Appendix A

TO

FACILITY LICENSE NO. R-126

DOCKET NO. 50-407

TECHNICAL SPECIFICATIONS AND BASES
FOR
THE UNIVERSITY OF UTAH
NUCLEAR REACTOR

JULY 2011

TECHNICAL SPECIFICATIONS AND BASES FOR THE UNIVERSITY OF UTAH TRIGA NUCLEAR REACTOR

1. INTRODUCTION

1.1 Scope

This document constitutes the Technical Specifications for the Facility License No. R-126 as required by 10 CFR 50.36 and supersedes all prior Technical Specifications. This document includes the "Basis" to support the selection and significance of the specifications. Each basis is included for information purposes only. They are not part of the Technical Specifications, and they do not constitute limitations or requirements to which the licensee must adhere.

1.2 Format

These specifications are formated to NUREG-1537 and ANSI/ANS 15.1-2007.

1.3 Definitions

Audit: An audit is a quantitative examination of records, procedures or other documents after implementation from which appropriate recommendations are made.

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

Channel Calibration: A 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 include a Channel Test.

Channel Check: A 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.

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

Confinement: Confinement is an enclosure of the overall facility that is designed to limit the release of effluents between the enclosure and its external environment through controlled or defined pathways. These are rooms MEB 1205 (A through K) and 1206 in Merrill Engineering Building.

Control Rod: A control rod is a device fabricated from neutron absorbing material, which is used to establish neutron flux changes and to compensate for routine reactivity changes. A control rod may be coupled to its drive unit allowing it to perform a safety function when the coupling is disengaged. Types of control rods shall include:

1. **Regulating Rod (Reg Rod):** The regulating rod is a control rod having an electric motor drive and scram capabilities. Its position may be varied manually or by the servo-controller.
2. **Shim/Safety Rod:** A shim safety rod is a control rod having an electric motor drive and scram capabilities.

Core Lattice Position: The core lattice position is defined by a particular hole in the top grid plate of the core. It is specified by a letter indicating the specific ring in the grid plate and a number indicating a particular position within that ring.

Excess Reactivity: Excess reactivity is that amount of reactivity that would exist if all control rods were moved to the maximum reactive condition from the point where the reactor is exactly critical ($k_{eff} = 1$) at reference core conditions.

Experiment: Any operation, hardware, or target (excluding devices such as detectors or foils) which is designed to investigate non-routine reactor characteristics or which is intended for irradiation within an irradiation facility. Hardware rigidly secured to a core or shield structure so as to be a part of their design to carry out experiments is not normally considered an experiment. Specific experiments shall include:

1. **Secured Experiment:** A secured experiment is any experiment or component of an experiment that is held in a stationary position relative to the reactor by mechanical means. The restraining forces 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 malfunctions.

2. **Unsecured Experiment**: An unsecured experiment is any experiment or component of an experiment that does not meet the definition of a secured experiment.
3. **Movable Experiment:** A movable experiment is one where it is intended that the entire experiment may be moved in or near the core or into and out of the core while the reactor is operating.

Experimental Facilities: Experimental facilities shall mean vertical in-pool irradiation facilities, vertical tubes, in-core irradiation ports such as the A fuel ring (central ring) or other empty fuel element positions, rotating specimen rack, pneumatic transfer system, sample holding dummy fuel elements and any other in-tank irradiation facilities.

Fuel Element: A fuel element is a single TRIGA® fuel element.

Instrumented Element: An instrumented element is a special fuel element in which one or more thermocouples have been embedded for the purpose of measuring the fuel temperatures during reactor operation.

Irradiation: Irradiation shall mean the insertion of any device or material that is not a part of the existing core or experimental facilities into an experimental facility so that the device or material is exposed to radiation available in that experimental facility.

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

Operable: A system or component shall be considered operable when it is capable of performing its intended function.

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

Operational Core: An operational core shall be a fuel element core, which operates within the licensed power level and satisfies all the requirements of the Technical Specifications.

Reactivity Worth of an Experiment: The reactivity worth of an experiment is the value of the reactivity change that results from the experiment, being inserted into or removed from its intended position.

Reactor Operating: The reactor is operating whenever it is not secured or shut down.

Reactor Operator (RO): An individual who is licensed to manipulate the controls of a reactor.

Reactor Safety Systems: Reactor safety systems are those systems, including their associated input channels, which are designed to initiate, automatically or manually, a reactor scram for the primary purpose of protecting the reactor.

Reactor Secured: The reactor is secured when:

1. Either there is insufficient moderator available in the reactor to attain criticality or there is insufficient fissile material in the reactor to attain criticality under optimum available conditions of moderation and reflection; or,
2. All of the following exist:
   - 2.1 The three (3) neutron absorbing control rods are fully inserted as required by technical specifications,
   - 2.2 The reactor is shutdown,
   - 2.3 The console key switch is in the “off” position and the key is removed from the console,
   - 2.4 No experiments are being moved or serviced that have, on movement, reactivity worth exceeding the maximum value allowed for a single experiment, or of one dollar, whichever is smaller, and,
   - 2.5 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.

Reactor Shutdown: The reactor is shut down when it is subcritical by at least one dollar both in the reference core condition and for all allowed ambient conditions, with the reactivity worth of all installed experiments and irradiation facilities included.

Reference Core Condition: The reference core condition is the condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<$ 0.30).

Review: A review is a qualitative examination of records, procedures or other documents prior to implementation from which appropriate recommendations are made.

Safety Channel: A safety channel is a measuring channel in the reactor safety system.

Scram time: Scram time is the elapsed time from the initiation of a scram signal to the time the slowest scrammable control rod is fully inserted.

Senior Reactor Operator (SRO): An individual who is licensed to direct the activities of ROs. Such an individual is also an RO.

Should, Shall, and May: The word “shall” is used to denote a requirement; the word “should” is used to denote a recommendation; and the word “may” to denote permission, neither a requirement nor a recommendation.

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 and will remain subcritical without further operator action, starting from any permissible operating condition with the most reactive rod is in its most reactive position.

Surveillance Intervals: Allowable surveillance intervals shall not exceed the following:

1. Biennial - interval not to exceed 30 months
2. Annual - interval not to exceed 15 months
3. Semiannual - interval not to exceed 7.5 months
4. Quarterly - interval not to exceed 4 months
5. Monthly - interval not to exceed 6 weeks
6. Weekly - interval not to exceed 10 days

2. SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Safety Limit – Fuel Element Temperature

Applicability

This specification applies to the maximum temperature of the reactor fuel.

Objective:

The objective is to define the maximum fuel temperature that can be permitted with confidence that a fuel cladding failure will not occur.

Specifications

1. The temperature in a stainless-steel clad, high hydride fuel element shall not exceed 1,000 ^{o}C (1,273.15 ^{o}K) under any conditions of operation, and
2. The temperature in an aluminum clad, low hydride fuel element shall not exceed 500 ^{o}C (773.15 ^{o}K) under any conditions of operation.

Basis

The important parameter for a TRIGA reactor is the fuel element temperature. This parameter is well suited as a single specification especially since it can be measured. A loss in the integrity of the fuel element cladding could arise from a buildup 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 disassociation of fuel moderator. The magnitude of this pressure is determined by the fuel-moderator temperature and the ratio of hydrogen to zirconium ratio in the alloy.

The safety limit for the stainless steel clad, high hydride TRIGA fuel is based on data, including the experimental evidence obtained during high performance reactor tests on this fuel. These data indicate that the stress in the cladding because of hydrogen pressure from the disassociation of zirconium hydride will remain below the ultimate stress, provided that the temperature of the fuel does not exceed 1,150 ^{o}C (1,423.15 ^{o}K) and the fuel cladding is water cooled.

The safety limit for the aluminum clad, low hydride fuel elements is based on avoiding the phase change in the zirconium hydride, which might cause excessive distortion of a fuel element. This phase change takes place at 530 ^{o}C (803.15 ^{o}K). Additional information is given in the TRIGA Report, GA-471, August 1958.

It has been shown by experience that operation of TRIGA reactors at power level of 1,500 kW will not result in damage to the fuel. Several reactors of this type have operated successfully for years at power level of up to 1,500 kW. Analysis and measurements have shown that a power level of 1,500 kW corresponds to a peak fuel temperature of 600 ^{o}C (~873.15 ^{o}K). Therefore, establishing the Safety Limit at 500 ^{o}C ensures that the fuel integrity is maintained (**SAR 4.2.1** and **4.5.3**).

