UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FACILITY OPERATING LICENSE

DOCKET NO. 50-602

UNIVERSITY OF TEXAS AT AUSTIN

License No. R-129

1. The U.S. Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for license, filed by University of Texas at Austin, on November 9, 1984, as supplemented, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. Construction of the facility was completed in substantial conformity with Construction Permit No. CPRR-123, of June 4, 1985, the provisions of the Act, and the rules and regulations of the Commission;

   C. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   D. There is reasonable assurance (i) that the activities authorized by this license can be conducted without endangering the health and safety of the public and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   E. The licensee is technically and financially qualified to engage in the activities authorized by this operating license in accordance with the regulations of the Commission;

   F. The licensee is a nonprofit educational institution and will use the facility for conducting educational activities, and has satisfied the applicable provisions of 10 CFR Part 140, "Financial Protection Requirements and Indemnity Agreements," of the Commission's regulations;

   G. The issuance of this license will not be inimical to the common defense and security or to the health and safety of the public;

   H. The issuance of this license is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied; and

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I. The receipt, possession, and use of the byproduct and special nuclear materials as authorized by this license will be in accordance with the Commission's regulations in 10 CFR Parts 30 and 70, including Sections 30.33, 70.23 and 70.31.

2. Facility License No. R-129 is hereby issued to the University of Texas at Austin as follows:

A. The license applies to the TRIGA Mark II nuclear reactor (the facility) owned by the University of Texas at Austin (the licensee). The facility is located on the licensee's site in Austin, Texas, and is described in the licensee's application for license of November 9, 1984, as supplemented.

B. Subject to the conditions and requirements incorporated herein, the Commission hereby licenses the University of Texas at Austin:

(1) Pursuant to Section 104c of the Act and 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," to possess, use, and operate the facility at the designated location in Austin, Texas, in accordance with the procedures and limitations set forth in this license;

(2) Pursuant to the Act and 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," to receive, possess, and use up to 5.8 kilograms of contained uranium-235 enriched to less than 20 percent in the isotope uranium-235 in the form of reactor fuel; up to 20 grams of contained uranium-235 of any enrichment in the form of fission chambers; up to 10 milligrams of uranium-233, 50 milligrams of contained uranium-235 of any enrichment, 10 milligrams of plutonium-240, 40 milligrams of plutonium-239, and 10 milligrams of plutonium-241 in the form of foils; 1 gram of plutonium-239, and 10 grams of contained uranium-235 of any enrichment in the form of reference materials; and to possess, but not separate, such special nuclear material as may be produced by the operation of the facility.

(3) Pursuant to the Act and 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material," to receive, possess, and use a 6-curie sealed plutonium-beryllium neutron source and a 2-curie sealed americium-beryllium neutron source in connection with operation of the facility; 1200 micrograms of californium-252 encapsulated in stainless steel in connection with operation of the facility; 10 kilocuries of cobalt-60 in the form of sealed stainless steel pins; up to 0.1 curie of byproduct material, atomic number 3-83, in the form of reactor components transferred from Facility Operating License No. R-92; and to possess, use, but not separate except for byproduct material produced in reactor experiments, any amount of byproduct material in the form of reactor fuel transferred from Facility Operating License No. R-92 and, such byproduct material as may be produced by operation of the facility.

(4) Pursuant to the Act and 10 CFR Part 40, "Domestic Licensing of Source Material," to receive, possess, and use up to 8 milligrams of uranium-236 and 150 grams of uranium-238 in the form of foils.

C. This license shall be deemed to contain and is subject to the conditions specified in Parts 20, 30, 50, 51, 55, 70, and 73 of 10 CFR Chapter I, to all applicable provisions of the Act, and to the rules, regulations, and orders of the Commission now or hereafter in effect and to the additional conditions specified below:

(1) Maximum Power Level

The licensee is authorized to operate the facility at steady-state power levels not in excess of 1100 kilowatts (thermal) and in the pulse mode with reactivity insertions not to exceed 2.2 percent $\Delta k/k$.

(2) Technical Specifications

The Technical Specifications contained in Appendix A are hereby incorporated in the license. The licensee shall operate the facility in accordance with the Technical Specifications.

(3) Physical Security Plan

The licensee shall fully implement and maintain in effect all provisions of the physical security plan approved by the Commission and all amendments and changes made pursuant to the authority of 10 CFR 50.90 and 10 CFR 50.54(p). The approved plan, which is exempt from public disclosure pursuant to the provisions of 10 CFR 2.790(d), is entitled "Physical Security Plan for the UT [University of Texas] TRIGA Mark II Reactor Facility," Revision 1, dated August 1990.

D. This license is effective as of the date of issuance and shall expire twenty years from its date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Thomas E. Murley

Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

Enclosure:
Appendix A Technical
Specifications

Date of Issuance: January 17, 1992

Appendix A
Technical Specifications
Revision 1

Docket 50-602

The University of Texas at Austin
TRIGA Reactor

December 1990

Table of Contents

1.0 DEFINITIONS

1.1 Certified Operators

An individual authorized by the U.S. Nuclear Regulatory Commission to carry out the responsibilities associated with the position requiring the certification.

1.1.1 Senior Reactor Operator

An individual who is licensed to direct the activities of reactor operators. Such an individual may be referred to as a class A operator.

1.1.2 Reactor Operator

An individual who is licensed to manipulate the controls of a reactor. Such an individual may be referred to as a class B operator.

1.2 Instrumentation Channel

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

1.2.1 Channel Test

Channel test is the introduction of a signal into the channel for verification that it is operable.

1.2.2 Channel Check

Channel check is a qualitative verification of acceptable performance by observation of channel behavior. This verification, where possible, shall include comparison of the channel with other independent channels or systems measuring the same variable.

1.2.3 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.

1.3 Confinement

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

1.4 Experiment

Any operation, component, or target (excluding devices such as detectors, foils, etc.), which is designed to investigate non routine reactor characteristics or which is intended for irradiation within the pool, on or in a beam tube or irradiation facility and which is not rigidly secured to a core or shield structure so as to be part of their design.

1.4.1 Experiment, Moveable

A moveable experiment is one where it is intended that all or part of the experiment may be moved in or near the core or into and out of the reactor while the reactor is operating.

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.

1.4.3 Experimental Facilities

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

1.5 Fuel Element, Standard

A fuel element is a single TRIGA element of standard type. Fuel is U-ZrH clad in stainless steel clad. Hydrogen to zirconium ratio is nominal 1.6.

1.6 Fuel Element, Instrumented

An instrumented fuel element is a special fuel element fabricated for temperature measurement. The element shall have at least one thermocouple embedded in the fuel near the axial and radial midpoints.

1.7 Mode; Manual, Auto, Pulse, Square Wave

Each mode of operation shall mean operation of the reactor with the mode selection switches in the manual, auto, pulse or square wave position.

1.8 Steady-state

Steady-state mode operation shall mean any operation of the reactor with the mode selection switches in the manual, auto or square wave position. The pulse mode switch will define pulse operation.

1.9 Operable

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

1.10 Operating

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

1.11 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.

1.11.1 Instrument Channel Level

At the protective instrument channel level, protective action is the generation and transmission of a trip signal indicating that a reactor variable has reached the specified limit.

1.11.2 Instrument System Level

At the protective instrument system level, protective action is the generation and transmission of the command signal for the safety shutdown equipment to operate.

1.11.3 Reactor Safety System Level

At the reactor safety system level, protective action is the operation of sufficient equipment to immediately shut down the reactor.

1.12 Reactivity, Excess

Excess reactivity is that amount of reactivity that would exist if all the control rods were moved to the maximum reactive condition from the point where the reactor is exactly critical.

1.13 Reactivity Limits

The reactivity limits are those limits imposed on the reactor core excess reactivity. Quantities are referenced to a reference core condition.

1.14 Reactor Core, Standard

A standard core is an arrangement of standard TRIGA fuel in the reactor grid plate and may include installed experiments.

1.15 Reactor Core, Operational

An operational core is a standard core for which the core parameters of excess reactivity, shutdown margin, fuel temperature, power calibration, and reactivity worths of control rods and experiments have been determined to satisfy the requirements set forth in the Technical Specifications.

1.16 Reactor Operating

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

1.17 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 initiation of manual protective action.

