SAFETY RELATED DOCUMENT

Reed Reactor Facility

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TECHNICAL SPECIFICATIONS FOR THE REED COLLEGE TRIGA MARK 1 REACTOR

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1.0 DEFINITIONS

1.1 Confinement

Confinement means a closure on the overall facility which controls the movement of air into it and out through a controlled path.

1.2 Certified Operators

An individual authorized by the U.S. Nuclear Regulatory Commission to carry out the responsibilities associated with the position of Reactor Operator or Senior Reactor Operator.

1.3 Channel, Instrumentation

A channel is the combination of sensor, line, amplifier or other electronics, and output device which are connected for the purpose of measuring the value of a parameter.

1.3.1 Channel Test

Channel test is the introduction of an appropriate signal (*ie*. nuclear for a nuclear channel, physical activation for a level sensor) into the channel sensor and measurement of channel output for verification that the entire channel is operable.

1.3.2 Channel Check

Channel check is a qualitative verification of acceptable performance of a channel or portion of a channel by observation of channel behavior (*eg*. comparison of independent channels, introduction of electronic signals into the channel).

1.3.3 Channel Calibration

Channel calibration is an adjustment of the channel such that its output corresponds with acceptable accuracy to known values of the parameter which the channel measures. Calibration shall encompass the entire channel, including equipment actuation, alarm, or trip and shall be deemed to include a channel test.

1.4 Experiment

a) Any apparatus, device, or material installed in the core or experimental facilities (except for underwater lights, fuel element storage racks, and the like) which is not a design component of these facilities, or

b) Any operation designed to measure reactor parameters or characteristics.

1.4.1 Experiment, Movable

A **movable experiment** is one where it is intended that the entire experiment may be moved in or near the core or into and out of the reactor while the reactor is operating (*eg*. pneumatic tube irradiations).

1.4.2 Experiment, Secured

A **secured experiment** is any experiment, experiment facility, or component of an experiment that is held in a stationary position relative to the reactor by mechanical means. The restraining force must be substantially greater than those to which the experiment might be subjected by hydraulic, pneumatic, buoyant, or other forces which are normal to the operating environment of the experiment, or by forces which can arise as a result of credible conditions (*eg*. rotary specimen rack irradiations).

1.4.3 Experimental Facilities

Experimental facilities shall mean rotary specimen rack, pneumatic transfer tube, central thimble, and irradiation facilities in the core or in the pool.

1.5 Limiting Conditions for Operation

Limiting Conditions for Operation (LCO) are those administratively established constraints on equipment and operational characteristics which shall be adhered to during operation of the facility. The LCO's are the lowest functional capability or performance level required for safe operation of the facility.

1.6 Operable

Operable means a component or system is capable of performing its intended function.

1.7 Operating

Operating means a component or system is performing its intended function.

1.8. Operations Boundary

Operations Boundary means the perimeter of the extended facilities in which materials produced in the reactor are normally utilized, and includes the Reactor Facility and associated laboratories, store room, and conference room, all located on the same level within the Chemistry Building, and shown in Fig. 4-2 of the Safety Analysis Report.

1.9 Protective Action

Protective action is the initiation of a signal or the operation of equipment within the reactor safety system in response to a variable or condition of the reactor facility having reached a specified limit.

2.0 Reactivity, Excess

Excess reactivity is that amount of reactivity remaining in the core when the reactor is in the zero-power-critical condition.

1.10 Reactor Bay

The **reactor bay** consists of the room in the Reactor Facility containing the reactor.

1.11 Reactor Core, Operational

An **operational core** is an arrangement of standard TRIGA Mark I fuel elements for which the parameters of excess reactivity, shutdown margin, power calibration, and reactivity worths of control rods and experiments have been determined to satisfy the requirements set forth in the Technical Specifications.

1.12 Reactor Facility

Reactor Facility refers to the specially designed and constructed addition to the Reed College Chemistry Building, and comprising the reactor bay, mechanical room, control room, ventilation loft, and exit corridor.

1.13 Reactor Operating

The reactor is operating whenever it is not secured or shutdown.

1.14 Reactor Safety Systems

Reactor safety systems are those systems, including their associated input channels, which are designed to initiate automatic reactor protection or to provide information for the initiation of manual protective action.

1.15 Reactor Secured

The reactor is secured when either:

1.15.1

It contains insufficient fissile material or moderator present in the reactor, control rods, or adjacent experiments to attain criticality under optimum available conditions of moderation and reflection, or

1.15.2

All of the following conditions are met:

a. The minimum number of neutron absorbing control rods are fully inserted such that the reactor is subcritical by a margin greater than $1.00 in the reference core condition with all experiments accounted for. (Reactor Shutdown)

b. The console key switch is in the off position, and the key is removed from the console and under the control of a certified operator or stored in a locked storage area.

c. No work is in progress involving core fuel, core structure, installed control rods, or control rod drives unless they are physically decoupled from the control rods.

d. No experiments in or near the reactor are being moved or serviced that have, on movement, a reactivity worth exceeding the maximum allowed for a single experiment or $1.00 which ever is smaller.

1.16 Reactor Shutdown

The reactor is shutdown when it is subcritical by a margin greater than $1.00 in the reference core condition with all experiments accounted for.

1.17 Reference Core Condition

The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (less than $0.07).

1.18 Research Reactor

A **research reactor** is a device designed to support a self-sustaining neutron chain reaction for research, development, educational, training, or experimental purposes, and which may have provisions for the production of radionuclides.

1.19 Rod, Control

A **control rod** is a device fabricated from neutron absorbing material which is used to establish neutron flux changes and to compensate for routine reactivity losses. A control rod may be coupled to its drive unit allowing it to perform a safety function when the coupling is disengaged.

1.19.1 Regulating Rod

A **regulating rod** is a low worth control rod used to maintain an intended power level and may be varied manually or by a servo-controller. The regulating rod shall have scram capability.

1.19.2 Safety Rod

A **safety rod** is a control rod having an electric motor drive and scram capability.

1.19.3 Shim Rod

A **shim rod** is a control rod having an electric motor drive and scram capability. A shim rod may be varied manually or by a servo-controller.

1.20 Safety Limit

Safety limits are limits on important process variables which are found to be necessary to reasonably protect the integrity of the principal physical barriers which guard against the uncontrolled release of radioactivity. The principal physical barrier is the fuel element cladding.

1.21 Scram

A **scram** is the shutdown of the reactor caused by interruption of the magnet current to the control rods.

1.21.1 Inadvertent Scram

An **inadvertent scram** is an unscheduled shutdown when the reason for the unscheduled shutdown is known (*eg*. missed a range switch operation).

1.21.2 Unexplained Scram

An **unexplained scram** is an unscheduled shutdown the cause of which cannot be immediately determined.

1.22 Scram Time

Scram time is the elapsed time between reaching a limiting safety-system setting and total insertion of control rods.

1.23 Shall, Should, and May

The word **shall** is used to denote a requirement. The word **should** is used to denote a recommendation. The word **may** is used to denote permission, neither a requirement nor a recommendation.

1.24 Shutdown Margin

Shutdown margin shall mean the minimum shutdown reactivity necessary to provide confidence that the reactor can be made or maintained substantially subcritical by means of the control and safety systems starting from any permissible operating condition although the most reactive rod is in its most reactive position, and that the reactor will remain substantially subcritical without further operator action.

