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ORNL
CENTRAL FILES NUMBER

CF-57-7-51

DATE: July 16, 1957
SUBJECT: DESCRIPTION OF ORNL POOL TYPE
CRITICAL FACILITY
TO: File
FROM: A. E. G. Bates

COPY NO. 78

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A. General Description of Facility

The facility is a low powered, high enriched (90 to 95% U-235) ordinary light water-cooled and moderated, beryllium oxide reflected assembly. It is generally similar to the present Bulk Shielding Reactor at ORNL, the principal modification being that the grid plate is arranged to accommodate both ORR and BSR fuel elements. The principal function of the facility is to augment the BSR and ORR programs. It is designed to duplicate the nuclear characteristics of the BSR and provide properties similar to the ORR when the latter operates under conditions of low power and natural convection water cooling.

1. Location

The PTCF is located in the north-west corner of the existing BSR pool. It is rigidly fixed to the pool base and north wall rather than being mounted on a movable bridge as is the BSR. Figure 1 shows the layout of the BSR Building and the locations of the two facilities. Positive stops will prevent the existing BSR bridge from being moved far enough northward to bring the two facility cores within range of significant interaction.

2. Reactor

a. Core and Supports

The core is supported on a laminated aluminum grid plate which in turn is mounted on a suitable aluminum structure and a heavy aluminum bed plate rigidly fastened to the pool bottom. The bed plate serves to anchor experimental setups when required. The grid plate constitutes the sole positioning means for the fuel elements and reflector pieces. The control rods and their drive mechanisms are also positioned and supported by the grid plate but due to their great length (approximately 20 feet) are further

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FIGURE "1"

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PROJECT	NO.
PLAN OF BSR BUILDING	
ONE FINE ROOMS LABORATORY	
DESIGNED BY	
UNION CARBIDE NUCLEAR COMPANY	
A DIVISION OF UNION CARBIDE CORP.	
NEW YORK, N.Y.	
DATE: 3/67	
PROJECT: RCB-SKS	

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guided at the working platform as indicated in Figure 2. When BSR fuel elements are used the full grid plate is required. When ORR fuel is to be substituted, the reactor core is dismantled and the top lamination of the grid plate is lifted off exposing sockets machined to accept the somewhat different end pieces found on this fuel. Adaptors are added to the beryllium oxide pieces and the control rod assemblies to make them fit the ORR type sockets. The 9 x 7 lattice provides 63 fuel, control rod, or reflector positions. Figure 2 shows a typical working configuration using a 7 x 4 lattice surrounded by beryllium oxide pieces. Four of the fuel positions are occupied by control rods leaving 24 spaces for standard BSR or ORR fuel elements.

b. Control Rods

Three shim rods and one regulating rod are supplied. A typical shim rod assembly is shown in Figure 3. The rod drive and associated guide tube, magnet, synchro repeaters, and various position switches are mounted directly onto a modified BSR fuel element. Several advantages accrue from this design. For example, the rod itself is completely enclosed within the modified fuel element thereby preventing any contact between the rod and adjacent normal fuel elements. This prevents, first, unintentional withdrawal of any of the adjacent fuel elements by the control rod because of binding resulting from friction, misalignment, or the presence of foreign objects and second, hang-up of the rod in case a scram is demanded. Further, it prevents the removal of the rod and its drive assembly without simultaneous removal of the attached modified fuel element. The worth of the rod is

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FIGURE *2

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BY 60342
ON 02-1-54
BY 60342

AUTOMATIC DRAWING		DATE 10-1-54
POOL TYPE CRITICAL REACTOR SUB-SONIC		
REACTOR ASSEMBLY		
DR. H. H. HARRIS, ENGINEER		
UNION CARBIDE NUCLEAR COMPANY		
A DIVISION OF UNION CARBIDE AND CARBIDE CORPORATION		
APPROVED	DATE 10-1-54	APPROVED
W. H. HARRIS		W. H. HARRIS
REVISION		REVISION
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2		2
3		3
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5		5
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10		10

RCB-5405

MATERIALS LIST					
ITEM NO.	QTY	DESCRIPTION	UNIT	PRICE	TOTAL

APPROVED WORKMAN		DATE
POOL TYPE Chemical Agents Bldg 200		
CONTROL ROD ASSEMBLY		
ONE RAZOR BLADE LOCKDOWN APPROX 4'		
UNITED STATES NUCLEAR COMPANY A MEMBER OF UNITED CARBIDE AND CARBON CORPORATION		
BY [Signature]		SIGNED
[]	[]	RCD-SK7

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approximately 2 to 2-1/4 % $\Delta k/k$. Physically it is comparable to those used in the BSR (See ORNL-991, May 8, 1951), being different principally in that a more versatile and more quickly releasing electro-magnet is employed.