1.18 Reactor Secure

The reactor is secure when:

1.18.1 Subcritical :

There is 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

1.18.2 The following conditions exist :

a. The minimum number of neutron absorbing control rods are fully inserted in shutdown position, as required by technical specifications.

b. The console key switch is in the off position and the key is removed from the lock.

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 are being moved or serviced that have, on movement, a reactivity worth equal to or exceeding one dollar.

1.19 Reactor Shutdown

The reactor is shutdown if it is subcritical by at least one dollar in the reference core condition with the reactivity of all installed experiments included.

1.20 Reference Core Condition

The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<.30 dollars).

1.21 Research Reactor

A research reactor is defined as 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 radioisotopes.

1.22 Rod, Control

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

1.22.1 Shim Rod

A shim rod is a control rod having an electric motor drive and scram capabilities.

1.22.2 Regulating Rod

A regulating rod is a 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.

1.22.3 Standard Rod

The regulating and shim rods are standard control rods.

1.22.4 Transient Rod

A transient rod is a control rod used to initiate a power pulse that is operated by a motor drive and/or air pressure. The transient rod shall have scram capability.

1.23 Safety Limits

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

1.24 Scram Time

Scram time is the elapsed time between reaching a limiting safety system set point and a specified control rod movement.

1.25 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.

1.26 Shutdown Margin

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

1.27 Shutdown, Unscheduled

An unscheduled shutdown is defined as any unplanned shutdown of the reactor caused by actuation of the reactor safety system, operator error, equipment malfunction, or a manual shutdown in response to conditions which could adversely affect safe operation, not including shutdowns which occur during testing or check-out operations.

1.28 Value, Measured

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

1.29 Value, True

The true value is the actual value of a parameter.

1.30 Surveillance Activities

Surveillance activities (except those specifically required for safety when the reactor is shutdown), may be deferred during reactor shutdown, however, they must be completed prior to reactor startup unless reactor operation is necessary for performance of the activity. 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.

1.31 Surveillance Intervals

Maximum intervals are to provide operational flexibility and not to reduce frequency. Established frequencies shall be maintained over the long term. Allowable surveillance intervals shall not exceed the following:

1.31.1
5 years (interval not to exceed 6 years).

1.31.2
2 years (interval not to exceed 2-1/2 years).

1.31.3
Annual (interval not to exceed 15 months).

1.31.4
Semiannual (interval not to exceed 7-1/2 months).

1.31.5
Quarterly (interval not to exceed 4 months).

1.31.6
Monthly (interval not to exceed 6 weeks).

1.31.7
Weekly (interval not to exceed 10 days).

1.31.8
Daily (must be done during the calendar day).

2.0 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limit

Specification(s)

The maximum temperature in a standard TRIGA fuel element shall not exceed 1150°C for fuel element clad temperatures less than 500°C and shall not exceed 950°C for fuel element clad temperatures greater than 500°C. Temperatures apply to any condition of operation.

2.2 Limiting Safety System Settings

2.2.1 Fuel Temperature

Specification(s)

The limiting safety system setting shall be 550°C as measured in an instrumented fuel element. One instrumented element shall be located in the B or C ring of the reactor core configuration.

2.2.2 Power Level (Manual, Auto, Square Wave)

Specification(s)

The maximum operating power level for the operation of the reactor shall be 1100 kilowatts in the manual, auto and square wave modes.

2.2.3 Reactivity Insertion (Pulse)

Specification(s)

The maximum transient reactivity insertion for the pulse operation of the reactor shall be 2.2% $\Delta k/k$ in the pulse mode.

3.0 LIMITING CONDITIONS FOR OPERATION

3.1 Reactor Core Parameters

3.1.1 Excess Reactivity

Specification(s)

Maximum excess reactivity shall be 4.9% $\Delta k/k$.

3.1.2 Shutdown Margin

Specification(s)

The reactor shall not be operated unless the shutdown margin provided by control rods is greater than 0.2% $\Delta k/k$ with:

a. The reactor in the reference core condition.

b. The most reactive control rod fully withdrawn.

c. All moveable experiments in their most reactive state.

3.1.3 Transient Insertions

Specification(s)

Total worth of the transient rod shall be limited to 2.8% $\Delta k/k$, and the total withdrawal time for the rod shall not exceed 15 seconds.

3.1.4 Fuel Elements

Specification(s)

The reactor shall not be operated with fuel element damage except for the purpose of locating and removing the elements. A fuel element shall be considered damaged and must be removed from the core if:

a. In measuring the elongation, the length exceeds the original length by 2.54 mm (1/10 inch).

b. In measuring the transverse bend, the bend exceeds the original bend by 1.5875 mm (1/16 inch).

c. A clad defect exists as indicated by release of fission products or visual observation

3.2 Reactor Control and Safety System

3.2.1 Control Assemblies

Specification(s)

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

a. Control rods shall not be operable if damage is apparent to the rod or drive assemblies.

b. 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.

c. Maximum reactivity insertion rate of a standard control rod shall be less than 0.2% $\Delta k/k$ per second.

3.2.2 Reactor Control System

Specification(s)

The reactor shall not be operable unless the minimum safety interlocks are operable. The following control system safety interlocks shall be operable:

Interlocks Rod Drive Control	Number Operable	Function	Effective Mode Manual*	 Pulse
a. Startup Withdrawal Standard control rods Transient control rod	4	prevent rod withdrawal for less than 2 counts per sec	X	
b. Simultaneous Withdrawal Standard control rods Transient control rod	4	prevent rod withdrawal for two or more rods	X	
c. Non pulse condition Transient control rod	1	prevent withdrawal for drive not down except square wave	X	
d. Pulse Withdrawal Standard control rods	3	prevent withdrawa of non pulse rods		X
e. Transient Withdrawal Transient control rod	1	prevent rod withdrawal for more than 1 kilowatt power		X

*Manual mode includes Auto and Square Wave modes

3.2.3 Reactor Safety System

Specification(s)

The reactor shall not be operable unless the minimum safety channels are operable. The following control rod scram safety channels shall be operable.

Safety Channel	Number Operable	Function	Effective Mode Manual*	Pulse
a. Fuel Temperature	2	Scram at ≤550°C	X	X
b. Power Level	2	Scram at ≤1.1 Mw	X	
Pulse Power	1	Scram at ≤2000Mw		X
c. High Voltage	2	Scram on loss	X	X
d. Magnet Current	1	Scram on loss	X	X
e. Manual Scram Console Button	1	Scram on demand	X	X
f. Watchdog Trip Microprocessor scan rate	2	Scram on loss of timer reset	X	X

*Manual mode includes Auto and Square Wave modes

3.2.4 Reactor Instrument System

Specification(s)

A minimum configuration of measuring channels shall be operable. The following minimum reactor parameter measuring channels shall be operable:

Measuring Channel	Number Operable	Effective Mode Manual*	Pulse
a. Fuel Temperature	2	X	X
b. Power Level	2	X	
c. Pulse Power	1		X
d. Pulse Energy	1		X

*Manual mode includes Auto and Square Wave modes

3.3 Operational Support Systems

3.3.1 Water Coolant Systems

Specification(s)

Corrective action shall be taken or the reactor shut down if any of the following (a.-d.) reactor coolant conditions are observed:

a. The bulk pool water temperature exceeds 48°C.

b. The water depth is less than 6.5 meters measured from the pool bottom to the pool water surface.

c. The water conductivity exceeds 5.0 μmho/cm for the average value during measurement periods of one month.

d. The pressure difference during heat exchanger operation is less than 7 kPa (1 psig) measured between the chilled water outlet pressure and the pool water inlet pressure to the heat exchanger.

e. Pool water data from periodic measurements shall exist for water pH and radioactivity. Radioactivity measurements shall include total alpha-beta activity and gamma ray spectrum analysis.

3.3.2 Air Confinement Systems

Specification(s)

Corrective action shall be taken or the reactor shut down if any of the following air confinement conditions do not exist:

a. Equipment shall be operable to isolate the reactor area by closure of room ventilation supply and exhaust dampers, and shutdown of system supply and exhaust fans.

b. The reactor room ventilation system shall have an automatic signal to isolate the area if air particulate radioactivity exceeds preset values.

c. An auxiliary air purge system to exhaust air from experiment systems shall have a high efficiency particulate filter.

d. Room ventilation shall require two air changes per hour or exhaust of pool areas by the auxiliary air purge system.

