**Technical Specifications for the
Pool Critical Assembly**

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OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION • FOR THE DEPARTMENT OF ENERGY

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Operations Division

TECHNICAL SPECIFICATIONS

FOR THE

POOL CRITICAL ASSEMBLY

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TECHNICAL SPECIFICATIONS
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1. GLOSSARY OF TERMS

The following list is a glossary of terms frequently used in the discussions in the Technical Specifications.

- 1.1 Abnormal Occurrence - An abnormal occurrence is any of the following:
 - a. Any actual safety system setting less conservative than specified in 2.2, Limiting Safety System Settings.
 - b. Operation in violation of a Limiting Condition for Operation.
 - c. 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.
 - d. Release of fission products of a magnitude to indicate a failure of the principal physical boundary.
 - e. An uncontrolled or unanticipated change in reactivity.
 - f. 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.
 - g. An uncontrolled or unanticipated release of radioactivity.
- 1.2 Calibration - An adjustment of electronic, mechanical, pneumatic, or other sensing systems such as the output of the system responds, with acceptable range and accuracy, to known values of the parameter that the system measures or to known input signals when access to the primary element is limited.
- 1.3 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 ERDA Manual Chapter 0540 and pursuant to IAD 8401-6.
- 1.4 Channel Calibration - A channel calibration is an adjustment of the channel such that its output responds, with acceptable range and accuracy, to known values of the parameter that the channel measures or to known input signals when access to the primary element is limited.

- 1.5 Channel Check - A channel check is 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.
- 1.6 Channel Test - A channel test is the introduction of an appropriate signal into a channel to verify that it is operable.
- 1.7 Core Configuration - The disposition of reactor core elements within the reactor, including position, number, and fuel mass.
- 1.8 Degradation of the Reactor Shutdown System -
 - a. 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 setting (LSSS) or the premature termination of the protective action; for example, reactor coolant flow rate decreases to below the LSSS without an automatic trip; the relatching of neutron-absorbing rods prior to achieving the required shutdown margin.
 - b. 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 LSSS; for example, in a two-out of three system, the drift of the setpoints of two flow channels to values beyond the LSSS or an improper calibration procedure which would result in several setpoint adjustments being effectively beyond the LSSS.
 - c. Class 3 - Failure or malfunction of one or more components, personnel error, or procedural inadequacy which reduces the capability of the reactor shutdown to the extent that the occurrence of a random single failure would prevent the protective action at the LSSS; for example, in a two-out-of-three system, the drift of a single channel setpoint to a value beyond the LSSS.
 - d. 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 when required (conditions and LSSS) by the Technical Specifications, for example, in a two-out-of-four system, one undervoltage relay failed to perform during a test.

- 1.9 Engineered Safety Features - Features of a unit, other than reactor trip or those used only for normal operation, that are provided to prevent, limit, or mitigate the release of radioactive material.
- 1.10 Excess Reactivity - Excess reactivity is the excess k_{eff} above unity that would exist if all the shim-safety rods and regulating rod were fully withdrawn.
- 1.11 Experiment An experiment is any apparatus (other than the reactor components and structure), device, or material placed in the reactor core region, in an experimental facility, or in line with a beam of radiation emanating from the reactor.
- 1.12 Flight Time - Flight time is the time interval between the introduction of a fast scram signal and the actuation of the seat switch of the rod being tested. Flight time measurements are normally made with the rod withdrawn to the upper limit of its travel.
- 1.13 Fuel Element - Fuel elements are core pieces that can be inserted into the PCA grid and that contain a fissionable material for use in the production of energy.
- 1.14 Functional Test - A functional test is a test of a component or system of components to assure that the component or system of components perform as per design when called upon.
- 1.15 Ganged-Rod Position - This is a term used to describe the relationship of shim-safety rod positions. Any number of shim-safety rods are said to be at ganged-rod position if they are withdrawn equidistant from their seats.
- 1.16 Limiting Conditions for Operation - Limiting Conditions for Operation (LCO) are those administratively established constraints required for safe operation of the facility.
- 1.17 Limiting Safety System Settings - Limiting Safety System Settings (LSSS) are those limiting values for settings of the safety channels at which point protective action must be initiated.

