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STANDARD OPERATING PROCEDURE FOR THE POOL CRITICAL ASSEMBLY

E. B. Johnson

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Neutron Physics Division

STANDARD OPERATING PROCEDURE FOR THE POOL CRITICAL ASSEMBLY

E. B. Johnson

Date Issued

AUG 12 1960

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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INTRODUCTION

The Pool Critical Assembly (PCA) is a versatile research tool intended to augment the Bulk Shielding Reactor (BSR) and the Oak Ridge Research Reactor (ORR) programs by handling most of the low power (up to 10 kw) experiments for these two reactors. It is used by the ORSORT classes for experiments and by the Reactor Controls Department for field testing of proposed modifications in control instrumentation. While it is impractical to attempt to describe all potential experimental arrangements or to predict modifications in the routine Operating Procedure necessitated by nonroutine conditions, most of the material contained in this document is applicable equally to routine and nonroutine conditions.

The philosophy of operation for this reactor has been evolved from several years' experience with the BSR and from almost two years' experience with the PCA itself. The instrumentation for the PCA is quite similar to that of the BSR and the control system is designed to "fail safe" under all foreseeable conditions. (The details of the instrumentation are discussed in another section of the Operating Procedure.) The operator is considered an integral part of the control system, not solely for his mechanical actions, but primarily for his ability to evaluate conditions indicated by the control instrumentation and to use judgment in his response. Every reasonable effort is made to ensure that the reactor safety system is capable of responding as intended to abnormal conditions, and under no circumstances is routine operation permitted with any portion of the safety system disabled.

BRIEF DESCRIPTION OF THE PCA

The Pool Critical Assembly is located near the northwest corner of the pool of the Bulk Shielding Facility. The support structure for the core and control chamber guides is mounted on a plate anchored to the floor of the pool. The support structure for the tops of the rod drives, the chamber lift tubes, and the control power and signal cable trough is attached to the pool wall at the surface of the pool. The loading platform is located above the pool rail over the cable trough and the core. The control system console is located off the northwest side of the pool room.

The PCA was designed to receive fuel elements with either round (BSR-type) or square (ORR-type) end boxes. This is accomplished by means of "stacked" grid plates, the BSR grid plate (round holes) resting on top of the ORR grid plate (square holes), and positioned by dowel pins from the bottom of the BSR grid into properly located holes in the top of the ORR grid. When a core consisting of ORR fuel elements is to be installed, the BSR grid plate is lifted off with the special handling tool, making the ORR grid plate available.

Control of a core consisting of either BSR or ORR fuel elements is normally accomplished by means of four BSR-type control rods and associated drive mechanisms. The rods are moved within special control rod fuel elements. Three of the control rods contain boron carbide as the neutron-absorbing material and are designated as shim-safety rods. The fourth rod is a shell of type 347 stainless steel and is called the regulating rod. The shim-safety rods are supported by electromagnets; the extension tubes on the magnets are, in turn, directly attached to the individual drive motor shafts. These rods may be positioned by the manual operation of the appropriate switches on the control panel. The regulating rod is attached directly to its drive mechanism and may be positioned

either by manual operation or by the servomechanism. The special fuel elements through which these rods travel are identical, each containing about 70 grams of U^{235} in nine fuel-bearing plates. The special control rod elements may be positioned in the ORR grid plate by the use of adapters which support the rod elements at the correct height for the ORR fuel elements. These same rod elements are used without adapters in the BSR grid plate. Figure 1 shows the installation in the pool of the BSF.

In addition to the normal four control rods, there can be incorporated into the reactor safety circuits two more control devices which may be either control rods or safety plates ("guillotines"). The safety plates consist of cadmium sheets, supported on each side by aluminum, located on the outside of a core and positioned in the grid plate by BSR-type plugs.

ORGANIZATION

The responsibility for the schedule and operation of the PCA rests with the Bulk Shielding Facility of the Neutron Physics Division. Actual operation of the Assembly may be carried out by either an operator or a supervisor. Appendix A contains the current list of supervisors and operators for this installation. It will be modified when necessary as provided herein.

Supervisors

The supervisors for the PCA have complete responsibility for the safe operation and general condition of the installation. Only under the personal direction of a supervisor may the following operations be performed: (1) changes in the core or the reflector; (2) changes in instrumentation or wiring of the control system; (3) deviations from the prescribed "Standard Operating Procedure," which may be necessary to conduct certain chamber performance checks; (4) installation of new experiments. Reactor operation involving new fuel elements may be

