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TECHNICAL SPECIFICATIONS

FOR THE

UNIVERSITY OF CALIFORNIA, IRVINE
TRIGA MARK I NUCLEAR REACTOR

REVISED:

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1.0 DEFINITIONS

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

1.1 Reactor Shutdown - The reactor is in a shutdown condition when sufficient control rods are inserted so as to assure that it is subcritical by at least $1.00 of reactivity.

1.2 Reactor Secured - The reactor is secured when all. the following conditions are satisfied:

a. The reactor is shutdown;

b. Power to the control rod magnets and actuating solenoids is off, and the key removed;

c. No work is in progress involving fuel or in-core experiments or maintenance of the core structure, control rods, or control rod drive mechanisms.

1.3 Reactor Operation - The reactor is in operation when it is not secured.

1.4 Standard Control Rod - A standard control rod is one having rack and pinion, electric motor drive, and scram capability.

1.5 Transient Control Rod

a. Adjustable Transient Rod - an adjustable transient rod is one having both pneumatic and electro-mechanical drives and with scram capability.

b. Fast Transient Rod - A fast transient rod is one that is pneumatically operated and has scram capability.

1.6 Operable - A system or device is operable when it is capable of performing its intended functions in a normal manner.

1.7 Cold Critical - The reactor is in the cold critical condition when it is critical with the fuel and bulk water temperatures the same (≈20°C).

1.8 Steady-State Mode - The reactor is in the steady-state mode when the reactor mode selection switch is in the steady-state or automatic position. In this mode, reactor power is held constant or is changed on periods greater than three seconds.

1.9 Pulse Mode - The reactor is in the pulse mode when the reactor mode selection switch is in the pulse position. In this mode, reactor power is increased on periods less than one second by motion of the transient control rod(s).

1.10 Experiment - An experiment is:

a. Any apparatus, 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;

b. Any operation designed to measure reactor characteristics.

1.11 Untried Experiment - An untried experiment is any experiment not previously performed in this reactor.

1.12 Experimental Facilities - Experimental facilities are the pneumatic transfer systems, central thimble, rotary specimen rack, and the in-core facilities (including single element positions, three-element positions, and the seven element position).

1.13 Abnormal Occurrence - An abnormal occurrence is any of the following:

a. Any actual safety system setting less conservative than specified in the Limiting Safety System Settings section of the Technical Specifications;

b. Operation in violation of a limiting condition for operation;

c. An engineered safety system component failure which could render the system incapable of performing its intended function;

d. Release of fission products from a fuel element;

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 could have caused the existence or development of an unsafe condition in connection with the operation of the reactor.

1.14 Standard Thermocouple Fuel Element - A standard thermocouple fuel element is a standard fuel element containing three sheathed thermocouples imbedded near the axial and radial center of the fuel element.

1.15 Measured Value - The measured value of a process variable is the value of the variable as it appears on the output of a channel.

1.16 Measuring Channel - A measuring channel is the combination of sensor, lines, amplifiers and output device which are connected for the purpose of measuring the value of a process variable.

1.17 Reactor Safety System - The reactor safety system is that combination of channels and associated circuitry which forms the automatic protective system for the reactor or provides information which requires manual protective action to be initiated.

1.18 Operating - Operating means a component or system is performing its intended function in its normal manner.

1.19 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 other independent channels or methods measuring the same variable.

1.20 Channel Test - A channel test is the introduction of a signal into the channel to verify that it is operable.

1.21 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 which the channel measures.

1.22 Reference Core - A reference core is a core with a configuration similar to the core configuration existing at the initial start-up of the reactor.

1.23 Ring - A ring is one of the six concentric bands of fuel elements surrounding the central opening of the core. The rings are designated by the letters B through G, with the letter B used to designate the innermost band.

1.24 Three Element Positions - Two generally triangular-shaped sections cut out of the upper grid plate, one encompassing ring holes D5, E6 and E7 and the other D14, E18 and E19. When fuel elements are placed in these locations a special fixture provides lateral support. With the fixture and fuel removed, an experiment up to 2.4 in. in diameter may be inserted.

1.25 Seven Element Position - A hexagonal section which can be removed from the upper grid plate for insertion of specimens up to 4.4 in. in diameter after relocation of the six B-ring elements and removal of the central thimble.

1.26 Closed Packed Array - A closed packed array is a fuel loading pattern in which the fuel elements are arranged in the core by filling the inner rings first.

1.27 Surveillance Activities - Activities required at pre-defined intervals to assure performance of reactor and safety related components. During prolonged periods when the reactor remains shutdown, Technical Specification Surveillance Requirements 4.1 (fuel element dimensions), 4.2 (control rod integrity), and 4.3 (fuel temperature safety limit) may be deferred. However, they must be completed prior to reactor start-up except for 4.2 (a), 4.3 (d), and 4.3 (f) which require reactor operation in order to be accomplished.

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limit - Fuel Element Temperature

Applicability

This specification applies to the fuel element temperature.

Objective

The objective is to define the maximum fuel element temperature that can be permitted with confidence that no fuel element cladding damage will result.

Specification

The temperature in a stainless steel clad, high hydride fuel element shall not exceed 1000°C under any conditions of operation.

Bases

The safety limitations of the TRIGA fuel are described in the Safety Analysis Report (SAR) for the UC Irvine TRIGA, Section 8. The important process variable for a TRIGA reactor is the fuel element temperature. This parameter is well suited as a single specification since it can be measured. A loss in the integrity of the fuel element cladding could arise from an excessive build-up of pressure between the fuel moderator and the cladding. The pressure is caused by the presence of fission product gases and the dissociation of the hydrogen and zirconium in the fuel moderator. The magnitude of this pressure is determined by the fuel moderator temperature.

The safety limit for the stainless steel clad, high hydride ($ZrH_{1.7}$) fuel element is based on data (SAR pages 8.38 through 8.40 and University of Illinois SAR pages III-56 through III-59) which indicate that the stress in the cladding (due to the hydrogen pressure from the dissociation of the zirconium hydride) will remain below the yield stress provided the temperature of the fuel does not exceed 1000°C.

2.2 Limiting Safety System Settings

Applicability

This specification applies to the trip setting for the fuel element temperature channel.

Objective

The objective is to prevent the safety limit from being exceeded.

Specification

For a core composed entirely of stainless steel clad, high hydride fuel elements, limiting safety system settings apply according to the location of the standard thermocouple fuel element which shall be located in the B-or C-ring as indicated in the following table:

Location	Limiting Safety System Setting
B-ring	800°C
C-ring	755°C

Bases

Stainless steel clad, high hydride fuel element: The limiting safety system settings that are indicated represent values of the temperature, which if exceeded, shall cause the reactor safety system to initiate a reactor scram. Since the fuel element temperature is measured by a fuel element designed for this purpose, the limiting settings are given for different locations in the fuel array. Under these conditions, it is assumed that the core is loaded so that the maximum fuel temperature is produced in the B-ring. If the fuel element temperature is measured in the C-ring, the respective temperature is the limiting safety system setting.

3.0 LIMITING CONDITIONS FOR OPERATION

3.1 Reactivity

Applicability

These specifications apply to the reactivity condition of the reactor, and the reactivity worths of control rods and experiments, and apply for all modes of reactor operation.

Objective

The objective is to assure that the reactor can be shut down at all times and to assure that the fuel temperature safety limit will not be exceeded.

Specifications

The reactor shall not be operated unless the following conditions exist:

a. The shutdown margin referred to the cold, xenon-free condition, with the highest worth rod fully withdrawn, is greater than \$0.50;

b. The total reactivity worth of the two transient control rods is less than \$3.00;

c. Any experiment with a reactivity worth greater than \$1.00 is securely fastened so as to prevent unplanned removal from or insertion into the reactor;

d. The excess reactivity is less than \$3.00;

e. The reactivity worth of an individual experiment is not more than \$3.00;

f. The total reactivity worth of all experiments is limited so that the shutdown margin referred to the cold xenon-free condition with all rods in is at least \$0.50;

g. The total of the absolute values of the reactivity worth of all experiments in the reactor is less than \$3.00;

h. The drop time of a standard control rod from the fully withdrawn position to 90 percent of full reactivity insertion is less than one second; and

i. The neutron power level indication ~~count rate~~ on the startup channel is greater than 1 x 10^{-7}% of full power.~~two counts per second~~.

Bases

The shutdown margin required by specification 3.1a is necessary so that the reactor can be shut down from any operating condition and remain shutdown after cooldown and xenon decay even if one control rod (including a transient control rod) should stick in the fully withdrawn position.

Specification 3.1b is based on Section 8.5 of the SAR. The power level at which a pulse could be initiated in an accident may be as high as 100°C At 100 kw, the peak temperature of the fuel will be 115°C. The calculations indicate that a \$3.00 pulse will result in a peak temperature of only 502°C, well below the safety limit.

Specification 3.1c is based on the same calculations. By restricting each experiment to \$1.00, an additional margin is provided to allow for considerable uncertainty in experiment worth.

Specification 3.1c through 3.1g are intended to provide additional margins between those values of reactivity changes encountered during the course of operations involving experiments and those values of reactivity which, if exceeded, might cause a safety limit to be exceeded.

Specification 3.1 h is intended to assure prompt shutdown of the reactor in the event a scram signal is received.

Specification 3.1 i is intended to assure that sufficient neutrons are available in the core to provide a signal at the output of the startup channel during approaches to criticality.

3.2 Pulse Operation

Applicability

These specifications apply to operation of the reactor in the pulse mode.