2.2 Limiting Safety System Settings

Applicability

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

Objective

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

Specifications

1. For a core composed entirely of stainless steel clad, high hydride fuel elements, or a core composed of stainless steel clad, high hydride fuel elements, with aluminum clad, low hydride fuel elements in the F or G hexagonal ring only, limiting safety system settings apply according to the location of the instrumented fuel as indicated in the following table:

Location of Instrumented Fuel Element	**Limiting Safety System Setting for SS Cladding**
B-hexagonal ring	800 ^{o}C (1,073.15 ^{o}K)
C-hexagonal ring	755 ^{o}C (1,028.15 ^{o}K)
D-hexagonal ring	680 ^{o}C (953.15 ^{o}K)
E-hexagonal ring	580 ^{o}C (853.15 ^{o}K)

2. For a core composed of aluminum clad, low hydride fuel elements installed in other than the F or G hexagonal ring, limiting safety system settings apply according to the location of the instrumented fuel element, as indicated in the following table:

Location of Instrumented Fuel Element	**Limiting Safety System Setting for Al Cladding**
B-hexagonal ring	460 ^{o}C (733.15 ^{o}K)
C-hexagonal ring	435 ^{o}C (700.15 ^{o}K)
D-hexagonal ring	390 ^{o}C (663.15 ^{o}K)
E-hexagonal ring	340 ^{o}C (613.15 ^{o}K)

Basis

The UUTR is equipped with two independent instrumented fuel elements that monitor the fuel temperature in the core. The fuel temperature is displayed on the reactor console. Exceeding the set point will initiate a SCRAM. For a core composed entirely of stainless steel clad, high hydride fuel elements or a core composed of aluminum clad, low hydride fuel elements in the F or G hexagonal ring only, limiting safety system settings apply according to the location of the instrumented fuel as indicated in **SAR Table 7.2-1** or this TS requirement. The fuel temperature monitoring channels consists of a K type thermocouple and an Omega CN9000A temperature controller. The useful range is 0 ^{o}C (273.15 ^{o}K) to 800 ^{o}C (1,073.15 ^{o}K) with a ±1 ^{o}K accuracy. Fuel temperature setpoints for the SCRAM function are set at 200 ^{o}C (473.15 ^{o}K) for 100 kW operation.

From the experience of running the UUTR at 90kW power, the instrumented fuel elements indicate that the fuel element temperature for the C-ring and D-ring are 110 ^{o}C (~383.15 ^{o}K) and 95 ^{o}C (368.15 ^{o}K) respectively (measured temperature). The fuel temperature decreases toward the outer fuel rings. Therefore, the fuel temperature in the E-ring will not exceed the safety limit of 460 ^{o}C. According to the PARET-ANL calculation, the maximum centerline fuel temperature for the UUTR at 100kW power is 129.67 ^{o}C (402.82 ^{o}K) (**SAR 4.6, Table 4.6-1**). The TS does not limit the presence of the aluminum elements in the B-ring, but for mixed cores with the aluminum clad elements in one of the inner rings (B through E-ring), the maximum (B-ring) limiting safety system temperature setting is 460 ^{o}C.

During the steady state operation at 100 kW, temperatures were calculated for the beginning- of-life reference UUTR core. Linear extrapolation of temperature and power indicates that an instrumented fuel element power of 1.895 kW will produce 121.7 °C (394.85 ^{o}K) in the instrumented fuel element at the midplane thermocouple location (**SAR 4.2.1.4, Table 4.2-3**). The highest ratio of maximum to minimum power for elements in the C-ring was calculated to be 1.266 (**SAR 4.5.2.3, Table 4.5-6**), so if the instrumented fuel element is generating 1.895 kW, the maximum power in any C-ring element would be limited to 1.895 x 1.266 = 2.399 kW. For a power of 2.399 kW, the maximum temperature anywhere in the C-ring fuel element will be 154.1 ^{o}C (427.25 ^{o}K). These values are well below the safety limits.

3. LIMITING CONDITIONS FOR OPERATION (LCO)

3.1 Reactor Core Parameters

3.1.1 Steady-State Operation

Applicability

This specification applies to the energy generated in the reactor during steady-state operation.

Objective

The objective is to assure that the fuel temperature safety limit shall not be exceeded during steady-state operation.

Specifications

The reactor power level shall not exceed 100 kW.

Basis

Thermal-hydraulics calculations and design analysis are described in **SAR 4.6** addressing the fuel temperature limits during steady-state operation of the UUTR.

3.1.2 Shutdown Margin

Applicability

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

Objective

The objective is to assure that the reactor can be shut down at all times.

Specifications

The reactor shall not be operated unless the shutdown margin provided by control rods shall be greater than $0.50 with:

1. The irradiation facilities and experiments in place and the total worth of all non-secured experiments in their most reactive state,

2. The most reactive control rod fully-withdrawn, and,

3. The reactor in the reference core condition

Basis

The value of the shutdown margin assures that the reactor can be shut down from any operating condition even if the most reactive control rod (which is a safety control rod) should remain in the fully-withdrawn position (**SAR 4.2, 4.5.3.9**).

3.1.3 Core Excess Reactivity

Applicability

This specification applies to the reactivity condition of the reactor and the reactivity worths of control rods and experiments. It applies for all modes of operation.

Objective

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

Specifications

The maximum available excess reactivity based on the reference core configuration shall not exceed $1.20.

Basis

As shown in **SAR 4** this amount of excess reactivity will provide the capability to operate the reactor at full power with experiments in place. The primary limitation providing reactivity safety, however, is the shutdown margin requirement discussed in previous specification.

Changing the core configuration, or adding negative worth experiments will make core excess reactivity more negative and shutdown margin less positive. The only activity which could result in requiring fuel movement to meet shutdown margin and core excess limit would be the unusual activity of adding an experiment with large positive reactivity worth.

3.1.4 Core Configuration

Applicability

This specification applies to the configuration of fuel elements and in-core experiments.

Objective

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

Specifications

1. The reactor core shall be an arrangement of TRIGA LEU cylindrical stainless-steel clad, high hydride fuel-moderator elements and aluminum clad, low hydride fuel-moderator elements with neutron reflectors provided by up to 12 graphite and 12 heavy water elements in aluminum cladding.
2. The reflector, excluding experiments and experimental facilities, shall be a combination of water, graphite and heavy water.
3. Fuel shall not be removed from or inserted into the core unless the reactor is subcritical by more than the calculated worth of the most reactive fuel element.
4. Control rods shall not be removed manually from the core unless the core has been shown to be subcritical with all control rods fully withdrawn from the core.

Basis

1. The UUTR utilizes solid fuel elements, developed by General Atomics (GA), in which the zirconium-hydride moderator is homogeneously combined with enriched uranium. The unique feature of these fuel-moderator elements is the prompt temperature coefficient of reactivity, which gives the TRIGA reactor its built-in safety by automatically limiting the reactor power to a safe level in the event of a power excursion. The UUTR reactor core consists of a lattice of cylindrical stainless steel clad, high hydride (U-$ZrH_{1.6}$) fuel-moderator elements, and aluminum clad, low hydride (U-$ZrH_{1.0}$) fuel-moderator elements. Neutron reflection in the radial direction is provided by 12 graphite and 12 heavy water elements in an aluminum cladding. Also the core is immersed in a water tank, which acts as a thermal shield and a moderator. The core components are contained between top and bottom

aluminum grid plates. The top grid plate has 126 positions for fuel elements and control rods arranged in 6 concentric rings around a central port (used for high flux irradiations) (**SAR 4.2**, **4.5**).

2. The core will be assembled in the reactor grid plate located at the bottom of tank filled with light water. Light water of the tank, in combination with graphite and heavy water reflector elements can be used for neutron economy and to enhance requirements for experimental facilities.

3. Manual manipulation of fuel elements will be allowed only when single fuel element manipulation cannot result in an inadvertent criticality.

4. Manual movement of control rods will be allowed only when single manipulation cannot result in an inadvertent criticality.

3.1.5 Reactivity Coefficients

Not Applicable.

3.1.6 Fuel Parameters

Applicability

This specification applies to all fuel elements.

Objective

The objective is to maintain integrity of the fuel element cladding.

Specifications

The reactor shall not operate with damaged fuel elements, except for the purpose of locating damaged fuel elements. A fuel element shall be considered damaged and must be removed from the core if any of the following conditions are met:

1. The transverse bend exceeds 0.0625 inches over the length of the cladding,
2. Its length exceeds its original length by 0.125 inches,
3. A cladding defect exists as indicated by release of fission products,
4. Visual inspection identifies bulges, gross pitting, or corrosion, or
5. Fuel burnup of Uranium-235 in the UZrH fuel matrix exceeds 50% of the initial content.