The regulating rod will be a duplicate of the one used in the BSR. Its worth will be approximately 0.5 % $\Delta k/k$. It is driven by an On-Off type servo and operates independently of the safety system. The drive is direct and not through a magnet as in the case of the shim rods.

c. Water Biological Shield

Since the PTCF is to be located at the same depth of water (17'-8" to the horizontal center line of the core) as the BSR core and since the flux levels will normally be lower than those of the BSR, the radiation hazard will be correspondingly smaller. (See ORNL-1823 and ORNL-2081).

d. Operating Platform

The platform will rest on and be attached to the concrete wall of the pool, with any additional bracing required being placed below the platform. It will provide ready access to the rod drive motors, position switches, and other equipment. The platform will be arranged in three sections, the center one extending from the reactor to the north wall being fixed, while those to the east and west being removable. Removal of the east and west sections will allow the existing building crane to bring experiments directly against the three usable faces of the reactor if desired. Raceways will be provided under the fixed platform section for the various cables and wires running to the chambers, rod and fission chamber drive mechanisms, as well as for experimental use as required. The fixed section

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of the platform will also provide mounting points for the upper guides of the rod and fission chamber drive assemblies.

Access to the platform is gained by using a removable short ladder. Alongside of the ladder and a part of the fixed center section of the platform is the electrical junction box. In this box cables and wires from the motors, chambers, etc. at the facility are joined to those from the control cabinet in the control room. Buried conduit is used to tie the junction box to the control cabinet. Approximately fifty percent of the conduits installed are assigned as "spares" for use of experimenters and control system changes and the like.

B. Facility Control

1. Control Rods

Three shim rods and one regulating rod are used, these having withdrawal speeds of 6 and 48 inches per minute respectively. This results in an average change of approximately 0.037 $\Delta k/k$ per second total for the three shims and 0.0182 $\Delta k/k$ per second for the regulating rod. All four rods are driven by induction type A.C. motors from a fixed frequency source, thereby positively limiting the maximum rod speeds under all conditions.

The regulating rod may be used with the servo system when desired to provide automatic control of the reactor at constant power level.

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2. Control Instrumentation

a. General

The instrumentation is conventional for this type of reactor and is similar to that employed with the BSR. It is shown in block diagram form in Figure 4. Attention is also directed to reports ORNL-991 dated May 8, 1957, ORNL-1139 dated April 4, 1952, and ORNL-2240 dated January 21, 1957, for details of the systems and individual components.

b. Description

Nuclear information is transmitted to the operator and to the control and safety systems from several channels as follows:

- (1) Level Safety. Three PCP chambers supply current to three Level Safety Channels.
- (2) Period. One compensated chamber supplies current to a Log N and Period Channel.
- (3) Linear. One compensated chamber supplies current to a Leeds and Northrup micromicroammeter and the servo channel.
- (4) Counting Rate. One fission chamber supplies pulses to a Linear Amplifier, Pulse Height Selector, Scaler and Log Count Rate Meter. It further supplies period information at starting levels.

c. Chambers

The three types listed above are the same as are currently in use at various ORNL reactors including the BSR. No purge gas supply is used

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with the chambers since all are of the sealed type. Both the PCP and compensated chambers are of ORNL design. The fission chamber is one designed and fabricated by Westinghouse (See WAPD-44). All chambers will be installed in a manner similar to that employed for the BSR.

3. Control System

a. General

Figure 5 is the Block Diagram of the control system for this facility. Two methods of starting are provided, the usual "Manual" start and an auxiliary "Instrument" start. The latter may be looked on as being experimental in nature. The flux is normally held at any selected level automatically with the servo system or may also be maintained by the operator using the shim rod controls provided. All rod movements are accomplished through a relay system so arranged electrically that any failure of operating coils will not in itself produce or result in hazardous conditions.