Objective

The objective is to prevent the fuel temperature safety limit from being exceeded during pulse mode operation.

Specifications

The reactor shall not be operated in the pulse mode unless, in addition to the requirements of Section 3.1, the following conditions exist:

a. The transient rods are set such that their reactivity worth upon withdrawal is less than \$3.00; and

b. The steady-state power level of the reactor is not greater than 1 kilowatt.

Bases

Specification 3.2a is based on Figure 7-4 of the SAR which shows that the temperature rise expected for a pulse insertion of \$3.00 is less than 500°C.

Specification 3.2b is intended to prevent inadvertent pulsing from a high steady-state power level such that the final peak temperature might approach the safety limit.

3.3 Reactor Instrumentation

Applicability

This specification applies to the information which must be available to the reactor operator during reactor operation.

Objective

The objective is to require that sufficient information is available to the operator to assure safe operation of the reactor.

Specification

The reactor shall not be operated unless the measuring channels described in the following table are operable and the information is displayed in the control room:

Measuring Channel	Minimum Number Operable	Operating Mode in which Required
Fuel Element Temperature	1	All Modes
Reactor Power Level	2	Steady-State
Reactor Power Level (high range)	1	Pulse Mode
Startup Power Level~~Count Rate~~	1	During Reactor Startup
Area Radiation Monitors	2	All Modes
Continuous Air Radiation Monitor	1	All Modes

Bases

The fuel temperature displayed at the control console gives continuous information on the process variable which has a specified safety limit.

The neutron detectors assure that measurements of the reactor power level are adequately covered at both low and high power ranges.

The radiation monitors provide information to operating personnel of any impending or existing danger from radiation so that there will be sufficient time to evacuate the facility and take the necessary steps to prevent the spread of radioactivity to the surroundings.

3.4 Reactor Safety System

Applicability

This specification applies to the reactor safety system channels.

Objective

The objective is to require the minimum number of reactor safety system channels that must be operable in order to assure that the fuel temperature safety limit is not exceeded.

Specification

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

Measuring Channel	Minimum Number Operable	Function	Operating Mode in which Required
Fuel Element Temperature	1	Scram	All Modes
Reactor Power level	1	Scram	Steady-State Mode
Reactor Power Level	1	Prevent transient rods ~~Pulse Mode not~~ firing when power is >1 Kw	Pulse Mode
Manual Button	1	Scram	All Modes
Seismic Switch	1	Scram	All Modes
Startup Power level~~Count Rate~~	1	Prevent control rod withdrawal when power level indication is less than 1 x 10^{-7} %.~~neutron count rate is less than 2 per second~~	Reactor Startup
Standard Control Rod Position	1	Prevent application of air to fast transient rod when all other rods are not fully inserted	Steady-State Mode
Adjustable Transient Cylinder Position	1	Prevent application of air to adjustable transient rod unless cylinder is fully down	Steady-State Mode

Bases

The interlocks which prevent the firing of the transient rods in the steady-state mode or if the power level is greater than 1 kilowatt prevent inadvertent pulses. The interlock to prevent startup of the reactor with less than 1 x 10^{-7}% power ~~two neutrons per second~~ indicated on the startup channel assure that sufficient neutrons are available to assure proper operation of the startup channel.

The fuel temperature scram provides the protection to assure that if a condition results in which the limiting safety system setting is exceeded, an immediate shutdown will occur to keep the fuel temperature below the safety limit. The power level scram is provided as added protection against abnormally high fuel temperature and to assure that reactor operation stays within the licensed limits. The manual scram allows the operator to shut down the system if an unsafe or abnormal condition occurs. The seismic switch will shut down the reactor if major earth movement (M.M. VI or above) occurs in case the operator is prevented from operating the manual scram at the time.

3.5 Release of Argon 41

Applicability

This specification applies to the release of radioactive argon 41 from the facility exhaust system.

Objective

The objective is to assure that exposures to the public resulting from the release of argon 41 generated by reactor operation, will not exceed the limits of 10 CFR Part 20 for unrestricted areas.

Specification

Releases of argon 41 from the reactor room exhaust shall not be made in concentrations greater than $4 \times 10^{-\cancel{8}7}$ μc/ml averaged over a year.

Basis

It is shown in Section 8.4.4 of the SAR, pages 8-18 through 8-23 that the release of argon 41 will be diluted by a factor of at least 40 in reaching a potential exposure site even in the poorest dispersion conditions. At a concentration level of 1×10^{-9} μCi/ml, for constant immersion, the maximum conceivable annual exposure will be 5 mrem to an individual and is well within acceptable limits. ~~at the above concentration will not result in exposures in unrestricted areas in excess of the limits of 10 CFR Part 20.~~

3.6 Ventilation System

Applicability

This specification applies to the operation of the reactor facility ventilation system.

Objective

The objective is to assure that the ventilation system is in operation to mitigate the consequences of the possible release of radioactive materials resulting from reactor operation.

Specification

The reactor shall not be operated unless the facility and building ventilation system is in operation and the emergency exhaust shutdown system has been verified to be operable within the preceding 30 days. An exception may be made for periods of time not to exceed two days to permit repairs to the system. During such periods of repair:

a. The reactor shall not be operated in the pulse mode; and

b. The reactor shall not be operated with experiments in place whose failure could result in the release of radioactive gases or aerosols.

Basis

It is shown in Section 8.7.5 of the SAR that operation of the emergency exhaust shutdown system reduces off-site doses to below 10 CFR Part 20 limits in the event of a TRIGA fuel element failure, and in 8.4.4 and 8.4.5 that operation of the normal system adequately dilutes the argon 41 released even under unusual experimental operations. The specifications governing operation of the reactor while the ventilation system is undergoing repair preclude the likelihood of fuel element failure during such times. It is shown in Section 8.6 that, if the reactor were to be operating at full steady-state power, fuel element failure will not occur even if all the reactor tank water were to be lost immediately.

3.7 Pool Water Level

Applicability

This specification applies to the pool water level.

Objective

The objectives are to assure that an adequate level of water is maintained above the core and that prompt corrective action will be initiated in the unlikely event that pool-water leaks from the tank.

Specification

The pool water level shall normally be maintained approximately 19 feet above the reactor top grid plate. A pool water level measuring channel shall sound an alarm at ~~in~~ the UCI Police Dispatch Desk ~~the Physical Plant Control Center~~ if the water level in the reactor tank drops to 13 feet or less above the top grid plate. The measuring channel shall be operable except during periods of maintenance on the channel. If the measuring channel is inoperable, the level of the pool water shall be verified to be normal by visual observation at least every ten (10) hours. Whenever the duration of inoperability exceeds five (5) consecutive days, the reactor shall not be operated until repairs are completed and normal operation of the water level measuring channel has been verified. If either the alarm actuates or visual observation indicates that water level is not normal, prompt corrective action shall be taken.

Basis

Section 8.6 of the SAR discusses the results of loss of pool water from the Irvine TRIGA reactor. Section 8.6.2 shows that fuel cladding rupture is unlikely even following operation at full licensed power. Calculations in Section 8.6.3 indicate that ten hours after a leak develops in the pool or five hours after the water level (13 ft) alarm sounds, the radiation levels in the room above the reactor facility would be 0.028 mr/hr with the reactor shutdown. Both instrument and visual monitoring at the intervals specified will provide adequate time for corrective action. Written procedures, approved in accordance with Specification 6.3, shall define emergency actions to be taken.

3.8 Limitations on Experiments

Applicability

This specification applies to experiments placed in the reactor and its experimental facility.

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 unless the following conditions exist:

a. Fueled experiments are limited such that the total inventory of iodine isotopes 131 through 135 in the experiment is not greater than 0.3 curies and the Strontium 90 inventory is not greater than 1 microcurie;

b. The quantity of known explosive materials to be irradiated is less than 25 milligrams and the pressure produced in the experiment container upon accidental detonation of the explosive has been experimentally determined to be less than the design pressure of the container; and

c. Experiments containing materials corrosive to reactor components, compounds highly reactive with water, potentially explosive materials or liquid fissionable materials are doubly encapsulated.

Basis

It is shown in the SAR p. 8.53, that a release of 0.024 curies of iodine activity will result in a maximum dose to the thyroid of a person in an unrestricted area of less than 1/20 of the permissible dose. The limit on iodine inventory is set at 10 times this value. The limit for Strontium 90 is that which corresponds to the iodine yield of 0.3 curies for a given number of fission events and would be no hazard. Specifications 3.8b and 3.8c reduce the likelihood of damage to reactor components resulting from experiment failure.

4.0 SURVEILLANCE REQUIREMENTS

4.1 Fuel

Applicability

This specification applies to the surveillance requirement for the fuel elements.

Objective

The objective is to assure that the dimensions of the fuel elements remain within acceptable limits.

Specifications

a. The standard fuel elements shall be measured for length and bend at intervals separated by not more than 500 pulses of magnitude greater than $1.00 of reactivity, but the intervals shall not exceed 36 months. Fuel follower control rods shall be measured for bend at the same time interval.

b. A fuel element indicating an elongation greater than 1/10 of an inch over its original length or a lateral bending greater than 1/16 of an inch over its original bending shall be considered to be damaged and shall not be used in the core for further operation.

   A fuel follower control rod shall be considered to be damaged and shall not be used for further operation if it indicates a lateral bending greater than 1/16 of an inch over the fuel containing portion of the rod.

c. Fuel elements in the B- and C-ring shall be measured for possible distortion in the event that there is indication that fuel temperatures greater than the limiting safety system setting on temperature may have been exceeded.