3.3.3 Radiation Monitoring Systems

Specification(s)

Radiation monitoring while the reactor is operating requires the following minimum conditions :

a. A continuous air monitor (particulate) shall be operable with readout and audible alarm. The monitor shall sample reactor room air within 5 meters of the pool at the pool access level. Alarm set point shall be equal to or less than a measurement concentration of 2 x 10^{-9} μCi/cm3 with a two hour particulate accumulation.

The particulate continuous air monitor shall be operating when the reactor is operating. A set point of the monitor will initiate the isolation signal for the air ventilation system.

The particulate air monitor may be out of service for a period of 1 week provided the filter is evaluated daily, and a signal from the argon-41 continuous air monitor is available to provide information for manual shutdown of the HVAC.

b. A continuous air monitor (argon-41) shall be operable with readout and audible alarm. The monitor shall sample exhaust stack air from the auxiliary air purge system when the system is operating. Alarm set point shall be equal to or less than a measurement concentration of 2 x 10^{-5} μCi/cm3 for a daily release.

The argon-41 continuous air monitor shall be operating when the auxiliary air purge system is operating. The average annual concentration limit for release at the stack shall be 2 x 10^{-6} μCi/cm3.

If the argon-41 monitor is not operable, operating the reactor with the auxiliary air purge system shall be limited to a period of ten days.

c. Area radiation monitors (gamma) shall be operable with readout and audible alarm. Alarm set point shall be a measurement value equal to or less than 100 mr/hr.

One area radiation monitor shall be operating at the pool level when the reactor is operating. Two additional area radiation monitors shall be operating at other reactor areas when the reactor is operating.

3.4 Limitations on Experiments

3.4.1 Reactivity

Specification(s)

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

a. A moveable experiment shall have a reactivity worth less than 1.00 dollar.

b. The reactivity worth of any single secured experiment shall be less than 2.50 dollars.

c. The total of absolute reactivity worths of reactor core experiments shall not exceed 3.00 dollars, including the potential reactivity which might result from malfunction, flooding, voiding, or removal and insertion of the experiments.

3.4.2 Materials

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. Guidance for classification of materials shall use the "Handbook of Laboratory Safety" Tables of Chemical Information published by CRC Press.

b. If a capsule fails and releases material which could damage the reactor fuel or structure by corrosion or other means, removal and physical inspection 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, or his designated alternate, and determined to be satisfactory before operation of the reactor is resumed.

c. Explosive materials in quantities greater than 25 milligrams shall not be irradiated in the reactor or experimental facilities. Explosive materials in quantities less than 25 milligrams may be irradiated provided the pressure produced upon detonation of the explosive has been calculated and/or experimentally demonstrated to be less than the design pressure of the container.

d. Each fueled experiment shall be controlled such that the total inventory of iodine isotopes 131 through 135 in the experiment is no greater than 750 millicuries and the maximum strontium inventory is no greater than 2.5 millicuries.

e. Experiment materials, except fuel 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 room or the atmosphere, the airborne concentration of radioactivity averaged over a year would not exceed the occupational limits for maximum permissible concentration.

f. In calculations pursuant to e. above, the following assumptions shall be used: (1) If the effluent from an experimental facility exhausts through a holdup tank 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 vapors can escape. (3) For materials whose boiling point is above 55°C 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. (4) Limits for maximum permissible concentrations are specified in the appropriate section of 10CFR20.

4.0 SURVEILLANCE REQUIREMENTS

4.1 Reactor Core Parameters

4.1.1 Excess Reactivity

Specification(s)

Excess reactivity shall be determined annually or after significant control rod or reactor core changes.

4.1.2 Shutdown Margin

Specification(s)

Shutdown margin shall be determined annually or after significant control rod or reactor core changes.

4.1.3 Transient Insertion

Specification(s)

Transient rod function shall be evaluated annually or after significant control rod or reactor core changes. The transient rod drive and associated air supply shall be inspected annually, and the drive cylinder shall be cleaned and lubricated annually.

A comparison of pulse data shall be made with previous measurements at annual intervals or each time the interval to the previous measurement exceeds the annual interval.

4.1.4 Fuel Elements

Specification(s)

The reactor fuel elements shall be examined for physical damage by a visual inspection, including a check of the dimensional measurements, made at biennial intervals.

4.2 Reactor Control and Safety System

4.2.1 Control Assemblies

Specification(s)

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

a. Each control rod shall be inspected at biennial intervals by visual observation.

b. The scram time of a scramable control rod shall be measured annually or after maintenance to the control rod or drive.

c. The reactivity insertion rate of a standard control rod shall be measured annually or after maintenance to the control rod or drive.

4.2.2 Reactor Control System

Specification(s)

The minimum safety interlocks shall be tested at semiannual intervals or after repair or modification.

4.2.3 Reactor Safety System

Specification(s)

The minimum safety channels shall be calibrated annually or after repair or modifications. A channel test shall be done prior to each days operation, after repair or modifications, or prior to each extended period of operation.

4.2.4 Reactor Instrument System

Specification(s)

The minimum configuration of instrument channels shall be calibrated annually or after repair or modification. Calibration of the power measuring channels shall be by the calorimetric method. A channel check and channel test of the fuel temperature instrument channels and power level instrument channels shall be made prior to each days operation or prior to each extended period of operation.

4.3 Operational Support Systems

4.3.1 Water Coolant Systems

Specification(s)

The following measurements shall monitor the reactor coolant conditions:

a. The pool temperature channel shall have a channel calibration annually, channel check monthly and will be monitored during reactor operation.

b. The pool water depth channel shall have a channel calibration annually, channel check monthly and will be monitored during reactor operation.

c. The water conductivity channel shall have a channel calibration annually and pool water conductivity will be measured weekly.

d. The pressure difference channel shall have a channel test prior to each days operation, after repair or modifications, or prior to each extended period of operation of the heat exchanger and will be monitored during operation.

e. Measure pool water pH with low ion test paper or equivalent quarterly. Sample pool water radioactivity quarterly for total alpha-beta activity. Analyze pool water sample by gamma spectroscopy annually for isotope identification.

4.3.2 Air Confinement Systems

Specification(s)

The following actions shall demonstrate the air confinement conditions:

a. Annual examination of door seals and isolation dampers.

b. Monthly functional tests of air confinement isolation.

c. Monthly check of the auxiliary air purge system valve alignments for experimental areas.

d. Daily check of ventilation system alignment for proper exhaust conditions prior to reactor operation.

4.3.3 Radiation Monitoring Systems

Specification(s)

The following conditions shall apply to radiation monitoring systems:

a. Calibrate particulate air monitor at semiannual intervals and check operability weekly.

b. Calibrate argon-41 air monitor at biennial intervals and check operability monthly.

c. Calibrate area radiation monitors at semiannual intervals and check operability weekly prior to reactor operation.

4.4 Limitations on Experiments

4.4.1 Reactivity

Specification(s)

The reactivity of an experiment shall be measured before an experiment is considered functional.

4.4.2 Materials

Specification(s)

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

[DE]SIGN FEATURES

5.1 Site and Facility Description

5.1.1 Location

Specification(s)

a. The site location is in the northeast corner of The University of Texas at Austin Balcones Research Center.

b. The TRIGA reactor is installed in a designated room of a building constructed as a Nuclear Engineering Teaching Laboratory.

c. The reactor core is assembled in an above ground shield and pool structure with horizontal and vertical access to the core.

d. License areas of the facility for reactor operation shall consist of the room enclosing the reactor shield and pool structure, and the adjacent area for reactor control. (room 1.104, corridor 3.200; and rooms 3.202, 3.204, and 3.208)

5.1.2 Confinement

Specification(s)

a. The reactor room shall be designed to restrict leakage and will have a minimum enclosed air volume of 4120 cubic meters.

b. Ventilation system should provide two air changes per hour and shall isolate air in the reactor area upon detection of a limit signal related to the radiation level.

c. An air purge system should exhaust experiment air cavities and shall be filtered by high efficiency particulate absorption filters.

d. All exhaust air from the reactor area enclosure shall be ejected vertically upward at a point above the facility roof level.