Basis

Gross failure or obvious visual deterioration of the fuel is sufficient to warrant declaration of the fuel as damaged. The elongation and bend limits are the values found acceptable to the USNRC (NUREG-1537).

3.2 Reactor Control and Safety System

3.2.1 Control Rods

Applicability

This specification applies to the function of the control rods.

Objective

The objective is to determine that the control rods are operable.

Specification

The reactor shall not be operated unless the control rods are operable. Control rods shall not be considered operable if:

1. Damage is apparent to the rod or rod drive assemblies,
2. The scram time exceeds 2 seconds, or
3. The rate of reactivity insertion by control rod motion exceeds $0.30 per second.

Basis

The three control rods assure that the reactor shall be promptly shut down when a scram signal is initiated. Experience and analysis have indicated that for the range of transients anticipated for a TRIGA reactor, the specified scram time is adequate to assure the safety of the reactor (**SAR 4.2.2, 4.5.3.10**). All three-control rods have the same rise time. Therefore, the obtained $0.053/second is much lower than this TS requirement of $0.30/sec. The shutdown margin must be greater than $0.50 (**TS 3.1.2**) and the excess reactivity must be less than $1.20 (**TS 3.1.3**).

The scram time shall not exceed 2 seconds measured from the time when one of the scram set points is exceeded (power level or fuel temperature) to time when the slowest scrammable control rod (which is a safety control rod) is fully inserted into the core. The scram time specification is satisfied when the sum of the response times of the slowest responding safety channel (that could be either power level or fuel temperature exceeding the corresponding limits), plus the fall time of the slowest scrammable control rod (which is a safety control rod), is less than or equal to 2 seconds.

3.2.2 Reactor Measuring Channels

Applicability

This specification applies to the information, which shall be available to the RO during reactor operation.

Objective

The objective is to specify the minimum number of measuring channels that shall be available to the operator to assure safe operation of the reactor.

Specifications

The reactor shall not be operated in the specified mode unless the minimum number of measuring channels listed in this table is operable:

Measuring Channel	Minimum Number Operable
Start-up Count Rate	1
Fuel element temperature	1
Linear power level	1
Percent power level	1

Basis

Start-up Count Rate: The neutron count rate in the UUTR core must be greater than 2 cps for the reactor to be operable (**SAR 4.2.4**).

Fuel element temperature: Fuel element temperature displayed at the control console gives continuous information on this parameter, which has a specified safety limit.

Linear and percent power level: The linear and percent power level monitors assure that the reactor power level is adequately monitored during the reactor operation.

3.2.3 Reactor Safety System

Applicability

This specification applies to the reactor safety system channels.

Objective

The objective is to specify the minimum number of reactor safety system channels that shall be available to the operator to assure safe operation of the reactor.

Specifications

The reactor shall not be operated unless the minimum number of safety channels described in Table 1 and 2, are operable[1].

Table 1. Minimum reactor safety channels

Safety channel	Minimum Number Operable	Function
Fuel element temperature	1	Scram at 200 ^{o}C (473.15 ^{o}K)
Linear power level[2]	1	Scram at 100 kW
Percent power level[2]	1	Scram at 110% of full licensed power
Manual Console scram	1	Manual scram
Magnet current key switch	1	Manual scram
Console power supply	1	Scram on loss of electrical power
Reactor tank water level	1	Scram at 15.5 inches below the top of the UUTR tank

Table 2. Minimum interlocks

Safety System Interlock	Minimum Number Operable	Function
Startup count rate interlock	1	Prevent control rod withdrawal when neutron count rate is less than 2 counts per second
Control rod withdrawal interlocks	All control rods	Prevent manual withdrawal of more than one control rod simultaneously

[1] If any required safety channel or interlock becomes inoperable while the reactor is operating for reasons other than identified in this TS, the channel shall be restored to operation within 5 minutes or the reactor shall be immediately shutdown.

[2] Any single linear or percent power level channel or interlock may be inoperable while the reactor is operating for the purpose of performing a channel check, channel test, or channel calibration.

Basis

Safety System Measuring Channel

Fuel element temperature scram: The fuel element temperature scram is set to one fifth of the LSSS for the stainless steel clad, high hydride fuel element located in the B-hexagonal ring, which is 200 ^{o}C (473.15 ^{o}K) (**SAR 7.2.3.2**). This is more than adequate to account for uncertainties in instrument response and core position of the instrumented fuel element. (**SAR 4.6**)

Power level scram: Linear power channel scram is at 100kW, and percent power channel scram is at 110% of full licensed power. Therefore, the UUTR is operated at around 90kW without scramming the reactor unnecessarily. The difference in around 10kW allows for expected and observed instrument fluctuations at the normal full operating power at 90kW. Conversely, **SAR 13.2.2** shows that this set point is more than sufficient to prevent the operator from inadvertently exceeding the licensed power.

*Manual console scram***:** The manual scram must be functional at all times the reactor is in operation. It has no specified value for a scram set point. It is initiated by the RO manually.

*Magnet current key switch***:** The reactor key must be in the key hole and "on" position during the reactor operation. If the reactor key is removed from the key hole and moved to "off" position, the magnet current in the control system will be interrupted and all three control rods will be dropped in to the core. The reactor will be scrammed.

*Console power supply***:** If the reactor console loses the electrical power, the reactor will be scrammed even if the UPS (Uninterrupted Power System) is installed.

*Reactor tank water level***:** The UUTR pool water must have a specific water level to avoid the reactor scram. The distance from the top of the reactor tank to the surface of the pool water must be less than 15.5 inches.

Safety System Interlock

*Startup count rate interlock***:** The control rod withdrawal interlock prevents the operator from adding reactivity when the startup count rate falls below 2 cps because the count rate is insufficient to produce meaningful instrumentation response. If the operator were to insert reactivity under this condition, the period could quickly become very short resulting in an inadvertent power excursion. A neutron source is added to the core to create sufficient instrument response so that the operator can recognize and respond to changing conditions.

*Control rod withdrawal interlocks***:** The single rod withdrawal interlock prevents the operator from removing multiple control rods simultaneously assuring that reactivity insertions from control rod manipulation is controlled. The analysis presented in **SAR 13.2.2** and **SAR 4.2.2** show that the reactivity insertion due to the removal rate of the most reactive control rod (which is the safety control rod), or all the control rods simultaneously, is still well below the reactivity insertion TS limit of $0.30/sec.

3.3 Coolant System

Applicability

This specification applies to the primary water of the reactor tank.

Objective

The objective is to assure that there is an adequate amount of water in the reactor tank for fuel cooling and shielding purposes, and that the bulk temperature of the reactor tank water remains sufficiently low to guarantee reactor tank integrity.

Specifications

The reactor primary water shall exhibit the following parameters:

1. The reactor tank water level alarm shall indicate loss of coolant if the tank water level decreases greater than 15.5 inches from the top of the UUTR water tank,
2. The reactor tank water temperature shall be less than 35 ^{o}C (308.15 ^{o}K),
3. The conductivity of the reactor tank water shall be less than 5 μmhos/cm,
4. The pH shall be between 5.5 and 7.5, and,
5. The reactor shall not be operated if the radioactivity of reactor pool water exceeds the limits of 10 CFR 20 Appendix B Table 3 for radioisotopes with half-lives > 24 hours.

Basis

1. The distance from the top of the reactor tank to the surface of the pool water must be less than 15.5 inches for reactor to be operable without setting the alarm (**SAR 5.2**).
2. The bulk water temperature limit is necessary, according to the reactor manufacturer, to ensure that the aluminum reactor tank maintains its integrity and is not degraded (**SAR 4.3**).
3. Experience at many research reactor facilities has shown that maintaining the conductivity within the specified limit provides acceptable control of corrosion (NUREG-1537) (**SAR 5.2.3**).
4. The pH of reactor tank water is kept between 5.5 and 7.5 (**SAR 5.3**) assuring the water is kept chemically neutral.
5. A monthly checkout of the reactor tank water is performed using a high

purity gamma spectroscopy system. Typical survey shows that the total activity of the reactor tank water ranges between 0.3 to 0.7 nCi/l ($7.0x10^{-7}$ μCi/ml). This amount of activity is substantially lower than 10 CFR 20 Appendix B (Table 3) requirements. Analyses using a high purity gamma spectroscopy system show that limiting the activity to this level will not result in any person being exposed to concentrations greater than those permitted by 10 CFR Part 20.

