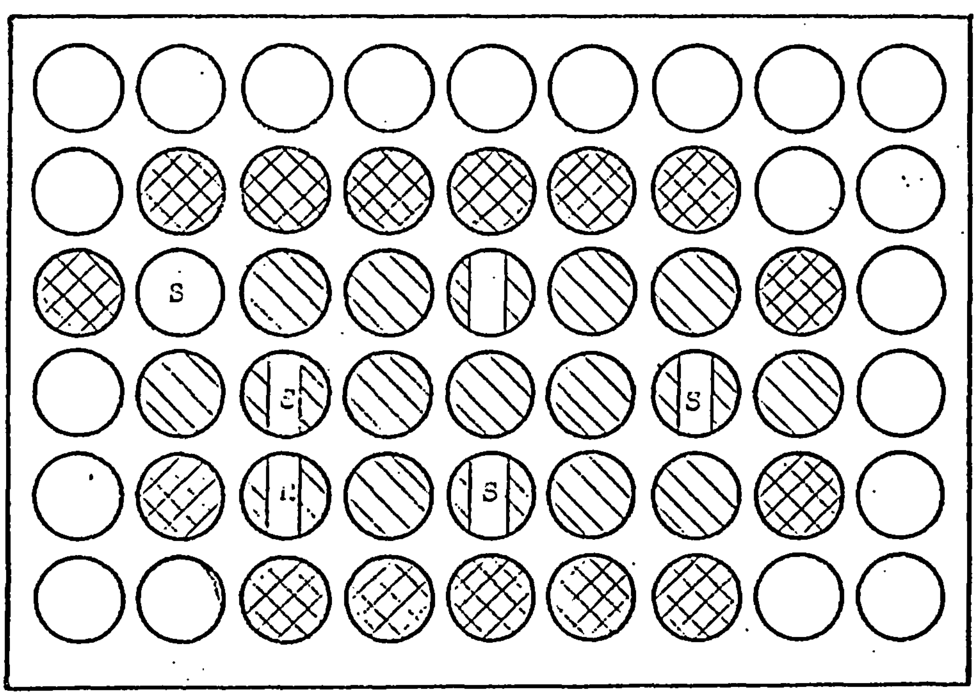


FIGURE 3

ROD POSITIONS: SR-1 23 SR-2 12.49 SR-3 18.99 RR 13

LOADING NO. 24D TOTAL FUEL (U-235)= 2540 gms

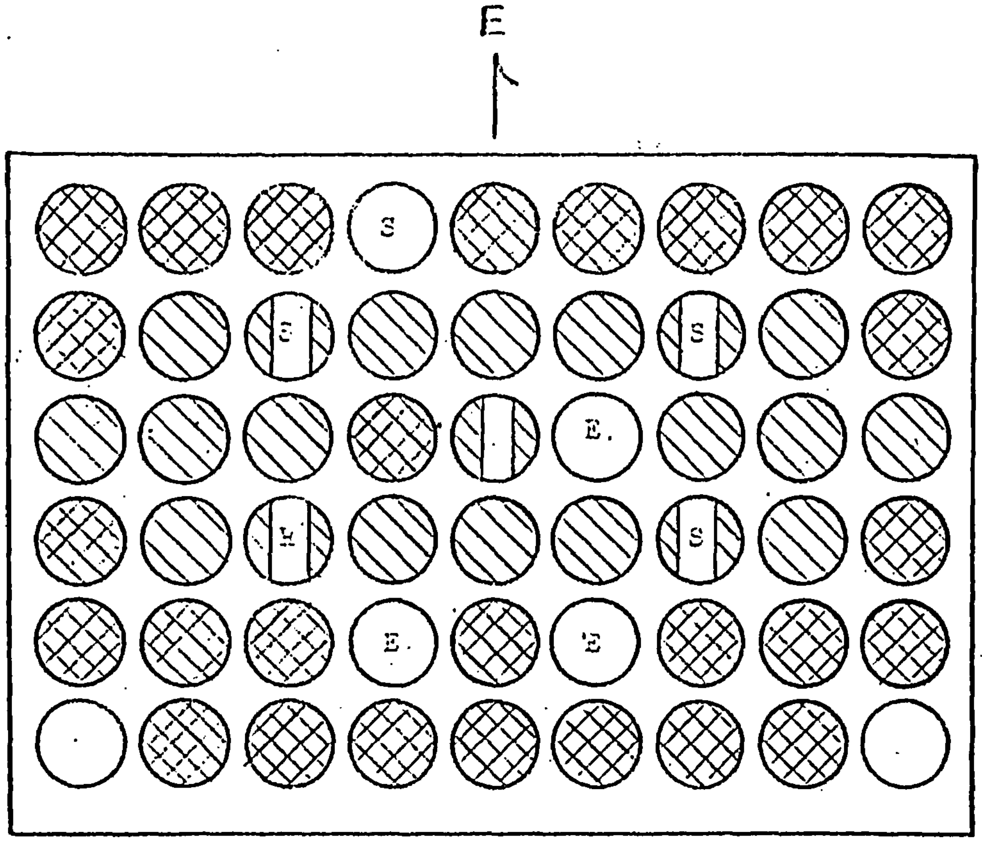


FIGURE 4

ROD POSITIONS: SR-1 15.07 SR-2 14.28 SR-3 15.45 RR 12.3

LOADING NO. 27II TOTAL FUEL (U-235) = 3,230 gms

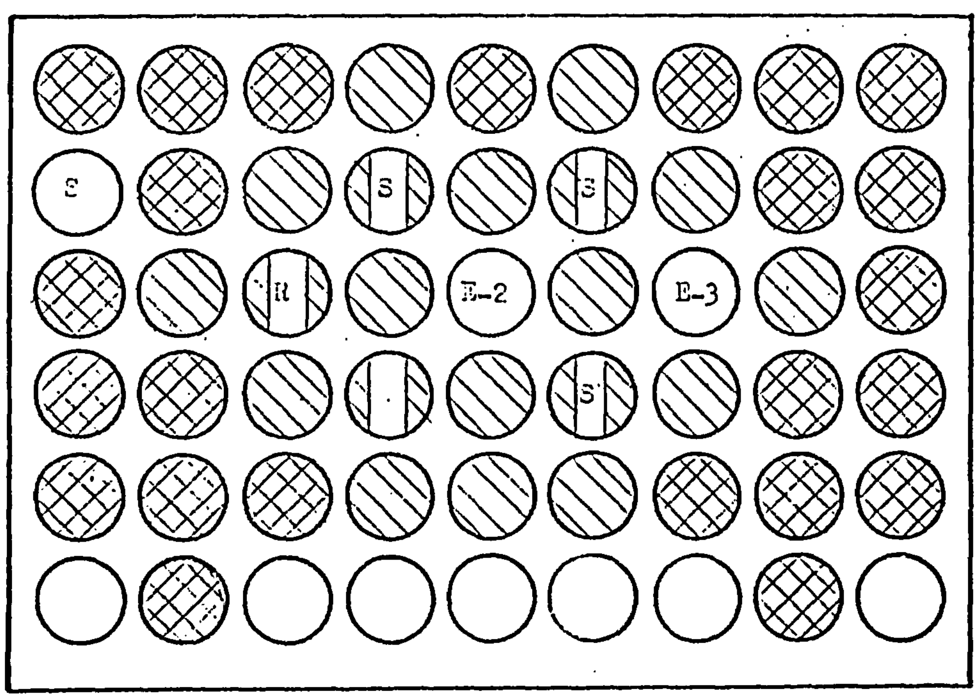


FIGURE 5

ROD POSITIONS: SR-1 14.61 SR-2 14.70 SR-3 14.62 RR 12.15

LOADING NO. 29 TOTAL FUEL (U-235) = 3,060 gms

4. Identify the personnel on the Curtiss-Wright Hazards Committee. To whom do they report and, in case of a dispute between operations and the hazards committee, who resolves the issue?

Member	Reports to
C. F. Leyse, Ex Officio	J. W. Dickey, Manager, Research Division
W. F. Sjoborg	S. H. Klein, Manager, Experimental Operations
M. T. Beam	C. F. Leyse, Chief, Nuclear Sciences and Engr. Dept.
F. W. Kleimola	R. W. Sliger, Ass't. Chief, Nuclear Sciences and Engr. Dept.
W. F. Hall	S. H. Klein, Manager, Experimental Operations
J. W. Sausville	C. F. Leyse, Chief, Nuclear Sciences and Engr. Dept.
N. R. Wheelock (Chairman)	C. F. Leyse, Chief, Nuclear Sciences and Engr. Dept.

In case of dispute the issue is submitted to Mr. C. F. Leyse, Chief of the Nuclear Sciences and Engineering Department, for decision.