Bases

The most severe stresses induced in the fuel elements result from pulse operation of the reactor, during which differential expansion between the fuel and the cladding occurs and the pressure of the gases within the elements increases sharply. The above limits on the allowable distortion of a fuel element have been shown to correspond to strains that are considerably lower than the strain expected to cause rupture of a fuel element and have been successfully ap lied at other TRIGA installations. The surveillance interval is selected based on the past history of more frequent , uneventful, inspections for over 20 years at this facility and experience at other TRIGA facilities with similar power levels, fuel type, and operational modes. It is also designed to reduce the possibilities of mechanical failures as a result of handling elements, and to minimize potential radiation exposures to personnel.

4.2 Control Rods

Applicability

This specification applies to the surveillance requirements for the control rods.

Objective

The objective is to assure the integrity of the control rods.

Specifications

a. The reactivity worth of each control rod shall be determined annually, but at intervals not to exceed eighteen months.

b. Control rod drop times shall be determined annually, but at intervals not to exceed eighteen months.

c. The control rods shall be visually inspected for deterioration at intervals not to exceed three years.

d. On each day that pulse mode operation of the reactor is planned, a functional performance check of the transient (pulse) rod system shall be performed.

   Annually, at intervals not to exceed eighteen months, the transient (pulse) rod drive cylinder and the associated air supply system shall be inspected, cleaned, and lubricated as necessary.

Bases

The reactivity worth of the control rods is measured to assure that the required shutdown margin is available and to provide a means for determining the reactivity worths of experiments inserted in the core. The visual inspection of the control rods and measurement of their drop times are made to determine whether the control rods are capable of performing properly. The surveillance intervals are selected based on the past history of more frequent , uneventful, inspections for over 20 years at this facility and experience at other TRIGA facilities with similar power levels, fuel type, and operational modes. They are also designed to reduce the possibilities of mechanical failures as a result of handling control rods, and to minimize radiation exposures to personnel.

4.3 Reactor Safety System

Applicability

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

Objective

The objective is to assure that the safety system will remain operable and will prevent the fuel temperature safety limit from being exceeded.

Specifications

a. A channel test of each of the reactor safety system channels shall be performed prior to each day's operation or prior to each operation extending more than one day.

b. A channel check of the fuel element temperature measuring channel shall be performed daily whenever the reactor is in operation or when pulse operation is planned.

c. A channel check of the power level measuring channels shall be performed daily whenever the reactor is in operation.

d. A channel calibration by the calorimetric method shall be made of the power level monitoring channels annually, but at intervals not to exceed eighteen months.

e. A calibration of the temperature measuring channels shall be performed annually, but at intervals not to exceed eighteen months. This calibration shall consist of introducing electric potentials in place of the thermocouple input to the channels.

f. A verification of the original calibration of the temperature measuring channels shall be performed annually, but at intervals not to exceed eighteen months. This verification shall consist of. comparing the measured temperature in a reference core at a known power level with the temperature measured in the reference core during the initial startup of the reactor.

Basis

The daily tests and channel checks will assure that the safety channels are operable. The annual calibrations and verifications will permit any long-term drift of the channels to be corrected. The history of operations at this facility over the last 20 years has shown that annual checks will allow correction for the very small amounts of drift observed.

4.4 Pool Water Level Channel

Applicability

This specification applies to the pool water level channel required by Section 3.7 of these specifications.

Objective

The objective is to assure that the channel is operable.

Specifications

The pool water level measuring channel shall be verified to be operable at intervals not to exceed two months.

Basis

This verification will assure that a continued warning system for a loss-of-coolant accident is maintained,

4.5 Radiation Monitoring Equipment

Applicability

This specification applies to the radiation monitoring equipment required by Section 3.3 of these specifications.

Objective

The objective is to assure that the radiation monitoring equipment is operating and to verify the appropriate alarm settings.

Specification

The alarm -set points for the radiation monitoring instrumentation shall be verified daily during periods when the reactor is in operation.

Basis

Surveillance of the equipment will assure that sufficient protection against radiation is available.

4.6 Maintenance

Applicability

This specification applies to the surveillance requirements following maintenance of control or safety system.

Objective

The objective is to assure that a system is operable before being used after maintenance has been performed.

Specification

Following maintenance or modification of a control or safety system or component, it shall be verified that the system is operable prior to its return to service.

Basis

This specification assures that work on the system or component has been properly carried out and that the system or component has been properly reinstalled or reconnected before reliance for safety is placed on it.

5.0 DESIGN FEATURES

5.1 Reactor Fuel

Applicability

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

Objective

The objective is to assure that the fuel elements are of such a design and fabricated in such a manner as to permit their use with a high degree of reliability with respect to their mechanical integrity.

Specifications

a. Standard Fuel Element: The standard fuel element shall contain uranium-zirconium hydride, clad in 0.020 inch of 304 stainless steel. It shall contain a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20 percent. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atom.

b. Loading: The elements shall be placed in a closely packed array except for experimental facilities or for single positions occupied by control rods and a neutron start-up source.

Basis

These types of fuel elements have a long history of successful use in TRIGA reactors.

5.2 Reactor Building

Applicability

This specification applies to the building which houses the reactor facility.

Objective

The objective is to assure that provisions are made to restrict the amount of release of radioactivity from the reactor facility.

Specifications

a. The reactor shall be housed in a closed room designed to restrict leakage when in operation, when the facility is unmanned, or when spent fuel is being handled exterior to a cast.

b. The minimum free volume of the reactor room shall be 1,000 cubic feet.

c. The building shall be equipped with a ventilation system capable of exhausting air or other gases from the reactor room at a minimum of 70 feet above ground level.

Basis

In order that the movement of air can be controlled, the reactor area contains no windows that can be opened. The room air is exhausted through an independent exhaust and discharged at roof level with other exhausts to provide dilution.

5.3 Fuel Storage

Applicability

This specification applies to the storage of reactor fuel at times when it is not in the reactor core.

Objective

The objective is to assure that fuel which is being stored will not become supercritical and will not reach unsafe temperatures.

Specifications

a. All fuel elements shall be stored in a geometrical array where the keff is less than 0.8 for all conditions of moderation.

b. Irradiated fuel elements and fuel devices shall be stored in an array which will permit sufficient natural convection cooling by water or air such that the fuel element or fueled device temperature will not exceed 800°C.

Basis

New fuel is stored in their shipping containers. Hot fuel is stored in pits described in the submittal dated June 5, 1969. These pits are designed to hold 19 elements, an amount which cannot form a critical array. Very hot fuel is stored in racks in the main tank where cooling water is provided.

6.0 ADMINISTRATIVE CONTROLS

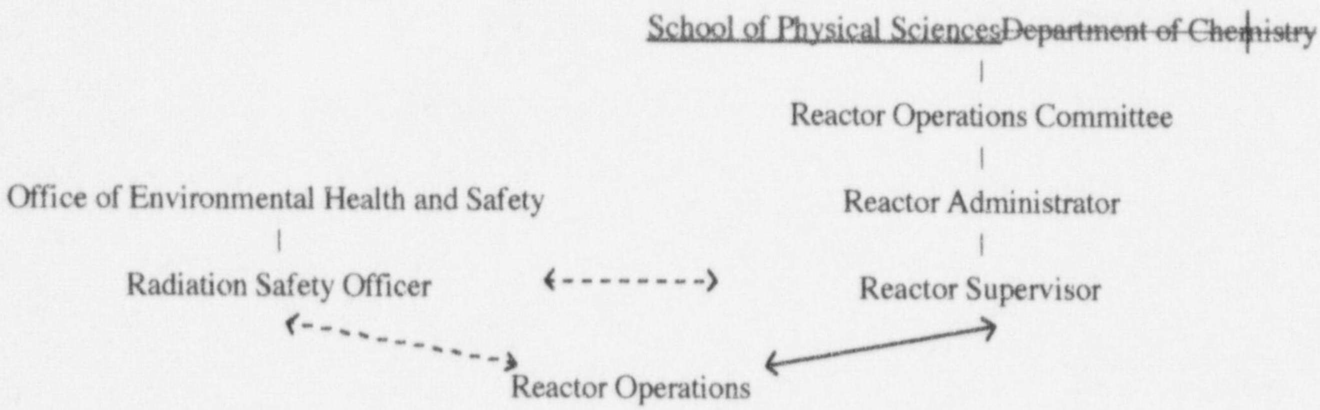
6.1 Organization

a. The reactor facility shall be an integral part of the ~~Chemistry Department of the~~ School of Physical Sciences of the University of California, Irvine. The reactor shall be related to the University structure as shown in Chart I.

b. The reactor facility shall be under the direction of the Reactor Administrator who shall be a tenure member of the UCI~~Chemistry Department~~ faculty and supervised by a~~the~~ Reactor Supervisor who shall be a qualified licensed senior operator for the facility. The Reactor Supervisor~~He~~ shall be responsible for assuring that all operations are conducted in a safe manner and within the limits prescribed by the facility license and the provisions of the Reactor Operations Committee.

c. There shall be a Radiation Safety Officer responsible for the safety of operations from the standpoint of radiation protection. The Radiation Safety Officer~~He~~ shall report to the Office of Environmental Health and Safety which is an organization independent of the reactor operations organization as shown in Chart I.