5.1.3 Safety Related Systems

Specifications

Any modifications to the air confinement or ventilation system, the reactor shield, the pool or its penetrations, the pool coolant system, the core and its associated support structure, the rod drive mechanisms or the reactor safety system shall be made and tested in accordance with the specifications to which the systems were originally designed and fabricated. Alternate specifications may be approved by the Nuclear Reactor Committee. A system shall not be considered operable until after it is tested successfully.

5.2 <u>Reactor Coolant System</u>

5.2.1 Natural Convection

Specification(s)

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

5.2.2 Siphon Protection

Specification(s)

Pool water level shall be protected by holes for siphon breaks in pool water system pipe lines.

5.3 <u>Reactor Core and Fuel</u>

5.3.1 Fuel Elements

Specification(s)

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

a. Uranium content: 8.5 Wt% uranium enriched to a nominal 19.7% Uranium-235.

b. Zirconium hydride atom ratio: nominal 1.6 hydrogen to zirconium, ZrH_x.

c. Cladding: 304 stainless steel, nominal .020 inches thick.

5.3.2 Control Rods

Specification(s)

The shim, regulating, and transient control rods shall have scram capability, and

a. Include stainless steel or aluminum clad and may be followed by air or aluminum, or for a standard rod may be followed by fuel with stainless steel clad.

b. Contain borated graphite, B_4C powder, or boron and its compounds in solid form as a poison.

c. The transient rod shall have a mechanical limit. An adjustable limit will allow a variation of reactivity insertions.

d. Two shim rods, one regulating rod and the transient rod are the minimum control rods.

5.3.3 Configuration

Specification(s)

The reactor shall be an arrangement of core single grid positions occupied by fuel elements, control rods, and graphite elements. Single element positions may be occupied by voids, water or experiment facilities. Special multielement positions or single element positions may be occupied by approved experiments.

5.4 Reactor Fuel Element Storage

Specification(s)

a. All fuel elements shall be stored in a geometrical array where the 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 temperature will not exceed design values.

5.5 Reactor Pool Irradiator

Specification(s)

The irradiator assembly shall be an experiment facility.

a. A 10,000 Curie gamma irradiator may be located in the reactor pool. The irradiator isotope shall be cobalt-60.

b. Location of the assembly shall be at a depth of at least 4.5 meters and at a distance of at least 0.5 meters from the reactor core structure.

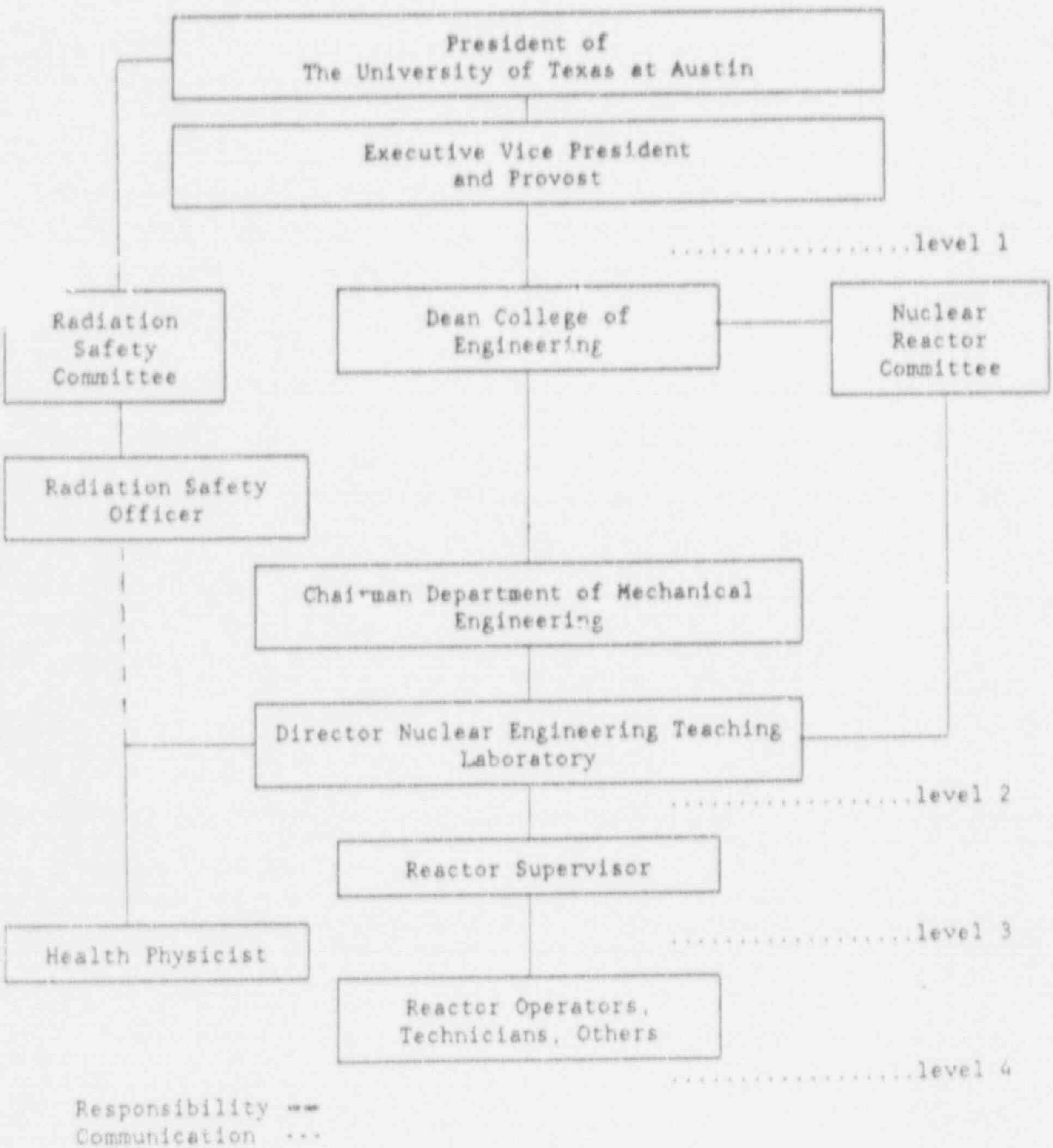
c. Pool water sample requirements shall monitor pool water for source leakage. At a pool water activity of 2.5×10^{-5} $\mu Ci/cm^3$ the gamma irradiator components shall be tested to locate and remove any leaking source.

6.0 ADMINISTRATIVE CONTROLS

6.1 Organization

6.1.1 Structure

The facility shall be under the control of the Director or a supervisory Senior Reactor Operator. The management for operation of the facility shall consist of the organizational structure established as follows:



6.1.2 Responsibility

The Director shall be responsible to the Dean of the College of Engineering and the Chairman of the Department of Mechanical Engineering for safe operation and maintenance of the reactor and its associated equipment. The Director or a supervisory Senior Reactor Operator shall review and approve all experiments and experimental procedures prior to their use in the reactor. Individuals of the management organization shall be responsible for the policies and operation of the facility, and shall be responsible for safeguarding the public and facility personnel from undue radiation exposures and for adhering to the operating license and technical specifications

6.1.3 Staffing

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

a. A reactor operator in the control room.

b. A second person in the facility area that can perform prescribed written instructions. Unexpected absence for two hours shall require immediate action to obtain an alternate person.

c. A senior reactor operator readily available. The available operator should be within thirty minutes of the facility and reachable by telephone.

Events requiring the direction of a senior reactor operator shall be:

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

b. Relocation of any experiment with a reactivity worth of greater than one dollar.

c. Recovery from an unscheduled shutdown or significant power reduction.

d. Initial startup and approach to power.

A list of reactor facility personnel by name and telephone number shall be available to the operator in the control room. The list shall include:

a. Management personnel.

b. Radiation safety personnel.

c. Other operations personnel.

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 licensed operators shall be subject to an approved NRC (Nuclear Regulatory Commission) program.

6.2 Review and Audit

6.2.1 Composition and Qualifications

A Nuclear Reactor Committee shall consist of at least three (3) members appointed by the Dean of the College of Engineering that are knowledgeable in fields which relate to nuclear safety. The university radiological safety officer shall be a member or an ex-officio member. The committee will perform the functions of review and audit or designate a knowledgeable person for audit functions.