- 1.18 Movable Experiment - A movable experiment is one in which it is intended that the entire experiment or part of it may be moved in or near the core while the reactor is operating.
- 1.19 Nominal Full Power - 100 kW (Administrative Limit).
- 1.20 Operable - A component or system is operable when it is capable of performing its intended function in a normal manner.
- 1.21 Operating - A component or system is operating when it is performing its intended function in a normal manner.
- 1.22 Power Operation - Operation at power levels in excess of 1 kW (sometimes referred to as "operation at power").
- 1.23 Reactor Safety System - The reactor safety system is that combination of measuring channels and associated circuitry which forms the automatic protective system of the reactor.
- 1.24 Reactor Secured - That overall condition in which all of the following conditions are satisfied:
- a. Reactor shutdown.
 - b. Electrical power to the control rod circuits is switched off and switch key is in proper custody.
 - c. No work in progress involving in-core components, experiments, or installed control rod drives.
- 1.25 Reactor Shutdown - The reactor is in a shutdown condition when all shim-safety rods are fully inserted or when it is in a reactivity condition equivalent to one in which all shim-safety rods are fully inserted.
- 1.26 Regulating Rod - A regulating rod is a neutron-absorbing core component used to control the reactor through servo action by varying its position in the reactor core.
- 1.27 Release Time - The release time is the time interval between a fast scram signal and the first detectable movement of the magnet armature.
- 1.28 Safety Channel - A safety channel is a combination of detectors, amplifiers and associated circuitry that forms an input to the automatic protective system and is designed to initiate a reactor shutdown for the primary purpose of protecting the reactor.
- 1.29 Safety Limit - Safety Limits are limits on important process variables which are found to be necessary to reasonably protect the integrity

of certain of the physical barriers which guard against the uncontrolled release of radioactivity.

- 1.30 Shim-Safety Rods - Shim-safety rods (control rods) are the neutron-absorbing core components used to control the reactor power by varying their position in the reactor core.
- 1.31 Shutdown Margin - The shutdown margin is the amount of reactivity which must be added to a shutdown reactor to make it critical.
- 1.32 Shutdown Mechanisms - The shutdown mechanisms consist of any of the following:
 - a. Scram - Gravity insertion of all shim safety rods.
 - b. Reverse - Motor driven insertion of all shim safety rods at their normal insertion speed.
- 1.33 Specifications for PCA Fuel Elements and/or PCA Shim Rod Elements - Detailed material and fabrication specifications, quality assurance requirements, and associated engineering drawings approved by ORNL Operations Division management.
- 1.34 Time Intervals -
 - a. Biennially - To be performed once each two years at intervals not to exceed 30 months.
 - b. Annually - To be performed once each year at intervals not to exceed 14 months.
 - c. Semiannually - To be performed two times annually at intervals not to exceed 8 months.
 - d. Quarterly - To be performed four times annually at intervals not to exceed 5 months.
 - e. Monthly - To be performed once each month at intervals not to exceed 60 days.
 - f. Weekly - To be performed once each week at intervals not to exceed 10 days.
 - g. Daily - To be performed once each day at intervals not to exceed 2 days.
- 1.35 Tried Experiment - A tried experiment is either of the following:
 - a. An experiment previously approved and performed in this reactor.
 - b. An experiment of similar size, shape, composition, and location as an experiment previously approved and performed in this reactor.

2. SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limits

Applicability:

This specification applies to the process variables associated with core thermal and hydraulic performance when operating. The variable is reactor power.

Objective:

The objective is to establish limits for the critical process variables which, if not exceeded, will provide confidence that the integrity of the fuel-element cladding will not be breached.

Specifications:

The reactor power shall not exceed 3.5 MW.

Bases:

The safety limit set forth in this specification has been established to ensure operation at or below a power level at which there is a wide burnout margin. The critical heat flux for natural convection cooling and 120°F inlet temperatures as interpolated from the experimental data of Gambill and Bundy¹ is about 1.25×10^5 Btu/ft²hr. The maximum heat flux in the BSR (BSR and PCA are quite similar in this respect) has been very conservatively estimated to be 2.51×10^4 Btu/ft²hr/MW (Ref. 2,3). Hence the burnout power level is about 5 MW under natural convection conditions.

The inlet water temperature is normally automatically controlled at 100°F, and operation of the reactor is administratively prohibited if the inlet temperature exceeds 120°F. Since the pool contains ~130,000 gal (1.06×10^6 lb) of water, nearly 2 hours operation at 3.5 MW is required to raise the pool water temperature 20°F to the administrative limit. Rapid changes in coolant inlet temperature, therefore, need not be considered since there is adequate time for supervisory action to effect administrative control.

2.2 Limiting Safety System Settings

Applicability:

These specifications apply to the safety system action set points for the reactor process variables related to the safety limits.

Objective:

The objective of this specification is to provide limiting values of the set points of the safety channels so that automatic protective action, sufficient to provide confidence that the criteria set forth in the safety limits (Section 2.1) are satisfied, will occur when required.

Specifications:

The LSSS on the power of the reactor shall be 200 kW.

