ORNL/TM-9870

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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Operating Manual for the Health Physics Research Reactor

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy: A09 Microfiche A01

ORNL/TM-9870

Contract No. DE-AC05-84OR21400

Operations Division
Reactor Operations Section

OPERATING MANUAL FOR THE HEALTH PHYSICS RESEARCH REACTOR

Compiled by
Health Physics Research Reactor Staff

Date Published - November 1985

NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and, therefore, does not represent a final report.

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
DEPARTMENT OF ENERGY

Approved by:

J. H. Swanks, Director Operations Division	R. V. McCord, Head Reactor Operations Section	L. B. Holland Reactor Supervisor

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1. INTRODUCTION: ORGANIZATION, TRAINING, AND RECORDS

1.1 INTRODUCTION

This manual is intended to serve as a guide in the operation and maintenance of the Health Physics Research Reactor (HPRR) of the Health Physics Dosimetry Applications Research (DOSAR) Facility. It includes descriptions of the HPRR and of associated equipment such as the reactor positioning devices and the derrick. Procedures for routine operation of the HPRR are given in detail, and checklists for the various steps are provided where applicable. Emergency procedures are similarly covered, and maintenance schedules are outlined. Also, a bibliography of references giving more detailed information on the DOSAR Facility is included.

Changes to this manual will be approved by at least two of the following senior staff members: (a) the Operations Division Director, (2) the Reactor Operations Department Head, (c) the Supervisor of Reactor Operations TSF-HPRR Areas. The master copy and the copy of the manual issued to the HPRR Operations Supervisor will always reflect the latest revisions.

1.2 THE DOSAR FACILITY

The DOSAR Facility is located in an area approximately two miles southeast of the Laboratory and includes a reactor building which houses the HPRR, a building which is used for calibrations, and a reactor control building. The control building houses the reactor controls, administrative offices, experimental laboratories, and an experiment assembly preparation area used to assemble the object(s) to be irradiated in the reactor building. The relative locations of the buildings are shown in Fig. 1.1. The distance between the reactor and the control building is approximately 800 ft (240 m).

1.2.1 Reactor Building

The working area of the reactor building is approximately 72 ft long and 32 ft wide. An overhead bridge crane of five-ton capacity spans the width of the building and travels the full length. A 12-ft-wide, 15-ft-high double door at one end of the building opens to an outside concrete pad, which is 30 ft wide and 70 ft long. At the other end of the building, a 6-ft-wide, 8-ft-high double door opens onto a truck unloading dock. A lean-to with no inside entrance to the reactor

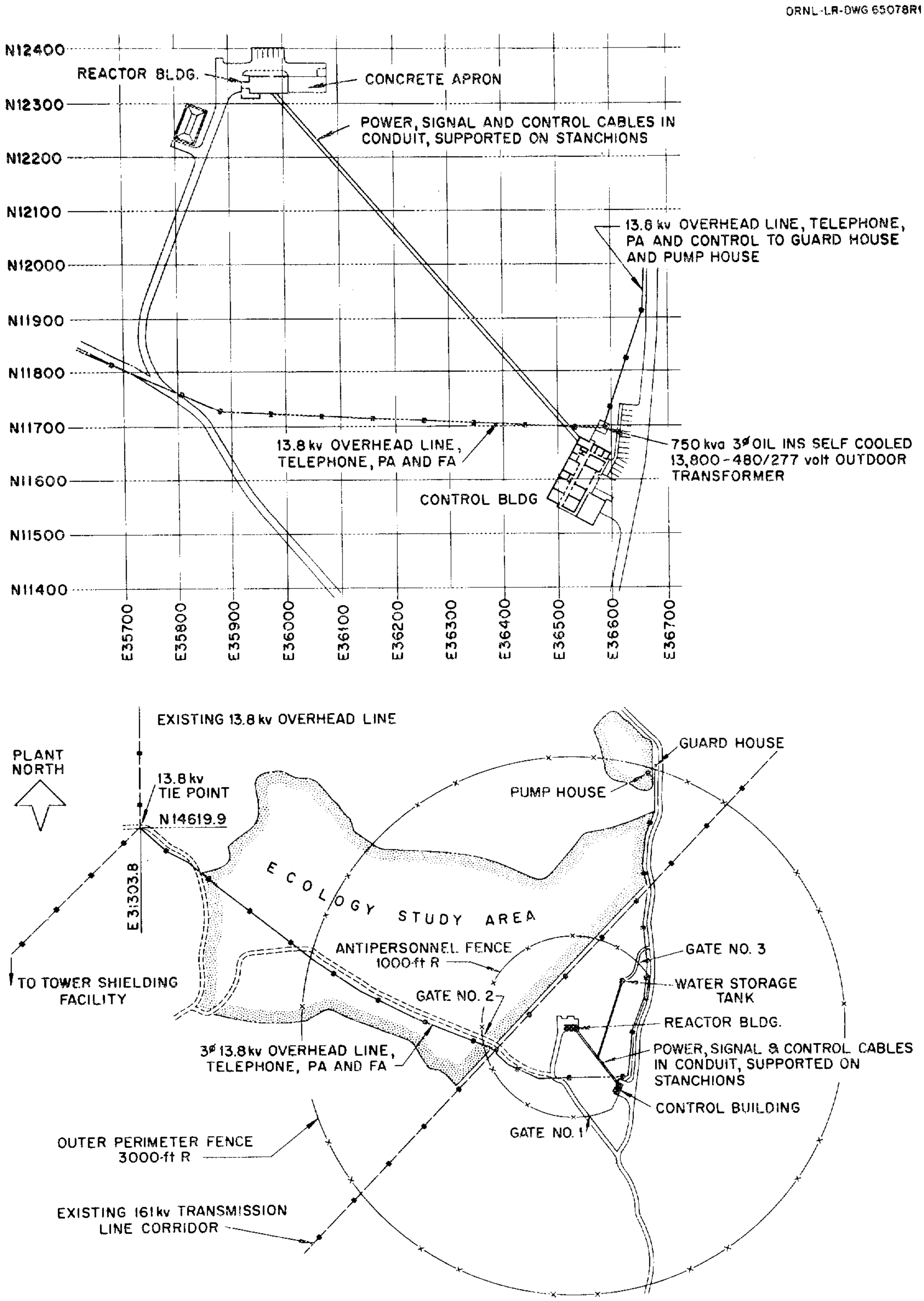

Fig. 1.1. Plot plan of DOSAR Facility, showing locations of reactor and control buildings.

building houses service rooms for electrical equipment, an auxiliary generator set, etc. Concrete pits for storing the reactor, the positioning device, and other facilities associated with the HPRR are described in Section 3.

1.2.2 Control Building

The control building, a one-story structure, is approximately 133 ft long and 56 ft wide and has a 1-ft-thick reinforced-concrete roof for shielding the occupants from skyshine radiation. The side of the building facing the reactor building is set into the hill separating the two buildings, thereby affording additional shielding. To provide better shielding, the roof and walls of the counting room are 2-ft-thick reinforced concrete.

The DOSAR Facility is located approximately one mile to the northeast of the Tower Shielding Facility (TSF); and because of this close proximity, the reactor operations at the TSF and the DOSAR Facility are under the same administrative control.

1.3 HPRR ADMINISTRATIVE ORGANIZATION

The structure of the administrative organization for the HPRR is shown in Fig. 1.2, and its relation to the DOSAR Facility Administration is shown in Fig. 1.3. The Health and Safety Research Division, through the DOSAR Facility Supervisor, has the overall responsibility for operation of the DOSAR Facility. The Operations Division is responsible for the safe and efficient operation of the HPRR on the schedule specified by the DOSAR Facility Supervisor consistent with the limitations and procedures in this manual.

1.3.1 DOSAR Facility Supervisor

Responsible for the overall operation of the DOSAR Facility.

1.3.2 Reactor Operations Section Head

Responsible for the operation and maintenance of the reactors operated by the Operations Division. Also responsible for implementing modifications to the reactor and all of its auxiliary equipment.

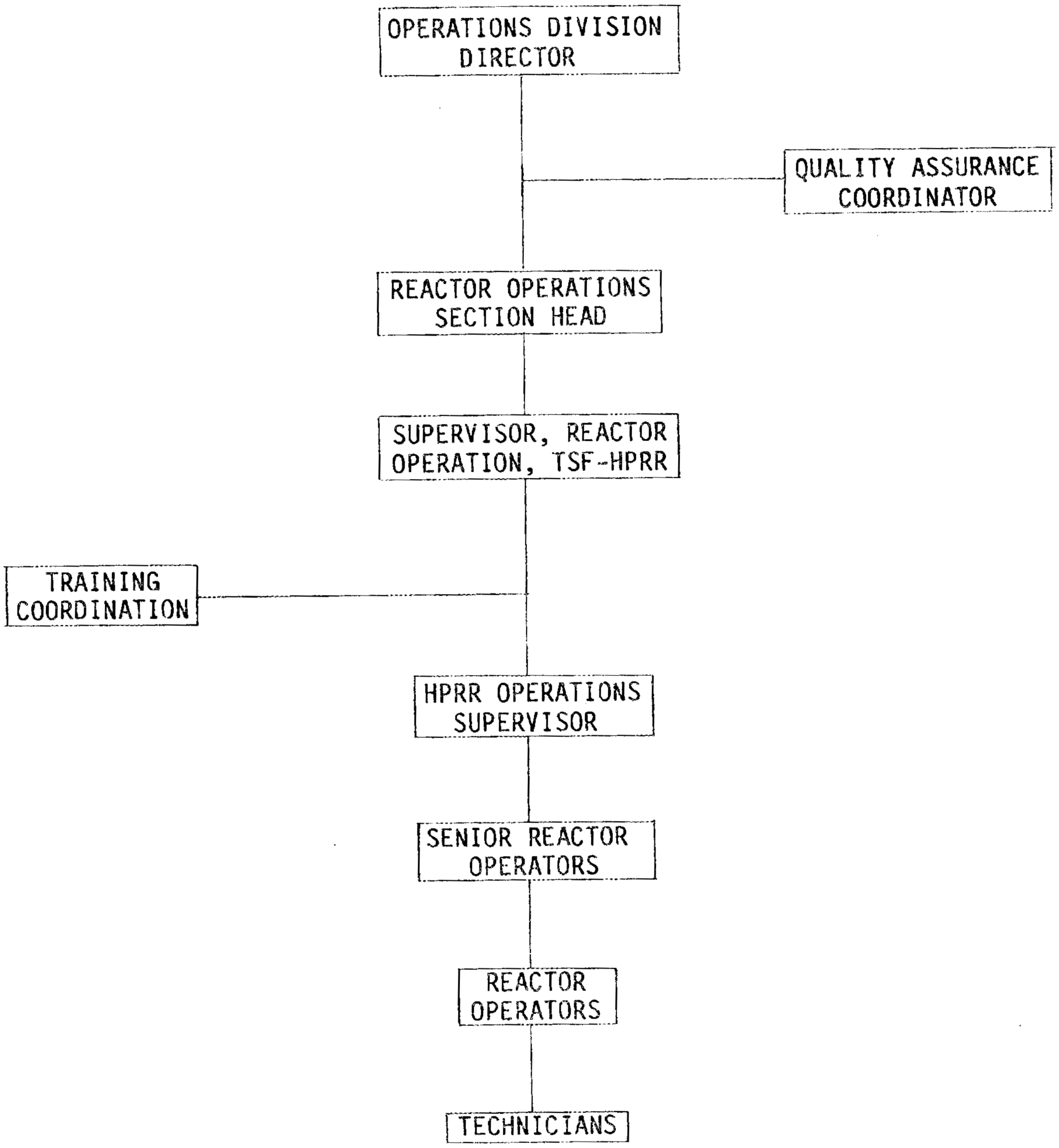

Fig. 1.2. Organization chart for Health Physics Research Reactor operating staff.

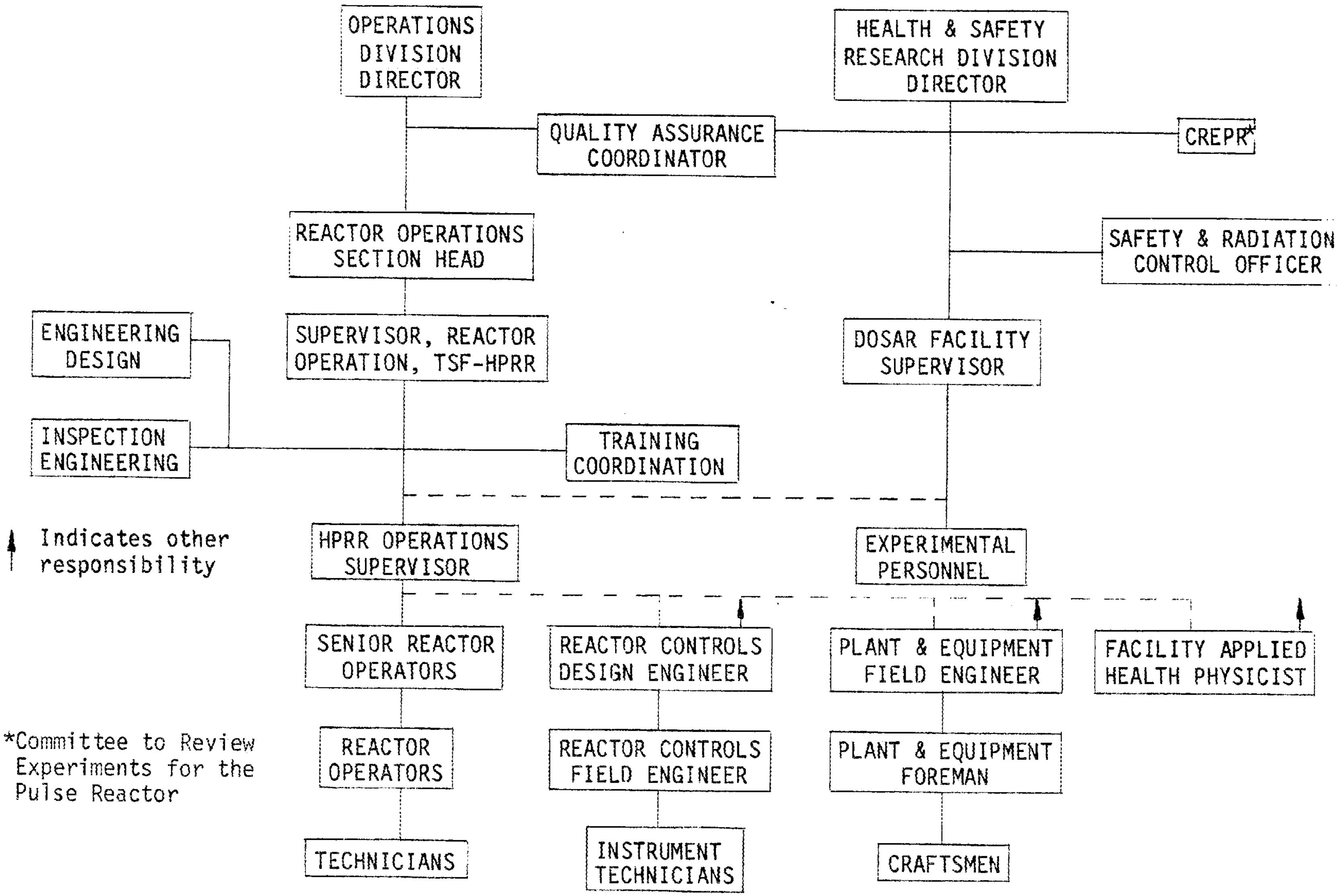

Fig. 1.3. Organization chart for Health Physics Research Reactor staff.

1.3.3 Supervisor, Reactor Operations TSF-HPRR Areas

Responsible for preparing operating and maintenance procedures for the reactor and facility and for seeing that personnel carry out their assigned duties according to Laboratory, Operations Division, and HPRR procedures.

1.3.4 Senior Reactor Operator

Responsible for operating the HPRR in a safe manner as prescribed in this manual and maintaining a permanent record of the operations, maintenance performed, and any other pertinent information. In the event of an emergency, has the responsibility and authority to take the necessary remedial action. One Senior Operator from the Operations Division will be designated as Operations Supervisor.

1.3.5 Reactor Operator

Operates the reactor and reactor-handling equipment for any routine experiment in accordance with these procedures and assists the Senior Operator with the assembly and disassembly of the reactor.

1.3.6 Training Coordinator

The operating staff establishes a training program in accordance with DOE and Operations Division requirements for Reactor Operators and Senior Reactor Operators so that material for operators and trainees is covered at scheduled intervals. An Operations Division training coordinator administers written and oral examinations, grades examinations, and keeps a file and reports results of examinations to the Director of the Operations Division.

1.3.7 Reactor Controls Design Engineer

Engineers all changes in reactor control system and submits Reactor Control Change Notices and recommends changes in reactor control system as new equipment is available.

1.3.8 Plant and Equipment Field Engineer

Coordinates efforts of Engineering, Plant and Equipment, and Quality Department personnel with regard to construction, maintenance, etc., at or for the HPRR and recommends improvements in operating equipment, maintenance, etc.

1.3.9 Reactor Controls Field Engineer (RCFE)

Supervises instrument technicians in the installation, inspection, calibration, and maintenance of detectors and electronic equipment; sees that first priority is given to maintaining the reactor in a safe operating condition and that second priority is given to maintaining the current experimental program; and sees that necessary records are kept.

With regard to reactor maintenance, is responsible for the work being carried out in accordance with written procedures and for alterations being made only with the prior consent of the Director of the Operations Division and the Superintendent of the Reactor Controls Department of the Instrumentation and Controls Division.

1.3.10 Instrument Technician (Instrumentation and Controls Division)

Performs routine maintenance of all existing electronic equipment and installs new equipment under the supervision of the RCFE. Performs routine maintenance on the reactor controls which consists of one-for-one replacement of defective parts at the discretion of the RCFE or the Senior Operator.

1.3.11 DOSAR Technician (Health and Safety Research Division)

Assists the operator in assembly and disassembly of the reactor, assists in the setup of experiments, sees that reactor building is maintained in an orderly condition, and assists the operator in performing operational checks.

1.4 EXPERIMENT APPROVALS

The DOSAR Facility Staff will be responsible for the design of all experiments (including those of outside contractors) which utilize the HPRR as a source of radiation. The HPRR Operations Supervisor from the Operations Division is a permanent member of the DOSAR Facility Staff.

A description of all proposed experiments or family of experiments (description to be prepared by the experimenter) will be reviewed by the DOSAR Facility Staff and the HPRR Operations Supervisor. If approved, the proposal will then be presented to the Committee to Review Experiments for the Pulse Reactor (CREPR), a Health and Safety Research Division committee, and an information copy will be sent to the head of the Laboratory's Reactor Operations Review Committee (RORC). After reviewing the proposed experiment, CREPR will provide the Supervisor of Reactor Operation TSF-HPRR Areas with written notification of its recommendation and will send an information copy of all favorable recommendations to the head of the RORC and to the Director of the Operations Division. On February 21, 1968, CREPR (formerly Burst Reactor Experiment Review Committee) gave general approval for steady-state operations (within HPRR operating limits) and also general approval for pulse experiments where the worth of the experiment does not exceed 25¢ in reactivity.

1.5 TRAINING AND CERTIFICATION OF PERSONNEL

New personnel will attend Laboratory orientation courses in health physics and job safety as soon as they are scheduled. They will be assigned to work with related trained personnel in the organization and be given increasing amounts of responsibility based on their response to on-the-job training. For training records, see Section 1.6.

1.5.1 Reactor Operator

To be accepted as a trainee for reactor operation, an individual must have a college degree or a Laboratory-recognized equivalent. Training will include a series of study sessions covering the material outlined in ORNL/TM-9785 and on-the-job training. On-the-job training will proceed concurrently with the study sessions under the direction of the operations supervisor. To qualify as an operator, an individual must first complete, to a certified senior operator's satisfaction, the following items on the HPRR Training Record:

1. Complete the required items on the training checklist.
2. Make the daily checks.
3. Perform prestartup checks, bring the reactor to power, and change the power level.
4. Shut down the reactor routinely and make the end-of-shift checks.
5. Make the weekly checks.

6. Operate the reactor positioning equipment.
7. Demonstrate knowledge of safety and radiation control procedures.

When the above requirements have been met, the senior operator will sign the individual's training record. To be fully qualified, the trainee must achieve a score of 70% or above in each category and achieve an overall score of 80% for the entire written, oral, and operating examinations administered by the Operations Division's authorized examiner (the training coordinator). The operator must undergo a medical examination and be certified by the ORNL Health Division. The standards used will be the applicable ones in effect at the time, including 10 CFR, Part 55, U.S. Regulatory Guide 1.134, Rev. 1, March 1979, and ANSI N546, 1976. For an individual to be authorized to operate the reactor, the certification must be signed by the examiner, the Reactor Operations Section Head, and the Director of the Operations Division.

To maintain certification, an operator must:

1. keep informed of any changes in the facility,
2. operate the reactor in steady-state operation quarterly,
3. participate in a pulse operation at intervals not to exceed eight months,
4. pass a written examination administered by the training coordinator on handling abnormal reactor conditions and emergencies every year,
5. pass written, oral, and operating examinations administered by the training coordinator on all subjects in the training guide every two years,
6. have a medical examination at least every two years and be certified by the ORNL Health Division (The standards used will be the applicable ones in effect at the time, including 10 CFR, Part 55, U.S. Regulatory Guide 1.134, Rev. 1, March 1979, and ASNI N546, 1976.), and
7. have a certification signed by the examiner, the Reactor Operations Section Head, and the Director of the Operations Division.

1.5.2 Senior Reactor Operator

In order for an operator to qualify as a senior operator, proficiency must be demonstrated to a certified senior operator in the remaining items on the operator's training record as shown on the following page.

1. Completed all items on the training checklist.
2. Performed complete pulse operation.
3. Performed the operational checks.
4. Participated in the assembly and disassembly of the reactor.
5. Participated in a critical experiment.

The operator also must have a medical examination at least every two years and be certified by the ORNL Health Division. The standard used will be the applicable ones in effect at the time, including 10 CFR, Part 55, U.S. Regulatory Guide 1.134, Rev. 1, March 1979, and ANSI N546, 1976.

When the above requirements have been met, the Senior Operator will sign the individual's training record. The trainee must then pass with a grade of 80% written, oral, and operating examinations administered by the Operations Division's authorized examiner. For an individual to be authorized to serve as a senior reactor operator, the certification must be signed by the examiner, the Reactor Operations Section Head, and the Director of the Operations Division.

To maintain certification, a senior operator must:

1. keep informed of any changes in the facility,
2. operate the reactor in steady-state operation quarterly,
3. participate in a pulse operation at intervals not to exceed eight months,
4. pass a written examination administered by the training coordinator on handling abnormal reactor conditions and emergencies every year,
5. pass written, oral, and operating examinations administered by the training coordinator on all subjects in the training guide every two years,
6. have a medical examination at least every two years and be certified by the ORNL Health Division (The standard used will be the applicable ones in effect at the time, including 10 CFR, Part 55, U.S. Regulatory Guide 1.134, Rev. 1, March 1979, and ANSI N546, 1976.), and
7. have a certification signed by the examiner, the Reactor Operations Section Head, and the Director of the Operations Division.

1.5.3 Recertification of Personnel

If an individual who has been certified as a qualified senior reactor operator or reactor operator does not stay informed on the day-to-day condition of the equipment and the experiments for more than three months or has been unable to perform the prescribed duties for that period, the operator must be reinstated by the immediate supervisor. The supervisor will inform the operator of all equipment and procedural changes, observe performance of routine duties, and if it is satisfactory, indicate on the training record that the operator is reinstated. For absences longer than two years, the individual must be formally recertified.

1.6 OPERATION AND MAINTENANCE RECORDS

The Reactor Operations Supervisor is responsible for maintaining a permanent record of the operation and maintenance of the HPRR and related equipment and documents relating to the operation and maintenance. Such records will be kept in an orderly fashion, with ease of data retrieval and auditability being major considerations.

These records include a general operations logbook; reactor checkout and operating log sheets; experiment plans; review and approval correspondence for experiments and reactor operation; maintenance records; change notices and calibration, inspection, and test data.

1.6.1 General Operations Logbook

Dated and signed entries will be made in ink in a bound general operations logbook for each reactor operation and for every abnormality, repair, alteration, or other significant occurrence. The series of logbooks thus filled will serve as a chronological history of the HPRR operations.

1.6.2 Routine Checkout and Operations Records

A permanent record of the routine operations of the HPRR will be maintained through preservation of the forms used by the operator(s). The HPRR Checkout Sheets, the Steady-State Log Sheets, and the Pulse Log Sheets (described in Section 4) will be filed in binders.

1.6.3 Experiment and Dosimetry Records

The DOSAR experimental staff is responsible for scheduling experiments, determining the reactor operation for obtaining the required radiation exposure, and maintaining a record of this information. The reactor operators will have access to these records.

1.6.4 Experiment and Operation Review and Approval Records

HPRR experiments that have not received blanket approval from the Committee to Review Experiments for the Pulse Reactor (CREPR) (see Section 1.4) will require review and approval. Records will be kept of all correspondence with CREPR. Operating authorizations and the correspondence with laboratory and DOE review committees will also be kept on file.

1.6.5 Change Memorandums

For procedural purposes, two types of change memorandums will be issued. One will cover changes in reactor controls and will be handled by HPRR and Instrumentation and Controls Division Personnel. The other will cover changes to be handled by the HPRR, Engineering, and Plant & Equipment personnel. Properly signed copies of all change memorandums will be kept on file.

1.6.5.1 Reactor protection and operation system changes

Changes will be made in accordance with Instrumentation and Controls Division Quality Assurance Procedure QA-IC-11, September 13, 1973.

1.6.5.2 HPRR design change

The design description will be outlined in a Mechanical Design Change Memo. The completed form must be approved by the TSF-HPRR Operation Supervisor, the Reactor Operations Section Head, a member of the Operations Division Technical Section, the Head of the Office of Operational Safety, and the Director of the Operations Division. If the change involves a change in the technical specifications, reactor protection system, reactivity control system, engineered safety features, or a safety question not reviewed in the safety analysis report, it must be reviewed by the RORC and DOE-ORO. The field changes will not be started until the change notice is properly processed and the necessary engineering is completed. Upon completion of the field work required to accomplish the change, the Field Engineer or the HPRR Operations Supervisor will sign and date the copy of the change notice. Marked Drawings will be returned to the responsible design specialists, noting any deviations to be incorporated into the as-built drawings. The

Operations Supervisor will also sign the change notice when revised drawings are issued and when necessary procedure changes are issued.

1.6.6 Maintenance Records

Records will be maintained both for routine and nonroutine maintenance. To minimize unscheduled shutdowns, routine maintenance will be scheduled as outlined in Chapter 7. Records will be maintained to indicate that the work has been completed.

1.6.6.1 Instrumentation and Control maintenance records

Records will be kept by Instrumentation and Control personnel of all abnormalities and subsequent repairs and alterations to the reactor instruments and controls and for equipment closely related to the reactor.

1.6.6.2 Plant and Equipment maintenance records

Records will be kept of all abnormalities and subsequent repairs and alterations to equipment at the reactor building (Building 7709) and for any items in the control building (Building 7710) which are directly related to reactor operation.

1.6.7 Calibration, Inspection, and Test Data

Many calibrations, inspections, and tests are required during routine operation and maintenance of the HPRR. Records will be kept both to document the completion of such tests and also to preserve the numerical values obtained.

1.6.8 Operator Training and Certification Records

Each individual will maintain a record of training activities. Copies of certification and recertification records will be maintained in the Division Training Coordination Office.

2. DESCRIPTION OF THE REACTOR

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2. DESCRIPTION OF THE REACTOR

2.1 MECHANICAL

The ORNL Health Physics Research Reactor (HPRR) core and superstructure are shown in Fig. 2.1 as they appeared at the time of the initial critical experiments. A cutaway drawing of the core is shown in Fig. 2.2. The final reactor assembly is essentially unchanged from this initial design.

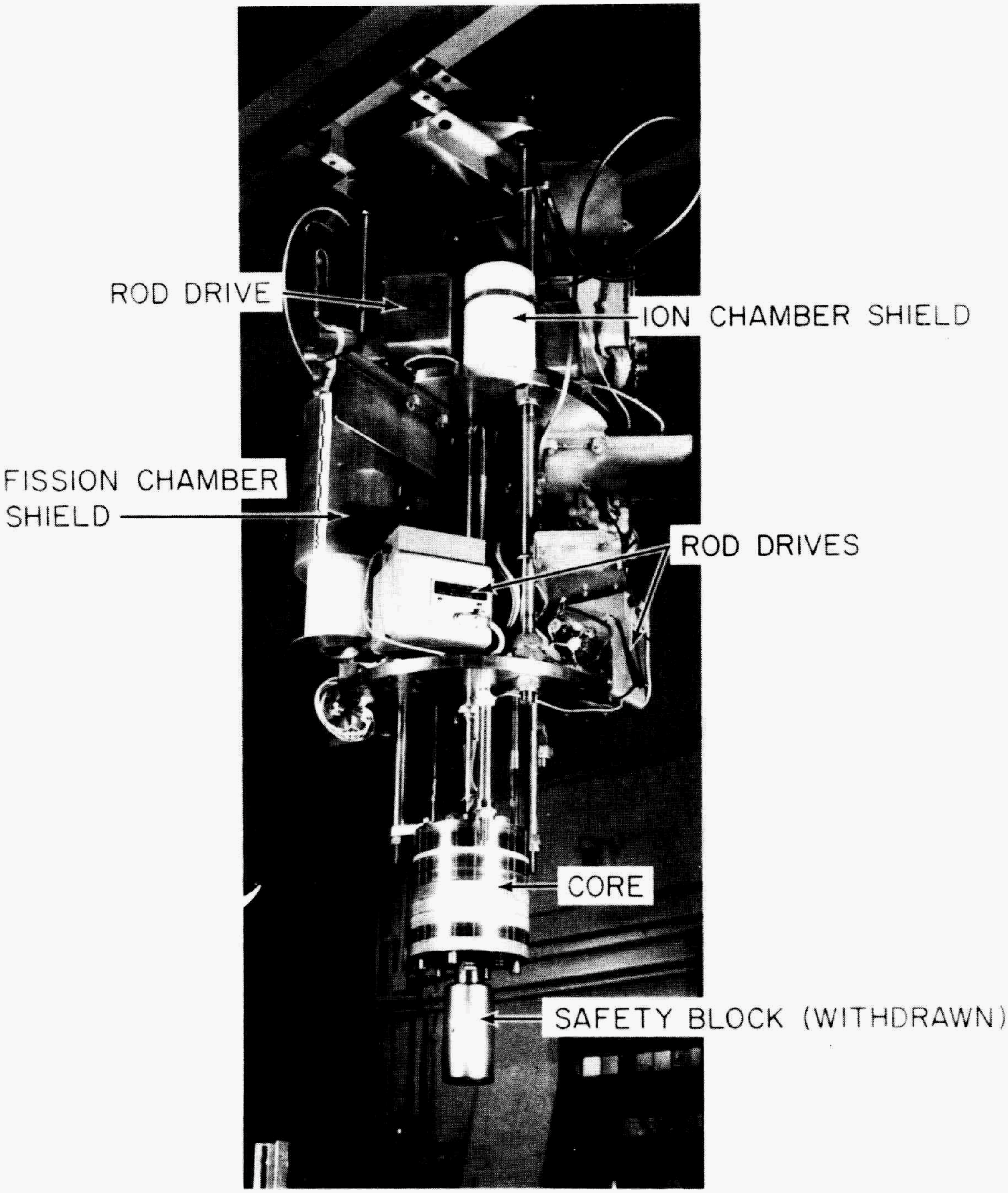
The reactor assembly drawings are NDA Dwg. Nos. 12066, 12067, and 12069; and the core assembly drawing is ORNL Dwg. No. D-54965, all of which are on file in the General Engineering print files.

2.1.1 Core

The reactor core is basically a right annulus of 90 wt % uranium (93.14 wt % U^{235}) and 10 wt % molybdenum alloy, nominally 8 in. in outside diameter, 2 in. in inside diameter, and 9.06 in. long, surrounding a 2-in.-diam stainless steel central rod. Part of the fuel annulus consists of a U-Mo safety block, 3.375 in. in outside diameter, 2 in. in inside diameter, and 6.5 in. long, which is threaded onto the stainless steel rod and then pinned to prevent unthreading. The center rod is attached to the steel center supporting shaft by means of a bayonet-type quick disconnect. The lugs of the bayonet are threaded onto the center supporting shaft and pinned. The central safety-block rod has a receptable designed to accept the lugs and to support the rod (and safety block) when rotated 90°. The bayonet latch is then pinned to prevent it from being unlatched. The center supporting shaft terminates in a magnet keeper.

The major nonmovable components of the core consist of eleven annular U-Mo disks ranging in thickness from 0.0625 to 1.313 in. The seven lower disks that surround the safety block when it is in the inserted position are 3.531 in. in inside diameter, and the four disks above the safety block are 2.156 in. in inside diameter. All eleven disks are held together with nine 0.75-in.-diam U-Mo bolts that thread into helicoil inserts in the 1-in.-thick bottom plate. In each bolt there is a 0.332-in.-diam by 7.438-in.-long hole extending along the bolt axis from the top down which enhances the energy-absorption capability of the bolt and provides a cavity for a 0.281-in.-diam by 7.625-in.-long U-Mo shim pin. A 0.313-in.-diam vertical sample-irradiation hole extends through the length of the core 2.210 in. from the core center. This hole may be

Photo 37516A



Core Attached to Reactor Support Structure During Critical Experiments.

Fig. 2.1. HPRR core and superstructure.

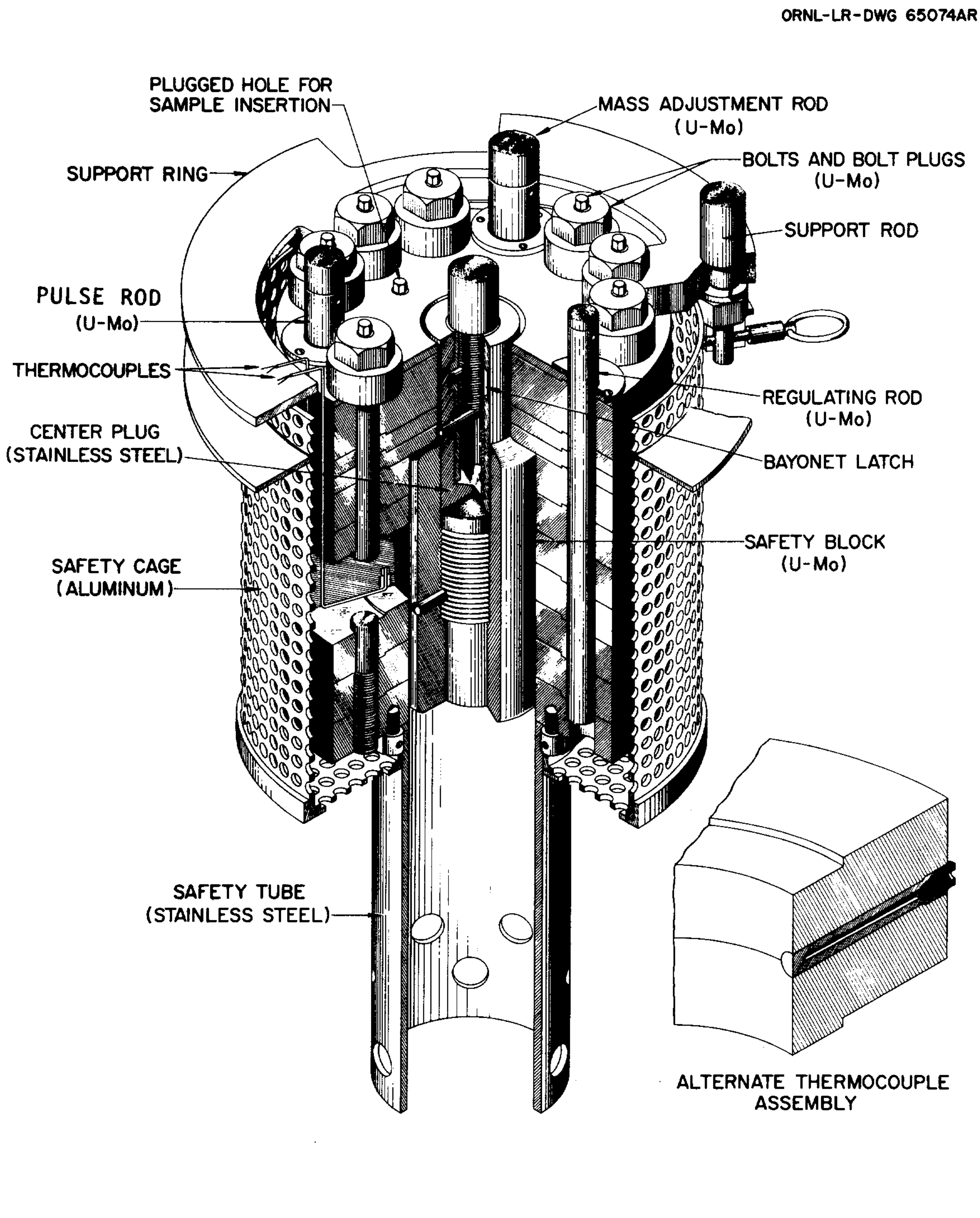


Fig. 2.2. Health Physics Research Reactor.

left empty, filled with a U-Mo plug, or filled with a sample as the experiment dictates.