CHART I



6.2 Review

a. There shall be a Reactor Operations Committee which shall review reactor operations to assure that the facility is operated in a manner consistent with public safety and within the terms of the facility license.

b. The responsibilities of the Committee include, but are not limited to the following:

1. Review and approval of experiments utilizing the reactor facilities;
2. Review and approval of all proposed changes to the facility, procedures, and Technical Specifications;
3. Determination of whether a proposed change, test, or experiment would constitute an unreviewed safety question or a change in the Technical Specifications;
4. Review of the operation and operational records of the facility;
5. Review of abnormal performance of plant equipment and operating anomalies;
6. Review of unusual or abnormal occurrences and incidents which are reportable under 10 CFR 20 and 10 CFR 50; and
7. Approval of individuals for the supervision and operation of the reactor.

c. The Committee shall be composed of at least five members, one of whom shall be a health physicist designated by the Office of Environmental Health and Safety of the University. The Committee shall be proficient in all areas of reactor operation and reactor safety. The membership of the Committee shall include at least one~~two~~ members who is~~are~~ not associated with the School of Physical Sciences.~~Department of Chemistry~~.

d. The Committee shall have a written statement defining such matters as the authority of the Committee, the subjects within its purview, and other such administrative provisions as are required for effective functioning of the Committee. Minutes of all meetings of the Committee shall be kept.

e. A quorum of the Committee shall consist of not less than a majority of the full Committee and shall include the chairman or his designee.

f. The Committee shall meet at least semi-annually, at intervals not to exceed nine months.

6.3 Operating Procedures

Written procedures, reviewed and approved by the Reactor Operations Committee, shall be in effect and followed for the following items. The procedures shall be adequate to assure the safety of the reactor but should not preclude the use of independent judgment and action should the situation require such.

a. Startup, operation, and shutdown of the reactor.

b. Installation or removal of fuel elements, control rods, experiments, and experimental facilities.

c. Actions to be taken to correct specific and foreseen potential malfunctions of systems or components, including responses to alarms, suspected primary coolant system leaks, and abnormal reactivity changes.

d. Emergency conditions involving potential or actual release of radioactivity, including provisions for evacuation, re-entry, recovery, and medical support.

e. Maintenance procedures which could have an effect on reactor safety.

f. Periodic surveillance of reactor instrumentation and safety systems, area monitors and continuous air monitors.

Substantive changes to the above procedures shall be made only with the approval of the Reactor Operations Committee. Temporary changes to the procedures that do not change their original intent may be made by the Reactor Supervisor. All such temporary changes to procedures shall be documented and subsequently reviewed by the Reactor Operations Committee.

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

In the event a safety limit is exceeded, or thought to have been exceeded:

a. The reactor shall be shut down and reactor operation shall not be resumed until authorized by the NRC~~AEC~~.

b. An immediate report of the occurrence shall be made to the Chairman of the Reactor Operations Committee, and reports shall be made to the NRC~~AEC~~ in accordance with Section 6.7 of these specifications.

c. A report shall be made which shall include an analysis of the causes and extent of possible resultant damage, efficacy of corrective action, and recommendations for measures to prevent or reduce the probability of reoccurrence. This report shall be submitted to the Reactor Operations Committee for review, and a suitable similar report submitted to the NRC~~AEC~~ when authorization to resume operation of the reactor is sought.

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

In the event of an abnormal occurrence, as defined in Section 1.13 of the specifications, the following action shall be taken:

a. The Reactor Supervisor shall be notified and corrective action taken prior to resumption of the operation involved.

b. A report shall be made which 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 reoccurrence. This report shall be submitted to the Reactor Operations Committee for review.

c. Where appropriate, a report shall be submitted to the NRC~~AEC~~ in accordance with Section 6.7 of these specifications.

6.6 Plant Operating Records

a. In addition to the requirements of applicable regulations, and in no way substituting therefor, records and logs shall be prepared and retained for a period of at least 5 years of the following items, as a minimum:

1. Normal plant operation;
2. Principal maintenance activities;
3. Abnormal occurrences;
4. Equipment and component surveillance activities;
5. Gaseous and liquid radioactive effluents released to the environs;
6. Off-site environmental monitoring surveys;
7. Fuel inventories and transfers;
8. Facility radiation and contamination surveys;
9. Radiation exposures for all personnel;
10. Experiments performed with the reactor.

b. Updated, corrected, and as-built drawings of the facility shall be retained for the facility life.

6.7 Reporting Requirements

In addition to the requirements of applicable regulations, and in no way substituting therefore, reports shall be made to the NRC~~AEC~~ as follows:

a. An immediate report (by telephone and telegraph to the NRC~~AEC~~ Headquarters~~Region V Compliance~~ Office) of:

1. Any accidental off-site release of radioactivity above permissible limits, whether or not the release resulted in property damage, personal injury or exposure; and
2. Any violation of a safety limit.

b. A report within 24 hours (by telephone or telegraph to the NRC~~AEC~~ Headquarters~~Region V Compliance~~ Office) of:

1. Any significant variation of measured values from a corresponding predicted or

previously measured value of safety-connected operating characteristics occurring during operation of the reactor;

2. Incidents or conditions relating to operation of the facility which prevented or could have prevented the performance of engineered safety features as described in these specifications; and

3. Any abnormal occurrences as defined in Section 1.13 of these specifications.

c. A report within 10 days (in writing to the Document Control Desk~~Director, Division of Reactor Licensing~~, USNRC~~AEC~~, Washington, D. C. 20555~~20545~~) of:

1. Any significant variation of measured values from a corresponding predicted or previously measured value of safety-connected operating characteristics occurring during operation of the reactor;

2. Incidents of conditions relating to operation of the facility which prevented or could have prevented the performance of engineered safety features as described in these specifications; and

3. Any abnormal occurrences as defined in Section 1.13 of these specifications.

d. A report within 30 days (in writing to the Document Control Desk~~Director, Division of Reactor Licensing~~, USNRC~~AEC~~, Washington, D. C. 20555~~20545~~) of:

1. Any substantial variance from performance specifications contained in these specifications or in the Safety Analysis Report;

2. Any significant change in the transient or accident analyses as described in the Safety Analysis Report;

3. Any changes in facility organization; and

4. Any observed inadequacies in the implementation of administrative or procedural controls.

e. A report within 60 days after criticality of the reactor (in writing to the Document Control Desk~~Director, Division of Reactor Licensing~~, USNRC~~AEC~~, Washington, D. C. 20555~~20545~~) upon receipt of a new facility license or an amendment to the license authorizing an increase in reactor power level or the installation of a new core, describing the measured values of the operating conditions or characteristics of the reactor under the new conditions, including:

1. Total control rod reactivity worth;

2. Reactivity worth of the single control rod of highest reactivity worth;

3. Total and individual reactivity worths of any experiments inserted in the reactor; and

4. Minimum shutdown margin both at room and operating temperatures.

f. A routine report in writing to the Document Control Desk~~Director, Division of Reactor Licensing~~, USNRC~~AEC~~, Washington, D. C. 20555~~20545~~) within 60 days after completion of the first six months of facility operation and at the end of each 12-month period thereafter, providing the following information:

1. A narrative summary of operating experience (including experiments performed) and of changes in facility design, performance characteristics and operating procedures related to reactor safety occurring during the reporting period;

2. A tabulation showing the energy generated by the reactor (in megawatt hours), the amount of pulse operation, the number of hours the reactor was critical;

3. The number of emergency shutdowns and inadvertent scrams, including the reasons therefore;

4. Discussion of the major maintenance operations performed during the period, including the effect, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required;

5. A summary of each change to the facility or procedures, tests, and experiments carried out under the conditions of Section 50.59 of 10 CFR 50;

6. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or prior to the point of such release or discharge;

7. A description of any environmental surveys performed outside the facility; and

8. A summary of radiation exposures received by facility personnel and visitors, including the dates and time of significant exposures, and a summary of the results of radiation and contamination surveys performed within the facility.

6.8 Review of Experiments

a. All proposed experiments utilizing the reactor shall be evaluated in writing by the experimenter and the Reactor Supervisor (and the Radiation Safety Officer when appropriate) to assure compliance with the provisions of the utilization license, theTechnical Specifications, and 10 CFR 20. If, in the judgment of the Reactor Supervisor, the experiment meets with the above provisions and is not an "untried experiment" ~~he shall schedule~~ the experiment may be scheduled. Otherwise it will be ~~he shall~~ submitted ~~it~~ to another member of the Reactor Operations Committee for written evaluation and thence to the Reactor Operations Committee for final approval as indicated in Section 6.2 above. When pertinent, the evaluation shall include:

   1. The reactivity worth of the experiment;

   2. The integrity of the experiment, including the effects of changes in temperature, pressure, or chemical composition;

   3. Any physical or chemical interaction that could occur with the reactor components; and

   4. Any radiation hazard that may result from the activation of materials or from external beams.

b. Prior to the performing of an experiment not previously performed in the reactor, it shall be reviewed and approved in writing by the Reactor Operations Committee. Their review shall consider the following information:

   1. The purpose of the experiment;

   2. A procedure for the performance of the experiment; and

   3. The written evaluations made as in Paragraph a. above.

c. A request for radioisotopes or the irradiation of materials shall be handled in the same manner as many other experiment except that a series of irradiations can be approved as one experiment. The expiration date for such approvals shall be one year or the expiration date of the applicant's appropriate radioactive materials license. For each irradiation, the applicant shall submit an "Irradiation Request" to the Reactor Supervisor. Thisd request shall contain information on the target material including the amount, chemical form, and packaging. For the purposes of Paragraph a. above, routine irradiations, which do not contain nuclear fuel or known explosive materials and which do not constitute a significant threat to the integrity of the reactor or to the safety of individuals, may be classified as "tried experiments".

d. In evaluating experiments, the following assumptions shall be used for the purpose of determining whether failure of the experiment would cause the appropriate limits of

10 CFR 20 to be exceeded:

1. If the possibility exists that airborne concentrations of radioactive gases or aerosols may be released within the facility, 100 percent of the gases or aerosols will escape;
2. If the effluent exhausts through a filter installation designed for greater than 99 percent efficeincy for 0.3 micron particles, at least 10% of gases or aerosols will escape; and
3. For a material whose boiling point is above 55°C and where vapors formed by boiling this material could escape only through a column of water above the core, at least 10% of these vapors will escape.