Bases:

The limiting safety system settings were chosen such that when measurement uncertainties and anticipated transient conditions are considered there is confidence that the criteria set forth in the safety limits are at all times satisfied.

3. LIMITING CONDITIONS FOR OPERATION

3.1 System Reactivity

Applicability:

These specifications apply to the reactivity condition of the reactor and its associated components.

Objective:

The objective is to ensure that the reactor can be made subcritical and maintained in a subcritical condition whenever required, and to prevent the occurrence of any condition that might add a significant amount of uncontrolled reactivity.

Specifications:

- a. Excess Reactivity Loaded in the Core - The core excess reactivity shall be less than or equal to 50% of the reactivity worth of the shim safety rods when they are withdrawn in the ganged position. In addition, the reactor core will be so arranged that the shut-down margin with the highest worth shim rod withdrawn shall be greater than 0.8% $\Delta k/k$ relative to the cold, clean condition. Any core configuration different from previous cores will be assembled using the approach-to-critical method. The total mass of fuel in the core will be adjusted to comply with the above requirements before criticality for steady state power operation is attained. (Failure to meet these requirements during criticality tests of a new core configuration or for other investigative purposes shall not be regarded as a violation of the specifications provided corrective action is taken prior to startup for power operation.)
- b. Reactivity Worth of Experiments - The limitations on reactivity worth of experiments either within the core or sufficiently close to the reactor to produce significant interactions are specified in Section 3.5.
- c. Minimum Distance - The minimum distance between the BSR core and the PCA core shall be maintained at greater than 10 inches by means of mechanical stops.

Bases:

- a. The limitation on excess reactivity is expressed in terms of relative rod worths rather than in absolute terms, because the absolute worths of the shim-safety rods are a function of the specific fuel mass and configuration of the core. Only on very rare occasions is there sufficient core excess reactivity to perform a complete shim-safety rod calibration since experiments performed in the PCA require that the shim-safety rods be withdrawn to near the upper limit to minimize the flux perturbations due to neutron absorbers being present in the core. This assures that no one rod can produce criticality and that the shim-safety rod worths are distributed in a manner that minimizes the consequences of the uncontrolled withdrawal of a single rod.
- b. Reactor experiments are examined to determine their reactivity effects and also their potential for increasing or decreasing the reactivity of the system; and specific requirements are imposed to ensure that reactor experiments cannot, by failure or misoperation, significantly affect the reactivity balance of the reactor. This is discussed further in Section 3.5.
- c. It has been determined that this distance is adequate to prevent interaction between the two cores.⁴

3.2 Reactor Control and Safety System

Applicability:

This specification applies to the safety, control, and surveillance instrumentation and to the mechanical components of these systems that are required for startup and operation.

Objective:

The objective is to ensure that an adequate complement of safety, control, and surveillance instrumentation together with the requisite mechanical components are available during startup and operation.

Specifications:3.2.1 Minimum Reactor Instrumentation Requirements

The minimum complement of reactor safety and measuring instrumentation required for startup and operation is specified in Table 3.1.

Table 3.1. Minimum Instrumentation Required
for Reactor Operation

Description	Number
<u>Safety or Protective Channels</u>	
Safety level channels	2
Log N channels	1 ^a
Manual scram	1
<u>Measuring Channels</u>	
Fission chamber channel	1 ^a

^aStartup only, not needed with the reactor at steady state.

3.2.2 Mechanical Control System

- a. Number of Shim-Safety Rods - The reactor shall not be operated with less than three shim safety rods.
- b. Maximum Release Time - The release time of the shim-safety rods shall be less than 30 ms.
- c. Maximum Flight Time - The maximum flight time shall be 800 ms or less.
- d. Maximum Rate of Reactivity Addition - The maximum rate of positive reactivity addition (by movement of the shim-safety rods) shall be limited to 0.15% $\Delta k/k$ per second.
- e. Maximum Reactivity Available to the Servo System - The maximum reactivity available to the servo control system shall be limited to 0.75% $\Delta k/k$.

Bases:

The reactor control and safety system is designed to prevent the only credible cause for a massive release of fission products from the PCA fuel, namely, overheating to an extent sufficient to cause melting and destruction of the integrity of the fuel cladding. Such a condition could be brought about either by an increase in power beyond the capacity for heat removal, a decrease in the heat transfer capability of the system, or a combination of both.

The requirement that the above listed minimum instrumentation be operable and that the associated mechanical components be operable is sufficient to guarantee against these conditions.

The release and flight times prescribed are those which could reasonably be expected when the shim-safety rods are free to fall within their guides and thus ensure that the rods are unrestricted and free to fall when called upon to do so.

