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1. DEFINITIONS

The following frequently used terms are defined to aid in the uniform interpretation of these specifications. Capitalization is used in the body of the Technical Specifications to identify defined terms.

ACTION	Actions are steps to be accomplished in the event a required condition identified in a "Specification" section is not met, as stated in the "Condition" column of "Actions." In using Action Statements, the following guidance applies: • Where multiple conditions exist in an LCO, actions are linked to the (failure to meet a "Specification") "Condition" by letters and number. • Where multiple action steps are required to address a condition, COMPLETION TIME for each action is linked to the action by letter and number. • AND in an Action Statement means all steps need to be performed to complete the action; OR indicates options and alternatives, only one of which needs to be performed to complete the action. • If a "Condition" exists, the "Action" consists of completing all steps associated with the selected option (if applicable) except where the "Condition" is corrected prior to completion of the steps
ANNUAL	12 months, not to exceed 15 months
CHANNEL CALIBRATION	A channel calibration is an adjustment of the channel to that its output responds, with acceptable range and accuracy, to known values of the parameter that the channel measures.
BIENNIAL	Every two years, not to exceed a 28 month interval
CHANNEL CHECK	A channel check is a qualitative verification of acceptable performance by observation of channel behavior. This verification shall include comparison of the channel with expected values, other independent channels, or other methods of measuring the same variable.
CHANNEL TEST	A channel test is the introduction of an input signal into a channel to verify that it is operable. A functional test of operability is a channel test.
CONTROL ROD (STANDARD)	A standard control rod is one having an electric motor drive and scram capability.
CONTROL ROD (TRANSIENT)	A transient rod is one that is pneumatically operated and has scram capability.
DAILY	Prior to initial operation each day (when the reactor is operated), or before

	an operation extending more than 1 day
ENSURE	Verify existence of specified condition or (if condition does not meet criteria) take action necessary to meet condition
EXHAUST PLENUM	The air volume in the reactor bay atmosphere between the pool surface and the reactor bay exhaust fan
EXPERIMENT	An EXPERIMENT is (1) any apparatus, device, or material placed in the reactor core region (in an EXPERIMENTAL FACILITY associated with the reactor, or in line with a beam of radiation emanating from the reactor) or (2) any in-core operation designed to measure reactor characteristics.
EXPERIMENTAL FACILITY	Experimental facilities are the beamports, thermal column, pneumatic transfer system, central thimble, rotary specimen rack, and the in-core facilities (including non-contiguous single-element positions, and, in the E and F rings, as many as three contiguous fuel-element positions).
IMMEDIATE	Without delay, and not exceeding one hour. *NOTE:* *IMMEDIATE permits activities to restore required conditions for up to one hour; this does not permit or imply deferring or postponing action*
INDEPENDENT EXPERIMENT	INDEPENDENT Experiments are those not connected by a mechanical, chemical, or electrical link to another experiment
LIMITING CONDITION FOR OPERATION (LCO)	The lowest functional capability or performance levels of equipment required for safe operation of the facility.
LIMITING SAFETY SYSTEM SETTING (LSSS)	Settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit placed, the setting shall be chosen so that the automatic protective action will correct the abnormal situation before a safety limit is exceeded.
MEASURED VALUE	The measured value of a parameter is the value as it appears at the output of a MEASURING CHANNEL.
MEASURING CHANNEL	A MEASURING CHANNEL is the combination of sensor, lines, amplifiers, and output devices that are connected for the purpose of measuring the value of a process variable.
MOVABLE EXPERIMENT	A MOVABLE EXPERIMENT is one that may be moved into, out-of or near the reactor while the reactor is OPERATING.
NONSECURED EXPERIMENT	NONSECURED Experiments are these that should not move while the reactor is OPERATING, but are held in place with less restraint than a secured experiment.

OPERABLE	A system or component is OPERABLE when it is capable of performing its intended function in a normal manner
OPERATING	A system or component is OPERATING when it is performing its intended function in a normal manner.
PULSE MODE	The reactor is in the PULSE MODE when the reactor mode selection switch is in the pulse position and the key switch is in the "on" position. *NOTE:* *In the PULSE MODE, reactor power may be increased on a period of much less than l second by motion of the transient control rod.*
REACTOR SAFETY SYSTEM	The REACTOR SAFETY SYSTEM is that combination of MEASURING CHANNELS and associated circuitry that is designed to initiate reactor scram or that provides information that requires manual protective action to be initiated.
REACTOR SECURED MODE	The reactor is secured when the conditions of either item (1) or item (2) are satisfied: (1) There is insufficient moderator or insufficient fissile material in the reactor to attain criticality under optimum available conditions of moderation and reflection (2) All of the following: a. The console key is it the OFF position and the key is removed from the lock b. No work is in progress involving core fuel, core structure, installed control rods, or control rod drives (unless the drive is physically decoupled from the control rod) c. No experiments are being moved or serviced that have, on movement, a reactivity worth greater than $1.00
REACTOR SHUTDOWN	The reactor is shutdown if it is subcritical by at least $1.00 in the REFERENCE CORE CONDITION with the reactivity worth of all experiments included.
RING	A ring is one of the five concentric bands of fuel elements surrounding the central opening (thimble) of the core. The letters B through F, with the letter B used to designate the innermost ring,
REFERENCE CORE CONDITION	The condition of the core when it is at ambient temperature (cold) and the reactivity worth of xenon is negligible (<$0.30)
SAFETY CHANNEL	A safety channel is a MEASURING CHANNEL in the REACTOR SAFETY SYSTEM
SECURED EXPERIMENT	A secured EXPERIMENT is an EXPERIMENT held firm1y in place by a mechanical device or by gravity providing that the weight of the

	EXPERIMENT is such that it cannot be moved by force of less than 60 lb.
SECURED EXPERIMENT WITH MOVABLE PARTS	A secured EXPERIMENT with movable parts is one that contains parts that are intended to be moved while the reactor is OPERATING.
SHALL (SHALL NOT)	Indicates specified action is required/(not to be performed)
SEMIANNUAL	Every six months, with intervals not greater than 8 months
SHUTDOWN MARGIN	The shutdown margin is 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 that the reactor will remain subcritical without further operator action
STANDARD THERMOCOUPLE FUEL ELEMENT	A standard thermocouple fuel element is stainless steel clad fuel element containing three sheathed thermocouples embedded in the fuel element.
STEADY-STATE MODE	The reactor is in the steady-state mode when the reactor mode selector switch is in either the manual or automatic position and the key switch is in the “on” position.
TECHNICAL SPECIFICATION VIOLATION	A violation of a Safety Limit occurs when the Safety Limit value is exceeded. A violation of a Limiting Safety System Setting or Limiting Condition for Operation) occurs when a “Condition” exists which does not meet a “Specification” and the corresponding “Action” has not been met within the required “Completion Time.” If the “Action” statement of an LSSS or LCO is completed or the “Specification” is restored within the prescribed “Completion Time,” a violation has not occurred. *NOTE* *“Condition,” “Specification,” “Action,” and “Completion Time” refer to applicable titles of sections in individual Technical Specifications*

2. SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

2.1 Fuel Element Temperature Safety Limit

2.1.1 Applicability

This specification applies when the reactor in STEADY STATE MODE and the PULSE MODE.

2.1.2 Objective

This SAFETY LIMIT ensures fuel element cladding integrity

2.1.3 Specification

(1)	Stainless steel clad, high-hydride fuel element temperature SHALL NOT exceed 1150°C.
(2)	Steady state fuel temperature shall not exceed 750°C.

2.1.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A Stainless steel clad, high-hydride fuel element temperature exceeds 1150°C. OR Fuel temperature exceeds 750°C in steady state conditions	A.1 Establish SHUTDOWN condition AND A.2 Report per Section 6.8	A.1 IMMEDIATE A.2 Within 24 hours

2.1.5 Bases

Safety Analysis Report, Section 3.5.1 (Fuel System) identifies design and operating constraints for TRIGA fuel that will ensure cladding integrity is not challenged.

NUREG 1282 identifies the safety limit for the high-hydride ($ZrH_{1.7}$) fuel elements with stainless steel cladding based on the stress in the cladding (resulting from the hydrogen pressure from the dissociation of the zirconium hydride). This stress will remain below the yield strength of the stainless steel cladding with fuel temperatures below 1,150°C. A change in yield strength occurs for stainless steel cladding temperatures of 500°C, but there is no scenario for fuel cladding to achieve 500°C while submerged; consequently the safety limit during reactor operations is 1,150°C.

