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MASTER

Technical Specifications
Health Physics Research Reactor

OAK RIDGE NATIONAL LABORATORY

OPERATED BY UNION CARBIDE CORPORATION · FOR THE DEPARTMENT OF ENERGY

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Operations Division

TECHNICAL SPECIFICATIONS
HEALTH PHYSICS RESEARCH REACTOR

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and

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Oak Ridge, Tennessee 37830
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for the
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PREFACE

These technical specifications define the key limitations that must be observed for safe operation of the Health Physics Research Reactor (HPRR) and an envelope of operation within which there is assurance that these limits will not be exceeded. These specifications were written to satisfy the requirements of the Department of Energy (DOE) Manual Chapter 0540, September 1, 1972, and they cannot be changed without the concurrence of the Reactor Operations Review Committee (RORC) of the Oak Ridge National Laboratory (ORNL) and the approval of the Oak Ridge Operations Office of DOE.

It is generally accepted that electromechanical safety systems having sufficiently fast speed of response to protect pulse reactors against pulses capable of damaging the reactor are impractical and that safety is achieved through administrative control. L. C. Oakes noted this and concluded that the probability for accidents in pulse reactors is somewhat higher than for accidents in conventional (water cooled) reactors.[1] Projected accidents do not represent a danger to personnel and accidental excursions have not approached the projected limits. In the Health Physics Research Reactor Hazards Summary[2] the Maximum Credible Accident (MCA)* postulated for the HPRR is a pulse of 10^{19} fissions. The maximum accidental excursion achieved for a similar bare assembly in air has been 6.1×10^{17} fissions.[3] A pulse of 10^{19} fissions would destroy the reactor core but would not represent a danger to operating personnel or to persons outside the outer perimeter fence. A pulse of 10^{19} fissions would require a reactivity addition of 50 cents in excess of that required to achieve a prompt critical condition. Such an accidental reactivity addition would be difficult to achieve but it is statistically possible. The prevention of such a condition remains primarily one of administrative control.

The various specifications given are intended to ensure that operations are conducted in a manner to assure that such prevention remains effective.

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*Presently referred to as Design Basis Accident (DBA).

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

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TECHNICAL SPECIFICATIONS FOR THE HEALTH PHYSICS RESEARCH REACTOR

GLOSSARY OF TERMS

The following frequently used terms are defined to aid in the uniform interpretation of these specifications.

1. Abnormal Occurrence -

   a. Operating in violation of a limiting condition for operation.
   b. A release of radioactive material of a magnitude sufficient to indicate a change in integrity of the core.
   c. An uncontrolled or unanticipated change in reactivity.
   d. An observed inadequacy in the implementation of either administrative or procedural controls such that the inadequacy could have caused the existence or development of an unsafe condition in connection with the operation of the reactor.
   e. A pulse yield in excess of 1.4×10^{17} fissions.
   f. Any actual safety system setting less conservative than specified in Sect. 2.2, Limiting Safety System Settings.
   g. 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.

2. Certified Operator (RO or SRO) - Any individual who has successfully completed the training, examination, and certification for reactor operator (RO) or senior reactor operator (SRO) pursuant to DOE Manual Chapter 0540 and pursuant to IAD 8401-6.

3. Channel - A system of components to perform a specific function with respect to measurement or control of system parameters.

4. Channel Calibration - An adjustment of the channel such that its output responds, within acceptable range and accuracy, to known values of the parameter which the channel measures or to known input signals when access to the primary element is limited.

5. Channel Check - A qualitative verification of acceptable performance by observation of channel behavior. This verification shall include comparison of the channel with expected values or other independent channels or methods of measuring the same variable.

6. Channel Test - The introduction of an input signal into the channel to verify that it is operable.

7. Control Element - A device integral to the reactor that has the designed purpose of changing the reactivity in the reactor by perturbing the neutron population.

8. Critical - Capable of sustaining a nuclear chain reaction. An assembly of fissile material is critical when it has an effective neutron multiplication factor equal to unity, i.e., the neutron population in the assembly in any one generation is statistically equal to that in the immediately preceding generation, provided all the neutrons in the assembly result from fissions in the assembly.

   a. Delayed Critical - Identical with critical. The term is used to emphasize that delayed neutrons are necessary to achieve the critical state.

   b. Prompt Critical - Condition when only prompt neutrons contribute to a nuclear chain reaction.

9. Degradation of the Reactor Shutdown System -

   Class 1. The actual failure of the reactor shutdown system to initiate the protective action when the reactor variable has exceeded the limiting safety system settings or the premature termination of the protective action.

   Class 2. Failure or malfunction of components, personnel error, or procedural inadequacy which, due to its effect on multiple units would, by itself, prevent the reactor shutdown system from providing the protective action at the limiting safety system settings.

   Class 3. Failure or malfunction of one or more components, personnel error, or procedural inadequacy which reduces the capability of the reactor shutdown system to the extent that the occurrence of a random single failure would prevent the protective action at the limiting safety system settings.

Class 4. Failure or malfunction of one or more components, personnel error, or procedural inadequacy affecting a limited number of units such that, although the degree of redundancy may be reduced, the reactor shutdown system retains, even after the application of the single failure criterion, the ability to provide the protective action required (conditions and limiting safety system settings) by the technical specifications.

10. Experiment -

a. Any apparatus, device, or material placed near the reactor.
b. Any operation designed to measure reactor characteristics.

11. Limiting Conditions for Operation - Those administratively established constraints required for safe operation of the facility.

12. Limiting Safety System Settings - Settings on instruments which initiate automatic protective action at a level such that a safety limit will not be exceeded.

13. Measuring Channel - That combination of sensor, lines, amplifiers, and output devices which are connected for the purpose of measuring the value of a reactor variable.

14. Neutron Decay Interval - The time interval in the pulse preparation sequence during which a fixed amount of reactivity is removed from the core to allow the neutron population in the core to decay.

15. Operable - Capable of performing its intended function normally.

16. Operating - Performing its intended function in the normal manner.

17. Operating Modes -

a. Steady State - Operation of the reactor at an essentially constant power level over long periods of time.

b. Low Power - Operation of the reactor at a nominal power of 100 watts or less in pulse preparation or steady-state mode.

c. Pulse Operation Preparation - Low power operation used to establish proper reactivity in the reactor prior to pulse operation.

d. Pulsing - Inserting reactivity in excess of $1.00 into a core near delayed critical to initiate a prompt critical excursion.

18. Personnel Radiation Protection System - A system of barriers with interlocks at access points which tie into the reactor safety system and effect a reactor shutdown if violated (see Sect. 3.11).

19. Pulse - The generation of the order of 10^{16} or more fissions within a time interval of 1000 microseconds or less.

20. Reactor Secured - That overall condition where all of the following conditions are satisfied:

a. Reactor is shut down.

b. Electrical power to the control element drive or actuating circuits and the reactor positioning device is switched off and the switch keys are in proper custody.

c. No work is in progress involving control element drives or fuel handling.

21. Reactor Safety System - That combination of measuring channels, associated circuitry, actuators, and reactivity controlling elements which forms the automatic protective system of the reactor or provides information that requires manual protection to be initiated.

22. Reactor Shutdown - That subcritical condition of the reactor where the negative reactivity is equal to or greater than the shutdown margin.

23. Safety Limit - Limit on core temperature necessary to prevent fuel melting and the release of radioactivity.

24. Shutdown Margin - The amount of reactivity required to attain criticality from a given subcritical condition.

25. Surveillance - Monitoring, checking, testing, calibrating, or inspecting systems or components related to verifying that operations are consistent with the technical specifications.