1.25 Startup

Startup is the sequence of procedures and operations to be completed whenever the reactor is to be taken from a Reactor Secured condition.

1.26 Surveillance Activities

Surveillance activities will have a prescribed frequency and scope to demonstrate performance of systems required under Limiting Conditions for Operations.

Two types of surveillance activities are specified, operability checks and calibrations. Operability checks are generally specified as monthly to quarterly. Calibrations are generally specified as annually to biennially.

1.27 Time Intervals

To provide operational flexibility, where time intervals for surveillance and audit activities are specified in the document, maximum intervals shall not exceed the following tolerance limits:

Specified interval	Tolerance limit
5 years	6 years
2 years (biennial)	2.5 years
1 year (annual)	15 months
6 months (semiannual)	7.5 months
3 months (quarterly)	4 months
2 months (bimonthly)	2.5 months
1 month (monthly)	6 weeks
weekly	10 days
daily	during the calendar day

Established frequencies shall be maintained over the long term.

Surveillance activities (except those specifically required for safety when the reactor is secured) may be deferred when the reactor is secured, however, they shall be completed prior to reactor startup. Surveillance activities scheduled to occur during an operating cycle which cannot be performed with the reactor operating may be deferred to the end of the cycle.

1.28 Units

The units in which a physical quantity are measured, may be expressed in metric or U. S. Customary, and compliance may be demonstrated in either system of units.

1.29 Value, Measured

The **measured value** is the value of a parameter as it appears on the output of a channel.

1.30 Value, True

The **true value** is the most accurately known value of a parameter.

1.31 Zero Power Critical

The reactor is **zero power critical** when the reactor power is stationary and the linear power channel reads between one (1) and ten (10) watts. This is the operational range in which the excess reactivity is measured during reactor operations.

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limit

Applicability:

This specification applies to the reactor core parameters which constitute a safety limit. The safety limit avoids incurring any significant off-site impacts as a result of an accident at the Reed Reactor Facility.

Objective:

The objective is to define conditions that can be permitted with confidence that no damage to the fuel element and/or cladding will result.

Specification:

The safety limit for a mixed core is a fuel temperature of 540ºC, corresponding to a phase transition in aluminum-clad fuel with a composition of $ZrH_{1.1}$ (see M.T. Simnad et al, *Nucl. Tech.* 28,31(1976)).

Basis:

The safety limit has been specified for aluminum-clad fuel, since stainless-clad fuel, with a composition of $ZrH_{1.65}$, is not subject to a phase transition anywhere in the temperature range of interest. In addition, standard stainless-clad elements have been certified in many TRIGA reactors for operation at steady powers of 1 MW, and for $3.00 pulsed insertions of reactivity. Thus, the ensuing safety analysis will be restricted to a discussion of the behavior of the aluminum-clad elements under two abnormal accident conditions:

1. Complete and instantaneous loss of reactor pool water from a steady state power condition following operation at maximum power.

2. A step insertion of the total excess reactivity available in the core ($3.00), starting from a steady power less than 1 kW.

If the reactor has been operating at 250 kW for an infinite time just prior to the instantaneous loss of cooling water, with convective cooling of the core by air, the maximum fuel temperature would be less than 150ºC, a temperature well below the safety limit or the melting point of the aluminum cladding. The equilibrium pressure resulting from fission gases, entrapped air, and hydrogen at 150ºC is less than 30 psi. This pressure produces a stress of 660 psi, whereas the yield stress for the aluminum cladding is >5000 psi at 150ºC. The main hazard would be from the high radiation levels above the unshielded core (see "Safeguards Analysis Report for TRIGA Reactors Using Aluminum-Clad Fuel," GA-7860, March 16, 1967).

On the basis of extensive $3.00 pulsing of aluminum-clad fuel in the Mark I Prototype TRIGA at General Atomics, it was determined that fuel integrity was maintained, although fuel distortion did take place. Maximum fuel-element temperature, following the pulse, was less than 500ºC. On the basis of these experiments, it has been concluded that aluminum-clad fuel is well able to withstand any conceivable $3.00 reactivity insertion in a non-pulsing TRIGA reactor (see RRF Safety Analysis Report, Sec. 7, April 15, 1967).

2.2 Limiting Safety System Setting

Applicability:

This specification applies to the settings that prevent the safety limit from being reached.

Objective:

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

Specification:

The linear power and percent power channels shall initiate a scram at no greater than 110 percent of 250 kW (no greater than 275 kW).

Basis:

The basis for 275 kW is that this safety system setting will prevent the limit of Section 2.1 from being reached. Experience and equipment specifications indicate that setpoint accuracy remains within 9 percent error between surveillance intervals.

3.0 LIMITING CONDITIONS FOR OPERATION

3.1 Reactor Core Parameters

3.1.1 Excess Reactivity

Applicability:

This specification applies to the reactivity of the reactor core including experiments in terms of the available excess reactivity above the cold, xenon free, zero power critical condition.

Objective:

The objective is to prevent the reactor safety limit from being reached by limiting the potential reactivity available in the reactor.

Specifications(s):

Maximum excess reactivity shall be $3.00 with equilibrium samarium and with experiments in place for the cold, xenon free, zero power critical condition. It is assumed that beta-effective is 0.0075 for the Reed Reactor.

Basis:

The maximum specified excess core reactivity is sufficient to provide the core rated power, and for xenon compensation. Prior to the development of the pulsing type fuel used on present TRIGA pulsing reactors, the prototype TRIGA reactor at General Atomic, using Al-clad fuel as is used in this reactor, was pulsed safely many times with $3.00 insertions. See RRF Safety Analysis Report.

3.1.2 Shutdown Margin

Applicability

This specification applies to the reactivity margin by which the reactor core will be considered shutdown.

Objective

The objective is to assure that the reactor can be shut down safely by a margin that is sufficient to compensate for the failure of a control rod or the movement of an experiment.

Specification(s)

The reactor shall not be operated unless the shutdown margin provided by control rods is greater than $0.53 with:

a. The reactor in the reference core condition.

b. The most reactive control rod fully withdrawn.

c. The highest worth movable experiment in its most reactive state.

Basis

The value of the shutdown margin assures that the reactor can be shut down from any operating condition even if the highest worth control rod should remain in the fully withdrawn position and a movable experiment is in a high reactivity state.

3.1.3 Fuel Elements

Applicability

This specification applies to the mechanical condition of the fuel.

Objective

The objective is to ensure that the reactor is not operated with damaged fuel that might involve release of fission products.

Specification(s)

The reactor shall not be operated with damaged fuel. A fuel element shall be considered damaged and must be removed from the core and stored in accordance with Section 5.4 if:

a. A visual inspection reveals damage or deterioration of fuel element cladding such as cracks, visible corrosion deposits or distortion.

b. A clad defect exists as indicated by release of fission products.

Basis

The performance of TRIGA fuel elements under Reed Reactor Facility operating conditions has been evaluated in the documents referenced in the Basis for Section 2.1. If evidence of damage is observed or fission products detected, the integrity of the cladding has been compromised.

3.1.4 Core Configuration

Applicability

This specification applies to the configuration of fuel elements, control rods, experiments and other reactor grid plate components.

Objective

The objective is to assure that provisions are made to restrict the arrangement of fuel elements and experiments to provide assurance that excessive power densities will not be produced.