Therefore, the important process variable for a TRIGA reactor is the fuel element temperature. This parameter is well suited as a single specification, and it is readily measured. During operation, fission product gases and dissociation of the hydrogen and zirconium builds up gas inventory in internal components and spaces of the fuel elements. Fuel temperature acting on these gases controls fuel element internal pressure. Limiting the maximum temperature prevents excessive internal pressures that could be generated by heating these gases.

Fuel growth and deformation can occur during normal operations, as described in General Atomics technical report E-117-833. Damage mechanisms include fission recoils and fission gases, strongly influenced by thermal gradients. Operating with maximum long-term, steady state fuel temperature of 750°C does not have significant time- and temperature-dependent fuel growth.

2.2 Limiting Safety System Settings (LSSS)

2.2.1 Applicability

This specification applies when the reactor in STEADY STATE MODE

2.2.2 Objective

The objective of this specification is to ensure the safety limit is not exceeded.

2.2.3 Specifications

(1)	Power level SHALL NOT exceed 1,250 kW (th) in STEADY STATE MODE of operation

2.2.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Steady state power level exceeds 1,250 kW (th)	A.1 Reduce power to less than 1,250 kW (th) OR A.2. Establish REACTOR SHUTDOWN condition	A.1 IMMEDIATE A.2. IMMEDIATE

2.2.5 Bases

Analysis in Chapter 4 demonstrates that if operating thermal (th) power is 1,250 kW, the maximum steady state fuel temperature is less than the safety limit for steady state operations by a large margin. For normal pool temperature, calculations in Chapter 4 demonstrate that the heat flux of the hottest area of the fuel rod generating the highest power level in the core during operations is less than the critical heat flux by a large margin up to the maximum permitted cooling temperatures; margin remains even at temperatures approaching bulk boiling for atmospheric conditions. Therefore, steady state operations at a maximum of 1,250 kW meet requirements for safe operation with respect to maximum fuel temperature and thermal hydraulics by a wide margin. Steady state operation of 1,250 kW was assumed in analyzing the loss of cooling and maximum hypothetical accidents. The analysis assumptions are protected by assuring that the maximum steady state operating power level is 1,250 kW.

In 1968 the reactor was licensed to operate at 250 kW with a minimum reactor safety system scram set point required by Technical Specifications at 110% of rated full power, with the scram set point set conservatively at 104%. In 1993 the original TRIGA power level channels were replaced with more reliable, solid state instrumentation. The actual safety system setting will be chosen to ensure that a scram will occur at a level that does not exceed 1,250 kW.

3. Limiting Conditions for Operation (LCO)

3.1 Core Reactivity

3.1.1 Applicability

These specifications are required prior to entering STEADY STATE MODE or PULSING MODE in OPERATING conditions; reactivity limits on experiments are specified in Section 3.8.

3.1.2 Objective

This LCO ensures the reactivity control system is OPERABLE, and that an accidental or inadvertent pulse does not result in exceeding the safety limit.

3.1.3 Specification

(1)	The maximum available core reactivity (excess reactivity) with all control rods fully withdrawn is less than $4.00 when: 1. REFERENCE CORE CONDITIONS exists 2. No experiments with net negative reactivity worth are in place
(2)	The reactor is capable of being made subcritical by a SHUTDOWN MARGIN more than $0.50 under REFERENCE CORE CONDITIONS and under the following conditions: 1. The highest worth control rod is fully withdrawn 2. The highest worth NONSECURED EXPERIMENT is in its most positive reactive state, and each SECURED EXPERIMENT with movable parts is in its most reactive state.

3.1.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Reactivity with all control rods fully withdrawn exceeds $4.00	A.1 ENSURE REACTOR SHUTDOWN AND A.2 Configure reactor to meet LCO	A.1 IMMEDIATE A.2 Prior to continued operations

B. The reactor is not subcritical by more than $0.50 under specified conditions	B.1.a ENSURE control rods fully inserted AND B.1.b Secure electrical power to the control rod circuits AND B.1.c Secure all work on in-core experiments or installed control rod drives AND B.2 Configure reactor to meet LCO	B.1 IMMEDIATE B.2 Prior to continued operations

3.1.5 Bases

The value for excess reactivity was used in establishing core conditions for calculations (Table 13.4) that demonstrate fuel temperature limits are met during potential accident scenarios under extremely conservative conditions of analysis. Since the fundamental protection for the KSU reactor is the maximum power level and fuel temperature that can be achieved with the available positive core reactivity, experiments with positive reactivity are included in determining excess reactivity. Since experiments with negative reactivity will increase available reactivity if they are removed during operation, they are not credited in determining excess reactivity.

Analysis (Chapter 13) shows fuel temperature will not exceed l,150°C for the stainless-steel-clad fuel in the event of inadvertent or accidental pulsing of the reactor. Section 13.2 demonstrates that a $3.00 reactivity insertion from critical, zero power conditions leads to maximum fuel temperature of 746°C, while a $1.00 reactivity insertion from a worst-case steady state operation at 107 kW leads to a maximum fuel temperature of 869°C, well below the safety limit.

The limiting SHUTDOWN MARGIN is necessary so that the reactor can be shut down from any operating condition, and will remain shut down after cool down and xenon decay, even if one control rod (including the transient control rod) should remain in the fully withdrawn position.

3.2 PULSED MODE Operations

3.2.1 Applicability

These specifications apply to operation of the reactor in the PULSE MODE.

3.2.2 Objective

This Limiting Condition for Operation prevents fuel temperature safety limit from being exceeded during PULSE MODE operation.

3.2.3 Specification

(1)	The transient rod drive is positioned for reactivity insertion (upon withdrawal) less than or equal to $3.00

3.2.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. With all stainless steel clad fuel elements, the worth of the pulse rod in the transient rod drive position is greater than $3.00 in the PULSE MODE	A.1 Position the transient rod drive for pulse rod worth less than or equal to $3.00 OR A.2 Place reactor in STEADY STATE MODE	A.1 IMMEDIATE OR A.2 IMMEDIATE

3.2.5 Bases

The value for pulsed reactivity with all stainless steel elements in the core was used in establishing core conditions for calculations (Table 13.4) that demonstrate fuel temperature limits are met during potential accident scenarios under extremely conservative conditions of analysis.

3.3 MEASURING CHANNELS

3.3.1 Applicability

This specification applies to the reactor MEASURING CHANNELS during STEADY STATE MODE and PULSE MODE operations.

3.3.2 Objective

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

3.3.3 Specifications

(1)	The MEASURING CHANNELS specified in TABLE 1 SHALL be OPERATING
(2)	The neutron count rate on the startup channel is greater than the minimum detector sensitivity

TABLE 1: MINIMUM MEASURING CHANNEL COMPLEMENT

MEASURING CHANNEL	Minimum Number Operable	
	STEADY STATE MODE	PULSE MODE
Reactor power level[1]	2	1
Primary Pool Water Temperature	1	1
Reactor Bay Differential Pressure	1	1
Fuel Temperature	1	1
22 foot Area radiation monitor	1	1
0 or 12 foot Area monitor	1	1
Continuous air radiation monitor[2]	1	1
EXHAUST PLENUM radiation monitor[2]	1	1

NOTE[1]: One “Startup Channel” required to have range that indicates <10 W
NOTE[2]: High-level alarms audible in the control room may be used

3.3.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A.1 Reactor power channels not OPERATING (min 2 for STEADY STATE, 1 PULSE MODE)	A.1.1 Restore channel to operation OR A.1.2 ENSURE reactor is SHUTDOWN	A.1.1 IMMEDIATE A.1.2 IMMEDIATE

CONDITION	REQUIRED ACTION	COMPLETION TIME
A.2 High voltage to reactor power level detector less than 90% of required operating value	A.2.1 Establish REACTOR SHUTDOWN condition AND A.2.2 Enter REACTOR SECURED mode	A.2. IMMEDIATE
B. Primary water temperature, reactor bay differential pressure or fuel temperature CHANNEL not operable	B.1 Restore channel to operation OR B.2 ENSURE reactor is SHUTDOWN	A.1 IMMEDIATE A.2 IMMEDIATE
C. 22 foot Area radiation monitor is not OPERATING	C.1 Restore MEASURING CHANNEL OR C.2 ENSURE reactor is shutdown OR C.3 ENSURE personnel are not on the 22 foot level OR C.4 ENSURE personnel on 22 foot level are using portable survey meters to monitor dose rates	C.1 IMMEDIATE C.2 IMMEDIATE C.3 IMMEDIATE C.4 IMMEDIATE
D. 0 or 12 foot Area monitor is not OPERATING	D.1 Restore MEASURING CHANNEL OR D.2 ENSURE reactor is shutdown OR D.3 ENSURE personnel are not in the reactor bay OR D.4 ENSURE personnel entering reactor bay are using portable survey meters to monitor dose rates	D.1 IMMEDIATE D.2 IMMEDIATE D.3 IMMEDIATE D.4 IMMEDIATE