5. Give a description of typical experimental programs to be carried out at 4 Mw operation.

1) Irradiation Studies

Irradiation studies will be performed on various materials for irradiation damage effects. Typical examples might be the determination of the ductile brittle transition temperature in steel or carbonaceous materials studied for changes in physical properties.

2) Nuclear Environmental Testing

Electronic and nuclear components will be irradiated while in operation and the characteristics determined with various fluxes. Typical components would be standard electronic tubes, transistors, and passive components such as resistors and capacitors. In addition, new nuclear detectors will be tested for their characteristics.

3) <u>Fuel Element Irradiation</u>

Metallic and ceramic fuel elements will be irradiated to various burnouts and metallographic and ceramographic examination performed.

4) <u>Isotope Production</u>

Various isotopes will be produced to support manufacturing and research work for Curtiss-Wright Division.

5) <u>Training</u>

The reactor will be used to acquaint company personnel and customer's personnel with reactor operation techniques.

6. Describe possible accidents due to incorrect loading or intermixing of 10-plate and 19-plate fuel elements; describe possible accidents due to incorrect loading or intermixing of graphite and beryllium-oxide reflectors; describe possible accidents due to intermixing of fuel assemblies and reflector units. Analyze consequences of such accidents. How do these compare with the postulated maximum credible accident?

The enclosed chart (TABLE I) depicts various combinations of erroneous intermixing of fuel and reflector elements, and the results thereof.

In evaluating TABLE I, it should be noted that when reproducing known loadings, Curtiss-Wright standard operational procedures require that all loading be performed with the safety rods at 13 inches (shim range) and that the log count rate, period, and linear power recorders be monitored during the loading operation. The loading operation itself is carried out slowly at the direction of the operator monitoring the instruments. Thus, addition of sufficient excess to achieve prompt criticality at shim range is precluded.

The most serious situation considered, that of substituting one or more 10-plate elements for 19-plate element(s), as detailed in TABLE I, would result in nucleate boiling in the 10-plate element(s), as indicated in TABLE II. This may result in unstable operation of the reactor. This would not compare with the magnitude of the maximum credible accident, which Curtiss-Wright has evaluated in Hazards Report No. CWR 4062.

TABLE I. ELEMENT INTERCHANGE SITUATIONS

Situation	Type Interchange	Core Loading *	Effect on Criticality	Significant Effect on Heat Transfer	Remarks
** Fuel for Fuel	10 plate for 19 plate	Unknown	None #	Yes	Nucleate boiling may occur at hot spot in 10-plate element.
Fuel for Fuel	10 plate for 19 plate	Known	Slight Decrease in K	Yes	Nucleate boiling may occur at hot spot in 10-plate element.
Fuel for Fuel	19 plate for 10 plate	Unknown	None #	No	No significant change
Fuel for Fuel	19 plate for 10 plate	Known	Slight Increase in K	No	No significant change
Reflector for Reflector	Graphite for BeO	Unknown	None #	No	No significant change
Reflector for Reflector	Graphite for BeO	Known	Slight Decrease in K	No	No significant change
Reflector for Reflector	BeO for graphite	Unknown	None #	No	No significant change
Reflector for Reflector	BeO for graphite	Known	Slight Increase in K	No	No significant change
Fuel for Reflector	Any	Unknown	None #	No	No significant change
Fuel for Reflector	Any	Known	Max. Increase in K of 1.02% (19 plate for Graphite at Front Edge)	No	No significant change
Reflector for Fuel	Any	Unknown	None #	No	No significant change
Reflector for Fuel	Any	Known	Decrease in K	No	No significant change

* A "known" loading has previously been in operation. Information regarding critical mass, rod positions and excess reactivity, is available. "Unknown" loading refers to a configuration which has never been studied.

** Ref: Safety factor against burnout 1.7. Reference used DP-363 "Burnout of Heating Surfaces in Water" by R.L. Menegus, 3/59.

In the case of an "unknown" loading, a critical experiment is mandatory; therefore, any difference in critical rod positions due to the interchange will not be observed.