The remaining core pieces are the mass adjustment rod, the regulating rod, and the pulse rod, each movable, 9 in. long, and 1.000, 0.625, and 0.750 in. in diameter, respectively. The mass adjustment rod and the pulse rod are fabricated from U-Mo alloy. Two types of regulating rods are used. One is U-Mo alloy and the other is aluminum into which a U-Mo pin can be inserted as necessary. The holes for these rods are 1.094, 0.719, and 0.859 in. in diameter, are 3.125 in. from the core center, and are spaced 120° apart, and are lined with 8.375-in.-long stainless steel tubes to provide a smooth continuous guiding surface for the rods. Each tube terminates in a flange at its upper end and is held in place with a stainless steel retaining ring that fits over the flange and is attached to the top disk of the core with stainless steel machine screws.

Except for the U-Mo test specimens and one full-length plug for the sample-irradiation hole, all fuel surfaces are clad with a maximum of 0.005 in. of nickel or are aluminum ion plated. Aluminum ion plating is a recent development and will be used on new or reworked core pieces. In addition, the safety block, the three movable rods, and the bolt threads were flash-coated with chromium. The threaded parts of the bolts are overplated with gold to provide a better antigalling surface when threaded into the stainless steel helicoils in the bottom core plate.

The inventory of uranium on hand in the HPRR when the bottom plate was changed in 1975 is given in Table 2.1. (Current inventories are kept on appropriate SF accountability forms.) The disks are listed in the same order in which they occur in the core, with the possible exception that the ninth and tenth pieces from the top may be interchanged, since they are identical in shape and differ in U^{235} content by only 107 g. With all rods fully inserted, the basic core (fully loaded core No. 1 with U-Mo regulating rod in 1985) has a reactivity of approximately 152¢.

2.1.2 Remotely Movable Fuel Pieces

There are three or four remotely movable fuel pieces in the HPRR core. In the order of their worth, they are the safety block, the mass adjustment rod, the pulse rod, and the regulating rod (Fig. 2.2). An aluminum rod is usually used as the regulating rod but a U-Mo rod is available for calibration purposes. A summary of the mechanical design

Table 2.1. Inventory of uranium in August 1985

Component	Drawing No.	Process batch No.	Weight of U^{235} (g)
	Inventory of fully loaded core No. 1		
Disks[a]			
No. 1, 3/16 in. thick	NDA-12073	883-1370	1,999
No. 2, 1 5/16 in. thick	ORNL-D-54868	-1586	12,306
No. 3, 7/16 in. thick	NDA-12154	-1373	4,029
No. 4, 7/16 in. thick	-12154	-1368	3,956
No. 5, 15/16 in. thick	-12141[b]	-1360	7,479
No. 6, 15/16 in. thick	-12141	-1399	7,460
No. 7, 1 in. thick	-12072	-1365	7,388
No. 8, 15/16 in. thick	-12141	-1500	7,308
No. 9, 15/16 in. thick[c]	-12141[b]	-1359	7,424
No. 10, 15/16 in. thick[c]	-12141[b]	-1501	7,317
No. 11, 1 in. thick	-12071	-1361	7,602
Bolts (nine)	-12076	-1503 thru -1508 -1524 thru -1526	8,590
Bolt inserts (nine)	-12077	-1512 thru -1519 and -1533	1,005
Mass adjustment rod	-12078	-1521	994
Burst rod	-12078	-1523	899
Regulating rod	-12078	-1522	613
Sample-irradiation-hole plug, 8 1/4 in. long	-12080	-1578	105
Safety block	-12074	-1531	9,416
			95,890
	Inventory of spare parts and samples		
Sample-irradiation-hole plugs			
9.06 in. long (one)	NDA-12080[d]	883-1594	121
4.53 in. long (one)	-12080[d]	-1598	63
9.06 in. long (one)	-12080[d]		121
Bolts (three)	-12076	-1819	959
	-12076	-1821	958
	-12076	-1832	959

Table 2.1. Continued

Component	Drawing No.	Process batch No.	Weight of U^{235} (g)
Inventory of spare parts and samples			
Irradiation-hole samples			
9.06 in. long (six)		-1786	122
		-1811	119
		-1812	119
		-1813	120
		-1814	120
		-1815	120
4.53 in. long (one)		-1816	52
Disks			
7/16 in. thick	-12154	-1400	4,094
1/8 in. thick		-1371	1,161
1/16 in. thick		-1376	583
3/16 in. thick	-12142	-1362	1,850
With radial hole, 1/2 in. thick			3,505
Unplated, 1/2 in. thick			4,133
Fission-distribution measurement samples[e]			
43 pieces, 0.365-in. diam x 0.0625 in. thick			64
22 pieces, 0.25-in. diam x 0.0625 in. thick			14
1 piece, 0.295-in. diam x 0.125 in. thick			1.9
50 pieces, 0.295-in. diam x 0.0625 in. thick			49.4
10 pieces, 0.295-in. diam x 0.50 in. thick			80.1
4 pieces, 2-in. diam x 0.0313 in. thick			92.2
10 pieces, 0.295-in. diam x 0.25 in. thick			40
40 pieces, 0.375-in. diam x 0.25 in. long			245
2 pieces, 0.375-in. diam x 1.50 in. long			74
1 piece, 0.375-in. diam x 3 in. long			74
4 pieces, 0.375-in. diam x 0.50 in. long			49.4
			20,033
		Total inventory available	116,585

[a]Listed in order from top down. [b]Except for thermocouple.

[c]Disks 9 and 10 are interchangeable. [d]Except for length.

[e]For irradiation in either the radial hole or the regular vertical sample-irradiation hole.

features of the movable fuel pieces, as well as of the core, is given in Table 2.2.

2.1.2.1 Control rods

The 1.000-in.-diam mass adjustment rod and the 0.625-in.-diam regulating rod are motor-driven, with the drive motors and associated gear trains being mounted on the superstructure plate immediately above the core. The travel of each rod is limited in both directions by switches interlocked with the drive motor. When in the inserted position, each rod is fully contained in the core. These rods do not have scram capability.

2.1.2.2 Safety block

The 3.375-in.-OD by 2-in.-ID safety block is also motor-driven and is connected through a magnet to a drive unit mounted on the intermediate superstructure plate above the core. The safety block is equipped with an antirotational device to make the SAFETY BLOCK INSERTED position more reproducible which improves the accuracy of achieving the target yield. When scrammed, the 6 1/2-in.-long safety block falls out of the bottom of the core into a 3 9/16-in.-ID stainless steel tube. The energy of the fall is taken up by a shock absorber composed of layers of rubber approximately 1/4 in. thick alternating with layers of brass approximately 1/16 in. thick, both in the form of disks surrounding the safety support rod and attached to it immediately below the magnet keeper. The shock absorber and the magnet are contained in a housing which is connected to the intermediate superstructure plate and serves to protect these components, as well as to limit the fall of the safety block. A microswitch located near the lower end of the housing is actuated by the shock absorber when the safety block is down. This switch is interlocked with certain reactor operations, which are explained in Section 4.

In order to decrease the time necessary to expel the safety block, a spring, which has approximately 50 lb force when compressed, surrounds the safety block support rod and is located between the stainless steel portions of the safety support block and a positioning stop attached to the lower surface of the superstructure plate immediately above the core. The positioning stop contains a guide bearing to maintain proper alignment of the safety block and extends down to the top of the core, where it functions as a physical limit to the upward travel of the

Table 2.2. Summary of the HPRR mechanical design characteristics

Core No. 1	
Reactor diameter	8 in.
Reactor height	9.06 in. (23.0 cm)
Fuel material	90 wt % U -- 10 wt % Mo
U^{235} enrichment	93.14%
Control rods	
Travel	Full core length
Weight	1.928 kg of U-Mo (MAR)[a]
	Hollow aluminum (RR)[b]
	1.746 kg of U (MAR)
	0.658 kg of U (RR)
Diameter	1.0900 in. (MAR)
	0.625 in. (RR)
Length	9 in.
Type of drive	Electric motor
Speed	2.5 in./min
Safety block	
Travel	8.2 in.
Weight	11.19 kg of U-Mo
	10.11 kg of U
Outside diameter	3.375 in.
Length	6.500 in.
Initial acceleration on scram	2.28 g
Release time of electromagnet	0.004 s
Type of drive	Electric motor
Insertion speed	1.9 in./min
Pulse rod	
Travel	8.9 in.
Weight	1.065 kg of U-Mo
	0.965 kg of U
Diameter	0.750 in.
Length	10.5 in.
Type of drive	Pneumatic cylinder
Insertion time	Approximately 0.16 s

[a]Mass adjustment rod.

[b]Regulating rod (A 0.726-kg U-Mo rod may be used.).

stainless steel safety support block and hence to the upper travel of the safety block.

In order to ensure that the safety support block assembly is firmly seated against the stop and yet does not pull the magnet and keeper apart, the magnet is connected to the safety-drive lead screw through an overtravel spring. When the spring has been compressed about 0.1 in., a microswitch is actuated and turns off the drive motor. The safety-block drive unit includes the feature of automatically driving the magnet down to the magnet keeper when the reactor is scrammed. The automatic rundown is turned off by a microswitch located in the bracket to which the magnet is attached. When the magnet is driven down, a pin about 2 in. long attached to the center of the keeper passes through the center of the magnet and actuates the microswitch just before the magnet and keeper come in contact. The operator can drive the safety-block magnet down at any time with the safety-block position switch on the reactor console, which bypasses the automatic run-down limit switch and allows the magnet to be run down until it comes in contact with the keeper.

A second microswitch, located on a bracket on the intermediate superstructure plate, turns off the drive unit soon after magnet-keeper contact is made.

2.1.2.3 Pulse rod

The 0.750-in.-diam pulse rod is actuated by a 2-in.-bore pneumatic cylinder mounted on the superstructure plate immediately above the core. This cylinder is normally operated with a pressure of 60 to 70 psi and is capable of injecting the pulse rod into the core in about 160 ms. The pulse rod has a stroke of 8.9 in., and when fully inserted, the bottom of the rod protrudes 1.13 in. below the bottom of the core. Microswitches indicate whether or not the pulse rod is at its lower limit or upper limit and are appropriately interlocked in the operating sequence. During steady-state operations, the gas pressure is removed from the system, and the pulse rod is locked in the core by means of a motor-operated latch provided for this purpose. During pulse operation, a second latch locks the pulse rod out except at the appropriate point in the sequence. The latches are appropriately interlocked in the operating sequence, and limit switches indicate their positions. After completion of the pulse, air pressure is used to remove the pulse rod from the core, but a spring is also provided around the upper extension shaft of the pulse rod to eject the rod out the top of the core if the pneumatic system (or electric power) fails.

2.1.3 Core Supports and Guards

The core is attached to the superstructure by means of a stainless steel support ring bolted directly onto the core with three of the U-Mo bolts. The ring (shown in Figs. 2.1 and 2.3) is attached to the three support rods with three nuts and lock washers and extends outward approximately 2 in. Protective measures are provided in a crash plate, a safety tube, and a safety cage, all of which are designed to prevent damage to the core by collision with other objects and also to preclude an excessive reactiviy increase by surrounding objects getting too close.

2.1.3.1 Crash plate

The crash plate (Fig. 2.3) is a stainless steel plate attached to the superstructure and suspended below the core. The flanged ends of the three support legs are bolted to both the crash plate and the core support plate (i.e., the superstructure plate immediately above the core); however, the crash plate can easily be removed by means of pinned joints in the legs. This is sometimes done to reduce the mass in the vicinity of the core. In addition to protecting the core, the crash plate can also support the entire reactor assembly.

2.1.3.2 Safety tube

The safety tube is a 3 9/16-in.-ID stainless steel tube attached to the bottom of the core and designed to prevent the safety block from being inadvertently inserted because of the reactor being dropped or mishandled. This protective device, shown in Fig. 2.2, is especially needed during those times when the crash plate may be absent. The safety tube has a 1/4-in.-thick wall and is 9 1/2 in. long. It surrounds the safety block in its scrammed position, the tube protruding further below the core than the safety block by about 1 in. The tube is attached to the core by four 5/16-in.-diam stainless steel machine screws. By means of a slot cut in the flange, the safety tube can be positioned directly under a sample-irradiation hole so as to allow free passage of a nonthreaded sample through the bottom of the core. A

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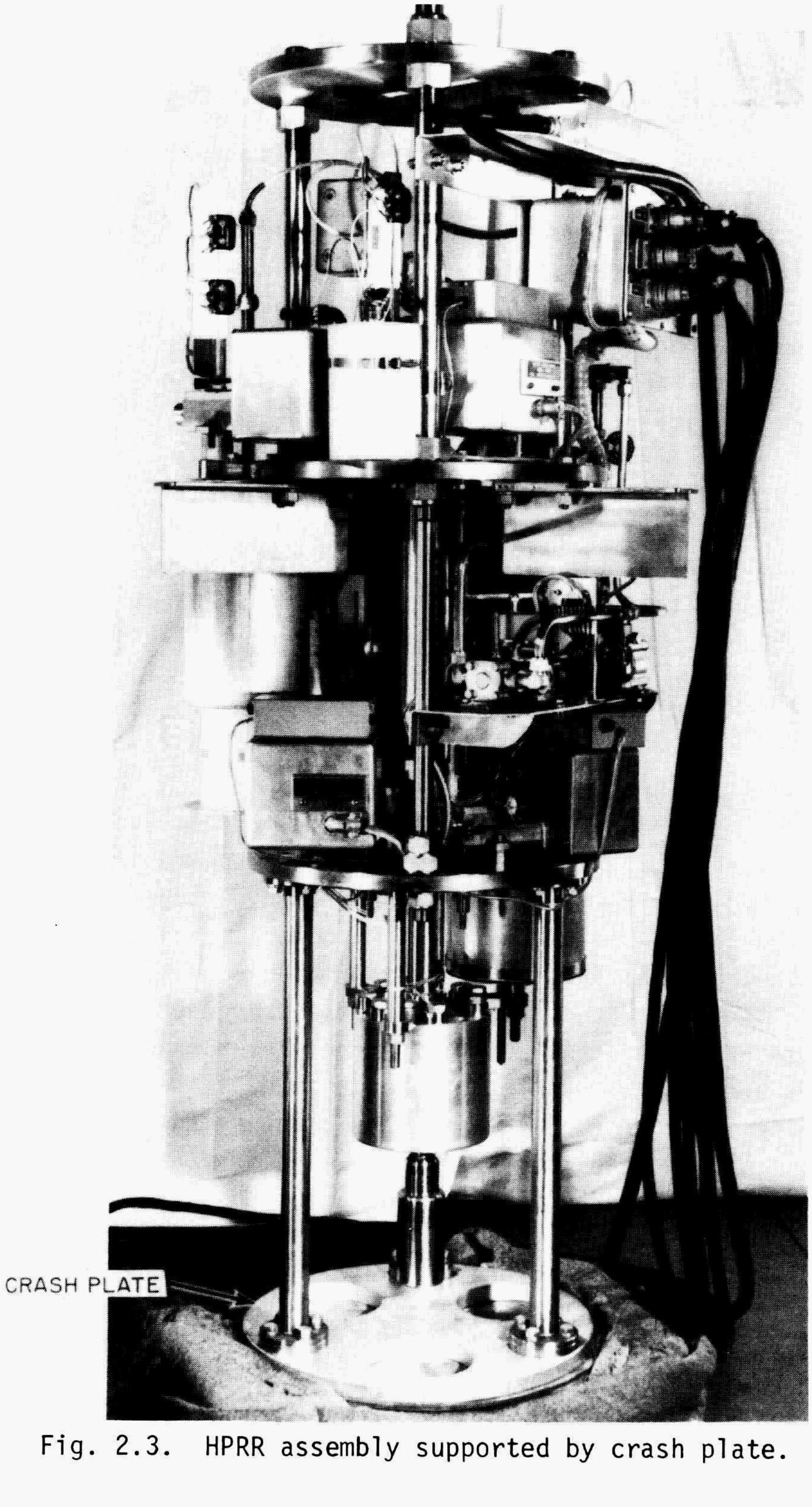

Fig. 2.3. HPRR assembly supported by crash plate.

stainless steel beaker is attached to the lower end of the safety tube to catch any radioactive materials.

2.1.3.3 Safety cage

A safety cage has been fabricated to surround the core and prevent any experimental apparatus from getting closer than approximately 3/4 in. of the core. The cage (Fig. 2.2) is fabricated from perforated aluminum (62% void) and is secure to the reactor superstructure with three 1/4-in.-diam pins which go through both the lugs provided for the purpose and the three core support shafts. The cage was designed so that the area in the region of the sample-irradiation-hole outlet is accessible.

2.1.4 Sample-Irradiation Hole

The sample-irradiation hole (Fig. 2.2) can be used to irradiate U-Mo samples or other samples for power calibrations and other purposes. The hole is 0.313 in. in diameter and extends vertically the entire length of the core at a position 2.210 in. from the vertical center line of the core.

2.1.5 Source and Drive

During operation, the source is withdrawn upward into a neutron shield mounted atop the elevator structure which supports the reactor (see Section 3.3). The source moves through a guide tube which is in two parts. The upper part is attached to the elevator structure, the lower part to the reactor superstructure. When the pickup mechanism (see Section 3.3) which is mounted on the elevator is used to lower the reactor, the two sections of the guide tube separate. Interlocks prevent driving the source out of its shield unless the pickup mechanism is at its up limit and the reactor is suspended from the pickup clamp or is suspended from the hydraulic lift and is raised up to the pickup clamp so that the guide tube is continuous.

The source for the reactor, when down (at INSERT limit), is positioned against the safety cage at about the midplane of the core. The source is interlocked so that it must be in the down position before the reactor can be operated.

2.2 INSTRUMENTATION AND CONTROLS

Block diagrams of the reactor instruments are given in Fig. 2.4, and the operational block diagram is shown in Fig. 2.5. The five types of information fed to the control system are the counting rate, log N period, level safety, level control, and temperature. A pulse-detector channel provides supplementary information during pulse operations. The various channels of information are discussed below, as well as the scram conditions, the automatic power-level-control servo, the annunciator system, the closed-circuit television system, and the radiation-monitoring instruments.

2.2.1 Counting-Rate Channels

There are two counting-rate channels fed by two fission chambers as shown in Fig. 2.4. Each channel is intended to serve as a startup channel and produces a measurable counting rate when the source is inserted. Both chambers are mounted at a fixed position on the reactor superstructure.

The counting-rate channels are interlocked in the safety system so that the safety block cannot be inserted unless one or the other channel is counting at least 2 counts/s.

2.2.2 Level-Safety Channels

In addition to the counting-rate chambers, the reactor has two noncompensated ion chambers (Fig. 2.4) which detect the neutron flux by means of a series of plates coated with boron enriched in ^{10}B. Each chamber contains two independent sections, one section in each chamber being capable of driving a safety channel to activate a scram signal. A scram is automatically initiated when the power level reaches a nominal 15 kW. A scram will cause the safety-block magnet and pulse-rod solenoid valves to rapidly (in 4 ms) deenergize when the sigma-bus voltage is raised by a high-level or period-trip signal.

2.2.3 Log N Period Channel

The log N period channel, which receives its signal from the second section of one of the two ion chambers (Fig. 2.4), has a useful range of approximately six decades. The level signal is fed from the chamber to a log N period amplifier and from there to a log N recorder and a period

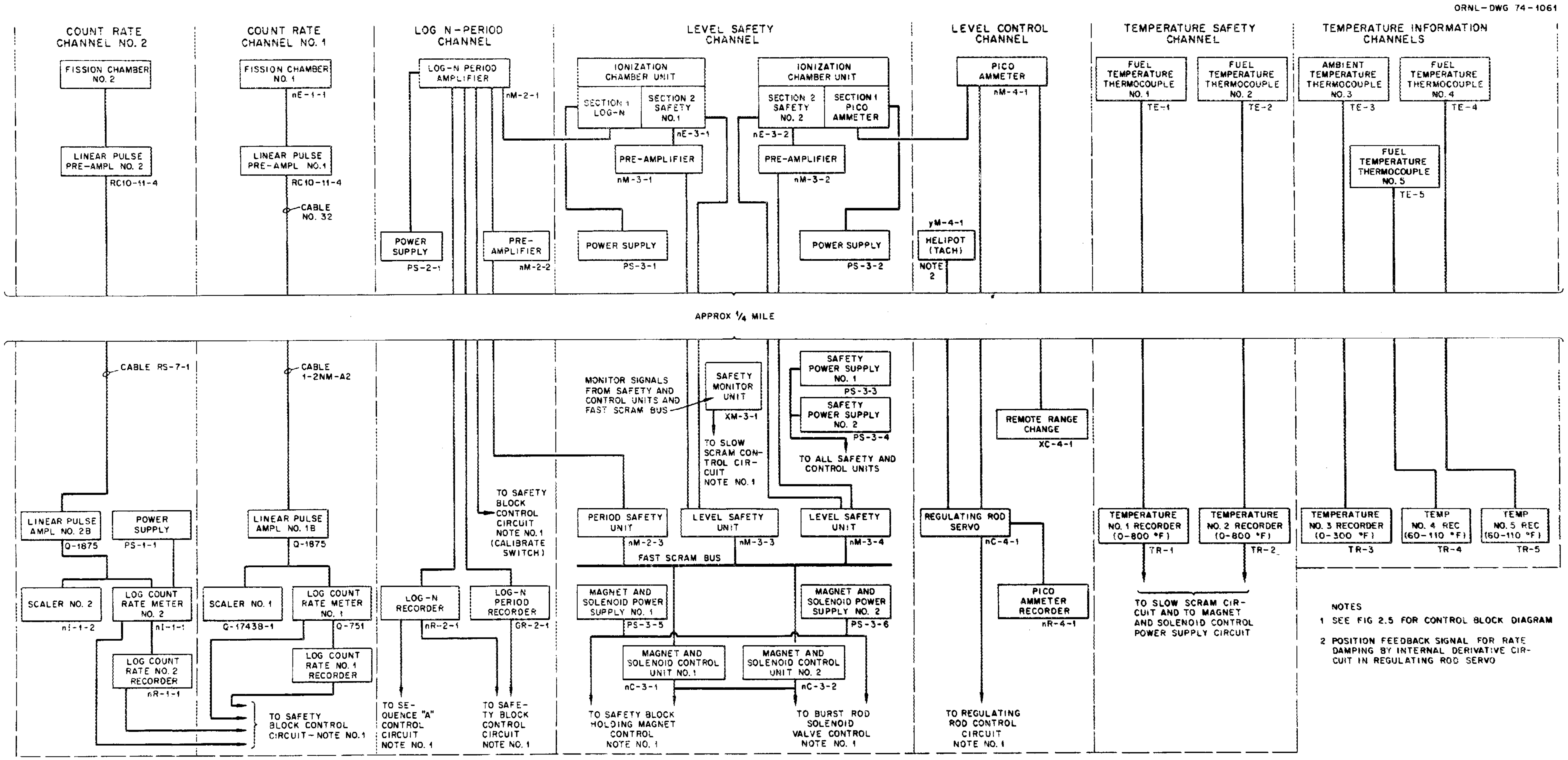

Fig. 2.4. Block diagram of HPRR instruments.

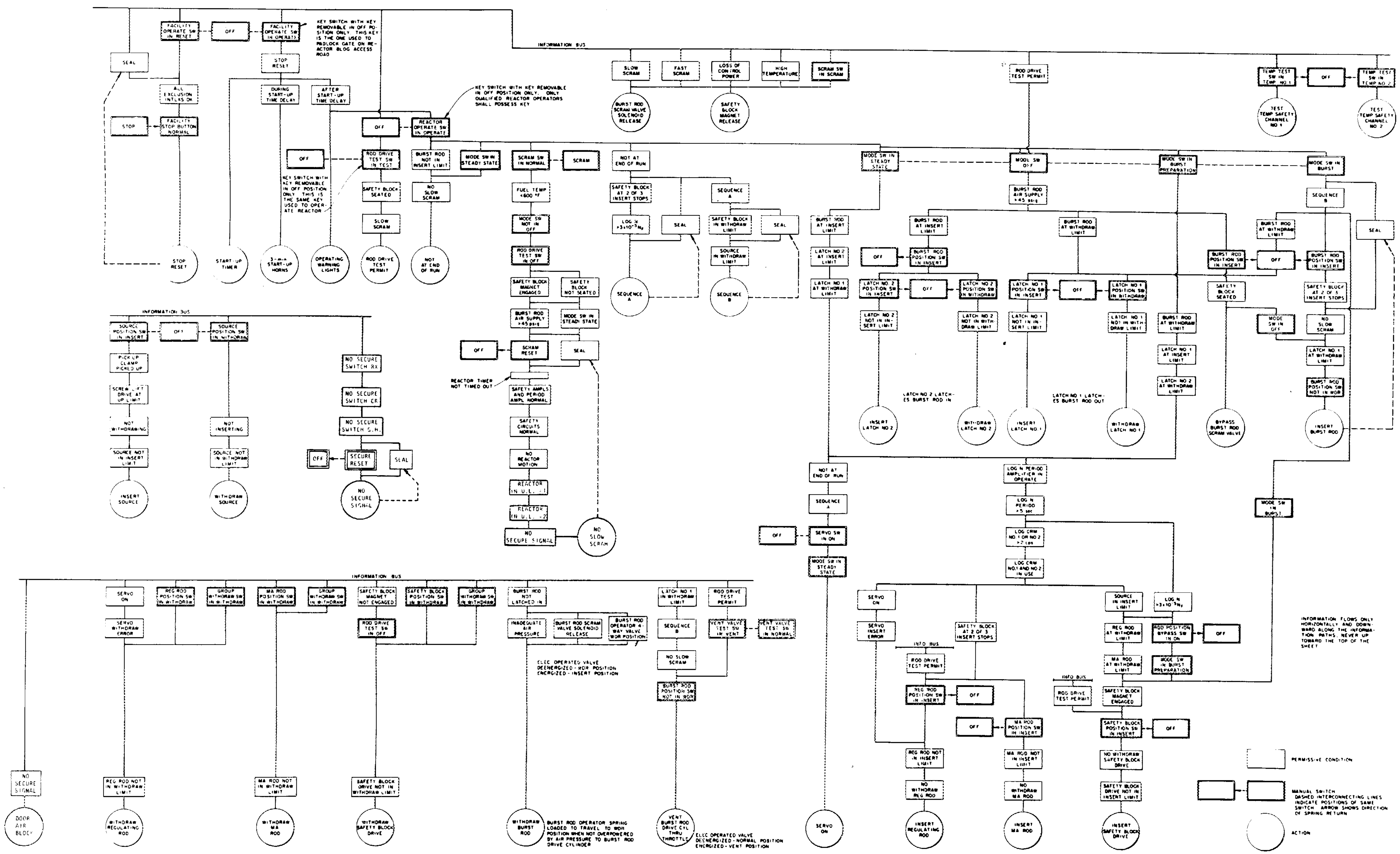

Fig. 2.5. HPRR operational block diagram.

recorder. The signal is also fed through a preamplifier to the period safety unit, which is connected to the fast-scram bus and may be used to shut down the reactor if the period goes below 1 s. (This shutdown feature interferes with low-level pulse operation and may be disconnected.) The period recorder is interlocked with all the movable components so that no reactivity can be added if the period is less than 5 s. The log N recorder is subject to errors as large as 20% and therefore indicates the overall trend of the power level but cannot be used for period measurements or accurate determinations of relative power level.

2.2.4 Level-Control Channel

A relatively accurate linear indication of neutron flux extending from full power down approximately six decades is accomplished by the use of a multirange picoammeter to measure the current from the second section of the other ion chamber (Fig. 2.4). In addition, this channel furnishes the signal necessary for automatic control of the power.

2.2.5 Temperature Safety Channels

The temperature of the core must be known in order to prevent overheating of the U-Mo alloy and to keep the available excess reactivity constant prior to a pulse. The temperature rise is also useful for enabling quick estimates to be made of the size of a pulse. Five iron-constantan thermocouples (Fig. 2.4), each enclosed in a thin-walled stainless steel tube and grounded to the tube at the point of the junctions are used for temperature control.

Thermocouples 1 and 2 in core 1 are installed at locations at which the fission densities in the core are, respectively, 15 and 7% below the peak fission density. Thermocouples 1 and 2 in core 2 are installed at locations that are 11% below the peak fission density. Another difference is that the thermocouples in core 1 are silver-soldered to brass plugs in their respective core disk, whereas the thermocouples in core 2 are pressed in fuel pins that are inserted radially in their respective fuel disk. In both cores, these thermocouples are part of the safety system of the reactor, and if the temperature rises above 600°F at either thermocouple, a reactor slow scram will be initiated. Each thermocouple connects to a single-point recorder having a range of 0 to 800°F and measures the relative total heat rise of the core resulting from a pulse.

Thermocouple 3 is suspended in air at the reactor.

Thermocouples 4 and 5 are located, respectively, (1) under a stainless steel washer under a U-Mo bolt and (2) between the safety tube and the core, and are pressed firmly against the core surface. Both are connected to individual recorders and are used to measure the ambient temperature of the core during a pulse experiment. The temperature channels for each have a range of 60 to 110°F.

2.2.6 Pulse-Detection Channel

In addition to the normal reactor instruments, a photodiode and a 1/8-in.-thick plastic scintillator detector is attached to the reactor superstructure near the core so that during a pulse it supplies a signal proportional to the fission rate. The signal can be applied to an oscilloscope which reproduces the shape of the entire excursion for photographing. The oscilloscope trigger is actuated by a signal from a second photodiode, which has a more sensitive NaI crystal as the detector and which is also attached to the reactor superstructure.

2.2.7 Automatic Power-Level-Control Servo

The reactor power level may be controlled automatically during steady-state operation by use of a servo mechanism which receives information from the picoammeter and adjusts the reactivity by movement of the regulating rod. The servo maintains the reactor power level at the chosen fraction of full scale for whatever range is selected on the picoammeter. The servo is especially useful for maintaining a given power level for a considerable length of time or for maintaining a steady power level when the reactor is heating or cooling.

2.2.8 Shutdown Initiation

Fast shutdowns are initiated through highly reliable, well-monitored electronic channels which require about 4 ms to cause the magnet to release the safety block. Slow shutdowns are initiated through a relay which requires approximately 100 ms to cut off the magnet current. Both types also deenergize the pulse-rod solenoid control valves. A fast shutdown is initiated by:

1. a power greater than 15 kW, and
2. a reactor period of less than 1 s (when it is in use).

A slow shutdown is initiated by:

1. a low air pressure (if in pulse mode),
2. a loss of electric power,
3. a core temperature greater than 600°F,
4. a manual scram request,
5. opening of the reactor building doors,
6. opening of the exclusion-area gate No. 1 or turning off any area interlock key,
7. depression of a FACILITY STOP button,
8. certain failures of the safety system,
9. hydraulic lift bleed down (reactor lowered more than 1.0 cm), or
10. depressing reactor secure switch.

2.2.9 Annunciator System

Two types of audible alarms each accompanied by a visible alarm, alert the operator at the console to an abnormal condition. The annunciators for which the audible alarm is a single-stroke gong are listed below along with the action or condition that actuates the alarm:

1. SAFETY MONITOR actuated
2. SAFETY MODULE REMOVED
3. LOG N PERIOD <5 s
4. FAST SCRAM (Reactor power exceeds 15 kW or log N period <1 s.)
5. FUEL TEMPERATURE HIGH (core temperature >600°F)
6. L.P. CYLINDER PRESSURE LOW (if in pulse mode, an air-tank pressure <60 psi)
7. AREA INTERLOCK (Gate No. 1 in 1000-ft-radius fence open, door in reactor bay opened, or area interlock key in console turned off)
8. SLOW SCRAM

The annunciators for which the audible alarm is a buzzer, are listed below along with the action or condition that actuates the alarm:

1. FACILITY STOP button depressed
2. TEMPERATURE RECORDER POWER FAILURE
3. CONTROL BUILDING DOORS OPENED, only when operating in the Restricted Access Mode (power above 100 W or in pulse mode or Restricted Access Requested)

4. PIT NO. 1 LIQUID LEVEL exceeds 6 in.
5. RESTRICTED ACCESS REQUEST when the RESTRICTED ACCESS REQUEST button is depressed, the power indication on the Log N recorder exceeds 100 W, or the reactor is in the PULSE MODE of operation
6. CONTROL BUILDING MONITORS reading exceeds 20 mR/h when the FACILITY OPERATE switch is OFF
7. REACTOR BUILDING MONITORS reading exceeds 20 mR/h on either monitor when the FACILITY OPERATE switch is OFF
8. PIT NO. 2 LIQUID LEVEL exceeds 6 in.
9. LOW TANK PRESSURE (nitrogen supply pressure for pit door air motor <1260 psi)
10. LOW HEADER PRESSURE (nitrogen header pressure for pit door air motor <100 psi)

The operating sequence for the annunciators is given in Table 2.3.

Table 2.3. Annunciator system operating sequence

Step	Condition	Red light	White light	Audible alarm
1	Normal	Dim	Dim	Off
2[a]	Abnormal, until acknowledgement	Bright	Bright	On
3	Abnormal, after acknowledgement	Bright	Off	Off
4[b]	Normal condition returns, before reset	Off	Bright	Off
5	Normal, after reset	Dim	Dim	Off

[a]If, after Step 2, normal condition returns before the ACKNOWLEDGE button is operated, the annunciator remains in condition 2 until the ACKNOWLEDGE button is operated, after which the annunciator goes directly to Step 4.

[b]If, after Step 4, abnormal condition returns before the reset button is operated, the annunciator returns to Step 2.

2.2.10 Closed-Circuit Television

Three closed-circuit television systems monitor the reactor and the interior of the reactor building during experiments. Control of these monitors is from the reactor control room. Receivers are located in the reactor control room, and a monitor screen can be placed in the experimental laboratories. The three television pickups are located as follows: one, with remote-focus control and capable of wide-angle operations, at the east end of the building for monitoring the entire building; one, with fixed focus and fixed position mounted on the south side of the building for monitoring the reactor; and the third one, a portable unit capable of remote control of pan, tilt, and focus adjustment, located on a movable tripod so that it can be placed at critical positions to monitor the experiment or the reactor.

2.2.11 Radiation-Detection Instruments

Radiation levels and air activity are continuously monitored in the reactor building and the control building. Information on these monitors is presented in Health Physics and Safety Guidelines for the DOSAR Facility[1]. This document also describes the portable survey instruments, counting equipment, etc., available for radiological safety purposes.

2.3 PERFORMANCE CHARACTERISTICS

The previous operating experience with the HPRR, prior to startup at the HPRR Facility, consisted of the following:

1. Critical experiments[2] to determine the critical mass and to measure the temperature coefficients, fission-density distributions, reactivities as a function of the position of the movable core pieces, and the effects of reflectors
2. A series of experiments[3] at the Critical Experiments Facility for the purpose of calibrating the pulse rod with respect to fission yield and studying the physics of the pulse phenomena for this core
3. Operation BREN[4,5] at the Nevada Test Site, which consisted of steady-state operation for periods of several hours at power levels up to about 1.45 kW and a series of relatively low-level pulses.