3.4 Confinement

Applicability

These specifications apply to the area housing the reactor and the ventilation system controlling that area.

Objective

The objective is to provide restrictions on radioactive airborne materials releases into environment.

Specifications

1. Confinement is required for reactor operation and/or any movement of irradiated fuel, and,
2. To achieve confinement, the ventilation system shall be operating in accordance with **TS 3.5**.

Basis

1. During reactor operation and/or any movement of irradiated fuel there is the potential for release of radioactivity from fuel elements. Confinement will limit the consequences to the public from such a release.
2. During reactor operation and/or any movement of irradiated fuel, the potential for release of radioactivity from fuel elements will be controlled by operating ventilation system.

3.5 Ventilation System

Applicability

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

Objective

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

Specifications

The reactor shall not be operated unless the ventilation system is fully operable which is when:

1. The pressure difference between the reactor room and outside of the Merrill Engineering Building is larger than 0.1 inches-of-water.

2. In the event of a substantial release of airborne radioactivity within the reactor area, the ventilation system will be secured or operated in the limited intake mode to prevent the release of a significant quantity of airborne radioactivity from the reactor area.

Basis

In the operational mode of the ventilation system, the air in the controlled access area (reactor room area) is constantly being exchanged. The air leaving the facility has a volumetric flow rate of more than 100 CFM per each of the two fume hoods. The result of this is a negative pressure of greater than 0.01 inches of water in the reactor room.

The worst-case maximum total effective dose equivalent is well below the applicable annual limit for individual members of the public and building residents during the maximum hypothetical accident (MHA) (**SAR 13.2.1**).

3.6 Emergency Power

Not Applicable.

3.7 Radiation Monitoring Systems and Effluents

3.7.1 Radiation Monitoring Systems

Applicability

This specification applies to the radiation monitoring information, which must be available to the RO during reactor operation.

Objective

The objective is to specify the minimum radiation monitoring channels that shall be available to the operator to assure safe operation of the reactor.

Specifications

The reactor shall not be operated unless the minimum number of radiation monitoring channels is operating as in the accompanying table:

Radiation Monitoring Channels	Number
Area Radiation Monitor (ARM)	1
Continuous Air Monitor CAM (particulate, noble gas, and iodine)[1]	1

Basis

The radiation monitors provide information to operating personnel regarding routine releases of radioactivity and any impending or existing radiation. Their operation will provide sufficient time to evacuate the facility or take the necessary steps to prevent the spread of radioactivity to the surroundings. The calculations show that for routine operations and under the accident scenarios identified in **SAR 13.2.1.1**, predicted occupational and general public doses are below the applicable annual limits specified in 10 CFR 20 (**SAR 11.1.1.1** and **SAR 13.2.1**).

[1] The reactor can be operable for 48 hours without the CAM system (**SAR 5.6**) but with the operable ARM system.

3.7.2 Effluents

Applicability

This specification applies to the release rate of ^{41}Ar.

Objective

The objective is to ensure that the concentration of the ^{41}Ar in the unrestricted areas shall be below the applicable effluent concentration value in 10 CFR 20.

Specifications

The annual average concentration of ^{41}Ar discharged into the unrestricted area shall not exceed 1 x10^{-8} μCi/ml at the point of discharge averaged over one year.

Basis

Based on the calculation as shown in the **SAR 11.1.1.1.6**, the equilibrium Argon-41 concentration during full power steady state at 100 kW in the reactor room area would be 0.024 Bq/cm^3 (6.4 x 10^{-7} μCi /cm^3) which is significantly below the 10 CFR 20 Derived Air Concentration (DAC) limit of 3 x 10^{-6} μCi /cm^3.

For the external radiological assessment as indicated in **SAR Table 11.1-2**, the peak down concentration of ^{41}Ar produced by the UUTR at a power level of 100 kW is less than the 10 CFR 20, Appendix B, effluent concentration of 1 x 10^{-8} μCi /cm^3 for all meteorological conditions.

3.8 Experiments

3.8.1 Reactivity Limits

Applicability

These specifications apply to experiments installed in the reactor and its irradiation facilities.

Objective

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

Specifications

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

1. The absolute value of the reactivity worth of any single secured or unsecured experiment shall be less than $1.00, and,

2. The sum of the absolute values of the reactivity worths of all experiments shall be less than $1.20.

Basis

The UUTR limits the worth of a single experiment to assure that sudden removal of the experiment will not cause the fuel temperature to rise above the critical temperature level of 500 ^{o}C (773.15 ^{o}K).

By limiting the absolute values of the reactivity worths of all experiments in the reactor at one time to $1.20, it assures that the removal of the total worth for all experiments not to exceed the fuel element temperature limit of 500 ^{o}C (773.15 ^{o}K) for an aluminum element and 1,000 ^{o}C (1,273.15 ^{o}K) for a stainless steel element.

Regardless of any other administrative or physical requirements, this limit has been shown in **SAR 13.2.2** to protect the reactor during the fuel's entire lifetime.

3.8.2 Materials

Applicability

This specification applies to experiments installed in the reactor and its irradiation facilities.

Objective

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

Specifications

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

1. Explosive materials, such as gunpowder, TNT, nitroglycerin, or PETN, in quantities greater than 25 milligrams TNT equivalent shall not be irradiated in the reactor or irradiation facilities. Explosive materials in quantities less than 25 milligrams TNT equivalent may be irradiated provided the pressure produced upon detonation of the explosive has been calculated and/or experimentally demonstrated to be less than half the design pressure of the container, and,
2. Experiments containing corrosive materials shall be doubly encapsulated. The failure of an encapsulation of material that could damage the reactor shall result in removal of the sample and physical inspection of potentially damaged components.

Basis

This specification is intended to prevent damage to reactor components resulting from failure of an experiment involving explosive materials. Operation of the reactor with the reactor fuel or structure potential damages is prohibited to avoid potential release of fission products.

3.8.3 Failures and Malfunctions

Applicability

This specification applies to experiments installed in the reactor and its irradiation facilities.

Objective

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

Specifications

Where the possibility exists that the failure of an experiment under normal operating conditions of the experiment or reactor, credible accident conditions in the reactor, or possible accident conditions in the experiment could release radioactive gases or aerosols to the reactor room or the unrestricted area, the quantity and type of material in the experiment shall be limited such that the airborne radioactivity in the reactor room or the unrestricted area will not result in exceeding the applicable dose limits in 10 CFR 20, assuming that:

1. 100% of the gases or aerosols escape from the experiment,
2. If the effluent from an irradiation 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,
3. If the effluent from an irradiation facility exhausts through a filter installation designed for greater than 99% efficiency for 0.3 micron particles, at least 10% of these aerosols can escape, and,
4. For materials whose boiling point is above 54.4 ^{o}C (130 ^{o}F or 327.6 ^{o}K) and where vapors formed by boiling this material can escape only through an undisturbed column of water above the core, 10% of these vapors can escape.

Basis

This specification is intended to meet the purpose of 10 CFR 20 by reducing the likelihood that released airborne radioactivity to the reactor bay or unrestricted area surrounding the UUTR will result in exceeding the total dose limits to an individual as specified in 10 CFR 20.

3.9 Facility Specific LCOs

There are no facility specific LCOs at the UUTR.

4 SURVEILLANCE REQUIREMENTS

4.0 General

Applicability

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

Objective

The objective is to verify the proper operation of any system related to reactor safety.

Specifications

1. Surveillance requirements may be deferred during reactor shutdown (except **TS 4.3 (1)** and **(5)**); however, they shall be completed prior to reactor startup unless reactor operation is required for performance of the surveillance. Such surveillance shall be performed as soon as practicable after reactor startup. Scheduled surveillance, which cannot be performed with the reactor operating, may be deferred until a planned reactor shutdown.
2. Any additions, modifications, or maintenance to the ventilation system, the core and its associated support structure, the pool or its penetrations, the pool coolant system, the rod drive mechanism or the reactor safety system shall be made and tested in accordance with the specifications to which the systems were originally designed and fabricated or to specifications reviewed by the Reactor Safety Committee (RSC). A system shall not be considered operable until after it is successfully tested.

Basis

This specification is related to changes in reactor systems, which could directly affect the safety of the reactor. As long as changes or replacements to these systems continue to meet the original design specifications, then it can be assumed that they meet the presently accepted operating criteria.

4.1 Reactor Core Parameters

Applicability

This specification applies to the surveillance requirements for reactor core parameters.