Final Version

TECHNICAL SPECIFICATIONS

FOR THE

UNIVERSITY OF CALIFORNIA, IRVINE
TRIGA MARK I NUCLEAR REACTOR

REVISED:

NOVEMBER 1998

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1.0 DEFINITIONS

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

1.1 Reactor Shutdown - The reactor is in a shutdown condition when sufficient control rods are inserted so as to assure that it is subcritical by at least $1.00 of reactivity.

1.2 Reactor Secured - The reactor is secured when all. the following conditions are satisfied:

a. The reactor is shutdown;

b. Power to the control rod magnets and actuating solenoids is off, and the key removed;

c. No work is in progress involving fuel or in-core experiments or maintenance of the core structure, control rods, or control rod drive mechanisms.

1.3 Reactor Operation - The reactor is in operation when it is not secured.

1.4 Standard Control Rod - A standard control rod is one having rack and pinion, electric motor drive, and scram capability.

1.5 Transient Control Rod

a. Adjustable Transient Rod - an adjustable transient rod is one having both pneumatic and electro-mechanical drives and with scram capability.

b. Fast Transient Rod - A fast transient rod is one that is pneumatically operated and has scram capability.

1.6 Operable - A system or device is operable when it is capable of performing its intended functions in a normal manner.

1.7 Cold Critical - The reactor is in the cold critical condition when it is critical with the fuel and bulk water temperatures the same (≈20°C).

1.8 Steady-State Mode - The reactor is in the steady-state mode when the reactor mode selection switch is in the steady-state or automatic position. In this mode, reactor power is held constant or is changed on periods greater than three seconds.

1.9 Pulse Mode - The reactor is in the pulse mode when the reactor mode selection switch is in the pulse position. In this mode, reactor power is increased on periods less than one second by motion of the transient control rod(s).

1.10 Experiment - An experiment is:

a. Any apparatus, 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;

b. Any operation designed to measure reactor characteristics.

1.11 Untried Experiment - An untried experiment is any experiment not previously performed in this reactor.

1.12 Experimental Facilities - Experimental facilities are the pneumatic transfer systems, central thimble, rotary specimen rack, and the in-core facilities (including single element positions, three-element positions, and the seven element position).

1.13 Abnormal Occurrence - An abnormal occurrence is any of the following:

a. Any actual safety system setting less conservative than specified in the Limiting Safety System Settings section of the Technical Specifications;

b. Operation in violation of a limiting condition for operation;

c. An engineered safety system component failure which could render the system incapable of performing its intended function;

d. Release of fission products from a fuel element;

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 could have caused the existence or development of an unsafe condition in connection with the operation of the reactor.

1.14 Standard Thermocouple Fuel Element - A standard thermocouple fuel element is a standard fuel element containing three sheathed thermocouples imbedded near the axial and radial center of the fuel element.

1.15 Measured Value - The measured value of a process variable is the value of the variable as it appears on the output of a channel.

1.16 Measuring Channel - A measuring channel is the combination of sensor, lines, amplifiers and output device which are connected for the purpose of measuring the value of a process variable.

1.17 Reactor Safety System - The reactor safety system is that combination of channels and associated circuitry which forms the automatic protective system for the reactor or provides information which requires manual protective action to be initiated.

1.18 Operating - Operating means a component or system is performing its intended function in its normal manner.

1.19 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 other independent channels or methods measuring the same variable.

1.20 Channel Test - A channel test is the introduction of a signal into the channel to verify that it is operable.

1.21 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 which the channel measures.

1.22 Reference Core - A reference core is a core with a configuration similar to the core configuration existing at the initial start-up of the reactor.

1.23 Ring - A ring is one of the six concentric bands of fuel elements surrounding the central opening of the core. The rings are designated by the letters B through G, with the letter B used to designate the innermost band.

1.24 Three Element Positions - Two generally triangular-shaped sections cut out of the upper grid plate, one encompassing ring holes D5, E6 and E7 and the other D14, E18 and E19. When fuel elements are placed in these locations a special fixture provides lateral support. With the fixture and fuel removed, an experiment up to 2.4 in. in diameter may be inserted.

1.25 Seven Element Position - A hexagonal section which can be removed from the upper grid plate for insertion of specimens up to 4.4 in. in diameter after relocation of the six B-ring elements and removal of the central thimble.

1.26 Closed Packed Array - A closed packed array is a fuel loading pattern in which the fuel elements are arranged in the core by filling the inner rings first.

1.27 Surveillance Activities - Activities required at pre-defined intervals to assure performance of reactor and safety related components. During prolonged periods when the reactor remains shutdown, Technical Specification Surveillance Requirements 4.1 (fuel element dimensions), 4.2 (control rod integrity), and 4.3 (fuel temperature safety limit) may be deferred. However, they must be completed prior to reactor start-up except for 4.2 (a), 4.3 (d), and 4.3 (f) which require reactor operation in order to be accomplished.

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limit - Fuel Element Temperature

Applicability

This specification applies to the fuel element temperature.

Objective

The objective is to define the maximum fuel element temperature that can be permitted with confidence that no fuel element cladding damage will result.

Specification

The temperature in a stainless steel clad, high hydride fuel element shall not exceed 1000°C under any conditions of operation.

Bases

The safety limitations of the TRIGA fuel are described in the Safety Analysis Report (SAR) for the UC Irvine TRIGA, Section 8. The important process variable for a TRIGA reactor is the fuel element temperature. This parameter is well suited as a single specification since it can be measured. A loss in the integrity of the fuel element cladding could arise from an excessive build-up of pressure between the fuel moderator and the cladding. The pressure is caused by the presence of fission product gases and the dissociation of the hydrogen and zirconium in the fuel moderator. The magnitude of this pressure is determined by the fuel moderator temperature.

The safety limit for the stainless steel clad, high hydride ($ZrH_{1.7}$) fuel element is based on data (SAR pages 8.38 through 8.40 and University of Illinois SAR pages III-56 through III-59) which indicate that the stress in the cladding (due to the hydrogen pressure from the dissociation of the zirconium hydride) will remain below the yield stress provided the temperature of the fuel does not exceed 1000°C.

2.2 Limiting Safety System Settings

Applicability

This specification applies to the trip setting for the fuel element temperature channel.

Objective

The objective is to prevent the safety limit from being exceeded.

Specification

For a core composed entirely of stainless steel clad, high hydride fuel elements, limiting safety system settings apply according to the location of the standard thermocouple fuel element which shall be located in the B-or C-ring as indicated in the following table:

Location	Limiting Safety System Setting
B-ring	800°C
C-ring	755°C

Bases

Stainless steel clad, high hydride fuel element: The limiting safety system settings that are indicated represent values of the temperature, which if exceeded, shall cause the reactor safety system to initiate a reactor scram. Since the fuel element temperature is measured by a fuel element designed for this purpose, the limiting settings are given for different locations in the fuel array. Under these conditions, it is assumed that the core is loaded so that the maximum fuel temperature is produced in the B-ring. If the fuel element temperature is measured in the C-ring, the respective temperature is the limiting safety system setting.

3.0 LIMITING CONDITIONS FOR OPERATION

3.1 Reactivity

Applicability

These specifications apply to the reactivity condition of the reactor, and the reactivity worths of control rods and experiments, and apply for all modes of reactor operation.

Objective

The objective is to assure that the reactor can be shut down at all times and to assure that the fuel temperature safety limit will not be exceeded.

Specifications

The reactor shall not be operated unless the following conditions exist:

a. The shutdown margin referred to the cold, xenon-free condition, with the highest worth rod fully withdrawn, is greater than \$0.50;

b. The total reactivity worth of the two transient control rods is less than \$3.00;

c. Any experiment with a reactivity worth greater than \$1.00 is securely fastened so as to prevent unplanned removal from or insertion into the reactor;

d. The excess reactivity is less than \$3.00;

e. The reactivity worth of an individual experiment is not more than \$3.00;

f. The total reactivity worth of all experiments is limited so that the shutdown margin referred to the cold xenon-free condition with all rods in is at least \$0.50;

g. The total of the absolute values of the reactivity worth of all experiments in the reactor is less than \$3.00;

h. The drop time of a standard control rod from the fully withdrawn position to 90 percent of full reactivity insertion is less than one second; and

i. The neutron power level indication on the startup channel is greater than 1×10^{-7}% of full power..

Bases

The shutdown margin required by specification 3.1a is necessary so that the reactor can be shut down from any operating condition and remain shutdown after cooldown and xenon decay even if one control rod (including a transient control rod) should stick in the fully withdrawn position.

Specification 3.1b is based on Section 8.5 of the SAR. The power level at which a pulse could be initiated in an accident may be as high as 100°C At 100 kw, the peak temperature of the fuel will be 115°C. The calculations indicate that a \$3.00 pulse will result in a peak temperature of only 502°C, well below the safety limit.