CONDITION	REQUIRED ACTION	COMPLETION TIME
E. Continuous air radiation monitor is not OPERATING	E.1 Restore MEASURING CHANNEL OR E.2 ENSURE reactor is shutdown OR E.3.a ENSURE EXHAUST PLENUM radiation monitor is OPERATING AND E.3.b Restore MEASURING CHANNEL	E.1 IMMEDIATE E.2. IMMEDIATE E.3.a. IMMEDIATE E.3.b Within 30 days
F. Exhaust plenum radiation monitor is not OPERATING	F.1 Restore MEASURING CHANNEL OR F.2 ENSURE reactor is shutdown OR F.3.a ENSURE continuous air radiation monitor is OPERATING AND F.3.b Restore MEASURING CHANNEL	F.1 IMMEDIATE F.2. IMMEDIATE F.3.a. IMMEDIATE F.3.b Within 30 days
G. The neutron count rate on the startup channel is not greater than the minimum detector sensitivity	G.1 Do not perform a reactor startup OR G.2 Perform a neutron-source check on the startup channel prior to startup	G.1 IMMEDIATE G.2 IMMEDIATE

3.3.5 Bases

Maximum steady state power level is 1,250 kW; neutron detectors measure reactor power level. Chapter 4 and 13 discuss normal and accident heat removal capabilities. Chapter 7 discusses radiation detection and monitoring systems, and neutron and power level detection systems.

According to General Atomics, detector voltages less than 90% of required operating value do not provide reliable, accurate nuclear instrumentation. Therefore, if operating voltage falls below the minimum value the power level channel is inoperable.

Primary water temperature indication is required to assure water temperature limits are met, protecting primary cleanup resin integrity. The reactor bay differential pressure indictor is required to control reactor bay atmosphere radioactive contaminants. Fuel temperature indication provides a means of observing that the safety limits are met.

The 22-foot and 0-foot area radiation monitors provide information about radiation hazards in the reactor bay. A loss of reactor pool water (Chapter 13), changes in shielding effectiveness (Chapter 11), and releases of radioactive material to the restricted area (Chapter 11) could cause changes in radiation levels within the reactor bay detectable by these monitors. Portable survey instruments will detect changes in radiation levels.

The air monitors (continuous air- and exhaust plenum radiation-monitor) provide indication of airborne contaminants in the reactor bay prior to discharge of gaseous effluent. Iodine channels provide evidence of fuel element failure. The air monitors provide similar information on independent channels; the continuous air monitor (CAM) has maximum sensitivity to iodine and particulate activity, while the air monitoring system (AMS) has individual channels for radioactive particulate, iodine, noble gas and iodine.

When filters in the air monitoring system begin to load, there are frequent, sporadic trips of the AMS alarms. Although the filters are changed on a regular basis, changing air quality makes these trips difficult to prevent. Short outages of the AMS system have resulted in unnecessary shutdowns, exercising the shutdown mechanisms unnecessarily, creating stressful situations, and preventing the ability to fully discharge the mission of the facility while the CAM also monitors conditions of airborne contamination monitored by the AMS. The AMS detector has failure modes than cannot be corrected on site; AMS failures have caused longer outages at the K-State reactor. The facility has experienced approximately two-week outages, with one week dedicated to testing and troubleshooting and (sometimes) one-week for shipment and repair at the vendor facility.

Permitting operation using a single channel of atmospheric monitoring will reduce unnecessary shutdowns while maintaining the ability to detect abnormal conditions as they develop. Relative indications ensure discharges are routine; abnormal indications trigger investigation or action to prevent the release of radioactive material to the surrounding environment. Ensuring the alternate airborne contamination monitor is functioning during outages of one system provides the contamination monitoring required for detecting abnormal conditions. Limiting the outage for a single unit to a maximum of 30 days ensures radioactive atmospheric contaminants are monitored while permitting maintenance and repair outages on the other system.

Chapter 13 discusses inventories and releases of radioactive material from fuel element failure into the reactor bay, and to the environment. Particulate and noble gas channels monitor more routine discharges. Chapter 11 and SAR Appendix A discuss routine discharges of radioactive gasses generated from normal operations into the reactor bay and into the environment. Chapter 3 identifies design bases for the confinement and ventilation system. Chapter 7 discusses air-monitoring systems.

Experience has shown that subcritical multiplication with the neutron source used in the reactor does not provide enough neutron flux to correspond to an indicated power level of 10 Watts. Therefore an indicated power of 10 Watts or more indicates operating in a potential critical condition, and at least one neutron channel is required with sensitivity at a neutron flux level corresponding to reactor power levels less than 10 Watts (“Startup Channel”). If the indicated neutron level is less than the minimum sensitivity for both the log-wide range and the multirange linear power level channels, a neutron source will be used to determine that at least one of the channels is responding to neutrons to ensure that the channel is functioning prior to startup.

3.4 Safety Channel and Control Rod Operability

3.4.1 Applicability

This specification applies to the reactor MEASURING Channels during STEADY STATE MODE and PULSE MODE operations.

3.4.2 Objective

The objectives are to require the minimum number of REACTOR SAFETY SYSTEM channels that must be OPERABLE in order to ensure that the fuel temperature safety limit is not exceeded, and to ensure prompt shutdown in the event of a scram signal.

3.4.3 Specifications

(1)	The SAFETY SYSTEM CHANNELS specified in TABLE 2 are OPERABLE
(2)	CONTROL RODS (STANDARD) are capable of 90% of full reactivity insertion from the fully withdrawn position in less than 1 sec.

TABLE 2: REQUIRED SAFETY SYSTEM CHANNELS

Safety System Channel or Interlock	Minimum Number Operable	Function	Required OPERATING Mode	
			STEADY STATE MODE	PULSE MODE
Reactor power level	2	Scram	YES	NA
Manual scram bar	1	Scram	YES	YES
CONTROL ROD (STANDARD) position interlock	1	Prevent withdrawal of standard rods in the PULSE MODE	NA	YES
Pulse rod interlock	1	Prevent inadvertent pulsing while in STEADY STATE MODE	YES	NA

3.4.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Any required SAFETY SYSTEM CHANNEL or interlock function is not OPERABLE	A.1 Restore channel or interlock to operation OR A.2 ENSURE reactor is SHUTDOWN	A1. IMMEDIATE A2. IMMEDIATE

3.4.5 Bases

The power level scram is provided to ensure that reactor operation stays within the licensed limits of 1,250 kW, preventing abnormally high fuel temperature. The power level scram is not credited

in analysis, but provides defense in depth to assure that the reactor is not operated in conditions beyond the assumptions used in analysis (Table 13.2.1.4).

The manual scram allows the operator to shut down the system if an unsafe or abnormal condition occurs.

The CONTROL ROD (STANDARD) interlock function is to prevent withdrawing control rods (other than the pulse rod) when the reactor is in the PULSE MODE. This will ensure the reactivity addition rate during a pulse is limited to the reactivity added by the pulse rod.

The pulse rod interlock function prevents air from being applied to the transient rod drive when it is withdrawn while disconnected from the control rod to prevent inadvertent pulses during STEADY STATE MODE operations. The control rod interlock prevents inadvertent pulses which would be likely to exceed the maximum range of the power level instruments configured for steady state operations.

3.5 Gaseous Effluent Control

3.5.1 Applicability

This specification applies to gaseous effluent in STEADY STATE MODE and PULSE MODE.

3.5.2 Objective

The objective is to ensure that exposures to the public resulting from gaseous effluents released during normal operations and accident conditions are within limits and ALARA.

3.5.3 Specification

(1)	The reactor bay ventilation exhaust system SHALL maintain in-leakage to the reactor bay
(2)	Releases of Ar-41 from the reactor bay exhaust plenum to an unrestricted environment SHALL NOT exceed 30 Ci per year.