26. Target Yield - The number of fissions expected to occur in a particular pulse operation.

27. Time Intervals - In reference to surveillance or tests.

   a. Annually - To be performed once each year at intervals not to exceed 14 months.

   b. Semiannually - To be performed twice each year at intervals not to exceed 8 months.

   c. Quarterly - To be performed four times each year at intervals not to exceed 5 months.

   d. Weekly - To be performed once each week at intervals not to exceed 10 days.

28. Tried Experiment - An experiment previously performed with this reactor or an experiment that duplicates conservatively one of similar size, shape, composition, and location previously performed with this reactor.

1.0 GENERAL

1.1 The Dosimetry Applications Research Facility

The Health Physics Dosimetry Applications Research (DOSAR) Facility, an integral part of the Oak Ridge National Laboratory (ORNL), was constructed for the performance of health physics and biomedical experiments. It is located within a controlled-access area approximately two miles southeast of the main laboratory complex and consists of a reactor building which houses the Health Physics Research Reactor (HPRR), a control building, and an auxiliary building. The control building houses the reactor controls, administrative offices, experimental laboratories, and an experimental assembly preparation area used to assemble the object(s) to be irradiated. The reactor is located behind a hill 800 ft from the other buildings. Adequate personnel- and visitor-control policies have been established so that only necessary operating personnel and persons having legitimate business are permitted within the controlled access area around the DOSAR.

1.2 The Health Physics Research Reactor

The Health Physics Research Reactor (HPRR) became operational at the Oak Ridge National Laboratory on May 31, 1963. A small, unshielded and uncooled fast pulse reactor, the HPRR was designed as a versatile tool for research in health physics and related fields. The core is a right-circular cylinder (8 in. diameter and 9 in. high) of enriched uranium (93.14% ^{235}U) alloyed with 10 wt % molybdenum.

Steady-state power levels range from less than 0.1 W to 10 kW, and the yields in pulse mode range from 10^{16} to 10^{17} fissions per pulse. For a pulse of 10^{17} fissions, the pulse width at half-maximum pulse height is about 50 microseconds. It is with respect to operating the HPRR in the above modes that the technical specifications contained in this document are presented. ORNL-3248, August 24, 1962, Health Physics Research Reactor Hazards Summary[4] served as a basis for the generation of these specifications.

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limits

Applicability:

This specification applies to the maximum temperature of the fuel alloy attained during either pulse or steady-state mode of operation and the time at temperature for steady-state operation.

Objective:

The objective is to prevent melting of fuel alloy and phase change of the alloy core.

Specifications:

a. The maximum fuel temperature shall not exceed 1830°F.

b. The core temperature shall not be maintained above a temperature of 700°F for periods in excess of 4 hours.

Bases:

The maximum temperature achieved with the HPRR was 790°F (rise of 720°F) which occurred during preoperational testing at the ORNL Critical Experiments Facility[5] during a pulse with a yield of 1.8 X 10^{17} fissions. To heat the HPRR fuel to the 2100°F melting temperature would require a pulse of 5.2 X 10^{17} fissions.[6] During initial preoperational testing in a similar reactor, the Army Pulse Radiation Facility (APRF) Reactor, the maximum core temperature reached 1616°F with no release of fission products in a pulse of 3.68 X 10^{17} fissions.[7] In later testing at the APRF the maximum core temperature exceeded the 2100°F melting temperature for uranium-molybdenum (10 wt% Mo) and it did not result in any detectable external or airborne radiation hazard.[8] These results demonstrate that pulse operation with maximum temperature of 1830°F for the HPRR would result in no undue release of radioactivity or risk to personnel.

The time at temperature limitation is based on the requirement that no phase change of the gamma stabilized U-Mo alloy fuel material occur. The minimum time for initial phase transformation[9] is approximately 25 hours at temperatures in the neighborhood of 880°F. At lower temperatures the time for initial phase transformation increases, becoming 2000 hours at 600°F and essentially infinite at temperatures below 570°F.

2.2 Limiting Safety System Settings

Applicability:

This specification applies to the set points for the safety channels monitoring the reactor temperature and power generation.

Objective:

The objective is to establish the level of the reactor variables at which the automatic protection action is initiated in order to preclude extended operation with the core temperature in excess of that where phase change of the U-Mo fuel initiates.

Specification:

The limiting safety system settings shall be as follows:

Temperature = 650°F,
Power = 20 kW maximum.

Bases:

Pulse Operation - In pulse operation the reactor is put on a super prompt critical excursion by inserting reactivity in excess of $1.00 into a core configuration that is near delayed critical. The temperature coefficient of reactivity is such that it terminates the prompt critical excursion in microseconds and the neutron generation rate decays until the reactor is operating at delayed critical at a power level consistent with the reactor temperature. In these excursions, the HPRR achieves power levels of the order of 50,000 MW without damage to the core. The reactor achieves its maximum power in a large pulse in a time span too short for the power level safety system to act. In this mode the purpose of the safety system is to terminate the delayed critical operation and then to keep the reactor shut down. The total fissions, the peak power, and the peak temperature are functions of the total reactivity in the core at the time of the pulse. In pulse operation the prevention of damage or of exceeding the safety limit can only be accomplished through administrative controls as discussed in subsequent sections (see Sections 3.1, 3.2, 3.3, 3.5, 3.6, and 3.12).

Steady-State Operation - The function of the power level safety system during steady-state operation is to ensure that the power level remains in a range where the sensitivity of the temperature scrams is effective in preventing the reactor core from reaching temperatures where phase change will occur. A power level scram of 20 kW is sufficient to ensure this.

Since the limiting safety system temperature scram is 650°F the time at temperature above 650°F for steady-state operation is essentially zero.

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3.0 LIMITING CONDITIONS FOR OPERATION

3.1 Reactivity

Applicability:

This specification applies to the reactivity of the reactor and the reactivity worth of control elements and experiments.

Objective:

The objective is to ensure that the reactor can be shut down at all times and that the safety limits will not be exceeded.

Specification:

The following reactivity conditions are required for reactor operation:

1. The maximum reactivity worths of the mass adjustment rod and the regulating rod shall be limited to \$2.00 and \$1.00 respectively.

2. The shutdown margin shall be at least \$10.00.

3. The reactor shall be at least \$0.25 subcritical with the safety block inserted and the mass adjustment and regulating rods withdrawn.

4. The maximum rate of reactivity addition in the steady-state mode of operation shall be \$0.085/sec.

5. The static reactivity worth of the pulse rod (reactivity worth determined in steady-state operation) shall be limited to \$1.20.

Bases:

The reactivity worth of the control rods was designed to accommodate a variety of experiments with the reactor operated in either the pulse or steady-state mode. The reactivity worth of the safety block, the primary shutdown element, was designed to be sufficient to ensure rapid shutdown with minimal movement. The required shutdown margin of \$10.00 is more than the combined worth of the mass adjustment rod, the regulating rod and the pulse rod plus the reactivity worth of the reactor storage pit. The reactivity worth of the safety block which contains 10 kg of ^{235}Uranium is approximately \$20.00.[10] The reactivity worth of the storage pit is \$1.[illegible]3.[11]

The reactor at delayed critical is designed to experience the rapid (msec) insertion of sufficient reactivity (>\$1.00) in the absence of a source of neutrons to produce a pulse in excess of 10^{17} fissions without damage to the reactor. The resulting prompt critical excursion or pulse is quenched or turned over by the temperature rise of the core material in microseconds. The limitation to prohibit the attainment of delayed criticality with the insertion of the safety block is, therefore, merely to ensure orderly operation. The limitation on the rate of reactivity insertion during steady-state operation is to ensure that in the event of misoperation the safety system will be able to effect a reactor shutdown in the conventional manner in milliseconds.