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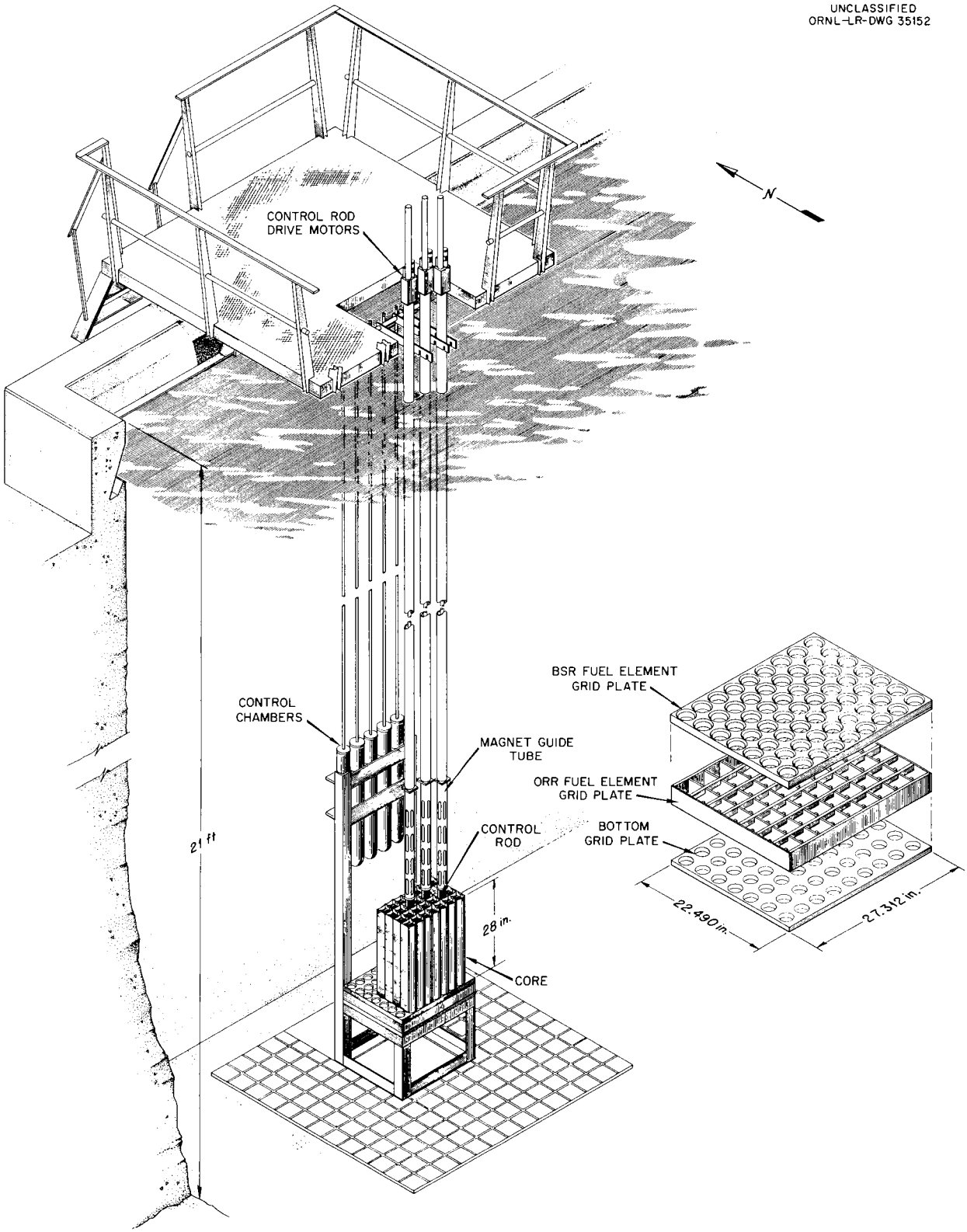

Fig. 1. The Pool Critical Assembly.

carried out only by a supervisor until it is determined that sufficient experience has been gained with the new fuel to put operation on a routine basis. In the event of an emergency connected with the reactor in any way, the reactor supervisor has the responsibility and authority to take the proper remedial action. An emergency is defined as any reactor abnormality which cannot be or is not corrected by the controls on the reactor console.

The reactor supervisors have the responsibility for the training and approval of operators of the reactor. Such approval shall be indicated by signing and dating the copy of page 14 of this document which is located in PCA Log Book No. 1. Since training will usually be done under the direction of one of the supervisors, the approval signature should be that of the supervisor who recommended the approval of an operator.

The reactor supervisors have the responsibility for the review and safety of all experiments performed with this reactor, as amplified in a later section.

Operators

A PCA operator may take the reactor critical, make changes in neutron level as required by the experiment, and shut the reactor down, as specified in Appendix B, Sections I, II, and III. For routine operations the reactor may be left with an operator. All nonroutine operations require the presence of a supervisor.

Since the amount of available excess reactivity in the reactor depends upon the requirements of the experiment to be performed, and may vary between about 0.1% and 2.5%, an operator who is approved for low available excess reactivities may not necessarily be approved for reactivities above 0.5%. The type of approval for each operator is indicated in Appendix A.

In order to maintain his approval, an operator must demonstrate his familiarity with the reactor at intervals no greater than three months. It shall be the responsibility of the operator to keep his approval active.

Under no condition shall the same person actively serve as operator of both the BSR and the PCA at the same time.

Experiments

Experiments scheduled for the PCA shall be described in reasonable detail in the current reactor log book in advance of their installation. Each experiment shall be reviewed by at least three members of the BSF Experiment Review Committee. Each member of the committee shall indicate his approval by signing the proposal in the log book, together with any comments he may make. Any questions not resolved satisfactorily by such review shall be referred to the Experiment Review Committee of the Neutron Physics Division.

The letter of approval for operation of this reactor specifies that "Experiments involving the potential loading of large amounts of excess reactivity will be limited to not more than 2.5% available excess by rigidly affixing neutron poisons which cannot be removed from the active lattice without prior removal of adjacent fuel."* Should any proposed experiment require deviation from this stipulation, prior approval for the experiment must be obtained from AEC, in addition to the normal review received by all PCA experiments.

Whenever experimental apparatus is placed against the reactor in such a manner as to significantly reduce the reactivity, the fuel added to maintain criticality will be unloaded before the reactor is left unattended. Exceptions

---

*Letter from S. R. Sapirie to C. E. Center, dated December 3, 1957. Subject: "Pool-Type Critical Assembly (PTCA)."

to this rule may be made when the apparatus is permanently attached. Equipment may be considered permanently attached if it is mechanically mounted on the reactor support mounting plate in such a way that its position relative to the core cannot be accidently altered and cannot be intentionally altered without the exertion of considerable effort. When any experimental device is left unattended, its condition shall be such that any credible change would result in a reduction in reactivity.