Based upon Spert data cited in the BSR Safety Analysis report² restriction of the reactivity addition rate to 0.15% $\Delta k/k$ per second guarantees that during a startup runaway the maximum fuel surface temperature would not exceed 320°F which is well below the melting point.

During normal operation the reactor is operated by means of a servo system which provides automatic shimming to compensate for small positive and negative reactivity changes. The PCA has a delayed neutron fraction equivalent to $\sim 0.81\% \Delta k/k$, and the positive reactivity available to the servo is maintained less than this value to prevent the possibility of prompt criticality as a result of servo action.

3.3 Cooling System

Applicability:

These specifications apply to the conditions which must exist in order for the reactor pool to supply cooling water to the reactor and provide adequate shielding for the reactor core.

Objective:

The objective is to ensure an adequate supply of cooling water to provide heat removal, shielding, and moderation to the reactor.

Specifications:

- a. Coolant Temperature - During reactor operation the bulk coolant temperature shall not exceed 120°F.
- b. Shielding - The height of the water in the pool shall be maintained at a level sufficient to protect against radiation exposures in excess of the limits specified in ERDAM 0524.
- c. Radioactivity Level - The radioactivity in the cooling water shall be maintained at a level low enough to provide protection against radiation exposures in excess of those specified in ERDAM 0524.

Bases:

- a. The critical heat flux calculations and resulting safety limit and LSSS values were determined using an inlet temperature of 120°F. Thus, if this value is not exceeded, these limits remain conservative with respect to the inlet temperature.
- b,c. Normally the radiation levels in the occupied areas near the reactor pool are considerably less than those specified by ERDAM-0524; however, in order to allow for abnormal operations and experimental operations, the legislated limits are specified.

3.4 Radiation Monitoring Equipment

Applicability:

This specification applies to the monitoring of radiation levels and airborne activity in the reactor building.

Objective:

The objective is to ensure that a sufficient number and variety of operable instruments to adequately monitor radiation levels throughout the building are available.

Specifications:

The reactor shall not be operated unless the following minimum requirements for operable area radiation monitors are met or backup measures approved by the reactor supervisor or his designated alternate are provided:

- a. At least one operable constant air monitor shall be located at appropriate points within the reactor building.
- b. At least one operable monitron shall be located at appropriate points within the building.

Bases:

The minimum required number of radiation monitors in the building provides protection and warning of elevated levels of radiation so that there will be sufficient time to evacuate the building or portions of the building and to take necessary steps to prevent the spread of radioactivity to the surroundings.

3.5 Limitations on Experiments

Applicability:

These specifications apply to all experiments installed in the PCA.

Objective:

The objective of these specifications is to establish general limits for PCA experiments that will protect the reactor from damage and shall limit radiation exposure to both on-site and off-site personnel to as low as practicable levels.

Specifications:

The following limitations apply to all in-reactor experiments:

a. Reactivity - The following limits apply to individual experiments:

- (1) Experiments that can cause a positive reactivity change greater than $0.5\% \Delta k/k$ and that are movable experiments shall be equipped with a mechanical insertion-and-removal system having the same reliability as the reactor control-system drives. The reactivity insertion rate by these mechanisms shall not exceed $0.01\% \Delta k/k \text{ s}^{-1}$.
- (2) Experiments that can cause a positive reactivity change greater than $0.5\% \Delta k/k$ due to motion but that need not be moved while the reactor is critical shall be so firmly supported that no credible circumstance can cause them to be moved while the reactor is critical.
- (3) Experiments that can cause a positive reactivity change greater than $0.5\% \Delta k/k$ due to being damaged by temperature or pressure shall be instrumented to cause an appropriate reactor power or reactivity reduction if such temperature or pressure is approached. This is in addition to the safeguards built into the experiment to control the temperature and/or pressure.
- (4) The combined reactivity worth of all experiments that can add positive reactivity to the core due to a common-mode failure shall be $\leq 50\%$ of the shutdown margin of the shim-safety rod control system.

b. Hydraulic Stability - All in-core experiments shall be designed to withstand the hydraulic forces and each assembly shall be staked, welded, or adequately held to avoid loss into the reactor.

c. Temperature - Heat developed in any experiments by gamma absorption, fissions, electric heaters, etc., shall be dissipated by an

adequate coolant flow. Under normal conditions, the temperature of the outer container shall not exceed the saturation temperature of the reactor coolant.

- d. Explosives - No explosives or mixtures of material that under credible circumstances can detonate shall be irradiated in the reactor.
- e. Pressure Containment - Where failure of pressure-containing walls of an experiment can cause a hazard to personnel or to the reactor, the container shall meet the intent of applicable pressure vessel codes. The design for each such container shall be reviewed by a competent engineer and written approval obtained from the Operations Division and the Reactor Experiment Review Committee (RERC).