TABLE II. HEAT TRANSFER ANALYSIS OF ITEMS 1 AND 2 TABLE I

*Basic Core Loading	19 Plate		10 Plate	
Thermal Power, kw	4,000	4,000	1,760	1,760
**Case Number	I	II	III	IV
Fuel Assembly Analyzed	19 Plate	10 Plate	19 Plate	10 Plate
Coolant Velocity, ft/sec	3.2	5.4	1.76	3.0
Mass Flow Rate, lb/hr-ft^2	715,000	1,200,000	393,000	670,000
Reynold's Number	8,000	28,800	4,400	16,000
Film Coefficient	1,100	1,430	681	895
Maximum Heat Flux, Btu/hr ft^2	75,500	151,000	27,000	54,000
Maximum Film Drop, °F	68.6	105.0	39.6	60.3
Coolant Temp. Rise to Hot Spot, °F	7.2	8.5	10.5	5.5
Maximum Fuel Surface Temp., °F	166.0	203.0	141.0	156.0
Hot Spot Surface Temp., °F	217.0	279.0	174.0	200.0
Hot Spot Rods Inserted, °F	246.0	323.0	190.0	225.0
Burnout Heat Flux, Btu/hr ft^2	820,000	950,000	750,000	890,000
***Safety Factor Against Burnout	6.5	3.8	16.6	9.9

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*Flow Rate	1200 gpm
Coolant Inlet Temp.	90°F
Hot Spot Saturation Temp.	240°F

***Including 1.67 hot channel factor

**Case Number

Core Loading:	I	II	III	IV
19 Plate Assemblies	15	15	1	1
Control Assemblies	4	4	4	4
10 Plate Assemblies	1	1	15	15
TOTAL	20	20	20	20
Fuel Plates per Control Assembly	10	10	6	6

Grams U-235 per Plate

19 Plate Assembly	10 gm/plate
10 Plate Assembly	17 gm/plate

CURTISS-WRIGHT RESEARCH REACTOR
STANDARD OPERATIONAL PROCEDURES

TITLE: Display and Numbering System for Core Elements

August 10, 1959

A. Element Numbering System

1. Purpose

In order to maintain accurate records of element usage it is essential that each element be numbered in such a manner so as to be distinguishable from all other elements. This is accomplished by engraving a combination of Roman and Arabic numerals on fuel elements and a combination letter and Arabic number on reflectors.

2. Significance of Numbers

Roman numerals are used to describe a type of fuel element; that is a full fuel, partial fuel on the convex side, partial fuel on the concave side, and rod elements. Arabic numerals identify individual elements on one type and are numbered consecutively from 1 through 100 for 10 plate and 101 and above for 19 plate. The table on the following page lists the color and numbering code for display cards (Section B-1) and elements expected to be used in the CWRR.

3. Significance of Letters

Letters are used only on reflector elements. G is used to designate graphite, B indicates beryllium oxide, and E stands for experimental or isotope production element. Core access elements will not be numbered.

B. Reactor Element Display

1. Purpose

Although the position of all reactor elements is at all times recorded in the log book, it is desirable to have a graphic representation for the sake of clarity. The Curtiss-Wright system provides 2 panels representing all possible element positions; one panel for core position and the other showing storage rack locations (see the two figures on the following pages). Each element has its counterpart in a 4-inch-square card. Every card is labeled so as to represent one particular element. By placing the cards in proper locations on the appropriate panel, every element can be accounted for as being either stored or in use in the core.

COLOR AND NUMBERING CODE FOR CARDS AND ELEMENTS

10 Plate Fuel Elements

Type	Background Color	Color of Number	Other Coloring	Typical Number
Full	Red	Black		I-1, I-2, etc.
80% fuel on convex side	Red	Black	4 yellow stripes	II-1, II-2, etc.
80% fuel on concave side	Red	Black	4 yellow stripes	III-1, III-2, etc.
60% fuel on convex side	Red	Black	3 yellow stripes	IV-1, IV-2, etc.
60% fuel on concave side	Red	Black	3 yellow stripes	V-1, V-2, etc.
40% fuel on convex side	Red	Black	2 yellow stripes	VI-1, VI-2, etc.
40% fuel on concave side	Red	Black	2 yellow stripes	VII-1, VII-2, etc.
20% fuel on convex side	Red	Black	1 yellow stripe	VIII-1, VIII-2, etc.
20% fuel on concave side	Red	Black	1 yellow stripe	IX-1, IX-2, etc.
Rod	Green	Black		X-1, X-2, etc.