Specification(s)

The core shall be an assembly of TRIGA Mark I aluminum clad and/or stainless-steel clad fuel-moderator elements arranged in a close-packed array except for:

a. replacement of single individual elements with in-core irradiation facilities or control rods.

b. two (2) separated experiment locations in the D through F rings, each occupying a maximum of three fuel element positions.

c. unoccupied grid plate positions may contain graphite filled dummy elements to increase moderation and reflection.

d. the reflector (excluding experiments and experimental facilities) which shall be water or a combination of graphite (clad in aluminum) and water.

e. the startup neutron source may occupy an F ring position.

Basis

Standard TRIGA cores have been in use for years, and their characteristics are well documented in the publications referenced in the basis for Section 2.1. The Specific Reed Reactor Facility configuration has been evaluated in the SAR.

3.2 Reactor Control and Safety System

3.2.1 Power Level

Applicability:

This specification applies to the energy generated in the reactor during normal operation, including testing and calibration.

Objective:

The objective is to ensure that the safety limit will not be exceeded during normal operation, including testing and calibration.

Specification:

The reactor power level shall not be raised above 250 kW as measured by the linear or percent power channels under any normal conditions of operation, including testing and calibration of instrumentation.

Basis:

Maintaining indicated reactor power levels below 250 kW will ensure that the safety limit will not be exceeded. For the purpose of testing overpower safety scrams, setpoints can be tested electronically.

3.2.2 Control Rod Assemblies

Applicability

This specification applies to control rods and attached mechanical assemblies.

Objective

The objective is to ensure that the control rods are operable so the reactor can be shut down to prevent fuel damage.

Specification(s)

The reactor shall not be operated unless the control rods are operable, and

a. There is no apparent damage to the drive assemblies.

b. The cladding has been breached.

c. The scram time measured from the instant a simulated signal reaches the value of a limiting safety system setting to the instant that the slowest scrammable control rod reaches its fully inserted position shall not exceed 1 second.

d. Maximum reactivity insertion rate of a control rod shall be less than $0.16 per second.

Basis

The apparent condition of the control rod assemblies will provide assurance that the rods will continue to perform reliably and as designed. The specification for rod scram time assures that the reactor will shut down promptly when a signal initiating a scram is generated. The specification for rod reactivity insertion rates assures that the reactor will start up controllably when rods are withdrawn. Analysis has indicated that for the range of transients anticipated for a TRIGA reactor the specified scram time and insertion rate is adequate to assure the safety of the reactor. (SAR Section 7.1 Reactor Power Transients)

3.2.3 Reactor Control System

Applicability

These specifications apply to logic of the reactor control system.

Objective

The objective is to specify the minimum control system interlocks that shall be operable for operation of the reactor.

Specification(s)

The following control system safety interlocks shall be operable:

a. Count Rate Interlock (one operable)

Withdrawal of any control rod shall be prevented if there are less than 2 neutron counts per second in the Count Rate Channel.

b. Rod Raising Interlock

Simultaneous withdrawal of 2 or more control rods shall be prevented by one set of interlocks.

Basis

Interlocks are specified to prevent function of the control rod drives unless certain specific conditions exist. The interlock to prevent startup of the reactor at power levels less than 2 neutron counts per second assures that sufficient neutrons are available for controlled reactor startup. The interlock which prevents simultaneous withdrawal of more than one control rod limits the maximum positive reactivity insertion rate.

3.2.4 Reactor Safety System

Applicability

These specifications apply to operation of the reactor safety system.

Objective

The objective is to specify the minimum safety system scrams which shall be operable for the operation of the reactor.

Specification(s)

There shall be one each of the following control rod scram safety channels operable:

a. Linear Power channel with a scram setting ≤ 110% of full power.

b. % Power channel with a scram setting ≤ 110% of full power.

c Manual Scram Bar on the control console shall initiate a scram on demand.

Basis

Automatic control rod insertion assures compliance with the limiting safety system setting in Section 2.2. Manual operation of the reactor safety system is considered part of the protective action of the reactor safety system.

3.2.4 Reactor Instrument System

Applicability

These specifications apply to measurements of reactor operating parameters.

Objective

The objective is to specify the minimum instrument system channels that shall be operable for operation of the reactor.

Specification(s)

The following minimum reactor parameter measuring channels shall be operable:

a. Linear Power Level (one only)

b. Percent Power Level (one only)

c. Neutron Startup Count Rate (one only).

Basis

The minimum measuring channels are sufficient to provide signals for reactor control and automatic safety system operation. Measurements of the same or different parameters provide redundancy.

3.3 Operational Support Systems

3.3.1 Water Coolant Systems

Applicability

This specification applies to the operating conditions for the reactor pool and coolant water systems.

Objective

The objective is to provide shielding from the reactor radiation, protection against corrosion of the reactor components, cooling of the reactor fuel, and to prevent leakage from the primary coolant system.

Specification(s)

The reactor shall be shut down and corrective action taken if the following reactor coolant water conditions are observed:

a. The bulk pool water temperature exceeds 48°C (120°F).

b. The surface of the pool water is measured to be more than 63 cm (25 inches) from the bottom of the bridge.

c. The water electrical conductivity is greater than 2.0 µmho/cm averaged for measurement periods of one month.

d. During heat exchanger operation, the pressure in the secondary system (measured at the secondary basket filter outlet) is less than 35 kPa (5 psi differential) greater than the pressure in the primary system (measured at the primary filter inlet). However, this limitation does not apply if the primary pump is off and the pool is valved off from the heat exchanger.

Basis

a. The bulk water temperature constraint assures that sufficient core cooling exists under all anticipated operating conditions and protects the resin of the water purification system from degradation or deterioration.

b. The pool water must cover the holes at the bottom 5 cm (2 inches) of the control rod barrels. The dampening action of the water through these holes reduces the bottoming impact when the rods are dropped by removal of the magnet current during a scram.

c. Average measurements of pool coolant water conductivity of 2.0 μmho/cm assure that water purity is maintained to control the effects of corrosion and activation of coolant water impurities.

d. Maintaining higher pressure in the secondary water system will insure that, in the event of a leak in the heat exchanger, pool water will not be lost to the environment. A pressure difference of 35 kPa (5 psi) will insure that this pressure is maintained even with maximum rated error on gauges.

3.3.2 Air Confinement Systems

Applicability

This specification applies to the air ventilation conditions in the reactor bay or experimental facilities during reactor operation.

Objective

The objective is to control the release of air from the reactor bay or experimental facilities under all conditions.

Specification(s)

The reactor shall not be operated unless minimum conditions for air confinement are functional. The following minimum conditions shall exist:

a. Equipment shall be operable to automatically isolate the reactor bay by closure of ventilation supply and exhaust dampers.

b. The double doors shall be closed and barred; the emergency exit door shall be closed and locked (the door shall be equipped with an emergency release mechanism); and the door between the control room and the reactor bay shall be closed except for personnel access.

Basis

The specifications for exhaust ventilation and confinement of the reactor bay provide control for airborne radioactive releases during operations such that the limits specified in 10 CFR 20 are not exceeded.

3.3.3 Radiation Monitoring Systems

Applicability

This specification applies to the radiation monitoring conditions in the reactor bay during reactor operation.

Objective

The objective is to monitor the radiation and radioactivity conditions in the area of the reactor.