3.5.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. The reactor bay ventilation exhaust system is not OPERABLE	A.1 ENSURE reactor is SHUTDOWN	A.1 IMMEDIATE
	OR	
	A.2.a Do not OPERATE in the PULSE MODE	A.2.a IMMEDIATE
	AND	
	A.2.b Secure EXPERIMENT operations for EXPERIMENT with failure modes that could result in the release of radioactive gases or aerosols.	A.2.b IMMEDIATE
	A.2.c ENSURE no irradiated fuel handing	A.2.b IMMEDIATE
	AND	
	A.2.d Restore the reactor bay ventilation exhaust system to OPERABLE	A.2.d Within 30 days

CONDITION	REQUIRED ACTION	COMPLETION TIME
Calculated releases of Ar-41 from the reactor bay exhaust plenum exceed 30 Ci per year.	Do not operate.	IMMEDIATE

3.5.5 Bases

The confinement and ventilation system is described in Section 3.5.4. Routine operations produce radioactive gas, principally Argon 41, in the reactor bay. If the reactor bay ventilation system is secured, SAR Chapter 11 Appendix A demonstrates reactor bay concentration of 0.746 Bq ml^{-1} ($2.01x10^{-5}$ μCi ml^{-1}), well below the 10CFR20 annual limit of 2000 DAC hours of Argon 41 at 6×10^{-3} μCi h/mL. Therefore, the reduction in concentration of Argon 41 from operation of the confinement and ventilation system is a defense in depth measure, and not required to assure meeting personnel exposure limits. Consequently, the ventilation system can be secured without causing significant personnel hazard from normal operations. Thirty days for a confinement and ventilation system outage is selected as a reasonable interval to allow major repairs and work to be accomplished, if required. During this interval, experiment activities that might cause airborne radionuclide levels to be elevated are prohibited.

It is shown in Section 13.2.2 of the Safety Analysis Report that, if the reactor were to be operating at full steady-state power, fuel element failure would not occur even if all the reactor tank water were to be lost instantaneously.

Section 13.2.4 addresses the maximum hypothetical fission product inventory release. Using unrealistically conservative assumptions, concentrations for a few nuclides of iodine would be in excess of occupational derived air concentrations for a matter of hours or days. ^{90}Sr activity available for release from fuel rods previously used at other facilities is estimated to be at most about 4 times the ALI. In either case (radio-iodine or -Sr), there is no credible scenario for accidental inhalation or ingestion of the undiluted nuclides that might be released from a damaged fuel element. Finally, fuel element failure during a fuel handling accident is likely to be observed and mitigated immediately.

SAR Appendix A shows the release of 30 Ci per year of Ar-41 from normal operations would result in less than 10 mrem annual exposure to any person in unrestricted areas.

3.6 Limitations on Experiments

3.6.1 Applicability

This specification applies to operations in STEADY STATE MODE and PULSE MODE.

3.6.2 Objectives

These Limiting Conditions for Operation prevent reactivity excursions that might cause the fuel temperature to exceed the safety limit (with possible resultant damage to the reactor), and the excessive release of radioactive materials in the event of an EXPERIMENT failure

3.6.3 Specifications

(1)	If all fuel elements are stainless steel clad, the reactivity worth of any individual EXPERIMENT SHALL NOT exceed $2.00
(2)	If two or more experiments in the reactor are interrelated so that operation or failure of one can induce reactivity-affecting change in the other(s), the sum of the absolute reactivity of such experiments SHALL NOT exceed $2.00.
(3)	Irradiation holders and vials SHALL prevent release of encapsulated material in the reactor pool and core area

3.6.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. INDEPENDENT EXPERIMENT worth is greater than $2.00	A.1 ENSURE the reactor is SHUTDOWN AND A.2 Remove the experiment	A.1 IMMEDIATE A.2 Prior to continued operations
C. An irradiation holder or vial releases material capable of causing damage to the reactor fuel or structure into the pool or core area	C.1 ENSURE the reactor is SHUTDOWN AND C.2 Inspect the affected area AND C.3 Obtain RSC review and approval	C.1 IMMEDIATE C.2 Prior to continued operation C.3 Prior to continued operation

3.6.5 Bases

Specifications 3.7(1) through 3.7(3) are conservatively chosen based on prior operation at 250 kW to limit reactivity additions to maximum values that are less than an addition which could cause temperature to challenge the safety limit.

Experiments are approved with expectations that there is reasonable assurance the facility will not be damaged during normal or failure conditions. If an irradiation capsule which contains material with potential for challenging the fuel cladding or pool wall, the facility will be inspected to ensure that continued operation is acceptable.

3.7 Fuel Integrity

3.7.1 Applicability

This specification applies to operations in STEADY STATE MODE and PULSE MODE.

3.7.2 Objective

The objective is to prevent the use of damaged fuel in the KSU TRIGA reactor.

3.7.3 Specifications

(1)	Fuel elements in the reactor core SHALL NOT be elongated more than 1/8 in. over manufactured length
(2)	Fuel elements in the reactor core SHALL NOT be laterally bent more than 1/8 in.

3.7.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Any fuel element is elongated greater than l/8 in. over manufactured length, or bent laterally greater than l/8 in.	Do not insert the fuel element into the upper core grid plate.	IMMEDIATE

3.7.5 Bases

The above limits on the allowable distortion of a fuel element have been shown to correspond to strains that are considerably lower than the strain expected to cause rupture of a fuel element and have been successfully applied at TRIGA installations. Fuel cladding integrity is important since it represents the only process barrier for fission product release from the TRIGA reactor.

3.8 Reactor Pool Water

3.8.1 Applicability

This specification applies to operations in STEADY STATE MODE, PULSE MODE, and SECURED MODE.

3.8.2 Objective

The objective is to set acceptable limits on the water quality, temperature, conductivity, and level in the reactor pool.

3.8.3 Specifications

(1)	Water temperature at the exit of the reactor pool SHALL NOT exceed 130°F with flow through the primary cleanup loop
(2)	Water conductivity SHALL be less than 5 µmho/cm
(3)	Water level above the core SHALL be at least 13 ft from the top of the core

3.8.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Water temperature at the exit of the reactor pool exceeds 130°F	A.1 ENSURE the reactor is SHUTDOWN AND A.2 Secure flow through the demineralizer AND A.3 Reduce water temperature to less than 130°F	A.1 IMMEDIATE A.2 IMMEDIATE A.3 IMMEDIATE
B. Water conductivity is greater than 5 µmho/cm	B.1 ENSURE the reactor is SHUTDOWN AND B.2 Restore conductivity to less than 5 µmho/cm	B.1 IMMEDIATE B.2 Within 4 weeks

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. Water level above the core SHALL be at least 13 ft from the top of the core for all operating conditions	C.1 ENSURE the reactor is SHUTDOWN AND C.2 Restore water level	C.1 IMMEDIATE C.2 IMMEDIATE

3.8.5 Bases

The resin used in the mixed bed deionizer limits the water temperature of the reactor pool. Resin in use (as described in Section 5.4) maintains mechanical and chemical integrity at temperatures below 130°F (54.4°C).

Maintaining low water conductivity over a prolonged period prevents possible corrosion, deionizer degradation, or slow leakage of fission products from degraded cladding. Although fuel degradation does not occur over short time intervals, long-term integrity of the fuel is important, and a 4-week interval was selected as an appropriate maximum time for high conductivity.

The top of the core is 16 feet below the top of the primary coolant tank. The lowest suction of primary cooling flow into the forced cooling loop is 3.5 feet below the top of the primary coolant tank (water level is maintained about 6 inches below the top of the tank).

The principle contributor to radiation dose rates at the pool surface is Nitrogen 16 generated in the reactor core and dispersed in the pool. Calculations in Chapter 11 show the pool surface radiation dose rates from Nitrogen 16 with 13 feet of water above the core are acceptable.

For normal pool temperature, calculations in Chapter 4 assuming 16 feet and 13 feet above the core demonstrate that the heat flux of the hottest area of the fuel rod generating the highest power level in the core during operations is less than the critical heat flux by a large margin up to the maximum permitted cooling temperatures; margin remains even at temperatures approaching bulk boiling for atmospheric conditions. Therefore, pool levels greater than 13 feet above the core meet requirements for safe operation with respect to maximum fuel temperature and thermal hydraulics by a wide margin.

Therefore, a minimum pool level of 13 feet above the core is adequate to provide shielding and support the core cooling.

3.9 Maintenance Retest Requirements

3.9.1 Applicability

This specification applies to operations in STEADY STATE MODE and PULSE MODE.

3.9.2 Objective

The objective is to ensure Technical Specification requirements are met following maintenance that occurs within surveillance test intervals.