All control, indicating, recording and electronic devices (except the pulse preamplifier) are assembled into a single metal enclosure with the various manual controls, position indicators, recorders, etc., arranged conveniently on the front panel. The enclosure is a "walk-in" type permitting ready access to all components for inspection, test or maintenance. The "On-Off" switch for the control system is provided with a lock, the key to which can be removed only when the switch is in the "Off" position. Turning the switch to "Off" scrams the control rods and blocks the control system from withdrawing them. To return to operation the key must be used to unlock the switch and the scram condition must be manually cleared by

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INFORMATION BUS

MATERIALS LIST

ITEM NO.	QTY.	NAME	REV.	APPROVED
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LEGEND

INFORMATION PATH

PERMISSIVE - MODES INFORMATION ONLY WHEN CONDITION DESCRIBED IN BUS IS TRUE

MANUAL SELECTOR - MODES INFORMATION ONLY WHEN THE ACTION IS MANUALLY SELECTED BY THE OPERATOR OR WHEN THE MODE IS MANUALLY SELECTED BY THE OPERATOR

MANUAL SELECTOR - AS ABOVE BUT WHEN THE ACTION IS MANUALLY SELECTED BY THE OPERATOR OR WHEN THE MODE IS MANUALLY SELECTED BY THE OPERATOR

MANUAL SELECTOR - AS ABOVE BUT WHEN THE ACTION IS MANUALLY SELECTED BY THE OPERATOR OR WHEN THE MODE IS MANUALLY SELECTED BY THE OPERATOR

MANUAL SELECTOR - AS ABOVE BUT WHEN THE ACTION IS MANUALLY SELECTED BY THE OPERATOR OR WHEN THE MODE IS MANUALLY SELECTED BY THE OPERATOR

NOT ALSO BE RELEASED WHEN THE INHIBIT ACTION PATH PASSING THROUGH THE BUS IS DETECTED AT ANY POINT.

ACTION - THE MODES OF THE ACTION IS TO BE TAKEN THE ACTION TWO LEVELS (HIGHEST PRIORITY) IN THE ACTION PATH. ACTION SEQUENCES WITH MANUALLY SELECTED BY THE OPERATOR.

AUXILIARY ACTION - ACTION NOT MANUALLY SELECTED BY THE OPERATOR. ACTION SEQUENCES WITH MANUALLY SELECTED BY THE OPERATOR.

CONDITION - CONTROL CONDITION CALLED THE MODES INFORMATION PATHS COMPLETE. MAY BE RESULT OF AN ACTION AND THE CASE OF REVERSE. MAY NOT BE IN THE CONDITION INFORMATION PATH.

FIGURE 5

FOR REFERENCE: DRAWING NO. 100-1-20

REVISIONS: 100-1-20

FOR TYPE CATALAN: 100-1-20

CF BLOCK DIAGRAM

ONE BLOCK DIAGRAM

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operating the "Reset" control. Figure 6 shows the front panel arrangement of instruments and controls.

This being an experimental critical facility, a number of different Start-up conditions may occur from time to time. By far the greatest number will, however, be with the core containing only cold clean fuel. Since this type of start-up is most frequently encountered and since it requires the instruments to measure the widest range of neutron flux (approximately ten decades) such start-ups are selected for consideration in the description.

b. Manual Start

Before starting the reactor and in either order, the operator will turn on the servo system and set into the micromicroammeter the desired power demand. The regulating rod will automatically withdraw to its upper travel limit. In this position it is best able to assume control of the facility when the desired flux level is reached.

As is customary, withdrawal of shim rods may be effected only when suitable instrument permission is granted. Referring to Figure 5 it will be seen that the counting channel is involved initially and in several ways. When all of these requirements are satisfied, operation of the "Group Withdraw" control handle will result in the simultaneous raising of all three shim rods. Sometime before reaching the upper limit of the counting channel range, a stable 25 to 30 second period will be established. In the process several false periods will be encountered and these should be recognized as such. Both real and false periods will deny further rod withdrawal as long as they exist. Once the flux reaches a level equivalent to 8000 counts per

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second fission chamber will be automatically withdrawn to a new position and thereby establish a second counting range. During the chamber relocating operation the counting channel will, of course, indicate periods different from the one actually existing in the facility. Blocking of shim rod withdrawal due to period limitations is lost but this is replaced by a block which is set up by movement of the fission chamber itself. Once the 25 to 30 second period has been established, the further withdrawal of rods will not be required. The flux will continue to increase steadily through the second counting range and the operator will simply follow the rise visually by watching the count rate meter.

As soon as the flux level rises sufficiently to be detected by the compensated chamber, the operator will transfer his attention to the Log N and Period Recorders. At about the same time the instrument permissives are automatically rearranged so that the Log N channel takes over all but the period functions from the counting channel.

When the flux level reaches the desired value the servo system will automatically assume control and will adjust the regulating rod as required to maintain that level. If for any reason the servo control fails, the operator can continue to hold the correct flux level by making small adjustments to shim rod positions as required. Individual rod positioning controls are provided for such purposes.