Under no circumstances may the bridge carrying the BSR, the instrument bridge, or any other possibly perturbing equipment be moved closer than 3 feet to the PCA or to installed experiments unless specific preparations have been made under the direction of a PCA supervisor. A PCA supervisor shall be present throughout the operation.

INSTRUMENTATION

The normal instrumentation for the PCA consists of eight chambers, the signals from which are displayed on the control panel (Figure 2). There are three PCA chambers (total ionization) which are used solely as safety channels and two compensated ionization chambers, one of which supplies the signal for the log N amplifier and the other of which supplies the signal for the servo amplifier. These five chambers are located above and behind the core, as shown in Fig. 1, and cannot be remotely positioned. Two monitrons, located as shown in Fig. 3, are connected into the reactor scram circuit. The reactor fission chamber (U^{235}) may be positioned in any unoccupied hole in the grid plate. In order to extend the range of this chamber, it is equipped with a drive unit which will raise it above the level of the core on a signal from the control panel. The lower limit of travel of this chamber positions it approximately at the centerline of a core. All

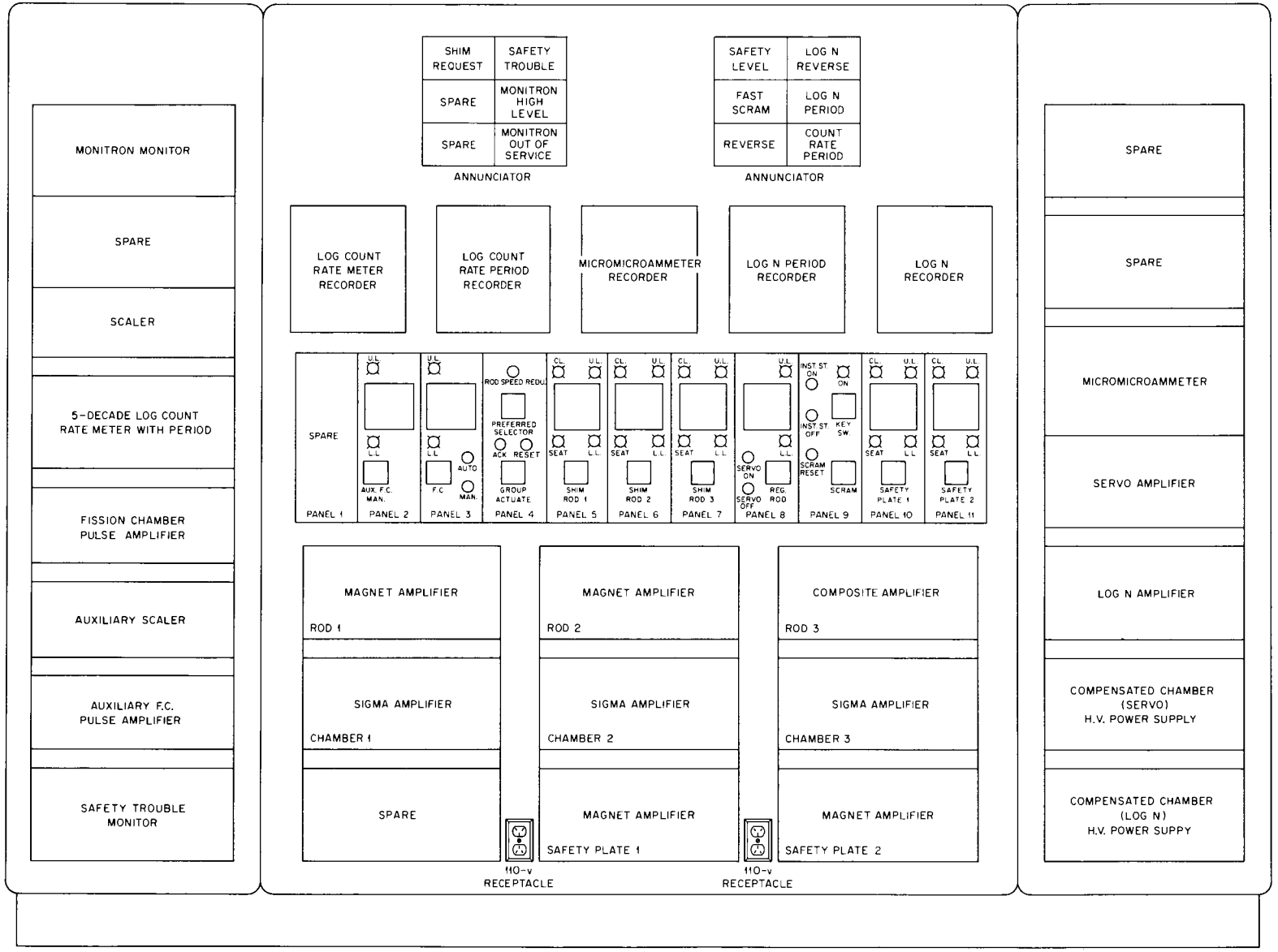

Fig. 2. Control Panel Layout for PCA.