Specification(s)

The reactor shall not be operated unless minimum conditions for radiation measurement are operable. The following minimum conditions shall exist:

a. A Continuous Air Monitor capable of detecting beta and gamma radiation in the air above the pool shall be operating with readout available to operators and audible alarm. Detection of elevated radioactivity levels by the Continuous Air Monitor shall initiate automatic isolation of the reactor bay.

b. An Area Radiation Monitor capable of detecting gamma radiation above the pool shall be operating with readout available to operators and audible alarm.

c. A portable survey meter capable of detecting 37 kBq (microcurie) levels of beta or gamma radiation shall be operable.

d. A portable ion chamber monitoring device or equivalent non-saturating personnel dosimetry instrument capable of determining beta and gamma exposure dose rate shall be operable.

e. The portable ion-chamber type radiation monitor may be substituted for the Area Radiation Monitor during periods of maintenance or repair.

f. The Gaseous Stack Monitor may be substituted for the Continuous Air Monitor during periods of maintenance or repair.

g. Alarm levels of the Continuous Air Monitor and the Gaseous Stack Monitor shall be set to insure that releases from the facility do not exceed the limits specified in 10 CFR 20.

Basis

The radiation monitors provide information to operating personnel of impending or existing hazards from radiation. This should provide sufficient time to evacuate the facility or take the necessary steps to maintain the exposure of personnel as low as practicable and to control the release of radioactivity. The Gaseous Stack Monitor initiates confinement upon alarm as does the Continuous Air Monitor. Therefore, substitution during maintenance or repair provides the same capability to initiate confinement without operator intervention.

3.4 Limitations on Experiments

3.4.1 Approval and Conduct of Experiments

Applicability

This specification applies to all experiments involving the reactor.

Objective

The objective is to ensure the safety of the reactor and its components during the performance of any experiment and to prevent excessive release of radioactive materials in the event of an experiment failure.

Specification(s)

a. Prior to performing any experiment, the proposed experiment or class of experiments shall be approved as provided in Section 6.4.

b. All experiments shall be carried out in accordance with established and approved written procedures. Minor changes to written procedures that do not significantly alter the experiment may be made by a Senior Reactor Operator provided these changes are documented.

Basis

The overriding consideration of reactor safety requires a thorough review and approval of proposed experiments prior to performing them.

3.4.2 Reactivity

Applicability

This specification applies to the reactivity worths associated with experiments.

Objective

The objective is to control the amount of reactivity worths associated with experiments to values that will prevent the reactor safety limit from being exceeded.

Specification(s)

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

a. Any movable experiment shall have a reactivity worth less than \$1.00.

b. Any secured experiment shall have a reactivity worth less than \$1.35.

c. The total reactivity worth of in-core experiments shall not exceed \$2.00. This shall include the potential reactivity which might result from malfunction, flooding, voiding, or removal and insertion of the experiments.

d. No experiment shall be performed if failure of such experiment could lead to a failure of a fuel element or of other experiments and these associated failures could result in a measurable increase in reactivity or a measurable release of radioactivity.

Basis

a. The worth of a single movable experiment is limited so that sudden removal movement of the experiment will not cause prompt criticality. The limited worth of a single movable experiment will not allow a reactivity insertion that would exceed the reactor safety limit.

b. The maximum worth of a secured experiment is limited so that the reactor safety limit will not be exceeded by removal of the experiment. Since these experiments are secured in place, removal from the reactor operating at full power would result in a relatively slow power increase such that the reactor protective systems would act to prevent excessive power levels from being attained.

c. The maximum worth of experiments is limited so that removal of the total worth of all experiments will not exceed the reactor safety limit.

d. The interaction of all experiments in the reactor is to be considered to assure the safety of the reactor under all anticipated operating conditions.

3.4.3 Materials

Applicability

These specifications apply to experiments (as defined in Section 1.5.a) installed in the reactor and its experimental facilities.

Objective

The objective is to prevent the release of radioactive material in the event of an experiment failure, either by failure of the experiment or subsequent damage to the reactor components.

Specification(s)

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

a. Experiments containing materials corrosive to reactor components, compounds highly reactive with water, potentially explosive materials, and liquid fissionable materials shall be doubly encapsulated.

b. Each experiment shall be controlled such that the total inventory of iodine isotopes 131 through 135 in the experiment is no greater than 56 GBq (1.5 Ci) and the maximum strontium-90 inventory is no greater than 0.2 GBq (5 mCi).

c. Explosive materials shall not be irradiated in the reactor or experimental facilities.

d. Experiment materials, except fissionable materials, which could off-gas, sublime, volatilize, or produce aerosols under:

1) normal operating conditions of the experiment or reactor,

2) credible accident conditions in the reactor,

3) possible accident conditions in the experiment

shall be limited in activity such that if 100% of the gaseous activity or radioactive aerosols produced escaped to the reactor bay or the irradiation facility atmosphere, the airborne concentration of radioactivity released averaged over a year would not exceed the limits of Appendix B of 10CFR20.

In calculations pursuant to the above, the following assumptions shall be used:

(1) If the effluent from an experimental facility exhausts through a system which closes automatically on high radiation level, at least 10% of the gaseous activity or aerosols produced will escape.

(2) If the effluent from an experimental facility exhausts through a filter installation designed for greater than 99% efficiency for 0.25 micron particles, at least 10% of these particles can escape.

(3) For materials whose boiling point is above 55°C (130°F) and where vapors formed by boiling this material can escape only through an undisturbed column of water above the core, at least 10% of these vapors can escape.

Basis

a. Double encapsulation is required to lessen the experimental hazards of some types of materials.

b. The 56 GBq (1.5 Ci) limitation on iodines 131 through 135 assures that in the event of failure of an experiment leading to total release of the iodine from the experiment, the exposure dose at the exclusion area boundary from iodine-131 does not exceed the limits of Table II, Appendix B, 10CFR20 averaged over one year.

c. This specification is intended to prevent damage to reactor components resulting from failure of an experiment involving explosive materials.

d. This specification is intended to reduce the likelihood that airborne activities in excess of the maximum allowable limits will be released to the atmosphere outside the facility boundary. Guidance for the calculations is provided.

3.4.4 Failures and Malfunctions of Experiments

Applicability

These specifications apply to the design of experiments and to actions to be taken upon experiment failure or malfunction.

Objective

The objective is to limit the consequences of experiment failure or malfunction.

Specification(s)

a. Credible failure of any experiment shall not result in releases or exposures in excess of established limits nor in excess of the limits established in Table II, Appendix B, 10CFR20 averaged over one year.

b. If a capsule fails and releases material which could damage the reactor fuel or structure by corrosion or other means, removal of the capsule and physical inspection of the reactor shall be performed to determine the consequences and need for corrective action. The results of the inspection and any corrective action taken shall be reviewed by the Director and determined to be satisfactory before operation of the reactor is resumed.

Basis

a. Experiments shall be designed to limit release of radioactivity under all credible accident conditions.

b. Operation of the reactor with the reactor fuel or structure damaged is prohibited to avoid release of fission products.

4.0 SURVEILLANCE REQUIREMENTS

4.1 Reactor Core Parameters

4.1.1 Excess Reactivity

Applicability

This specification applies to the measurement of reactor excess reactivity.

Objective

The objective is to periodically determine the changes in excess reactivity available for power generation.