During a long period of continuous operation, it is conceivable that the regulating rod might work itself nearly all the way out of the core

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while maintaining the desired flux level. The operator would ordinarily note this and, while observing the usual precautions, would withdraw one or another shim rod to work the regulating rod back to a more desirable middle position. If he fails to take corrective action before the regulating rod reaches its upper travel limit an alarm will be sounded to call his attention to the condition.

If, because of some unusual condition, the regulating rod is unable to hold down the flux level within its limits of travel, it will cause one shim rod to begin to insert (and without the operator's help) as soon as it reaches its lower limit switch. Such shim rod insertion will continue until enough absorber is added to bring the regulating rod out to its middle position to compensate for it. At this point a position switch on the regulating rod will end its demand for shim rod insertion. Provisions are included in the control to allow the operator to select any one shim rod as the "Preferred" rod for this purpose.

It is intended that, in operating this facility, all shim rods be withdrawn together and kept together. This guarantees a maximum of effectiveness in the rods in the event a scram signal initiates immediate reduction of the flux level.

c. Instrument Start

Such starts are completed without operator assistance once manually initiated. Note that in this case, however, the counting channel must be operating at 20 counts per second and in addition the fission chamber drive must be in "Automatic" and the regulating rod fully "withdrawn"

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in order for the operator to be able to obtain "Instrument Start". Once these conditions have been met and the operator has pressed the "Instrument Start" button the action of the control system will be essentially the same as during manual starts. The operator will observe the same initial continuous raising of the three shim rods, the temporary halting of withdrawal, as the false 25 to 30 second periods occur and the final blocking of rod withdrawal when the constant 25 to 30 second period obtains. At 8000 counts per second the fission chamber will travel to its second position and shim rod motion is locked out. The flux level will continue to rise, going through the second counting range and into the Log N range until the "Set Point" is reached. At this level the "Instrument Start" is terminated automatically and the servo system assumes control exactly as in the manual starts.

d. Auxiliary Features

For maintenance, provisions are included for operating the shim rod drive mechanisms without moving the shim rods. Two limitations are imposed on this operation; first, a scram results when this condition or "Mode" of operation is selected and second, withdrawal of the mechanism can proceed only as long as the shim rod itself is seated, that is, fully inserted into the core as determined by the seat switch.

Reverse, or automatic rod insertion results when any one or more of several situations arise. These include periods less than 7 seconds, level too high (any one of four channels) and safety instrumentation trouble. Reverse, as well as any other rod insertion request is arranged always to

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override any withdrawal request.

Scrams may be initiated manually from various points in the building as well as from the control cabinet itself. Operation of any of the remote scram switches results in the shutting down of both the BSR and the PTCR but the local button controls the PTCR only.

Scram switches as well as the scram circuit itself must be manually reset to clear such scrams.

The fission chamber drive may be operated in either of two manners, "Automatic" or "Manual". "Automatic" is required for "Instrument Start" and is useful during manual start while "Manual" is found desirable for making adjustments and operation checks within the counting range.

e. Monitrons

Two area monitoring units are used, one located near the working area at the pool and one in the control room. Both are tied into the facility scram circuit and also have self contained alarms.

4. Power System

Two feeders are supplied, one for instrument use only, and a second for motors, control and similar loads. The instrument supply is from a "clean" source and is regulated by suitably sized Sola units. By "clean" is meant that no intermittent loads are connected to the secondary of the immediate feeder transformer. The feeder transformer with the aid of the Solas provide filtering of line disturbances and random voltage spikes produced by relays and motor starting. Such disturbances often adversely affect the sensitive instrument channels.

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The instrument feeder is rated 60 amperes at 120 volts, single phase, 60 cycles, while the control feeder is rated 100 amperes, 120/240 volts, three wire, single phase, 60 cycles. Normal loads run some 30% to 50% of the capacity which leaves a reasonable margin for additions and experimental equipment.

5. Grounding

Copper busses are run along the bottom of the front and rear sections of the control cabinet to provide convenient grounding points for the electronic components. The metal cabinet itself is made electrically continuous and is tied to this same grounding bus at one point. To prevent circulating grounding conductor currents the two electrical feeders and their conduits are insulated from the cabinet and grounded separately elsewhere. A 2/0 copper grounding conductor is used to tie the cabinet ground busses to a suitable lug on an adjacent large-diameter fire water line near where it runs into the earth.

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