Each pulse requires a pulse preparation in which the reactivity in the core is set to give a target yield no more than 1.0×10^{17} fissions (see Sect. 3.2). The static reactivity worth of the pulse will be limited to \$1.20. The dynamic reactivity worth of the pulse rod (reactivity worth of the pulse rod that is effective in initiating prompt critical nuclear chain reaction in a pulse operation) is always somewhat less than that observed in a static determination of the reactivity worth of the pulse rod. Typically, when the HPRR pulse rod stroke is adjusted to have a static reactivity worth of \$1.15, the dynamic worth of the pulse rod is approximately \$1.08. The insertion of a pulse rod with a dynamic worth of \$1.20 into a delayed critical core with no reflecting material or source present would produce a pulse yield of less than 3.0×10^{17} fissions and a peak temperature rise of less than 1170°F. The resulting core temperature would be approximately 1240°F which is 590°F below the safety limit.

3.2 Pulse Yield

Applicability:

This specification applies to the maximum target fission yield.

Objective:

The objective is to ensure that the temperature of the core will not reach levels where phase transformation of the U-Mo fuel is significant.

Specification:

The maximum target pulse shall be 1.0×10^{17} fissions.

Bases:

A yield of 1.0×10^{17} fissions produce a maximum temperature of approximately 590^{o}F. This temperature is below the 650^{o}F that was selected as a temperature scram setting to minimize phase transformation (see Section 2.2 - Bases: Steady-State Operation).

3.3 Pulse Rod Reactivity Peaking

Applicability:

This specification applies to the reactivity worth of the pulse rod as a function of its position during its insertion into the core.

Objective:

The objective is to ensure that no more than the expected reactivity is added to the reactor with the pulse rod when it is inserted into the reactor to produce a pulse. (See Sects. 3.1 and 3.4.)

Specification:

The reactivity difference between the pulse rod at its position of maximum reactivity and at its fully inserted position shall be no more than 0.2¢.

Bases:

The optimum situation is that the reactivity worth of the pulse rod is at its maximum value when the rod is fully inserted. If the pulse rod worth goes through a maximum before it reaches the fully inserted position, a pulse may initiate at this position producing a larger than expected yield. The requirement, that the reactivity worth of the pulse rod at the inserted position be no more than 0.2 cents below its maximum worth, limits the error in pulse size due to pulse rod peaking to less than 10%.

3.4 Operation of Reactor Positioning Device

Applicability:

This specification applies to operation of the reactor positioning device during reactor operation.

Objective:

The objective is to prevent the possible inadvertent addition of reactivity due to movement of the reactor.

Specification:

The reactor positioning device shall not be operated during reactor operation.

Bases:

Movement of the reactor while it is being operated can change the reactivity in the core. During steady-state operation a change in reactivity would probably invalidate the experiment. During pulse operation an increase in reactivity after the neutron decay interval has been started would result in a larger than expected pulse and possibly damage the core. Interlocks will initiate a reactor shutdown when the controls for the reactor positioning device are operated.

3.5 Limitations on Experiments

Applicability:

This specification applies to experiments utilizing the reactor as a source of radiation.

Objective:

The objective is to prevent damage to the reactor or excessive release of radioactive materials in the event of an experiment failure.

Specifications:

The reactor shall not be operated except under the following conditions governing experiments:

1. The reactivity worth of the experiment shall be limited to values that can be achieved within the core reactivity limits specified in Section 3.1.
2. Explosive materials may be irradiated subject to the following conditions:
   a. The explosive material to be irradiated shall be a "bench safe" device or a fully contained (explosive) system.
   b. The amount of explosives irradiated shall be contained such that no significant damage shall occur to the reactor upon detonation of twice that amount of explosives.
3. Fissile experiments are limited such that:
   a. Total fissions produced during steady-state and/or pulse operations shall not exceed 10^{17} in any given sample.
   b. The fueled samples shall be encapsulated if the total number of fissions exceeds 5×10^{15}.
   c. Any experiment containing Pu shall be encapsulated.
   d. Fissile foils, when contained in B_{10} may be exposed to fluences up to 10^{15} nvt (>10 keV) in either mode of operation.

4. Experiments containing compounds subject to decomposition, materials corrosive to reactor components, and toxic or biologically hazardous materials shall be double encapsulated.
5. During the neutron decay interval in pulse preparation and during pulse operation after the decay interval:
   a. Interlocks shall prevent the regulating and mass adjustment rods from being inserted further into the core.
   b. An experiment component which can be remotely operated so as to change the reactivity in the core shall not be operated after the start of the neutron decay interval.

Bases:

Specification 2.a is intended to prevent damage to the reactor or the reactor components resulting from a failure of an experiment involving explosive materials.

Specification 3.a provides that the fission-product inventory in any fissionable irradiation experiment shall be limited to 10^{17} fissions so that even under the most extreme failure conditions (single pulses, 100% release), the integrated activity or dose at the 3000-meter exclusion boundary shall be less than that from 1% of the Maximum Credible Accident.[12]

Double encapsulation of hazardous materials to be placed in the reactor core is a recognized means of minimizing the likelihood of damage to the reactor components resulting from failure of an experiment involving such materials.

Experiments containing Pu shall normally be doubly encapsulated; however, the need for double encapsulation may be waived by the safety review committees provided that the sample, containers, procedures, or some other such feature inherent in the experiment provides a degree of safety commensurate with a second level of encapsulation.

Addition of a small amount of reactivity to the reactor just prior to a pulse will increase the size of the pulse and possibly damage the core. A 1¢ change in reactivity can change the yield by as much as 25%. Interlocks in the reactor control system prevent the addition of reactivity to the reactor by control rod motion once the neutron decay interval has been started. Administrative controls prohibit movement of any experimental component that can change the reactivity in the core during the neutron decay interval.

3.6 Core Fuel Integrity

Applicability:

This specification applies to the Uranium - 10 wt% Molybdenum (U-10 wt% Mo) fuel in the reactor.

Objective:

The objective is to ensure that the reactor is not operated when physical integrity of the core is compromised.

Specification:

The reactor shall not be operated if the core fuel is known to have cracks that could result in the displacement of any fuel in a way that could interfere with the motion of the safety block.

Bases:

Experience with U-10 wt% Mo fueled pulse reactors such as the Army Pulse Radiation Facility (APRF) Cores I[13] and II[14] and the Sandia Pulse Reactor II (SPR-II)[15] has shown that U-10 wt% Mo fuel pieces can be expected to develop cracks, either due to stresses developed at high pulse levels (>1.5 X 10^{17} fission/pulse) or due to stress corrosion. Stress corrosion can cause cracks even at low pulse levels (<1 X 10^{17} fission/pulse) or during steady-state operation. A small crack is not generally a hazard and does not affect the physical integrity of the core. Both the APRF and the SPR cores have been successfully operated with sizeable cracks not significant to the safety of the reactor.

3.7 Safety Block Response Times

Applicability:

This specification applies to the time intervals between the initiation of a reactor shutdown signal and the initial movement of a safety block (magnet release time) and to that between the initiation of the shutdown signal and the time the block drops to its normal shutdown position (total travel time, which includes release time).