19 Plate Fuel Elements

Type	Background Color	Color of Number	Other Coloring	Typical Number
Full	Red	Black		I-101, I-102, etc.
80% fuel on convex side	Red	Black	4 yellow stripes	II-101, II-102, etc.
80% fuel on concave side	Red	Black	4 yellow stripes	III-101, III-102, etc.
60% fuel on convex side	Red	Black	3 yellow stripes	IV-101, IV-102, etc.
60% fuel on concave side	Red	Black	3 yellow stripes	V-101, V-102, etc.
40% fuel on convex side	Red	Black	2 yellow stripes	VI-101, VI-102, etc.
40% fuel on concave side	Red	Black	2 yellow stripes	VII-101, VII-102, etc.
20% fuel on convex side	Red	Black	1 yellow stripe	VIII-101, VIII-102, etc.
20% fuel on concave side	Red	Black	1 yellow stripe	IX-101, IX-102, etc.
Rod	Green	Black		X-101, X-102, etc.

Reflectors

Type	Background Color	Color of Number	Other Coloring	Typical Number
Full graphite	Blue	Yellow		G-1, G-2, etc.
Full BeO	Blue	Red		B-1, B-2, etc.
Graphite I.P.E.	Black	Yellow		GE-1, GE-2, etc.
BeO I.P.E.	Black	Red		BE-1, BE-2, etc.
Core access	Black			
BeO source reflector	Yellow	Red		SB-1

2. Significance of Colors

The solid background colors identify an element as to general type. That is red for fuel, green for rod, blue for reflector, and black for isotope production elements. For reflector and isotope production elements the color of the numbers has significance. Yellow is used for graphite and red for beryllium oxide. A yellow stripe is used to designate the percentage of fuel in a partial element. Each stripe indicates 20% full fuel loading.

3. Significance of Numbers

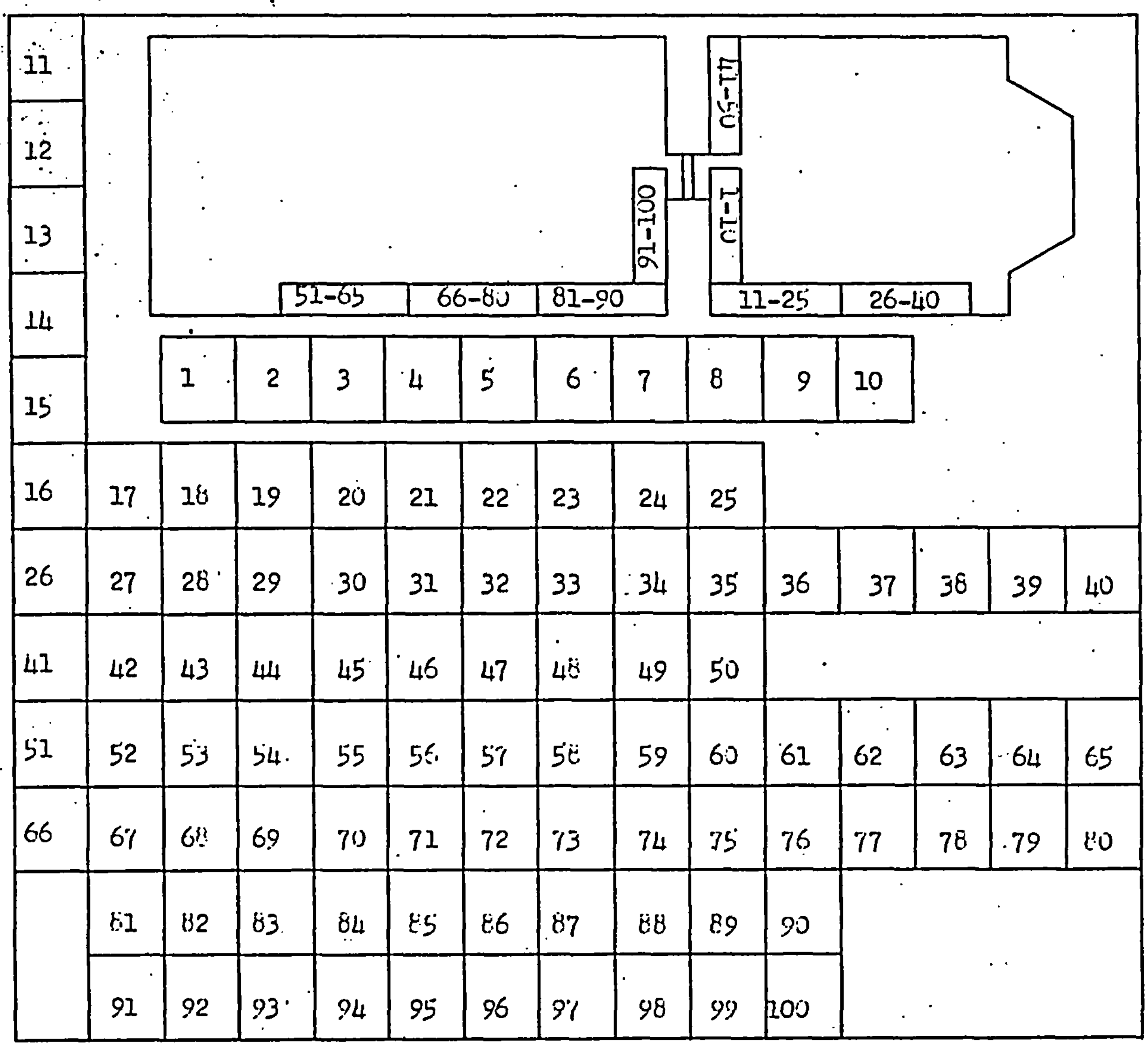
The numbers on the cards correspond to the number engraved on the actual element. This same number is to be used in keeping the reactor log and all other records.