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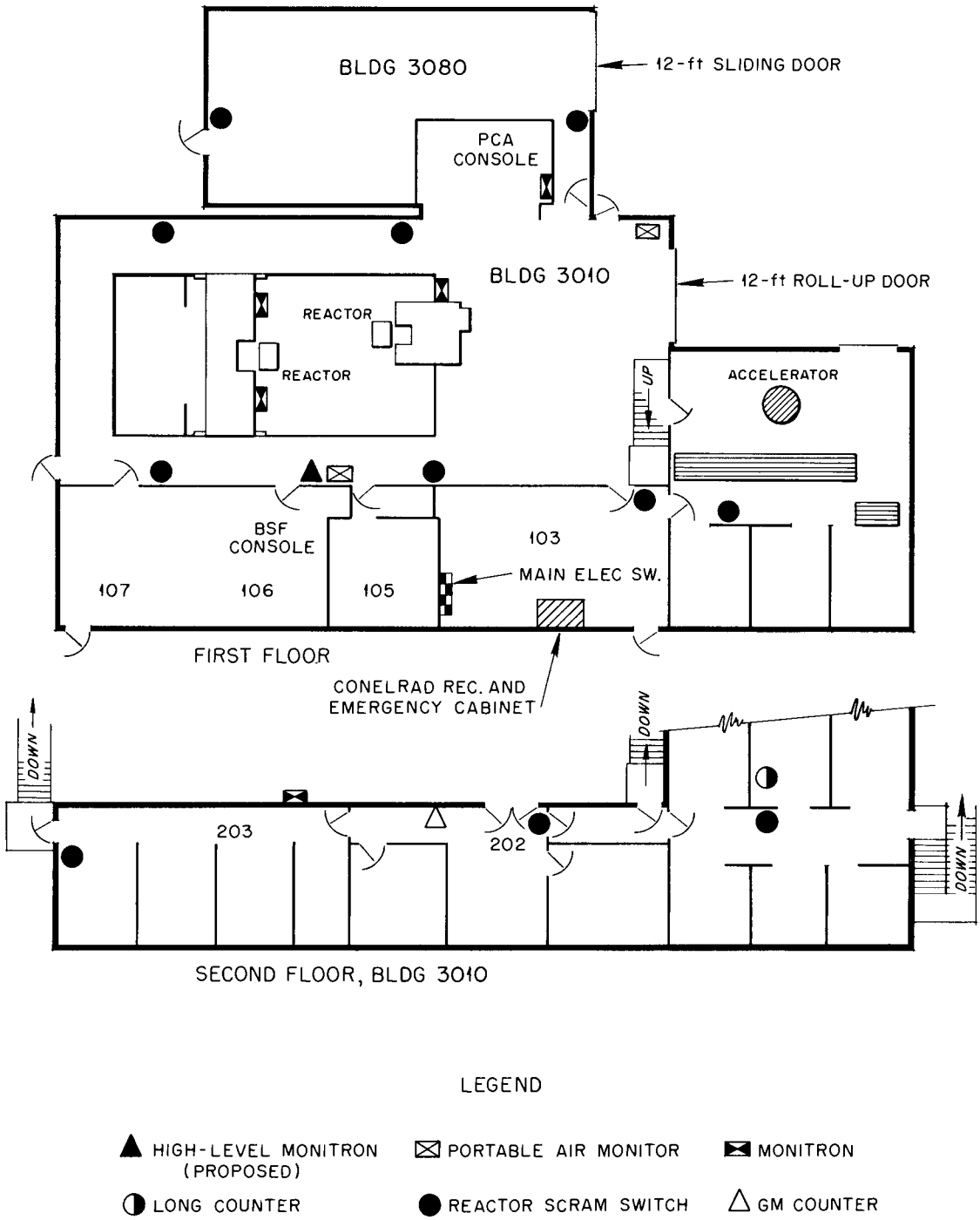

Fig. 3. Location of Scram Switches and Emergency Detection Devices at the BSF.

of these chambers with their associated instrumentation are interconnected and interlocked through the reactor control system as indicated in Fig. 4.

In addition, there is a second fission chamber installed primarily for critical tests, with remote positioning and scaler. It is not connected to the reactor control system, although its motion controls and signal are located on the control panel.

OPERATION

Since the PCA is intended as a research tool, most of the experiments are not routine. For this reason, no provision has been made for unattended operation when the reactor is critical or near critical. Operation shall be carried out as specified in Appendix B. An operator (or supervisor) must remain at the controls whenever the reactor is critical. The reactor may be left unattended with the key switch "on" only when definitely subcritical and when the conditions outlined in Appendix B, Section V, have been complied with.

There are two modes of startup available: Manual Start and Instrument Start. Under no conditions shall Instrument Start be used when there is as much as 1.5% available excess reactivity in the core. Since this mode of operation is limited over the first three decades above source level only by the period response of the log count rate channel, its use should be restricted to those core conditions under which a severe startup accident could not occur.