Bases:

- a. Reactivity
 - (1), (2), and (3) The upper limit of $0.5\% \Delta k/k$ for a reactivity change by an experiment ensures that such change will not result in prompt criticality. It also ensures that the servo system can immediately compensate for such change. The limit of $0.01\% \Delta k/k \text{ s}^{-1}$ for an intentional, controlled reactivity insertion rate ensures adequate compensation by the servo system.
 - (4) The restriction on the combined reactivity worth of all experiments guarantees that the shutdown margin is always adequate to make the reactor subcritical.
- b. Hydraulic Stability - The reactor components must be protected from damage that might result from the movement of an experiment in an uncontrolled manner due to hydraulic forces. The requirements of Specification 3.5 (b) will ensure this.
- c. Temperature - As with reactor components, the surfaces of experiment rigs are maintained below the saturation temperature of the reactor coolant to avoid steam blanketing and possible burnout.
- d. Explosives - The irradiation of explosives is avoided to protect reactor components from possible damage.

- e. Pressure Containment - Depending on location, failure of pressure-containing walls could affect reactivity or damage adjacent reactor components. Failure of pressure-containing walls external to the reactor may endanger personnel directly by impact projectiles or release of radioactive gases. The use of applicable pressure vessel codes insures that adequate safety margins are maintained.

4. SURVEILLANCE REQUIREMENTS

The surveillance requirements in this section apply to continuous system and facility operation. During periods of extended shutdown (periods of time greater than the minimum frequency listed), the stated requirements may be suspended. However, in this case, the requisite surveillance must be performed before the system is again considered operable.

4.1 System Reactivity

Applicability:

These specifications apply to the surveillance requirements for system reactivity.

Objective:

The objective is to ensure compliance with the specifications in Section 3.1 relative to system reactivity.

4.1.1 The Reactor Core

Specifications:

- a. Prior to the startup following significant changes to the reactor configuration or loading, including experiment and reflector changes, or annually, whichever of the above shall occur first, the ganged-rod position that represents 50% of the shim-safety rod worth shall be determined, providing there is sufficient excess reactivity to perform a rod calibration. If the reactor reaches criticality with the rods withdrawn to a lesser extent than this, the reactor shall be shut down and the situation corrected.

Prior to the startup following significant changes to the reactor configuration or loading, including experiment and reflector changes, whichever of the above shall occur first, each shim-safety rod shall be withdrawn to its upper limit to ensure that the reactor remains sufficiently subcritical with each rod withdrawn while the others are fully inserted. (This check is normally accomplished in conjunction with the approach-to-critical procedure.) Should the test fail, the reactor shall shut down and the situation corrected. If possible, the shim-safety rod shall be calibrated for reactivity worth whenever a

significant change in core loading is made following installation of a new rod or after major maintenance.

- b. When required, calculations shall be performed to ensure that the requirements of Section 3.1, specification "b" are met. Where uncertainty exists, measurements to determine the worth of experiments shall be performed. Additional specifications concerning experiments are listed in Section 4.5.

Basis:

These surveillance requirements for reactivity limitations are based upon more than 20 years of experience with the PCA which indicates that adherence to the required checks at the specified frequency is adequate to guarantee compliance with Section 3.1.

4.2 Reactor Control and Safety System

Applicability:

This specification applies to the surveillance requirements for the safety and measuring instrumentation and for the mechanical components of the control systems required for startup and operation.

Objective:

The objective is to ensure the continued operability of the control and safety systems.

4.2.1 Surveillance of Reactor Instrumentation

Specifications

a. Testing

- (1) The ~~safety-level~~ channels, the Log-N channel, and the fission chamber channel shall be tested:
 - (a) Prior to each startup following refueling or other changes in the reactor core configuration or a startup following an extended shutdown (≥ 8 hours).
 - (b) Prior to startup after any change or maintenance involving any component of these channels.

b. Calibration

- (1) The safety level, Log N, and fission chamber channels shall be calibrated quarterly or following major maintenance.

- (2) The PCA monitrons shall be calibrated and tested for operability semi-annually or following major maintenance.

c. Channel Checks

- (1) A channel check of those safety or protective channels required during operation shall be made prior to each startup following changes in the reactor configuration or a startup following an extended shutdown (>8 hours) or after maintenance.