Objective:

The objective is to ensure that the reactor can be shut down within a specified time.

Specifications:

1. The release time for the magnet shall not exceed 20 ms.
2. The total travel time (including release time) of the safety block from its normal operating position to its normal shutdown position shall not exceed 240 ms.

Bases:

The reactor is capable of being pulsed safely to a peak power in excess of 50,000 MW in a time scale that is too fast for the safety system to respond. The expansion of the core due to the temperature rise terminates the prompt critical excursion at a peak operating level determined by the total reactivity assembled for the pulse. If no safety system action were initiated the assembled core would continue to operate at delayed criticality at a level determined by the average temperature in the core. Post pulse energy deposition in the afterburst plateau or tail would increase the core temperature.

The safety system was designed to cut off the delayed critical tail operation and then to maintain the reactor in a subcritical condition. This action was confirmed in preliminary checkout of the reactor.[16] It was also determined in the preliminary checkout that the delayed critical operation is terminated for high level pulses (>5 X 10^{16} fissions) by the expulsion of the safety block by thermally induced shock in microseconds (approximately 225). Thus, in effect, the reactor has an inherent shutdown mechanism for the delayed critical tail operation for pulses greater than 5 X 10^{16} fissions which is much faster (microseconds) than the electronic safety system (milliseconds).

Measurements of the magnet release time and safety block travel time ensure that the safety block is functioning normally. The magnet release time specified above actually includes the magnet release time as described in the Hazards Summary[17] plus the time for a few mils initial motion of the safety block.

3.8 Instrumentation for Reactor Operation

Applicability:

This specification applies to the instrumentation channels that must be operable for reactor operation.

Objective:

The objective is to stipulate the minimum number of reactor instrument channels that must be operable in order to monitor and control reactor power, core temperature, and prepulse reactivity.

Specification:

The reactor shall not be operated unless the instrument system channels described in Table I are operable.

TABLE I

Instrument Channel	Minimum Number Operable	Number Installed
Neutron Counting Channels for Startup and for Measuring Prepulse Period	1	2
Log or Linear Power Indicating Channels	1	1 ea

TABLE I (Continued)

Instrument Channel	Minimum Number Operable	Number Installed
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

Bases:

A startup channel is required for monitoring the neutron generation rate in the reactor from source level up to a level at which other channels are indicating. The startup channels are also required to determine the reactivity above delayed critical if the pulse rod is to be inserted into a super delayed critical core configuration, since an error of 1¢ in reactivity could cause an error of 25% in pulse size. The startup channels and the log N or linear power channel provide the means to monitor reactor power from source level to maximum power. The power level safety channels can also be used to confirm the reactor power in the range from 5% to full power.

The core surface temperature channels and the core temperature safety channels ensure that the interior and surface temperature of the core can be monitored. A television channel is needed to observe the reactor and experiment during operation and remote handling.

3.9 Reactor Safety System

Applicability:

This specification applies to the instrumentation channels that perform a safety function.

Objective:

The objective is to stipulate the minimum number of reactor safety channels that must be operable in order to ensure the operability of the reactor safety system.

Specification:

The reactor shall not be operated unless the safety system channels described in Table II are operable.

TABLE II

Safety System Channel	Minimum No. Operable	Function
Core Temperature Safety Channels	2	Shut down reactor if measured core temperature exceeds 650°F.
Power Level Safety Channels	2	Shut down reactor if power exceeds 20 kW.

Bases:

In order to ensure that the safety limits will not be exceeded, the core temperature safety channels will shut down the reactor if the measured core temperature exceeds 650°F. Temperature measurements for the core safety channels are made at locations where the temperature will be 7 to 15% below the peak values as indicated by initial neutron flux distribution measurements.[18] The temperature shutdown is necessary because the reactor temperature may exceed 650°F even if the reactor is being operated at a power well below level safety channel shutdown point of 20 kW (See Sect. 2.2, Bases - Steady-State Operation).

Even though the reactor can sustain pulses to many thousands of megawatts, the power level safety channels initiate a reactor shutdown during steady-state operation if the power exceeds 20 kW. The setting was chosen primarily to help keep the core temperature within acceptable limits (See Sect. 2.2 - Bases, Steady-State Operation). The situation in pulse operation is quite different.

The core is capable of experiencing fission pulses in excess of 10^{17} fissions without damage. This results in peak power in excess of 50,000 megawatts. Since the pulse width at half maximum is of the order of 50 ms, neither the power level safety nor temperature channels is capable of acting in this time span. It is only the administrative control of reactivity established in the pulse preparation and the self-quenching characteristics of the core that protect the fuel from damage by a pulse. As discussed in Section 2.2, the power level safety channels in the reactor protection system are effective only in initiating the dropout of the safety block to terminate the delayed critical operation after the super prompt critical excursion has been terminated by temperature rise. For pulses in excess of 5×10^{16} fissions the core expansion due to rapid heating initiates a shock wave which drives the safety block out of the core to shut down the reactor before the safety system can function.

3.10 Mechanical Safety Devices

Applicability:

This specification applies to the use of the safety cage, safety tube, and crash plate.[19]

Objective:

The objective is to prevent the placement of experimental materials against the core and to prevent the safety block from being forced into the core if the reactor is accidentally dropped or is driven down against the floor or experimental material.

Specifications:

1. A safety cage and a safety tube shall be used during operation except when the Committee to Review Experiments for the Pulse Reactor (CREPR) authorizes otherwise for a specific test or experiment.
2. Either a safety tube or a crash plate will be used during operation.

Bases:

The safety cage establishes a point of closest approach to the core so that experiments will not touch the core or occupy the region immediately adjacent to the core. This is a region in which the reactivity effect of any material changes very rapidly with position. The use of the safety tube or crash plate ensures that no exterior force can be inadvertently applied to drive the safety block into the core.

3.11 Personnel Radiation Protection System

Applicability:

This specification applies to the methods for protection of personnel attempting to enter the experimental area near the reactor during reactor operation or inadvertently remaining in that area during timeout prior to reactor operation.

Objective:

The objective is to ensure that personnel cannot inadvertently enter the experimental area near the reactor or the reactor building during reactor operation and to provide to any individual inadvertently remaining in these areas a method of preventing reactor startup or of stopping reactor operation.

Specification:

During reactor operation the following conditions shall be satisfied:

1. Keys from all gates in the 1000-ft-radius exclusion fence must be in their proper switches on the reactor console and turned on.
2. Interlocks must 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 shall be operable to stop reactor operation:
   a. Three push buttons on the north wall inside the reactor building.
   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 shall be closed for all reactor operation.

5. The outer perimeter fence shall be closed for all operation except low-power operation.

Bases:

Procedures are established to ensure that, prior to operating the reactor, personnel inside the outer exclusion fence will be accounted for. For all operations personnel will be excluded from the area within the 1000-ft-radius fence which encircles the reactor building. All gates in this fence must be locked closed and the keys put in the reactor console and turned on before the reactor can be operated. Removal of any one of these keys from the reactor console will initiate a reactor shutdown. The main access gate in the 1000-ft-radius fence must be unlocked before it can be opened and then as a backup a reactor shutdown is initiated by interlocks which sense the gate opening.

An individual who inadvertently remains inside the reactor bay may stop the operation by depressing any one of three stop buttons spaced along the north wall or by opening any door to leave the building. The bay normally is locked so only authorized personnel have access. An individual who is inside the 1000-ft-radius fence and hears a warning horn may prevent reactor startup by depressing a stop button on the outside of the reactor building near the east door, the button inside the fence at the main gate, or the button at the reservoir.