Table 2.4 presents a summary of the performance characteristics of the various components of the reactor. The reactivity worth of the three rods (information is given for both U-Mo and aluminum regulating rods) as a function of position is given in Fig. 2.6, and the reactivity worth of the safety block as a function of both time after scram and position is given in Fig. 2.7. Vertical and radial fission-density distributions are shown in Figs. 2.8 and 2.9, respectively. Table 2.5

Table 2.4. Summary of performance characteristics of HPRR components for original core loading

Core No. 1	
Critical mass[a] with all rods in core	95.4 kg of U^{235}
Reactivity in fully loaded core	152 cents
Equilibrium temperature coefficient of reactivity	0.30 cent/°C (0.17 cent/°F)
Control rods	
Reactivity worth	195 cents (MAR[b]) 83 cents (RR[c]) 19 cents (RR[d])
Rate of reactivity addition at vertical center of core	13.3 cents/cm (MAR) 1.4 cents/s (MAR) 4.1 cents/cm (RR[c]) 0.4 cent/s (RR[c])
Safety block	
Reactivity worth	20 dollars
Rate of reactivity addition at insert limit	80.0 cents/cm 6.6 cents/s
Drop-out time for removing 1 dollar of reactivity after fast scram	0.038 s
Pulse rod	
Reactivity worth for 8.9-in. stroke	108 cents (approximately)
Rate of reactivity addition vertical center of core	7.7 cents/cm 3660 cents/s
Miscellaneous components	
Reactivity worth of sample-irradiation-hole plug	20 cents
Reactivity worth of bolt shim pin	16 cents
Reactivity worth of top 1/16 in. of fuel	23 cents

[a]Mass includes estimated weight of that portion of the control rods inside the core boundary and the estimated fuel worth of the safety cage.

[b]Mass adjustment rod.

[c]Regulating rod (U-Mo).

[d]Regulating rod (aluminum).

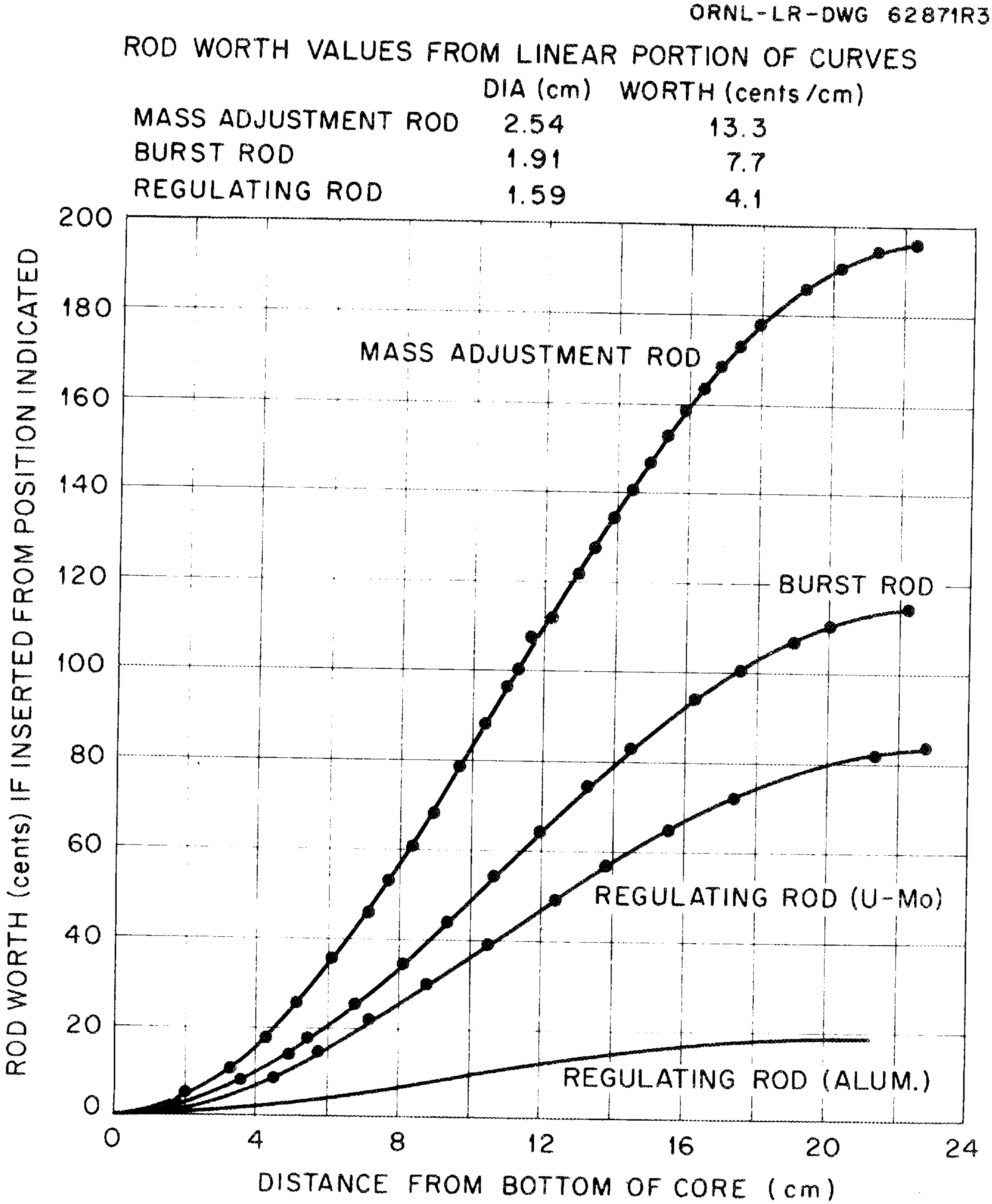

Fig. 2.6. Reactivity vs position for HPRR control rods and pulse rod for initial operation.

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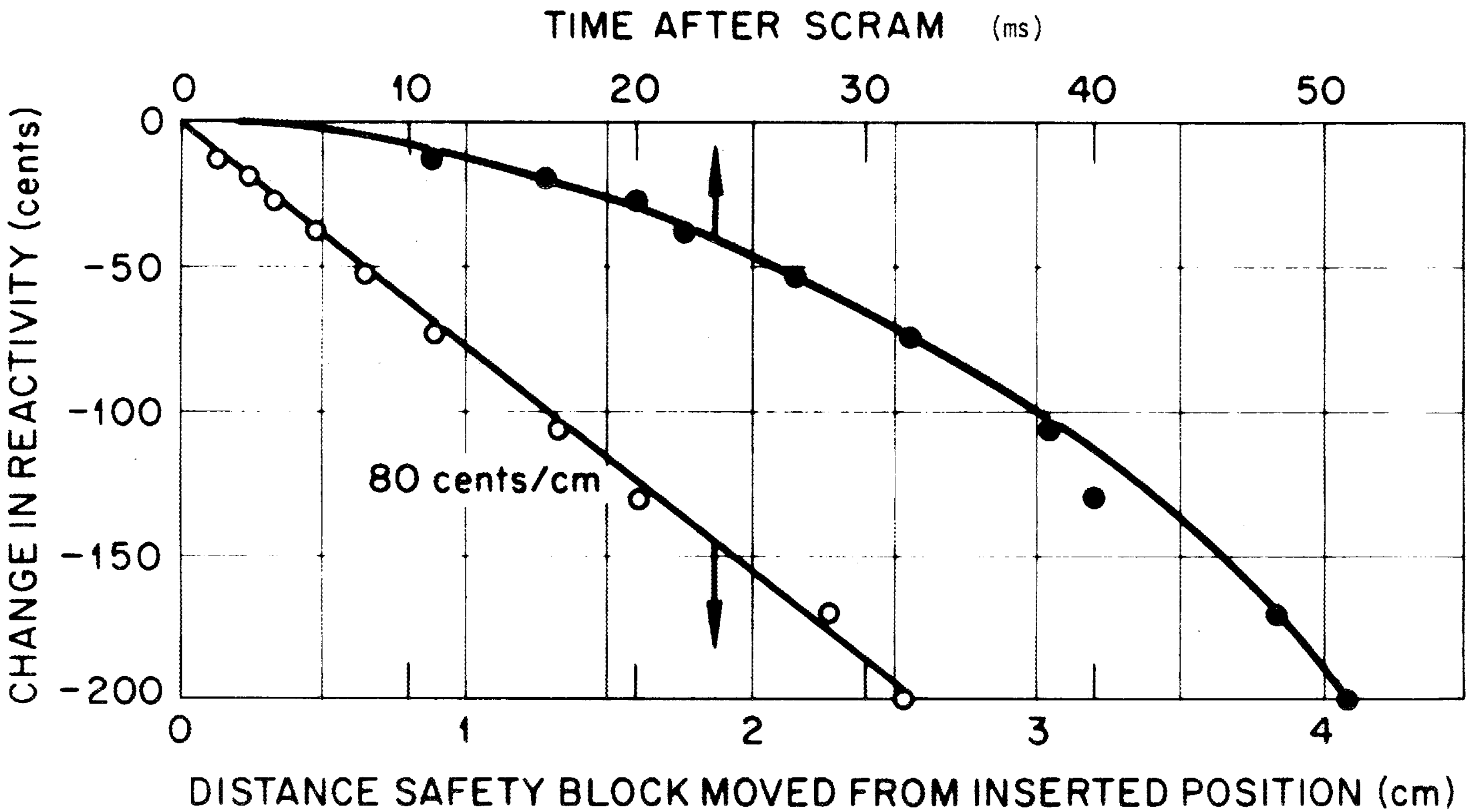

Fig. 2.7. Reactivity worth of HPRR safety block as a function of position and time after scram.

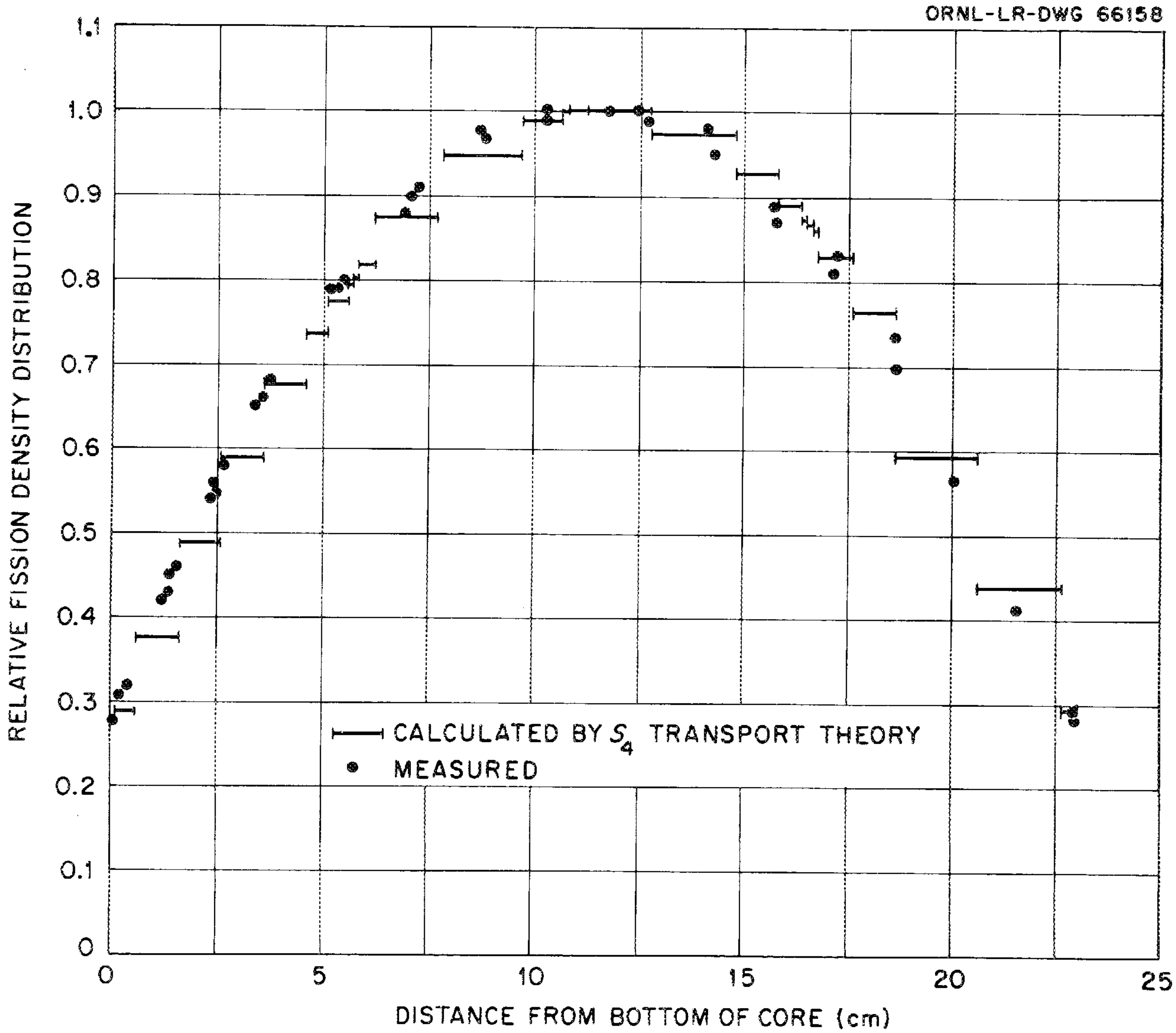

Fig. 2.8. Vertical fission density distribution in the irradiation hole of the HPRR.

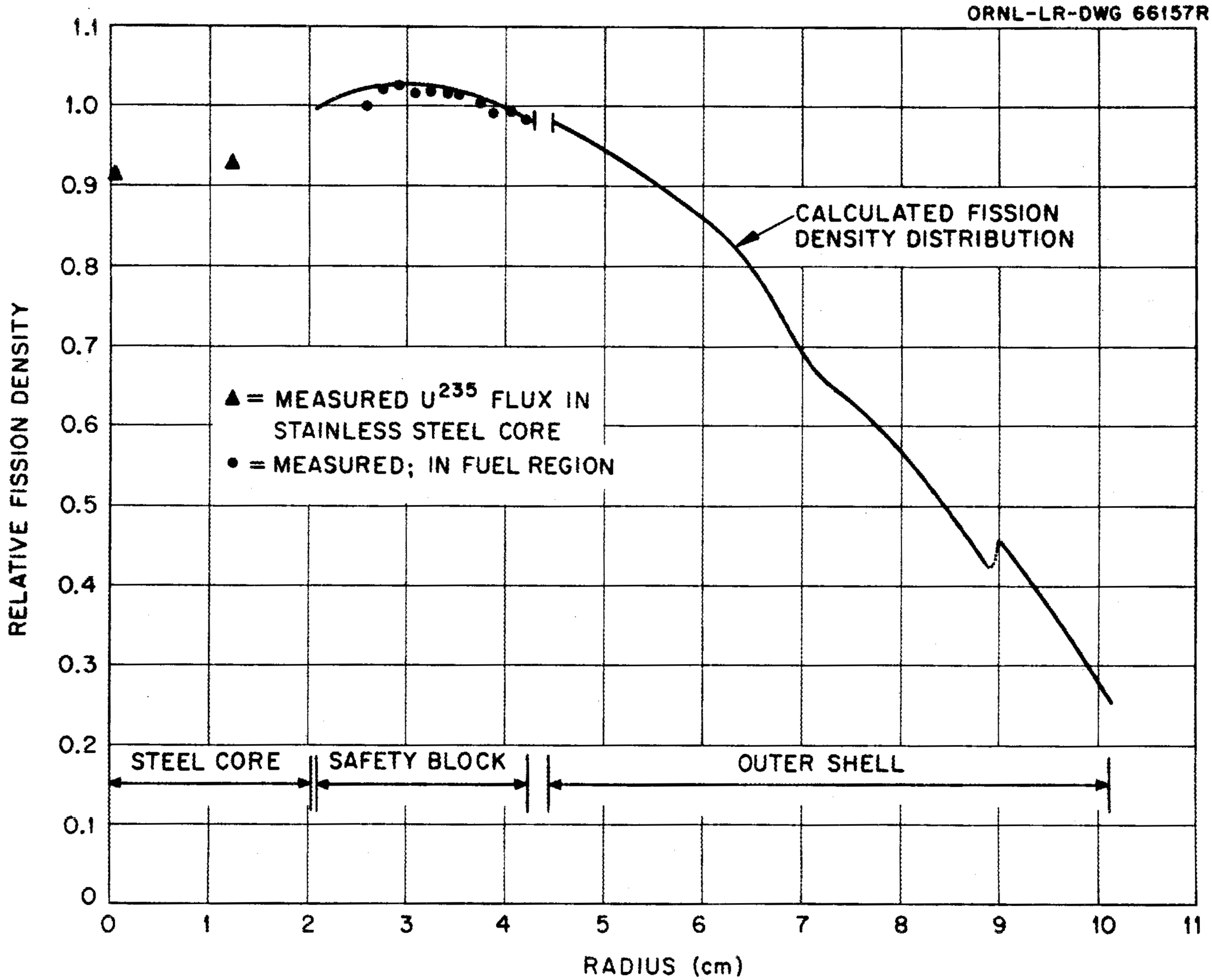

Fig. 2.9. Radial fission density distribution in the HPRR.

Table 2.5. Summary of HPRR overall performance characteristics

	Calculated[a] for pulse yield of 1×10^{17} fissions	Experimental, for pulse yield of 1.8×10^{17} fissions	Experimental, for pulse yield of 1.05×10^{17} fissions
Pulse performance characteristics			
Initial reactivity insertion above prompt critical, cents	7.6	11	9
Integrated neutron current 1 in. from reactor surface, neutrons/cm^2	2×10^{13}		
Total neutron leakage	1.3×10^{17}		
Peak power, MW	63,000	100,000	42,000
Initial reactor period, s	13	16	20
Pulse half-width, s	38	48	63
Maximum temperature rise, °F	740	720	415
Average temperature rise, °F	360	380	220
Cooling time (forced convection), h	2.5		
Cooling air required, cfm	1500-2000		
Steady-state performance characteristics			
Natural-convection cooling			
Maximum power, W	1000		
Maximum reactor temperature, °F	600		
Reactor surface temperature, °F	480		

[a]Calculations are for reference design[2].

is a summary of the overall performance of the reactor. The pulse shapes for various total yields are shown in Figs. 2.10 through 2.13.

The temperature limitation of 600°F is based on the requirement that the temperature be maintained low enough to minimize phase transformation of the gamma-stabilized U-Mo alloy fuel material and thus to minimize dimensional changes. The minimum time for initial phase transformation is approximately 25 h at temperatures in the neighborhood of 880°F. At lower temperatures, the time for initial transformation increases, becoming more than 2000 h at 600°F and essentially infinite at temperatures below 570°F.

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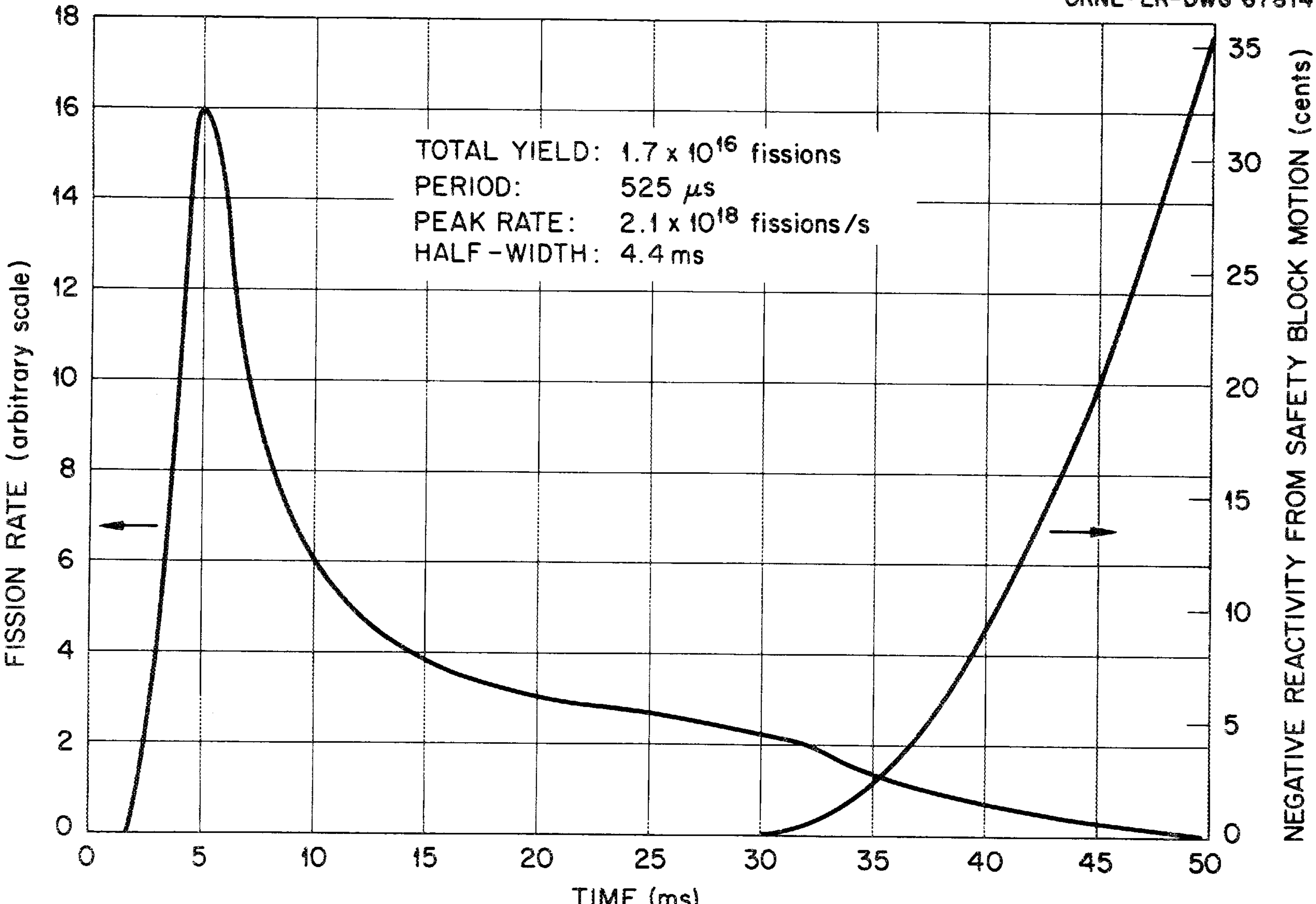

Fig. 2.10. Pulse shape for yield of 1.7×10^{16} fissions.

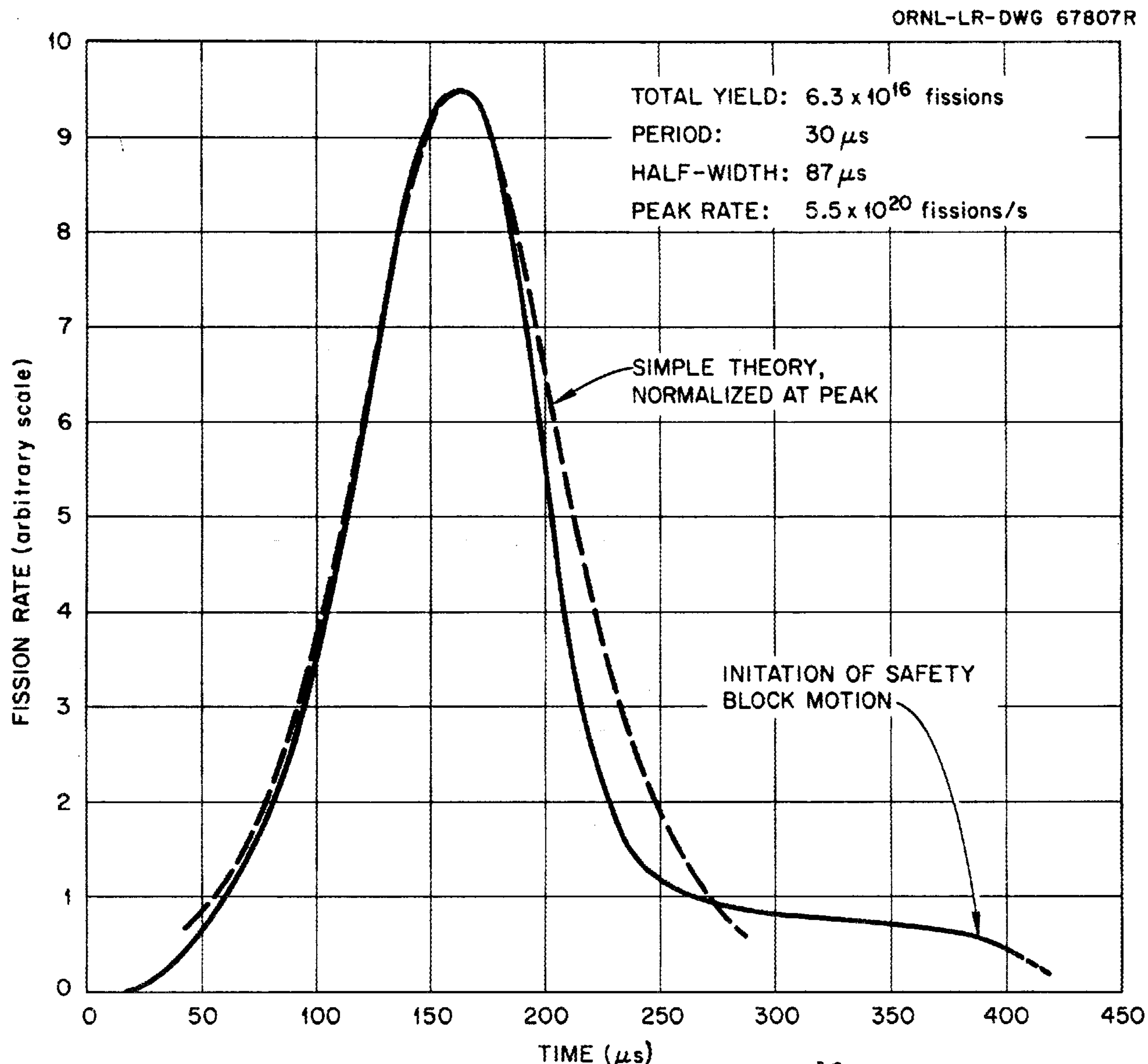

Fig. 2.11. Pulse shape for yield of 6.3 x 10^{16} fissions.

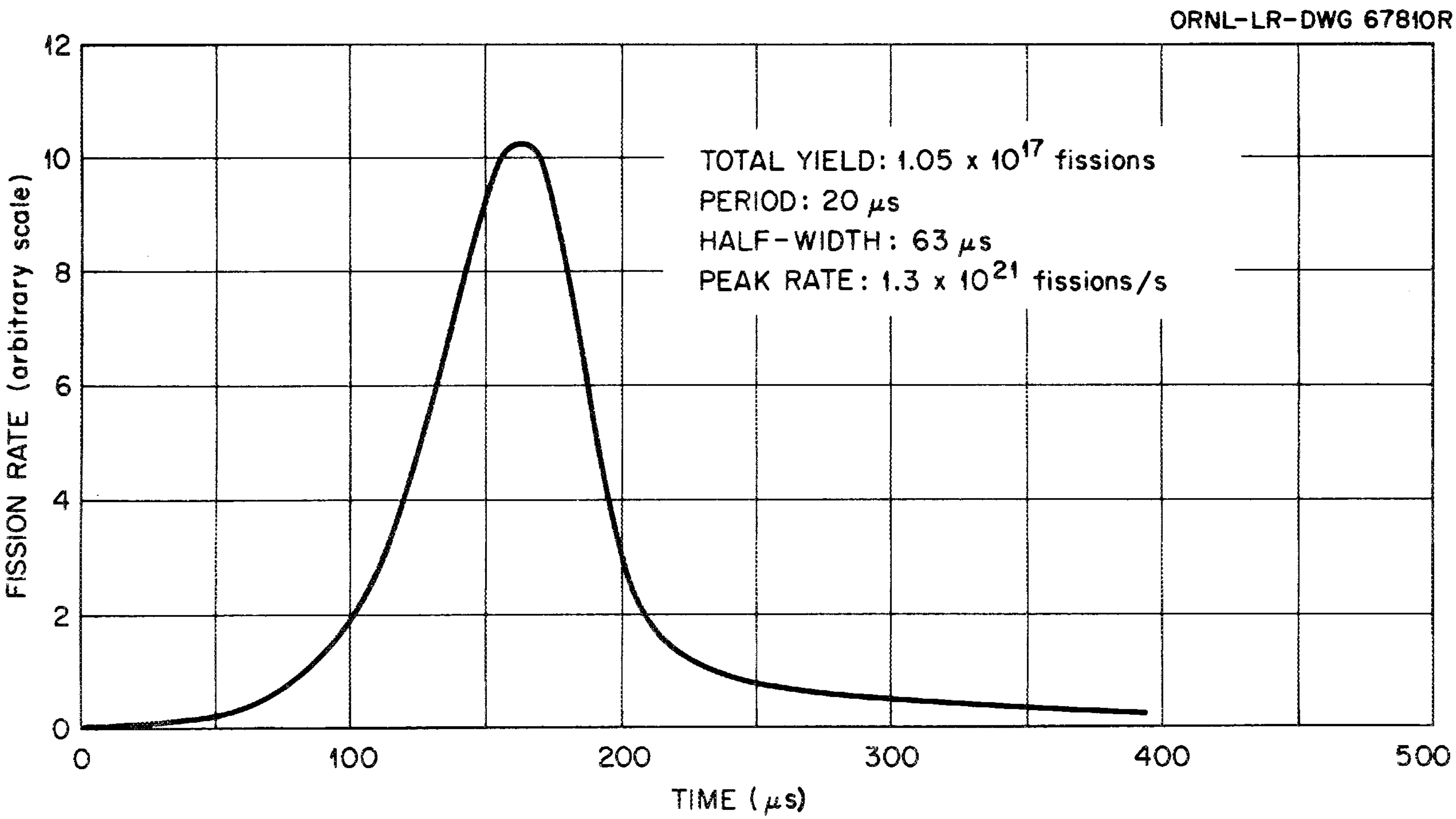

Fig. 2.12. Pulse shape for yield of 1.05×10^{17} fissions.

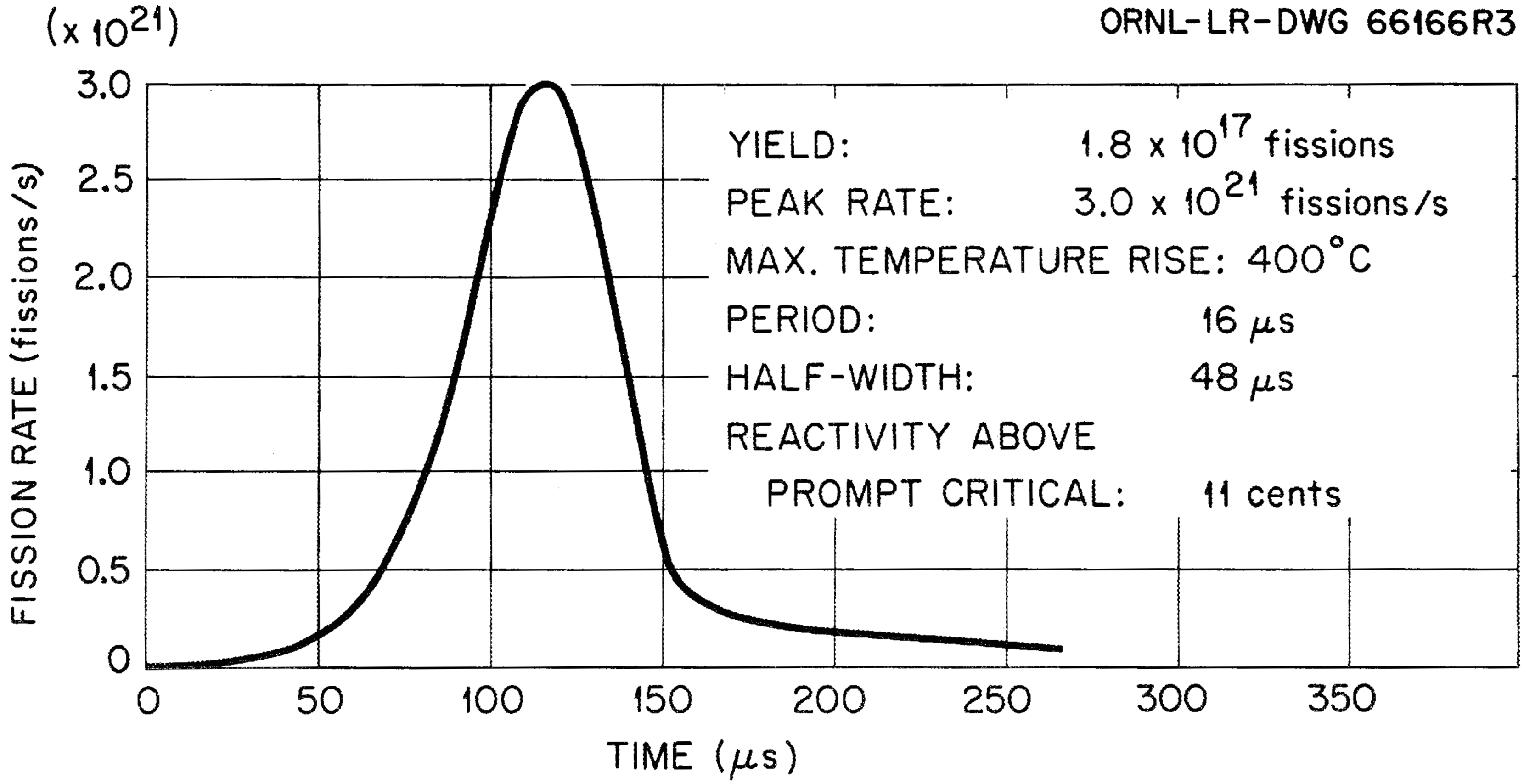

Fig. 2.13. Pulse shape for yield of 1.8×10^{17} fissions.

3. DESCRIPTION OF THE REACTOR HANDLING AND STORAGE FACILITIES

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3. DESCRIPTION OF THE REACTOR HANDLING AND STORAGE FACILILTIES

The reactor is normally attached to a hydraulic lift that is located in the reactor storage pit. To operate the reactor, the pit door is opened and the reactor is raised out of the pit with the lift (Fig. 3.1). When operation is completed, the reactor is lowered into the pit and the pit door is closed and latched. The reactor storage pit is located along the center line of and at the west end of the HPRR building (Building 7709)(Fig. 3.2). Storage pit No. 2 (also on the centerline) can also be used for storing the reactor when it is transported by the reactor positioning device for operation or maintenance. The positioning device moves along a set of tracks running the length of the building and extending to the end of an outside concrete apron. A derrick is available at the outside pad for use in moving shields and equipment. The positioning devices and storage pit doors can be operated only from the control panel in which the key switch is turned on. There are three control panels -- one in the control room and two in the reactor building. The hydraulic lift and the reactor storage pit door can only be operated from control panel No. 1 in the control room and control panel No. 2 which is the west panel in the reactor building.

3.1 REACTOR STORAGE PITS

The relative locations of the two reactor storage pits in the reactor building are shown in Fig. 3.3. The pits are approximately 5 ft long by 5 ft wide by 7 ft deep and are covered by electromechanically actuated 7-in.-thick steel doors. Each pit is provided with a supporting and positioning rack for storage of the reactor. The supporting and positioning rack is designed to provide the orientation and accuracy in location needed to permit remotely controlled withdrawal and replacement of the reactor with the reactor positioning device. To prevent increase of reactivity in the core due to water reflection, the pits are drained, by a 3-in.-diam untrapped drain line, to a retention pond located outside the reactor building at an elevation below the bottoms of the pits. Should water get into a pit and collect to a level of more than 6 in., it will be detected by a float-operated level switch and be annunciated in the control room.

The west storage pit (originally designated as pit No. 1) which contains a hydraulic lift and special security equipment is designated as the Reactor Storage Pit. The east pit is designated as storage pit No. 2.