Specification

Excess reactivity shall be determined at zero power critical as part of the startup procedure.

Basis

This specification assures determination of excess reactivity after all reactor core or control rod changes and after experiment installations. This specification monitors changes in the core excess reactivity as an indication of the condition of the reactor core and to insure compliance with excess reactivity limits in the Technical Specifications.

4.1.2 Shutdown Margin

Applicability

This specification applies to the measurement of reactor shutdown margin.

Objective

The objective is to periodically determine the core shutdown reactivity available for reactor shutdown.

Specification(s)

Shutdown margin shall be determined semiannually, after fuel movement, or control rod removal and replacement.

Basis

Semiannual determination of shutdown margin and measurements after reactor core or control rod changes detect significant changes in the core shutdown margin and insure compliance with specification 3.1.2.

4.1.3 Fuel Elements

Applicability

This specification applies to the inspection requirements for the fuel elements.

Objective

The objective is to visually inspect the physical condition of the fuel element cladding.

Specification(s)

At least 1/5 of all the fuel elements in the core shall be visually inspected each year with the fuel elements to be inspected rotated such that each fuel element shall be inspected at least once every five (5) years.

Basis

The frequency of inspection is based on the parameters most likely to affect the fuel cladding of a reactor operated at moderate power levels and utilizing fuel elements whose characteristics are well known as given in the references for Section 2.1.

4.1.4 Core Configuration

Applicability

This specification applies to the inspection requirements of the core configuration.

Objective

The objective is to ensure proper core configuration prior to operating the reactor.

Specification(s)

The reactor core configuration shall be visually inspected as part of the startup procedures prior to reactor operation.

Basis

Inspection for changes in core configuration and determination of proper core configuration for operation are done to insure compliance with specification 3.1.4.

4.2 <u>Reactor Control and Safety System</u>

4.2.1

Applicability

This specification applies to the calibration of reactor power level channels.

Objective

The objective is to ensure that the reactor power level does not exceed the safety limit.

Specification

The linear and %-power channels shall be calibrated annually by the calorimetric method.

Basis

Annual calibration of instrument channels based on actual measurements of the rate of rise in pool water temperature provides method of assuring compliance with the reactor safety limit based solely on well documented physical parameters.

4.2.2 Control Assemblies

Applicability

This specification applies to the surveillance of the control rods.

Objective

The objectives are to measure the control rod worths, to inspect the physical condition of the reactor control rods, and to establish the operable condition of the control rods by periodic measurement of the scram times and insertion rates.

Specification(s)

Control rod worths shall be determined annually or after significant core or control rod changes, and

a. Each control rod shall be visually inspected at biennial intervals.

a. The scram time of each control rod shall be measured semiannually.

b. The reactivity insertion rate of each control rod shall be measured annually.

Basis

Annual determination of control rod worths or measurements after significant core changes provide information about changes in reactor total reactivity and individual rod worths. The frequency of inspection for the control rods will provide periodic verification of the condition of the control rod assemblies. Verification will be by measurement and visual observation of absorber sections plus examination of linkages and drives. The specification intervals for scram time and insertion rate assure operable performance of the rods.

4.2.3 Reactor Control System

Applicability

This specification applies to the tests of the logic of the reactor control system.

Objective

The objective is to specify intervals for tests of the minimum control system interlocks.

Specification(s)

The minimum safety interlock channels shall be tested prior to startup as part of the startup procedure.

Basis

The routine test of the interlock logic at startup provides adequate information that the control system interlocks are operable.

4.2.4 Reactor Safety System

Applicability

This specification applies to test and calibration of the reactor safety system.

Objective

The objective is to specify intervals for test and calibration of the minimum safety system scrams.

Specification(s)

The minimum safety channels shall be calibrated annually and subject to electronic testing prior to each startup as part of the startup procedure and following modifications or repair.

Basis

The periodic calibration at annual intervals provides adequate information that the setpoints of the safety system scrams are accurate. Tests of the safety system prior to each planned operation and following modifications or repair assure that each intended scram function is operable.

4.2.5 Reactor Instrument System

Applicability

These specifications apply to calibrations and tests of reactor measurement channels.

Objective

The objective is to specify intervals for calibrations and tests of the minimum instrument channels.

Specification(s)

An electronic calibration test of each channel specified in section 3.2.4 shall be made prior to each startup as part of the startup procedure and following modifications or repair.

Basis

Tests are applied prior to reactor operation and following modifications or repair to verify each system is operable.

4.3 Operational Support Systems

4.3.1 Water Coolant Systems

Applicability

This specification applies to surveillance of the reactor pool and coolant water systems.

Objective

The objective is to maintain the reactor coolant conditions within acceptable specifications.

Specification(s)

The following measurements shall monitor the reactor coolant conditions:

a. The water temperature channel shall be calibrated annually and monitored continuously during reactor operation.

b. The pool level alarm shall be tested bimonthly, and monitored continuously during operation of the reactor.

c. The pool water conductivity shall be measured weekly.

d. The secondary low pressure alarm shall be tested semiannually and monitored continuously during operation.

Basis

Periodic calibrations and tests of measurement devices for the reactor coolant system parameters assure that the coolant system will perform its intended function.

4.3.2 Air Confinement Systems

Applicability

This specification applies to surveillance of the air confinement system in the reactor bay.

Objective

The objective is to demonstrate that the air confinement system is operable and that airborne releases of radioactive material are properly quantified.

Specification(s)

The following actions shall demonstrate the air confinement conditions:

a. Annual visual examination of isolation dampers.

b. Bimonthly tests of air confinement system operation.

c. Bimonthly visual examination of facility doors and closing mechanisms.

d. Annual calibration of the Gaseous Stack Monitor and air confinement trip points.

e. Annual calibration of the Continuous Air Monitor.

f. Weekly tests of the alarm set points of the Continuous Air Monitor.

Basis

Periodic evaluations of air confinement criteria are determined by examination, test, and calibration of the appropriate ventilation functions. The air confinement system provides control for radioactive releases during both routine and non-routine operating conditions.

4.3.3 Radiation Monitoring Systems

Applicability

This specification applies to the surveillance of the radiation monitoring channels.

Objective

The objective is to assure the radiation monitoring systems are operable.

Specification(s)

Surveillance of the minimum radiation monitors specified to be operable during reactor operation shall be performed as follows:

a. The Air Particulate Monitor and Radiation Area Monitor shall be calibrated at annual intervals.

b. The portable ion chamber(s) and portable survey meter(s) shall be calibrated at semiannual intervals.

c. The alarm set points of the Radiation Area Monitor shall be tested at weekly intervals.

d. The portable ion chamber(s) and portable survey meter(s) shall be tested as part of the startup procedure.

Basis

Periodic calibrations and frequent tests are specified to maintain reliable performance of the radiation monitoring instruments.

4.4 Limitations on Experiments

4.4.1 Approval

Applicability

This specification applies to surveillance of prior approval for all experiments involving the reactor.

Objective

The objective is to ensure no experiment is performed without prior review and approval as given in Section 6.4.

Specification(s)

No experiment using the reactor shall be performed without a copy of a description approved as given in Section 6.4 in the control room.

Basis

The Reactor Supervisor and Reactor Operators shall only use an approved description for conduct of an experiment.