3.9.3 Specifications

Maintenance activities SHALL NOT change, defeat or alter equipment or systems in a way that prevents the systems or equipment from being OPERABLE or otherwise prevent the systems or equipment from fulfilling the safety basis

3.9.4 Actions

CONDITION	REQUIRED ACTION	COMPLETION TIME
Maintenance is performed that has the potential to change a setpoint, calibration, flow rate, or other parameter that is measured or verified in meeting a surveillance or operability requirement	Perform surveillance OR Operate only to perform retest	Prior to continued, normal operation in STEADY STATE MODE or PULSE MODE

3.9.5 Bases

Operation of the K-State reactor will comply with the requirements of Technical Specifications. This specification ensures that if maintenance might challenge a Technical Specifications requirement, the requirement is verified prior to resumption of normal operations.

4. Surveillance Requirements

4.1 Core Reactivity

4.1.1 Objective

This surveillance ensures that the minimum SHUTDOWN MARGIN requirements and maximum excess reactivity limits of section 3.1 are met.

4.1.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SHUTDOWN MARGIN Determination	SEMIANNUAL
Excess Reactivity Determination	SEMIANNUAL
	Following Insertion of experiments with measurable positive reactivity
Control Rod Reactivity Worth determination	BIENNIAL

4.1.3 Basis

Experience has shown verification of the minimum allowed SHUTDOWN MARGIN at the specified frequency is adequate to assure that the limiting safety system setting is met

When core reactivity parameters are affected by operations or maintenance, additional activity is required to ensure changes are incorporated in reactivity evaluations.

4.2 PULSE MODE

4.2.1 Objectives

The verification that the pulse rod position does not exceed a reactivity value corresponding to $3.00 assures that the limiting condition for operation is met.

4.2.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
ENSURE Transient Pulse Rod position corresponds to reactivity not greater than $3.00	Prior to pulsing operations

4.2.3 Basis

Verifying pulse rod position corresponds to less than $3.00 ensures that the maximum pulsed reactivity meets the limiting condition for operation.

4.3 MEASURING CHANNELS

4.3.1 Objectives

Surveillances on MEASURING CHANNELS at specified frequencies ensure instrument problems are identified and corrected before they can affect operations.

4.3.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Reactor power level MEASURING CHANNEL	
CHANNEL TEST	DAILY
Calorimetric calibration	ANNUAL
CHANNEL CHECK high voltage to required power level instruments	DAILY
Primary pool water temperature CHANNEL CALIBRATION	ANNUAL
Reactor Bay differential pressure CHANNEL CALIBRATION	ANNUAL
Fuel temperature CHANNEL CALIBRATION	ANNUAL
22 Foot Area radiation monitor	
CHANNEL CHECK	DAILY
CHANNEL CALIBRATION	ANNUAL
0 or 12 Foot Area Radiation Monitor	
CHANNEL CHECK	DAILY
CHANNEL CALIBRATION	ANNUAL
Continuous Air Radiation Monitor	
CHANNEL CHECK	DAILY
CHANNEL CALIBRATION	ANNUAL
EXHAUST PLENUM Radiation Monitor	
CHANNEL CHECK	DAILY
CHANNEL CALIBRATION	ANNUAL
Startup Count Rate	DAILY

4.3.3 Basis

The DAILY CHANNEL CHECKS will ensure that the SAFETY SYSTEM and MEASURING CHANNELS are operable. The required periodic calibrations and verifications will permit any long-term drift of the channels to be corrected.

4.4 Safety Channel and Control Rod Operability

4.4.1 Objective

The objectives of these surveillance requirements are to ensure the REACTOR SAFETY SYSTEM will function as required. Surveillances related to safety system MEASURING CHANNELS ensure appropriate signals are reliably transmitted to the shutdown system; the surveillances in this section ensure the control rod system is capable of providing the necessary actions to respond to these signals.

4.4.2 Specifications

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Manual scram SHALL be tested by releasing partially withdrawn CONTROL RODS (STANDARD)	DAILY
CONTROL ROD (STANDARD) drop times SHALL be measured to have a drop time from the fully withdrawn position of less than 1 sec.	ANNUAL
The control rods SHALL be visually inspected for corrosion and mechanical damage at intervals	BIENNIAL
CONTROL ROD (STANDARD) position interlock functional test	SEMIANNUAL
Pulse rod interlock functional test	SEMIANNUAL
On each day that PULSE MODE operation of the reactor is planned, a functional performance check of the CONTROL ROD (TRANSIENT) system SHALL be performed.	Prior to pulsing operations each day a pulse is planned
The CONTROL ROD (TRANSIENT) rod drive cylinder and the associated air supply system SHALL be inspected, cleaned, and lubricated, as necessary.	SEMIANNUAL

4.4.3 Basis

Manual and automatic scrams are not credited in accident analysis, although the systems function to assure long-term safe shutdown conditions. The manual scram and control rod drop timing surveillances are intended to monitor for potential degradation that might interfere with the operation of the control rod systems. The verification of high voltage to the power level monitoring channels assures that the instrument channel providing an overpower trip will function on demand.

The control rod inspections (visual inspections and transient drive system inspections) are similarly intended to identify potential degradation that lead to control rod degradation or inoperability.

A test of the interlock that prevents the pulse rod from coupling to the drive in the state state mode unless the drive is fully down assures that pulses will occur only when in pulsing mode. A

test of the interlock that prevents standard control rod motion while in the pulse mode assures that the interlock will function as required.

The functional checks of the control rod drive system assure the control rod drive system operates as intended for any pulsing operations. The inspection of the pulse rod mechanism will assure degradation of the pulse rod drive will be detected prior to malfunctions.

4.5 Gaseous Effluent Control

4.5.1 Objectives

These surveillances ensure that routine releases are normal, and (in conjunction with MEASURING CHANNEL surveillances) that instruments will alert the facility if conditions indicate abnormal releases.

4.5.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Perform CHANNEL TEST of air monitor	ANNUAL
Verify negative reactor bay differential pressure	DAILY

4.5.3 Basis

The continuous air monitor provides indication that levels of radioactive airborne contamination in the reactor bay are normal.

If the reactor bay differential pressure gage indicates a negative pressure, the reactor bay exhaust fan is controlling airflow by directing effluent out of confinement.

4.6 Limitations on Experiments

4.6.1 Objectives

This surveillance ensures that experiments do not have significant negative impact on safety of the public, personnel or the facility.

4.6.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Experiments SHALL be evaluated and approved prior to implementation.	Prior to inserting a new experiment for purposes other than determination of reactivity worth
Measure and record experiment worth of the EXPERIMENT (where the absolute value of the estimated worth is greater than $0.40).	Initial insertion of a new experiment where absolute value of the estimated worth is greater than $0.40

4.6.3 Basis

These surveillances allow determination that the limits of 3.7 are met.

Experiments with an absolute value of the estimated significant reactivity worth (greater than $0.40) will be measured to assure that maximum experiment reactivity worths are met. If an absolute value of the estimate indicates less than $0.40 reactivity worth, even a 100% error will result in actual reactivity less than the assumptions used in analysis for inadvertent pulsing at low power operations in the Safety Analysis Report (13.2.3, Case I).

4.7 Fuel Integrity

4.7.1 Objective

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

4.7.2 Applicability

This specification applies to the surveillance requirements for the fuel elements in the reactor core.

4.7.3 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
The standard fuel elements SHALL be visually inspected for corrosion and mechanical damage, and measured for length and bend	500 pulses of magnitude equal to or less than a pulse insertion of 3.00$ AND Following the exceeding of a limited safety system set point with potential for causing degradation
B, C, D, E, and F RING elements comprising approximately 1/3 of the core SHALL be visually inspected annually for corrosion and mechanical damage such that the entire core SHALL be inspected at 3-year intervals, but not to exceed 38 months	ANNUAL

4.7.4 Basis

The most severe stresses induced in the fuel elements result from pulse operation of the reactor, during which differential expansion between the fuel and the cladding occurs and the pressure of the gases within the elements increases sharply.

Triennial visual inspection of fuel elements combined with measurements at intervals determined by pulsing as described is considered adequate to identify potential degradation of fuel prior to catastrophic fuel element failure.

4.8 Reactor Pool Water

This specification applies to the water contained in the KSU TRIGA reactor pool.

4.8.1 Objective

The objective is to provide surveillance of reactor primary coolant water quality, pool level, temperature and (in conjunction with MEASURING CHANNEL surveillances), and conductivity.

4.8.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify reactor pool water level above the inlet line vacuum breaker	DAILY
Verify reactor pool water temperature channel operable	DAILY
Measure reactor Pool water conductivity	DAILY
	At least every 20 days

4.9.3 Bases

Surveillance of the reactor pool will ensure that the water level is adequate before reactor operation. Evaporation occurs over longer periods of time, and daily checks are adequate to identify the need for water replacement.

Water temperature must be monitored to ensure that the limit of the deionizer will not be exceeded. A daily check on the instrument prior to reactor operation is adequate to ensure the instrument is operable when it will be needed.