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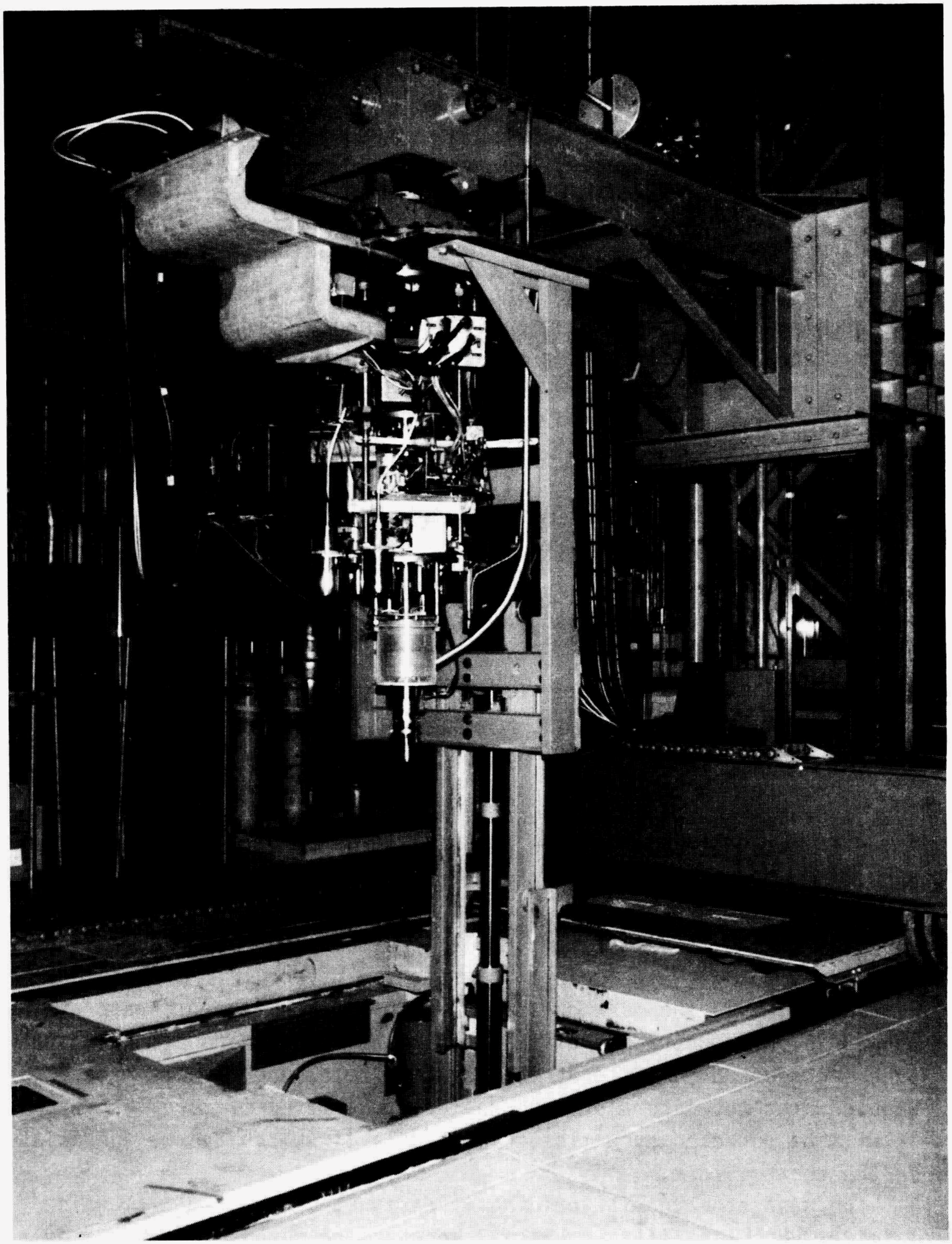

Fig. 3.1. HPRR suspended from hydraulic lift.

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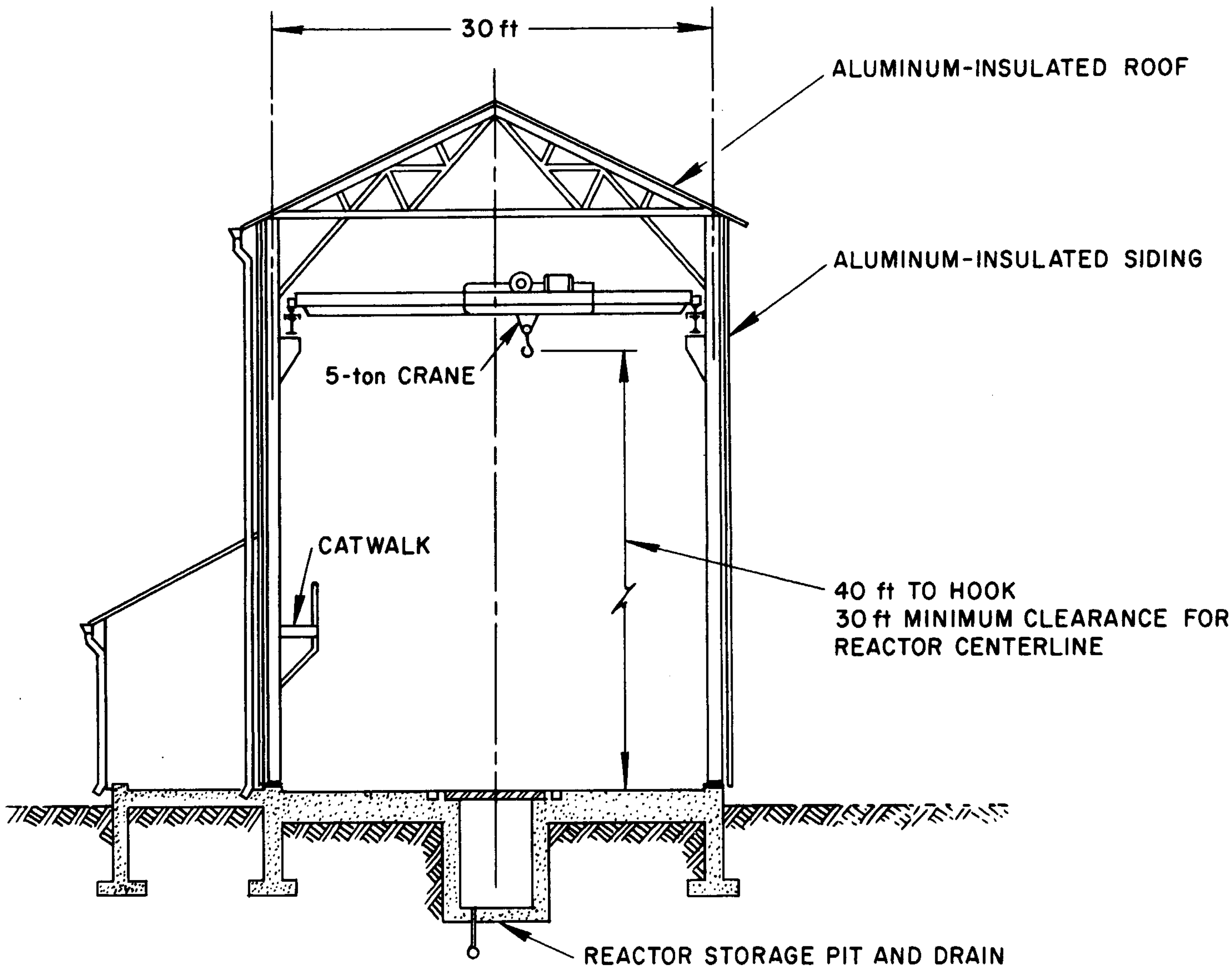

Fig. 3.2. HPRR building at DOSAR Facility.

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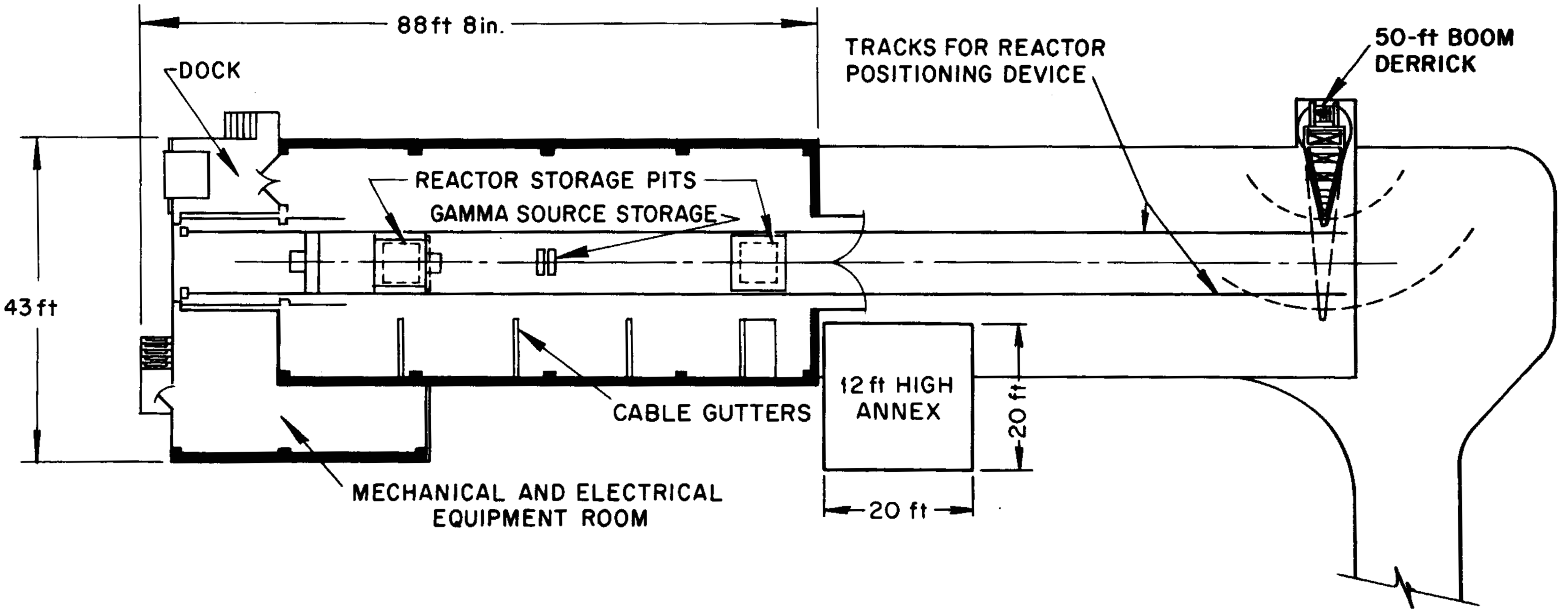

Fig. 3.3. Floor plan of HPRR building.

3.1.1 Storage Pit No. 2 Door

The pit door has OPEN and CLOSED limit switches.

3.1.2 Reactor Storage Pit Door

The reactor storage pit door is controlled by interlocks to provide both orderly operation and security of the reactor. The door has OPEN and CLOSED limit switches. The door is interlocked so that it cannot be closed when the reactor is suspended from the pickup mechanism in the pit, the pickup mechanism is suspended in the pit, the pickup mechanism is clear but the reactor is not correctly seated, or the hydraulic lift is not in the down position.

The door is normally driven by an electric motor which is geared to open or close the door. Power is supplied from the TVA grid or from a local auxiliary generator. In addition, the door may be closed with an air motor which has a monitored air supply. Interlocks also prevent closing of the door with the air motor until the reactor and hydraulic lift are correctly seated.

The door can be closed with either a switch on control panel No. 1 in the control room or control panel No. 2 on the west end of the reactor building. As part of a securing sequence, the door can be closed by depressing a pushbutton in the reactor bay, in the control room, or in Guard Post No. 23.

Opening the reactor storage pit door can only be accomplished during the day shift of a regular work day and after certain security requirements are met. This includes notifying Guard Headquarters, turning on power with a special key, actuating a cypher lock, and withdrawing door latches.

3.2 HYDRAULIC LIFT

The hydraulic lift which is located in the reactor storage pit is bolted to the reactor superstructure. The lift can be used to raise the reactor from its storage position to any position up to 1.5 m above the floor level when the proper conditions exist. It can be operated from control panel 1 or 2.

3.2.1 Pit Door

The reactor storage pit door must be open and both low- and high-pressure air supplies for pneumatic closing of the pit door must be above preset values of 1000 psi to permit operation of the hydraulic lift and above 1260 psi to clear the annunciator.

3.2.2 Lift Operation

The security inspector must turn on a permissive circuit to allow lift operation; then the lift is raised by turning the control handle to UP which turns on a hydraulic pump. Limit switches cut off the pump when the reactor is elevated to the correct height. The height is established by actuation of switches on the top of the reactor superstructure pressing against the pickup clamp on the reactor positioning device. The reactor height position indication on the reactor positioning device is set to give a correct indication of reactor height when the reactor pickup mechanism is at its upper travel limit, the pickup clamp T-bar is on DISCHARGE, and the reactor is raised by the hydraulic lift. Two switches establish the height; one cuts off the pump when the lift is at the proper height, and the second turns on the pump if the lift bleed down is >1.0 cm. For this operation, a strike on the reactor superstructure must be turned clockwise to actuate the reactor-engaged limit switch which permits operation of the source drive. To lower the reactor with the hydraulic lift, the control handle is turned to DOWN which opens a solenoid to bleed the hydraulic fluid back to its reservoir. Two frequently used reactor heights are 1.4 and 1.5 m. The elevator preset limits have been set so that the PRESET UP limit will provide a reactor height of 1.5 m and the PRESET DOWN limit will provide a reactor height of 1.4 m.

3.3 REACTOR POSITIONING DEVICE

The various components of the reactor positioning device are shown in Fig. 3.4, which depicts the reactor being supported directly above a storage pit. Figure 3.5 is a photograph of the positioning device supporting the reactor -- minus the core and control cables -- above the apron outside the control building. The device can be operated from either of two control panels in the reactor building or from a third panel in the control building. It can raise the midpoint of the reactor to any desired elevation up to 5.2 m above the floor and to any

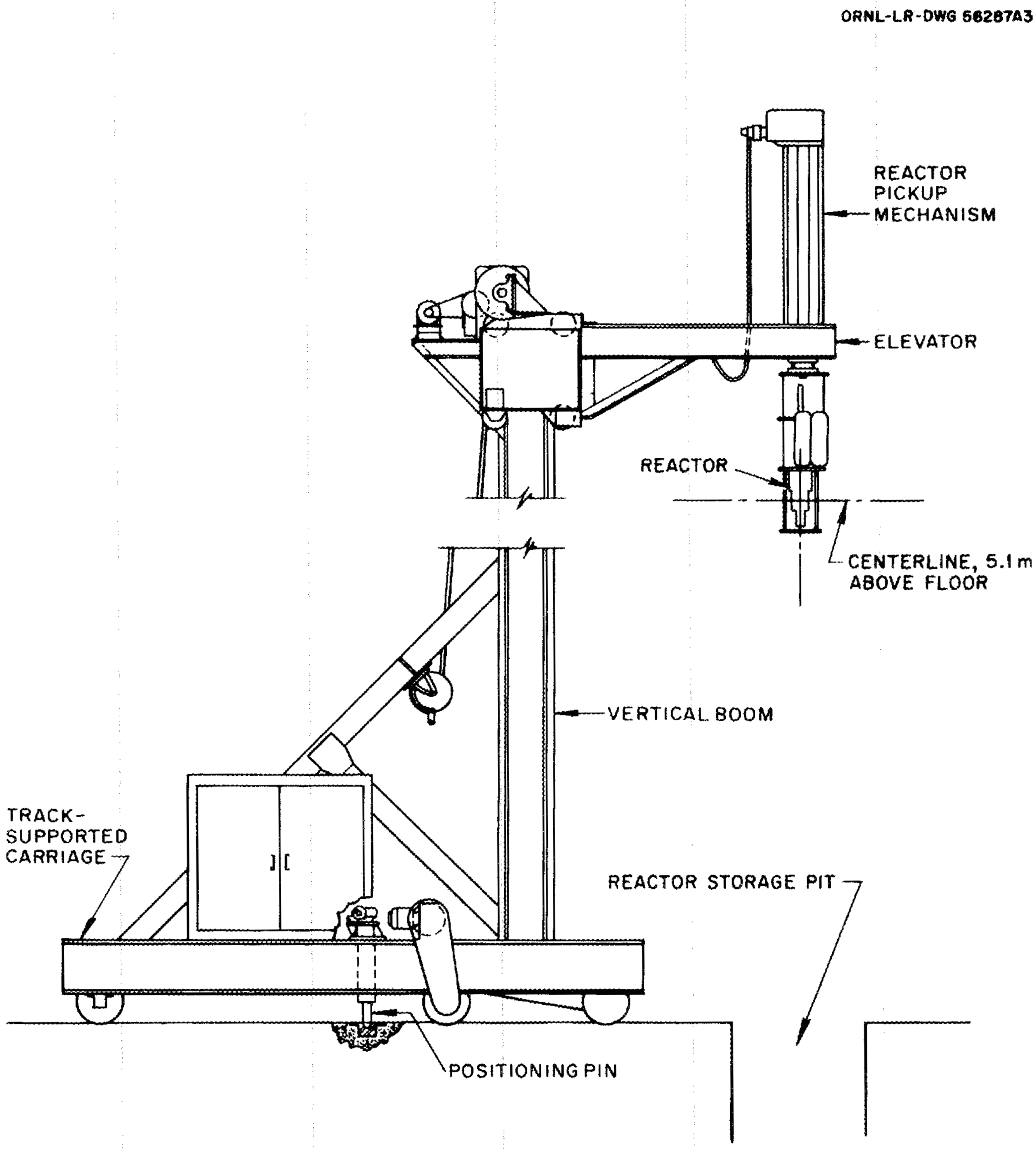

Fig. 3.4. Reactor positioning device.

ORNL-PHOTO 59473

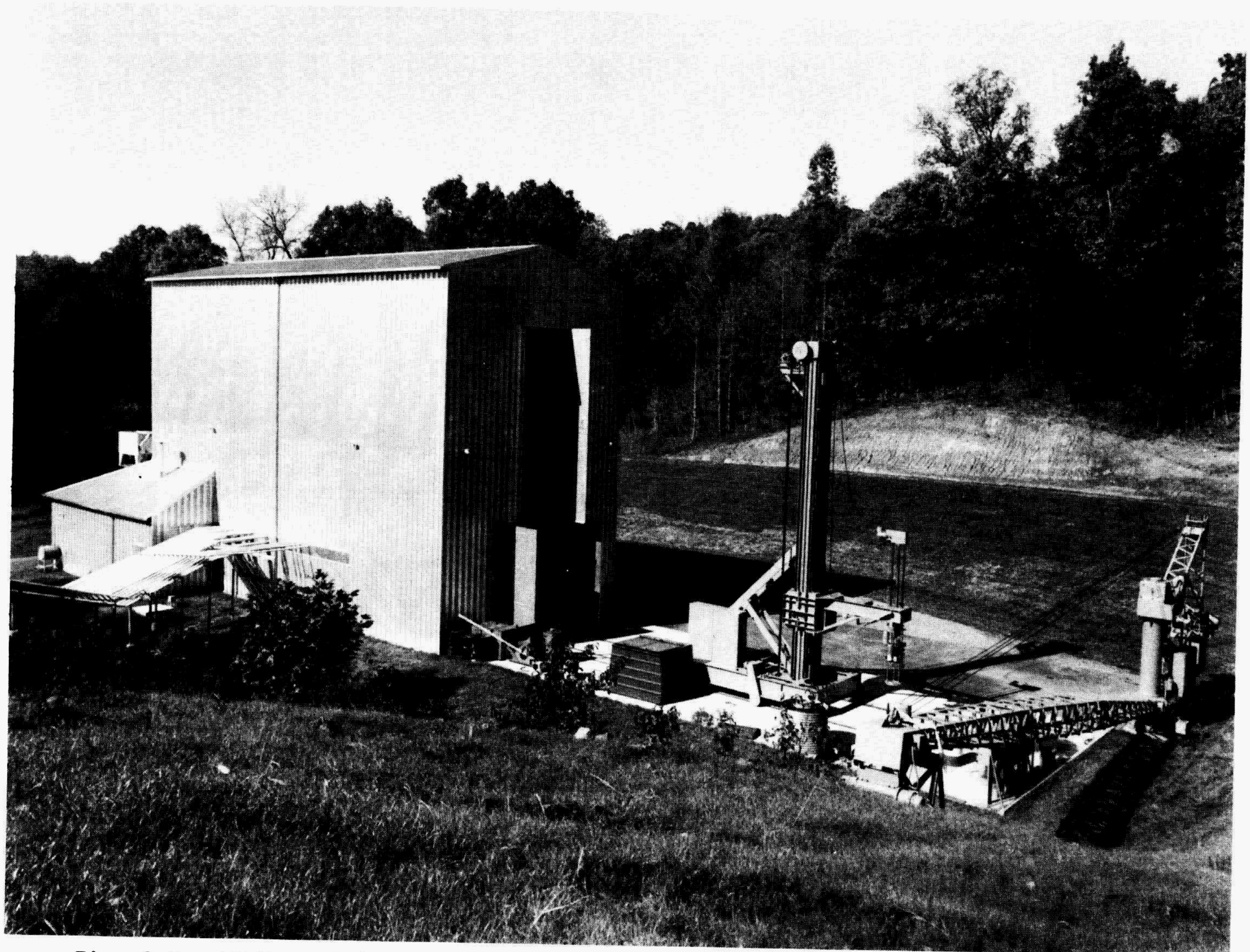

Fig. 3.5. HPRR positioning device and derrick outside reactor storage building.

predetermined position along the center line of the reactor building and the outside concrete pad; in each case the device has a positioning accuracy of ± 1 cm.

The elevator on the positioning device is movable with a dual-chain drive. A movable screw-driven pickup mechanism is mounted on the elevator for picking up the reactor. The movement of the elevator is indicated by dials located on each control panel and calibrated in centimeters. When the pickup mechanism is returned to its upper limit after picking up the reactor, the calibrated dials may be set to indicate the height of the reactor above the floor. Both drives are remotely controlled.

The positioning device can be located to within about 1 in. of a fixed position by a mechanism on the track that trips a limit switch on the positioning device and stops the drive motor. The final positioning is achieved by driving a spring-loaded beveled rod, or drift pin, on the positioning device (Fig. 3.4) into a receptacle mounted on the floor at the fixed position. The receptacle is designed so that when the pin is driven into it the positioning device can be moved forward or backward enough for the pin to be driven all the way down. There are three receptacles for the drift pin located permanently in the floor. One is located at each pit so as to locate the positioning device relative to each pit and a third one is positioned to stop the reactor at the previously designated experiment location. A special bracket can be attached to the rails to locate the positioning device at other locations.

The interlocks and limit switches used to enhance smooth and safe remotely controlled movement of the positioning device are described below.

3.3.1 Horizontal Drive

Limit switch trips are set to stop the positioning device at the appropriate place at both pits and at the experiment position. The horizontal drive motor is interlocked so that it will not operate unless (1) the pickup mechanism is at its upper limit, (2) the elevator has been raised to position the reactor at least 2 ft above the floor level, and (3) the drift pin is up. Interlocks permit operation of the horizontal drive only when the reactor is above floor level and when the drift pin is up.

3.3.2 Pickup Mechanism

Interlocks permit the pickup mechanism to be moved only when the pickup clamp (see below) is rotated to the discharge or to the pickup position. The upward limit of travel of the pickup mechanism is established by a limit switch. Three switches can inhibit downward motion of the mechanism. One actuates to stop downward motion when the pressure plate of the pickup clamp engages the reactor superstructure and compresses a heavy spring, the second when the pickup clamp T-bar pushes against any fixed object such as the floor or the reactor superstructure, and the third when the lower limit of travel is reached.

3.3.3 Pickup Clamp

In order to pick up the reactor, the pickup mechanism must be driven downward so that the pickup bar, in the discharge position, passes through a rectangular slot in the top plate of the reactor superstructure. The mechanism is driven downward until the pressure plate of the pickup clamp pushes against the top plate and compresses a spring above the pressure plate. When the spring is compressed, a limit switch is actuated to cut off the mechanism drive. The pickup bar can then be rotated 90° to the pickup position. A Geneva mechanism ensures that the pickup bar stops correctly aligned either with the slot in the top plate or 90° to the slot. When the pickup mechanism is driven upward, the bar is pulled up against the top plate and the spring above the pressure plate is only partially decompressed so that the top plate is clamped between the bar and the pressure plate of the pickup clamp. An interlock requires that the spring above the pressure plate be fully compressed before the pickup bar can be rotated.

3.3.4 Elevator

Motion of the elevator is inhibited unless the reactor is suspended from the pickup mechanism. With the reactor suspended, the elevator can be driven upward until the up limit switch is actuated. To drive the elevator downward, the pickup mechanism must be in the up limit. Limits of downward motion are then established by the position of the reactor storage pit door. If the pit door is closed, downward motion is stopped by a switch when the reactor is above the floor level. If the pit door is open and the drift pin on the reactor positioner is in the receptacle for the reactor storage pit, the elevator can be driven downward to lower the reactor into the pit until the motion is stopped by the down limit switch.

3.4 REACTOR POSITIONING DEVICE OPERATION

The reactor may be transferred from the hydraulic lift to the positioning device for operation or maintenance provided the necessary security arrangements have been made.

The device can be operated from either of two control panels in the reactor building or from a panel in the control room, but only from that panel in which the key-operated switch is turned ON. The key may be removed only in the OFF position for the two control panels in the reactor building. At each panel, all positioning power may be turned off by turning the key switch CCW to the EMERGENCY POWER OFF position. The key may be removed from the control panel in the control room when the switch is in the EMERGENCY POWER OFF position so that the system can be left with all power off. For maintenance work, the device is usually operated from the west control panel in the reactor building.

The procedures for operating the positioning device and transferring the reactor are outlined below.

3.4.1 Transfer of Reactor from Hydraulic Lift to the Positioning Device

1. Open the reactor storage pit door (see Section 4.1.1.1).
2. Rotate the striker for reactor attached limit switch 90° CCW.
3. Remove the 12 bolts which attach the reactor superstructure to the hydraulic lift.
4. Manually actuate the pickup clamp spring compressed limit switch and the reactor-attached limit switch and hold them while the reactor pickup clamp T-bar is rotated to the PICKUP position; limit switch and Geneva mechanism stops bar at correct orientation.
5. Manually actuate the reactor attached limit switch and turn the elevator down switch to DOWN BYPASS (to bypass the PRESET DOWN limit) and drive the elevator to its DOWN LIMIT; pickup mechanism must be at its UP LIMIT to do this.
6. Manually actuate the two limit switches as in Step 4 and rotate the T-bar to the DISCHARGE position.
7. Lower the pickup mechanism against the top superstructure plate above the reactor; mechanism has overtravel spring and limit switch to stop it.

8. Rotate pickup clamp to PICKUP position; limit switch stops T-bar at correct orientation.
9. Raise reactor by means of the pickup mechanism; a limit switch will stop upward travel.
10. Visually inspect reactor.
11. Raise the elevator drive to the 2-ft CLEAR limit or the desired elevation. CAUTION: The reactor height indication is set for the correct position with the reactor suspended from the hydraulic lift. The elevator switch may be turned to RAISE which will stop at PRESET UP limit or RAISE BYPASS which will stop only at the UP limit.

3.4.2 Moving the Reactor Horizontally

1. Raise the drift pin; a switch limits upward travel and actuates UP position on panels.
2. Turn horizontal drive switch to FAST FORWARD and depress bypass switch just to get positioner off the limit position. Check that area is clear during horizontal movement. CAUTION: Support for control cables may snag overhead hoist or control cable. Drive will stop at previous experiment position, wherever movable receptacle may be set, or at storage pit No. 2.
3. Lower drift pin; torque switch will stop drive and actuate indicating light. If drift pin is in a permanent receptacle, a limit switch will actuate indicating lights.

3.4.3 Transfer of Reactor to Hydraulic Lift

1. Raise drift pin; limit will stop drive.
2. Turn horizontal drive switch to Fast Reverse, and depress bypass switch until the positioning device moves off limit switch; limit switch will stop positioner at the positions indicated in Item 2 of 3.4.2 and must be restarted each time except at the reactor storage pit position.
3. Lower drift pin; TORQUE SWITCH OPERATED and DRIFT PIN DOWN lights will be illuminated when drive stops.
4. Lower elevator to its DOWN limit; must turn control handle to LOWER BYPASS if elevator is above the PRESET DOWN limit.
5. Lower pickup mechanism; limit switch will stop drive and SPRING COMPRESSED indication will be indicated.
6. Rotate pickup clamp to DISCHARGE, limit switches will stop drive at correct position.

7. Raise pickup mechanism; limit will stop drive (mechanism must stay in the UP limit so source drive will operate correctly when the reactor is raised with the hydraulic lift).
8. Manually actuate spring compressed and reactor attached limit switches and rotate pickup clamp T-bar to PICKUP; limit switch will stop the drive.
9. Manually actuate reactor attached limit switch and raise pickup mechanism; limit switch will stop drive.
10. Manually actuate reactor attached limit switch and turn elevator control handle to RAISE drive so that the elevator will stop at PRESET UP limit. This will position the reactor on the hydraulic lift at 1.5 m.
11. To set elevator at 1.4 m, manually actuate the reactor attached limit switch and lower elevator drive with handle in the DOWN (not DOWN BYPASS) position until PRESET DOWN stops elevator.
12. Manually actuate the spring compressed and reactor attached limit switches and rotate the pickup clamp T-bar to the DISCHARGE position, limit switch will stop drive.
13. Rotate striker for the reactor attached limit switch 90° CW.
14. Attach aluminum plate to the hydraulic lift with the 12 bolts.
15. Close the pit door.
16. Raise the motor-driven latch. (See Section 4.1.6 for shutdown procedure.)

3.5 DERRICK

A 5-ton-capacity derrick is located at the end of the concrete pad outside the reactor building as shown in Fig. 3.5. The derrick hook has a clear vertical movement of 56 ft above the concrete slab at a distance of 10 ft from the vertical center line of the derrick. The derrick can be used for handling equipment and, when a special eye designed for the hook is attached to the top superstructure plate of the reactor, can be used to suspend the reactor well above the concrete pad. Two overload interlocks are on the derrick, one on the cable that raises and lowers the boom and one on the lifting cable. When not in use, the derrick boom may be lowered to rest on a stand located just off the concrete pad. There are three limit switches on the derrick -- one which stops the rotation of the derrick when the boom is lined up with the stand, one which stops rotation of the derrick 270° clockwise from the first position, and one which prevents excessive slackening of the boom cables after the boom comes to rest.

4. ROUTINE HPRR OPERATING PROCEDURES

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4. ROUTINE HPRR OPERATING PROCEDURES

The HPRR has two operating modes: a steady-state mode for which the nominal upper limit of the operating power is 10 kW, with the level scrams set at 150% of full power, and a pulse mode for which the nominal maximum yield is 1 x 10^{17} fissions. Procedures for operating the reactor under both modes are given in this chapter. For each type of operation, the procedures are divided into sections on preoperational duties at the reactor building and at the control building, preoperational checkouts, startup and operation, and shutdown and postoperational duties. Sections 4.1.1 through 4.1.6 give all the steps for steady-state operation of the reactor inside the HPRR building.

Pulse operations, of course, require a separate set of procedures; but once again many of the pre- and postoperational steps are the same, and the operator is referred back to the steady-state-operation procedures.

In general, the operator is not allowed to deviate from the procedure being used, although minor changes may be made by the reactor operator with the written approval of the Supervisor of Reactor Operation TSF-HPRR Areas. Changes that the Supervisor of Reactor Operations judges to be major ones will be referred to the Reactor Operations Review Committee for approval prior to their incorporation in the procedures.

In addition to performing the routine operation and maintenance procedures, the security of the nuclear material must be considered at each stage of the operation and maintenance. The actions that must be taken to access the control room, the reactor area, the reactor building, or the reactor storage pit are outlined in Chapter 9.

The reactor will be suspended from the hydraulic lift for normal operation and storage. The reactor may be operated while suspended from the positioning device after special arrangements are made with security. The reactor will be suspended from the positioning device for maintenance and inspections. Procedures for operating the positioning device are given in Section 3.4.

The reactor operator may, on his own initiative, shut down the reactor without delay any time that he believes safety requires it. In addition, the DOSAR Facility supervisor or someone whom he may designate to represent him, the applied health physicist assigned to the DOSAR facility, the Operations Supervisor, a senior operator, or the Supervisor of Reactor Operation TSF-HPRR Areas may direct the reactor to be shut down without delay.

No reactor operation will be initiated unless all required electrical, electronic, and mechanical equipment used in positioning and operating the reactor is in good working condition.

The reactor operator has the authority to limit the number of persons in the control room to those necessary for the operation.

4.1 STEADY-STATE OPERATION PROCEDURE

The routine operation of the reactor in the steady-state mode will be according to the stepwise procedure described below. A part of the operating procedure consists in filling out the HPRR Checkout Sheet and the HPRR Steady-State Log Sheet. Each item should be checked as it is performed or considered.

The HPRR Steady-State Log will be used to provide an orderly description of the reactor operation. Each experiment will be identified by an operation number and a run number. The operation number will run consecutively and will cover one day's operation. The run numbers will run consecutively and will correspond to the experiments performed during an operation. If the experiment is continued into another day, the run number will start over again. If a given run lasts for an extended period, new readings should be taken every hour by the operator and should be recorded in the adjacent columns (the run designation for each additional column will, in this instance of course, be the same).

4.1.1 Preoperational Duties

4.1.1.1 Initial Duties at Control Building

1. Check with Security and place control room on ACCESS.
2. Check the previous entries in the general operations log book to see that no problem areas have been left uncorrected and to determine what, if any, special conditions exist.
3. Have the Senior Reactor Operator approve any experimental setup.
4. Turn on reactor power switch, L1.
5. Reset the secure system by depressing red push button on console and light should go out.
6. Have Security put the reactor storage pit door on ACCESS. (This and the following steps may be done in the reactor building. If they are done in the control room, guard headquarters should be notified before proceeding to No. 7).
7. Obtain key and turn on reactor positioner panel power.

8. Enter numbers in cypher lock (between 0800 and 1700 h only and not more than 30 min before security forces are scheduled to arrive).
9. After time out is completed and security personnel are present, unlock solenoid latch.
10. Withdraw motor-driven latch.
11. Depress rotary solenoid switch and open the reactor storage pit door. Solenoid switch may be released when reactor storage PIT DOOR CLOSED limit light goes out.

4.1.1.2 Duties at Reactor Building

1. Check with Security at 4-6646 and place reactor building on ACCESS; call the Guard at 6-5940 to enter reactor area. Guard will accompany anyone going to the reactor bay if the reactor storage pit door is open or will be opened.
2. If reactor storage pit door is not open, proceed as in Steps 7-11 above.

CAUTION

The reactor will not be raised from the storage pit with anyone in the reactor bay unless there is a Tactical Response Team present.

3. After the door is opened, check for any liquid or debris in the bottom of the pit.
4. Retrieve the last sulfur foil and place a new foil in the desired position (D, H, or both).
5. Help set up any experimental equipment.
6. Check that experimental equipment will permit unrestricted movement of the reactor.
7. Check that all experimental equipment is rigidly fastened.
8. Make an estimate of the reactivity worth of all reflectors, including experimental equipment, on the basis of a conservative comparison with known reflector standards (see Section 6.2), and record total on Checkout Sheet. Since the fully loaded core [i.e., with all rods (includes U-Mo regulating rod) and the safety block inserted] is about 152 cents (82 cents with aluminum regulating rod) supercritical and the mass adjustment and U-Mo regulating rods are worth about 278 cents (213 cents with aluminim regulating rod), then when only the safety block is inserted, the core is at least 126 cents subcritical. Therefore, to ensure that the reactor does not become critical before the safety block is inserted and to allow for reactor control, the total worth of reflectors should be no more than

75 cents unless an appropriate amount of reactivity is removed from the core with the removable fuel pieces.

9. Check the air pressure on the storage pit door drive motor system (see Section 3.2.1).
10. Check that the reactor positioner elevator, the pickup mechanism, and T-bar are correctly positioned.
11. Check the sensitivity of the picoammeter.
12. Calibrate the log N amplifier and return it to the operate position.
13. Check that all personnel have left the 1000-ft-radius fence exclusion area, close the reactor building doors, and call the Guard at 6-5940 to exit reactor area.
14. Close, lock, and remove key from the main gate in the 1000-ft-radius fence.