Specification 3.1c is based on the same calculations. By restricting each experiment to $1.00, an additional margin is provided to allow for considerable uncertainty in experiment worth.

Specification 3.1c through 3.1g are intended to provide additional margins between those values of reactivity changes encountered during the course of operations involving experiments and those values of reactivity which, if exceeded, might cause a safety limit to be exceeded.

Specification 3.1 h is intended to assure prompt shutdown of the reactor in the event a scram signal is received.

Specification 3.1 i is intended to assure that sufficient neutrons are available in the core to provide a signal at the output of the startup channel during approaches to criticality.

3.2 Pulse Operation

Applicability

These specifications apply to operation of the reactor in the pulse mode.

Objective

The objective is to prevent the fuel temperature safety limit from being exceeded during pulse mode operation.

Specifications

The reactor shall not be operated in the pulse mode unless, in addition to the requirements of Section 3.1, the following conditions exist:

a. The transient rods are set such that their reactivity worth upon withdrawal is less than $3.00; and

b. The steady-state power level of the reactor is not greater than 1 kilowatt.

Bases

Specification 3.2a is based on Figure 7-4 of the SAR which shows that the temperature rise expected for a pulse insertion of $3.00 is less than 500°C.

Specification 3.2b is intended to prevent inadvertent pulsing from a high steady-state power level such that the final peak temperature might approach the safety limit.

3.3 Reactor Instrumentation

Applicability

This specification applies to the information which must be available to the reactor operator during reactor operation.

Objective

The objective is to require that sufficient information is available to the operator to assure safe operation of the reactor.

Specification

The reactor shall not be operated unless the measuring channels described in the following table are operable and the information is displayed in the control room:

Measuring Channel	Minimum Number Operable	Operating Mode in which Required
Fuel Element Temperature	1	All Modes
Reactor Power Level	2	Steady-State
Reactor Power Level (high range)	1	Pulse Mode
Startup Power Level	1	During Reactor Startup
Area Radiation Monitors	2	All Modes
Continuous Air Radiation Monitor	1	All Modes

Bases

The fuel temperature displayed at the control console gives continuous information on the process variable which has a specified safety limit.

The neutron detectors assure that measurements of the reactor power level are adequately covered at both low and high power ranges.

The radiation monitors provide information to operating personnel of any impending or existing danger from radiation so that there will be sufficient time to evacuate the facility and take the necessary steps to prevent the spread of radioactivity to the surroundings.

3.4 Reactor Safety System

Applicability

This specification applies to the reactor safety system channels.

Objective

The objective is to require the minimum number of reactor safety system channels that must be operable in order to assure that the fuel temperature safety limit is not exceeded.

Specification

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

Measuring Channel	Minimum Number Operable	Function	Operating Mode in which Required
Fuel Element Temperature	1	Scram	All Modes
Reactor Power level	1	Scram	Steady-State Mode
Reactor Power Level	1	Prevent transient rods firing when power is >1 kilowatt	Pulse Mode
Manual Button	1	Scram	All Modes
Seismic Switch	1	Scram	All Modes
Startup Power level	1	Prevent control rod withdrawal when power level indication is less than 1×10^{-7} %.	Reactor Startup
Standard Control Rod Position	1	Prevent application of air to fast transient rod when all other rods are not fully inserted	Steady-State Mode
Adjustable Transient Cylinder Position	1	Prevent application of air to adjustable transient rod unless cylinder is fully down	Steady-State Mode

Bases

The interlocks which prevent the firing of the transient rods in the steady-state mode or if the power level is greater than 1 kilowatt prevent inadvertent pulses. The interlock to prevent startup of the reactor with less than 1×10^{-7}% power indicated on the startup channel assure that sufficient neutrons are available to assure proper operation of the startup channel.

The fuel temperature scram provides the protection to assure that if a condition results in which the limiting safety system setting is exceeded, an immediate shutdown will occur to keep the fuel temperature below the safety limit. The power level scram is provided as added protection against abnormally high fuel temperature and to assure that reactor operation stays within the licensed limits. The manual scram allows the operator to shut down the system if an unsafe or abnormal condition occurs. The seismic switch will shut down the reactor if major earth movement (M.M. VI or above) occurs in case the operator is prevented from operating the manual scram at the time.

3.5 Release of Argon 41

Applicability

This specification applies to the release of radioactive argon 41 from the facility exhaust system.

Objective

The objective is to assure that exposures to the public resulting from the release of argon 41 generated by reactor operation, will not exceed the limits of 10 CFR Part 20 for unrestricted areas.

Specification

Releases of argon 41 from the reactor room exhaust shall not be made in concentrations greater than 4×10^{-8} μc/ml averaged over a year.

Basis

It is shown in Section 8.4.4 of the SAR, pages 8-18 through 8-23 that the release of argon 41 will be diluted by a factor of at least 40 in reaching a potential exposure site even in the poorest dispersion conditions. At a concentration level of 1×10^{-9} μCi/ml, for constant immersion, the maximum conceivableannual exposure will be 5 mrem to an individual and is well within acceptable limits.

3.6 Ventilation System

Applicability

This specification applies to the operation of the reactor facility ventilation system.

Objective

The objective is to assure that the ventilation system is in operation to mitigate the consequences of the possible release of radioactive materials resulting from reactor operation.

Specification

The reactor shall not be operated unless the facility and building ventilation system is in operation and the emergency exhaust shutdown system has been verified to be operable within the preceding 30 days. An exception may be made for periods of time not to exceed two days to permit repairs to the system. During such periods of repair:

a. The reactor shall not be operated in the pulse mode; and

b. The reactor shall not be operated with experiments in place whose failure could result in the release of radioactive gases or aerosols.

Basis

It is shown in Section 8.7.5 of the SAR that operation of the emergency exhaust shutdown system reduces off-site doses to below 10 CFR Part 20 limits in the event of a TRIGA fuel element failure, and in 8.4.4 and 8.4.5 that operation of the normal system adequately dilutes the argon 41 released even under unusual experimental operations. The specifications governing operation of the reactor while the ventilation system is undergoing repair preclude the likelihood of fuel element failure during such times. It is shown in Section 8.6 that, if the reactor were to be operating at full steady-state power, fuel element failure will not occur even if all the reactor tank water were to be lost immediately.

3.7 Pool Water Level

Applicability

This specification applies to the pool water level.

Objective

The objectives are to assure that an adequate level of water is maintained above the core and that prompt corrective action will be initiated in the unlikely event that pool-water leaks from the tank.

Specification

The pool water level shall normally be maintained approximately 19 feet above the reactor top grid plate. A pool water level measuring channel shall sound an alarm at the UCI Police Dispatch Desk if the water level in the reactor tank drops to 13 feet or less above the top grid plate. The measuring channel shall be operable except during periods of maintenance on the channel. If the measuring channel is inoperable, the level of the pool water shall be verified to be normal by visual observation at least every ten (10) hours. Whenever the duration of inoperability exceeds five (5) consecutive days, the reactor shall not be operated until repairs are completed and normal operation of the water level measuring channel has been verified. If either the alarm actuates or visual observation indicates that water level is not normal, prompt corrective action shall be taken.

Basis

Section 8.6 of the SAR discusses the results of loss of pool water from the Irvine TRIGA reactor. Section 8.6.2 shows that fuel cladding rupture is unlikely even following operation at full licensed power. Calculations in Section 8.6.3 indicate that ten hours after a leak develops in the pool or five hours after the water level (13 ft) alarm sounds, the radiation levels in the room above the reactor facility would be 0.028 mr/hr with the reactor shutdown. Both instrument and visual monitoring at the intervals specified will provide adequate time for corrective action. Written procedures, approved in accordance with Specification 6.3, shall define emergency actions to be taken.

3.8 Limitations on Experiments

Applicability

This specification applies to experiments placed in the reactor and its experimental facility.

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 unless the following conditions exist:

a. Fueled experiments are limited such that the total inventory of iodine isotopes 131 through 135 in the experiment is not greater than 0.3 curies and the Strontium 90 inventory is not greater than 1 microcurie;

b. The quantity of known explosive materials to be irradiated is less than 25 milligrams and the pressure produced in the experiment container upon accidental detonation of the explosive has been experimentally determined to be less than the design pressure of the container; and

c. Experiments containing materials corrosive to reactor components, compounds highly reactive with water, potentially explosive materials or liquid fissionable materials are doubly encapsulated.

Basis

It is shown in the SAR p. 8.53, that a release of 0.024 curies of iodine activity will result in a maximum dose to the thyroid of a person in an unrestricted area of less than 1/20 of the permissible dose. The limit on iodine inventory is set at 10 times this value. The limit for Strontium 90 is that which corresponds to the iodine yield of 0.3 curies for a given number of fission events and would be no hazard. Specifications 3.8b and 3.8c reduce the likelihood of damage to reactor components resulting from experiment failure.

4.0 SURVEILLANCE REQUIREMENTS

4.1 Fuel

Applicability

This specification applies to the surveillance requirement for the fuel elements.

Objective

The objective is to assure that the dimensions of the fuel elements remain within acceptable limits.

Specifications

a. The standard fuel elements shall be measured for length and bend at intervals separated by not more than 500 pulses of magnitude greater than $1.00 of reactivity, but the intervals shall not exceed 36 months. Fuel follower control rods shall be measured for bend at the same time interval.

b. A fuel element indicating an elongation greater than 1/10 of an inch over its original length or a lateral bending greater than 1/16 of an inch over its original bending shall be considered to be damaged and shall not be used in the core for further operation.