3.12 Outdoor Reactor Operation Restrictions

Applicability:

This specification applies when the reactor is to be operated outside the reactor building.

Objective:

The objective is to prevent reactivity change resulting from weather changes.

Specifications:

Whenever the reactor is to be operated outside of the reactor building the operation shall be according to a specific experiment plan approved by the Committee to Review Experiments for the Pulse Reactor and the Reactor Operations Review Committee.

The reactor shall not be operated outside if it is raining or if the wind speed is greater than 30 mph.

Bases:

Because the potential reactivity effects of precipitation and high winds are unpredictable, the operating procedures prohibit moving the reactor to the outdoor test site during such weather conditions, and require that the reactor be moved indoors immediately should either condition occur or appear imminent when the reactor is outdoors.

3.13 Reactor Storage Pit

Applicability:

This specification applies to use of the reactor storage pit.

Objective:

The objective is to prevent the addition of reactivity resulting from water accumulation while the reactor is in its storage pit.

Specification:

The reactor shall be left unattended in its storage pit only after it is confirmed that the pit drain screens are free of debris.

Bases:

To prevent the accumulation of water in the pit the area around the building was contoured to provide good drainage for rainwater, and the pit was designed with an untrapped drain line which runs to a holdup reservoir. Administratively (see Sect. 6.12) the use of water in the reactor bay is limited. If, while the reactor is stored in its pit, water does get into the pit it will drain out through the untrapped line. Should water accumulate in the pit, sensors will alert the operator who will remove the reactor from the pit with the positioning device.

3.14 Neutron Detectors

Applicability:

This specification applies to the availability of operable neutron detectors during nonoperating periods.

Objective:

The objective is to ensure that personnel in the reactor building are warned immediately and unmistakably if the neutron level exceeds a preset value.

Specification:

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

Bases:

Administrative procedures have been established to ensure that personnel will not be in the reactor bay when the reactor is operated and that personnel will not cause the reactor to achieve a critical condition during maintenance or experimental setups. In case a high neutron level condition occurs inadvertently, however, the safest course of action is to move away at the fastest speed possible. Early detection and an unambiguous warning ensure egress as quickly as possible if such a condition should occur. A continued warning alerts personnel not to reenter the area when neutrons are present.

*This is equivalent to a reactor power of 0.02 watts when the reactor is at the primary experimental position.

4. SURVEILLANCE

4.1 Reactivity

Applicability:

This specification relates to the surveillance requirements of the reactivity in the core and of the reactivity worth of the control elements.

Objective:

The objective is to verify that the reactivity in the core during steady-state operation will not permit the reactor to become critical during safety block insertion, and that the reactivity in the core when the pulse rod is inserted is within acceptable limits.

Specification:

1. Whenever there has been a change in the core, the control elements or their drives, and at least annually, a check shall be made of the operating position of the control rods with the reactor at delayed critical. This shall 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 1. do not correspond to expected values and at least annually the regulating rod shall be calibrated.

3. Whenever the calibration in 2. does not agree with previous calibrations within 4¢ the mass adjustment rod shall be calibrated.

4. The reactivity worth of untried experiments shall be determined in accordance with approved procedures.

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 shall be determined in accordance with approved procedures.

Bases:

The check of the operating positions of the control rods will verify that the reactivity in the core is the expected value. The calibration of the regulating rod will provide information that shows the flux distribution in the core is as expected. With the fixed rod drive speeds the rate of reactivity insertion will be confirmed if the rod calibrations do not change.

By following the approved procedures it will be ensured that the reactivity in experiments and the reactivity worth of the pulse rod remain within conservative limits.

4.2 Pulse Yield

Applicability:

This specification applies to surveillance requirements for pulse target yield.

Objective:

The objective is to ensure that the desired amount of reactivity is present in the core at the time of a pulse.

Specifications:

1. The personnel requirements for pulse operation shall be as specified in Section 6.3.
2. The experiment limitations shall be as in Section 3.5.
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 2 months, calibration pulses shall be made before a maximum yield pulse is attempted.
4. For each pulse the operating sequence shall 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 pupulation decays to background.

e. A reassembly to conditions established in b.

f. Pulse rod insertion.

Bases:

The above specifications follow established fast pulse reactor practice which has been shown to be satisfactory both at the HPRR and other facilities in regard to both safety and practicality of operation. Having one qualified individual operating and a second one checking assures that experimental operations follow approved procedures and that the amount of prepulse reactivity has been correctly established in the core prior to pulse.

4.3 Pulse Rod Reactivity Peaking

Applicability:

This specification applies to the requirement for surveillance of pulse rod positioning.

Objective:

The objective is to verify that the reactivity contribution from the pulse is at maximum when the rod is fully inserted.

Specification:

The physical positioning of the pulse rod shall 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 shall be recalibrated and repositioned as necessary to meet specifications.

Bases:

The core and rod configuration have been altered very few times and then only after review and proper approvals. As long as the check and calibrations are made after any core or pulse rod alteration, the annual check of the physical positioning is sufficient to ensure that no more than the expected reactivity will be inserted by the pulse rod.

4.4 Operation of Reactor Positioning Device

Applicability:

This specification applies to the surveillance of the interlock which terminates reactor operation if the controls of the reactor positioning device are operated.

Objective:

The objective is to verify that operation of any controls to position the reactor initiates a reactor shutdown.

Specification:

At least annually and after maintenance, a check shall be made to verify that any attempt to cause horizontal or vertical movement by means of the reactor positioning device controls shall cause a reactor shutdown.

Bases:

Experience has shown that the specified frequency of checking the reactor positioning device is a sufficient indication that this interlock will remain operable.

4.5 Limitations on Experiments

Applicability:

This specification applies to the surveillance of the limitations on experiments.

Objective:

The objective is to ensure that damage to the reactor or excessive release of hazardous materials shall not occur.

Specifications:

1. Measurements shall be performed to determine the reactivity worth of the experiment. The information describing the reactivity worth of the experiment shall be recorded in the Operations Log Book.

2. All explosive materials shall 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 must be verified and approved by Inspection Engineering. The results reported by Inspection Engineering must be recorded on the experiment plan or the Operations Log Book.

3. A calculation must be performed verifying that the total number of fissions generated in the experiment will be less than the specified limit of 10^{17}. If the number of fissions generated is greater than 5×10^{15}, a container must be employed to house the sample(s). The container must be verified to be leak proof up to at least twice the pressure that will be generated inside the container. Encapsulation of Pu experiments must be verified.

4. The containers used to doubly encapsulate hazardous material shall 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 shall be recorded on the experiment plan or in the Operations Log Book.

5. The interlocks specified in Section 3.5 shall be tested as follows:

a. The control rod insertion interlocks shall 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 shall be checked prior to the start of each experiment for which remote operation has been authorized.

Bases:

Specification 1 assures that the reactivity worth of an experiment is known before the experiment is conducted and that the worth is determined under conditions which can be directly controlled by the reactor operator.

Specification 2 assures that any explosive materials are handled in a manner consistent with established procedures and that the aftereffects of any detonation either are contained without damage to the reactor or will result in no loss of protective actions by the reactor protection systems.

Specification 3 provides that the reactor operator will have prior knowledge concerning the estimated effect of the experiment on the reactor system and that any potential release of radioactive materials will be minimized. Similarly, specification 4 provides the same type of assurance when other materials are irradiated.