Water conductivity must be checked to ensure that the deionizer is performing properly and to detect any increase in water impurities. A daily check is adequate to verify water quality is appropriate and also to provide data useful in trend analysis. If the reactor is not operated for long periods of time, the requirement for checks at least every 20 days will ensure water quality is maintained in a manner that does not permit fuel degradation.

4.9 Maintenance Retest Requirements

4.9.1 Objective

The objective is to ensure that a system is OPERABLE within specified limits before being used after maintenance has been performed.

4.9.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Evaluate potential for maintenance activities to affect operability and function of equipment required by Technical Specifications	Following maintenance of systems of equipment required by Technical Specifications
Perform surveillance to assure affected function meets requirements	Prior to resumption of normal operations

4.9.3 Bases

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

5. Design Features

5.1 Reactor Fuel

5.1.1 Applicability

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

5.1.2 Objective

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

5.1.3 Specification

(l) The high-hydride fuel element shall contain uranium-zirconium hydride, clad in 0.020 in. of 304 stainless steel. It shall contain a maximum of 9.0 weight percent uranium which has a maximum enrichment of 20%. There shall be 1.55 to 1.80 hydrogen atoms to 1.0 zirconium atom.

(2) For the loading process, the elements shall be placed in a close packed array except for experimental facilities or for single positions occupied by control rods and a neutron startup source.

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5.1.4 Bases

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

5.2 Reactor Fuel and Fueled Devices in Storage

5.2.1 Applicability

This specification applies to reactor fuel elements in storage

5.2.2 Objective

The objective is to ensure fuel elements or fueled devices in storage are maintained Subcritical in a safe condition.

5.2.3 Specification

(1) All fuel elements or fueled devices shall be in a safe, stable geometry

(2) The k_{eff} of all fuel elements or fueled devices in storage is less than 0.8

(3) Irradiated fuel elements or fueled devices will be stored in an array which will permit sufficient natural convection cooling by air or water such that the fuel element or fueled device will not exceed design values.

5.2.4 Bases

This specification is based on American Nuclear Society standard 15.1, section 5.4.

5.3 Reactor Building

5.3.1 Applicability

This specification applies to the building that houses the TRIGA reactor facility.

5.3.2 Objective

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

5.3.3 Specification

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

(2) The minimum free volume of the reactor room shall be approximately 144,000 cubic feet.

(3) The building shall be equipped with a ventilation system capable of exhausting air or other gases from the reactor room at a minimum of 30 ft. above ground level.

5.3.4 Bases

To control the escape of gaseous effluent, the reactor room contains no windows that can be opened. The room air is exhausted through an independent exhaust system, and discharged at roof level to provide dilution.

5.4 Experiments

5.4.1 Applicability

This specification applies to the design of experiments.

5.4.2 Objective

The objective is to ensure that experiments are designed to meet criteria.

5.4.3 Specifications

(1) EXPERIMENT with a design reactivity worth greater than $1.00 SHALL be securely fastened (as defined in Section l, Secured Experiment).

(2) Design shall ensure that failure of an EXPERIMENT SHALL NOT lead to a direct failure of a fuel element or of other experiments that could result in a measurable increase in reactivity or a measurable release of radioactivity due to the associated failure.

(3) EXPERIMENT SHALL be designed so that it does not cause bulk boiling of core water

(4) EXPERIMENT design SHALL ensure no interference with control rods or shadowing of reactor control instrumentation.

(5) EXPERIMENT design shall minimize the potential for industrial hazards, such as fire or the release of hazardous and toxic materials.

(6) Each fueled experiment shall be limited such that the total inventory of iodine isotopes 131 through 135 in the experiment is not greater than 5 millicuries except as the fueled experiment is a standard TRIGA instrumented element in which instance the iodine inventory limit is removed.

(7) Where the possibility exists that the failure of an EXPERIMENT (except fueled EXPERIMENTS) could release radioactive gases or aerosols to the reactor bay or atmosphere, the quantity and type of material shall be limited such that the airborne concentration of radioactivity averaged over a year will not exceed the limits of Table II of Appendix B of 10 CFR Part 20 assuming 100% of the gases or aerosols escape.

(8) The following assumptions shall be used in experiment design:

a. If effluents from an experimental facility exhaust through a hold-up tank which closes automatically at a high radiation level, at least 10% of the gaseous activity or aerosols produced will escape.

b. If effluents from an experimental facility exhaust through a filter installation designed for greater than 99% efficiency for 0.3 micron particles, at least 10% of the aerosols produced will escape.

c. For materials whose boiling point is above 130ºF and where vapors formed by boiling this material could escape only through an undisturbed column of water above the core, at least 10% of these vapors will escape.

(9) Use of explosive solid or liquid material with a National Fire Protection Association Reactivity (Stability) index of 2, 3, or 4 in the reactor pool or biological shielding SHALL NOT exceed the equivalent of 25 milligrams of TNT without prior NRC approval.

5.4.4 Basis

Designing the experiment to reactivity and thermal-hydraulic conditions ensure that the experiment is not capable of breaching fission product barriers or interfering with the control systems (interferences from other - than reactivity - effects with the control and safety systems are also prohibited). Design constraints on industrial hazards ensure personnel safety and continuity of operations. Design constraints limiting the release of radioactive gasses prevent unacceptable personnel exposure during off-normal experiment conditions.

6. Administrative Controls

6.1 Organization and Responsibilities of Personnel

(a) Structure.

The reactor organization is related to the University structure as shown in SAR Figure 12.1 and Technical Specifications Figure TS.1 below.

Kansas State University (KSU) holds the license for the KSU TRIGA Reactor, located in the KSU Nuclear Reactor Facility in Ward Hall on the campus of Kansas State University. The chief administrating officer for KSU is the President. Environment, safety and health oversight functions are administered through the Vice President for Administration and Finance, while reactor line management functions are through the Provost Chief Academic Officer.

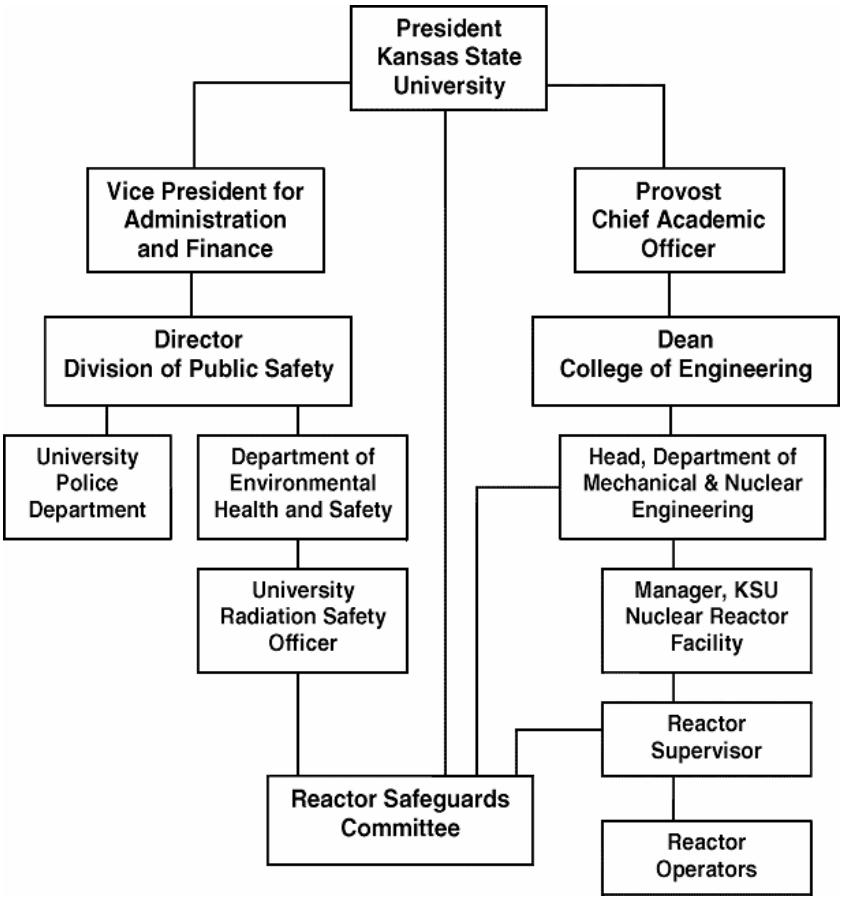

Figure TS.1: Organization and Management Structure for the K-State Reactor

Radiation protection functions are divided between the University Radiation Safety Officer (RSO) and the reactor staff and management, with management and authority for the RSO separate from line management and authority for facility operations. Day-to-day radiation protection functions implemented by facility staff and management are guided

by approved administrative controls (Reactor Radiation Protection Program or RPP, Facility Operating Manual, operating and experiment procedures); these controls are reviewed and approved by the RSO as part of the Reactor Safeguards Committee (with specific veto authority). The RSO has specific oversight functions assigned though the RPP. The RSO provides routine support for personnel monitoring, radiological analysis, and radioactive material inventory control. The RSO provides guidance on request for non-routine operations such as transportation and implementation of new experiments.