   A fuel follower control rod shall be considered to be damaged and shall not be used for further operation if it indicates a lateral bending greater than 1/16 of an inch over the fuel containing portion of the rod.

c. Fuel elements in the B- and C-ring shall be measured for possible distortion in the event that there is indication that fuel temperatures greater than the limiting safety system setting on temperature may have been exceeded.

Bases

The most severe stresses induced in the fuel elements result from pulse operation of the reactor, during which differential expansion between the fuel and the cladding occurs and the pressure of the gases within the elements increases sharply. The above limits on the allowable distortion of a fuel element have been shown to correspond to strains that are considerably lower than the strain expected to cause rupture of a fuel element and have been successfully applied at other TRIGA installations. The surveillance interval is selected based on the past history of more frequent , uneventful, inspections for over 20 years at this facility and experience at other TRIGA facilities with similar power levels, fuel type, and operational modes. It is also designed to reduce the possibilities of mechanical failures as a result of handling elements, and to minimize potential radiation exposures to personnel.

4.2 Control Rods

Applicability

This specification applies to the surveillance requirements for the control rods.

Objective

The objective is to assure the integrity of the control rods.

Specifications

a. The reactivity worth of each control rod shall be determined annually, but at intervals not to exceed eighteen months.

b. Control rod drop times shall be determined annually, but at intervals not to exceed eighteen months.

c. The control rods shall be visually inspected for deterioration at intervals not to exceed three years.

d. On each day that pulse mode operation of the reactor is planned, a functional performance check of the transient (pulse) rod system shall be performed.

   Annually, at intervals not to exceed eighteen months, the transient (pulse) rod drive cylinder and the associated air supply system shall be inspected, cleaned, and lubricated as necessary.

Bases

The reactivity worth of the control rods is measured to assure that the required shutdown margin is available and to provide a means for determining the reactivity worths of experiments inserted in the core. The visual inspection of the control rods and measurement of their drop times are made to determine whether the control rods are capable of performing properly. The surveillance intervals are selected based on the past history of more frequent , uneventful, inspections for over 20 years at this facility and experience at other TRIGA facilities with similar power levels, fuel type, and operational modes. They are also designed to reduce the possibilities of mechanical failures as a result of handling control rods, and to minimize radiation exposures to personnel.

4.3 Reactor Safety System

Applicability

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

Objective

The objective is to assure that the safety system will remain operable and will prevent the fuel temperature safety limit from being exceeded.

Specifications

a. A channel test of each of the reactor safety system channels shall be performed prior to each day's operation or prior to each operation extending more than one day.

b. A channel check of the fuel element temperature measuring channel shall be performed daily whenever the reactor is in operation or when pulse operation is planned.

c. A channel check of the power level measuring channels shall be performed daily whenever the reactor is in operation.

d. A channel calibration by the calorimetric method shall be made of the power level monitoring channels annually, but at intervals not to exceed eighteen months.

e. A calibration of the temperature measuring channels shall be performed annually, but at intervals not to exceed eighteen months. This calibration shall consist of introducing electric potentials in place of the thermocouple input to the channels.

f. A verification of the original calibration of the temperature measuring channels shall be performed annually, but at intervals not to exceed eighteen months. This verification shall consist of. comparing the measured temperature in a reference core at a known power level with the temperature measured in the reference core during the initial startup of the reactor.

Basis

The daily tests and channel checks will assure that the safety channels are operable. The annual calibrations and verifications will permit any long-term drift of the channels to be corrected. The history of operations at this facility over the last 20 years has shown that annual checks will allow correction for the very small amounts of drift observed.

4.4 Pool Water Level Channel

Applicability

This specification applies to the pool water level channel required by Section 3.7 of these specifications.

Objective

The objective is to assure that the channel is operable.

Specifications

The pool water level measuring channel shall be verified to be operable at intervals not to exceed two months.

Basis

This verification will assure that a continued warning system for a loss-of-coolant accident is maintained,

4.5 Radiation Monitoring Equipment

Applicability

This specification applies to the radiation monitoring equipment required by Section 3.3 of these specifications.

Objective

The objective is to assure that the radiation monitoring equipment is operating and to verify the appropriate alarm settings.

Specification

The alarm -set points for the radiation monitoring instrumentation shall be verified daily during periods when the reactor is in operation.

Basis

Surveillance of the equipment will assure that sufficient protection against radiation is available.

4.6 Maintenance

Applicability

This specification applies to the surveillance requirements following maintenance of control or safety system.

Objective

The objective is to assure that a system is operable before being used after maintenance has been performed.

Specification

Following maintenance or modification of a control or safety system or component. it shall be verified that the system is operable prior to its return to service.

Basis

This specification assures that work on the system or component has been properly carried out and that the system or component has been properly reinstalled or reconnected before reliance for safety is placed on it.

5.0 DESIGN FEATURES

5.1 Reactor Fuel

Applicability

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

Objective

The objective is to assure that the fuel elements are of such a design and fabricated in such a manner as to permit their use with a high degree of reliability with respect to their mechanical integrity.

Specifications

a. Standard Fuel Element: The standard fuel element shall contain uranium-zirconium hydride, clad in 0.020 inch of 304 stainless steel. It shall contain a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20 percent. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atom.

b. Loading: The elements shall be placed in a closely packed array except for experimental facilities or for single positions occupied by control rods and a neutron start-up source.

Basis

These types of fuel elements have a long history of successful use in TRIGA reactors.

5.2 Reactor Building

Applicability

This specification applies to the building which houses the reactor facility.

Objective

The objective is to assure that provisions are made to restrict the amount of release of radioactivity from the reactor facility.

Specifications

a. The reactor shall be housed in a closed room designed to restrict leakage when in operation, when the facility is unmanned, or when spent fuel is being handled exterior to a cast.

b. The minimum free volume of the reactor room shall be 1,000 cubic feet.

c. The building shall be equipped with a ventilation system capable of exhausting air or other gases from the reactor room at a minimum of 70 feet above ground level.

Basis

In order that the movement of air can be controlled, the reactor area contains no windows that can be opened. The room air is exhausted through an independent exhaust and discharged at roof level with other exhausts to provide dilution.

5.3 Fuel Storage

Applicability

This specification applies to the storage of reactor fuel at times when it is not in the reactor core.

Objective

The objective is to assure that fuel which is being stored will not become supercritical and will not reach unsafe temperatures.

Specifications

a. All fuel elements shall be stored in a geometrical array where the keff is less than 0.8 for all conditions of moderation.

b. Irradiated fuel elements and fuel devices shall be stored in an array which will permit sufficient natural convection cooling by water or air such that the fuel element or fueled device temperature will not exceed 800°C.

Basis

New fuel is stored in their shipping containers. Hot fuel is stored in pits described in the submittal dated June 5, 1969. These pits are designed to hold 19 elements, an amount which cannot form a critical array. Very hot fuel is stored in racks in the main tank where cooling water is provided.

6.0 ADMINISTRATIVE CONTROLS

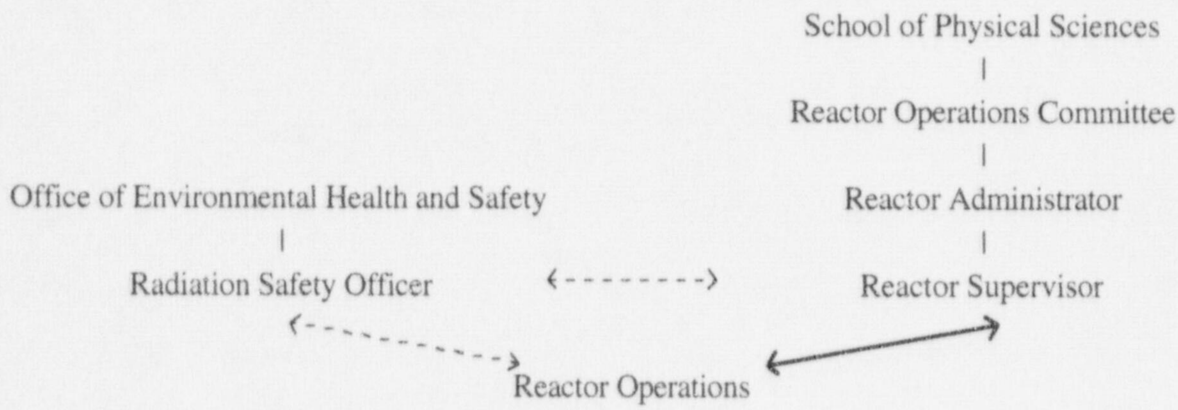
6.1 Organization

a. The reactor facility shall be an integral part of the School of Physical Sciences of the University of California, Irvine. The reactor shall be related to the University structure as shown in Chart I.

b. The reactor facility shall be under the direction of the Reactor Administrator who shall be a tenure member of the UCIfaculty and supervised by a Reactor Supervisor who shall be a qualified licensed senior operator for the facility. The Reactor Supervisor shall be responsible for assuring that all operations are conducted in a safe manner and within the limits prescribed by the facility license and the provisions of the Reactor Operations Committee.

c. There shall be a Radiation Safety Officer responsible for the safety of operations from the standpoint of radiation protection. The Radiation Safety Officer shall report to the Office of Environmental Health and Safety which is an organization independent of the reactor operations organization as shown in Chart I.