The only emergency procedure normally available during reactor operation is that of scramming the reactor. This may be accomplished either by means of the large red button on the control panel, the use of which will scram only the PCA, or by means of any of the ten external scram buttons located around the building as shown in Fig. 3, the use of which will scram both the BSR and the PCA. The external scram buttons are intended for emergency use and should not

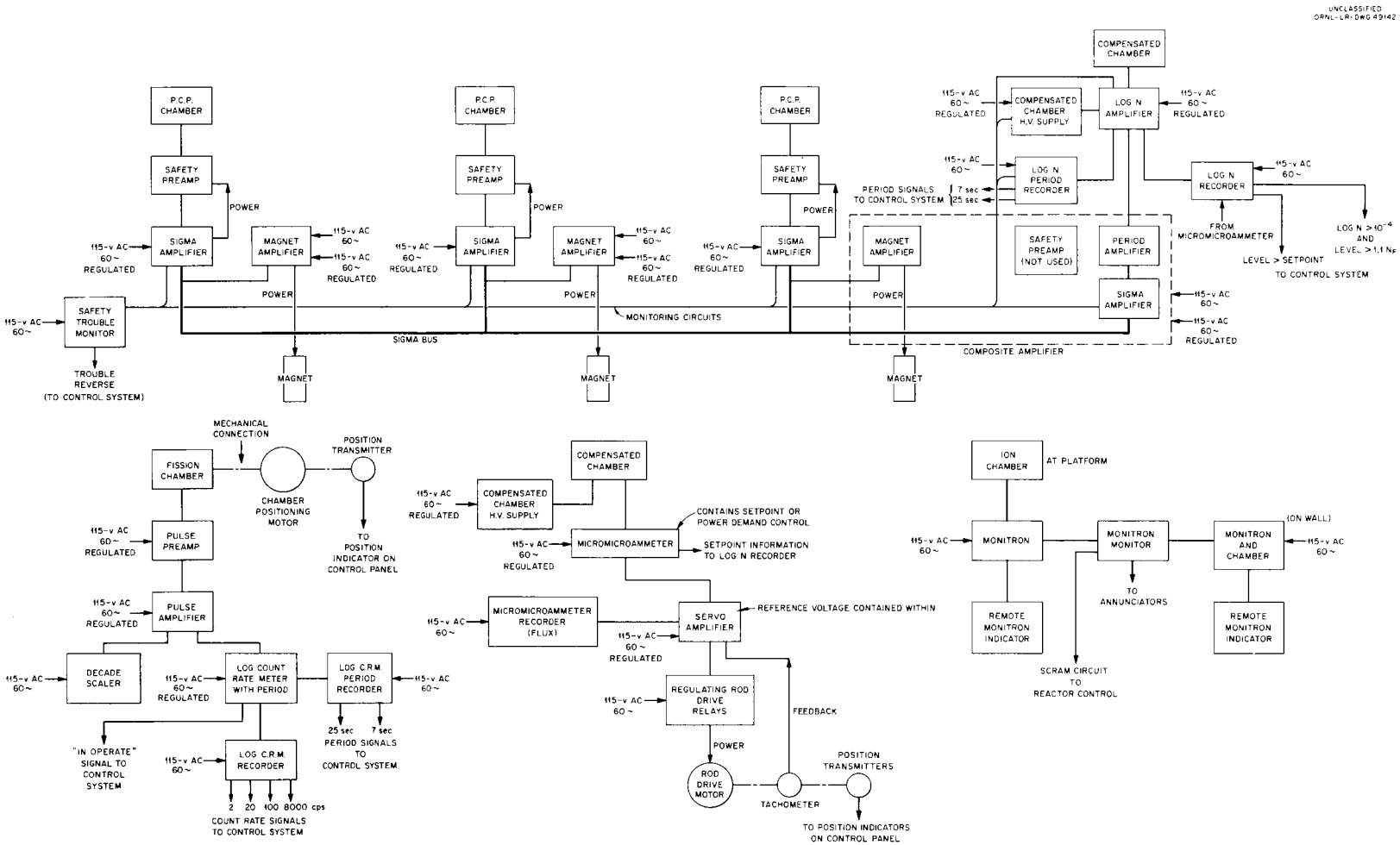

Fig. 4. Single-Line Instrument Diagram for PCA.

be used as a means of reactor shutdown except in an emergency or when being tested.

Whenever the operator is in doubt about the safety of further reactor operation, he should scram the reactor. Unnecessary scrams are not prohibitively expensive for this installation, and the operator should not hesitate to use this means of shutdown.

After any scram for emergency reasons, the operator should notify a reactor supervisor and should not attempt to operate the reactor until given a clearance by the supervisor. In the unlikely event that such a scram occurs when the operator in charge of the reactor is unable to contact a supervisor, he should not start up again unless the cause of the conditions leading to the scram are completely understood and entered in the reactor log book, together with any remedial action taken. This procedure should be followed for instrument scrams and for scrams initiated by the operator.

Routine Checks

There are several operations which are performed at intervals to check the performance of the reactor safety system. These may be extended and modified as development of control instrumentation progresses. Some of these tests are performed before any startup, as indicated in Appendix B, and summarized on the "Daily Check List" on the reactor control panel. The operation of external scram buttons is checked on the first working day of every month in cooperation with the BSR. Checks of chamber response, including the monitrons, are made at the discretion of the supervisor on duty, and either by him or under his personal supervision.

Whenever any modification is made which might affect the functioning of a control rod (such as changing its location in the grid plate, installing a new magnet amplifier, sigma amplifier, new control rod, or a new electromagnet), the

performance of the rod shall be completely checked. This shall include the determination of the drop and lift magnet currents, the determination of the ability of all safety circuits to scram the rod, and the determination of its free travel from lower limit to upper limit, as indicated from the control panel. The results of such tests shall be entered in the reactor log book by the person who performed them.

Reactor Log Book

The reactor log book is intended to be a biography of the PCA. As such, it must contain all information pertinent to the condition and operation of the installation. It is desirable that it contain at least some information concerning the proposed experiment and the experimental results when practical. It is the responsibility of the operator on duty to make certain that proper and complete information is recorded in ink in the current log book.