4.2.2 Surveillance of Mechanical Control System

Specifications:

- a. The release time and flight time for each shim-safety rod shall be measured quarterly or any time that the shim-safety rod is moved to a new position, or following maintenance to a shim-safety rod or its related drive mechanisms.
- b. The maximum rate of reactivity addition by the shim-safety rods shall be determined following a significant increase in total worth of the shim-safety rods, whenever there is a significant change in core configuration, or annually, providing there is sufficient excess reactivity to perform rod calibrations.
- c. A measurement of the positive reactivity assigned to the servo-control system shall be made following a significant increase in the worth of the control rod as determined from shim-safety rod worth measurements or annually.

Bases:

The specified channel checks, tests, and calibrations will provide assurance that the various measuring channels are operating properly with reliable and correct output signals. The time intervals between checks, tests, and calibrations are based on over 20 years of experience with similar instrumentation in the PCA and other ORNL reactors.

4.3 Cooling System

Applicability:

This specification applies to the surveillance requirements of the primary coolant system.

Objective:

The objective is to ensure the continuing integrity of the cooling system and to ensure compliance with the specifications set forth in Section 3.3.

Specifications:

- a. The temperature of the pool water shall be checked at intervals not to exceed three hours when operating.
- b. When the reactor is operating, the height of the water above the reactor shall be checked once per shift.
- c. During operation an independent check of the radioactivity of the pool water shall be made daily.

Basis:

The pool water level is constantly monitored, hence the surveillance required is adequate.

Even at 2 MW BSR operation (which is the principal heat source) and with no secondary cooling, the pool water temperature cannot rise at a rate in excess of 6° F per hour. Thus the surveillance is adequate.

Continuous monitoring of the pool water radioactivity and the daily check is supplemented by the complement of radiation protection instruments in the building. Hence the surveillance is adequate to fulfill the requirements of Section 3.3.

4.4 Radiation Monitoring Equipment

Applicability:

This specification applies to the surveillance requirements for the area radiation monitoring equipment.

Objective:

The objective is to ensure that the radiation monitoring equipment is operable.

Specifications:

A calibration and a test of the radiation monitoring equipment for operability shall be conducted at least semiannually and after major maintenance.

Bases:

Area radiation monitors are simple radiation detection devices and experience has indicated that they operate quite reliably for long periods

of time. These devices are primarily used to detect the presence of radiation where none had previously existed. Their alarm point is set at a small value above background and absolute accuracy is not essential. Hence, the semiannual test for operability is considered adequate to ensure that the equipment remains in proper operation.

4.5 Limitations on Experiments

Applicability:

This specification applies to the surveillance requirements for experiment limitations.

Objective:

The objective is to ensure compliance with the specifications set forth in Section 3.5 regarding limitations on experiments.

Specifications:

- a. The Technical Assistance Department of the Operations Division shall review and examine all experiments proposed for insertion into the reactor for safety, potential hazards, and compatibility with the operation of the reactor and other experiments.
- b. New or unusual experiments shall be submitted with recommendations of the Technical Assistance Department to the Reactor Experiment Review Committee (RERC) for review in accordance with the provisions of Section 6.11 of these Technical Specifications.
- c. Tried experiments may be approved by the Technical Assistance Department without further review by the RERC.

Bases:

Review of experiments in accordance with the above specifications adequately ensures compliance with the specifications set forth in Section 3.5.

5. DESIGN FEATURES

5.1 Reactor Fuel

Applicability:

This specification applies to the fuel elements used in the reactor core.

Objective:

The objective is to ensure that the fuel elements are of such design and are fabricated in such a manner as to permit their use with a high degree of confidence in their reliability with respect to their physical and nuclear characteristics.*

Specifications:a. Reactor Fuel Elements

- (1) The fuel elements for the reactor consist of "MTR" plate-type elements with cores containing uranium highly enriched in ^{235}U . The material requirements shall be as follows:
 - (a) Fuel plate U-Al alloy, U_3O_8 -Al cermet, or U-Al_x intermetallic, Al cladding
 - (b) ^{235}U enrichment: up to 97%
 - (c) Number of plates per element: 10-25
 - (d) Nominal weight of ^{235}U per element: ≤ 350 g
- (2) Fuel element design and core loading shall be correlated by experiment and calculation to ensure that the maximum operating heat flux will always be below the critical heat flux by a factor of at least 1.6 (see Reference 3).
- (3) All fuel elements fabricated for normal use as reactor fuel shall conform to the ORNL "Specifications for BSR Fuel Elements," and in addition vendors shall develop and implement a quality assurance program equivalent to RDT F2-4T. For internal fabrication the quality assurance program should be equivalent to RDT F2-2T.
- (4) Before awarding a contract to fabricate fuel elements, an ORNL site inspection team shall evaluate the prospective

*It should be noted that the PCA and BSR fuel elements are similar and the PCA grid can also accommodate ORR elements.

vendor's operation and make a positive determination that the vendor is capable of producing elements which have an acceptably low probability of failure in the reactor.