Experience has shown that a direct operational test of the control rod interlock at the specified interval is sufficient to ensure that the interlock remains operable.

Each experiment for which remote operation is authorized will have to be set up for the remote operation at the time of the experiment. A check prior to the initial operation is the best way to ensure that the interlock system is operable.

4.6 Core Fuel Integrity

Applicability:

This specification applies to the surveillance of core fuel integrity.

Objective:

The objective is to ensure that the reactor is not operated with cracks in the fuel that affect the physical integrity of the core.

Specification:

Annually the safety block and the interior and exterior of the assembled core shall be examined visually for cracks. A similar examination shall also be made whenever formation of a crack is suspected.

Bases:

The above specification was established based on operating experience and the fact that any significant crack can be observed visually with the core assembled.

4.7 Safety Block Response Times

Applicability:

This specification applies to the surveillance requirements for the safety block response times.

Objective:

The objective is to verify that the safety block response times are within the limits specified in Section 3.7.

Specification:

The magnet release time and the travel time of the safety block shall be measured at least semiannually and whenever maintenance is performed that could affect magnet release and travel time.

Bases:

Experience has shown that the specified frequency of checking is a sufficient indication that the performance remains within the required limits.

6.8 Instrumentation for Reactor Operation

Applicability:

This specification applies to the surveillance requirements for the channels that provide information for reactor operation.

Objective:

The objective is to verify that correct information is supplied to the operator and that control functions operate correctly.

Specifications:

Prior to the initial operation of an operating day a check shall 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 shall be calibrated annually and after maintenance that could affect the calibration of the channels. The operation of all devices that affect reactor control shall be checked after maintenance and at least annually.

Bases:

An interlock which requires a counting rate of at least two counts per second in the neutron startup channel ensures that sufficient neutrons are available for proper operation of the startup channel. The operational checks and channel calibrations verify that the equipment is functioning as it was intended.

4.9 Reactor Sa . . . tem

Applicabili . :

This specification applies to the surveillance requirements for the reactor safety system.

Objective:

The objective is to verify that the reactor safety system is operable and will be able to prevent the safety limits from being exceeded.

Specifications:

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

Bases:

The channel tests and manual scram checks will verify that the safety channels are operable. The daily checks indicate any drift in the indications. The core temperature rise versus time comparisons provide an independent calibration check for the power-monitoring channels.

4.10 <u>Mechanical Safety Devices</u>

<u>Applicability</u>:

This specification applies to the procedures to be followed whenever work is performed on the core or control elements.

<u>Objective</u>:

The objective is to ensure that the safety cage and safety tube or crash plate are in place whenever the reactor is operated.

<u>Specification</u>:

Whenever maintenance is performed on the reactor core or control elements, the safety cage and either safety tube or crash plate shall be in place when the work is completed.

<u>Bases</u>:

Upon the completion of any core maintenance and prior to any reactor startup, the visual inspection of the core, as required by the reassembly and startup checklists, is adequate to ensure the correct and required installation of the mechanical safety devices.

4.11 <u>Personnel Radiation Protection System</u>

<u>Applicability</u>:

This specification applies to the surveillance requirements for the personnel protection system.

<u>Objective</u>:

The objective is to ensure that the systems function and that barriers exist as required to prevent inadvertent entry into the area around the operating reactor and that anyone inadvertently left in the area can prevent startup of the reactor.

<u>Specification</u>:

The operation of each channel shall be checked annually and after maintenance. The fences shall be inspected annually.

Bases:

Experience has shown that the annual checks and inspections are sufficient to ensure the systems are operable and the barriers are intact.

4.12 Outdoor Reactor Operation Restrictions

Applicability:

This specification applies to the surveillance of instrumentation, power equipment and weather conditions prior to outdoor operation.

Objective:

The objective is to ensure that the reactor is not operated outdoors when it is raining or threatening to rain or unstable weather conditions prevail.

Specification:

Whenever the reactor is to be operated outdoors, a special checklist shall be used that will include a check that the wind speed indicator, one TV channel and the auxiliary power generator are operable. The weather forecast and the actual weather conditions shall be checked just prior to operation.

Bases:

A direct operational check prior to outdoor operation is a satisfactory method to ensure operability of the required instrumentation and equipment. The final judgment concerning operation will reside with the Senior Operator just prior to operation.

4.13 Reactor Storage Pit

Applicability:

This specification applies to the requirement for surveillance of the storage pit drain and water level detectors.

Objective:

The objective is to ensure that the drain from the storage pit is clear and that the water level sensor and alarm are operable.

Specifications:

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 shall be flushed semiannually.
3. The water level alarm system shall be checked quarterly and after maintenance on the system.

Bases:

Experience has shown that flushing the drains semiannually is sufficient to ensure that there is no hidden blockage of the line. Quarterly checks of the water level sensor and alarm will ensure that the system is operable.

4.14 Neutron Detectors

Applicability:

This specification applies to the surveillance requirements of the neutron detector systems required in the reactor bay during nonoperating periods.

Objective:

The objective is to ensure that the neutron detector systems are operable.

Specifications:

1. Operation of the neutron detector system shall be checked monthly when the reactor is operated and after maintenance.
2. The neutron detector systems shall be calibrated quarterly and after maintenance.
3. The compressed-gas-warning horn shall be checked semiannually and after maintenance.

4. The operation of the horn trouble monitor shall be checked semiannually and after maintenance.
5. The auxiliary power supply will be checked monthly.

Bases:

Operation of the neutron detector systems is observed each time the reactor is operated. A monthly check will be made to ensure they operate at a predetermined level. Calibration of the detectors by maintenance personnel on a quarterly basis and operation of the horn and air supply alarms on a semiannual basis are sufficient to ensure the system is operable. Experience has shown that monthly check of the auxiliary power supply is sufficient to ensure its availability.

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5.0 DESIGN FEATURES

Design features unique to the reactor and its auxiliary equipment are briefly described below.

5.1 Reactor Fuel

The fuel is a stablized gamma-phase alloy of 90 wt% uranium and 10 wt% molybdenum (U-Mo). The gamma phase is used because of the isotropy of the mechanical and physical properties. Molybdenum is used as the alloying agent because it is effective in stablizing the gamma phase, it provides slower transformation kinetics for the $\gamma \rightarrow \alpha + \delta$ reaction due to stress and temperature, and it results in a high yield strength alloy. Several reasons dictate the selection of the 10 wt% molybdenum in the alloy. Below 5 wt% molybdenum the gamma phase of the U-Mo alloy is less stable and above 10 wt% the alloy is extremely difficult to cast, to fabricate, and to machine, and it possesses little ductility. In addition, a molybdenum content in excess of 10 wt% adversely affects the neutron spectra and pulse widths desired for pulse reactors.

It has been shown that the thermal expansion properties of the fuel provide a negative temperature coefficient that operates effectively to ensure pulse termination for pulses up to approximately two times the maximum target pulse.[20] The static temperature coefficient of reactivity was found to be 0.17 cents/^{o}F in the range of 68-243^{o}F.[21]

5.2 Reactor Site

The reactor is housed in a building that is located between two offshoots of Copper Ridge approximately 2.1 miles southeast of ORNL, 5 to 12 miles from the city of Oak Ridge and 17 to 25 miles from the city of Knoxville. The nearest ORNL facilities, the Tower Shielding Facility (TSF) and the High Flux Isotope Reactor (HFIR) are more than 1.14 miles from the HPRR. The HPRR and the TSF are situated within a general exclusion area which is enclosed by a 6-ft-high chain link fence topped with three strands of barbed wire. Within the exclusion area the TSF and the HPRR are separated by a 5-ft-high field wire fence. The embayment of the Tennessee Valley Melton Hill Dam which forms a natural boundary of the restricted area reaches a point 0.6 miles from the reactor.