4.4.2 Reactivity

Applicability

This specification applies to surveillance of the reactivity of experiments.

Objective

The objective is to assure the reactivity of an experiment does not exceed the allowable specification.

Specification(s)

The reactivity of any experiment designed to be performed with the reactor operating shall be measured at zero power critical before the experiment is performed. This specification may not apply to pneumatic tube experiments at the discretion of the Director with the concurrence of the Reactor Review Committee.

Basis

The measured reactivity or determination that the reactivity is not significant will provide data that the configuration of the experiment or experiments is allowable.

4.4.3 Materials

Applicability

This specification applies to the surveillance requirements for materials inserted into the reactor.

Objective

The objective is to prevent the introduction of materials that could damage the reactor or its components.

Specification(s)

Any surveillance conditions or special requirements shall be specified as a part of the experiment approval.

Basis

An evaluation of all experiments is performed to classify the materials to be irradiated as corresponding to the specifications of the experiment description.

5.0 DESIGN FEATURES

5.1 Site and Facility Description

5.1.1 Location

Applicability

This specification applies to the Reed Reactor Facility location and specific facility design features.

Objective

The objective is to specify those features which are related to the Safety Analysis evaluation.

Specification(s)

a. The Reed Reactor Facility is in the eastern part of the Reed College campus in the city of Portland, Multnomah County, Oregon.

b. The TRIGA Mark I research reactor is installed in the reactor bay.

c. The reactor core is assembled in a below ground shield and pool structure with vertical access to the core.

d. The restricted access area of the Reed Reactor Facility shall consist of the reactor bay, the mechanical room, ventilation loft, and the reactor control room.

e. Reed College owns and can exclude persons from the area within 76 m (250 feet) from the center of the Reactor pool.

Basis

a. The Reed Reactor Facility site is located in an area owned and controlled by the Reed Institute.

b. The Reed Reactor Facility addition has been designed with characteristics related to the safe operation of the reactor.

c. The shield and pool structure has been designed for structural integrity below ground and for radiation levels approximately 1 mrem/hr at locations adjacent to the reactor pool in the reactor bay.

d. The restricted access to specific facility areas assures that proper controls are established for the safety of the public and for the security of special nuclear materials.

e. The area of exclusion from the facility assures that proper controls can be established for the safety of the public.

5.1.2 Air Confinement

Applicability

This specification applies to the design features which control air released from the reactor bay.

Objective

The objective is to assure that provisions are made to control or restrict the airborne release of radioactivity to the environment.

Specification(s)

a. The reactor bay shall be designed to restrict leakage and shall have a minimum enclosed air volume of 340 cubic meters (12,000 cubic feet).

b. Under normal operating conditions, the ventilation system shall provide two (2) air changes per hour and shall maintain a slight negative pressure in the reactor bay relative to ambient conditions.

c. Upon detection of a limit signal related to the radiation level, the air confinement system shall automatically restrict unfiltered air exhaust as described in Section 3.3.2.b.

d. All air or other gas exhausted from the reactor bay and from associated experimental facilities during reactor operation shall be released to the environment at a minimum of 3.7 meters (12 feet) above ground level.

Basis

a. The enclosed air volume determines the concentration of airborne radionuclides in the reactor bay.

b. Exchange of air in the reactor bay prevents the buildup of gaseous radioactivity. Maintaining a slight negative pressure in the reactor bay ensures that air leaving the bay passes through monitoring systems and is released through the stack.

c. Elevated radiation levels automatically prevent the uncontrolled release of unfiltered air from the reactor bay as described in Section 3, Limiting Conditions of Operation.

d. Release of air from the facility at a minimum of 3.7 meters above the ground surface provides for dispersion and dilution of releases.

5.1.3 Safety Related Systems

Applicability

This specification applies to any addition, modification, and non-routine modifying maintenance to any system related to reactor safety.

Objective

The objective is to assure the proper function of any system related to reactor safety.

Specification(s)

Any addition, modification, or non-routine modifying maintenance to the core and its associated support structure, the pool structure, the control rod drive mechanisms, the reactor safety system, the air confinement system, and the water coolant system shall be made and tested in accordance with the specifications to which the systems or components were originally designed and fabricated, or to specifications approved by the Reactor Review Committee as suitable and not involving an unreviewed safety question. The reactor shall not be placed in operation until the affected system has been verified to be operable.

Basis

Changes to the above systems could affect the safe operation of the reactor and must be approved by the Reactor Review Committee including an analysis of any unreviewed safety questions (10CFR50.59).

5.2 Reactor Coolant System

Applicability

This specification applies to the reactor coolant system.

Objective

The objective is to assure that adequate water is available for cooling and shielding during reactor operation.

Specification(s)

a. The reactor core shall be cooled by natural convection of water.

b. Siphoning of the pool water shall be prevented by holes in the pool water system pipe lines. These holes shall be no more than 53 cm (21 inches) below the bottom of the bridge.

Basis

a. Thermal and hydraulic calculations which show that a TRIGA core can operate in a safe manner at power levels specified for the Reed Reactor Facility are presented in the RRF Safety Analysis Report.

b. Siphon breaks prevent the loss of coolant water caused by inadvertent pumping or accidental siphoning.

5.3 Reactor Core and Fuel

5.3.1 Fuel Elements

Applicability

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

Objective

The objective is to assure that the fuel elements are designed and fabricated to permit their use with a high degree of reliability with respect to their physical and nuclear characteristics.

Specification(s)

The standard TRIGA fuel element at fabrication shall have the following characteristics:

a. Uranium content: 8.5 weight percent (wt%) uranium enriched to a nominal 20% Uranium-235.

b. Aluminum Clad Standard TRIGA Fuel Elements:

Zirconium to hydrogen atom ratio nominally 1:1
Cladding: 0.76 mm (0.030 in.) of Aluminum.

c. Stainless Steel Clad Standard TRIGA Fuel Elements:

Zirconium to hydrogen atom ratio nominally 1:1.6
Cladding: 0.51 mm (0.020 in.) of stainless steel type 304.

d. The length of a fuel element shall be 72.1 cm (28.4 in.).

e. The diameter of a fuel element shall be 3.73 cm (1.47 in.).

Basis

The Design Basis of the standard TRIGA core demonstrates that 250 kilowatt steady state operation represents a conservative safety limit for the maximum temperature generated in the fuel as presented in the references to Section 2.1 Safety Limits.

5.3.2 Control Rods

Applicability

This specification applies to the control rods.

Objective

The objective is to assure that the control rods are designed to permit their use as neutron absorbers with a high degree of reliability and safety.

Specification(s)

The safety, shim, and regulating control rods shall have scram capability, and shall contain borated graphite, B_4C powder, or boron and its compounds in solid form as a neutron absorber which is encased i[illegible]minum cladding.

Basis

The neutron absorbing requirements for the control rods are satisfied by using borated graphite, B_4C powder, or boron and its compounds. These materials must be contained in a suitable clad material, such as aluminum, to insure mechanical stability during movement and to isolate the neutron absorber from the pool water environment. Scram capabilities are provided for rapid insertion of the control rods which is the primary safety feature of the reactor.

5.4 Reactor Fuel Element 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 stored fuel will not become critical and will not exceed design temperatures.

Specification(s)

a. All fuel elements shall be stored in a geometrical ay where the calculated effective multiplication is less than 0.8 for all conditions of moderation.

b. Irradiated fuel elements and fueled 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 ten rature will not exceed design values.