b. Shim-Rod Element

- (1) The shim-rod elements consist of a partial fuel element containing MTR fuel plates similar to those used in the fuel elements with a central aluminum housing and guide for the shim-safety rod. The material requirements shall be as follows:
 - (a) Fuel Plates: U-Al alloy, U_3O_8 -Al cermet, or $U-Al_x$ intermetallic, Al cladding
 - (b) ^{235}U enrichment: $\leq 97\%$
 - (c) Number of plates: 8-20
 - (d) Nominal weight of ^{235}U per element: ≤ 250 grams
- (2) Same as Section 5.1, Specification "a.(2)."
- (3) Same as Section 5.1, Specification "a.(3)" except "Specifications for BSR Shim Rod Elements."
- (4) Same as Section 5.1, Specification "a.(4)."

Basis:

Calculations during the design and experience during operation of the reactor indicate that fuel elements and shim rods having these characteristics meet the criteria for reliability and performance.

5.2 Reactor Building

Applicability:

This specification applies to the building that houses the reactor.

Objective:

The objective is to ensure that provisions are made to house the reactor and restrict entry of unauthorized personnel.

Specifications:

The reactor is housed in a steel frame building with corrugated metal siding. The main part of the building is the bay area which contains the pool and the reactor. The remainder of the building contains offices, instrument rooms, and control room.

Bases:

The bay area containing the reactor is kept locked when not in use. It contains intrusion alarms which are sounded at ORNL guard headquarters in the event of unauthorized entry into the bay area.

5.3 Fuel Storage and Handling

Applicability:

This specification applies to storage facilities for new and irradiated fuel.

Objective:

The objective is to store fuel in such a manner as to ensure subcritical conditions and ensure adequate cooling and shielding for irradiated fuel.

Specifications:a. For Storage and Handling Outside the Reactor

- (1) Fuel elements and/or shim-safety rods shall be stored in storage facilities which have been reviewed, approved, and declared critically safe by ORNL's Criticality Committee. The criterion used is that k_{eff} shall not exceed 0.95.
- (2) The transfer of fuel elements and/or shim-rod elements between approved storage facilities shall be only by authorization of the reactor supervisor or his authorized representative.
- (3) Irradiated fuel shall be stored in a manner which will provide natural convection cooling and adequate shielding.

b. For Handling Within the Reactor

- (1) All transfers shall be authorized by the reactor supervisor or his authorized representative.
- (2) All transfers shall be by written request which provides for identification of all fuel elements handled.

Bases:

All fuel units used in the PCA are fabricated according to specifications that have been developed to ensure dimensional control to guarantee that the elements will fit into a fixed, nonadjustable grid, to ensure that the fuel content is within rigid limits, to ensure that the cladding will safely contain fission products for the life of the elements, and to guarantee structural integrity of the assembled elements.

Stored fuel elements shall be maintained in a geometry that will prevent criticality. The methods of preventing and/or handling criticality hazards outside of the reactor core must be approved by the ORNL Criticality Committee, and this approval is documented in completed Nuclear Safety Requests. Critical experiments have been performed and these data are used in evaluating requests.

6. ADMINISTRATIVE CONTROLS

6.1 Organization

The Oak Ridge National Laboratory, which is owned by the Department of Energy and operated under contract by the Nuclear Division of Union Carbide Corporation, shall be responsible for operation and supervision of the facility. The Operations Division shall be directly responsible for the operation of the facility. The relationship of the reactor to the Laboratory's structure is shown in Figure 6.1.

6.2 Personnel Qualification

- a. The reactor shall be operated by personnel examined and qualified under the general provisions of ERDA Manual Chapter 0540, ERDAM Appendix 8401-II, and IAD 8401-6 and approved by the Operations Division Director.
- b. Jobs requiring an operator or a senior operator qualification are indicated in Figure 6.1 (Organizational Chart).

6.3 Staff Requirements

- a. The minimum personnel on duty during reactor operation shall be:
One certified PCA senior operator.
- b. The control room shall be attended by at least one certified PCA senior operator at all times during reactor operation.
- c. At least one certified PCA senior operator shall be present in the control room during reactor startup.

6.4 Facility Modifications

- a. It shall be the responsibility of the Division Director to ensure that changes in technical specifications or modifications to the plant protection system, reactivity control systems, or engineered safety features, or changes that involve a safety question not reviewed in the safety analysis report shall receive prior review and authorization by the RORC and/or DOE in accordance with the requirements of ORNL Standard Practice Procedure 18-B and ORO Manual Chapter 0540.
- b. Certain mechanical and instrumentation and control design changes may be made by the contractor provided the effect of the change does not

Fig. 6.1. Organizational Chart.

involve a change in a technical specification or an unreviewed safety question. Formal procedures shall be established for documenting important mechanical and instrumentation and control design changes.