Operating personnel are housed in a reinforced concrete building that has 1-ft-thick walls and contains a counting room which has 2-ft-thick boronated concrete walls and roof. The building is located outside an exclusion fence which is located on a 1000-ft-radius from the reactor. One side of the control building is set into the side of the hill between the reactor and the control building.

Conservative calculations show that the fission product release from a Maximum Credible Accident (Design Basis Accident) would not result in exposures in excess of permissible levels for individuals at the point of closest approach to the reactor along the exclusion fence, 3000 feet.[22]

6.0 ADMINISTRATIVE CONTROL

6.1 Organization

The Oak Ridge National Laboratory, which is owned by the United States Department of Energy (DOE) and operated under contract by the Nuclear Division of Union Carbide Corporation, shall be responsible for operation and supervision of the reactor. The Operations Division shall be directly responsible for the operation of the reactor. The relationship of the reactor operating staff to the Laboratory's structure is shown in Figure 1.

6.2 Personnel Qualifications

The reactor shall be operated by personnel examined and certified under the general provisions of DOE Manual Chapter 0540, Appendix 8401-II, and IAD-8401-6 and approved by the Operations Division Director.

6.3 Minimum Staff Requirements

Steady-State Operation

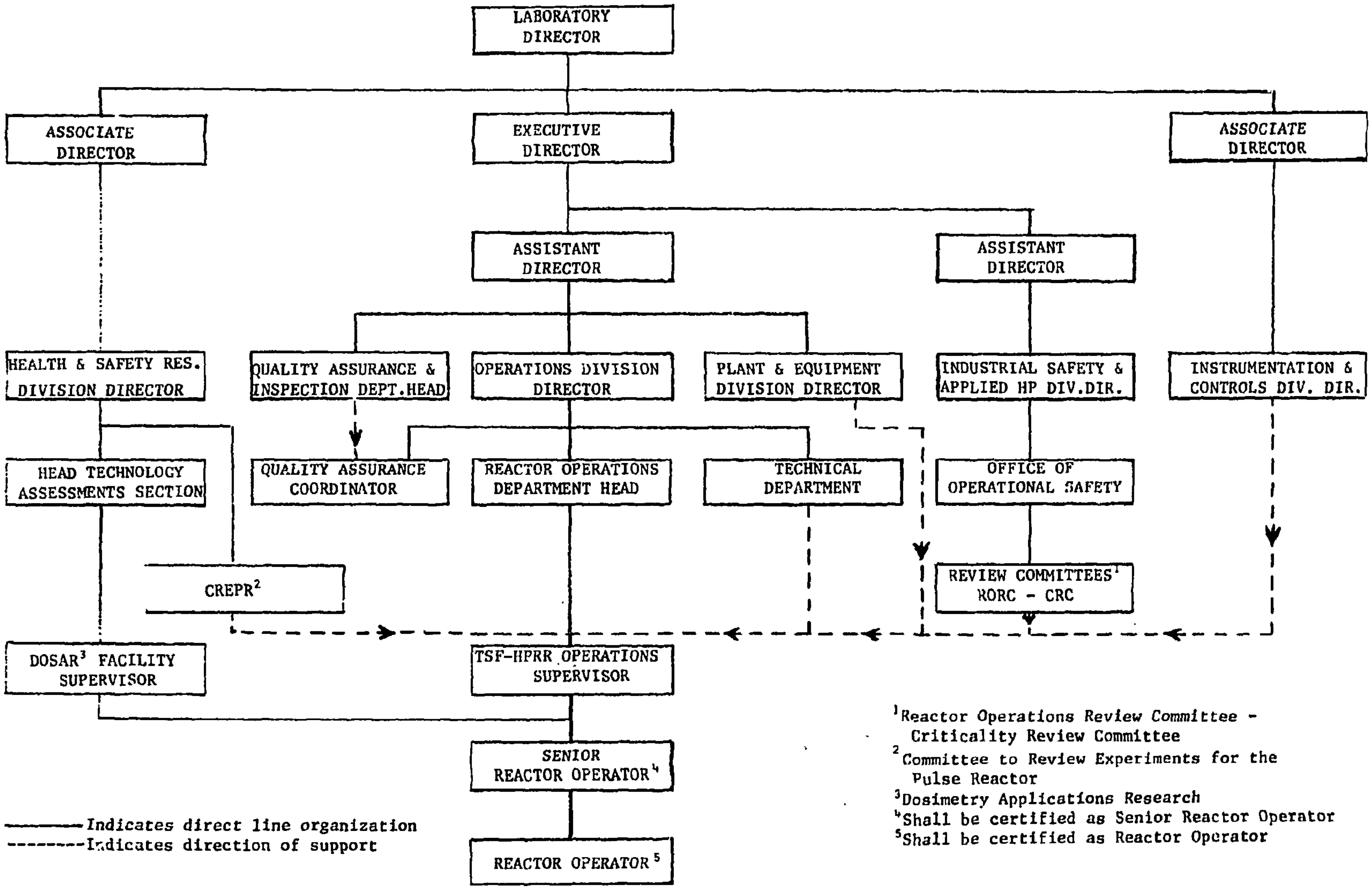
1. A Senior Reactor Operator and one other person shall be present in the control building when the reactor is operated.
2. Either a Senior Reactor Operator or a Reactor Operator shall be present in the control room during reactor operation.

Pulse Operation

One Senior Reactor Operator and one Reactor Operator shall be present during pulse preparation and pulse operation.

Core Maintenance and Reactivity Adjustments

1. A Senior Reactor Operator, a Reactor Operator, and one other DOSAR staff member shall be present whenever the core is being removed from or installed on the reactor



[1] Reactor Operations Review Committee - Criticality Review Committee
[2] Committee to Review Experiments for the Pulse Reactor
[3] Dosimetry Applications Research
[4] Shall be certified as Senior Reactor Operator
[5] Shall be certified as Reactor Operator

Fig. 1. HPRR Organization Chart

superstructure and whenever the core is being disassembled or reassembled.

6.4 Facility Modifications

1. Changes in technical specifications or changes that involve an unreviewed safety question shall require prior review and approval by the Laboratory Reactor Operations Review Committee (see Sect. 6.11) and review and authorization by DOE.

2. Certain mechanical and instrumentation and controls design changes may be made by the contractor provided the effect of the change does not involve a change in the technical specifications or an unreviewed safety question. Formal procedures shall be used for documenting important mechanical and instrumentation and controls design changes.

6.5 Operating Procedures

1. The reactor shall be operated in accordance with documented operating procedures. In no instance will the operating procedures designate authorization to operate the reactor in violation of any specification listed in this document. The procedures shall be adequate to ensure safe operation of the reactor but should not preclude the use of independent judgment and action should the situation require such. Detailed written procedures shall be provided for, but not limited to, the following:

   (a) Emergency and abnormal conditions.
   (b) Reactor startup, operation, and shutdown.
   (c) Installation and removal of fuel components, control rods, and all nonpermanent reactor components.

2. A standard method shall be used to change operating procedures as necessary to ensure that all persons concerned are notified of the change and that a permanent record is made. Permanent procedure changes must be formally written and approved by at least two of the following senior staff members:

(a) Operations Division Director,

(b) Reactor Operations Department Head,

(c) TSF-HPRR Operations Supervisor,

(d) Senior Reactor Operator.