Emergency Procedure

The procedure for emergencies involving high radiation levels ("Emergency Procedure for Building 3010, Bulk Shielding Facility, Emergency Area No. 2") is posted in the PCA control room. Each operator should be familiar with this document and its location.

Appendix A

PCA SUPERVISORS AND OPERATORS

The following persons are designated as reactor supervisors:

K. M. Henry	Phone 5-1544, Oak Ridge
E. B. Johnson	Phone 5-6429, Oak Ridge
F. C. Maienschein	Phone 5-3805, Oak Ridge.

The following persons are designated as reactor operators:

Experiments Involving a Maximum of 2.5% Excess Reactivity:

	Approved by	Date

Experiments Involving < 0.5% Excess Reactivity:

	Approved by	Date

Appendix B

STANDARD OPERATING PROCEDURE

I. Reactor Startup Check List

Before attempting to take the reactor critical on either manual or instrument startup, the operator shall follow the procedure outlined below. A summary of this check list is posted on the reactor control panel for reference. If any instrument or circuit is not functioning properly in accordance with the tests described below, the reactor is not to be taken critical.

The shutdown condition of the reactor will depend somewhat on the experiment in progress. However, certain invariant conditions can be specified: (1) key switch off, key removed and in possession of the responsible supervisor; (2) all control rods and other control devices in their lower limits; (3) log N on "ground;" (4) multiplier on micro-microammeter on lowest position; (5) log count rate meter on "Calibrate;" (6) source away from a cold core; and (7) the switches supplying power to the rod drive motors (L-2), the annunciators (L-4), and the recorders (L-8) off. Any deviation from this condition should be entered in the reactor log book by the responsible operator, together with the reason for the deviation.

1. Read carefully all entries made in the reactor log book since the operator's last contact with the reactor.
2. Turn on switches supplying power to the rod drives (L-2) and annunciators (L-4).
3. Insert key in lock and turn. Throw switch to turn on power. The green "Operate" light above the key switch should come on.

4. Push the "Scram Reset" button to supply current to the magnets.
5. Ascertain that the voltages of the ionization chamber power supplies are within the operating range and that the magnet amplifiers indicate current to the magnets.
6. Calibrate the fission chamber log count rate meter: Turn the selector switch to the position "$2x10^4$." Adjust the control labeled "$2x10^4$" until the meter indicates $2x10^4$ counts per second. Turn the selector switch to the position "60." Adjust the control labeled "60" until the meter reads 60 counts per second. Repeat until both calibrate points indicate the proper count rate without further adjustment. Turn the selector switch to "Operate" position.
7. Ascertain that the radiation level indicated by the monitrons is normal. An indication of radiation above normal should be carefully investigated and the findings entered in the reactor log book.
8. Raise the magnet-supported rods at least one inch above the lower limit. Push red scram button on the control panel. All these rods should drop. Reset scram.
9. Calibrate log N meter:
   (a) Selector switch should be on "ground" position. Log N meter should read 0.0001 (extreme left black line on the meter dial). To change meter pointer position, turn adjustment marked "ground set."

(b) Turn selector switch to "Lo Calibrate." The meter pointer should now be aligned with the "Lo Calibrate" red line on the left side of the meter (a scale reading of about 0.0002). To correct pointer position, turn adjustment marked "Calibrate."

(c) Turn selector switch to "Hi Calibrate." The meter pointer should now be aligned with the "Hi Calibrate" red line on the right side of the meter (a scale reading of about 20). To correct pointer position, turn adjustment marked "Gain." Note: If adjustment is needed in any position, the whole procedure (a, b, c) should be repeated until the meter shows correct readings. Return selector switch to "Ground" position.

10. Test scram circuits:

(a) Raise one rod at least one inch above lower limit. Push scram test button (unlabeled) on log N amplifier. The period sigma should cause the rod to drop. Repeat with each magnet-supported rod.

(b) Turn selector switch on log N amplifier to "Operate."

(c) Check each sigma amplifier by raising each rod independently at least one inch above lower limit. Insert a small probe into the hole labeled "Scram" on a sigma amplifier. The rod should drop. Repeat until each rod has been checked with each sigma amplifier.

11. Ascertain that the fission chamber is at its lower limit and that the neutron source is adjacent to the core.
    (a) If the scaler and log count rate meter indicate a satisfactory count rate, raise the fission chamber well above the core. The previously observed count rate should disappear.
    (b) Note the pulse height setting on the Pulse Amplifier. Determine the pulse height at which noise is observed. (This should not vary appreciably from previous settings.) Enter the value in the reactor log book and return the pulse height to the previous setting if it was satisfactory.
    (c) Return the fission chamber to its lower limit.
12. Check the micro-microammeter to be sure that the multiplier is on the lowest position (lowest current).
13. Servo amplifier: set the demand helipot for the desired scale reading (fraction of full scale to be selected on the multiplier) on the recorder as indicated by the "Demand" meter on the amplifier.
14. Turn on the recorders (L-8), ascertain that all recorders are indeed on, and manually standardize each.
15. Reset abnormal lights and clear annunciator panel.
16. Take the reactor critical, as specified in the following sections, and to the neutron level required for the experiment.

II. Reactor Startup

Manual Start

The following procedure assumes that the core is loaded so that withdrawal of the control rods to the proper positions will produce criticality.