6.2.2 Charter and Rules

The operations of the Nuclear Reactor Committee shall be in accordance with an established charter, including provisions for:

a. Meeting frequency (at least once each six months).

b. Quorums (not less than one-half the membership where the operating staff does not represent a majority).

c. Dissemination, review, and approval of minutes.

d. Use of subgroups.

6.2.3 Review Function

The review function shall include facility operations related to reactor and radiological safety. The following items shall be reviewed:

a. Determinations that proposed changes in equipment, systems, tests, experiments, or procedures do not involve an unreviewed safety question.

b. All new procedures and major revisions thereto, 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. Changes in technical specifications or license.

e. Violations of technical specifications or license.

f. Operating abnormalities or violations of procedures having safety significance.

g. Other reportable occurrences.

h. Audit reports.

6.2.4 Audit Function

The audit function shall be a selected examination of operating records, logs, or other documents. An audit will be by a person not directly responsible for the records and may include discussions with cognizant personnel or observation of operations. The following items shall be audited and a report made within 3 months to the Director and Nuclear Reactor Committee:

a. Conformance of facility operations with license and technical specifications at least once each calendar year.

b. Results of actions to correct deficiencies that may occur in reactor facility equipment, structures, systems, or methods of operation that affect safety at least once per calendar year.

c. Function of the retraining and requalification program for reactor operators at least once every other calendar year.

d. The reactor facility emergency plan and physical security plan, and implementing procedures at least once every other year.

6.3 <u>Operating Procedures</u>

Written operating procedures shall be prepared, reviewed and approved by the Director or a supervisory Senior Reactor Operator and the Nuclear Reactor Committee prior to initiation of the following activities:

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

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

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

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

e. Administrative controls for operation, maintenance, and the conduct of experiments or irradiations that could have an effect on reactor safety.

f. Personnel radiation protection, consistent with applicable regulations or guidelines, and shall include a management commitment and programs to maintain exposures and releases as low as reasonably achievable.

g. Implementation of required plans such as the emergency plan or physical security plan.

Substantive changes to the above procedures shall be made effective after approval by the Director or a supervisory Senior Reactor Operator and the Nuclear Reactor Committee. 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 or a supervisory Senior Reactor Operator. 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 or a supervisory Senior Reactor Operator.

6.4 Experiment Review and Approval

All new experiments or classes of experiments shall be approved by the Director or a Supervisory Senior Reactor Operator and the Nuclear Reactor Operations Committee.

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 supervisory senior reactor operator.

6.5 Required Actions

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

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

a. The reactor shall be shut down and reactor operation shall not be resumed until a report of the violation is prepared and authorization to restart by the Nuclear Regulatory Commission (NRC) is issued.

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

c. The safety limit violation shall be subsequently reported to the NRC.

d. A safety limit violation report shall be prepared and submitted to the Nuclear Reactor Committee. The report shall describe: (1) Applicable circumstances leading to the violation including, when known the cause and contributing factors, (2) Effect of the violation on reactor facility components, systems, or structures and on the health and safety of the public, (3) Corrective actions taken to prevent recurrence.

6.5.2 Action to be Taken in the Event of an Occurrence that is Reportable.

In the event of a reportable occurrence, the following action 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 his designated alternate.

b. Occurrence shall be reported to the Director or his designated alternate and to the Nuclear Regulatory Commission as required.

c. Occurrence shall be reviewed by the Nuclear Reactor Committee at the next regularly scheduled meeting.

6.6 Reports

All written reports shall be sent within the prescribed interval to the NRC, Washington D.C. 20555, Attn: Document Control Desk, with a copy to the Regional Administrator, Region IV.

6.6.1 Operating Reports

Routine annual reports covering the activities of the reactor facility during the previous calendar year shall be submitted within three months following the end of each prescribed year. Each annual operating report shall include the following information:

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

b. The unscheduled shutdowns 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, including conclusions that no unreviewed safety questions were involved.

e. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the university 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 allowed or recommended, a statement to this effect is sufficient.

f. A summary of exposures received by facility personnel and visitors where such exposures are greater than 25% of that allowed or recommended.

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

6.6.2 Special Reports

6.6.2.1
A written report within 30 days to the NRC of:

a. Permanent changes in the facility organization involving Director or Supervisor.

b. Significant changes in transient or accident analysis as described in the Safety Analysis Report.

6.6.2.2
A report to NRC Operation Center and Region IV 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 within 14 days that describes the circumstances of the event of any of the following:

a. Violation of fuel element temperature safety limit.

b. Release of radioactivity above allowable limits.

c. Other reportable occurrences.

Other events that will be considered reportable events are listed in this section. (Note: Where components or systems are provided in addition to those required by the technical specifications, the failure of 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.)

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

b. Operation in violation of limiting conditions for operation established in technical specifications unless prompt remedial action is taken.

c. 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.

d. An unanticipated or uncontrolled change in reactivity greater than one dollar. Reactor trips resulting from a known cause are excluded.

e. 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.

f. 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.

6.6.2.3
A written report within 90 days after the completion of startup tests or 9 months after initial criticality, which ever is earlier, of the startup test program, to the NRC of:

Characteristics of the reactor such as critical mass, excess reactivity, power calibration, control rod calibrations, shutdown margin and experiment facility worths, describing the measured values of the operating conditions including:

a. Total control reactivity worth and reactivity of the rod of highest reactivity worth.

b. Minimum shutdown margin of the reactor both at ambient and operating temperatures.

c. An evaluation of facility performance to date in comparison with design conditions and measured operating characteristics, and a reassessment of the safety analysis when measurements indicate that there may be substantial variance from prior analysis submitted with the license application.

6.7 Records

The 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 the 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. Offsite environmental monitoring surveys required by technical specifications.
c. Events that impact or effect decommissioning of the facility
d. Radiation exposure for all personnel monitored.
e. Updated drawings of the reactor facility.

6.7.2 Records to be Retained for a Period of at Least Five Years or for the Life of the Component Involved Whichever is Shorter:

a. Normal reactor facility operation (supporting documents such as checklists, log sheets, etc. shall be maintained for a period of at least one year).
b. Principal maintenance operations.
c. Reportable occurrences.
d. Surveillance activities required by technical specifications.
e. Reactor facility radiation and contamination surveys where required by applicable regulations.
f. Experiments performed with the reactor.
g. Fuel inventories, receipts, and shipments.
h. Approved changes in operating procedures.
i. Records of meeting and audit reports of the review and audit group.

6.7.3 Records to be Retained for at Least One Licensing Cycle:

Retraining and requalifications of licensed operations personnel. Records of the most recent complete cycle shall be maintained at all times the individual is employed.

APPENDIX

A.1.0 DOCKET 50-602 INFORMATION

The Technical Specifications of this document depend on the analysis and conclusions of the Safety Analysis Report. Descriptive information important to each specification is presented in the form of the applicability, objective and bases. This information defines the conditions effective for each technical specification, except administrative conditions, for the Docket 50-602 facility.

A.1.1 Applicability

The applicability defines the conditions, parameters, or equipment to which the specification applies.

A.1.2 Objective

The objective defines the goals of the specification in terms of limits, frequency, or other controllable item.

A.1.3 Bases

The bases presents information important to the specification, including such things as justification, logical constraints and development methodology.

A.2.0 SAFETY LIMITS & LIMITING SAFETY SYSTEM SETTINGS APPLICABILITY, OBJECTIVES AND BASES

A.2.1 Safety Limit

Applicability

This specification applies to the temperature of the reactor fuel in a standard TRIGA fuel element.

Objective

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

Bases

The important parameter for a TRIGA reactor is the fuel element temperature. This parameter is well suited as a single specification since it can be measured directly. A loss in the integrity of the fuel element cladding could arise from a build-up of excessive pressure between the fuel-moderator and the cladding if the fuel temperature exceeds the safety limit. The pressure is caused by the presence of air, fission product gases, and hydrogen from the dissociation of the hydrogen and zirconium in the fuel-moderator. Hydrogen pressure is the most significant component. The magnitude of this pressure is determined by the fuel-moderator temperature and the ratio of hydrogen to zirconium in the alloy.