4.1.1.3 Duties at Control Building

1. Check TV monitors for adequacy of lighting, field of view, etc. (see Section 8.7 for minimum equipment necessary for operation).
2. Turn hydraulic lift operate switch to RAISE (momentary contact will turn pump on). Observe the lift operation via the closed circuit television monitor. Pump should cut off and UP light be illuminated when reactor is at proper position.
3. Check date of last run at a reactor power sufficient to bring all chambers on scale. (If more than one week has elapsed since this was done, the reactor must be operated at this power before the experiment can proceed. This power level is required for checking the level safety channels to see that they are operating properly.)
4. Turn on reactor building exhaust fan, if needed.
5. See that all console switches are in suitable prestartup positions (such as handles vertical, with switches reading OFF, STOP, or NORMAL).
6. See that console lights indicate that conditions are suitable for startup, in which case the following console lights should normally be illuminated:

   a. FACILITY OFF
   b. END OF RUN
   c. source INSERT LIMIT
   d. MAGNET ENGAGED
   e. SAFETY BLOCK WITHDRAWN
   f. S. BLK DRIVE WDR LIMIT

g. pulse rod INSERT LIMIT
h. latch No. 1 (pulse rod withdrawn) LATCH OPEN
i. latch No. 2 (pulse rod inserted) LATCH CLOSED
j. regulating rod WITHDRAW LIMIT
k. mass adjustment rod WITHDRAW LIMIT
l. servo OFF
m. SCRAM RESET

7. Check counting-rate channel response to source.

4.1.2 Preoperational Checkouts

The preoperational checkouts are of two types: those to verify the safety of personnel within the area and those to assure that all systems associated with the operation of the reactor are working properly. Every person entering the DOSAR facility 3000-ft exclusion area through the normal access gate will be issued a numbered badge by the guard. Personnel entering the area from the TSF will obtain prior approval from the HPRR operations supervisor and will give him their TSF badge numbers. Such persons will lock behind them the gate in the fence separating the TSF and HPRR areas. The HPRR operations supervisor will post the TSF badge numbers on the HPRR console.

Whenever the reactor is in operation, no one is permitted within the 1000-ft-radius fence around the reactor building. If the reactor power is 100 W or less, the radiation level between the 1000- and 3000-ft fences is such that personnel may have free access to the area. When the reactor power is above 100 W, only controlled access is permitted and then only under the supervision of the reactor operator or an applied health physicist in accordance with Health Physics Operating Limits. During an actual pulse, everyone within the 3000-ft fence must be inside the reactor control building.

To facilitate personnel control, an electric rotating beacon is located at the guard post 23, electric signs labeled "Do Not Exit Without Approval of Reactor Operator," and rope gates are located at the control building exit doors; also an annunciator which alarms when the control building doors are opened is located at the reactor console. The signs are turned on and the annunciator is activated when the reactor log N power recorder exceeds the 100-W level, when sequence "B" is achieved in pulse preparation (see Section 4.2.4), or when the operator in anticipation of such operation turns the conrolled access switch to ON. When the beacons are activated, the guard will permit no one to enter the 3000-ft exclusion area without first obtaining permission from the Reactor Operator. When pulse operation is satisfactorily concluded or the reactor power is reduced to 100 W or less, the operator may or may not choose to maintain controlled access.

As before, each item on the HPRR Checkout Sheet should be checked as the procedures are followed.

4.1.2.1 Startup Warning Checkout (Unrestricted Access or Restricted Access)

If Unrestricted Access mode is in effect, perform the following steps:

1. Check that the reactor is in the Unrestricted Access mode of operation.
2. Check the reactor console for TSF badge numbers. If any numbers are posted, locate the personnel they are assigned to and inform them of the applicable restrictions.
3. Obtain from the guard all badge numbers assigned to persons in the exclusion area and list them on the checkout sheet.
4. Announce over the public address system that the reactor is about to be operated and specify the area access restrictions. Request everyone to report his DOSAR badge number either directly to the operator in the control room or over an intercom station. An individual may also report the badge numbers of others within his view at their request.
5. Turn on all four gate key switches.
6. Turn facility operate key switch to RESET and then to OPERATE.
7. Have security inspector in room 103 turn lift permissive ON, turn on reactor positioner power switch, and raise reactor with hydraulic lift; when lift is stopped automatically, both REACTOR OPERATION POSITION LIMIT SWITCH LIGHTS should be illuminated.
8. Check off badge numbers against badge list. When numbers are reported in, repeat numbers (or number) to person reporting in to establish accuracy.

If Controlled Access mode is in effect, perform the following steps:

1. Check that the reactor is in the Controlled Access mode of operation.

2. Check the reactor console for TSF badge numbers. If any are posted, locate the personnel they are assigned to and inform them of the applicable restrictions.
3. Obtain from the guard all badge numbers assigned to persons in the exclusion area and list on the checkout sheet.
4. Announce over the public address system that the reactor is about to be operated and specify the area access restrictions. Request everyone to report his DOSAR badge number either directly to the operator in the control room or over an intercom station. An individual may also report the badge numbers of others within his view at their request.
5. Turn on all four gate key switches.
6. Place reactor in Controlled Access mode and turn facility on switch to RESET and then OPERATE.
7. Have security inspector in room 103 turn life permissive ON; turn on reactor positioning power switch and raise the reactor with the hydraulic lift; when lift is stopped automatically, both REACTOR OPERATION POSITION LIMIT SWITCH LIGHTS should be on.
8. Check off badge numbers against badge list. When numbers are reported in, repeat numbers (or number) to person reporting in to establish accuracy.

4.1.2.2 Checkout After 3-min Waiting Period

1. Turn reactor operate key switch to OPERATE.
2. Turn operate mode switch to STEADY STATE.
3. Reset the scram switch.
4. See that annunciators are clear.
5. Record the magnet current and the upper set point. The magnet current should correspond to the value posted on the front of the level-safety monitor. The upper set point should be 10 mA above the normal current.
6. Make the following scram checks with the safety block raised approximately 1 in.:

    a. Check manual scram switch (2).
    b. Check level-safety unit No. 1 with scram test button.
    c. Repeat Step b with level-safety unit No. 2.
    d. Turn temperature test switch to TEMP No. 1 and hold until recorder 1TE indicates temperature is greater than 600°F. If

everything is normal, the slow scram and the "fuel temp high" annunciator will be actuated.

e. Turn temperature test switch to TEMP No. 2 and hold until recorder 2TE indicates temperature is greater than 600°F. If everything is normal, the slow scram and the "fuel temp high" annunciator will be actuated.

f. Lower the reactor a short distance, then return it to raised position. In addition to the slow scram indication both REACTOR OPERATION POSITION LIMIT SWITCH LIGHTS should go out.

7. Set picoammeter on most sensitive range.
8. If servo is to be used, set demand appropriately, at least approximately, at this time.
9. Provide the necessary preoperational information on the HPRR Steady-State Log Sheet, that is, the core position, core temperatures, etc. For the reactor core position, give the height of the center of the reactor core above floor level and the horizontal distance of the center of the core from its position when directly above the west pit.

4.1.3 Procedure for Starting Up and Operating Reactor

The operator is now ready to proceed with startup and operation of the reactor PROVIDED that the following conditions exist:

1. Calibration switch (at reactor) for log N period amplifier is on OPERATE.
2. Period is greater than 5 s.
3. Either fission chamber count-rate-meter recorder shows at least 2 counts/s.
4. Source is in inserted limit, or log N recorder reads more than 0.004 (4×10^{-5} of full power).
5. Regulating rod is at WITHDRAW LIMIT.
6. Mass adjustment rod is at WITHDRAW LIMIT.
7. The 3-min waiting period has been completed.

If the above conditions do not exist, interlocks will prevent insertion of the safety block, and the operator will be unable to accomplish Step 3 below. Therefore, the operator should recheck the items listed above to determine which needs correction so that the procedure on the following page can be continued.

1. Push the scram reset button. This turns off the SCRAM RESET light, and the following lights on the control panel should now be on:

   a. FACILITY ON
   b. REACTOR OPERATE PERMIT
   c. source INSERT LIMIT
   d. MAGNET ENGAGED
   e. SAFETY BLOCK WITHDRAWN
   f. S. BLK DRIVE WDR LIMIT
   g. pulse rod INSERT LIMIT
   h. latch No. 1 LATCH OPEN
   i. latch No. 2 LATCH CLOSED
   j. servo OFF
   k. regulating rod WITHDRAW LIMIT
   l. mass adjustment rod WITHDRAW LIMIT

2. Reset the annunciators. Record any that do not clear, determine why they do not clear, and take appropriate action.
3. Turn the safety block position switch to INSERT. The switch is spring-loaded to return to OFF upon release. The safety block position indicator gives the distance in inches of the safety block is from its fully inserted position. As the safety block moves in, the MAGNET ENGAGED light remains on, the SAFETY BLOCK SEATED light goes out, and the S. BLK DRIVE WDR LIMIT light goes out. Although a previous estimate of the reactivity associated with the experiment will have been made so as to prevent the reactor from going critical as the safety block is inserted, watch the startup channels as the safety block is inserted. If the neutron multiplication becomes appreciably more than 10, which is about the multiplication normally obtained upon safety block insertion into the unreflected core, then insert the safety block stepwise to determine whether the neutron population stabilizes. If it appears that the system will become critical before the safety block is fully inserted, stop the experiment and remove the necessary amount of reactivity enhancement from around the reactor.
4. If the count rate appears normal, continue the stepwise insertion of the safety block until the SAFETY BLOCK INSERTED light comes on and the overtravel spring is compressed about 0.1 in. at which time a limit switch automatically turns off the drive motor and the SAFETY BLOCK DRIVE INSERT light comes on.

5. Select either the regulating rod or the mass adjustment rod for continued reactivity increases. If the servo is to be used and especially if a temperature rise is expected, it will probably be best to insert the regulating rod an inch or so and then achieve criticality with the mass adjustment rod. In this manner, the regulating rod is inserted enough for the servo to make stabilizing adjustments when the reactor just reaches critical but not enough to prevent further insertion to compensate for fairly large temperature rises. Each control and position indicator reads zero when the rod is fully inserted, and therefore, the dial indicates directly in inches the distance that the rod is withdrawn from the core. The regulating rod and the mass adjustment rod are not interlocked and can be moved at the same time, but this should not be done.
6. Continue to increase the reactivity in steps amounting to about 1/4 to 1/2 in. of the control rod at a time until a condition of steadily increasing power level is obtained. An early indication of power level is from the fission chamber channels.
7. In general, allow the power level to rise on a stable period and measure the beginning of an exposure from 1/e of full power. Unless a given experiment requires the determination of critical conditions at power levels less than about 0.1 W, it will not be necessary to withdraw the source during an experiment. As the power level rises, keep the picoammeter on scale by turning the range selector to successively higher currents. The magnet current will decrease with increasing power level, although the decrease is not linear with power increases, the greater part of the decrease occurring as the power level approaches the predetermined scram level. If the reactor period is shorter than 50 s, the heating effects during the power rise will be small.
8. When the desired power level has been reached, as indicated by the picoammeter, bring the reactor to delayed critical by using either control rod. If the servo is to be used, however, bring the reactor to approximately delayed critical with the mass adjustment rod and then turn on the servo. Although the servo demand should have been set approximately previously, it may be necessary to make further adjustments to set the desired power level.
9. When the power has stabilized at the desired level, indicate on the Steady-State Log Sheet the time that the exposure began, that is, the time that the power level was 1/e of full power.

10. On the Steady-State Log Sheet also fill in the thermocouple readings, rod positions, safety block current, and instrument readings. Note that the time the set of readings is made should also be indicated.
11. Once the reactor is operating smoothly, the principal task will be to watch for any appreciable inadvertent changes of reacivity and to take the proper corrective action. If the reactor is operated at a level of several watts for a few minutes, the temperature rise will reduce the reactivity, and the servo, if it is on, will drive the regulating rod in to compensate. If the rise is sufficient, the regulating rod may be driven to its limit. In this case, the regulating rod can be conveniently retracted by inserting the mass adjustment rod stepwise and allowing the servo to compensate with the regulating rod at each step until the regulating rod has been withdrawn sufficiently.
12. If the run extends over a long period of time, take thermocouple readings, rod positions, etc., again and enter on the Steady-State Log Sheet, repeating at least once an hour.

4.1.4 Shutdown Procedures

A routine shutdown of the reactor can be accomplished in four different ways, and the operator should be thoroughly familiar with all four, which are given in 2.a through 2.d below.

The operator should also know the procedure for effecting an emergency manual scram, given in the second shutdown procedure outlined below, and for automatically securing the reactor. In addition, the operator should keep in mind that the reactor may be automatically scrammed, either because of some malfunction in the system or because of an emergency that the instruments detected. In this case, the operator must again follow a set procedure, which includes determining whether an emergency exists. This procedure is also given below.

4.1.4.1 Normal shutdown

1. Turn servo handle to OFF position.

2. Reduce reactivity by either a, b, c, or d below, depending on the experiment and conditions at the time:

   a. Use manual scram switch. This will drop out the safety block but will not automatically withdraw the control rods. If there is no reason to hold the rods in their positions, bring them out, by means of their individual control switches.
   b. Retract a control rod with safety block remaining inserted. This procedure will be used if for some reason it is desired to reduce the reactivity slowly. In any case, the safety block must be completely withdrawn from the core for final shutdown.
   c. Run the safety block, regulating rod, and mass adjustment rod out by means of their position switches.
   d. Run timer automatic scram. The RUN timer can be preset to drop out the safety block after an elapsed operating time as in a.

3. Record the time that the exposure ended in the space provided on the Steady-State Log Sheet and also on the power-level charts and on the temperature charts operating at shutdown. The time of shutdown on the power-level charts is the time that reactivity reduction began if it is abrupt, or 1/e of full power if power level is reduced gradually. Also, mark the date, the run number, and the nominal power level on the power and temperature charts and indicate the positions on the charts corresponding to the end of the run.
4. Turn reactor operate switch and facility operate switch to OFF.
5. Lower reactor into the storage pit; have security officer in room 103 secure the hydraulic lift permissive system.
6. Announce that the reactor has been shut down.

4.1.4.2 Emergency manual scram

1. Turn the red scram handle in either direction.
2. Check radiation levels on control room instruments, and, if appropriate, initiate applicable emergency procedure (Section 10).
3. Record the time of the scram in the general operations logbook.
4. Describe the events necessitating the scram in the logbook.

4.1.4.3 Reactor secure scram

This shutdown method should only be used when there is a perceived attempt at unauthorized access to the reactor on in a planned test.

1. Depress secure push button switch in the control room, the reactor building, or guard post 23.
2. Check that the radiation levels are dropping, that the safety block has scrammed, that the hydraulic lift seats, that the reactor storage pit door closes, and the motor-driven latch is raised.
3. Turn off the reactor positioner power and secure the key and have security inspector in room 103 secure the lift permissive system.
4. Turn off reactor power switch L1.
5. Cooperate with Security personnel to prohibit unauthorized access to the control room or the reactor building.
6. After the threat has been removed, make the necessary log entries, etc.
7. Reset the Secure System by depressing red push button on console. This must also be done after power outages.

4.1.4.4 Unexpected automatic scram

1. Turn servo switch to OFF.
2. Check the radiation level on control room instruments, and, if appropriate, initiate applicable emergency procedure (Section 10).
3. Note in the general operations logbook that a scram occurred and note the annunciators that came on at the time of the scram.
4. Record the time of the scram in the general operations logbook.

Unless emergency procedures as set forth in Section 10 are called for, continue as follows:

5. If the reason for the scram is obvious, record it in the general operations logbook and make appropriate corrections.
6. If the reason for the scram is not immediately obvious, take the following actions.

    a. Notify the Operations Supervisor.
    b. If the period scram is in use, check the period recorder to see if short period caused the scram.
    c. Check the power-level readings that were on the log N recorder and on the picoammeter just prior to the scram and compare the two for consistency.
    d. Check the temperature readings for the various channels, compare them, and also compare them with power-level readings for consistency.

e. Check the magnet current monitor on the safety monitor to see if high magnet current caused the scram. The safety magnet high-current trip is actuated by a contact on the meter pointer, and the pointer will remain upscale until reset.

7. If the instruments indicate that a high power level was the cause of the scram, perform the following steps:

   a. Withdraw all rods in order to lower reactivity as much as possible.
   b. Survey the experiment as much as possible with the closed-circuit television monitors to see if any experimental apparatus has moved toward the reactor.
   c. If the reactor appears safe, request a Tactical Response Team (TRT), proceed with them to the reactor building, and examine the experimental setup to determine if the rise of the power level can be explained.

Scrams may be caused by transient electronic abnormalities, which leave no direct evidence of the cause. In such cases, it would appear that there is no reason not to continue experimentation; but before another run is attempted, the operations supervisor should review the situation until satisfied that none of the above-listed items caused the scram and that the scram is indeed due to a transient phenomenon. The operations supervisor may then check out the reactor safety system and, if it appears to function normally, proceed with the experiment. The checkout will consist of the daily checkout of the level safety system, the manual scram, and a survey of the reactor and experimental equipment to ensure that nothing has moved or been displaced. (This survey may be made with television monitors.) If there is any indication that the safety system is not functioning properly, routine reactor operation will be suspended until the trouble is located and proper repairs are made. After the repairs are effected, the operation of the safety system will be checked out electronically by I&C personnel.

4.1.5 Procedure for Successive Runs

If the experiment is to consist of a series of runs requiring intervening changes in the experimental setup, the procedure for performing the second and succeeding runs is shown on the following page.

1. Follow normal shutdown procedures outlined in Section 4.1.4.
2. Proceed to the reactor building and make the necessary changes as in Section 4.1.1.2 in accordance with Laboratory regulations concerning radiation.
3. If someone is posted at the main gate to account for all persons entering and leaving the 1000-ft exclusion area, a new roll call may not be necessary; see Step 11.
4. If an operations supervisor has approved the experimental setup, perform Steps a through c listed below:

   a. Check relative location of experimental apparatus and surrounding area to ensure the unobstructed movement of the reactor to its proper location.
   b. Check experimental apparatus to see that everything is securely fastened.
   c. Make an estimate of the reactivity worth of all reflectors, including experimental equipment, on the basis of a conservative comparison with known reflector standards (see Section 6.2), and record in the appropriate column on the Checkout Sheet.

5. Fix television cameras and lights on reactor and experimental equipment as necessary.
6. See that all personnel have evacuated the 1000-ft fence exclusion area, close reactor building doors, call the Guard at 6-5940 to exit area, and close gates in fence around 1000-ft-radius exclusion area.
7. Check television monitors in the control building for adequacy of lighting, field of view, etc.
8. Raise the reactor with the hydraulic lift as in item 6 in Section 4.1.2.1.
9. See that all console switches are in suitable prestartup positions (such as handles vertical, with switches reading OFF, STOP, or NORMAL).
10. See that console lights indicate that conditions are suitable for startup, in which case the following console lights should normally be illuminated:

    a. FACILITY OFF
    b. END OF RUN
    c. source INSERT LIMIT
    d. MAGNET ENGAGED
    e. SAFETY BLOCK WITHDRAWN

   f. S. BLK DRIVE WDR LIMIT
   g. pulse-rod INSERT LIMIT
   h. latch No. 1 LATCH OPEN
   i. latch No. 2 LATCH CLOSED
   j. regulating rod WITHDRAW LIMIT
   k. mass adjustment rod WITHDRAW LIMIT
   l. servo OFF
   m. SCRAM RESET

11. If the gate has been guarded per Step 3 of this section, and Unrestricted Access Mode of operation is used, go to Step 12; if not, perform the startup warning checkout as in Section 4.1.2, then go to Step 12.
12. Turn reactor operate key switch to OPERATE.
13. Turn operate mode switch to STEADY STATE.
14. At the end of the 3-min waiting period, reset the scram switch.
15. See that annunciators are clear.
16. Set picoammeter on most sensitive range.
17. If servo is to be used, set demand appropriately, at least approximately, at this time.
18. Provide the necessary preoperational information on the HPRR Steady-State Log Sheet, as before.
19. Proceed with the steps given in Section 4.1.3 for starting up and operating the reactor.

4.1.6 Postoperational Shutdown Procedures

The following duties are normally performed after maintenance or at the end of the last run each shift and should be indicated on the Checkout Sheet where applicable:

1. Put the reactor in standby condition as follows:

   a. Run mass adjustment rod to its withdraw limit.
   b. Run regulating rod to its withdraw limit.
   c. Check that safety block has been automatically run down to its withdraw limit.
   d. Place the pulse rod in the desired position (See Section 4.2).

2. Turn the reactor operate and the facility operate switches to OFF; remove the facility operate key from the console.

3. Lower reactor into its pit and instruct security inspector to secure hydraulic lift permissive circuit.
4. Close the pit door.
5. Raise the motor-driven latch and dismiss security personnel.
6. Turn off reactor power switch.
7. Turn off reactor positioner power and secure keys.
8. Announce that the reactor has been shut down.
9. If it is desired to continuously monitor the radiation level or the temperature after the pulse or run, then manually turn on the recorders at this time.
10. Note in the general operations logbook that the experiment was accomplished without difficulties, or describe any difficulties that were encountered and the steps taken to correct them.
11. Indicate the experiment number, date, and time of operation or pulse on the appropriate charts.
12. Write in the general operations logbook that the experiment proceeded without incident, if it did, or describe any difficulties or abnormalities that occurred. Describe any other aspects of the experiment that may be of future value.
13. After filling in the Steady-State or Pulse Log Sheet, place it in the proper loose-leaf binder as part of the permanent record.
14. Secure the reactor building.
15. Secure the control room.

    NOTE: For shutdown after maintenance, the reactor building may be secured after item 5 above, but guard headquarters should be notified before performing items 6 and 7.

4.2 PULSE-OPERATION PROCEDURE

The previous pulse operations of the HPRR include two groups of experiments conducted at the ORNL Critical Experiments Laboratory and at the Nevada Test Site. These experiments are described elsewhere (See Appendix A, Nos. 3 and 5.).

Basically, firing a pulse consists of rapidly introducing approximately 108 cents of reactivity in the pulse rod into an otherwise critical or near-critical core, thereby assembling a configuration of material that is a few cents above prompt critical. The power level rises rapidly until the negative temperature coefficient of reactivity reduces the system to a subprompt-critical but not subcritical condition, at which time the power level decreases because the delayed neutrons do not contribute appreciably to the reactivity during the time interval of the pulse. The delayed neutrons do make an appreciable contribution to the total fissions within a few milliseconds; and if there were no scram devices, the core would rise in temperature until the negative temperature coefficient reduced the reactivity to delayed critical. The fast scram will reduce the reactivity below delayed critical within a few milliseconds.

For pulses having yields of approximately 1×10^{17} fissions, or somewhat less, the safety block will remove appreciable amounts of reactivity within 1 ms. From the initial pulse experiments[1], there is evidence to indicate that at these high yields the rapid increase of temperature creates forces that expel the safety block sooner than the normal scram.

The stroke of the pulse rod is such that when inserted into an otherwise delayed-critical and unperturbed core it will produce a yield of nearly 1×10^{17} fissions; the yield will increase fairly rapidly with the reactivity added, and a change of 1 cent will increase the yield by approximately 25%. Hence, reactivity measurements must be fairly precise for these high yields. If it is necessary to add reactivity to the delayed-critical core in order to obtain pulses of 1×10^{17} fissions, a fact that will be determined by the calibration experiments, the reactivity, ρ, will be determined by measuring the stable reactor period, T, with two counting-rate channels and correlating T with ρ by means of the well-known inhour relation:

$$\rho(\text{cents}) = 1/0.64 \left(\frac{168.84}{T + 80.4} + \frac{4.59.2}{T + 32.8} + \frac{112.25}{T + 8.98} + \frac{84}{T + 3.52} + \frac{6.51}{T + 0.88} + \frac{0.89}{T + 0.33} \right) .$$

Positive reactivities as measured by the two counting-rate channels must agree within 0.3 cent for pulses as large as 1×10^{17} fissions to ensure that not too much reactivity has been introduced. Negative reactivities may be determined from negative periods or from control rod settings, depending upon the desired accuracy -- determinations from periods being more accurate than those from control rod settings.

The routine determination of the yield of a pulse will be made by measuring the core temperature rise at a given point and correlating this with yield, using experimental yield vs temperature data. When desirable, this method will be supplemented by measuring the reciprocal reactor period for the initial power rise during a pulse and correlating with the yield and/or by determining the activation of sulfur pellets exposed in a standard position.

The operation of the HPRR in the pulse mode will be according to the stepwise procedure outlined below. The checkout of the reactor for pulse operation is not appreciably different from that for steady-state operations, and the same Checkout Sheet will be used. As before, the Checkout Sheet should be filled out as the procedures are followed. The Steady-State Log Sheet will be replaced with a HPRR Pulse (Burst) Log Sheet (Example 4.1), and one sheet should be used for each pulse attempt.

4.2.1 Preoperational Duties

The preoperational duties for pulse operation, both those at the reactor building and those at the control building, are essentially the same as the duties for steady-state operation, and therefore, where applicable, the operator is referred to Section 4.1. However, there are several additional steps required for pulse operation, as pointed out in the following procedures.

4.2.1.1 Duties at reactor building

In addition to the steps listed in 4.1.1, check that the pulse drive air supply is turned on before leaving the reactor building.

4.2.1.2 Duties at control building

Perform steps listed in 4.1.1 through 8, and then:

1. Turn on pulse-drive air supply solenoid.
2. Raise the pulse rod to its upper limit as follows:

    a. Verify that latch No. 1 light indicates LATCH OPEN.
    b. Place rod drive test switch (behind console) to TEST PERMIT.
    c. Turn operation mode switch to OFF.
    d. Place pulse-rod position switch on INSERT and hold there, since this switch is spring-loaded to return to OFF. This will put air pressure on the cylinder and hold the rod in if the air pressure is greater than 60 psig.
    e. Move latch No. 2 to WITHDRAW position and hold there until LATCH OPEN light comes on.
    f. Move pulse-rod position switch to WITHDRAW and hold there until WITHDRAW LIMIT light comes on.

HPRR PULSE LOG SHEET

SHEET OF

OPERATION NO.	B	DATE	OPERATORS

EXPERIMENTER. DESCRIPTION OF EXPERIMENT:

CREPR APPROVAL

PREOPERATIONAL DATA	TARGET YIELD (FISSIONS)	REACTOR CORE POSITION		
	Δ REACTIVITY REQUIRED	HEIGHT ABOVE FLOOR		
	FOILS	DISTANCE FROM PIT NO. 1		
	SULFUR	ESTIMATED INCREASE IN PULSE ROD WORTH FROM REFLECTORS:		
		REACTIVITY WORTH OF EXPERIMENT:	ESTIMATED	MEASURED

PREPARATION FOR BURST	LEVEL POWER DIAL READINGS		
	SAFETY BLOCK ①	REG. ROD ②	MA ROD ③
	DETERMINATION OF ROD SETTINGS FOR BURST		
	Δ REACTIVITY REQUIRED ④	NEW REG. ROD SETTING ⑤	MEMORY POINTERS SET ⑥
	MEASURED PERIOD AND CORRESPONDING REACTIVITY		
	⑦ FROM CHANNEL NO. 1	PERIOD	REACTIVITY
	⑧ FROM CHANNEL NO. 2	PERIOD	REACTIVITY

PULSE	CONTROLLED ACCESS GATE CLOSED ⑩	μμA RANGE ⑫		
	BADGE CHECK ⑪	INSTRUMENTS READY ⑬		
	MEMORY POINTERS CHECKED ⑭			
		TIME	T.C. NO. 4	T.C. NO. 5
	⑨ STARTED SAFETY BLOCK WITHDRAWAL			
	⑮ STARTED SAFETY BLOCK INSERTION			
	⑯ TIME OF PULSE			

YIELD		T.C. NO. 1	T.C. NO. 2	
	TEMP. AFTER PULSE, °F.			
	TEMP. BEFORE PULSE, °F.			
	TEMP. RISE, Δ° F.			
	BURST YIELD (FISSIONS)			
	BY T.C. RISE			$\times 10^{16}$
	BY SULFUR FOIL			$\times 10^{16}$
	OTHER			$\times 10^{16}$
	WAIT TIME BEFORE PULSE	PULSE ROD INSERTION TIME		

2nd BADGE CHECK		
1	26	51
2	27	52
3	28	53
4	29	54
5	30	55
6	31	56
7	32	57
8	33	58
9	34	59
10	35	60
11	36	61
12	37	62
13	38	63
14	39	64
15	40	65
16	41	66
17	42	67
18	43	68
19	44	69
20	45	70
21	46	71
22	47	72
23	48	73
24	49	74
25	50	75

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Example 4.1

g. Leaving pulse-rod switch in the WITHDRAW position, turn latch No. 1 switch to INSERT and hold there until LATCH CLOSED light comes on.
h. Return pulse-rod switch to OFF.
i. Return rod-drive test permit switch to OFF.

4.2.2 Preoperational Checkouts

4.2.2.1 Startup Warning Checkout

The procedure for the startup warning checkout is the same as that in Section 4.1.2 with free-access restrictions.

4.2.2.2 Checkout After 3-min Waiting Period

The procedure for the checkout after the 3-min waiting period is the same as that in Section 4.1.2 through Step 7. Then fill in the preliminary information at the top of the HPRR Pulse Log Sheet. The pulse number should correspond to the total number of pulse attempts for the core being used. The reactor position should be the height of the center of the core above the floor and the horizontal distance of the center of the core from its position when directly over the west pit. The target pulse yield and the reactivity estimated to be necessary to give the yield should also be recorded on the log sheet at this point.

4.2.3 Procedure for Starting Up and Attaining Desired Reactivity

The operator is now ready to start up the reactor and set the reactivity to the amount called for by the experimental conditions. The first four steps are the same as those used for steady-state operation, and, as in the steady-state operation, interlocks will prevent addition of reactivity to the core unless the following set of conditions exist:

1. Calibration switch (at reactor) for log N period amplifier is on OPERATE.
2. Period is greater than 5 s.
3. Either fission chamber count-rate-meter recorder shows at least 2 counts/s.
4. Source is in inserted limit, or log N recorder reads more than 0.004.
5. Regulating rod is at WITHDRAW LIMIT.

6. Mass adjustment rod is at WITHDRAW LIMIT.
7. The 3-min waiting period has been completed.

If the operator is unable to accomplish Step 3 below, recheck the items listed above to determine which needs correction so that the procedure listed below can be continued.

CAUTION

> The operator is reminded that pulse operation is inherently more dangerous than steady-state operation. The operator will, therefore, meticulously follow the Pulse (Burst) Log Sheet or, if the experiment requires a change in procedure, a written variation approved by the area supervisor. If instruments other than the reactor controls need to be observed or manipulated, the supervisor will assign such duties to personnel in advance so that the operator will be responsible only for performing the pulse.

1. Push the scram reset button. This turns off the SCRAM RESET light, and the following lights on the control panel should now be on:

   a. FACILITY ON
   b. REACTOR OPERATE PERMIT
   c. source INSERT LIMIT
   d. MAGNET ENGAGED
   e. Safety block WITHDRAWN
   f. S. BLK DRIVE WDR LIMIT
   g. pulse rod WITHDRAW LIMIT
   h. latch No. 1 LATCH CLOSED
   i. latch No. 2 LATCH OPEN
   j. servo OFF
   k. regulating-rod WITHDRAW LIMIT
   l. mass adjustment rod WITHDRAW LIMIT

2. Reset the annunciators. Record any that do not clear, determine why they do not clear, and take appropriate action.
3. Turn the safety block position switch to INSERT. The switch is spring-loaded to return to OFF upon release. The safety block position indicator gives directly in inches the distance of the safety block from its fully inserted position. As the safety block moves in, the MAGNET ENGAGED light remains on, the SAFETY BLOCK SEATED light goes out, and the S. BLK DRIVE WDR LIMIT light goes out. Although a previous estimate of the reactivity associated with

the experiment will have been made so as to prevent the reactor from going critical as the safety block is inserted, watch the startup channels as the safety block is inserted. If the neutron multiplication becomes appreciably more than 10, which is the approximate multiplication normally obtained upon safety block insertion into the unreflected core, insert the safety block stepwise to determine whether the neutron population stabilizes. If it appears that the system will become critical before the safety block is fully inserted, stop the experiment and remove the necessary amount of reactivity from the reactor.

4. If the count rate appears normal, continue the stepwise insertion of the safety block until the SAFETY BLOCK INSERTED LIMIT light comes on and the overtravel spring is compressed about 0.1 in., at which time a limit switch automatically turns off the drive motor and the SAFETY BLOCK DRIVE INSERT light comes on.
5. Continue increasing the reactivity by stepwise insertions of the regulating rod, 1/4 to 1/2 in. at a time, until it is fully inserted. It is not necessary that the regulating rod be at the fully inserted position in order to perform a pulse; however, it has been in that position for all pulses performed at the ORNL Critical Experiments Laboratory and at the Nevada Test Site, and the fully inserted position is a good one for maintaining a reproducible reactor configuration and should be used if possible.
6. Continue increasing the reactivity with the mass adjustment rod until a positive period is obtained and allow the power level to rise until the SEQUENCE A light on the panel comes on. (Sequence A consists of the deactivation of a series of interlocks which is necessary before a pulse can be performed. Before Sequence A can be accomplished, the end-of-run light must be off, the safety block must have been inserted to its limit, and the power level must have been at least 10^{-5} of full power. When the SEQUENCE A light comes on, it is an indiction that the sequence has been completed.)
7. Remove the source to WITHDRAW LIMIT and check the log sheet accordingly.
8. If the target reactivity is such that reactivity must be added to the delayed-critical core, proceed with Steps a through g below (if the target reactivity is zero, go to Step 9; if it is such that reactivity must be removed, go to Step 10):

    a. Lower the power level by withdrawing the mass adjustment rod appropriately. The power level should be allowed to decay to somewhat below the level that gives good statistics (4×10^3 to 12×10^3) with the counting-rate channels so that, when the mass adjustment rod is reinserted to the position estimated to give the desired reactivity, the counting rate will not become too high to be counted before a stable period has been reached.

b. Reinsert the mass adjustment rod an amount estimated to be necessary to give the desired positive period.

c. Take counts with the scalers for a fixed period of time at regular intervals, over about two decades of power change. The automatic system is set to take a 10-s count each minute.

d. When a sufficient number of counts have been taken to plot a curve, reduce the reactivity somewhat by running the safety block down a short distance.

e. While the power level decreases slowly, plot the data on semi-log paper as a function of time and determine the reactor period indicated by each counting-rate channel. (The period is equal to the time required for the power level to change by a factor of e.)

f. Determine the reactivity corresponding to each period determination and ascertain whether sufficient reactivity has been added to the core. The reactivities determined from the two counting-rate channels must agree to within 0.3 cent of each other.

NOTICE: It may be desirable to recheck the period or to check the reproducibility of positioning the safety block without repositioning the regulating rod or the mass adjustment rod. For this purpose a ROD POSITION BYPASS button is provided which will allow the safety block to be reinserted without moving the control rods. Each time this procedure is carried out it is considered to be a "trial" period, as noted on the log sheet.

g. Record on the log sheet the required information for each trial period, that is, the control rod dial readings, the safety block dial reading (the overtravel should be the same each time), and the period and corresponding reactivity resulting from the measurement.

9. If the target reactivity is zero, that is, if a delayed-critical core is to be used, then:

a. Lower the power level by withdrawing the mass adjustment rod until the counting rate is low enough to give good counting statistics.

b. Bring the reactor to delayed critical by making adjustments with the mass adjustment rod while noting the level on the picoammeter. Then take counts with the counting-rate channels after each adjustment to determine when the counting rate becomes constant.

c. Record on the log sheet the required information for trial period 1 (see Step 8.g, above). In this case, of course, the period will be infinite and the reactivity zero.

10. If the target reactivity is such that reactivity must be removed from the delayed-critical core, then:

    a. Bring the reactor to delayed critical with the regulating rod fully inserted by making adjustmments with the mass adjustment rod and observing the counting rate with the picoammeter or the counting-rate channels.

    b. Use the reactivity-vs-position curve for the regulating rod (Fig. 2.6) to determine the position that the regulating rod must be in for the desired amount of reactivity to be subtracted, and set the rod at that position.

    c. Measure the period and corresponding reactivity and enter the appropriate information on the log sheet, remembering that in this case the period will be negative. If the reactivity obtained is not that desired, reinsert the mass adjustment and regulating rods sufficiently to obtain a positive period, raise the power level, and repeat the procedure until the desired reactivity is obtained.

4.2.4 Preparing for and Firing of Pulse

When the assembly has been adjusted to the desired reactivity, the operator is ready to prepare for and fire the pulse as follows:

1. Reduce the neutron population to background by running the safety block to its fully withdrawn position with the safety block position switch. Sequence "B" light should come on. Record on the log sheet the time that the withdrawal was initiated.
2. Record on the log sheet the temperature of thermocouples Nos. 4 and 5 as read from the 60° to 110°F recorders. Also record the time that the readings were made (should be at the beginning of the decay period).

3. Account for all personnel in the 3000-ft exclusion area as outlined in Section 4.1.2 for controlled access mode.
4. When the neutron population has decayed for approximately 10 min, determine the variation with time of the counting rate until the variation is negligible.
5. If the pulse detection equipment is to be used, make the following checks during the decay period:

   a. Verify that the power to the pulse channel is on.
   b. See that the ordinate (v/cm) and abscissa (s/cm) sweeps on the oscilloscopes are set at the desired values.
   c. Make sure that the Polaroid cameras are loaded with film.
   d. See that the cameras are ready.