Temporary changes to the procedures that do not alter the original procedure intent shall be made, when required, by issuing special operating instructions. Special operating instructions shall be approved by at least two senior reactor operators.

3. Facility radiation control procedures shall be maintained and made available to all operations personnel.[23]

4. A Senior Reactor Operator shall certify that each proposed experimental setup complies with experiment approval.

5. There shall be a personnel head-count badge system in use covering all personnel entering the HPRR area. Prior to low-power operation it shall be established that all personnel in the area are outside the 1000-ft-radius exclusion fence. Prior to high-power operation only controlled access is permitted and then only under the supervision of the reactor operator in accordance with documented procedures. During an actual pulse everyone within the 3000-ft-radius fence shall be inside the reactor control building.

6.6 Action to be Taken in the Event a Safety Limit is Exceeded

1. The reactor shall be shut down and reactor operation shall not be resumed until authorized by DOE.

2. An immediate report shall be made to the ORNL Office of Operational Safety.

3. A report shall be made no later than the next work day to DOE.

4. A report shall be made which shall 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

shall be sent to the Reactor Operations Review Committee and a similar report submitted to DOE when authorization to resume operation of the reactor is sought.

6.7 Action to be Taken in the Event of an Abnormal Occurrence

In the event of an abnormal occurrence (see Glossary of Terms) the following action shall be taken:

1. The TSF-HPRR Operations Supervisor and other appropriate management personnel shall be notified and corrective action taken prior to resumption of the operation involved.

2. A report shall be made that shall 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 Manual Chapter 0502.

3. Where required, a report shall be submitted to DOE.

6.8 Actions to be Taken in Regard to Potential Degradations of a Reactor Shutdown System

1. Immediate remedial actions required:

   (a) Upon experiencing a Class 1 degradation of the reactor shutdown system, the reactor shall be shut down immediately by manual scram or other emergency backup means that may be necessary.

   (b) Upon the discovery of a Class 2 degradation of the reactor shutdown system, the reactor shall be shut down immediately in an orderly (nonemergency) manner, except when the situation warrants more urgent shutdown action be taken.

   (c) Upon the discovery of a Class 3 degradation of the reactor shutdown system, the contractor shall take the applicable course of action below:

(1) For coincident logic systems, the degraded unit shall be promptly placed (or kept) in the tripped state until operability is restored, except for the brief time necessary to determine the operability of the redundant channels. If the action above would result in an automatic scram, this requirement should be satisfied instead by the prompt initiation of an orderly shutdown.

(2) For one-out-of-two or -three systems, where a bypass of a channel for short time periods is authorized in order to permit testing or repair, the bypassed condition may be retained. If operability cannot be regained by the end of the period authorized for bypass, the reactor shall be immediately shut down in an orderly manner, except when the situation warrants more urgent shutdown action be taken.

(d) Upon the discovery of a Class 4 degradation of the reactor shutdown system, the contractor shall ascertain the root cause of the degradation and implement appropriate corrective action designed to correct the specific degradation and to reduce the probability of similar occurrences.

2. Authorization for restartup of the reactor:

Following the occurrence of either a Class 1 or Class 2 degradation of the reactor shutdown system, authorization from DOE is required for restartup of the reactor.

3. Notification to DOE:

(a) In the event of a Class 1 degradation, ORNL shall verbally notify DOE immediately and provide a written report within five calendar days.

(b) In the event of a Class 2 degradation, the contractor shall verbally notify DOE as expeditiously as practical but within 24 hours and provide a written report within five calendar days.

(c) In the event of a Class 3 degradation, the contractor shall provide a written report to DOE within five calendar days.

(d) In the event of a Class 4 degradation, the contractor shall include the occurrence in a written report to DOE provided no later than 30 days following the occurrence.

6.9 Additional Reporting Requirements

1. A report shall be made no later than the next work day to the Safety and 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 Manual Chapter 0524.

   (b) Any violation of a safety limit (see Sect. 2.1).

   (c) Any exposures to personnel in controlled and uncontrolled areas that exceed the standards in DOE Manual Chapter 0524.

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

6.10 Plant Operating Records

In addition to the requirements of applicable regulations, and in no way substituting therefor, records and logs shall be prepared of at least the following items and retained for a period of at least six years:

1. Normal plant operation.
2. Principal maintenance activities.
3. Abnormal occurrences.
4. Equipment and component surveillance activities required by the technical specifications.
5. Fuel inventories and transfers.
6. Experiments performed with the reactor.
7. Updated, corrected, and as-built drawings of the facility which shall be retained for the lifetime of the facility.

6.11 Review Committees

1. Reactor Operations Review Committee

There shall be a Reactor Operations Review Committee (RORC) responsible for periodically conducting an independent safety review of the reactor facility. The members of the RORC shall be appointed by the Director of the Laboratory and shall not be directly involved in the operation of the reactor. The committee members shall collectively possess expertise in all areas of reactor operations and safety.

The RORC shall meet with the operating personnel as frequently as it deems necessary to keep informed of any operational problems or potential hazards. The committee shall conduct at least one formal review each year and the minutes of this review shall be reported in writing to the Director of the Laboratory. In compliance with the requirements of IAD-8401-7, the RORC shall review any proposed modifications that have safety significance. The RORC, which has the overall responsibility for reviewing experiments utilizing the HPRR, may initiate an experiment review after it receives notice of action by the Health and Safety Research Division Committee to Review Experiments for the Pulse Reactor (see below). A detailed description of the RORCs function is presented in Reference 24.

2. Health and Safety Research Division Committee to Review Experiments for the Pulse Reactor

The members of the Committee to Review Experiments for the Pulse Reactor (CREPR) shall be appointed by the Director of the Health and Safety Research Division. The committee shall review all new experiments which will be performed with the reactor. CREPR shall review proposed experiments in such detail as to ensure that no credible failure or malfunction of the experiment could create a positive change in reactivity during pulse operation. CREPR shall review experiments from the standpoint of personnel and equipment safety, and reactor integrity. The committee shall, as it deems necessary, place limits upon any materials, systems, components or operations that may present a hazard to personnel or to the reactor. The committee shall, in executing its responsibility, make recommendations or establish conditions on design, construction, and operation of an experiment. CREPR may recommend approval for an individual experiment or recommend blanket approval for related experiments to the DOSAR Facility Supervisor provided it meets the specifications in Section 3.5. CREPR forwards information copies of action taken to the RORC which has the overall responsibility for reviewing experiments utilizing the HPRR (see Sect. 6.11.1).

3. Criticality Committee

There shall be a Criticality Committee responsible for the review and approval of operations which involve handling, storage, transportation, and disposal of significant quantities of fissile material. The committee shall, on request, serve as a consulting group and provide assistance in problems involving criticality. The committee shall conduct an annual review of all areas containing significant amounts of fissile material to ensure that approved procedures are being followed. A detailed description of the committee's function and methods of review is presented in Reference 25.

6.12 Limitations on Water in Reactor Bay

Because water is a good neutron reflector, its use in the reactor building is restricted. The only water line which enters the reactor room is one that supplies a fire hose. The cutoff valve outside the building shall be kept locked in the closed position and shall not be unlocked except by personnel authorized by the TSF-HPRR Reactor Operations Supervisor. An authorized personnel list shall be supplied to the Fire Department and the Laboratory Shift Supervisor and shall be maintained at the fire alarm boxes in the Control Building (7710) and the Reactor Building (7709).

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