6.5 Operating Procedures

- a. The reactor shall be operated in accordance with documented operating procedures. In no instance shall the operating procedures designate authorization to operate the reactor outside the bounds of any specifications 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:
 - (1) Emergency and abnormal conditions including evacuations.
 - (2) Reactor startup, operation, and shutdown.
 - (3) Installation and removal of fuel elements, control rods, and all non-permanent reactor components.
 - (4) Routine maintenance of control rod drives and reactor safety systems.
- b. 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 shall require the approval of at least two of the following senior staff members:
 - (1) Operations Division Director
 - (2) Reactor Operations Department Head
 - (3) Reactor Supervisor, ORR-BSR-PCA
 - (4) Assistant Reactor Supervisor, ORR-BSR-PCA
 - (5) Certified PCA Senior Operator

Temporary procedure changes that do not alter their original intent shall be made, when required, by issuing special operating instructions. Such special operating instructions shall be approved by at least two of the senior staff members listed above.
- c. Radiation control procedures shall be maintained and made available to all Operations personnel.

6.6 Action To Be Taken in the Event
a Safety Limit Is Exceeded

In the event a safety limit is exceeded:

- a. The reactor shall be shut down and reactor operation shall not be resumed until authorized by DOE.
- b. An immediate report shall be made to the Director of the Office of Laboratory and Personnel Protection.
- c. A report shall be made to DOE no later than the next work day.
- d. A report shall be made which shall include an analysis of the causes and the extent of possible resultant damage, the 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 (RORC) 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, as defined in Section 1, the following action shall be taken:

- a. The reactor supervisor and other appropriate management personnel shall be notified and corrective action taken.
- b. 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 ERDA Manual Chapter 0502.
- c. When required, a report shall be submitted to DOE.

6.8 Reporting Requirements

- a. 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:
 - (1) Any release of radioactivity to the environment above the permissible limits specified in ERDA Manual Chapter 0524.
 - (2) Any violation of a safety limit (Section 2.1).

- (3) Any exposures to personnel in controlled and uncontrolled areas that exceed the standards in ERDA Manual Chapter 0524.
- b. A report shall be made within three work days to DOE-ORO of any violation of the Technical Specifications.

6.9 Actions To Be Taken in Regard to Potential Degradations of a Reactor Shutdown System

- a. Immediate remedial actions required:
 - (1) Upon experiencing a Class 1 degradation of the reactor shutdown system, the PCA shall immediately shut down by manual scram or other emergency backup means that may be necessary.
 - (2) Upon the discovery of a Class 2 degradation of the reactor shutdown system, the PCA shall immediately be shut down in an orderly (non-emergency) manner, except when the situation warrants more urgent shutdown action.
 - (3) Upon the discovery of a Class 3 degradation of the reactor shutdown system, ORNL shall take the applicable course of action below:
 - (a) For coincidence logic system, 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.
 - (b) 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.
 - (4) Upon the discovery of a Class 4 degradation of the reactor shutdown system, ORNL shall ascertain the cause of the degradation and implement appropriate corrective action designed to correct the specific degradation and to reduce the probability of similar occurrences.

b. Required notification to DOE:

- (1) In the event of a Class 1 degradation, ORNL shall verbally notify DOE immediately and provide a written report within five calendar days.
- (2) 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.
- (3) In the event of a Class 3 degradation, the contractor shall provide a written report to DOE within five calendar days.
- (4) 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.

c. Authorization for re-startup 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.

6.10 Operating Records

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

- a. Normal plant operation
- b. Principal maintenance activities
- c. Abnormal occurrences
- d. Equipment and component surveillance activities required by the Technical Specifications
- e. Fuel inventories and transfers
- f. Experiments performed with the reactor
- g. Updated, corrected, and as-built drawings of the facility (these shall be retained for the lifetime of the facility).

6.11 Review Committees

6.11.1 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. A detailed description of the committee's function and method of review is presented in Reference 5.

6.11.2 Reactor Experiment Review Committee

There shall be a Reactor Experiment Review Committee (RERC) responsible for reviewing any new or unusual experiments proposed for insertion into the reactor. The RERC 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 greater than the reactor safety system was designed to accommodate. The committee shall review experiments from the standpoint of personnel and equipment safety and the continuity of reactor operations. The committee shall, as it deems necessary, place limits upon any material, systems, components, effluents, 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. A detailed description of the committee's functions and method of review is presented in Reference 5.

6.11.3 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 functions and method of review is presented in Reference 5.

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