6. Record on the log sheet the temperature measurements of thermocouples 1 and 2 and the time that the readings were made.
7. Turn operation mode switch to BURST (PULSE).
8. Make a second reading of thermocouples 4 and 5 and record on the log sheet, along with the time that the readings were made, and compare with previous readings. For target pulses having yields between 5×10^{16} and 1×10^{17} fissions, the difference between the two readings at this point must not be greater than 2.5°F, and for pulses of lesser yield they must not be greater than 3.5°F. If a greater difference is observed, start again, beginning with Section 4.2.3 and going through all steps preceding this one.
9. Routinely the time lapse from Step 8 to the pulse is approximately 5 min. If there are delays which appreciable increase this time, a third reading will be recorded of thermocouples 4 and 5. For target pulses having yields between 5×10^{16} and 1×10^{17} fissions, the difference between the present reading and the reading in Step 2 must not exceed 3.5°F, and for pulses of lesser yields, they must not exceed 4.5°F. If a greater difference is observed, start again, beginning with Section 4.2.3 and going through all steps preceding this one.
10. Announce that the pulse is about to take place so that others participating in the experiment will be alerted.
11. Turn pulse-rod latch No. 1 switch to WITHDRAW and hold until the No. 1 LATCH OPEN light comes on.
12. Turn the safety block position switch to INSERT and hold it in this position until the safety block drive insert limit is reached unless an unusual rise in count rate occurs, in which case the reactor

should be shut down. (It will not be possible to insert the safety block unless the interlocks of Sequence B have been deactivated. Sequence B requires, in addition to the deactivations called for by Sequence A, that the source and the safety block both be at their withdraw limits.) If a photographic record of the pulse is to be made, announce "open shutters" when the safety block is fully inserted.

13. Turn the pulse-rod switch to insert and hold until pulse occurs (experience has shown that typically there is a delay of about 1 s between the firing of the pulse rod and the pulse, but the time may vary from no delay to several seconds.)
14. Release the pulse rod switch handle.
15. Make the following entries on the Pulse Log Sheet:

    a. Time that the pulse occurred
    b. Maximum readings given by thermocouples 1 and 2 after the pulse
    c. Temperature rise at each thermocouple position caused by the pulse
    d. Fission yield of the pulse, as determined from temperature rise vs yield data obtained from earlier HPRR experiments.
       NOTE: If the pulse exceeded 2×10^{17} fissions, the core must be disassembled and inspected by the Operations Supervisor for evidence of mechanical damage.

16. Place Pulse Log Sheet with all previous log sheets in a loose-leaf binder.
17. Enter previous total integrated power, the integrated power of this run, and the resulting total on the Checkout Sheet.
18. If more pulse experiments are to follow, lower reactor into the pit, turn on fan to cool the core, and latch the pulse rod in its WITHDRAW LIMIT as follows:

    a. Confirm that latch No. 1 LATCH OPEN light is on.
    b. Confirm that the pulse rod is at the WITHDRAW limit.
    c. Turn mode switch to OFF and turn latch No. 1 switch handle to INSERT and hold there until latch No. 1 LATCH CLOSED light comes on.

19. If a steady-state experiment is to follow the pulse just completed, latch the pulse rod in its INSERT limit as follows:

    a. Confirm that the reactor is scrammed.
    b. Confirm that both latch No. 1 and latch No. 2 LATCH OPEN lights are on.
    c. Put mode switch on OFF.
    d. Turn pulse-rod switch handle to INSERT and check that pulse-rod INSERT LIMIT light comes on.
    e. While holding the pulse-rod handle on INSERT, turn latch No. 2 switch handle to INSERT and hold there until latch No. 2 LATCH CLOSED light comes on.

4.2.5 Procedure for Successive Pulses

If the experiment is to consist of a series of pulses requiring intervening changes in the experimental setup, the procedure for performing the second and succeeding runs is as follows:

1. Move mass adjustment and regulating rods to their WITHDRAW limits.
2. Proceed to the reactor building and make the necessary changes in accordance with Laboratory regulations concerning radiation. (Guard will accompany anyone going to the reactor bay if the reactor storage pit door is open or will be opened.)
3. If someone is posted at the gate to account for all persons entering and leaving the 1000-ft exclusion area, a new roll call will not be necessary until Step 22 is reached.
4. After all changes in the experiment have been made, perform those steps listed below that are appropriate to the operation:

    a. Check relative location of exprimental apparatus and surrounding area to ensure the unobstructed movement of the reactor to its proper location.
    b. Check experimental apparatus to see that everything is securely fastened.
    c. Make an estimate of the reactivity worth of all reflectors, including experimental equipment, on the basis of a conservative comparison with known reflector standards (see Section 6.2), and record in the appropriate column on the Checkout Sheet.

d. Estimate the effect of any reflectors involved in the experiment on the pulse-rod reactivity worth (see Section 6.3), and record estimate on the HPRR Pulse Log Sheet.

5. Fix television cameras and lights on reactor and experimental equipment as necessary.
6. See that all personnel have evacuated the 1000-ft-fence exclusion area, close reactor building doors, call Security personnel at 6-5940 to exit area, and close gates in fence around exclusion area.
7. Check television monitors in the control building for adequacy of lighting, field of view, etc.
8. Raise the reactor with the hydraulic lift as in item 6 in Section 4.1.2.1.
9. See that all console switches are in suitable prestartup position (such as handles vertical, with switches reading OFF, STOP, or NORMAL).
10. See that console lights indicate that conditions are suitable for startup, in which case the following console lights should normally be illuminated:

    a. FACILITY OFF
    b. END OF RUN
    c. source INSERT LIMIT
    d. MAGNET ENGAGED
    e. SAFETY BLOCK WITHDRAWN
    f. S. BLK DRIVE WDR LIMIT
    g. pulse-rod WITHDRAW LIMIT
    h. latch No. 1 LATCH CLOSED
    i. latch No. 2 LATCH OPEN
    j. regulating-rod WITHDRAW LIMIT
    k. mass adjustment rod WITHDRAW LIMIT
    l. servo OFF
    m. SCRAM RESET

15. If the gate has been guarded per Step 3 of this section, go to Step 16; if not, perform the startup warning checkout (unrestricted access mode) as in Section 4.1.2, then go to Step 16.
16. Turn reactor key switch to OPERATE.
17. Put operation mode switch on BURST (PULSE) PREPARATION.
18. At the end of the 3-min waiting period, reset the scram switch.
19. See that annunciators are clear.

20. Set picoammeter on most sensitive range.
21. Provide the necessary preoperational information on the HPRR Pulse Log Sheet, as before.
22. Proceed with the steps given in Section 4.2.3 for starting up the reactor and in Section 4.2.4 for preparing and firing the pulse.

4.2.6 Postoperational and Shutdown Procedures

1. Put reactor in standby condition as follows:

   a. Run mass adjustment rod to its withdraw limit.
   b. Run regulating rod to its withdraw limit.
   c. Check that safety block has been automatically run down to its withdraw limit.

2. Turn the reactor operate and the facility operate switches to OFF; remove the facility operate key from the console.
3. Lower reactor into its pit.
4. Close the pit door.
5. Raise the motor-driven latch and dismiss security personnel.
6. Announce that the reactor has been shut down.
7. If it is desired to continuously monitor the radiation level or the temperature after the burst, then manually turn on the recorders at this time.
8. Indicate the experiment number, date, and time of pulse on the appropriate charts.
9. Write in the general operations log book that the experiment proceeded without incident, if it did, or describe any difficulties or abnormalities that occurred. Describe any other aspects of the experiment that may be of future value.

5. REACTOR INSPECTION PROCEDURES

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5. REACTOR INSPECTION PROCEDURES

The procedures given in Section 4 are for working with the reactor while it is completely assembled and attached to the hydraulic lift. The procedures here in Section 5 cover the removal of the core from the reactor superstructure after it has been transferred to the reactor positioning device. It also covers the disassembly of the core pieces, the inspection of the core pieces, the inspection of the reactor machinery, and the restoration of the reactor to service.

Removal of the core provides opportunity for inspecting the reactor superstructure while the usual gamma-ray hazard is not present. Detailed periodic inspections should be made at this time, along with any special inspections and repair of any components that require attention.

It is emphasized that these procedures in Section 5 apply only to reactor core configurations whose nuclear characteristics have been confirmed. If a new core is to be installed, the procedures described in Section 6 will be followed.

5.1 CORE REMOVAL AND DISASSEMBLY

The core is removed from the reactor superstructure periodically so that the fuel may be inspected for signs of deterioration. The core is also removed in other cases to reduce the gamma-ray hazard while certain reactor maintenance is being performed and to provide access to the reactor machinery.

5.1.1 Precautions and Preparation

Removal or disassembly of the reactor core should preferably be performed while the level of radiation from the core is low. For scheduled disassembly, this background should be below 100 mrad/h as measured at 1 m horizontally from the core.

A minimum staff of three persons, one of whom is a Senior Operator and one an Operator, is required for core removal and/or disassembly. Security personnel must be present in the reactor area before work is started, but they are not a part of the operating staff.

All persons present during the disassembly will wear the self-reading pocket dosimeters and film badges as required by ORNL procedures. Those actively performing the work will also wear, as necessary, gloves, and film-ring dosimeters. At least one of the active participants will carry an audible gamma-ray alarm (chirper).

Reactor components will not be handled with bare hands. Nonfueled pieces can be handled with gloved hands, while U-Mo pieces will be handled by extensions (pliers, tweezers, tongs, trays, cups, holders) to provide separation distance. Tools may be handled with bare hands or gloved hands, but it should be noted that contamination transfer may occur. Contamination levels associated with the HPRR have been favorably low, but it is advisable at the conclusion of the job to check all tools used in this work for contamination before they are returned to their place of storage. Likewise, hands will be washed and checked after each work session.

An orderly tool cabinet at the start of the job will be helpful. Checklist 5.1.1 will be used to verify that the proper tools and supplies are present for use during the core removal and disassembly process.

5.1.2 Core Removal and Disassembly Procedure

(Numbers relate to numbered items on Checklist 5.1.2.)

1. Transfer the reactor from the hydraulic lift to the positioning device.
2. Drive the control rod drives and the safety block drive to their WITHDRAW limits. With the safety block drive in the limit, the shaft is restrained from shifting while the safety block is being removed. With the control rods at their WITHDRAW limits, they are out of the way for core removal.
3. Unlatch the pulse rod so that it is free to move up and down.
4. Drive the neutron source to its withdraw limit. This reduces the neutron background at the core and also permits the pickup mechanism drive to be operated.
5. Position the reactor at any convenient height above that required for closing the pit door.
6. Close the pit door to provide a working platform around the reactor or move the reactor to another location.
7. Record the gamma radiation level at 1 m from the reactor core.
8. Check for contamination on the stainless steel core support ring and other members which may require handling.
9. Place the heavy-weight track cover across the rail north of the reactor. This cover lies flat and is suitable for use at the reactor.

10. Place the light-weight track cover at the core disassembly area east of the target position. This will aid the passage of the core cart over the tracks.
11. Use pliers to loosen the pulse-rod-inserted switch. Let the demounted switch hang by its lead wires, which may be deenergized by opening the main breaker switch behind the console.
12. Remove safety cage by pulling three quick-release pins. Note that a pin's mechanism will not release the pin unless the handle loop is pulled or pushed.
13. Use the Allen wrench with the extended T-handle to remove the safety-tube cap screws.
14. Remove the roll pin located near the top of the safety block stainless steel insert (not the one through the U-Mo body of the safety block). A special roll-pin punch rod is used for this operation, along with a hammer or plastic mallet.
15. Center the core-handling cart (see Fig. 5.1) below the reactor, so that final vertical contact can be made by: (a) raising the core-cart receptacle; (b) lowering the core by means of the positioner elevator; (c) lowering the core by means of the positioner pickup mechanism. Use care when nesting the safety block into its core-cart receptacle. The disadvantage of each type of final vertical motion should be noted, thus: (a) raising the core-cart receptacle requires considerable hand-cranking, even with the "fast" crank (the "slow" crank is never needed); (b) the elevator speed is almost too fast for accurate positioning; (c) the pickup mechanism requires the console power to be on in order to satisfy a source-position interlock. The suggested procedure is to use the elevator drive to lower the reactor until the safety block is near the top of its core-cart receptacle, use the pickup mechanism to lower the safety block nearly to the bottom of the receptacle, then hand-crank the core cart until contact is made between receptacle and safety block.
16. The safety block is removed after disengaging it at its bayonet coupling. This is accomplished by: (a) engaging the flats of the safety block stainless steel adapter with the phenolic wrench; (b) turning the safety block 90° CCW (note that the safety block bayonet coupling has the characteristics of a left-hand thread); and (c) lowering the core receptacle slightly and observing that the safety block moves downward. A light tapping of the safety block with the phenolic wrench may be required. Then lower to completely disengage.

ORNL-PHOTO 60454

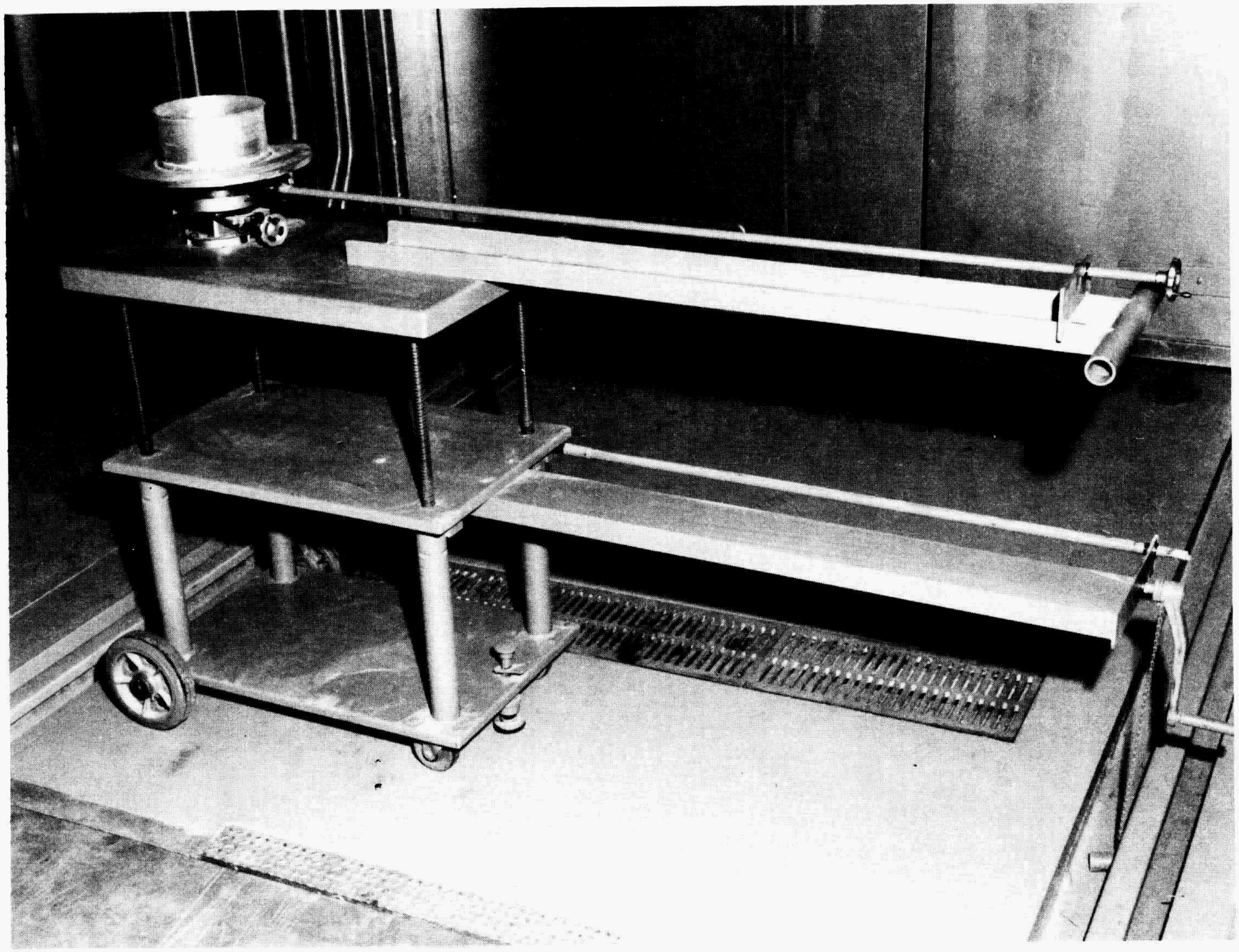

Fig. 5.1. Table for assembling and disassembling core.

17. Roll the cart containing the safety block away from the reactor. Then carry the safety block in its receptacle to a safe storage place along the south wall of the reactor bay. (The weight of the radioactive block and carrier is approximately 50 lbs.)
18. As necessary, place a shield of concrete blocks or lead bricks between the safety block and workers, and set up appropriate HP radiation zone warning tags and ropes.
19. Move the core receptacle up to contact the core, but remember that the core rests on the receptacle shelf rather than on the receptacle bottom.
20. Loosen the proper U-Mo bolt and remove thermocouple 4.
21. Disconnect thermocouples 1 and 2 at the phenolic plugs. Once uncoupled, these thermocouple leads to the core should be supported by hand until the core has been moved to its disassembly location.
22. Remove three stainless steel nuts to uncouple the core from the reactor.
23. Lower core away from superstructure with cart elevator.
24. Leave the stainless steel support ring attached to the core while the core assembly is wheeled on the core cart to the disassembly area. Leave the core on the cart and set up appropriate HP radiation zone warning tags and ropes.
25. Run the rod drives to their lower (INSERT) limits so that their screw safety-lock devices become accessible. To latch the pulse rod at its insert limit, it is necessary to manually operate its insert limit switch.
26. Remove roll pins with a hammer and a drift pin (punch) of the correct size. It is advisable to use a "bucking" (backup) block behind the shaft near the pin to absorb most of the shock when hammering.
27. Using special holding tools, unscrew the U-Mo control rods and carry them to their place of storage. Place control rods (still in their holders) on blotter paper at a remote location and erect appropriate HP radiation zone warning tags and ropes.
28. After each U-Mo bolt is unscrewed, transport it with nonmetallic pliers (made from a fuse puller) to the blotter paper in the radiation zone. Also remove the stainless steel core support ring and six stainless steel spacer rings and move them to the blotter paper.
29. Remove anchor screws, control-rod hole liners, and glory-hole plug and transport them to the blotter paper in the radiation zone.

30. Unstack the U-Mo fuel disks one at a time, using the special core plate tool designed for this purpose. Confirm that the tool grips each fuel piece properly before it is removed from the stack and transported to a zoned and posted blotter paper area. Note that an adapter is used with the tool to handle the fuel pieces having larger center holes. Fuel plates with thermocouples require two persons to move them safely. Spread out the stored plates for convenience of inspection and for added assurance that the stored array is critically safe.

5.1.3 Precautions While Core is Detached

(Numbers relate to numbered items on Checklist 5.1.3.)

1. It is important that detached fuel pieces be stored properly from a criticality and health physics standpoint and also to minimize the chance for loss or damage.
2. No extra U-Mo fuel will routinely be stored in the reactor bay. Any extra fuel temporarily present for substitution purposes will be stored in bird cages in storage pit No. 2.
3. After U-Mo core components have been placed in radiation zones per approved health physics procedures, similar attention should be given to other major activated core components such as the safety tube, the stainless steel core support ring, the safety block bayonet sleeve, and the control rod tubular guides if they have been removed for inspection.
4. Flooding has not been a problem at the HPRR. The subject is presented as a reminder that moderate quantities of liquids are sometimes present in the reactor bay in the form of water-filled phantoms or shielding tanks, and these should not be near while the core is off the superstructure.
5. Fuel pieces should not be stored next to the graphite thermal pile or in other areas where they might be damaged by movement of stored materials, by motion of the bridge crane, or from oil dripping from the bridge crane.
6. Review with Security the safeguards required for proper protection during the period that the uranium components are separated from the reactor superstructure.
7. Certain screws, roll pins, and other reactor hardware may be left on the core-handling cart or with the safety cage, but all such parts must be carefully controlled not only because plans call for their

reuse but also because such activated pieces must not be mixed in with general hardware, from a radiation safety standpoint.

5.2 CORE INSPECTION

The core is inspected to determine the condition of the fuel plating, integrity of the fuel pieces, and the reliability of the bolts and fasteners.

Experience with pulse reactors indicates that failure of U-Mo fuel pieces starts as a small crack at a point of high stress (inner or outer surface of a core ring adjacent to a hole) and progresses through the piece as a function of time at elevated temperature. An inspection of the assembled core with the safety block removed is sufficient to reveal if any problem areas exist. This is denoted as a minor inspection. Complete disassembly of the core and examination of each component is a major inspection which is outlined below.

Inspection of the core is made in an orderly manner. The various checklists, to be filled out as the work progresses, serve to document the fact that the work has been done and also to minimize the chance that important steps in the procedures might be overlooked.

5.2.1 Preparation for Major Core Inspection

The items appearing on Checklist 5.2.1 will likely be needed only if the core fuel plates will be unstacked for a major inspection. Inspection of the assembled core requires primarily the use of an adjustable light and magnifiers for inspecting the interior surfaces of the stacked fuel plates.

5.2.2 Inspection of U-Mo Fuel Plates and Safety Block

Describing the appearance of the various U-Mo fuel pieces as outlined on Checklist 5.2.2 is subject to qualitative judgment on the part of the inspector. While leaving much to be desired, this type of record may be helpful in identifying regions of deterioration from year to year which may be of concern. Generous use of the space under COMMENTS is encouraged for describing any unusual conditions observed.

The inspector is cautioned to use only nonmetallic pliers for maneuvering the U-Mo plates and bolts to avoid scarring them.

5.2.3 Inspection of U-Mo Bolts

A record of the U-Mo inspection will be made on Checklist 5.2.3.

The condition of the threads is important since incipient galling (cold-welding) of the threads to their mating threads in the bottom fuel plate may perhaps be avoided if trouble is detected early enough.

Dimensional measurements have never revealed any changes in any of the HPRR bolts, so complete measurements of all bolts need not be made at every inspection.

5.2.4 Inspection of Miscellaneous Core Components

Checklist 5.2.4 will be used to record the inspection of miscellaneous core components. Inspection of these parts is not mandatory at each core inspection; however, if no disassembly is made, that fact should be documented on the checklist in the spaces provided.

5.2.5 Alteration of Core Components

Checklist 5.2.5 applies to all U-Mo fuel pieces and all other components that are removed with the core. Descriptions of any cleaning, repairs, improvements, or changes are needed both to aid those who will do similar work in the future and to inform reviewers of such work, however minor it may be.

5.2.6 Substitution of Core Components

If any new U-Mo fuel pieces or other components are introduced into the core assembly, they will be described on Checklist 5.2.6.

5.2.7 Reassembly of Core Components

Before the restacking of the fuel plates is begun, Checklist 5.2.7 is started. The first entry ensures that the proper core inspections have been made and that the appropriate checklists have been completed.

Next, the checklist calls for a listing of the U-Mo fuel pieces to be assembled, with an assurance that no extra fuel components are present.

When the first fuel plate (No. 11) is put on the cart to start the stack, it is carefully placed so that the stack will be advantageously oriented when it is raised for reassembly to the reactor superstructure. As each successive plate is added, care is taken to avoid building a twist into the stack so that the bolt and rod holes are skewed. A special tool is available to align the holes. If the close-fitting control rod tubular guides are used for correcting the rotational orientation of the fuel stack, care must be taken to avoid damaging these thin-walled sleeves. The much stouter 3/4-in. U-Mo bolts may also be used for this purpose, but their clearance in their holes is greater and the precision of orientation achieved is not quite so good.

The stainless steel spacer sleeve with the notch for receiving thermocouple No. 4 must be correctly located on the east side of the core at this time, as it will be impossible to remove U-Mo bolts to relocate this spacer after the core is attached to the superstructure. The control rod guide tubes are installed and the U-Mo bolts are torqued while the core assembly is still on the handling cart.

5.3 INSPECTION OF SAFETY BLOCK DRIVE AND MAGNET ASSEMBLY

For a minor inspection in place, the magnet face and its armature must be separated. Place the rod drive test switch in the TEST position and drive the safety block magnet in the INSERT direction for about an inch. With the magnet and armature thus separated, the faces can be inspected through special ports designed for this purpose. Cotton-tipped swabs, either dry or moistened with alcohol, may be used to clean these mating surfaces.

5.3.1 Disassembly of Safety Block Drive System

The removal for closer inspection of the safety block drive system and the magnet assembly is accomplished by following the steps on Checklist 5.3.1.

Remove the threaded and pinned bayonet sleeve from the lower end of the safety block support shaft and the ejection springs from the safety block shaft. It should be noted that the threaded end of the shaft and the bayonet sleeve are activated by virtue of their proximity to the core and bare-hand contact should be avoided.

Run the safety block drive to its INSERT (upper) limit.

Lower the reactor into its storage position in the pit, disengage the reactor positioner and raise the pickup mechanism drive to the limit. Leave the pit door open.

Turn off power to the reactor superstructure by deenergizing the main breaker in the back of the reactor console.

Unfasten all wires, etc., that are connected to the reactor superstructure top plate and aluminum cover plate and remove the sulfur foil holder. It is not necessary to dissassemble or remove the bracket which holds the sulfur foil holder and the source guide tube.

Remove the aluminum cover plate and the top reactor superstructure plate. The plate is very heavy, and at least two men should remove it.

Uncouple the safety block drive electrical connections at the two quick-disconnect couplings.

The safety block drive motor and gearbox assembly is held in place by three socket head cap-screws. Loosen these screws with a special T-handle extension wrench and record what shims, if any, are found serving to align the gearbox assembly to make the magnet traverse the exact center line of its enclosure tube. Restoration of shims will likely be required when the motor-and-gearbox assembly is reinstalled after inspection.

Remove the safety block drive assembly. This requires careful coordination by two workers. The magnet must be at its upper (safety block INSERTED) limit.

Remove the safety block shaft from above with one man pushing the shaft upward from below. As noted earlier the lower end is activated.

5.3.2 Inspection of Safety Block Drive and Magnet

Follow the steps in Checklist 5.3.2 while inspecting the safety block drive and magnet components. Inspect runout of the armature face and the MAGNET ENGAGED switch actuator by slowly rotating the safety block shaft assembly in a lathe while contacting the proper surfaces with dial indicators.

The alignment of the magnet face with respect to its axis is checked by clamping the magnet drive assembly to a table top, with the threaded drive shaft oriented exactly vertical as indicated by a combination level-and-square tool. The magnet face is then made exactly horizontal by installing appropriate local shims and by careful adjustment of the magnet mounting screws, permitting a trace of flexibility to encourage final self-alignment.

If the safety block drive gearbox is opened for inspection, care must be taken not to disturb the synchro drive train as this might alter the established safety block position readout at the console.

5.3.3 Reassembly of Safety Block Drive System

Follow the steps in Checklist 5.3.3 while reassembling the safety block drive system to the superstructure.

Returning the safety block shaft to its operating position is a hazardous operation because of the possibility of shearing fingertips between the shock absorber spacers and the enclosure tube. Start lowering the shaft within its guide bearing while gripping it by the small-diameter uppermost projection, then drop the assembly after its shock absorber has entered the top of its enclosure tube. The action of the shock absorber will prevent shock damage from occurring as a result of this fall.

Check operation of the safety-block-seated switch.

Install the safety block drive assembly, remake the electrical connections, and turn on the power at the reactor console power panel. Check and adjust the alignment of the magnet in the guide tube. It must be demonstrated that the magnet does not press against the walls of this tube at any point along its traverse, and the drive assembly is shifted horizontally and shimmed as required to achieve this objective. Make sure all screws are tight when the work is completed.

Replace the superstructure top plate and aluminum cover plate and tighten the nuts that hold them. Reanchor the peripheral wires as necessary and replace the sulfur foil holder.

Move the reactor positioner pickup mechanism down to pick up the reactor superstructure. Check the operation of the T-bar to ensure that the positioner will pick up and discharge the reactor properly.

5.4 INSPECTION OF COMPONENTS ON SUPERSTRUCTURE

Follow the steps in Checklist 5.4 while inspecting components on the reactor superstructure. The items are self explanatory except for the following notes.

Using the special three-contacts gauge block, determine how far each of the three safety block contacts extends below the safety block's mechanical stop. Clip the ground wire of the gauge block to any convenient part of the reactor to prevent receiving mild shocks from the 28-V, three-contacts system.

A safety block contact can be adjusted only after it has been removed from the reactor. Removal of a contact assembly is achieved by the use of a special two-pronged tool. The forks of the tool are used to force two restraining springs upward while the contact assembly is lifted upward and away from its normal location.

Three-contact lead wires nearest the reactor core are insulated with ceramic beads to withstand radiation damage. Inspect the electrical insulation near the core for any signs of deterioration.

Any shimming or other adjustments which might change the location of the pulse rod air cylinder must be carefully documented since such changes could alter the effective reactivity worth of the pulse rod stroke.

5.5 RESTORATION OF CORE TO SUPERSTRUCTURE

Fill out Checklist 5.5 as this work progresses. The checklist serves not only as a reminder of various details that should not be overlooked but also as a record of what changes (if any) have been made during this inspection. In this way, future problems might be traced to certain maintenance or lack of maintenance, and improved inspection and maintenance schedules and techniques may be developed with the help of these continuing records.

The first four items summarize the extent of overall disassembly and the completeness of reassembly of the noncore components. The remaining items are essentially the reverse of Checklist 5.1.2 which was used for core removal and disassembly. Proper alignment of the control rods within their holes is achieved by shifting the respective drive assemblies horizontally and carefully shimming between the drives and their baseplate.

5.6 POST-INSPECTION REACTOR CHECKS

Fill our Checklist 5.6 as this work progresses. The first part of this list demonstrates that the reactor functions properly both mechanically and electrically. These checks are made with the reactor not operating.

The operational checks making up the latter part of the checklist are to demonstrate that the safety shutdown devices are reliable and that the nuclear characteristics of the reactor have not been appreciably altered by the inspection work just completed. The reactor is returned to the hydraulic lift for these checks.

CHECKLIST 5.1.1 TOOLS AND SUPPLIES FOR CORE REMOVAL AND DISASSEMBLY

Name ______________________ Date ____________________

______ 1. Checklist for reactor disassembly

______ 2. Health Physics survey and personnel monitoring equipment

______ 3. Health Physics radiation warning tags

______ 4. DO NOT OPERATE tags

______ 5. Blotter paper

______ 6. Clean cotton rags

______ 7. Gloves: ___ pr. cotton; ___ pr. thin nylon; ___ pr. rubber

______ 8. Core handling cart (see Fig. 5.1)

______ 9. Safety block receptable for cart

______ 10. Core receptacle for cart

______ 11. Track covers (2)

______ 12. Screwdrivers (1 large, 1 small)

______ 13. Large pliers

______ 14. Allen wrench set

______ 15. T-handled Allen wrench (1/4-in. size, for safety tube removal)

______ 16. Punch rod for safety block roll pin (1/8-in.), and hammer or mallet

______ 17. Safety block wrench (phenolic)

______ 18. Two adjustable end wrenches (8-in. or 10-in. size)

______ 19. Flashlight (with good batteries)

______ 20. Nonmetallic pliers (modified fuse-puller) for handling U-Mo core bolts

______ 21. Special core plate handling tool (for lifting both types of core plates individually)

______ 22. Handling tools for control rods.

CHECKLIST 5.1.2 CORE REMOVAL AND DISASSEMBLY PROCEDURE

Name ______________________ Date ____________________

______ 1. Reactor transferred from hydraulic lift to positioning device

______ 2. Reg. rod, M.A. rod, and Safety Block Drives at their WITHDRAW limits

______ 3. Pulse rod latches at WITHDRAW limit

______ 4. Source at its WITHDRAW (shielded) limit

______ 5. Reactor about 1 m above storage pit

______ 6. Pit door below reactor closed

______ 7. Beta-gamma radiation 1 m from core reads ______ mrad/h

______ 8. Reactor contamination levels acceptable

______ 9. Heavy track cover placed across rail north of reactor

______ 10. Light track cover placed across north rail at center of building

______ 11. PULSE ROD INSERTED switch assembly demounted

______ 12. Safety tube end cover removed; safety cage removed

______ 13. Safety tube removed

______ 14. Safety block roll pin removed

______ 15. Core handling cart, with safety block receptacle in place, in position

______ 16. Safety block removed

______ 17. Safety block in its receptacle stored in a safe place

______ 18. Necessary Health Physics radiation zone warning tags and ropes erected

______ 19. Core receptacle on cart and positioned against core

______ 20. TC4 removed from under U-Mo bolt head

______ 21. TC1 and TC2 disconnected at phenolic junctions above core

______ 22. Core uncoupled from superstructure

(Sheet 1 of 2)

CHECKLIST 5.1.2 (Continued)

Name ____________________ Date ________________

______ 23. Core support ring lowered away from superstructure studs

______ 24. Cart with core moved to safe location 4 m east of target and HP radiation zone warning tags and ropes erected

IF CONTROL RODS ARE TO BE REMOVED:

______ 25. Control rods at their INSERT limits

______ 26. Roll pins and locking wire removed

______ 27. Control rods unscrewed and stored on blotter paper in a radiation zoned location

IF CORE IS TO BE DISASSEMBLED:*

______ 28. Nine U-Mo bolts removed and stored in a rediation zoned location along with the stainless steel core support ring and six spacers

______ 29. Control rod hole liners and U-Mo glory-hole plug removed and stored in a radiation zoned location

______ 30. U-Mo fuel plates unstacked and stored in a critically safe array in a radiation zoned location

*Record existing torques found on the nine U-Mo bolts. Read CW from the M.A. rod and restore each bolt to its as-found torque before measuring the next one.

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________ (lb-ft)

(Sheet 2 of 2)

CHECKLIST 5.1.3 PRECAUTIONS WHILE CORE IS DETACHED

Name ______________________ Date ________________

______ 1. U-Mo fuel from core properly stored in safe locations

		QUANTITY	HP TAGGED	HP ROPED	HP SHIELDED
U-Mo fuel plates:	Stacked on cart				
	Unstacked				
U-Mo bolts:	Still in core				
	Separated				
U-Mo bolt inserts:	Still in bolts				
	Separated				
U-Mo glory-hole plug:	Still in core				
	Separated				

______ 2. Extra U-Mo components in the reactor bay: none ______, or described as follows: ______________________

______ 3. Major activated core components properly stored per Health Physics procedures

______ 4. Stored U-Mo fuel safe from flooding

______ 5. Stored U-Mo fuel safe from falling objects and mechanical damage

______ 6. Stored U-Mo fuel safe from theft and under proper surveillance (describe protective measures under COMMENTS below)

______ 7. All core parts safely stored where parts will not be lost or damaged.

COMMENTS:

CHECKLIST 5.2.1 PREPARATION FOR MAJOR CORE INSPECTION

Name ______________________ Date __________________

_____ 1. Inspection tables in place

_____ 2. Blotter paper sheets fastened to inspection tables

_____ 3. Lead bricks on inspection table: number of bricks: _____; minimum shielding thickness: _____ in.

_____ 4. Binocular microscope on inspection table

_____ 5. Microscope light (with appropriate extension cord)

_____ 6. Camera (Describe: ______________________________)

_____ 7. Film (Quantity: ______________________________)

_____ 8. Nonmetallic pliers (modified fuse-puller)

_____ 9. Tweezers

_____ 10. Cotton swabs

_____ 11. Cleaning solvents (Describe: ______________________)

_____ 12. Special fuel plate handling tool (with plate-size adapter)

(List additional items needed)

_____ 13.

_____ 14.

_____ 15.

COMMENTS:

CHECKLIST 5.2.2 INSPECTION OF U-MO FUEL PLATES AND SAFETY BLOCK

Name ______________________ Date ____________________

______ Previous fuel plate inspection checklist reviewed.

Were fuel plates unstacked for present inspection? ______ yes; ______ no

Symbols: G = Good
F = Fair
P = Poor
U = Unsatisfactory
(1)(2) etc. = Comments 1,2, etc.

	FUEL PLATE NUMBER											
	1	2	3	4	5	6	7	8	9	10	11	SB
General appearance												
Plating continuity												
Plating smoothness												
Plating adhesion												
Plating color												
Old cracks changed? (yes, no)												
New cracks noted? (yes, no)												
Other irregularities (describe under Comments)												

COMMENTS: ____

____

____

____

____

CHECKLIST 5.2.3 INSPECTION OF U-MO BOLTS

Name ______________________ Date ____________________

______ Previous U-Mo bolt inspection checklist reviewed.

Were bolts removed for present inspection? ______ yes; ______ no

Symbols: G = Good
F = Fair
P = Poor
U = Unsatisfactory
(1)(2) etc. = Comments 1,2 etc.