CHART I



6.2 Review

a. There shall be a Reactor Operations Committee which shall review reactor operations to assure that the facility is operated in a manner consistent with public safety and within the terms of the facility license.

b. The responsibilities of the Committee include, but are not limited to the following:

1. Review and approval of experiments utilizing the reactor facilities;
2. Review and approval of all proposed changes to the facility, procedures, and Technical Specifications;
3. Determination of whether a proposed change, test, or experiment would constitute an unreviewed safety question or a change in the Technical Specifications;
4. Review of the operation and operational records of the facility;
5. Review of abnormal performance of plant equipment and operating anomalies;
6. Review of unusual or abnormal occurrences and incidents which are reportable under 10 CFR 20 and 10 CFR 50; and
7. Approval of individuals for the supervision and operation of the reactor.

c. The Committee shall be composed of at least five members, one of whom shall be a health physicist designated by the Office of Environmental Health and Safety of the University. The Committee shall be proficient in all areas of reactor operation and reactor safety. The membership of the Committee shall include at least one member who is not associated with the School of Physical Sciences..

d. The Committee shall have a written statement defining such matters as the authority of the Committee, the subjects within its purview, and other such administrative provisions as are required for effective functioning of the Committee. Minutes of all meetings of the Committee shall be kept.

e. A quorum of the Committee shall consist of not less than a majority of the full Committee and shall include the chairman or his designee.

f. The Committee shall meet at least semi-annually, at intervals not to exceed nine months.

6.3 Operating Procedures

Written procedures, reviewed and approved by the Reactor Operations Committee, shall be in effect and followed for the following items. The procedures shall be adequate to assure the safety of the reactor but should not preclude the use of independent judgment and action should the situation require such.

a. Startup, operation, and shutdown of the reactor.

b. Installation or removal of fuel elements, control rods, experiments, and experimental facilities.

c. Actions to be taken to correct specific and foreseen potential malfunctions of systems or components, including responses to alarms, suspected primary coolant system leaks, and abnormal reactivity changes.

d. Emergency conditions involving potential or actual release of radioactivity, including provisions for evacuation, re-entry, recovery, and medical support.

e. Maintenance procedures which could have an effect on reactor safety.

f. Periodic surveillance of reactor instrumentation and safety systems, area monitors and continuous air monitors.

Substantive changes to the above procedures shall be made only with the approval of the Reactor Operations Committee. Temporary changes to the procedures that do not change their original intent may be made by the Reactor Supervisor. All such temporary changes to procedures shall be documented and subsequently reviewed by the Reactor Operations Committee.

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

In the event a safety limit is exceeded, or thought to have been exceeded:

a. The reactor shall be shut down and reactor operation shall not be resumed until authorized by the NRC.

b. An immediate report of the occurrence shall be made to the Chairman of the Reactor Operations Committee, and reports shall be made to the NRC in accordance with Section 6.7 of these specifications.

c. A report shall be made which shall include an analysis of the causes and extent of possible resultant damage, efficacy of corrective action, and recommendations for measures to prevent or reduce the probability of reoccurrence. This report shall be submitted to the Reactor Operations Committee for review, and a suitable similar report submitted to the NRC when authorization to resume operation of the reactor is sought.

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

In the event of an abnormal occurrence, as defined in Section 1.13 of the specifications, the following action shall be taken:

a. The Reactor Supervisor shall be notified and corrective action taken prior to resumption of the operation involved.

b. A report shall be made which 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 reoccurrence. This report shall be submitted to the Reactor Operations Committee for review.

c. Where appropriate, a report shall be submitted to the NRC in accordance with Section 6.7 of these specifications.

6.6 Plant Operating Records

a. In addition to the requirements of applicable regulations, and in no way substituting therefor, records and logs shall be prepared and retained for a period of at least 5 years of the following items, as a minimum:

1. Normal plant operation;

2. Principal maintenance activities;

3. Abnormal occurrences;

4. Equipment and component surveillance activities;

5. Gaseous and liquid radioactive effluents released to the environs;

6. Off-site environmental monitoring surveys;

7. Fuel inventories and transfers;

8. Facility radiation and contamination surveys;

9. Radiation exposures for all personnel;

10. Experiments performed with the reactor.

b. Updated, corrected, and as-built drawings of the facility shall be retained for the facility life.

6.7 Reporting Requirements

In addition to the requirements of applicable regulations, and in no way substituting therefore, reports shall be made to the NRC as follows:

a. An immediate report (by telephone and telegraph to the NRC Headquarters Office) of:

1. Any accidental off-site release of radioactivity above permissible limits, whether or not the release resulted in property damage, personal injury or exposure; and

2. Any violation of a safety limit.

b. A report within 24 hours (by telephone or telegraph to the NRC Headquarters Office) of:

1. Any significant variation of measured values from a corresponding predicted or previously measured value of safety-connected operating characteristics occurring

during operation of the reactor;

2. Incidents or conditions relating to operation of the facility which prevented or could have prevented the performance of engineered safety features as described in these specifications; and

3. Any abnormal occurrences as defined in Section 1.13 of these specifications.

c. A report within 10 days (in writing to the Document Control Desk, USNRC, Washington, D. C. 20555) of:

1. Any significant variation of measured values from a corresponding predicted or previously measured value of safety-connected operating characteristics occurring during operation of the reactor;

2. Incidents of conditions relating to operation of the facility which prevented or could have prevented the performance of engineered safety features as described in these specifications; and

3. Any abnormal occurrences as defined in Section 1.13 of these specifications.

d. A report within 30 days (in writing to the Document Control Desk, USNRC, Washington, D. C. 20555) of:

1. Any substantial variance from performance specifications contained in these specifications or in the Safety Analysis Report;

2. Any significant change in the transient or accident analyses as described in the Safety Analysis Report;

3. Any changes in facility organization; and

4. Any observed inadequacies in the implementation of administrative or procedural controls.

e. A report within 60 days after criticality of the reactor (in writing to the Document Control Desk, USNRC, Washington, D. C. 20555) upon receipt of a new facility license or an amendment to the license authorizing an increase in reactor power level or the installation of a new core, describing the measured values of the operating conditions or characteristics of the reactor under the new conditions, including:

1. Total control rod reactivity worth;

2. Reactivity worth of the single control rod of highest reactivity worth;

3. Total and individual reactivity worths of any experiments inserted in the reactor; and

4. Minimum shutdown margin both at room and operating temperatures.

f. A routine report in writing to the Document Control Desk, USNRC, Washington, D. C. 20555) within 60 days after completion of the first six months of facility operation and at the end of each 12-month period thereafter, providing the following information:

1. A narrative summary of operating experience (including experiments performed) and of changes in facility design, performance characteristics and operating procedures related to reactor safety occurring during the reporting period;

2. A tabulation showing the energy generated by the reactor (in megawatt hours), the amount of pulse operation, the number of hours the reactor was critical;

3. The number of emergency shutdowns and inadvertent scrams, including the reasons therefore;

4. Discussion of the major maintenance operations performed during the period,

including the effect, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required;

5. A summary of each change to the facility or procedures, tests, and experiments carried out under the conditions of Section 50.59 of 10 CFR 50;

6. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or prior to the point of such release or discharge;

7. A description of any environmental surveys performed outside the facility; and

8. A summary of radiation exposures received by facility personnel and visitors, including the dates and time of significant exposures, and a summary of the results of radiation and contamination surveys performed within the facility.

6.8 Review of Experiments

a. All proposed experiments utilizing the reactor shall be evaluated in writing by the experimenter and the Reactor Supervisor (and the Radiation Safety Officer when appropriate) to assure compliance with the provisions of the utilization license, theTechnical Specifications, and 10 CFR 20. If in the judgment of the Reactor Supervisor, the experiment meets with the above provisions and is not an "untried experiment" the experiment may be scheduled. Otherwise it will be submitted to another member of the Reactor Operations Committee for written evaluation and thence to the Reactor Operations Committee for final approval as indicated in Section 6.2 above. When pertinent, the evaluation shall include:

1. The reactivity worth of the experiment;

2. The integrity of the experiment, including the effects of changes in temperature, pressure, or chemical composition;

3. Any physical or chemical interaction that could occur with the reactor components; and

4. Any radiation hazard that may result from the activation of materials or from external beams.

b. Prior to the performing of an experiment not previously performed in the reactor, it shall be reviewed and approved in writing by the Reactor Operations Committee. Their review shall consider the following information:

1. The purpose of the experiment;

2. A procedure for the performance of the experiment; and

3. The written evaluations made as in Paragraph a. above.

c. A request for radioisotopes or the irradiation of materials shall be handled in the same manner as many other experiment except that a series of irradiations can be approved as one experiment. The expiration date for such approvals shall be one year or the expiration date of the applicant's appropriate radioactive materials license. For each irradiation, the applicant shall submit an "Irradiation Request" to the Reactor Supervisor. Thisd request shall contain information on the target material including the amount, chemical form, and packaging. For the purposes of Paragraph a. above, routine irradiations, which do not contain nuclear fuel or known explosive materials and which do not constitute a significant threat to the integrity of the reactor or to the safety of individuals, may be classified as "tried experiments".

d. In evaluating experiments, the following assumptions shall be used for the purpose of determining whether failure of the experiment would cause the appropriate limits of 10 CFR 20 to be exceeded:

1. If the possibility exists that airborne concentrations of radioactive gases or aerosols may be released within the facility, 100 percent of the gases or aerosols will escape;
2. If the effluent exhausts through a filter installation designed for greater than 99 percent efficeincy for 0.3 micron particles, at least 10% of gases or aerosols will escape; and
3. For a material whose boiling point is above 55°C and where vapors formed by boiling this material could escape only through a column of water above the core, at least 10% of these vapors will escape.