Withdraw the regulating rod about half way. Then carefully withdraw the shim-safety rods toward the predetermined position (which the reactor log book will indicate), watching the fission chamber count rate information on both the scaler and log count rate meter for any indication of possible criticality. (With the regulating rod partially withdrawn, it is possible to "level out" with the servo at the desired neutron level should the reactor become critical before the previous shim-safety rod positions have been reached. This situation may well occur as a result of a few degrees' change in the bulk pool temperature.) If the reactor is not on a positive period when the shim-safety rods have been withdrawn to their upper limits, withdraw the regulating rod until the fission chamber log count rate channel indicates a positive period. It is probable that the fission chamber will give the only initial level indication from source level through critical. As the neutron level increases, the log N meter and recorder, the log N period meter and recorder, and the recorder on the micro-microammeter should indicate an increase. After the recorders associated with the compensated chambers are on scale, the reactor period should always be determined by inspection of all three channels (including the fission chamber), never from just one or from only a period recorder. A contact in each period recorder will prohibit rod withdrawal if a positive period of 25 sec or less is indicated by either recorder. Adjust the multiplier on the micro-microammeter, if necessary for the desired power level, but in steps no greater than a factor of 10 above the previous level. The reactor may be put on servo control at any time after a stable positive

period is established, and must be put on servo control (when available) when the desired neutron level is reached. In cases where the servo channel is inactive, the reactor must be leveled out manually. Adjust the shim-safety rod positions if necessary.

The recorder charts should show the date, time, experiment and run numbers if appropriate, and scale factor when relevant.

The same data should be recorded in the reactor log book, together with the positions of each control rod.

If the operation is "routine," fill out the reactor log sheets (Fig. 5) when critical and at least at hourly intervals thereafter.

Instrument Start

This mode of operation is to be used only when there is less than 1.5% available excess reactivity in the core, as mentioned above. In order for the operator to initiate "Instrument Start," the fission chamber log count rate recorder must indicate a count rate of at least 40 counts per second and the fission chamber drive must be in "Automatic." When these conditions are satisfied, the operator may activate the "Instrument Start" mode. The regulating rod will be withdrawn to its upper limit by the servo mechanism, and if the above conditions persist, the control system will pass from the instrument start mode to instrument start. In this case, the shim-safety rods will be withdrawn as a group, being limited by a contact in each period recorder (actually only that from the fission chamber log count rate channel is active at very low neutron levels) which prohibits rod withdrawal at a positive period of 25 sec or less. (A reverse is initiated if either period recorder indicates a positive period of 7 sec or less, and a scram is initiated if the log N period as seen by the period sigma in the composite amplifier reaches 3 sec. Either a reverse or a scram will

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POOL CRITICAL FACILITY

REACTOR DATA

Exp. No. _____ Run No. _____

Description _____

_____

Type Elements _____

Reactor Loading _____

Fission Chamber Location (Grid Plate) _____

Shim-Safety Rod No. 1 _____

Shim-Safety Rod No. 2 _____

Shim-Safety Rod No. 3 _____

Σ_1 _____ M_1 _____

Σ_2 _____ M_2 _____

Σ_3 _____ M_3 _____

Date _____ Page No. _____

Log Book No. _____ Page _____

Operator _____

Reactor On _____

Period Going Up _____

Reactor Full Power _____

Time	Power	Log N Power	$\mu\mu$ Ammeter (Servo)		Regulating Rod	Pool Temp.	Fission Chamber		Monitrons	
			Brown Reading	Factor			Position	Counts	No. 1	No. 2

Fig. 5. Reactor Log Sheet.

deactivate the instrument start mode and the servo control of the regulating rod.) Presumably by the time a count rate of 7×10^4 counts per second as indicated by the fission chamber log count rate channel is reached and the fission chamber is automatically withdrawn to a count rate as indicated by the level recorder of 10^3 counts per sec, the reactor should be on a stable positive period. The movement of the fission chamber prohibits further rod withdrawal by putting the control system back in instrument start mode. Instrument start mode will persist until either the demand neutron level is reached, the log N level recorder reaches 0.01 N_F (termed "log N confidence"), or the operator again pushes the "Instrument Start" button. The latter action should never be taken until the log count rate channel from the fission chamber has completely recovered from the reduction in count rate. When the desired neutron level has been reached, the servo will adjust the position of the regulating rod to maintain this level.

The recorder charts should show the date, time, experiment and run numbers if appropriate, and scale factor when relevant.

The same data should be recorded in the reactor log book, together with the positions of each control rod.

If the operation is "routine," fill out the reactor log sheets (Fig. 5) when critical and at least at hourly intervals thereafter.

III. Shutdown

When the reactor is to be shut down and left unattended (key switch off), all control rods and other control devices must be completely inserted into the core. This may be accomplished either by driving the control rods to the lower limits or by initiating a scram.

The routine shutdown condition will be produced as follows:

1. All control devices and magnets in lower limits.
2. Recorder charts properly marked.
3. Fission chamber selector switch on "calibrate."
4. Log N selector switch on "ground."
5. Neutron source away from a cold core.
6. Key switch off and key removed.
7. Switches supplying power to rod drive motors (L-2), annunciators (L-4), and recorders (L-8) off.

It may be desirable to take further precautions to assure the shutdown condition, such as removing some fuel from the core, or modifying the experimental equipment in use (such as flooding a void left adjacent to the core). Any deviation from the routine shutdown condition should be noted in the reactor log book, together with the reason.

IV. Approach to Critical

Much of the operation of this reactor is concerned with critical experiments. It is required that at least one supervisor conduct any critical test. As stated previously, under no conditions may an operator authorize changes in the core or reflector.

In addition to the normal control instrumentation, a second fission chamber channel is used for critical tests. It is identical to that channel which is incorporated into the control system, except that it contains no log count rate meter or recorder. It is positioned in the grid plate so that it will "see" a different view of the core than the reactor fission chamber as loading progresses.