	U-MO BOLT NUMBER								
THREADS ONLY:									
General appearance									
Plating continuity									
Plating adhesion									
Freedom from slivers									
Irregularities (see Comments)									
BODY AND HEAD:									
General appearance, color									
Plating continuity									
Plating adhesion									
Irregularities (see Comments)									
DIMENSIONS (by micrometer):									
Overall length									
Diameter near head									
Diameter near center									
Diameter near thread									

COMMENTS: ____

____

____

____

____

CHECKLIST 5.2.4 INSPECTION OF MISCELLANEOUS CORE COMPONENTS

Name ______________________________ Date ________________________

______ 1. ______ U-Mo bolt inserts inspected. (Not removed ______.)

______ 2. U-Mo glory-hole plug inspected. (Not removed __________.)

______ 3. Tubular guides inspected. (Not removed ________________.)

INSPECTION REPORT FOR TUBULAR GUIDES	STAINLESS STEEL TUBULAR GUIDES FOR CONTROL RODS		
	M.A. ROD	REG. ROD	PULSE ROD
No cracks between flange and tube			
Tube reasonably round			
Tube undamaged by plate shear forces			
Tube interior free of recent wear evidence			

______ 4. Nine screws for anchoring tubular guides inspected. (Not removed __________.)

______ 5. Core support ring inspected. (Not removed from core ___.)

______ 6. Six stainless steel spacer rings inspected. (Not removed __________.)

______ 7. Safety block stainless steel surface appears normal where it meets three contacts.

______ 8. Safety block bayonet and bayonet adapter fit together correctly. (Not fitted __________.)

COMMENTS:

CHECKLIST 5.2.5 ALTERATION OF CORE COMPONENTS

Name ______________________ Date __________

Core components were repaired, cleaned, or altered in compliance with the Technical Specifications and in the manner described below:

______ No alterations.

______ Alterations as follows: (Include description of any abrasives, solvents, or lubricants used.)

CHECKLIST 5.2.6 SUBSTITUTION OF CORE COMPONENTS

Name ______________________________ Date __________

New components introduced into the core assembly are described below and are in compliance with the Technical Specifications.

______ No new components.

______ New components as follows:

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

____

CHECKLIST 5.2.7 REASSEMBLY OF CORE COMPONENTS

Name ______________________ Date ________________

______ 1. Inspection of core finished and documented by completed checklists for:

____ a. U-Mo fuel plates and safety block (5.2.2)

____ b. U-Mo bolts (5.2.3)

____ c. Miscellaneous core components (5.2.4)

____ d. Alteration of core components (5.2.5)

____ e. Substitution of core components (5.2.6)

______ 2. All required U-Mo pieces present and quantities unchanged*

a. U-Mo fuel plates (quantity ______)*

b. U-Mo bolts (quantity ______)*

c. U-Mo bolt inserts (quantity ______)*

d. U-Mo glory hole plug (quantity ______)*

______ 3. No extra U-Mo pieces present at core reassembly point.

______ 4. Fuel plate adapter in place on core handling cart.

______ 5. Fuel plate No. 11 on core handling cart, properly oriented.

______ 6. Fuel plate No. 10 on core handling cart, properly oriented.

______ 7. Fuel plate No. 9 on core handling cart, properly oriented.

______ 8. Fuel plate No. 8 on core handling cart, properly oriented.

______ 9. Fuel plate No. 7 on core handling cart, properly oriented.

______ 10. Fuel plate No. 6 on core handling cart, properly oriented.

______ 11. Fuel plate No. 5 on core handling cart, properly oriented.

*Unchanged from those listed on CHECKLIST 5.1.3: PRECAUTIONS WHILE CORE IS DETACHED.

(Sheet 1 of 2)

CHECKLIST 5.2.7 (Continued)

_______ 12. Fuel plate No. 4 on core handling cart, properly oriented.

_______ 13. Fuel plate No. 3 on core handling cart, properly oriented.

_______ 14. Fuel plate No. 2 on core handling cart, properly oriented.

_______ 15. Fuel Plate No. 1 on core handling cart, properly oriented.

_______ 16. Stainless steel tubular guides for control rods installed.

_______ 17. Nine anchor screws for control rod guides installed.

_______ 18. Core support ring in place, properly oriented.

_______ 19. Three U-Mo bolts holding core support ring installed.

_______ 20. Six stainless steel spacers and remaining six U-Mo bolts installed.

_______ 21. All nine bolts pretorqued to __________ lb-ft.

_______ 22. All nine bolts finally torqued to __________ lb-ft.

_______ 23. U-Mo bolt inserts installed. (Quantity: _______)

_______ 24. Glory hole plug installed.

COMMENTS: ____

(Sheet 1 of 2)

CHECKLIST 5.3.1 DISASSEMBLY OF SAFETY BLOCK DRIVE SYSTEM

Name ______________________ Date ____________________

______ 1. Bayonet sleeve removed from safety block shaft.

______ 2. Ejection springs removed from safety block shaft.

______ 3. Safety block drive moved to INSERT (upper) limit.

______ 4. Reactor discharged in pit, with screw-lift drive up and storage pit door open.

______ 5. Main breaker in back of console deenergized.

______ 6. Sulfur foil holder removed.

______ 7. Wires and other peripheral items disconnected from reactor superstructure top plate.

______ 8. Aluminum cover plate and superstructure top plate removed.

______ 9. Electric cables for safety block drive disconnected at two couplings.

______ 10. Safety block drive assembly loosened. Shims and their locations were found to be as follows: ______________

____

____

______ 11. Safety block drive assembly removed.

______ 12. Safety block shaft containing shock absorbers and magnet armature removed.

COMMENTS: ____

____

____

____

____

CHECKLIST 5.3.2 INSPECTION OF SAFETY BLOCK DRIVE AND MAGNET

Name ____________________ Date ________________

_____ 1. Safety block shaft assembly inspected and appears normal. Describe changes and improvements under COMMENTS below.

_____ a. Shock absorbers pliable, properly located, lightly lubricated with graphite.

_____ b. Magnet armature tightly mounted, free of dirt. Face runout per dial indicator was ________________, now is ____________________.

_____ c. MAGNET ENGAGED switch actuator properly attached to armature. Runout per dial indicator was ________, now is ____________________.

_____ d. Main shaft free of cracks and scratches, threads not damaged, threads and shaft lightly lubricated with graphite.

_____ 2. Magnet assembly inspected and appears normal. Describe changes and improvements under COMMENTS below.

_____ a. Magnet face free of dirt and scratches.

_____ b. Alignment of magnet face with respect to axis checked __________, corrected ____________.

_____ c. Magnet screws properly tightened, safety wires secure.

_____ d. MAGNET ENGAGED switch tightly mounted, correctly adjusted, electrical leads and terminals anchored and insulated.

_____ 3. Safety block drive assembly inspected and appears normal. Describe degree of disassembly, changes, and improvements under COMMENTS below.

_____ 4. Shock absorber enclosure tube inspected and appears normal. Describe changes and improvements under COMMENTS below.

_____ a. Tube cleaned.

_____ b. Shaft bearing cleaned and lightly lubricated with graphite.

COMMENTS: ____

____

CHECKLIST 5.3.3 REASSEMBLY OF SAFETY BLOCK DRIVE SYSTEM

Name ______________________ Date ________________

______ 1. Safety block shaft returned to enclosure tube. (Beware of hazard to fingertips.)

______ 2. SAFETY BLOCK SEATED switch inspected and appears normal.

______ 3. Safety block drive assembly restored to operating position.

______ 4. Electric cables reconnected at two couplings.

______ 5. Main breaker in back of console reenergized.

______ 6. Magnet demonstrated to be centered in its enclosure tube, top and bottom; alignment shims installed and screws tightened. Shims and their locations are as follows:

____

____

____

______ 7. Superstructure top plate and aluminum cover plate restored to position and secured.

______ 8. Miscellaneous wires reanchored to superstructure top plate.

______ 9. Sulfur foil holder mounted on reactor.

______ 10. T-bar observed to function properly at pickup and discharge.

______ 11. Ejection springs placed in safety block shaft.

______ 12. Bayonet sleeve placed on safety block shaft and pinned.

COMMENTS: ______________________________________

____

____

____

____

CHECKLIST 5.4 INSPECTION OF COMPONENTS ON SUPERSTRUCTURE

Name ______________________ Date ______________________

______ 1. Three safety block contacts normal.

Contacts cleaned ______; removed ______, adjusted ______,

______ 2. Three contacts measured.

No. 1 = ______, No. 2 = ______, No. 3 = ______.

______ 3. Insulation on wires leading to three contacts intact.

______ 4. All limit switches and actuators inspected and secure.

Place A in box if adjustment of limit was made	Limit properly located	Terminal screws tight	Unit securely mounted
Safety block drive UP			
Safety block drive DOWN			
Regulating rod UP			
Regulating rod DOWN			
M.A. rod UP			
M.A. rod DOWN			
Pulse rod timer DOWN			
Pulse rod DOWN			
Pulse rod UP			
Pulse rod upper latch OPEN			
Pulse rod upper latch CLOSED			
Pulse rod lower latch OPEN			
Pulse rod lower latch CLOSED			

______ 5. Pulse rod air cylinder normal.

____ a. No shimming or other changes made

____ b. Changes made per COMMENTS below.

______ 6. Safety block drive motor and gear box normal.

______ 7. M.A. rod drive motor and gear box normal.

______ 8. Reg. rod drive motor and gear box normal.

______ 9. Pulse-rod latches normal.

______ 10. Pneumatic system normal and fittings tight.

(Sheet 1 of 2)

CHECKLIST 5.4 (Continued)

______ 11. Reservoir tank normal and fittings tight.
Last inspection by Quality Department______________(date).

______ 12. All control rod drive shafts normal. Cleaned and lubricated ______________.

______ 13. Safety block magnet and armature faces clean. Magnet assembly removed for inspection __________;
adjustments made __________________________.

______ 14. Safety block shock absorbers satisfactory.
Assembly removed for inspection ____________________.

______ 15. Safety block withdraw switch secure and wires clear.

______ 16. Terminal strips normal. Screws tightened ________________.

______ 17. All wiring neat, clear of drives, and not strained.
Wire ties added _______________________.

______ 18. Superstructure clean. Excess oil removed ________________.

COMMENTS:

(Sheet 2 of 2)

CHECKLIST 5.5 RESTORATION OF CORE TO SUPERSTRUCTURE

Name ______________________ Date ________________

______ 1. Checklist 5.2.7 completed for reassembly of core components.

______ 2. Checklist 5.3.3 completed for reassembly of safety block drive system.

______ 3. Superstructure component changes:

____ a. None.

____ b. Changes made as described under COMMENTS below.

______ 4. Superstructure noncore components installed:

	Not removed for this inspection	Removed, then reinstalled
Safety block shock absorber and magnet follower assembly		
Safety block magnet and drive motor assembly		
Drive motor assemblies for M.A. Rod and Reg. Rod		
Pulse-rod air cylinder, storage tank and other air system components		
Superstructure top plate (with T-bar slot) and aluminum cover		
Safety block ejection springs, bayonet adapter sleeve, and roll pin		

______ 5. Control rods installed and safety locked:

	Not removed for this inspection	Reattached to superstructure	Roll-pinned (P) Security wired (W)
Pulse rod			
M.A. rod			
Reg. rod			

______ 6. Control rods drive to their WITHDRAW (upper) limits.

______ 7. Core assembly (on cart) positioned properly below superstructure.

(Sheet 1 of 2)

CHECKLIST 5.5 (Continued)

______ 8. Core raised into position for attaching to superstructure.

______ 9. Three nuts (with lockwashers) attached to hold core to superstructure.

______ 10. Control rod alignments satisfactory.

____ a. Regulating rod realigned. (Describe shimming under COMMENTS below.)

____ b. M.A. rod realigned. (Describe shimming under COMMENTS below.)

______ 11. Thermocouples Nos. 1 and 2 plugged in at phenolic connectors.

______ 12. Thermocouple No. 4 anchored under U-Mo bolt head spacer.

______ 13. Safety block drive moved to its WITHDRAW (lower) limit.

______ 14. Core handling cart removed and prepared for transporting safety block.

______ 15. Safety block placed on cart and moved into position below core.

______ 16. Safety block attached to drive shaft using phenolic wrench (bayonet engages like left-hand thread).

______ 17. Safety block roll pin installed.

______ 18. Safety tube attached (use short screw on south side).

______ 19. Thermocouple No. 5 anchored between safety tube and bottom fuel plate.

______ 20. Safety cage attached.

______ 21. Safety tube end cover attached.

______ 22. Pulse rod INSERT limit switches attached.

COMMENTS: ____

____

____

(Sheet 2 of 2)

CHECKLIST 5.6 POST-INSPECTION REACTOR CHECKS

Name ____________________ Date ____________________

_____ 1. Main breaker switch behind console turned on.

_____ 2. Pulse rod motion looks and sounds normal. Describe any adjustments under COMMENTS below.

_____ 3. Reg. rod and M.A. rod motions look and sound normal.

_____ 4. Safety block drive motion looks and sounds normal (with safety block not picked up).

_____ 5. Pulse rod latches function properly.

_____ 6. Pulse rod limit lights function properly.

_____ 7. Reg. rod and M.A. rod limit lights function properly.

Reg. rod WITHDRAW reading ____________;

M.A. rod WITHDRAW reading ____________.

Reg. rod INSERT reading ____________;

M.A. rod INSERT reading ____________.

_____ 8. Three control rods measured with respect to bottom surface of core when at insert limit:

a. Pulse rod: ______________________________

b. M.A. rod: ______________________________

c. Reg. rod: ______________________________

_____ 9. Reactor prepared for operational checks. (Sulfur foil in place; pulse rod nitrogen supply turned on; reactor returned to hydraulic lift and raised; reactor building and gates locked; roll call taken; 3-min timeout completed.)

_____ 10. MAGNET ENGAGED and SAFETY BLOCK WDR. lights function properly.

_____ 11. SAFETY BLOCK DRIVE WDR. limit light functions properly. SB. DRIVE WDR. limit reading: ____________________.

CHECKLIST 5.6 (Continued)

______ 12. SAFETY BLOCK INSERTED and SB. DRIVE INSERTED limit lights function properly. SB. DRIVE INSERTED reading: ______.

______ 13. Three safety block contacts make up properly (per television observation).

______ 14. Magnet scram current measured: __________; __________.

______ 15. Solenoid scram current measured: __________; __________.

______ 16. Reactor bay reentered; three-contacts test switch (NW side of superstructure, near top) shifted from NORMAL to TEST.

______ 17. Safety block release and travel times measured.

S.B. release: __________; __________.

S.B. travel: __________; __________.

______ 18. Pulse rod insertion time measured: __________; __________.

______ 19. M.A. rod critical positions under standard conditions:

P rod IN, Reg. rod OUT ____; P rod OUT, Reg. rod OUT ____.

P rod IN, Reg. rod IN _____; P rod OUT, Reg. rod IN _____.

Reg. rod worth ____________; Reg. rod worth _____________.

P rod worth _______________; P rod worth ________________.

COMMENTS:

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6. SPECIAL REACTOR PROCEDURES

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6. SPECIAL REACTOR PROCEDURES

6.1 ASSEMBLING NEW REACTOR CORES: CRITICAL EXPERIMENTS

A series of critical experiments must be performed for each new core to be used in the HPRR. The procedure for performing the critical experiments is given below, and once they have been performed, the new core can then be assembled according to the procedures given in Section 5.1. (Step-wise changes such as the substitution of a fuel disk or a few U-Mo bolts in a core will not require a full critical experiment.)

If at any time during assembly of a new core it appears that the critical condition will be reached before the expected loading is attained, the following procedure must be discontinued until the reason for the premature criticality has been determined and corrected.

1. Read Section 5.1.1 and perform steps under Section 5.1.2.
2. Place the bottom 1-in.-thick disk (No. 11) in the disk adapter on the core assembly table (shown in Fig. 5.1). Then position a neutron source and a neutron-detecting chamber at reproducible points on opposite sides of the disk and determine the counting rate.
3. Add, in turn, disks Nos. 10, 9, and 8 (each 15/16 in. thick), repositioning the source and determining the counting rate after each disk is added.
4. Plot the reciprocal of the counting rates as a function of the U^{235} mass of the stack. Extrapolate these data to zero reciprocal counting rate to obtain an estimate of the critical mass and therefore critical height.
5. Place the stainless steel guide tube in pulse rod hole.
6. Place the stainless steel guide tube in regulating rod hole.
7. Place the stainless steel guide tube in mass adjustment rod hole.
8. Place stainless steel support ring (with lugs) over appropriate holes in top disk, taking care to orient the support ring properly relative to both the core and the source drive.
9. Bolt the assembly together with three of the nine U-Mo bolts.
10. Raise the top of the assembly table until the disks can be fastened to the reactor framework with the three stainless steel bolts and lock washers.
11. Remove assembly table and replace disk adapter with safety block adapter.
12. Place safety block in adapter and move and raise table until the safety block can be attached to its support shaft with bayonet-type latch.

13. Obtain a counting rate with the source inserted but with the safety block and control rods out; plot as in Step 4.
14. Proceed with the normal checkout and operating procedures of Section 4.1.
15. Observe the multiplication change, or approach criticality, as the safety block and control rods are inserted into the core. If criticality is not brought about with all rods inserted, obtain a count from the startup channel for this configuration and plot as in Step 4.
16. Shut down the reactor according to the normal shutdown procedure given in Section 4.1.4.
17. Remove the safety block and change adapter on the assembly table to the one for holding the disks.
18. Remove the disks from the reactor framework onto the assembly table.
19. Remove the three U-Mo bolts, add another disk, determine the counting rate, and repeat Steps 4 through 18.
20. Continue to add another disk, until the remaining six disks have been used, repeating Steps 4 through 18 after each addition. After for last disk has been added, bolt the guide-tube holding rings for the movable rods onto the top core piece.
21. Add three of the remaining six U-Mo bolts to the core, attach the core and safety block to the reactor framework, and obtain a counting rate both before and after safety block is inserted. Estimate the critical mass and plot the data on the same curve as the data in Step 4.
22. Remove safety block from reactor framework and lower core into disk adapter on assembly table.
23. Repeat Step 21 with the three remaining bolts.
24. If everything seems normal, determine critical control rod settings.
25. Calibrate the mass adjustment and regulating rods, determining reactivity worth of each as a function of its position in the core.
26. Determine reactivity worth of pulse rod by procedures given in Section 6.3.1.

6.2 DETERMINATION OF REACTIVITY WORTH OF REFLECTORS

Since the HPRR is extremely sensitive to all surrounding objects that might act as reflectors, no experiment can begin until the effects of all reflecting materials around the core are estimated and recorded on the HPRR Checkout Sheet (see Section 4.1). The effect of the floor was determined during the initial critical experiments with core No. 1 and will be approximately the same for any new core, but to this must be added the estimated effect of each experimental configuration and any other reflecting materials. The estimated reactivity worths of the experimental configurations will be based on conservative comparisons with reactivity worths determined previously for reflectors of similar size, shape, and composition. The procedure given below will be used for such determinations:

1. Follow the steps given for steady-state operation in Section 4.1 to determine the critical control rod positions in the core with no reflector in position.
2. Estimate the distance from the core that the reflector can be placed without increasing the core reactivity more than 25 cents. This distance should be a conservative estimate made by comparing, on a volume (or mass) and area basis, this reflector with one having a known reactivity.
3. Position the reflector at the required distance, determine the new critical rod settings, obtain the associated reactivity change from the rod calibration curves, and plot the reactivity change as a function of the reflector distance from the reactor surface.
4. Using the same procedure as in Step 2, estimate the distance that the reflector can be moved toward the reactor (or the reactor toward the reflector) without increasing its reactivity more than 10 cents (if the U-Mo shim pins have been removed, the limit will be 25 cents).
5. Repeat Step 3, plotting the total reactivity change from the no-reflector condition.
6. Make a linear extrapolation of the data to zero distance from the reactor and multiply this value by a factor of 2. Plot this point, and draw a curve through it and the two experimental points to obtain an estimate of the distance that the reflector can be moved toward the reflector without increasing its reactivity more than 10 cents (or more than 25 cents if the shim pins have been removed).
7. Move the reflector to a position no closer to the core than the limits set in Step 6, determine the new critical control rod settings and the associated change of reactivity from the previous position, and plot the total reactivity change from the no-reflector condition.
8. Draw a curve through the three experimental points and extrapolate the curve to zero distance from the core to obtain an estimate of the distance that the reflector can be moved toward the reactor without changing its reactivity more than 10 cents (or more than

25 cents if the shim pins have been removed). Move reflector to the new position, determine the new critical control rod settings and the associated change of reactivity from the previous position, and plot the total reactivity change from the no-reflector condition.

9. If the U-Mo shim pins are in the bolts, repeat Step 8 until the reflector is at the desired position or until its reactivity worth is 50 cents, whichever condition is reached first.
10. If the shim pins are not in the bolts, repeat Step 8 until the reflector contributes about 175 cents, after which the movements of the reflector should correspond to reactivity increases of no more than 10 cents. The procedure will then be continued until the reflector is at the desired position or until its reactivity is worth no more than 214 cents, whichever condition is reached first.

6.3 DETERMINATION OF REACTIVITY WORTH OF PULSE ROD: APPROACH TO MAXIMUM YIELD

Whenever changes are made in the HPRR core which affect the control rod worths, it will be necessary to redetermine the reactivity worth of the pulse rod. Similarly, whenever changes are made in the reflector used with the reactor, the effect of the reflector on the pulse rod must be known before pulse experiments can proceed on a routine basis. If comparable (or larger) reflectors have been measured, conservative estimates of the reflector effect on the pulse rod can be made, as called for in the pulse operation procedure given in Section 4.2.1. In any case, the worth of the pulse rod in each unreflected core must have been measured. Section 6.3.1 below gives the procedure to be followed to perform a series of pulses approaching the maximum pulse yield and providing data to evaluate the reactivity worth of the pulse rod when no reflector is present. The procedure to follow when determining the effect of a reflector on the pulse rod is given in Section 6.3.2.

6.3.1 Unreflected Core

In determining the worth of the pulse rod, the initial reactivities of the assembly must be conservatively low to allow for any error in estimating the worth of the pulse rod. The determination, therefore, will begin with a pulse experiment in which approximately 40 cents is subtracted from the delayed-critical core and the insertion of the pulse rod results in a core having a reactivity of only about 68 cents. The second pulse will result from a core having a reactivity of 78 cents, and so forth, until approximately 10 pulses are performed, the increments of reactivity increase being only about 2 cents during the last several pulses. Thus, the following steps will be used to evaluate the pulse rod:

1. Follow the steps outlined in Section 4.2 to perform a series of pulses for which the core conditions are approximately those given below:

Change in Reactivity of delayed-critical core (cents)	Estimated reactivity of core plus pulse rod (cents)
-40	68
-30	78
-20	88
-10	98
-8	100
-6	102
-4	104
-2	106
0	108
2	110

2. As each pulse is performed, plot a curve of relative fission yield vs reactivity of the core.
3. Make a determination of the absolute fission yield by exposing a U-Mo sample in the sample-irradiation hole or by exposing previously calibrated foils.
4. Determine the reactivity worth of the pulse rod by generating a curve of the reciprocal period vs reactivity added to (or subtracted from) the delayed-critical core for reciprocal periods greater than about 10^{-4} and then extrapolating this curve to $1/T = 0$. For periods of this magnitude, the delayed neutrons do not contribute appreciably to the initial power rise; therefore, the linear extrapolation of the curve to $1/T = 0$ corresponds to the prompt-critical condition, and the reactivity worth of the pulse rod is equal to 100 cents plus the amount of reactivity subtracted from the delayed-critical core to give the prompt-critical period.

6.3.2 Reflected Core

Any reflectors which measurably increase the reactivity of the core may change the worth of the pulse rod, and it must always be assumed that they will increase it to some extent. Here again, in determining the worth of the rod, the initial reactivities of the assembly must be conservatively low to allow for any errors in estimating the worth of the rod. The entire procedure is as follows:

1. Calibrate the pulse rod in the unreflected core.
2. Place the reflector on the same side of the core as the pulse rod in a position which will not increase the reactivity of the core by more than 50 cents. (Placing the reflector on the same side as the pulse rod will produce a maximum perturbation of the flux in the pulse rod.)
3. Follow the procedures given in Section 4.2 to perform a series of pulse experiments, based on the initial and succeeding reactivities of the core given below:

    a. The reactivity of the core (minus pulse rod) for the initial pulse will be that reactivity of the unreflected core (minus pulse rod) which gives a yield of 1×10^{17} fissions when the pulse rod is added minus the reactivity worth of the reflector; that is, $\rho_{\text{initial}} = \rho_{\text{bare core, } (10^{17} \text{ fissions})} - \rho_{\text{reflector}}$. If the effect of the reflector is relatively small, the reactivity of this initial core plus the pulse rod will be approximately 40 cents below prompt critical, assuming the reflector to be worth 50 cents.

    b. The reactivity to be subtracted from $\rho_{(\text{bare core, } 10^{17} \text{ fissions})}$ for succeeding bursts will be (assuming the reflector to be worth 50 cents), in order, 40, 30, 20, 15, 10, and 5 cents, or until a measurable temperature rise is obtained.

    c. After a pulse experiment has been performed which gives a measurable temperature rise, the reactivity of the core will be increased about 2 cents for each succeeding pulse.

4. After each pulse, plot the temperature as a function of the reactivity of the core on the same graph with the corresponding data

for the unreflected core. Compare the two curves to determine the increased worth of the pulse rod.

(NOTE: It may not be necessary to continue the pulse to the maximum yield to determine the increased worth of the pulse rod.)

7. MAINTENANCE OF REACTOR AND ASSOCIATED EQUIPMENT

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7. MAINTENANCE OF REACTOR AND ASSOCIATED EQUIPMENT

Maintenance of the HPRR and associated equipment will be done on a scheduled time-cycle or operation-cycle basis. The HPRR Reactor Supervisor will be responsible for checking and maintaining the mechanical components of the reactor on a calendar schedule or as determined by the number of steady-state operations or number of pulses, for seeing that the drainage system works properly, and for maintaining the control rod limit switches and selsyns on an operational basis. Calibration and checking of the temperature system and checking of the control system will be the responsibility of the Reactor Supervisor, with members of the Reactor Controls Department of the Instrumentation and Controls Division performing the maintenance. The Reactor Supervisor likewise will be responsible for the operational checking and maintenance of the reactor positioning device and associated building equipment, with members of the Plant and Equipment Division performing the maintenance. Checking and inspection of the hoisting equipment filter systems and pressure containing equipment will be the responsibility of the Quality Department.

The maintenance files kept in the HPRR control room will include a schedule of the inspection, calibration, and maintenance required; a record of the completion of those items; and procedures for performing them. Quality Department will maintain a programmed schedule of inspections; they forward copies of the scheduled inspections to the HPRR prior to their inspections and the results of the inspections after they are completed. The Plant and Equipment Division will cover, by programmed maintenance, the positioning device and associated building equipment. When the work is completed, the supervising foreman will initial and forward the cards, that show the work that was done, to the HPRR Operations Supervisor for recording. All maintenance, calibrations, and checks on I&C equipment will be recorded on cards and fed into their computer so that there is a permanent record of all work on each piece of equipment.

7.1 SCHEDULE FOR CHECKS, INSPECTIONS, AND MAINTENANCE

The schedule for checks, inspections, and maintenance for the HPRR and associated equipment is broken down into annual, semiannual, quarterly, and monthly inspections. The various groups responsible for the work are identified for each item with the following abbreviations:

Reactor Operator - RO
Instrumentation & Controls - IC
Quality Department - QD
Environmental & Occupational Safety - E&OS

7.1.1 HPRR Inspection and Maintenance Annual Checklist

1. Inspect all recorders - IC
2. Review control system switches, relays, etc. - RO, IC
3. Test all annunciators - RO, IC
4. Check control rod limit switches and selsyns - RO, PE
5. Inspect positioning device circuits and limit switches - RO, PE
6. Calibrate reactor building electrometers and control building monitron - IC
7. Inspect reactor core - RO
8. Calibrate regulating rod - RO
9. Inspect mechanical equipment on reactor superstructure - RO, PE
10. Perform high-power excursion test - RO
11. Review bookkeeping methods and forms - RO
12. Review procedures manual and update - RO
13. Inspect perimeter fence - RO, PE
14. Check operation of thermostat on water pipe in lavatory at reactor building - RO
15. Review maintenance schedule for reactor - RO
16. Review programmed maintenance card schedule - RO
17. Sort old recorder charts - RO
18. Check physical positioning of pulse rod - RO
19. Check that reactor positioner operation causes a reactor scram - RO
20. Reactor building bridge crane - QD
21. Outside boom derrick - QD
22. Reactor lifting fixture - QD
23. Reactor building exhaust filters - QD

7.1.2 HPRR Inspection and Maintenance Semiannual Checklist

1. Calibrate startup channel recorders - IC
2. Calibrate log N recorder - IC
3. Calibrate log N period recorder - IC

4. Calibrate picoammeter recorder - IC
5. Calibrate temperature recorders - IC
6. Review mainenance history of all electronic chassis - RO
7. Check personnel protection system - RO

    a. Check 5 gate switches
    b. Check main gate (2)
    c. Check reactor bay doors (5)
    d. Check stop buttons (6)
    e. Inspect 1000-ft-radius fence

8. Check portable beta-gamma survey instruments - E&OS
9. Measure safety block release and travel time - RO
10. Calibrate power measuring channels vs core temperature rise - RO
11. Hold an emergency drill - RO
12. Have Fire Department hose down reactor storage pits - RO
13. Write semiannual HPRR operating summary - RO
14. Check the operation of the Reactor Secure Switches (3) - RO
15. Check that hydraulic lift bleed down will cause a reactor scram (2) - RO
16. Fork lift truck - QD

7.1.3 Inspection and Maintenance Quarterly Checklist

1. Calibrate neutron detector system - IC
2. Check compressed-gas warning horn - IC
3. Check operation of horn trouble monitor - IC
4. Check pit water-level alarm - RO
5. Calibrate period preamplifier (reactor building) - IC
6. Calibrate period sigma amplifier (reactor building) - IC
7. Calibrate level-safety channels (reactor building) - IC
8. Calibrate sigma bus (reactor building) - IC
9. Adjust preamplifier grid offset (reactor building) - IC
10. Calibrate period channel with period simulator (reactor building) - IC, RO
11. Calibrate picoammeter (reactor building) - IC
12. Check servo amplifier (reactor building) - IC, RO
13. Check portable alpha and neutron detectors - E&OS
14. Measure and set scram current - RO, IC
15. Inspect all 5 locks and gates to reactor area - RO
16. Operators performed pulse operation to maintain qualification - RO

17. Run PHS curves on startup channels - RO
18. Check control rod insertion interlocks - RO
19. Check M.A. rod position with R.R. and P.R. in and out - RO

7.1.4 HPRR Inspection and Maintenance Monthly Checklist

1. Check all controlled-access doors and signs - RO
2. Check reactor building radiation warning lights - RO
3. Inspect reactor storage pit for water - RO
4. Check operation of short-wave radio - RO
5. Make HP survey of reactor bay - E&OS
6. Check FACILITY ON sign at gate No. 1 - RO
7. Check CONTROLLED ACCESS beacon at Post 23 - RO
8. Check response of neutron monitors in reactor bay as shown in control room - RO
9. Exercise the 5-ton outdoor crane in all its motions - RO

8. SUMMARY OF SURVEILLANCE REQUIREMENTS FROM THE UPPER TECHNICAL SPECIFICATIONS

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8. SUMMARY OF SURVEILLANCE REQUIREMENTS FROM THE HPRR TECHNICAL SPECIFICATIONS

The surveillance requirements of the Health Physics Research Reactor (HPRR) are summarized here for the convenience of the operators. Also included are the administrative requirements not stated elsewhere in the Health Physics Research Reactor Procedures Manual that require operator action. Definitions and the actual technical specifications are added where they contribute to understanding prescribed duties. Operators are reminded, however, that they must be familiar with the complete technical specifications.

8.1 REACTIVITY

1. Whenever there has been a change in the core, the control elements or their drives, and at least annually, a check will be made of the operating position of the control rods with the reactor at delayed critical. This will be done at an established reactor position with pulse rod inserted and again with the rod withdrawn.
2. Whenever core components or control elements are changed or whenever the checks in Step 1 do not correspond to expected values and at least annually the regulating rod will be calibrated and its worth must be limited to $1.00.
3. Whenever the calibration in Step 2 does not agree with previous calibrations within 4 cents, the mass adjustment rod will be calibrated and its worth must be limited to $2.00.
4. The reactivity worth of untried experiments shall be determined in accordance with Chapter 6 - Special Reactor Procedures. The reactor must always be $0.25 subcritical with the safety block inserted and the regulating and mass adjustment rods withdrawn.
5. Whenever changes are made in the core or control elements or an untried experiment is to be set up for pulse operation, the reactivity worth of the pulse rod will be determined in accordance with procedures in Section 6.3. Its static reactivity worth will be limited to $1.20.

8.2 PULSE YIELD

To ensure that the maximum target pulse will not exceed 1.0×10^{17} fissions, the following will be done:

1. The personnel requirements for pulse operation will be as specified in Section 8.15.

2. The experiment limitations will be as in Section 8.5.
3. After any changes of the reactor core, reactor superstructure, or material in the vicinity of the reactor or a period of time since the last pulse in excess of two months, calibration pulses will be made before a maximum yield pulse is attempted.
4. For each pulse, the operating sequence will include:

    a. operation at delayed critical,
    b. reactivity adjustment necessary to obtain the desired yield,
    c. confirmation of reactivity adjustment by period measurements if the pulse rod is to be fired into a supercritical core,
    d. a neutron decay interval in which the reactor is made subcritical while the neutron population decays to background,
    e. a reassembly to conditions established in b, and
    f. pulse rod insertion.

8.3 PULSE ROD REACTIVITY PEAKING

The physical positioning of the pulse rod will be measured at least annually. Whenever there has been a change in the pulse rod or a change in the core which could alter the position at which the pulse rod contributes its maximum reactivity, the pulse rod will be recalibrated and repositioned as necessary to ensure that the reactivity difference between the pulse rod at its position of maximum reactivity and at its fully inserted position will be no more than 0.2 cent.

8.4 OPERATION OF REACTOR POSITIONING DEVICE

At least annually and after maintenance, a check will be made to verify that any attempt to cause horizontal or vertical movement by means of the reactor positioning device control or bleed down of the hydraulic lift which lowers the reactor more than 1 cm below its specified operating position will cause a reactor shutdown.

8.5 LIMITATIONS ON EXPERIMENTS

1. Measurements will be performed to determine the reactivity worth of the experiment. The information describing the reactivity worth of the experiment will be recorded in the Operations Log Book.
2. All explosive materials will be either verified as a "bench safe" device or irradiated in a container which has been tested for full

containment of twice the amount of explosives to be irradiated. These containers will be verified and approved by the Quality Department. The results reported by the Quality Department will be recorded on the experiment plan or in the Operations Logbook.

3. A calculation will be performed to provide support that the total number of fissions generated in an experiment will be less than the specified limit of 10^{17}. If the number of fissions generated is predicted to be greater than 5×10^{15}, a container will be employed to house the sample(s). The container will be verified to be leak proof up to at least twice the pressure that will be generated inside the container. Encapsulation of Pu experiments will be verified.
4. Containers used to doubly encapsulate hazardous material will be verified as capable of withstanding at least twice the calculated maximum pressure generated and containing the materials inside the inner container. The information describing the container and testing procedures will be recorded on the experiment plan or in the Operations Logbook.
5. Interlocks that operate during the neutron decay interval in pulse preparation and during pulse operation will be tested as follows:

   a. The control rod insertion interlocks will be tested for operability at least quarterly and after maintenance that could affect the interlocks.
   b. Interlocks to prohibit addition of reactivity by remote operation of an experiment will be checked prior to the start of each experiment for which remote operation has been authorized.

8.6 CORE FUEL INTEGRITY

Annually, the safety block and the interior and exterior of the assembled core will be examined visually for cracks that could result in the displacement of fuel in a way that could interfere with movement of the safety block. A similar examination will also be made whenever formation of a crack is suspected.