The safety limit for the standard TRIGA fuel is based on calculations and experimental evidence. The results indicate that the stress in the cladding due to hydrogen pressure from the dissociation of zirconium hydride will remain below the ultimate stress provided that the temperature of the fuel does not exceed 1150°C and the fuel cladding does not exceed 500°C. For conditions that might cause the clad temperatures to exceed 500°C the safety limit of the fuel should be set at 950°C.

A.2.2 Limiting Safety System Setting

A.2.2.1 Fuel Temperature

Applicability

This specification applies to the protective action for the reactor fuel element temperature.

Objective

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

Bases

For non pulse operation of the reactor, the limiting safety system setting is a temperature which, if exceeded, shall cause a reactor scram to be initiated preventing the safety limit from being exceeded. A setting of 550°C provides a safety margin at the point of measurement of at least 400°C for standard TRIGA fuel elements in any condition of operation. A part of the safety margin is used to account for the difference between the true and measured temperatures resulting from the actual location of the thermocouple. If the thermocouple element is located in the hottest position in the core, the difference between the true and measured temperatures will be only a few degrees since the thermocouple junction is near the center and the mid plane of the fuel element. For pulse operation of the reactor, the same limiting safety system setting will apply. However, the temperature channel will have no effect on limiting the peak powers generated because of its relatively long time constant (seconds) as compared with the width of the pulse (milliseconds). In this mode, however, the temperature trip will act to limit the energy release after the pulse if the transient rod should not reinsert and the fuel temperature continues to increase.

A.2.2.2 Power Level (Manual, Auto, Square Wave)

Applicability

This specification applies to the protective action for the reactor during non pulse operation.

Objective

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

Bases

Thermal and hydraulic calculations indicate that standard TRIGA fuel elements may be safely operated at power levels in excess of 1500 kilowatts with natural convection cooling. Conservative estimates indicate that a departure from nucleate boiling ratio of approximately two will occur at about 1900 kilowatts. A limiting setting for the power level measurement at 1.1 megawatts assures sufficient margin for safety to allow for calibration errors. The power calibration goal is a measurement accuracy of 5% although an error of 10% may be representative of some measurements.

A.2.2.3 Reactivity Insertion (Pulse)

Applicability

This specification applies to the reactivity insertion for the reactor during pulse operation.

Objective

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

Bases

Calculations indicate that standard TRIGA fuel elements may be safely operated at transient conditions in excess of 2.2% $\Delta k/k$ with ambient cooling conditions. Conservative estimates indicate that a substantial safety margin exists for the rise of peak fuel temperature with reactivity insertions as large as 2.8% $\Delta k/k$.

A.3.0 LIMITING CONDITIONS FOR OPERATION APPLICABILITY, OBJECTIVES & BASES

A.3.1 Reactor Core Parameters

A.3.1.1 Excess Reactivity

Applicability

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

Objective

The objective is to prevent the fuel element temperature safety limit from being reached by limiting the potential reactivity available in the reactor for any condition of operation.

Bases

Maximum excess core reactivity is sufficient to provide the core rated power, xenon compensation and reactivity for shutdown. Analysis of the reactor core demonstrates that no single component represents sufficient potential reactivity to reach the fuel element temperature safety limit during any condition of operation.

A.3.1.2 Shutdown Margin

Applicability

This specification applies to the reactivity margin by which the reactor core will be considered shutdown when the reactor is not operating.

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.

Bases

The value of the shutdown margin assures that the reactor can be shut down from any operating condition. These conditions include the assumption that the highest worth control rod remains fully withdrawn and all moveable experiments are in the most reactive condition.

A.3.1.3 Transient Insertions

Applicability

This specification applies to the total potential worth of the transient rod and the allowable reactivity insertion for reactor pulse operation.

Objective

The objective is to limit the reactivity available for pulse insertion to a value that will not cause the fuel temperature safety limit to be exceeded.

Bases

Calculations demonstrate that the total insertion of all the transient rod worth will not exceed the fuel temperature safety limit. For a 2.8% Δk/k pulse a safety margin would exist between the fuel element safety limit and the rise of peak fuel temperature above an assumed ambient pool temperature of 50°C. A preset timer insures that the transient rod will not remain in the pulse position for an extended time after the pulse. Experiments with pulsed operation of TRIGA reactors by the manufacturer indicate that insertions up to 3.5% Δk/k have not exceeded the fuel temperature safety limit.

A.3.1.4 Fuel Elements

Applicability

This specification applies to the measurement parameters for the fuel elements.

Objective

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

Bases

The elongation limit has been specified to assure that the cladding material will not be subjected to stresses that could cause a loss of integrity in the fuel containment and to assure adequate coolant flow. The limit of transverse bend has been shown to result in no difficulty in disassembling the reactor core. Analysis of the removal of heat from touching fuel elements shows that there will be no hot spots resulting in damage to the fuel caused by this touching. Experience with TRIGA reactors has shown that fuel element bowing that could result in touching has occurred without deleterious effects.

A.3.2 Reactor Control and Safety System

A.3.2.1 Control Assemblies

Applicability

This specification applies to the function of the control rods.

Objective

The objective is to determine that the control rods are operable by specification of apparent physical conditions, the scram times for scrammable control rods and the reactivity insertion rates for standard control rods.

Bases

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 scram signal is initiated. The specification for rod reactivity insertion rates assures that the reactor will start up at a controllable rate 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.

A.3.2.2 Reactor Control System

Applicability

These specifications apply to logic of the reactor control system.

Objective

The objective is to determine the minimum control system interlocks operable for operation of the reactor.

Bases

Interlocks are specified to prevent function of the control rod drives unless certain specific conditions exist. Program logic of the digital processors implement the interlock functions.

Two basic interlocks control all rod movements in the manual mode. The interlock to prevent startup of the reactor at power levels less than 2 neutron cps, which corresponds to approximately 4 milliwatts, assures that sufficient neutrons are available for controlled reactor startup. Simultaneous withdrawal of more than one control rod is prevented by an interlock to limit the maximum positive reactivity insertion rate available for steady state operation.

Two basic interlocks control rod movements for the pulse mode. The interlock to prevent withdrawal of the motor driven rods in the pulse mode is designed to prevent changing the critical state of the reactor prior to the pulse. A power level interlock controls potential fuel temperature changes by setting a limit of less than 1 kilowatt for initiation of any pulse.

Interlocks applicable to the transient rod determine the proper rod operation during manual mode and pulse mode operation. The non pulse condition interlock determines the allowable position of the rod drive for actuation of the FIRE switch. Actuation of the switch applies the air impulse for removal of the transient rod from the reactor core.

Auto mode is a special condition of the manual mode with automatic control of the regulating rod. Square wave mode is also a special case of the manual mode with automatic control except that pulse logic applies to the initiation of the auto mode condition.

A.3.2.3 Reactor Safety System

Applicability

These specifications apply to operation of the reactor safety system.

Objective

The objective is to determine the minimum safety system scrams operable for the operation of the reactor.

Bases

Safety system scram functions consist of three types. These scram types are the limiting safety system settings, operable system conditions, and the manual or program logic scrams. The scrams cause control rod insertion and reactor shutdown.

Scrams for limiting safety system settings consist of signal trip levels that monitor fuel temperature and power level. The trip levels are conservative by a significant margin relative to the fuel element temperature safety limit.

Operation without adequate control and safety system power supplies is prevented by scrams on neutron detector high voltage and control rod magnet current.

Manual action of the scram switch, key switch, or computer actuation of watchdog timers will initiate a protective action of the reactor safety system. Either of two watchdog circuits provide updating timers to terminate operation in the event that key digital processing routines fail, such as a display system. Each watchdog circuit with four resettable timers contains one trip relay and monitors one microcomputer.

A.3.2.4 Reactor Instrument System

Applicability

These specifications apply to measurements of reactor operating parameters.

Objective

The objective is to determine the minimum instrument system channels to be operable for continued operation of the reactor.