Basis

The limits imposed by these specifications are given in the "Technical Specifications for the Reed Reactor Facility, 1968 edition", and are more conservative than the American National Standards Institute ANSI 15.1 "Technical Specifications for Research Reactors, 1982 edition." Storage of fuel elements in an array where the effective multiplication is less than 0.8 will prevent unintentional criticality.

6.0 ADMINISTRATIVE CONTROLS

6.1 Organization

6.1.1 Structure

The President of Reed College (level 1) has the responsibility for the reactor facility license. The management of the facility is the responsibility of the Facility Director (level 2), who reports to the President of Reed College through a Vice-President designated by the President. Administrative and fiscal responsibility is within the offices of President.

The minimum qualifications for the position of Facility Director are a degree in science or engineering and 2 years experience in reactor operation or an advanced degree in science or engineering.

The minimum qualification for the position of Reactor Supervisor (level 4) is possession of a Senior Reactor Operator's license.

In operational matters, the Reactor Operators (level 5) report to a Senior Reactor Operator.

The Reactor Health Physicist reports directly to the President (level 1). The qualifications for the Reactor Health Physicist is a graduate degree in radiation protection or the equivalent.

6.1.2 Responsibility

Responsibility for the safe operation of the reactor facility shall be within the chain of command shown in the organization chart. Individuals at the various management levels, in addition to having responsibility for the policies and operation of the reactor facility, shall be responsible for safeguarding the public and facility personnel from undue radiation exposures and for adhering to all requirements of the Operating License and Technical Specifications. The Facility Director shall review and approve all experiments and experimental procedures prior to their use in the reactor.

In all instances responsibilities of one level may be assumed by designated alternates or by higher levels, conditional upon appropriate qualifications.

6.1.3 Staffing

The minimum staffing when the reactor is not secured shall be:

a. A Certified Operator in the control room.

b. A second person within the Operations Boundary who can perform prescribed written instructions such as initiation of the first stages of the emergency plan including evacuation and initial notification procedures. The second person may leave for a period not to exceed 15 minutes.

c. A designated Senior Reactor Operator shall be readily available on call within the Chemistry Building. The available operator shall be on the

Reed Campus within ten (10) minutes of reaching the Reactor Facility and shall keep the operator on duty informed of a telephone number for contact.

Events requiring the direction of a Senior Reactor Operator shall be:

a. All fuel elements or control rod relocations within the reactor core region.

b. Relocation of any in-core experiment with a reactivity worth greater than $1.00.

c. Recovery from an inadvertent scram in which case documented verbal concurrence from a Senior Reactor Operator is required.

A list of Reed Reactor Facility personnel by name and telephone number shall be readily available in the control room for use by the operator. This list shall include:

a. Management Personnel

b. Health Physics Personnel

c. All Certified Operators.

6.1.4 Selection and Training of Personnel

The selection, training, and requalification of operators shall meet or exceed the requirements of American National Standard for Selection and Training of Personnel for Research Reactors ANSI/ANS - 15.4. Qualification and requalification of certified operators shall be subject to a program approved by the Nuclear Regulatory Commission (NRC).

6.2 <u>Reactor Review Committee (Review and Audit)</u>

The Reactor Review Committee (RRC) is established as a method for the independent review and audit of the safety aspects of Reed Reactor Facility operations and to advise the President of Reed College regarding these matters.

6.2.1 Composition and Qualifications

The RRC shall be composed of a minimum of five (5) members, not including ex-officio members. The committee shall be appointed by and report to the President of Reed College. The members of the committee shall collectively represent a broad spectrum of expertise in reactor technology and, in addition, represent community interests in safe operation of the Reed Reactor Facility. Individuals may be either from within or outside the operating organization. Qualified and formally approved alternates may serve in the absence of regular members. The Facility Director and the Reactor Health Physicist shall be ex-officio non-voting members of the RRC. The Chair of the RRC shall be responsible for:

Calling and Leading Meetings

Establishing the Meeting Agenda

Disseminating Minutes to Members of the RRC, Reed Reactor Facility Staff, and Reed Reactor Facility Management.

6.2.2 RRC Charter and Rules

The review and audit functions shall be conducted by the RRC in accordance with an established charter including the following:

a. Meeting Frequency

The RRC shall meet quarterly not to exceed four months between meetings and more frequently as circumstances warrant, consistent with effective monitoring of RRF activities.

b. Quorums

A quorum for action by the RRC shall be not less than one-half of the voting members. The majority vote of the RRC will be its official decision regarding safety aspects of the Reed Reactor Facility.

c. Dissemination, review, and approval of minutes in a timely manner

RRC Meeting minutes shall be disseminated to members and to the President of Reed College for review in a timely manner after each meeting and approved by the RRC at its next meeting.

6.2.3 Review Function

The following items shall be reviewed for adequacy by the RRC:

a. Determinations that proposed changes in equipment, systems, tests, experiments, or procedures do not involve an unreviewed safety question (10CFR50.59 Review).

b. All new procedures and major revisions thereto having safety significance, and proposed changes in reactor facility equipment or systems having safety significance.

c. All new experiments or classes of experiments that could affect reactivity or result in the release of radioactivity.

d. Proposed changes in technical specifications or facility license.

e. Reports of violations of technical specifications or facility license, or violations of internal procedures or instructions having safety significance.

f. Reports of: Operating abnormalities having safety significance; violation of safety limits; release of radioactivity from the site above allowed limits; operation with actual safety-system settings less conservative than allowed in the Technical Specifications; violation of a limiting condition of operation contained in the Technical Specifications unless prompt remedial action is taken; reactor safety system component malfunctions which render or could render the associated system incapable unless the malfunction is discovered during maintenance or periods of reactor shutdown, unanticipated or uncontrolled change in reactivity greater than $1.00; abnormal and significant degradation in reactor fuel, cladding, coolant boundary, or confinement boundary which could result in exceeding prescribed radiation exposure limits of personnel or release to the environment; and observed inadequacy in the implementation of administrative or procedural controls such that the inadequacy causes or could have caused the existence or development of an unsafe condition.

g. Audit reports.

6.2.4 Audit Function

The RRC shall perform or arrange for comprehensive examination of selected operating records, logs, and other documents. Discussions with cognizant personnel and observation of operations shall be used as appropriate. In no case shall the individual immediately responsible for the area audit that area. The following items shall be audited:

a. Facility operations for conformance to the Technical Specifications and applicable Facility License conditions annually.

b. The requalification program for certified operators at least once every other calendar year.

c. Results of actions to correct those deficiencies that may occur in reactor facility equipment, structures, systems, or methods of operation that affect reactor safety annually.

d. The Reed Reactor Facility Emergency Plan, Physical Security Plan, and implementing procedures at least once every other calendar year.

A written report of the findings of the audit shall be submitted to the President and RRC members within three months after the audit has been completed.

6.3 Operating Procedures

Written Standard Operating Procedures shall be prepared, and the RRC prior to initiation of the following activities:

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

b. Fuel loading, unloading, and movement within the reactor.

c. Routine maintenance of major components of systems that could have an effect on reactor safety.

d. Surveillance tests and calibrations required by the technical specifications or those that could have an effect on reactor safety.

e. Personnel radiation protection activities, procedures for which shall be developed and implemented with the advice of the Reactor Health Physicist.

f. Administrative controls on operations, maintenance, and the conduct of irradiations and experiments that could affect reactor safety.

g. Implementation of required plans such as the Emergency Plan or Physical Security Plan.

h. Additions, modifications, or non-routine modifying maintenance of reactor safety systems.