4. Maintaining Display

Any time an element is moved the transaction must be recorded on the display. The display must be modified at the time of the change so that it is always an up to the minute indication of the element location. When an element is removed from the pool its card must be removed from the display and given to the fuel custodian.

A1	A2	A3	A4	A5	A6	A7	A8	A9
B1	B2	B3	B4	B5	B6	B7	B8	B9
C1	C2	C3	C4	C5	C6	C7	C8	C9
D1	D2	D3	D4	D5	D6	D7	D8	D9
E1	E2	E3	E4	E5	E6	E7	E8	E9
F1	F2	F3	F4	F5	F6	F7	F8	F9

Core Display Board



Storage Display Board

June 30, 1959

CURTISS-WRIGHT RESEARCH REACTOR
STANDARD OPERATIONAL PROCEDURES

TITLE: Start-Up of Reactor Cooling System

The CWRR cooling system is equipped with a heat exchanger and cooling tower (see drawing on page 28) to provide adequate cooling for continuous operation at power levels in excess of 100 kw. The following procedure will be followed in operating this equipment:

A. Primary Cooling

1. Convection Cooling (For Operation at Less than 100 kw)

   a. Open plenum chamber flapper valve (handle on bridge in down position).

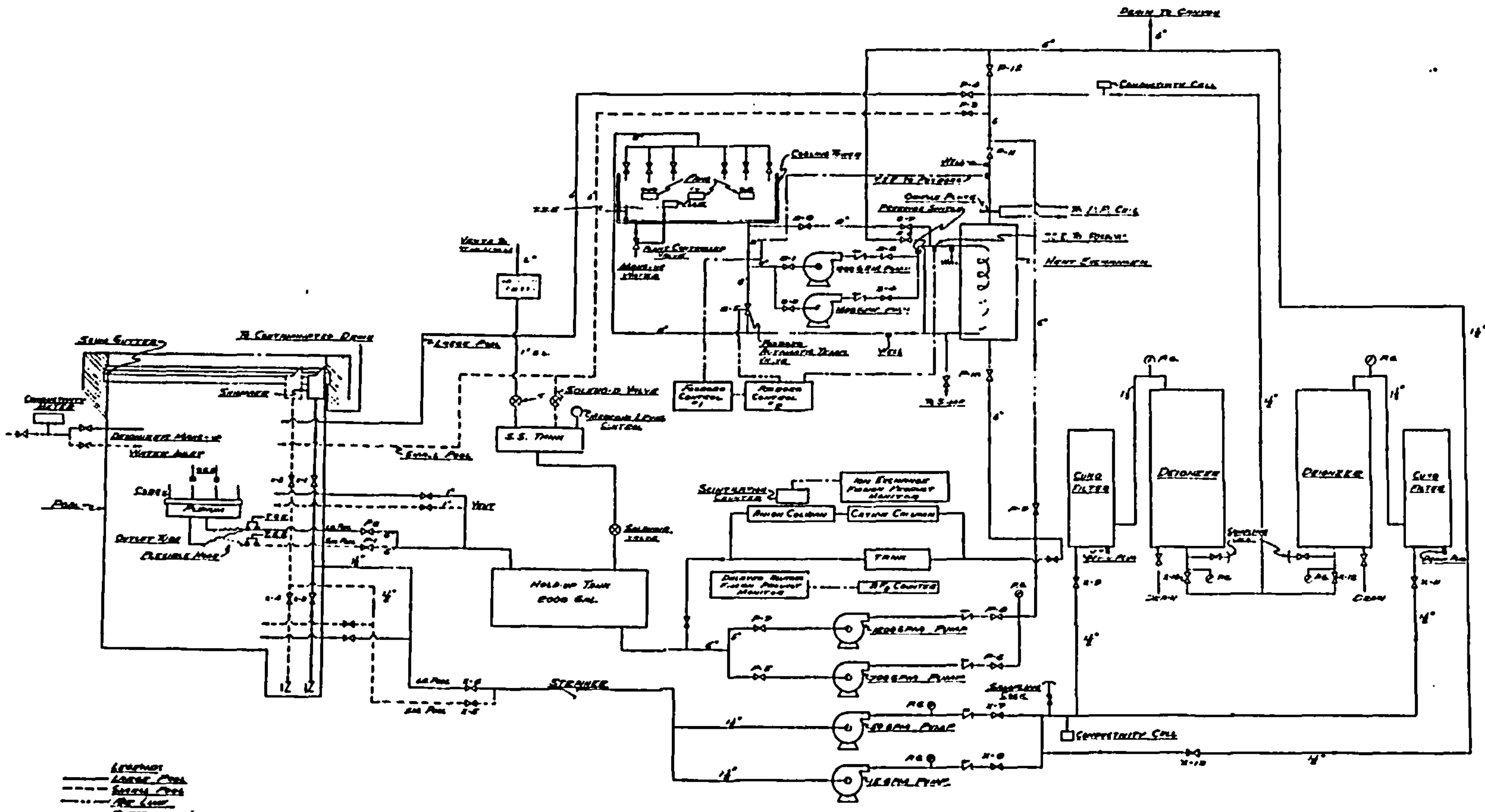
2. Forced Cooling (For Operation at Greater than 100 kw)

   a. Select Flow Rate

      1) 700 gpm primary (for operation between 100 and 1000 kw)

         a) Open valve P-1, small pool outlet, or P-2, large pool outlet.
         b) Open valve P-5, 700 gpm pump inlet.
         c) Close valve P-6, 700 gpm pump discharge. Note: Both primary pumps should be started against closed discharge valves.
         d) Open valve P-10, heat exchanger inlet.
         e) Open valve P-11, heat exchanger outlet.
         *f) Open valve P-3, small pool return, or P-4, large pool return. (With gate removed, it may be desired to return the water to the opposite pool from which it was drawn. In this case either the pair of valves P-1 and P-4, or P-2 and P-3 would be opened.)