Bases

The minimum measuring channels are sufficient to provide signals for automatic safety system operation. Signals from the measuring system provide information to the control and safety system for a protective action. Instruments provide redundancy by measurements of the same parameters and diversification by measurements of different parameters. Two redundant temperature thermocouple sensors monitor the fuel temperature limiting safety system setting. Two redundant percent power channels monitor the power level limiting safety system. A digital wide range channel may also function as a safety channel but only by diversification as a supplemental channel to an analog linear power channel. Pulse parameters of peak power and energy release are measurements of a single detector chamber. There are, however, two separate peak and energy monitoring circuits.

A.3.3 Operational Support System

A.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 assure that adequate conditions are maintained to provide shielding of the reactor radiation, protection against corrosion of the reactor components, cooling of the reactor fuel, and prevent leakage from the primary coolant.

Bases

The specifications for conditions of the pool water coolant system provide controls that are to control the radiation exposures and radioactive releases associated with the reactor fission product inventory.

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 deterioration.

b. A pool water depth of 6.5 meters is sufficient to provide more than 5.25 meters of water above the reactor core so that radiation levels above the reactor pool are at reasonable levels.

c. Average measurements of pool coolant water conductivity of 5.0 μmho/cm assure that water purity is maintained to control the effects of corrosion and activation of coolant water impurities.

d. A pressure difference at the heat exchanger chilled water outlet and the pool water inlet of 7 kPa will be sufficient to prevent loss of pool water from the primary reactor coolant system to the secondary chilling water system in the event of a leak in the heat exchanger.

e. Periodic sampling of pool water pH and radioactivity are supplemental measurements that assist evaluation of the overall conditions of the reactor pool. Protection of aluminum components requires a pH range of 5 to 8.5. Measurements of radioactivity in the pool water provide information to evaluate working hazards for personnel, leakage indications for radioactive sources in the pool, and monitoring for activation of unknown components in the water.

A.3.3.2 Air Confinement Systems

Applicability

This specification applies to the air ventilation conditions in the reactor area during reactor operation.

Objective

The objective is to control the release of air in the reactor area or experimental facilities.

Bases

The specifications for exhaust ventilation and isolation of the reactor bay provide control for radioactive releases for both routine and non routine operating conditions.

a. Air confinement of the reactor bay includes a provision for isolation of the air flow of the ventilation system. Dampers in the room supply air ducts and room return air ducts limit the leakage rate and total release of radioactive airborne materials to a fraction of the available volume.

b. A signal from a particulate air monitor in the vicinity of the reactor pool initiates the automatic isolation of the supply air dampers and return air dampers. The isolation process takes less than one minute and includes the shutdown of supply fan and exhaust fan. An equivalent to one maximum permissible concentration is the set point.

c. Air from experiment areas within the neutron flux regions of the core will ventilate separately from room air by way of a filter bank that includes a high efficiency particulate filter. Space is available to install a charcoal filter for special experiment conditions.

d. Control of concentrations of argon-41 in reactor room air depends on ventilation of the room air at a rate of two air changes per hour or operation of the auxiliary purge air system. Operation and isolation of the purge system is by manual control of damper and fan switches.

A.3.3.3 Radiation Monitoring Systems

Applicability

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

Objective

The objective is to monitor the radiation and radioactivity conditions in the reactor area to control exposures or releases.

Bases

The radiation monitors provide information to operating personnel of impending or existing hazards from radiation so that there will be sufficient time to take the necessary steps to control the exposure of personnel and release of radioactivity or evacuate the facility. Alarm setpoints do not include measurement uncertainty. These setpoints are measured values and not true values

a. Air particulate radioactivity accumulates on the filter of a continuous monitor that records the radiation levels. An alert and alarm set point including remote readouts at the reactor control console inform the operator of the monitor status and activity levels. An alarm limit at two thousand picocurie/milliliter detects particulate activity concentrations at the occupational values of 10CFR20. The alarm set point exceeds occupational values for any single fission product nuclide in the ranges 84-105 and 129-149. Seventy percent of the particulate isotopes are also detectable at the reference concentrations within two hours. The gaseous argon-41 monitor can provide fission product gas monitoring during repair of the particulate monitor.

b. Air gaseous radioactivity of argon-41 concentrations require monitoring of the levels for effluent release and occupational exposure. The alarm setpoint detects a release concentration that will not exceed ten times either the occupation value at the stack or the reference concentration at the ground. Calculations of a stack release concentration of 1.2 $\mu Ci/cm^3$ indicate that the equivalent ground level concentration is equivalent to $1x10^{-8}$ $\mu Ci/cm^3$. A license limit for the average annual concentration is necessary to fix the amount of allowable release. Periods of inoperable argon-41 monitoring equipment of up to 10 days limit the amount of release without measurement to a fraction of the total annual release.

c. Several area radiation monitors (six) are part of the permanent installation. Some locations are experiment areas in which shield configurations determine the levels of radiation during reactor operation. At the pool access area radiation levels substantial enough to be a high radiation level may occur. Alarm levels at 100 mr/hr will monitor radiation areas if the limit of 2 or 5 mr/hr is not reasonable.

A.3.4 Limitations on Experiments

A.3.4.1 Reactivity

Applicability

This specification applies to the reactivity of experiments located in the reactor core.

Objective

The objective is to control the amount of reactivity associated with experiments to values that will not endanger the reactor safety limit.

Bases

a. The worth of single moveable experiment is limited so that sudden removal movement of the experiment will not cause prompt criticality. Worth of a single unsecured experiment will not cause a reactivity insertion that would exceed the core temperature safety limit.

b. The maximum worth of a single experiment is limited so that the fuel element temperature safety limit will not be exceeded by removal of the experiments. Since experiments of such worth must be 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 all experiments is limited so that removal of the total worth of all experiments will not exceed the fuel element temperature safety limit.

A.3.4.2 Materials

Applicability

These specifications apply to experiments 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.

Bases

a. Double encapsulation requirements lessen the leakage hazards of some types of experiment materials.
b. Operation of the reactor with the reactor fuel or structure damaged is prohibited to avoid release of fission products.

c. Encapsulation requirements for explosive materials set a reference condition for the amount of material allowable for any reactor experiment. Damage from the explosive reaction depends on the available energy release and resultant gas creation. Approximate conditions for 25 milligrams of explosive material are the release of 25 calories (104 joules) of energy and 25 milliliters of gas. If a 1 milliliter volume is available for the reaction of an explosive material (density 1.654 gm/cm³), the energy will represent an instantaneous pressure of 1032 atmospheres and the gas release adds another 25 atmospheres. Stress calculations for a thin wall, cylindrical capsule specify the requirements for the wall thickness and diameter of the encapsulation. The relationship determines the stress limit as one fourth the product of the pressure times the capsule diameter to wall thickness ratio. An aluminum capsule with a 1 milliliter volume requires a ratio that does not exceed 5.2. At a volume of 5 milliliters capsule dimensions with a diameter of 2.6 cm requires a wall thickness of 1 mm. These limiting values are within the constraints of aluminum tubular construction components for experiment facilities and experiments.

d. Fission product inventory limits of 750 millicurie iodine and 2.5 millicurie strontium fix the potential accident release concentrations. These two isotopes represent the radioactive exposure risk to individuals for fission product nuclides with short (iodine) and long (strontium) half-lives. If the isotope iodine-131 represents the total inventory release of 750 millicuries, the facility annual average release, including building wake dilution of the total inventory, will be equivalent to the reference level concentration of 2×10^{-10} $\mu Ci/cm^3$. In the case of strontium-90 the release is less than 1/5 the reference level concentration of 5×10^{-12} $\mu Ci/cm^3$. Proper shutdown of the ventilation system by manual or automatic operation substantially reduces the effective total release. Any release of the total experiment inventory within the facility, however, in the form of iodine-131 or strontium-90 will exceed the occupational values within the facility for the oral ingestion or air inhalation of the radionuclides. As an extreme case the evacuation times to maintain the average annual concentration are 1 hour for iodine-131 and 1 month for strontium-90.

e. Accidental release of radioactive materials that cause airborne concentrations must meet 10CFR20 average annual limits. Concentration limits apply to occupational values that cause exposure within the facility and reference level concentrations that may exist as a release from the facility. Calculations assume a complete release of the material but also must define release rates and frequencies that are conservative or reasonable estimates of accident conditions.

f. This specification provides guidance for the calculation of conditions in part (e).