Substantive changes to the above procedures shall be made effective after approval of the Director, and the RRC. Minor modifications to the original procedures which do not change the original intent may be made by a Senior Reactor Operator, but the modifications must be approved by the Director within 14 days. Temporary deviations from the procedures may be made by a Senior Reactor Operator in order to deal with special or unusual circumstances or conditions. Such deviations shall be documented and reported to the Director.

6.4 Experiment Review and Approval

All new experiments or classes of experiments shall be approved in writing by the Director, or a designated alternate, and the RRC.

a. Approved experiments shall be carried out in accordance with established and approved procedures.

b. Substantive changes to previously approved experiments shall require the same review as a new experiment.

c. Minor changes to an experiment that do not significantly alter the experiment may be made by a Senior Reactor Operator.

6.5 Required Actions

6.5.1 Actions to be Taken in Case of a Safety Limit Violation

In the event of a safety limit violation, the following actions shall be taken:

a. The reactor shall be secured and reactor operation shall not be resumed until a report of the violation is prepared and authorization is received from the Nuclear Regulatory Commission (NRC).

b. The safety limit violation shall be promptly reported to the Director or a designated alternate.

c. The NRC shall be notified by the Director or a designated alternate within one (1) working day of the violation by telephone (see Section 6.6.2).

d. A safety limit violation report shall be submitted to the NRC within 14 days (see Section 6.6.2). The report shall describe the following:

(1) Applicable circumstances leading to the violation including, when known, the cause and contributing factors.

(2) Effect of the violation upon reactor facility components, systems, or structures and on the health and safety of personnel and the public.

(3) Corrective actions taken to prevent recurrence.

The report shall be reviewed by the RRC and any follow-up report shall be submitted to the NRC when authorization is sought to resume operation of the reactor.

6.5.2 Actions to be Taken in the Event of Other Reportable Occurrences

In the event of an occurrence which must be reported to the NRC according to Section 6.6.2, the following actions shall be taken:

a. Reactor conditions shall be returned to normal or the reactor shutdown. If it is necessary to shut down the reactor to correct the occurrence, operations shall not be resumed unless authorized by the Director or designated alternate.

b. The occurrence shall be reported to the Director or designated alternate immediately, and to the NRC within one (1) working day by telephone (see Section 6.6.2).

c. A written report describing the occurrence shall be submitted to the NRC within 14 days (see Section 6.6.2).

d. The occurrence shall be reviewed by the RRC at the next regularly scheduled meeting.

6.6 Reports

All written reports shall be sent within the prescribed interval to the Nuclear Regulatory Commission as required by 10CFR50.

6.6.1 Operating Reports

Routine annual reports covering the activities of the reactor facility during the previous twelve months shall be submitted within three months following the end of each prescribed year. These reports shall cover the same period as the Reed College Administrative Cycle. Each annual operating report shall include the following information:

a. A narrative summary of reactor operating experience including the energy produced by the reactor and the hours the reactor was critical.

b. The unexplained scrams including, where applicable, corrective action taken to preclude recurrence.

c. Tabulation of major preventive and corrective maintenance operations having safety significance.

d. Tabulation of major changes in the reactor facility and procedures, and tabulation of new tests or experiments or both, that are significantly different from those performed previously and are not described in the Safety Analysis Report, including conclusions that no unreviewed safety questions were involved and that 10 CFR 50.59 was applicable.

e. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the Reactor Facility as determined at or before the point of such release or discharge. The summary shall include to the extent practicable an estimate of individual radionuclides present in the effluent. If the estimated average release after dilution or diffusion is less than 25% of the concentration specified in 10 CFR 20 Appendix B, a statement to this effect is sufficient.

f. A summarized result of environmental surveys performed outside the facility.

g. A summary of exposures received by facility personnel and visitors, where such exposures are greater than 25% of that allowed or recommended in 10 CFR 20.

6.6.2 Special Reports

Special Reports are used to report unplanned events as well as planned major facility and administrative changes. These Special Reports shall contain and shall be communicated as follows:

a. A report that describes the circumstances of any of the events listed below shall be submitted to the U.S. Nuclear Regulatory Commission Regional Administrator of Region V by telephone not later than the following working day and confirmed in writing by telegraph or similar conveyance to be followed by a written report to the offices given in Section 6.6 within 14 days:

(1) Violation of the reactor safety limit (see Section 6.5.1).

(2) Release of radioactivity from the site above allowed limits.

(3) Other Reportable Occurrences (see Section 6.5.2).

(i) Operation with actual safety-system settings for required systems less conservative than the limiting safety-system settings specified in the technical specifications.

(ii) Operation in violation of limiting conditions for operation established in the technical specifications unless prompt remedial action is taken.

(iii) A reactor safety system component malfunction which renders or could render the reactor safety system incapable of performing its intended safety function unless the malfunction or condition is discovered during maintenance tests or periods of reactor shutdowns. (NOTE: Where components or systems are provided in addition to those required by the technical specifications, the failure of the extra components or systems is not considered reportable provided that the minimum number of components or systems specified or required perform their intended reactor safety function.)

(iv) An unanticipated or uncontrolled change in reactivity greater than $1.00. Reactor scrams resulting from a known cause are excluded.

(v) Abnormal and significant degradation in reactor fuel, or cladding, or both, coolant boundary, or confinement boundary (excluding minor leaks) where applicable, which could result in exceeding prescribed radiation exposure limits of personnel or environment, or both.

(vi) An observed inadequacy in the implementation of administrative or procedural controls such that the inadequacy causes or could have caused the existence or development of an unsafe condition with regard to reactor operations.

b. A written report shall be submitted to the NRC within 30 days of:

(1) Permanent changes in the Facility Organization at the level of Director or above.

(2) Significant changes in transient or accident analysis as described in the Safety Analysis Report.

6.7 Records

Facility records may be in the form of logs, data sheets, or other suitable forms. The required information may be contained in single or multiple records or a combination thereof.

6.7.1 Records to be Retained for the Lifetime of REED REACTOR FACILITY

(NOTE: Applicable annual reports, if they contain all of the required information, may be used as records in this section.)

a. Gaseous and liquid radioactive effluents released to the environs.

b. Radiation exposure for all personnel monitored.

c. Updated, corrected and as-built drawings, of the reactor facility.

d. Reed Reactor Facility radiation and contamination surveys.

e. Fuel inventories, receipts, and shipments.

6.7.2 Records to be Retained for a Period of At Least Five Years or for the Life Of The Component Involved if Less Than Five Years

a. Reed Reactor Facility operations, including unscheduled shutdowns, principal maintenance operations, reportable occurrences, surveillance activities required by technical specifications, experiments performed with the reactor.

b. Approved changes in operating procedures.

c. Records of meetings and audit reports of the RRC.

d. Shipments of radioactive materials.

6.7.3 Records to be Retained for at Least One Training Cycle

Retraining and requalification of certified operations personnel. Records of the most recent complete cycle shall be maintained at all times the individual is a Certified Operator at Reed Reactor Facility.