8.7 SAFETY BLOCK RESPONSE TIMES

The magnet release time and the travel time of the safety block will be measured at least semiannually and after maintenance is performed that could affect magnet release and travel time to ensure that:

1. The release time for the magnet will not exceed 20 ms.

2. The total travel time (including release time) of the safety block from its normal operation position to its normal shutdown position will not exceed 240 ms.

8.8 INSTRUMENTATION FOR REACTOR OPERATION

Prior to the initial operation of an operating day, a check will be made to ensure that the startup channel responds to a change in neutron flux.

The channels that provide information to the operator during operation will be calibrated annually and after mainenance that could affect the calibration of the channels. These channels are listed in Table 8.1.

Table 8.1. Instrument system channels

Instrument channel	Minimum No. operable	Number installed
Neutron counting channels for startup and for measuring prepulse period	1	2
Log or linear power indicating channels	1	1 ea
Power level safety channels	2	2
Core surface temperature channels for pulse preparation	2	2
Core temperature safety channels	2	2
Closed circuit television channels	1	3

The operation of all devices that affect reactor control will be checked after maintenance and at least annually.

8.9 REACTOR SAFETY SYSTEM

The safety system channels required for operation are shown in Table 8.2.

Table 8.2. Safety system channels

Safety system channel	Minimum No. operable	Function
Core temperature safety channel	2	Shut down reactor if measured core temperature exceeds 650°F (617 K)
Power level safety channels	2	Shut down reactor if power exceeds 20 kW

1. A channel test of the reactor safety system channels will be performed daily if the reactor is to be operated.
2. The manual scram will be checked prior to the first startup each day the reactor is operated.
3. A channel check of each of the measuring channels in the reactor safety system will be performed daily when the reactor is in operation.
4. A channel calibration of the reactor safety channels will be performed semiannually and after maintenance that could affect the calibration of the safety channels.
5. The power measuring channels will be calibrated versus core temperature rise as a function of time at least semiannually and after maintenance that could affect the calibration of the power measuring channels.

8.10 MECHANICAL SAFETY DEVICES

The specification for safety devices is as follows:

1. A safety cage and a safety tube are required during operation except when the Committee to Review Experiments for the Pulse Reactor (CREPR) authorizes otherwise for a specific test or expriment.
2. Either a safety tube or a crash plate is required during operation. To ensure compliance, the procedures (see Chapter 5) require that whenever maintenance is performed on the reactor core or control elements, a senior operator shall check and ensure that the safety cage and either safety tube or crash plate are in place when the work is completed.

8.11 PERSONNEL RADIATION PROTECTION SYSTEM

During reactor operation, the following conditions will be satisfied:

1. Keys from all gates in the 1000-ft-radius (304.8-m-radius) exclusion fence will be in their proper switches on the reactor console and turned on.
2. Interlocks will be operable to effect a reactor shutdown if the main access gate to the reactor area or any reactor bay door is opened.
3. Push buttons at the following locations will be operable to stop reactor operation:

    a. On the north wall inside the reactor building (three push buttons)
    b. Outside the reactor building near the east door
    c. Inside the fence at the main access gate to the reactor area
    d. At the reservoir

4. The 1000-ft-radius fence will be closed for all reactor operation.
5. The outer perimeter fence will be closed for all operation except low-power operation.

To ensure the above conditions are met, operation of each channel will be checked annually and after maintenance. The fences will be checked annually.

8.12 OUTDOOR REACTOR OPERATION RESTRICTIONS

Whenever the reactor is to be operated outside of the reactor building, the operation will be according to a specific experiment plan approved by the Committee to Review Experiments for the Pulse Reactor, the Reactor Operations Review Committee, and Security. A special checklist will be used that will include a check that the wind-speed indicator, one television channel, and the auxiliary power generator are operable. The weather forecast and the actual weather conditions will be checked just prior to operation.

The reactor will not be operated outside if it is raining or if the wind speed is greater than 55.6 km/h (40 mph).

8.13 REACTOR STORAGE PIT

1. The screened drain port in the pit and the drain line opening into the holdup reservoir shall be inspected and cleaned, if necessary, before the reactor is left unattended in the pit.
2. The drain will be flushed semiannually.
3. The liquid-level alarm system will be checked quarterly and after maintenance on the system.

8.14 NEUTRON DETECTORS

There are two neutron-sensitive detectors and associated electronics which will initiate an alarm if they detect neutron levels in excess of 25 mR/h* in the reactor bay when the reactor is not in operation. The alarm is an air-operated horn and warning lights. The system has an auxiliary power supply that is operable during a power outage, and there is a warning indication if the system is out of service.

To ensure the systems are operable, the following will be done:

1. Operation of the neutron detector system will be checked monthly when the reactor is operated and after maintenance.
2. The neutron detector systems will be calibrated quarterly and after maintenance.
3. The compressed-gas-warning horn and its gas supply will be checked semiannually and after maintenance.
4. The operation of the horn trouble monitor will be checked semi-annually and after mainenance.
5. The auxiliary power supply will be checked monthly.

8.15 MINIMUM STAFF REQUIREMENTS

8.15.1 Steady-State Operation

1. A senior reactor operator and one other person will be present in the control building when the reactor is operated.
2. Either a senior reactor operator or a Reactor Operator will be present in the control room during reactor operation.

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*This is equivalent to a reactor power of 0.2 W when the reactor is at the primary experimental position.

8.15.2 Pulse Operation

One senior reactor operator and one reactor operator will be present during pulse preparation and pulse operation.

8.15.3 Core Maintenance and Reactivity Adjustments

A senior reactor operator, a reactor operator, and one other DOSAR staff member will be present whenever the core is being removed from or installed on the reactor superstructure and whenever the core is being disassembled or reassembled.

8.16 ACTION TO BE TAKEN IN THE EVENT A SAFETY LIMIT IS EXCEEDED

Safety limits are:

1. The maximum fuel temperature shall not exceed 1830°F (1272 K).
2. The core temperature shall not be maintained above a temperature of 700°F (644 K) for periods in excess of 4 h.

In the event a safety limit is exceeded:

1. The reactor will be shut down and reactor operation will not be resumed until authorized by the DOE.
2. An immediate report will be made to the Laboratory Executive Director and the Office of Operational Safety.
3. A verbal report will be made no later than the next work day to DOE.
4. A written report will be made which will include an analysis of the causes and the extent of possible resultant damage, effectiveness of corrective action, and recommendations for measures to prevent or reduce the probability of recurrence. This report will be sent to the Reactor Operations Review Committee and a similar report submitted to the DOE when authorization to resume operation of the reactor is sought.

8.17 ACTION TO BE TAKEN IN THE EVENT OF AN ABNORMAL OCCURRENCE

Limiting safety system settings are:

Temperature = 650°F (617 K) maximum,
Power = 20 kW maximum.

An abnormal occurrence is defined as any actual safety setting less conservative than specified above, operating in violation of a technical specification, incidents or conditions which prevented or could have prevented the performance of the intended safety function of an engineered safety feature or the reactor safety system, an uncontrolled or unanticipated release of radioactivity in excess of the concentration described in DOE 5480.0, Attachment XI-I, an uncontrolled or unanticipated change in reactivity, an observed inadequacy in the implementation of either administrative or procedural controls, such that the inadequacy has caused the existence or development of an unsafe condition in connection with the operation of the reactor, or an uncontrolled or unanticipated release of radioactivity. In the event of an abnormal occurrence, the following action will be taken:

1. The TSF-HPRR Operations Supervisor and other appropriate management personnel will be notified and corrective action will be taken prior to resumption of the operation involved.
2. A written report will be made that will include an analysis of the cause of the occurrence, efficacy of corrective action, and recommendations for measures to prevent or reduce the probability of recurrence in accordance with DOE Order 5000.3, "Unusual Occurrence Reporting System."
3. A written report will be submitted to DOE.

8.18 REPORT REQUIREMENTS

1. A report will be made no later than the next work day to the Contracting Office Technical Representative, Environmental Control Division, DOE Oak Ridge Operations of the following conditions:

    a. Any release of radioactivity to the environment above the permissible limits specified in DOE Order 5480.1A, Chapter XI.
    b. Any violation of a safety limit (see Section 8.16).
    c. Any exposures to personnel in controlled or uncontrolled areas that exceed the standards in DOE Order 5480.1A, Chapter XI.

2. A report will be made within three work days to DOE-ORO of any violation of the technical specifications.

8.19 REVIEW REQUIREMENTS

1. Health and Safety Research Committee to Review Experiments for the Pulse Reactor (HASRD-CREPR)

   Experiments that involve the HPRR will be performed only after they have been formally approved by HASRD-CREPR. CREPR actions are reported to the RORC.

2. Reactor Operations Review Committee (RORC)

   Experiments that involve the HPRR will be reviewed by the RORC, if they require. Modifications to the reactor safety system that have safety significance will be reviewed by the RORC in compliance with the requirements of DOE Order 5480.1A, Chapter VI.

3. Criticality Review Committee (CRC)

   Operations involving the handling, storage, transportation, and disposal of significant quantities of fissile material will be performed in accordance with procedures approved by the CRC.

8.20 LIMITATIONS ON WATER IN REACTOR BAY

The fire hose cutoff valve outside the building shall be kept locked in the closed position and will not be unlocked except by personnel authorized by the TSF-HPRR Reactor Operations Supervisor. An authorized personnel list is supplied to the Fire Department and the Laboratory Shift Supervisor and maintained at the fire alarm boxes in the Control Building (7710) and the Reactor Building (7709).

9. REACTOR SECURITY AND SAFEGUARDS

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9. REACTOR SECURITY AND SAFEGUARDS

9.1 INTRODUCTION

As noted in Chapter 1, the HPRR is part of the DOSAR complex which is located within a separate security area southeast of the Laboratory. The reactor, which is located in Building 7709, contains Category I quantities of Special Nuclear Materials (SNM). The SNM total in the other DOSAR buildings (7710 and 7712) is a Category III B quantity.

The following sections outline the physical and technical aspects of the security systems and procedures for preventing unauthorized access to the HPRR during operation and maintenance.

9.2 PHYSICAL SECURITY

The DOSAR facility is enclosed within a 6-ft-high chain-link, outer perimeter fence (3000-ft radius) topped in some areas by 1-ft-high barbed-wire outriggers. The reactor building is enclosed by a 7-ft-high chain-link, antipersonnel fence (1000-ft radius) equipped with 1-ft-high barbed-wire outriggers and by a security fence which is within 50 ft of the building. Two emergency rotogates and a remotely controlled gate are located in the security fence. In addition, there is a 10-ft-high chain-link fence 3 ft from the reactor building with three rolls of razor-ribbon concertina wire stacked between the fence and the building walls. Gates in this fence are locked when the building is secured.

The doors to the reactor building which are constructed of sheet metal and hardened are kept locked. The doors to the control building (7710) and to the control room are kept locked when the building is not occupied. The control room door which is also hardened is locked whenever the reactor storage pit door is open. Keys to the building and the control panel are documented, protected, and kept to a minimum.

9.3 TECHNICAL SECURITY

The reactor bay and the control room are monitored by infra red, ultrasonic, and microwave motion detectors, balanced magnetic door R switches, closed-circuit television, and are illuminated with floodlights. Auxiliary power is supplied automatically to the lights and circuits in case of the loss of TVA power.

J. H. Swanks/W. Hagle (signature)	R. V. McCord (signature)	Leo B. Holland (signature)
J. H. Swanks, Director Operations Division	R. V. McCord, Head Reactor Operations Section	L. B. Holland Reactor Supervisor

The reactor building security fence is alarmed with an electric cable system and balanced magnetic switches on the rotogates. Roads leading to the reactor building have vehicle detectors buried in the roadways. Concrete barricades are strategically located to prevent unauthorized vehicular access to that area.

The reactor is stored in a reinforced concrete pit with a steel door which is equipped with a balanced magnetic switch and sound detectors. Opening the reactor storage pit door requires the presence of a Security Inspector in the control room or the reactor bay, notification to Guard Headquarters that the door is to be opened, operation of a key switch to turn on control power, actuation of a cypher lock, withdrawing a spring-actuated switch with a solenoid after a time delay, operating a motor to withdraw a latch, and actuating a rotary solenoid while operating the pit door drive motor. R

The reactor is normally supported above its storage pit by a hydraulic lift for operation. In addition to the normal method of returning the reactor to its storage pit and closing the door, there are three push lock-in buttons (one in the reactor bay, one at Guard Post 23, and one in the control room), any of which may be actuated to shut down the reactor, lower the reactor into its storage pit, close the pit door, and raise the motor-driven latch. The door may be closed with TVA-supplied power or power from the auxiliary generator, or with an air motor with a monitored air supply. The motor-driven latch may be operated with TVA power or power from the auxiliary generator. R

If it becomes necessary to store the reactor in storage pit No. 2, special arrangements must be made with Security.

9.4 REACTOR ACCESS

The HPRR operators will use the following procedures for authorizing entry or egress from the DOSAR facility or the HPRR building during reactor operation or maintenance:

1. The reactor operator will notify personnel at Guard Headquarters before entering the control room or the reactor bay. For the first time each day, the operator will place designated security switches in their appropriate positions. If the reactor storage pit door is

J. H. Swanks, Director, Operations Division | R. V. McCord, Head, Reactor Operations Section | L. B. Holland, Reactor Supervisor

9. REACTOR SECURITY AND SAFEGUARDS

9.1 INTRODUCTION

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The doors to the reactor building which are constructed of sheet metal and hardened are kept locked. The doors to the control building (7710) and to the control room are kept locked when the building is not occupied. The control room door which is also hardened is locked whenever the reactor storage pit door is open. Keys to the building and the control panel are documented, protected, and kept to a minimum.

9.3 TECHNICAL SECURITY

The reactor bay and the control room are monitored by ultrasonic and microwave motion detectors, balanced magnetic door switches, and closed-circuit television and are illuminated with floodlights. Auxiliary power is supplied automatically to the lights and circuits in case of the loss of TVA power.

The reactor building security fence is alarmed with an electric cable system and balanced magnetic switches on the rotogates. Roads leading to the reactor building have vehicle detectors buried in the roadways. Concrete barricades are strategically located to prevent unauthorized vehicular access to that area.

The reactor is stored in a concrete vault with a steel cover which is equipped with a balanced magnetic switch and sound detectors. Opening the cover requires the use of a key, actuation of a cypher lock, withdrawing a spring actuated switch with a solenoid after a time delay, withdrawing a motor-driven latch, actuation of a rotary solenoid, and opening the pit door drive motor.

The reactor is normally supported above its storage pit by a hydraulic lift for operation. In addition to the normal method of returning the reactor to its storage pit and closing the door, there are three push buttons (one in the reactor bay, one at guard post 23, and one in the control room), any of which may be operated to shut down the reactor, lower the reactor into its storage pit, close the pit door, and raise the motor-driven latch. The door may be closed with TVA-supplied power or power from the auxiliary generator, or with an air motor with a monitored air supply. The motor-driven latch may be operated with TVA power or power from the auxiliary generator.

If it becomes necessary to store the reactor in storage pit No. 2, special arrangements must be made with Security.

9.4 REACTOR ACCESS

The HPRR operators will use the following procedures for authorizing entry or egress from the DOSAR facility or the HPRR building during reactor operation or maintenance:

1. The reactor operator will notify personnel at Guard Headquarters upon access to the control room, the reactor bay, or the reactor storage pit or initiation of the time delay. The operator will place designated security switches in their appropriate positions when they respond.
2. Personnel on a preauthorized list will notify the Security Inspector at Post No. 23 to permit personnel they designate to enter or to egress the reactor area. The Security Inspector will open and close the remotely controlled gate in the security fence at the reactor building when designated personnel approach or depart that gate.

3. The operator will keep the control room door closed and locked whenever the reactor is out of the storage pit or the pit door is open.
4. The operator will notify Guard Headquarters before the reactor is to be removed from the storage vault specifying whether it is for operation or maintenance, so that Headquarters may dispatch the necessary personnel to DOSAR. The Security Inspector at Post 23 will inform the operator when the Security personnel are deployed, at which time the operator may pick up and/or position the reactor.

5. The operator will notify the Security Inspector at Post No. 23 when the reactor is to be removed from the storage vault so that the Security Inspector may take appropriate action.
6. During times when the reactor is considered vulnerable and/or is being operated, providing the radiation levels and transit times permit access without personnel exposures exceeding permissible limits, the operator may authorize the Security Inspectors at Post No. 23 to permit specific individual(s) to enter at the time the authorization is made. If the reactor is operating at high power (greater than 100 W), the operator will inform the Security Inspector when the authorized individuals have entered the control building. If an individual who has been admitted does not report to the control room in 5 min, the operator will take whatever steps are necessary to locate the individual.
7. Under the same conditions as in Step 6, the operator may permit individual(s) to leave the control building after informing the Security Inspector at Post No. 23 that the individual(s) is leaving the area. If the Security Inspector does not report back in 5 min, the operator will take whatever steps are necessary to locate the individual.

9.5 SECURITY MAINTENANCE

All changes will be documented in accordance with procedures outlined in Section 1.6.5. Whenever change impact security systems or procedures, the concurrence of the Director of the Laboratory Protection Division will be required.

When it is necessary to perform maintenance on or make changes in any security equipment in the reactor building or in the reactor control room which is in any way connected to the reactor control system, reactor control system components, or connecting leads, a senior operator or the reactor control engineer will oversee the installation.

10. EMERGENCY PROCEDURES

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10. EMERGENCY PROCEDURES

Emergencies involving the reactor are considered to fall into the categories of nonnuclear accidents, accidents resulting in potential radiation or criticality hazards, and nuclear accidents. However, since all situations that might create one of these emergencies cannot, obviously, be predicted, specific procedures cannot be included here. Therefore, the procedures given in Sections 10.1 through 10.3 for the most part specify the persons to be notified, the steps to be taken to protect personnel, and the things that can be done to prevent the situation from becoming more serious. Additional precautions that might be called for in a particular situation must result from the operator's knowledge and judgment.

In all emergencies, the DOSAR Facility Supervisor will have the responsibility for supervising all activities that are necessary in connection with the emergency. In these emergency procedures "DOSAR Facility supervisor" means the actual supervisor or someone designated to act for the supervisor for the day. If no such person has been designated, the operations supervisor will assume these responsibilities. In any case, the operations supervisor has the authority and responsibility to take whatever immediate action may be necessary to minimize or eliminate any criticality hazards and to safeguard personnel in accordance with established Laboratory procedures.

10.1 NONNUCLEAR ACCIDENT DURING REACTOR OPERATION

10.1.1 Control Building

If an emergency other than a fire in the control room occurs anywhere in the control building or surrounding area while the reactor is being operated, the following procedure will be executed:

1. The operator will:

   a. shut down the reactor immediately (see "Emergency Manual Scram," Section 4.1.4);
   b. notify the DOSAR Facility supervisor; and
   c. notify the Supervisor of Reactor Operation TSF-HPRR as soon as it is practical to do so.

2. Depending on the nature of the emergency, the DOSAR Facility supervisor will notify the area guard that the reactor has been shut down,

inform the guard of the personnel who will be required to enter the area as a result of the emergency, and will notify the Laboratory shift supervisor and Guard Headquarters.

If the emergency is caused by a fire in the control room while the reactor is being operated, the following action will be taken:

1. The operator will:

   a. shut down the reactor immediately (by emergency manual scram, Section 4.1.4);
   b. use the fire alarm box in the building to notify the Fire Department;
   c. notify the DOSAR Facility Supervisor;
   d. use the fire hose and CO_2 fire extinguisher located in the hallway immediately outside the control room, provided that the fire is small and of a type to be extinguished by such equipment; and
   e. notify the Supervisor of Reactor Operation TSF-HPRR as soon as it is practical to do so.

2. Depending on the nature of the emergency, the DOSAR Facility Supervisor will alert local personnel, notify the area guard that the reactor has been shut down, inform the guard of the personnel who will be required to enter the area as a result of the emergency, and notify the Laboratory Shift Supervisor and Guard Headquarters.

10.1.2 Reactor Building

If a nonnuclear emergency other than a fire occurs in the reactor building while an experiment is in progress, the following procedure will apply:

1. The operator will:

   a. shut down the reactor immediately (by emergency manual scram, Section 4.1.4);
   b. notify the DOSAR Facility Supervisor;
   c. notify the Supervisor of Reactor Operation TSF-HPRR as soon as it is practical to do so; and

d. survey the situation as much as possible with the television cameras to determine whether immediate action should be taken, such as raising the reactor above floor level, and to determine the degree of danger involved in entering the building.

2. Depending on the nature of the emergency, the DOSAR Facility supervisor will alert local personnel, notify the area guard that the reactor has been shut down, inform the guard of the personnel who will be required to enter the area as a result of the emergency, and notify the Laboratory Shift Supervisor and Guard Headquarters.

If the emergency results from a fire, which is the type of non-nuclear emergency most likely to occur in the reactor building, the following procedure will be put into effect:

1. The operator will:

   a. immediately shut down the reactor (by emergency manual scram, Section 4.1.4) and lower it into the pit;
   b. notify the Fire Department by the fire alarm box in the control building;
   c. perform Steps b through d given above for a non-nuclear emergency which is not a fire;
   d. if the fire requires a liquid extinguisher, have someone monitor the pit liquid level alarms; and
   e. if the fire is on the reactor structure itself or in the vicinity of the core and is not out of control, use the CO_2 fire extinguisher but do NOT use a liquid extinguisher. Do not, under any circumstance, direct the extinguisher nozzle toward the reactor core.

2. Depending on the nature of the emergency, the DOSAR Facility supervisor will alert local personnel, notify the area guard that the reactor has been shut down, inform the guard of the personnel who will be required to enter the area as a result of the emergency, and notify the Laboratory Shift Supervisor and Guard Headquarters.

10.2 ACCIDENTS INVOLVING POTENTIAL RADIATION OR CRITICALITY HAZARDS

Whereas Section 10.1 deals with emergencies involving the reactor that are definitely nonnuclear in nature and Section 10.3 deals with emergencies that are clearly nuclear ones, this section treats the "gray" areas in which an emergency might arise that would result in a nuclear accident unless proper preventive steps are taken. Although it is not possible to forsee all potential radiation or criticality hazards, procedures for some of the more obvious ones are given below. In each case, the DOSAR Facility Supervisor and Supervisor of Reactor Operation TSF-HPRR should be notified of an existing emergency if the situation is not immediately correctable.

10.2.1 Reactivity Increased by Reactor Falling Over on Floor

In handling the reactor with the positioning device, there is always the possibililty that the reactor will fall over on the floor. If this were to happen to the core without the safety block inserted in it, criticality would not occur unless the core fell near reflecting material that increased its reactivity by more than 20 dollars. However, whenever the reactor is being used in conjunction with any appreciable reflector and the reactor is dropped on the floor, the inherent criticality hazard is correspondingly increased, and the following procedure should be initiated immediately:

1. Any personnel in the reactor building should be evacuated to a safe distance.
2. The situation should be surveyed by television to determine the steps that can be taken to put the reactor upright without increasing the reactivity.
3. The reactor should be approached only if the radiation alarms have not sounded and only while appropriate radiation survey instruments are being used.
4. The situation should be resurveyed locally to ensure that the process of setting the reactor upright would not increase the reactivity; that is, any potential reflecting material should be moved away from the reactor.
5. The reactor should be lifted to an upright position by the most effective means, either the building crane or the auxiliary mobile cranes.

10.2.2 Accumulation of Reflector in Reactor Pit

Although improbable, it is conceivable that water or some other liquid reflector could accumulate in a pit in which the reactor is stored. (An accumulation to a level of 6 in. will be annunciated as described in Section 3.1.) If this happens, the reactor must be considered as near-critical, if not critical, since the amount of reactivity added will not be known. In this event, the following procedure should be followed:

1. All personnel should be evacuated immediately from the reactor building.
2. The reactor should be raised well above the liquid level.
3. The situation should be examined as much as possible with television.
4. The cause of the stopped drain should be determined as soon as possible.

10.2.3 Addition of Reactivity to Nonoperating Reactor by Movement of Experimental Apparatus

If the reactor and experimental apparatus have been positioned for an experiment and the apparatus or other equipment shifts toward the reactor so that it adds a significant but unknown amount of reactivity, the following procedure is applicable:

1. All personnel should be evacuated from the reactor building.
2. The situation should be surveyed as much as possible with the television cameras.
3. It may be possible to reduce the reactiviy of the reactor by moving the reactor.

10.2.4 Jamming of Safety Block

The safety block was designed to have sufficient clearance to prevent jamming under normal conditions; however, it is conceivable that a foreign object could cause the safety block to jam within the core. The condition would be recognized by failure of the "safety block seated" light to come on after a scram was initiated and by a slower than normal decrease of the power level. It would also be recognized by the failure of the safety block drive to drive the magnet to its lower limit. If the safety block becomes jammed, the following procedure applies:

1. The mass adjustment rod and the regulating rod should be withdrawn to their limits.

2. The safety block drive should be run down until it jams against the magnet keeper. This will indicate how far the safety block has moved out of the core.
3. The pulse rod should be withdrawn and latched out.
4. The situation should be appraised as much as possible by use of the television cameras.
5. If it seems advisable, the reactor should be moved away from any reflectors.
6. The DOSAR Facility Supervisor should be notified of the situation and advised of the restrictions that should be placed on personnel entering the 1000-ft exclusion area.
7. The Supervisor of Reactor Operation TSF-HPRR should be notified of the situation, and the entire operations staff should devise procedures for investigating and correcting the difficulty.

10.3 NUCLEAR ACCIDENT

The incorporation of molybdenum as an alloy in the HPRR fuel permits operation at a higher temperature than is possible in pulse-type reactors utilizing unalloyed uranium metal. However, it must be realized that, in light of the uncontrolled nuclear excursions and resultant damage reported[7] for unalloyed-core reactors, there is a strong probability that the HPRR could suffer an incident that would damage its core, even though it can survive excursions that would damage an unalloyed core.[8] The HPRR operating crew will, of course, be constantly alert to the possibility of subtle changes which could cause such an incident, but should one occur, the procedures outlined below indicate the action to be taken.

10.3.1 Preliminary Emergency Procedure

1. The operator will:

   a. shut down the reactor by the emergency manual scram procedure (Section 4.1.4), if it has failed to scram automatically;
   b. make a preliminary appraisal of the situation by observing the temperature records and power level records and by surveying with the closed-circuit television;
   c. notify the DOSAR Facility Supervisor of the emergency and convey all pertinent information; and

d. notify the Supervisor of Reactor Operation TSF-HPRR as soon as it is practical to do so.

2. The DOSAR Facility Supervisor will:

   a. alert local personnel,
   b. notify the facility applied health physicist,
   c. notify the area guard that an emergency exists, inform the guard of any restrictions on personnel leaving or entering the area, and
   d. notify the Laboratory Shift Supervisor and Guard Headquarters.

3. The DOSAR Facility supervisor and applied health physicist will, with the aid of the reactor operations staff, determine the extent of damage and the degree of contamination.

Then, depending on whether the radiation or contamination hazards are considered to be confined to inside the reactor building (local emergency) or to extend beyond it (Laboratory-wide emergency), the delineation of responsibility will be as outlined below in Section 10.3.2 or 10.3.3.

10.3.2 Local Emergency

1. The DOSAR Facility applied health physicist and the reactor operator will proceed to the reactor building to survey and evaluate the situation.
2. The DOSAR Facility Supervisor, aided by the health physicist and reactor operator, will devise and supervise cleanup procedures.

10.3.3 Laboratory-Wide Emergency

1. The DOSAR Facility applied health physicist will notify the chief of the ORNL Applied Health Physics Section.
2. The health physicist will determine the radiation and contamination hazards outside the control building and on the facility access road.
3. The DOSAR Facility Supervisor will determine whether the facility personnel should be evacuated or confined to the shielded counting room.
4. The health physicist and the operations supervisor will change to protective clothing and proceed to the reactor building with suit-

able portable radiation survey instruments to evaluate the existing radiation, contamination, and criticality hazards.

5. The Facility Supervisor will formulate and supervise cleanup procedures and site survey plans, with the ORNL emergency groups functioning as required.

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09-09-86	1.1	INTRODUCTION (N)	
	9.	REACTOR SECURITY & SAFEGUARDS TABLE OF CONTENTS (R)	
	9.3	TECHNICAL SECURITY (R)	
	9.4	REACTOR ACCESS (R) (N)	

Revised: September 1986

1. INTRODUCTION: ORGANIZATION, TRAINING, AND RECORDS

1.1 INTRODUCTION

This manual is intended to serve as a guide in the operation and maintenance of the Health Physics Research Reactor (HPRR) of the Health Physics Dosimetry Applications Research (DOSAR) Facility. It includes descriptions of the HPRR and of associated equipment such as the reactor positioning devices and the derrick. Procedures for routine operation of the HPRR are given in detail, and checklists for the various steps are provided where applicable. Emergency procedures are similarly covered, and maintenance schedules are outlined. Also, a bibliography of references giving more detailed information on the DOSAR Facility is included.

Changes to this manual will be approved by at least two of the following senior staff members: (a) the Operations Division Director, (2) the Reactor Operations Department Head, (c) the Supervisor of Reactor Operations TSF-HPRR Areas. The master copy and the copy of the manual issued to the HPRR Operations Supervisor will always reflect the latest revisions (see Section 9.5 for additional security requirements for N
Security Procedures).

1.2 THE DOSAR FACILITY

The DOSAR Facility is located in an area approximately two miles southeast of the Laboratory and includes a reactor building which houses the HPRR, a building which is used for calibrations, and a reactor control building. The control building houses the reactor controls, administrative offices, experimental laboratories, and an experiment assembly preparation area used to assemble the object(s) to be irradiated in the reactor building. The relative locations of the buildings are shown in Fig. 1.1. The distance between the reactor and the control building is approximately 800 ft (240 m).

1.2.1 Reactor Building

The working area of the reactor building is approximately 72 ft long and 32 ft wide. An overhead bridge crane of five-ton capacity spans the width of the building and travels the full length. A 12-ft-wide, 15-ft-high double door at one end of the building opens to an outside concrete pad, which is 30 ft wide and 70 ft long. At the other end of the building, a 6-ft-wide, 8-ft-high double door opens onto a truck unloading dock. A lean-to with no inside entrance to the reactor

J. H. Swanks, Director Operations Division	R. V. McCord, Head Reactor Operations Section	L. B. Holland Reactor Supervisor

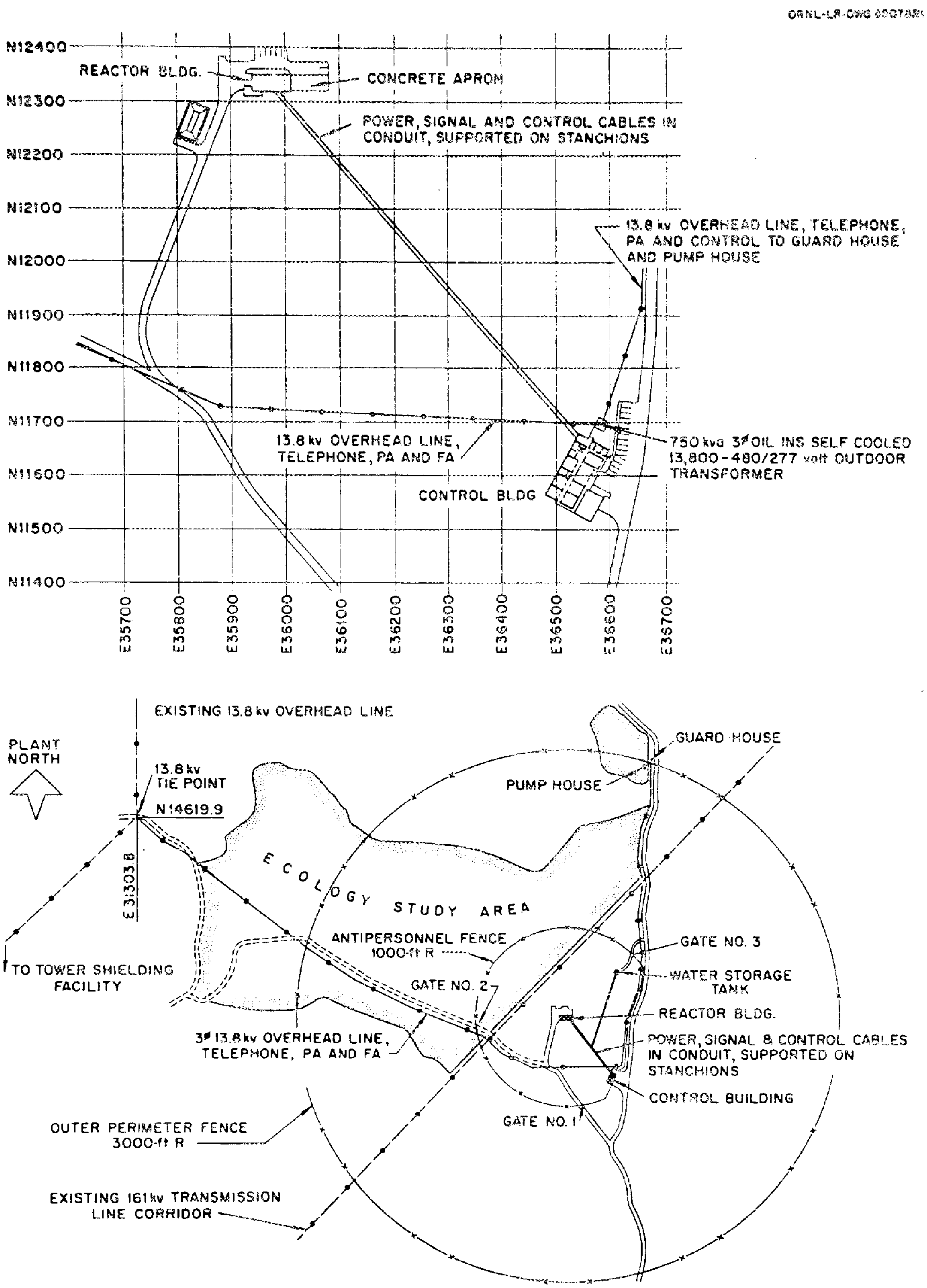

Fig. 1.1. Plot plan of DOSAR Facility, showing locations of reactor and control buildings.

9. REACTOR SECURITY AND SAFEGUARDS

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to be opened, additional Security Inspectors will be dispatched to their designated positions, depending upon the nature of the operation and/or maintenance. The Security Inspector in the control room will inform the operator when the necessary inspections are deployed at which time the operator may start the time delay. N

2. Personnel on a preauthorized list will notify the Security Inspector at Post 23 to permit personnel they designate to enter or to egress the reactor area. The Security Inspector will open and close the remotely controlled gate in the security fence at the reactor building when designated personnel approach or depart that gate.
3. The operator will keep the control room door closed and locked whenever the reactor is out of the storage pit or the pit door is open.
4. When the time delay is over, the operator may open the pit door. R
5. The operator will notify personnel at Guard Headquaters when the reactor is to be removed from the storage pit. The Security Inspector in the control room will then actuate a switch which permits the operator to raise the reactor out of its storage pit. R
6. During times when the reactor is considered vulnerable and/or is being operated, providing the radiation levels and transit times permit access without personnel exposures exceeding permissible limits, the operator may authorize the Security Inspectors at Post 23 to permit specific individual(s) to enter at the time the authorization is made. If the reactor is operating at high power (greater than 100 W), the operator will inform the Security Inspector when the authorized individuals have entered the control building. If an individual who has been admitted during high-power mode of operation does not report to the control room in 5 min, the operator will take whatever steps are necessary to locate the individual. R
7. Under the same conditions as in Step 6, the operator may permit individual(s) to leave the control building after informing the Security Inspector at Post 23 that the individual(s) is leaving the area. If the Security Inspector does not report back in 5 min, the operator will take whatever steps are necessary to locate the individual.
8. The reactor operator will notify personnel at Guard Headquarters and secure the reactor bay and the control room at the end of the day's operation. N

J H Swanks / [signature]   R V McCord   Leo B Holland

J. H. Swanks, Director Operations Division	R. V. McCord, Head Reactor Operations Section	L. B. Holland Reactor Supervisor

9.5 SECURITY MAINTENANCE

All changes will be documented in accordance with procedures outlined in Section 1.6.5. Whenever a change impacts security systems or procedures, the concurrence of the Director of the Laboratory Protection Division will be required.

When it is necessary to perform maintenance on or make changes in any security equipment in the reactor building or in the reactor control room which is in any way connected to the reactor control system, reactor control system components, or connecting leads, a senior operator or the reactor control engineer will oversee the installation.

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