Objective

The objective is to verify that the reactor does not exceed the authorized limits for power, shutdown margin, core excess reactivity, specifications for fuel element condition and verification of the total reactivity worth of each control rod.

Specifications

1. The shutdown margin shall be determined prior to each day's operation, prior to each operation extending more than one day, or following any change (>$0.25) from a reference core.
2. The total reactivity worth of each control rod shall be measured semi-annually or following any change (>$0.25) from a reference core.
3. The core excess reactivity shall be determined semi-annually or following any reactivity change (>$0.25) from a reference core.
4. Each planed change in core configuration shall be determined to meet the requirements of **TS 3.1.4** of these specifications before the core is loaded.
5. Inspection for transverse bend and length for fuel elements, cladding defect, overall visual inspection shall be performed biennially.
6. Fuel burnup of Uranium-235 in the UZrH fuel matrix shall not exceed 50% of initial content. Fuel burnup calculation shall be performed biennially.

Basis

Experience has shown that the identified frequencies will ensure performance and operability for each of these systems or components.

The value of a significant change in reactivity (>$0.25) is measurable and will ensure adequate coverage of the shutdown margin after taking into account the accumulation of poisons.

For inspection, looking at fuel elements from each ring biennially will identify any developing fuel integrity issues in the core. The fuel is inspected for defects including surface anomalies (spots or scratches of reddish brown, black, or white), cladding dents and bent pins. The UUTR core has upper and lower grids that have holes for a fuel element. A fuel element would not fit in the core if the transverse bend exceeds 0.0625 inches over the length of the cladding or its length exceeds its original length by 0.125 inches. An underwater camera can be used to check if any fuel element is placed correctly in the core (**SAR 4.2.5**).

An element is considered damaged if it meets the criteria outlined in **TS 3.1.6.** Also, if an element releases bubbles directly from the cladding region during or after being raised near the surface for visual inspection, then it may be assumed that a pin hole leak was induced through depressurization. A leaking fuel element is potentially very difficult to detect and recognize because of the low levels of activity associated with such a leak. There are two mechanisms of regular surveillance which may detect the release of active materials: the Continuous Air Monitor (CAM) and monthly spectroscopy of the tank water. The purpose of the CAM is to detect short-lived gaseous products from gross leakage. The purpose of the monthly spectroscopy is to detect and differentiate long-lived soluble products released in small quantities (**SAR 9.2.6**). An estimated calculated maximum fuel burnup (using MCNP5) for the UUTR is 8.91% for aluminum clad elements and 8.77% for stainless steel clad elements (**SAR 4.2.1.1**).

4.2 Reactor Control and Safety Systems

Applicability

This specification applies to the surveillance requirements of reactor control and safety systems.

Objective

The objective is to verify performance and operability of those systems and components, which are directly related to reactor safety.

Specifications

1. Control rod inspection: The control rods and drives shall be visually inspected for damage or deterioration biennially.
2. SCRAM time: The scram time shall be measured annually and following maintenance to the control element or their drives.
3. Control rod movement: The speed of the control rod movement shall be measured annually.
4. Fuel element temperature (channel calibration, channel test, and channel check): The fuel element temperature measuring channel shall be calibrated semi-annually. The channel test shall be performed annually. The channel check shall be performed prior and during start-up and during every operation of the reactor.
5. Linear power level (channel check and channel calibration): Channel check shall be performed for every operation of the reactor. Channel calibration shall be performed semi-annually.
6. Percent power level (channel check and channel calibration): Channel check shall be performed for every operation of the reactor and channel calibration shall be performed semi-annually.
7. Manual console scram (channel test): Manual console scram function channel test shall be performed prior to every reactor operation.
8. Magnet key current switch (channel test): The magnet key current channel test switch shall be performed prior to every reactor operation.
9. Console power supply (channel test): Console power supply system shall be channel tested prior to every reactor operation.
10. Reactor tank water level (channel check and channel test): Reactor tank water level shall be channel checked and channel tested prior to every

reactor operation.

11. Startup count rate interlock (channel test): Startup count rate interlock system shall be channel tested prior to every reactor operation.
12. Control rod withdrawal interlocks (channel check and channel test): Control rod interlock function shall be channel checked prior to every reactor operation. Control rod interlock function shall be channel tested prior to every reactor operation and semi-annually.

<u>Basis</u>

1. All three control rods are required to be inspected during biennial fuel inspection. Control rod removed from the core, cleaned up, and placed in the original positions after inspection.
2. Measurement of the scram time on an annual basis is a check not only of the scram system electronics, but also is an indication of the capability of the control elements to perform properly.
3. The control rod movement speed needs to be measured annually during control rod worth measurement. The reactivity insertion for each control rod should not exceed $0.30/sec.
4. Over 35 years of the UUTR operation showed that the fuel element temperature-measuring channel calibrated semi-annually, the fuel temperature channel tested annually and the channel check performed prior and during start-up and during every operation of the reactor have been sufficient to assure proper operation (**SAR 7.2.3.2**).
5. Experience shows that the linear power level channel calibration and channel check assure that the reactor is operated at the proper power levels.
6. Semi-annual percent power level channel calibration and channel check assure that the reactor is operated at the proper power level.
7. Manual console scram function is tested prior to every reactor operation assuring the function for the manual scram works properly.
8. Magnet key current switch provides a power to the console. An operator tests its proper function prior to every reactor operation.
9. Reactor will be scrammed if the power supply works incorrectly. A RO therefore tests the console power supply system prior to every reactor operation.
10. Reactor tank water level will scram the reactor if the water height is below 15.5 inches measured from the top of the reactor water tank. An operator checks and tests the water height level prior to every reactor operation.

11. Experience showed that source interlock system tested prior to every reactor operation will provide the required conditions for a proper reactor operation.

12. Control rod withdrawal interlocks prevent the withdrawal of more than one control rod at once. An interlock circuit is used to prevent rod withdrawal unless the source count level is above the required minimum value of at least 2 counts/second. Experience showed that control rod interlock function checked prior to every reactor operation and control rod interlock function tested prior to every reactor operation and semi-annually, are satisfactory in assuring that the reactor is operated properly.

The following table summarizes the frequency of channel test, channel check and channel calibration per specifications as listed in this TS:

Specification	**Channel Check Frequency**	**Channel Test Frequency**	**Channel Calibration Frequency**
Fuel element temperature	Prior to and during start-up and operation	Annually	Semi-annually
Linear Power level	During operation	NA	Semi-annually
Percent power level	During operation	NA	Semi-annually
Manual console scram	NA	Prior to and during start-up	N/A
Magnetic current key switch	NA	Prior to and during start-up	NA
Console power supply	Prior to operation	Prior to and during start-up	NA
Reactor tank water level	Prior to operation	Prior to operation	NA
Startup count rate interlock	NA	Prior to and during start-up	NA
Control rod withdrawal interloks	Prior to and during start-up and operation	Prior to and during start-up	Semi-annually

4.3 Coolant System

Applicability

This specification applies to the surveillance requirements for the reactor tank water.

Objective

The objective is to assure that the reactor tank water level and the bulk water temperature monitoring systems are operating, and to verify appropriate alarm settings.

Specifications

1. A channel check of the reactor tank water level monitor shall be performed monthly.
2. A channel test of the reactor tank water temperature system shall be performed prior to each day's operation or prior to each operation extending more than one day.
3. A channel calibration of the reactor tank water temperature system shall be performed semi-annually.
4. The reactor tank water conductivity and pH shall be measured monthly.
5. The reactor tank water radioactivity shall be measured monthly.

Basis

Experience has shown that the frequencies of checks on systems, which monitor reactor primary water level, temperature, and conductivity adequately, keep the tank water at the proper level and maintain water quality at such a level to minimize corrosion and maintain safety.

Reactor tank water conductivity is continuously monitored; it would be manually monitored on a monthly basis if the instruments failed. Radioactivity is indirectly monitored by an area radiation monitor placed near the reactor water tank and reactor ceiling, so gross activity increases would be detected immediately. Experience with TRIGA reactors indicates the earliest detection of fuel cladding leaks is usually from airborne activity, rather than pool water activity. The quarterly measurement can identify specific radionuclides.

Analysis has shown that as long as reactor tank water conductivity is less than 0.1 μS/cm (resistivity >10MΩ-cm), pool water pH is between 7.5 and 6.5. During periods of time when reactor tank water conductivity is greater than 0.1 μS/cm (resistivity <10MΩcm), reactor tank water pH must be measured to ensure compliance with **TS 3.3**.