A.4.0 SURVEILLANCE REQUIREMENTS OBJECTIVES & BASES

A.4.1 Reactor Core Parameters

A.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 core excess reactivity available for power generation.

Bases

Annual determination of excess reactivity and measurements after reactor core or control rod changes are sufficient to monitor significant changes in the core excess reactivity.

A.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.

Bases

Annual determination of shutdown margin and measurements after reactor core or control rod changes are sufficient to monitor significant changes in the core shutdown margin.

A.4.1.3 Transient Insertion

Applicability

This specification applies to surveillance of the transient rod mechanism and to observation of the reactor transient response.

Objective

The objective is to assure the function of the transient rod drive and to compare the reactor pulse insertion parameters.

Bases

Annual inspection of the pulse rod drive system should be sufficient to detect and correct changes in the system that could impair operability. Comparison of pulse parameter data should detect characteristic changes of reactor core transients.

A.4.1.4 Fuel Elements

Applicability

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

Objective

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

Bases

The frequency of inspection and measurement schedule is based on the parameters most likely to affect the fuel cladding of a pulsing reactor operated at moderate pulsing levels and utilizing fuel elements whose characteristics are well known.

A.4.2 Reactor Control and Safety System

A.4.2.1 Control Assemblies

Applicability

This specification applies to the surveillance of the control rods.

Objective

The objective is to inspect the physical condition of the reactor control rods and establish the operable condition of the rod by periodic measurement of the scram times and insertion rates.

Bases

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 of fueled sections 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. Deviations that are significant from acceptable standards will be promptly corrected.

A.4.2.2 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 test, check or calibration of the minimum control system interlocks.

Bases

The periodic test of the interlock logic at semiannual intervals provides adequate information that the function of the control system interlocks are functional. Changes to the interlock logic consist of revisions to the microcomputer algorithms (hardware, software or firmware) and repair of input or output circuits including devices that are sensors for the interlocks. Calibrations or checks of the control system logic are not considered applicable functions.

A.4.2.3 Reactor Safety System

Applicability

This specification applies to tests of the function of the reactor safety system.

Objective

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

Bases

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

A.4.2.4 Reactor Instrument System

Applicability

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

Objective

The objective is to specify intervals for test, check or calibration of the minimum instrument channels.

Bases

Annual calibration of instrument channels are scheduled to allow adjustments for changes in reactor and instrumentation parameters. Checks and tests prior to each system operation verify the function of key channels and systems.

A.4.3 Operational Support Systems

A.4.3.1 Water Coolant Systems

Applicability

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

Objective

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

Bases

Conditions for the reactor coolant are monitored by visual observation of measurements or automatic action of sensors. Periodic checks and tests of measurement devices for the reactor coolant system parameters assure that the coolant system will perform its intended function. Measurement frequencies of pool parameters relate to the time periods appropriate to detection of abnormal conditions. Pool temperature, depth, and heat exchanger pressure differences have an immediate effect on system operation. Water conductivity, pH as a supplemental indicator, and pool radioactive concentrations are conditions that develop at rates detectable at monthly to annual intervals.

A.4.3.2 Air Confinement Systems

Applicability

This specification applies to surveillance conditions for the air ventilation in the reactor area.

Objective

The objective is to demonstrate the function of confinement and release of air from the reactor bay.

Bases

Periodic tests and checks of air confinement conditions verify appropriate ventilation functions. Monitoring frequencies verify performance of the confinement system exhaust daily by an alignment check that includes observation of negative pressures. Tests of the isolation feature at monthly intervals assure the acceptable operation of the system.

A.4.3.3 Radiation Monitoring Systems

Applicability

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

Objective

The objective is to assure the radiation monitors are functional.

Bases

Periodic calibrations and frequent checks are specified to maintain reliable performance of the radiation monitoring instruments. Calibration and check frequencies follow the general recommendations of guidance documents.

A.4.4 Limitations on Experiments

A.4.4.1 Reactivity

Applicability

This specification applies to surveillance of the reactivity of experiments.

Objective

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

Bases

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

A.4.4.2 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.

Bases

A careful evaluation of all experiments is performed to classify the experiment as an approved experiment.

A.5.0 DESIGN FEATURES
OBJECTIVES & BASES

A.5.1 Site and Facility Descriptions

A.5.1.1 Location

Applicability

This specification applies to the TRIGA reactor site location and specific facility design features.

Objective

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

Bases

a. The TRIGA facility site is located in an area controlled by The University of Texas at Austin.

b. The room enclosing the reactor has been designed with characteristics related to the safe operation of the facility.

c. The shield and pool structure have been designed for radiation levels of less than 1 mrem/hr at locations that are not access ports to the reactor structure.

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

A.5.1.2 Confinement

Applicability

This specification applies to the boundary for control of air in the area of the reactor.

Objective

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

Bases

a. Calculations of the concentrations of released radionuclides within the reactor area depend on the available enclosed air volume to limit the concentrations to acceptable levels.

b. Control of the reactor area air exchange is by fan motors and isolation dampers for the supply and exhaust air which are controlled by a logic signal from a radiation sensor to provide automatic air confinement.

c. Emergency air ventilation is filtered to control the release of particulates and a pressure difference relative to the external ambient pressure is intended to prevent leakage of air without filtration.

d. Exhaust air during reactor operation is released at an elevated level for dispersion and is designed to provide a relative pressure difference to the external ambient pressure.

A.5.1.3 Safety Related Systems

Applicability

This specification applies to the requirements of any system related to reactor safety.

Objective

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

Bases

This specification relates to changes in reactor systems which could affect the safety of the reactor operation. Changes or substitutions to these systems that meet or exceed the original design specifications are assumed to meet the presently accepted operating criteria. Questions that may include an unreviewed safety question are referred to the reactor operation committee.

A.5.2 Reactor Coolant System

Applicability

This specification applies to the reactor coolant system composed of deionized water.

Objective

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

Bases

a. This specification is based on thermal and hydraulic calculations which show that a standard 85 element TRIGA core can operate in a safe manner at power levels up to 1,900 kW with natural convection flow of the coolant water and a departure from nucleate boiling ratio of 2.0.

b. Siphon breaks set the subsequent pool water level for loss of coolant without an associated water return caused by inadvertent pumping or accidental siphon of water from the pool.

A.5.3 Reactor Core and Fuel

A.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 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 physical and nuclear characteristics.

Bases

The design basis of the standard TRIGA core demonstrates that 1.5 megawatt steady or 36 megawatt-sec pulse operation presents a conservative limitation with respect to safety limits for the maximum temperature generated in the fuel. The fuel temperatures are not expected to exceed 550°C during any condition of normal operation.

A.5.3.2 Control Rods

Applicability

This specification applies to the control rods used in the reactor core.

Objective

The objective is to assure that the control rods are of such a design as to permit their use with a high degree of reliability with respect to their physical and nuclear characteristics.

Bases

The poison requirements for the control rods are satisfied by using neutron absorbing borated graphite, B_4C powder, or boron and its compounds. These materials must be contained in a suitable clad material, such as aluminum or stainless steel, to insure mechanical stability during movement and to isolate the poison 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. The transient control rod is designed for a reactor pulse.

A minimum configuration of control rods consist of two shim rods, a regulating rod and the transient rod.

The configuration of rods is necessary for the reactor to be operable. If the appropriate adjustments to the core reactivity are made the removal of one or more of the control rods will facilitate the necessary inspection and repair activities. Definitions for shutdown and subcritical require the reactor core to meet the subcritical constraint if any rod is out of the core and the reactor is to be shutdown.

A.5.3.3 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.

Bases

Standard TRIGA cores have been in use for years and their characteristics are well documented.

A.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 fuel storage will not achieve criticality and will not exceed design temperatures.

Bases

The limits imposed by these specifications are considered sufficient to provide conservative fuel storage and assure safe storage.

A.5.5 Gamma Pool Irradiator

Applicability

This specification applies to the gamma irradiator experiment facility in the reactor pool.

Objective

The objective is to assure that the use of the irradiator does not cause any threat to the reactor or safety question.

Bases

Location of the irradiator is at a distance from the reactor sufficient to avoid interference with reactor operation. Depth of the pool water for adequate shielding of the irradiator is also a constraint of the location

A.6.0 NOTES

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