When a new core loading is required, the appropriate grid plate will be made available and the control rods (and possibly other safety devices) positioned. The two fission chambers will be positioned (and will be at the lower limits of their travel) and the neutron source will be located against the existing portion of the core but in such a position that neutrons coming from the source must pass into fuel before reaching either fission chamber. The safety circuits will be checked as indicated above. As fuel elements are added, the approach to critical will be carefully monitored by the method of subcritical multiplication. The plot of reciprocal count rate vs U^{235} mass in the core will be maintained for both fission chamber channels and the extrapolation of this curve will be carefully noted before any fuel addition is made. Under no conditions may more than two fuel elements be added to the core before obtaining a new count rate, and then only when far from critical. At no time shall the amount of fuel in the core exceed the current extrapolated critical mass by more than one full fuel element.

The following practices shall be rigidly adhered to:

1. The supervisor on duty shall have complete authority over all activity in the control room and in the vicinity of the reactor.
2. Effective communication between the loading platform and the control panel shall be maintained.
3. The neutron source shall remain adjacent to the core throughout the experiment until it is intentionally removed to check criticality.
4. During the addition of a fuel element to the core, the magnet-supported control rods shall be positioned approximately half way between their upper and lower limits.

5. During the addition of a fuel element, the operator shall observe the signals from both fission chambers to determine the rate of increase of neutron level.
6. If it is the opinion of the operator that the neutron level is rising too rapidly, he may scram the rods. Should a scram occur, the person loading fuel will immediately remove the fuel element from the vicinity of the core without waiting for verbal instructions.
7. The person actually making the fuel addition will retain physical control of the element until notified by the supervisor at the control panel that the element may be released. Thus, until this notification is given, the element may be quickly removed from the reactor as an emergency procedure. Such action shall be dictated by the supervisor on duty.
8. The count rate for the subcritical multiplication plots shall be determined with all the control rods in their upper limits. Count rates may be determined for other positions of the control rods; in this case the resulting data would be plotted on separate graphs.
9. A core shall be loaded from the center toward the outside, keeping the current arrangement as symmetrical as possible. In no case shall an element be placed in a "hole" which has been left in the configuration. When a grid position is left vacant and surrounded by fuel, access to the position shall be blocked by positive means so that fuel cannot be inadvertently placed there.

10. When there is reason to suspect that a configuration is critical, the neutron source shall be removed from the core in order to observe the behaviour of the neutron population.

11. An accurate and complete record of the proceedings shall be kept in the reactor log book.

V. Unattended Operation

Although it is required that an operator remain at the console of the PCA whenever it is critical, operating experience has indicated that there may be extended periods of time during which the reactor is actually subcritical but is in potentially critical condition; i.e., a potentially critical core, key switch on, and control rods partially withdrawn, as for pulsing experiments. At the discretion of the supervisor on duty, steps can be taken to permit unattended operation under certain conditions without compromising the safety of the installation. These are:

1. The reactor shall be subcritical by an amount greater than the reactivity worth of any installed experimental apparatus such as beam tubes, detectors, etc.

2. A switch installed in line 24 on Relay Panel No. 1 inside the cubicle shall be put in the "off" position. This will block withdrawal of the control rods.

3. The door to the cubicle shall be locked and the key removed.

4. The switch connecting the microphone on the annunciator panel to the building PA system shall be "on."

5. Routine observation of the console, at least at hourly intervals, shall be made by the operator.

Appendix C

ANNUNCIATOR PANEL CONDITIONS AND POSSIBLE CAUSES

Annunciator*	Control Action	Possible Cause
Shim Request	None	Regulating rod in upper limit.
Safety Trouble	None	Log N on "ground;" or Negative period from log N to period amplifier in composite.
	Reverse	Chamber voltage abnormal; or Two or more abnormal conditions as seen by Safety Trouble Monitor.
Monitron High Level	Scram	An indication of radiation at either monitron $\geqslant$ 7.5 mr/hr.
Monitron Out of Service	Scram	Either monitron on high range; or Either monitron unplugged, power switch off, or selector switch off.
Safety Level	Scram	Current from any PCP chamber $\geqslant$ 150% full power.
	Reverse	Current from any PCP chamber $\geqslant$ level set on simplitrols on Safety Trouble Monitor.
Fast Scram	Scram	A scram produced by the response of the instrumentation; i.e., change in sigma bus level.
Reverse	Reverse	A period $\leqslant$ 7 sec as seen by either period recorder; or Level from any PCP chamber $\geqslant$ the setting on the associated simplitrol; or Two abnormal conditions as seen by Safety Trouble Monitor; or Level indicated by log N recorder = somewhere between a factor of 2 and 20 times that requested by the range set on the μμ ammeter.

Annunciator Panel Conditions and Possible Causes

(continued)

Annunciator*	Control Action	Possible Cause
Log N Reverse	Reverse	Level indicated by log N recorder = somewhere between a factor of 2 and 20 times that requested by the range set on the μμ ammeter.
Log N Period	Scram	Period ≤ 3 sec from log N amplifier to the period amplifier in the composite.
	Reverse	Period ≤ 7 sec indicated by the log N period recorder.
Count Rate Period	Reverse	Period ≤ 7 sec indicated by the log count rate recorder.

*All indications are accompanied by an alarm which must be acknowledged to silence. Often one trouble will cause two blocks of the annunciator panel to be activated, such as "Log N period" and "Reverse."

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