(b) Responsibility.

The President of the University shall be responsible for the appointment of responsible and competent persons as members of the TRIGA Reactor Safeguards Committee upon the recommendation of the *ex officio* Chairperson of the Committee.

The KSU Nuclear Reactor Facility shall be under the supervision of the Nuclear Reactor Facility Manager, who shall have the overall responsibility for safe, efficient, and competent use of its facilities in conformity with all applicable laws, regulations, terms of facility licenses, and provisions of the Reactor Safeguards Committee. The Manager also has responsibility for maintenance and modification of laboratories associated with the Reactor Facility. The Manager shall have education and/or experience commensurate with the responsibilities of the position and shall report to the Head of the Department of Mechanical and Nuclear Engineering.

A Reactor Supervisor may serve as the deputy of the Nuclear Reactor Facility Manager in all matters relating to the enforcement of established rules and procedures (but not in matters such as establishment of rules, appointments, and similar administrative functions). The Supervisor should have at least two years of technical training beyond high school and shall possess a Senior Reactor Operator's license. The Supervisor shall have had reactor OPERATING experience and have a demonstrated competence in supervision. The Supervisor is appointed by the Nuclear Reactor Facility Manager and is responsible for enforcing all applicable rules, procedures, and regulations, for ensuring adequate exchange of information between OPERATING personnel when shifts change, and for reporting all malfunctions, accidents, and other potentially hazardous occurrences and situations to the Reactor Nuclear Reactor Facility Manager. The Nuclear Reactor Facility Manager may also serve as Reactor Supervisor.

The Reactor Operator shall be responsible for the safe and proper operation of the reactor, under the direction of the Reactor Supervisor. Reactor Operators shall possess an Operator's or Senior Operator's license and shall be appointed by the Nuclear Reactor Facility Manager.

The University Radiation Safety Officer (RSO), or a designated alternate, shall (in addition to other duties defined by the Director of Environmental Health and Safety, Division of Public Safety) be responsible for overseeing the safety of Reactor Facility operations from the standpoint of radiation protection. The RSO and/or designated alternate shall be appointed by the Director of Environmental Health and Safety, Division of Public Safety, with the approval of the University Radiation Safety Committee, and shall report to the Director of Environmental Health and Safety, whose organization is independent of the Reactor Facility organization, as shown on SAR Figure 12.1.

The Nuclear Reactor Facility Manager, with the approval of the Reactor Safeguards Committee, may designate an appropriately qualified member of the Facility organization as Reactor Facility Safety Officer (RFSO) with duties including those of an intra-Facility

Radiation Safety Officer. The University Radiation Safety Officer may, with the concurrence of the Nuclear Reactor Facility Manager, authorize the RFSO to perform some of the specific duties of the RSO at the Nuclear Reactor Facility.

(c) Staffing.

Whenever the reactor is not secured, the reactor shall be under the direction of a (USNRC licensed) Senior Operator (designated as Reactor Supervisor). The Supervisor shall be on call, within twenty minutes travel time to the facility.

Whenever the reactor is not secured, a (USNRC licensed) Reactor Operator (or Senior Reactor Operator) who meets requirements of the Operator Requalification Program shall be at the reactor control console, and directly responsible for control manipulations.

In addition to the above requirements, during fuel movement a senior operator shall be inside the reactor bay directing fuel operations.

6.2 Review and Audit

(a) There will be a Reactor Safeguards Committee which shall review TRIGA reactor operations to assure that the reactor facility is operated and used in a manner within the terms of the facility license and consistent with the safety of the public and of persons within the Laboratory.

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

1. Review and approval of rules, procedures, and proposed Technical Specifications;

2. Review and approval of all proposed changes in the facility that could have a significant effect on safety and of all proposed changes in rules, procedures, and Technical Specifications, in accordance with procedures in Section 6.3;

3. Review and approval of experiments using the reactor in accordance with procedures and criteria in Section 6.4;

4. Determine whether changes in the facility as described in the safety analysis report (as updated), changes in the procedures as described in the final safety analysis report (as updated), and the conduct of tests or experiments not described in the safety analysis report (as updated) may be accomplished in accordance with 10 CFR 50.59 without obtaining prior NRC approval via license amendment pursuant to 10 CFR Sec. 50.90.

5. Review of abnormal performance of plant equipment and OPERATING anomalies;

6. Review of unusual or abnormal occurrences and incidents which are reportable under 10 CFR 20 and 10 CFR50;

7. Inspection of the facility, review of safety measures, and audit of operations at a frequency not less than once a year, including operation and operations records of the facility;

8. Requalification of the Nuclear Reactor Facility Manager and/or the Reactor Supervisor,

9. Review of container failures where released materials have the potential for damaging reactor fuel or structural components including:

   a. results of physical inspection

   b. evaluation of consequences

   c. need for corrective actions

(c) The Committee shall be composed of:

1. one or more persons proficient in reactor and nuclear science or engineering,

2. one or more persons proficient in chemistry, geology, or chemical engineering,

3. one person proficient in biological effects of radiation,

4. the Nuclear Reactor Facility Manager, *ex officio*,

5. the University Radiation Safety Officer, *ex officio*, and,

6. The Head of the Department of Mechanical and Nuclear Engineering, *ex officio*, or a designated deputy, to serve as chairperson of the Committee.

The same individual may serve under more than one category above, but the minimum membership shall be seven. At least five members shall be faculty members. The Reactor Supervisor, if other than the Nuclear Reactor Facility Manager, shall attend and participate in Committee meetings, but shall not be a voting member.

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

(e) A quorum shall consist of not less than a majority of the full Committee and shall include all *ex officio* members.

(f) Any permissive action of the Committee requires affirmative vote of the University Radiation Safety Officer as well as a majority vote of the members present.

(g) The Committee shall meet a minimum of two times a year. Additional meetings may be called by any member, and the Committee may be polled in lieu of a meeting. Such a poll shall constitute Committee action subject to the same requirements as for an actual meeting.

6.3 Procedures

(a) Written procedures, reviewed and approved by the Reactor Safeguards Committee, shall be followed for the activities listed below. The procedures shall be adequate to

assure the safety of the reactor, persons within the Laboratory, and the public, but should not preclude the use of independent judgment and action should the situation require it. The activities are:

1. Startup, operation, and shutdown of the reactor, including

   a. startup checkout procedures to test the reactor instrumentation and safety systems, area monitors, and continuous air monitors,

   b. prohibition of routine operations with failed (or leaking) fuel except to find leaking elements, and

   c. shutdown procedures to assure that the reactor is secured before OPERATING personnel go off duty.

2. Installation or removal of fuel elements, control rods, and other core components that significantly affect reactivity or reactor safety.

3. Preventive or corrective maintenance activities which could have a significant effect on the safety of the reactor or personnel.

4. Periodic inspection, testing or calibration of auxiliary systems or instrumentation that relate to reactor operation.

(b) Substantive changes in the above procedures shall be made only with the approval of the Reactor Safeguards Committee, and shall be issued to the OPERATING personnel in written form. The Nuclear Reactor Facility Manager may make temporary changes that do not change the original intent. The change and the reasons thereof shall be noted in the log book, and shall be subsequently reviewed by the Reactor Safeguards Committee.

(c) Determination as to whether a proposed activity in categories (1), (2) and (3) in Section 6.2.b above does or does not have a significant safety effect and therefore does or does not require approved written procedures shall require the concurrence of

   1. the Nuclear Reactor Facility Manager, and

   2. at least one other member of the Reactor Safeguards Committee, to be selected for relevant expertise by the Nuclear Reactor Facility Manager. If the Manager and the Committee member disagree, or if in their judgment the case warrants it, the proposal shall be submitted to the full Committee, and

   3. the University Radiation Safety Officer, or his/her deputy, who may withhold agreement until approval by the University Radiation Safety Committee is obtained.

   The Rector Safeguards Committee shall subsequently review determinations that written procedures are not required. The time at which determinations are made, and the review and approval of written procedures, if required, are carried out, shall be a reasonable interval before the proposed activity is to be undertaken.