4.4 Confinement

Applicability

This specification applies to the reactor confinement.

Objective

The objective is to assure that air is swept out of confinement and exhausted through a monitored release point (two fume hood systems located at Fuel Inspection area).

Specification

The ventilation system shall be verified operable in accordance with **TS 4.5** monthly.

Basis

Because the ventilation system is the only equipment required to achieve confinement, operability checks of the ventilation system meet the functional testing requirements for confinement. The pressure difference between the reactor room and outside of the Merrill Engineering Building should be larger than 0.1 inches-of-water. To keep this pressure difference, two fume hoods should be operated with the flow rate of 90 CFM or higher. Current flow rate for two fume hoods are >100 CFM.

4.5 Ventilation System

Applicability

This specification applies to the reactor area confinement ventilation system.

Objective

The objective is to assure the proper operation of the ventilation system in controlling releases of radioactive material to the unrestricted area.

Specifications

1. A channel check of the reactor area confinement ventilation system's ability to maintain a negative pressure in the reactor room with respect to surrounding areas shall be performed prior to each day's operation or prior to each operation extending more than one day.
2. A channel test of the reactor area confinement ventilation system's ability to be secured shall be performed monthly.
3. A channel test of the ventilation system's ability to operate in the limited intake mode shall be performed monthly.

Basis

Over 35 years of experience has demonstrated that tests of the ventilation system on the prescribed daily and annual basis are sufficient to assure proper operation of the system and its control over releases of radioactive material.

4.6 Emergency Power System

Not Applicable.

4.7 Radiation Monitoring Systems

Applicability

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

Objective

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

Specifications

1. A channel test of the ARM system, as in **TS 3.7.1**, shall be performed prior to each day's operation or prior to each operation extending more than one day.
2. A channel test of the CAM system, as in **TS 3.7.1**, shall be performed monthly.
3. A channel calibration of the radiation monitoring systems, as in **TS 3.7.1**, shall be performed annually.

Basis

1. The reactor checkout procedure requires the radiation level check-out for reactor room and stack release. An operator is expected to check the responses for the radiation monitoring system using Eu-152 checkout source for every day of reactor operation following the UUTR internal procedures.
2. The CAM detects particulate, iodine and noble gas from the reactor operation. Experience has shown that monthly verification (test) is adequate frequency to assure operability of the CAM system. An operator shall have 48 hours to repair the CAM system when it is broken.
3. Experience has shown that an annual calibration is adequate to correct for any variation in the system due to a change of operating characteristics over a long time span.

4.8 Experiments

Applicability

This specification applies to the surveillance requirements for experiments installed in the reactor and its irradiation facilities.

Objective

The objective is to prevent the conduct of experiments, which may damage the reactor or release excessive amounts of radioactive materials as a result of experiment failure.

Specifications

1. The reactivity worth of an experiment shall be estimated or measured, as appropriate, before reactor operation with said experiment.
2. An experiment shall not be installed in the reactor or its irradiation facilities unless a safety analysis has been performed and reviewed for compliance with **TS 3.8** by the RSC in full accord with **TS 6.2.3**, and the procedures, which are established for this purpose.

Basis

Evaluating an experiment prior to inserting in the reactor and its irradiation facilities will provide assurance that no damage to the reactor fuel or structure will occur. According to the **SAR 13.2.2**, with a $1.20 reactivity insertion, the fuel temperature and tank water temperature will stay below safety limits.

4.9 Facility-Specific Surveillance

Not Applicable.

5. DESIGN FEATURES

5.1 Site and Facility Description

Applicability

This specification applies to the University of Utah TRIGA Reactor site location and specific facility design features.

Objective

The objective is to specify the location of specific facility design features.

Specifications

1. The restricted area is that area inside the MEB 1205 A room through 1205 G room. The unrestricted area is that area outside the MEB 1205 A room through 1205 G room, and MEB 1206.
2. The Merrill Engineering Building houses the TRIGA reactor.
3. The reactor room shall be equipped with ventilation systems designed to exhaust air or other gases from the reactor room and release them from a stack at a minimum of 40 feet from ground level.
4. Emergency shutdown controls for the ventilation systems shall be located in the reactor control room.
5. Free volume of the reactor area shall be a minimum of $5.65x10^8$ cm^3.

Basis

The Utah Nuclear Engineering Facility and site description are strictly defined (**SAR 2**). The facility is designed such that the ventilation system will normally maintain a negative pressure in the reactor room with respect to the outside atmosphere so that there will be no uncontrolled leakage to the unrestricted environment (**SAR 9.1.4.1**). Controls for startup and normal operation of the ventilation system are located in the reactor control room (**SAR 9.1.2**). Proper handling of airborne radioactive materials (in emergency situations) can be conducted from the reactor control room with a minimum of exposure to operating personnel (**SAR 9.1**, **SAR 11.1.1.1**, and **SAR 13.2.4**).

5.2 Reactor Coolant System

Applicability

This specification applies to the tank containing the reactor and to the cooling of the core by the tank water.

Objective

The objective is to assure that coolant water shall be available to provide adequate cooling of the reactor core and adequate radiation shielding.

Specifications

1. The reactor core shall be cooled by natural convection water flow.
2. The reactor tank water inlet and outlet pipes to the heat exchanger and to the demineralizer shall be equipped with siphon breaks not less than 18 feet above the top of the core.
3. A reactor tank water level alarm shall be provided to indicate loss of coolant if the water level drops 15.5 inches from the top of the reactor tank.
4. The reactor tank water temperature shall be kept below 35 ^{o}C.

Basis

1. This specification is based on thermal and hydraulic calculations, which show that the TRIGA can operate in a safe manner at power levels up to 100 kW with natural convection flow of the coolant water (**SAR 4.6.1**).
2. In the event of accidental siphoning of tank water through inlet and outlet pipes of the heat exchanger or demineralizer system, the tank water level will not drop below 18 feet measured from the top of the UUTR core (**SAR 5.2**).
3. The scram set point and the alarm is set when the water level drops below 15.5 inches from the top of the reactor tank providing a timely warning so that corrective action can be initiated. The alarm and scram for the water level have the same set points. This alarm is located in the control room (**SAR 5.2**).
4. The UUTR water clean up system utilizes two resin beds that collect all minerals and dirt thus minimizing the neutron activation of the water in the reactor water tank. According to the manufacturer's information, the resins will melt if the temperature of the reactor water tank is over approximately

40 ^{o}C. Limiting the reactor water tank temperature to 35 ^{o}C keeps the resin beds safe from melting; a RO therefore shall check the water temperature every hour during the UUTR reactor operation.

5.3 Reactor Core and Fuel

5.3.1 Reactor Core

Applicability

This specification applies to the configuration of fuel and in-core experiments.

Objective

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

Specifications

1. The core assembly shall consist of TRIGA fuel elements.
2. The fuel shall be arranged in a close-packed configuration except for single element positions occupied by in-core experiments, irradiation facilities, graphite dummies, aluminum dummies, stainless steel dummies, control rods, heavy-water elements, startup sources, and vacant positions that are filled with water.
3. The reflector, excluding experiments and irradiation facilities, shall be water or a combination of graphite and heavy water elements and water.

Basis

1. Only TRIGA fuel elements are authorized to be used (**SAR 4.2**).
2. In-core water-filled experiment positions have been demonstrated to be safe in the Gulf Mark III reactor. The largest values of flux peaking will be experienced in hydrogenous in-core irradiation positions. Various non-hydrogenous experiments positioned in element positions have been demonstrated to be safe in TRIGA fuel element cores of up to 2-MW operation (**SAR 4.2, 4.5**).
3. The core will be assembled in the reactor grid plate, which is located in a reactor tank of light water. Water in combination with graphite and heavy water reflectors can be used for neutron economy and the enhancement of irradiation facility radiation requirements (**SAR 4.2**).

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.

Specifications

The shim, safety, and regulating control rods shall have scram capability and contain borated graphite, B_4C powder or boron, with its compounds in solid form as a poison, in aluminum or stainless steel cladding.

Basis

The poison requirements for the control rods are satisfied by using neutron absorbing borated graphite, B_4C powder or boron as compounds. These materials must be contained in a suitable cladding material such as aluminum or stainless steel to ensure mechanical stability during movement and to isolate the poison from the tank water environment. Scram capabilities are provided for rapid insertion of the control rods, which is the primary safety feature of the reactor (**SAR 4.2.2**).