         g) Close valves P-8, 1200 gpm pump discharge, P-12, primary loop drain, and P-9, heat exchanger bypass.
         h) Throw motor power switch (located on bus duct) to "on" position.
         i) Start 700 gpm pump.
         j) IMPORTANT. After several seconds, as pump approaches speed, open valve P-6, 700 gpm pump discharge.

* Purification system should be shut down during any alteration of pool return valve J or K.



REACTOR POOL COOLING CLEANING AND PURIFICATION SYSTEM

2) 1200 gpm primary (for operation at greater than 1000 kw).

a) Open valve P-1, small pool outlet, or P-2, large pool outlet.
b) Open valve P-7, 1200 gpm pump inlet.
c) Close valve P-8, 1200 gpm pump discharge. Note: Both primary pumps should be started against closed discharge valves.
d) Open valve P-10, heat exchanger inlet.
e) Open valve P-11, heat exchanger outlet.
*f) Open valve P-3, small pool return, or P-4, large pool return. (With gate removed, it may be desired to return the water to the opposite pool from which it was drawn. In this case either the pair of valves P-1 and P-4, or P-2 and P-3 would be opened.)
g) Be sure to close valves P-6, 700 gpm pump discharge, P-12, primary loop drain, and P-9, heat exchanger bypass.
h) Throw motor power switch (located on bus duct) to "on" position.
i) Start 1200 gpm pump.
j) IMPORTANT. After several seconds, as pump approaches speed, open valve P-6, 1200 gpm pump discharge.

Vent valves, located in pits along the south side of the pool are locked open, to prevent a leak in the primary piping from siphoning the pool water.

b. Close plenum chamber flapper valve after full flow has been established.