(d) Determination that a proposed change in the facility does or does not have a significant safety effect and therefore does or does not require review and approval by the full Reactor Safeguards Committee shall be made in the same manner as for proposed activities under (c) above.

6.4 Review of Proposals for Experiments

(a) All proposals for new experiments involving the reactor shall be reviewed with respect to safety in accordance with the procedures in (b) below and on the basis of criteria in (c) below.

(b) Procedures:

1. Proposed reactor operations by an experimenter are reviewed by the Reactor Supervisor, who may determine that the operation is described by a previously approved EXPERIMENT or procedure. If the Reactor Supervisor determines that the proposed operation has not been approved by the Reactor Safeguards Committee, the experimenter shall describe the proposed EXPERIMENT in written form in sufficient detail for consideration of safety aspects. If potentially hazardous operations are involved, proposed procedures and safety measures including protective and monitoring equipment shall be described.

2. If the experimenter is a student, approval by his/her research supervisor is required. If the experimenter is a staff or faculty member, his/her own signature is sufficient.

3. The proposal is then to be submitted to the Reactor Safeguards Committee for consideration and approval. The Committee may find that the experiment, or portions thereof, may only be performed in the presence of the University Radiation Safety Officer or Deputy thereto.

4. The scope of the EXPERIMENT and the procedures and safety measures as described in the approved proposal, Including any amendments or conditions added by those reviewing and approving it, shall be binding on the experimenter and the OPERATING personnel. Minor deviations shall be allowed only in the manner described in Section 6 above. Recorded affirmative votes on proposed new or revised experiments or procedures must indicated that the Committee determines that the proposed actions do not involve changes in the facility as designed, changes in Technical Specifications, changes that under the guidance of 10 CFR 50.59 require prior approval of the NRC, and could be taken without endangering the health and safety of workers or the public or constituting a significant hazard to the integrity of the reactor core.

5. Transmission to the Reactor Supervisor for scheduling.

(c) Criteria that shall be met before approval can be granted shall include:

1. The EXPERIMENT must meet the applicable Limiting Conditions for Operation and Design Description specifications.

2. It must not involve violation of any condition of the facility license or of Federal, State, University, or Facility regulations and procedures.

3. The conduct of tests or experiments not described in the safety analysis report (as updated) must be evaluated in accordance with 10 CFR 50.59 to determine if the test or experiment can be accomplished without obtaining prior NRC approval via license amendment pursuant to 10 CFR Sec. 50.90.

4. In the safety review the basic criterion is that there shall be no hazard to the reactor, personnel or public. The review SHALL determine that there is reasonable assurance that the experiment can be performed with no significant risk to the safety of the reactor, personnel or the public.

6.5 Emergency Plan and Procedures

An emergency plan shall be established and followed in accordance with NRC regulations. The plan shall be reviewed and approved by the Reactor Safeguards Committee prior to its submission to the NRC. In addition, emergency procedures that have been reviewed and approved by the Reactor Safeguards Committee shall be established to cover all foreseeable emergency conditions potentially hazardous to persons within the Laboratory or to the public, including, but not limited to, those involving an uncontrolled reactor excursion or an uncontrolled release of radioactivity.

6.6 Operator Requalification

An operator requalification program shall be established and followed in accordance with NRC regulations.

6.7 Physical Security Plan

Administrative controls for protection of the reactor plant shall be established and followed in accordance with NRC regulations.

6.8 Action To Be Taken In The Event A Safety Limit Is Exceeded

In the event a safety limit is exceeded:

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

(b) An immediate report of the occurrence shall be made to the Chair of the Reactor Safeguards Committee, and reports shall be made to the NRC in accordance with Section 6.11 of these specifications.

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

6.9 Action To Be Taken In The Event Of A Reportable Occurrence

(a) A reportable occurrence is any of the following conditions:

1. any actual safety system setting less conservative than specified in Section 2.2, Limiting Safety System Settings;

2. VIOLATION OF SL, LSSS OR LCO;

NOTES

Violation of an LSSS or LCO occurs through failure to comply with an "Action" statement when "Specification" is not met; failure to comply with the "Specification" is not by itself a violation.

Surveillance Requirements must be met for all equipment/components/conditions to be considered operable.

Failure to perform a surveillance within the required time interval or failure of a surveillance test shall result in the /component/condition being inoperable

3. incidents or conditions that prevented or could have prevented the performance of the intended safety functions of an engineered safety feature or the REACTOR SAFETY SYSTEM;

4. release of fission products from the fuel that cause airborne contamination levels in the reactor bay to exceed 10CFR20 limits for releases to unrestricted areas;

5. an uncontrolled or unanticipated change in reactivity greater than $1.00;

6. an observed inadequacy in the implementation of either administrative or procedural controls, such that the inadequacy has caused the existence or development of an unsafe condition in connection with the operation of the reactor;

7. an uncontrolled or unanticipated release of radioactivity.

(b) In the event of a reportable occurrence, the following actions shall be taken:

1. The reactor shall be shut down at once. The Reactor Supervisor shall be notified and corrective action taken before operations are resumed; the decision to resume shall require approval following the procedures in Section 6.3.

2. A report shall be made to include an analysis of the cause of the occurrence, efficacy of corrective action, and recommendations for measures to prevent or reduce the probability of recurrence. This report shall be submitted to the Reactor Safeguards Committee for review.

3. A report shall be submitted to the NRC in accordance with Section 6.11 of these specifications.

6.10 Plant Operating Records

(a) In addition to the requirements of applicable regulations, in 10 CFR 20 and 50, records and logs shall be prepared and retained for a period of at least 5 years for the following items as a minimum.

1. normal plant operation, including power levels;

3. principal maintenance activities;

4. reportable occurrences;

5. equipment and component surveillance activities;

6. experiments performed with the reactor;

7. all emergency reactor scrams, including reasons for emergency shutdowns.

(b) The following records shall be maintained for the life of the facility:

1. gaseous and liquid radioactive effluents released to the environs;

2. offsite environmental monitoring surveys;

3. fuel inventories and transfers;

4. facility radiation and contamination surveys;

5. radiation exposures for all personnel;

6. updated, corrected, and as-built drawings of the facility.

6.11 Reporting Requirements

All written reports shall be sent within the prescribed interval to the United States Nuclear Regulatory Commission, Washington, D.C., 20555, Attn: Document Control Desk.

In addition to the requirements of applicable regulations, and in no way substituting therefor, reports shall be made to the US. Nuclear Regulatory Commission (NRC) as follows:

(a) A report within 24 hours by telephone and fax or electronic mail to the NRC Operations Center and the USNRC Region IV of;

1. any accidental release of radioactivity above permissible limits in unrestricted areas, whether or not the release resulted in property damage, personal injury, or exposure;

2. any violation of a safety limit;

3. any reportable occurrences as defined in Section 6.9 of these specifications.

(b) A report within 10 days in writing of:

1. any accidental release of radioactivity above permissible limits in unrestricted areas, whether or not the release resulted in property damage, personal injury or exposure; the written report (and, to the extent possible, the preliminary telephone and telegraph report) shall describe, analyze, and evaluate safety implications, and outline the corrective measures taken or planned to prevent recurrence of the event;

2. any violation of a safety limit;

3. any reportable occurrence as defined in Section 1.1 of these specifications.

(c) A report within 30 days in writing of:

1. any significant variation of a MEASURED VALUE from a corresponding predicted or previously MEASURED VALUE of safety-connected OPERATING characteristics occurring during operation of the reactor;

2. any significant change in the transient or accident analysis as described in the Safety Analysis Report.

3. a change in personnel for the Department of Mechanical and Nuclear Engineering Chair, or a change in reactor manager

(d) A report within 60 days after criticality of the reactor in writing to the US Nuclear Regulatory Commission, resulting from a receipt of a new facility license or an amendment to the license authorizing an increase in reactor power level or the installation of a new core, describing the MEASURED VALUE of the OPERATING conditions or characteristics of the reactor under the new conditions.

(e) A routine report in writing to the US. Nuclear Regulatory Commission within 60 days after completion of the first calendar year of OPERATING and at intervals not to exceed 12 months, thereafter, providing the following information:

1. a brief narrative summary of OPERATING experience (including experiments performed), changes in facility design, performance characteristics, and OPERATING procedures related to reactor safety occurring during the reporting period; and results of surveillance tests and inspections;

2. a tabulation showing the energy generated by the reactor (in megawatt-hours);

3. the number of emergency shutdowns and inadvertent scrams, including the reasons thereof and corrective action, if any, taken;

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

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

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

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

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