5.3.3 Reactor Fuel

Applicability

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

Objective

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

Specifications

The individual TRIGA fuel elements shall have the following characteristics:

1. Uranium content: maximum of 8.5 wt% enriched to less than 20% ^{235}U,

2. Hydrogen-to-zirconium atom ratio (in the ZrH_x): between 1.0 and 1.60,

3. Cladding: 304 stainless steel or aluminum, nominal 0.02 or 0.03 inches thick respectively,

4. Identification: top pieces of fuel elements will have characteristic markings to allow visual identification of fuel elements, and

5. Burnable poisons: the fuel elements shall not include burnable poisons.

Basis

1, 2, and 3.

Each stainless steel clad, high hydride fuel element shall contain uranium-zirconium hydride and be cladded with 0.020 inch of 304 stainless steel. Each element shall contain a maximum of 20 weight percent uranium, which has a maximum enrichment of less than 20 percent and 1.6 hydrogen atoms to 1.0 zirconium atoms. Each aluminum clad, low hydride fuel element shall contain uranium-zirconium hydride and be cladded with 0.030 inch of aluminum or 0.020 inch of 304 stainless steel. Each element shall contain a maximum of 8.5 weight percent uranium, which has a maximum enrichment of less than 20 % and 0.9 to 1.6 hydrogen atoms to 1.0 zirconium atoms. These types of fuel elements have a long history of successful use in TRIGA reactors. More information is provided in **SAR 4.2.1**.

4. The UUTR has three different types of top pieces of the fuel elements: the old stainless steel, new stainless steel and the aluminum cladded fuel elements. The stainless steel cladded fuel elements have torpedo or triangular shape seen from the top view. Aluminum cladded fuel element has also triangular shape from the top view but it has different color from the stainless steel cladded fuel element. More detailed identification is achievable when using an underwater camera or binocular, both available at the facility (**SAR 4.2.4, Figure 4.2-7**).

5. The UUTR core does not use burnable poison fuel elements.

5.4 Fuel Storage

Applicability

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

Objective

The objective is to assure that fuel, which is being stored shall not become critical and shall not reach an unsafe temperature.

Specifications

1. All fuel elements shall be stored in a geometrical array where the k- effective is less than 0.9 for all conditions of moderation.
2. Irradiated fuel elements and fuel devices shall be stored in an array, which will permit sufficient natural convection cooling by water or air such that the temperature of the fuel element or fueled device will not exceed the safety limit.

Basis

The limits imposed are conservative and assure safe storage (NUREG-1537). Detailed calculations confirming that the stored fuel shall not become critical or overheat the cladding, are presented in **SAR 9.2.4** and **9.2.5**.

6. ADMINISTRATIVE CONTROLS

6.1 Organization

Individuals at the various management levels, in addition to being responsible for the policies and operation of the reactor facility, shall be responsible for safeguarding the public and facility personnel from undue radiological exposures and for adhering to all requirements of the operating license, technical specifications, and federal regulations.

6.1.1 Structure

The reactor administration shall be related to the University as shown in **Fig. 6-1.**

6.1.2 Responsibilities

The following specific organizational levels, and responsibilities shall exist:

1. The UUTR is an integral part of the Utah Nuclear Engineering Facilities (UNEF) of the University of Utah Nuclear Engineering Program (UNEP) at the University of Utah. The organization of the facility management and operation is illustrated in **Fig. 6-1**. The responsibilities and authority of each member of the operating staff shall be defined in writing, and

2. As indicated in **Fig. 6.1**, the RSC shall report to Level 1. Radiation safety personnel shall report to Level 2. Additional description of levels follows:

2.1 Level 1: Individual responsible for the reactor facility's licenses, i.e., the Associate Vice President for Research in the Office of Vice President for Research; The Vice President for Research will assign which of the Associate Vice Presidents for Research will be the responsible Level 1 individual.

2.2 Level 2: Individual responsible for reactor facility operation, i.e., the Utah Nuclear Engineering Facility (UNEF) Manager shall be the Director of the Utah Nuclear Engineering Program (UNEP).

2.3 Level 3: Individual responsible for day-to-day operation or shift shall be the Reactor Supervisor (RS). This person shall be an SRO.

2.4 Level 4: Operating staff shall be SROs, ROs, and trainees.

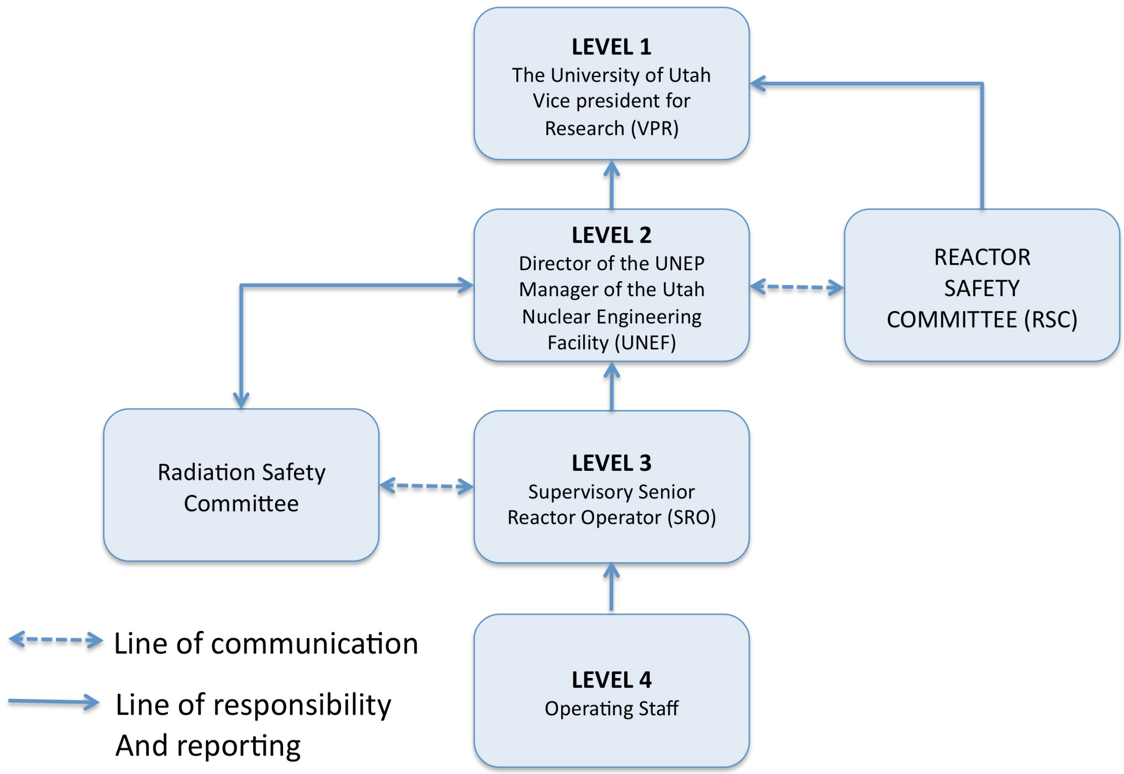

Figure 6-1 University of Utah Administrative Organization for Nuclear Reactor Operations

6.1.3 Staffing

1. The minimum staffing when the reactor is operating shall be:

1.1 A licensed RO or the RS in the control room,

1.2 A second person present in the UNEF able to carry out prescribed instructions, and,

1.3 If neither of these two individuals is the RS, the RS shall be readily available on call. Readily available on call means an individual who:

i. Has been specifically designated and the designation is known to the operator on duty,

ii. Can be rapidly contacted by phone by the operator on duty, and,

iii. Is capable of getting to the reactor facility within a reasonable time under normal conditions (e.g., 30 minutes or within a 15-mile radius).

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

2.1 UNEP Director and/or UNEF Manager

2.2 RS

2.3 Radiation Safety Officer

2.4 Any Licensed RO or SRO

3. Events requiring the direction of the RS:

3.1 Initial startup and approach to power of the day,

3.2 All fuel or control-rod relocations within the reactor core region,

3.3 Relocation of any in-core experiment or irradiation facility with a reactivity worth greater than one dollar, and,

3.4 Recovery from unplanned or unscheduled shutdown or significant power reduction.

6.1.4 Selection and Training of Personnel

The selection, training and requalification of operations personnel shall be in accordance with ANSI/ANS 15.4 – 1988; R1999, “Standard for the Selection and Training of Personnel for Research Reactors.”

6.2 Review and Audit

The RSC shall have primary responsibility for review and audit of the safety aspects of reactor facility operations. The RSC or a subcommittee thereof shall audit reactor operations semiannually. Minutes, findings or reports of the RSC shall be presented to Level 1 and Level 2 management within ninety (90) days of completion.