B. Secondary Cooling

Selection of flow rates for the secondary coolant will be based largely on experience and weather conditions; therefore, no hard and fast rules can be made with regard to power level vs. secondary flow. Before starting the secondary loop pumps, the level of water in the cooling tower should be sufficient to insure a full sump. (See SOP 305, page 31 of this report).

1. 800 gpm Secondary

a. Open valve S-1, 800 gpm pump inlet.
b. Close valve S-2, 800 gpm pump discharge.
c. Be sure that valves S-6, S-7, and S-8 (drains) are closed.
d. Valve S-5, cooling tower by-pass, will operate automatically.
e. Throw motor power switch (located on bus duct) to "on" position.
f. Start 800 gpm pump.
g. IMPORTANT. After several seconds, as pump approaches speed, open valve S-2, 800 gpm pump discharge.
h. Throw fan power switch (located on bus duct) to "on" position.
i. Start cooling tower fans, as required.

* Purification system should be shut down during any alteration of pool return valve J or K.

2. 1600 gpm Secondary

a. Open valve S-3, 1600 gpm pump inlet.
b. Close valve S-4, 1600 gpm pump discharge.
c. Be sure that valves S-6, S-7, and S-8 (drains) are closed.
d. Valve S-5, cooling tower by-pass, will operate automatically.
e. Throw motor power switch (located on bus duct) to "on" position.
f. Start 1600 gpm pump.
g. IMPORTANT. After several seconds, as pump approaches speed, open valve S-4, 1600 gpm pump discharge.
h. Throw fan power switch (located on bus duct) to "on" position.
i. Start cooling tower fans, as required.

3. 2400 gpm Secondary

a. Open valve S-3, 1600 gpm pump inlet.
b. Close valve S-4, 1600 gpm pump discharge.
c. Be sure that valves S-6, S-7, and S-8 (drains) are closed.
d. Throw motor power switch (located on bus duct) to "on" position.
e. Start 1600 gpm pump.
f. IMPORTANT. After several seconds, as pump approaches speed, open valve S-4, 1600 gpm pump discharge.
g. Open valve S-1, 800 gpm pump inlet.
h. Close valve S-2, 800 gpm pump discharge.
i. Throw motor power switch (located on bus duct) to "on" position.
j. Start 800 gpm pump.
k. IMPORTANT. After several seconds, as pump approaches speed, open valve S-2, 800 gpm pump discharge.
l. Throw fan power switch (located on bus duct) to "on" position.
m. Start cooling tower fans, as required.
n. Valve S-5, cooling tower by-pass, will operate automatically.

CURTISS-WRIGHT RESEARCH REACTOR
STANDARD OPERATIONAL PROCEDURES

TITLE: Filling and Draining the Secondary Cooling System

DATE : February 15, 1960

Reference

Drawing: "Reactor Pool Cooling, Cleaning and Purification System," included with SOP 301.

A. Introduction

Occasionally it will be necessary to drain the secondary cooling system, either to release water in which the concentration of soluble and particulate matter has become too high, or to prevent freezing in winter months. Operating experience will serve as a guide in the former case; weather expectations, operational requirements, and good judgment will determine the latter.

B. Procedure

1. Filling the Complete Secondary System

a. Close drain valves S-6 and S-8 located in the pit, and valve S-7 located above the pit near the heat exchanger.

b. Open the main supply valve located underground at the northeast corner of the cooling tower. The automatic float valve in the cooling tower reservoir, which is preset, keeps the water at the proper level. In winter months, when frequent draining is required to prevent freezing, it will be advisable to maintain only an inch or so of water in the basin, and operate the tower as a "wet slab," by taking advantage of the low winter temperature.

c. Open inlet and outlet pump valves S-1, S-2, S-3, and S-4. This precaution will prevent air pockets from building up in the system.

d. Open (1") one inch bleeder valve above sump pit. Keep this valve open until a steady flow of water runs, with no air bubbles present. This valve is tapped into the outlet line returning to the cooling tower from the heat exchanger.

2. Draining the Complete Secondary System

a. Close the underground supply valve.

SOP 305

b. Open drain valves S-6, S-7, and S-8.

c. Open inlet and outlet pump valves S-1, S-2, S-3, and S-4.

3. Draining the Heat Exchanger Only

a. Close inlet and outlet pump valves S-1, S-2, S-3, and S-4.

b. Close drain valves S-6 and S-8.

c. Open valve S-7.