6.2.1 RSC Composition and Qualifications

An RSC of at least five (5) members knowledgeable in fields, which relate to reactor engineering and nuclear safety, shall review and evaluate the safety aspects associated with the operation and use of the facility. Level 1 management shall appoint the RSC members and RSC chair. Individuals may be either from within or outside the University of Utah. Qualified and approved alternates may serve in the absence of regular members. The Level 2 and Level 3 should be the members of the RSC but they shall not comprise a majority of voting RSC members.

6.2.2 RSC Rules

The operations of the RSC shall be in accordance with written procedures including provisions for:

1. Meeting frequency (at least annually),
2. Voting rules,
3. Quorums (5 members, no more than two voting members may be of the operating staff at any time),
4. Method of submission and content of presentation to the committee,
5. Use of subcommittees, and,
6. Review, approval, and dissemination of minutes.

6.2.3 RSC Review Function

The responsibilities of the RSC, or designated Subcommittee thereof, include, but are not limited to, the following:

1. Review all changes made under 10 CFR 50.59,
2. Review of all new procedures and substantive changes to existing procedures,
3. Review of proposed changes to the technical specifications, license or charter,
4. Review of violations of technical specifications, license, or violations of internal procedures or instructions having safety significance,
5. Review of operating abnormalities having safety significance,
6. Review of all events from reports required in Sections 6.6.1 and 6.7.2 of these Technical Specifications,
7. Review of audit reports, and,
8. Review of the experiments and classes of the experiments.

6.2.4 RSC Audit Function

The RSC or a Subcommittee thereof shall audit reactor operations at least annually. The annual audit shall include at least the following:

1. Facility operations for conformance to the technical specifications and applicable license or charter conditions,
2. The retraining and requalification program for the operating staff,
3. The results of action taken to correct those deficiencies that may occur in the reactor facility equipment, systems, structures, or methods of operation that affect reactor safety, and
4. The Emergency Response Plan and implementing procedures.

6.3 Radiation Safety

The Radiation Health Physicist from the Radiological Health Department shall be responsible for implementation of the radiation safety program. The requirements of the radiation safety program are established in 10 CFR 20. The program shall use the guidelines of the ANSI/ANS 15.11 – 1993; R2004, "Radiation Protection at Research Reactor Facilities."

6.4 Procedures

Written operating procedures shall be adequate to assure the safety of operation of the reactor, but shall not preclude the use of independent judgment and action should the situation require such. Operating procedures shall be in effect for the following items:

1. Startup, operation and shutdown of the reactor,
2. Fuel loading, unloading, and movement within the reactor,
3. Maintenance of major components of systems that could have an effect on reactor safety,
4. Surveillance checks, calibrations, and inspections required by the technical specifications or those that have an effect on reactor safety,
5. Radiation protection,
6. Administrative controls for operations and maintenance and for the conduct of irradiations and experiments that could affect reactor safety or core reactivity,
7. Implementation of required plans such as emergency or security plans, and,
8. Use receipt, and transfer of by-product material held under the reactor license.

Substantive changes to the above procedures shall be made only after review by the RSC. Except for radiation protection procedures, unsubstantive changes shall be approved prior to implementation by the UNEP Director and documented by the UNEP Director within 120 days of implementation. Unsubstantive changes to radiation protection procedures shall be approved prior to implementation by the Radiation Safety Officer (RSO), and documented by the RSO within 120 days of implementation.

Temporary deviations from the procedures may be made by the responsible SRO in order to deal with special or unusual circumstances or conditions. Such deviations shall be documented and reported by the next working day to the UNEP Director.

6.5 Experiments Review and Approval

Approved experiments shall be carried out in accordance with established and approved procedures. Procedures related to experiment review and approval shall include:

1. All new experiments or class of experiments shall be reviewed by the RSC and approved in writing by the Level 2 or designated alternates prior to initiation, and,
2. Substantive changes to previously approved experiments shall be made only after review by the RSC and approved in writing by the Level 2 or designated alternates. Minor changes that do not significantly alter the experiment may be approved by Level 3 or higher.

6.6 Required Actions

6.6.1 Actions to Be Taken in Case of Safety Limit Violation

In the event a safety limit (fuel temperature) is exceeded:

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

2. An immediate notification of the occurrence shall be made to the UNEP Director, and Chairperson of the RSC, NRC, and,

3. A report, and any applicable follow-up report, shall be prepared and reviewed by the RSC. The report shall describe the following:

3.1 Applicable circumstances leading to the violation including, when known, the cause and contributing factors,

3.2 Effects of the violation upon reactor facility components, systems, or structures and on the health and safety of personnel and the public, and,

3.3 Corrective action to be taken to prevent recurrence.

6.6.2 Actions to Be Taken in the Event of an Occurrence of the Type Identified in Section 6.7.2 Other than a Safety Limit Violation

For all events, which are required by regulations or Technical Specifications to be reported to the NRC within 24 hours under Section 6.7.2, except a safety limit violation, the following actions shall be taken:

1. The reactor shall be secured and UNEP Director notified,

2. Operations shall not resume unless authorized by the UNEP Director,

3. The RSC shall review the occurrence at their next scheduled meeting, and,

4. A report shall be submitted to the NRC in accordance with Section 6.7.2 of these Technical Specifications.

6.7 Reports

6.7.1 Annual Operating Report

An annual report shall be created and submitted by the UNEP Director to the U.S. NRC by the end of July of each year consisting of:

1. A brief summary of operating experience including the energy produced by the reactor and the hours the reactor was critical,
2. The number of unplanned SCRAMs, including reasons therefore,
3. A tabulation of major preventative and corrective maintenance operations having safety significance,
4. A brief description, including a summary of the safety evaluations, of changes in the facility or in procedures and of tests and experiments carried out pursuant to 10 CFR 50.59,
5. A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licensee as measured at or prior to the point of such release or discharge. 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,
6. A summarized result of environmental surveys performed outside the facility, and,
7. A summary of exposures received by facility personnel and visitors where such exposures are greater than 25 % of that allowed.

6.7.2 Special Reports

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

1. A report not later than the following working day by telephone and confirmed in writing by facsimile to the NRC Headquarters Operation Center, and followed by a written report that describes the circumstances of the event within 14 days to the U.S. NRC, Attn: Document Control Desk, Washington, D.C. 20555, of any of the following:

1.1 Violation of the safety limit,

1.2 Release of radioactivity from the site above allowed limits,

1.3 Operation with actual safety system settings from required systems less conservative than the limiting safety system setting,

1.4 Operation in violation of limiting conditions for operation,

1.5 A reactor safety system component malfunction that renders or could render the reactor safety system incapable of performing its intended safety function. If the malfunction or condition is caused by maintenance, then no report is required,

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

1.7 Abnormal and significant degradation in reactor fuel or cladding, or both, coolant boundary, or confinement boundary (excluding minor leaks) where applicable, or

1.8 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, and

2. A report within 30 days in writing to the U. S. NRC, Attn: Document Control Desk, Washington, D.C. 20555 of:

2.1 Permanent changes in the facility organization involving Level 1- 2 personnel, and

2.2 Significant changes in the transient or accident analyses as described in the Safety Analysis Report.

6.8 Records

6.8.1 Records to be Retained for a Period of at Least Five Years or for the Life of the Component Involved if Less than Five Years

1. Normal reactor operation (but not including supporting documents such as checklists, log sheets, etc., which shall be maintained for a period of at least one year),
2. Principal maintenance activities,
3. Reportable occurrences,
4. Surveillance activities required by the Technical Specifications,
5. Reactor facility radiation and contamination surveys,
6. Experiments performed with the reactor,
7. Fuel inventories, receipts, and shipments,
8. Approved changes to the operating procedures, and,
9. RSC meetings and audit reports.

6.8.2. Records to be Retained for at Least One Certification Cycle

Records of retraining and requalification of licensed ROs and SROs shall be retained at all times the individual is employed or until the certification is renewed. For the purpose of this technical specification, a certification is an NRC issued operator license.

6.8.3 Records to be Retained for the Lifetime of the Reactor Facility

1. Gaseous and liquid radioactive effluents released to the environs,
2. Offsite environmental monitoring surveys,
3. Radiation exposures for all personnel monitored,
4. Drawings of the reactor facility, and
5. Reviews and reports pertaining to a violation of the safety limit, the limiting safety system setting, or a limiting condition of operation.