TECHNICAL SPECIFICATIONS

Kansas State University

TRIGA Mark II Nuclear Reactor Facility

License R-88

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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
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 periods 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 all of the following conditions are satisfied: (1) REACTOR SHUTDOWN condition exists (2) Electrical power to the control rod circuits is switched off and the switch key is in proper custody (3) No work is in progress involving in-core experiments, or installed control rod droves.
REACTOR SHUTDOWN	The reactor is in a shutdown (subcritical) condition when the negative reactivity of the cold, clean core is equal to or greater than the shutdown margin.
RING	A ring is one of the five concentric bands of fuel elements surrounding the central opening (thimble) of the core. The rings are designated by the letters B through F, with the letter B used to designate the innermost ring.
SAFETY CHANNEL	A safety channel is a MEASURING CHANNEL in the REACTOR SAFETY SYSTEM.
SECURED EXPERIMENT	A secured EXPERIMENT is an EXPERIMENT held firmly in place by a mechanical device or by gravity providing that the weight of the EXPERIMENT is such that it cannot be moved by a 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 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 1000°C.
(2)	Aluminum-clad, low-hydride fuel element temperature SHALL NOT exceed 530°C.

2.1.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
A. Stainless steel clad, high-hydride fuel element temperature exceeds 1000°C. OR Aluminum-clad, low-hydride fuel element exceeds 530°C	A.1 Establish SHUTDOWN condition AND Establish SECURED mode 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.

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.

The safety limit for the high-hydride ($ZrH_{1.7}$) fuel elements with stainless steel cladding is based on data presented in the "Hazards Report for the Oregon State University 250 kW TRIGA MARK II Reactor," General Atomic Report GA-6499, June 1965, first paragraph of Section 4.7, which indicates that the stress in the cladding (resulting from the hydrogen pressure from the dissociation of the zirconium hydride) will remain below the rupture stress provided the temperature of the fuel does not exceed 1,000°C. This analysis is described in Chapter 3 of the Facility Safety Analysis Report.

The temperature at which phase transitions may lead to cladding failure in aluminum-clad low-hydride fuel elements is reported to be 530°C; references: Technical Foundations of TRIGA, GA-471 (1958), pp. 63-72; also in "Hazards Analysis for the Oregon State University 250 kW TRIGA Mark II Reactor," (June 1965), Section 4.7. There is also extensive operating experience with aluminum-clad, low-hydride fuel; for example, with the Kansas State University TRIGA, which has been licensed since 1968 to operate with a mixed core of stainless-steel-clad high-hydride and aluminum-clad low-hydride elements at 250 kW and up to $2.00 pulses.

2.2 Limiting Safety System Settings (LSSS)

2.2.1 Applicability

This specification applies when the reactor is in the PULSE MODE.

2.2.2 Objective

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

2.2.3 Specifications

(1)	The LSSS for a STANDARD THERMOCOUPLE FUEL ELEMENT in a specified location SHALL NOT exceed the values listed in Table 1.

TABLE 1: LSSS FOR STANDARD THERMOCOUPLE FUEL ELEMENT LCOATIONS

Core Location	Limiting Safety System Setting
B-RING	600°C
C-RING	555°C
D-RING	480°C
E-RING	380°C

2.2.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
A. Temperature indications from a STANDARD THERMOCOUPLE FUEL ELEMENT in a position exceeds the specified value	A.1 Restore the temperature to less than or equal to the specified LSSS value OR A.2. Establish REACTOR SHUTDOWN condition	A.1 IMMEDIATE A.2. IMMEDIATE

2.2.5 Bases

This LSSS will prevent operating in violation of the Safety Limit.

For stainless steel, high-hydride fuel elements, the limiting safety system settings represent values of the temperature, which, if exceeded, cause the REACTOR SAFETY SYSTEM to initiate a reactor scram. Because the fuel element temperature is measured in a single fuel element designed for this purpose, the limiting settings are given for different locations of that element in the core. Maximum fuel temperature will be produced in the B-RING.

For the stainless-steel-clad, high-hydride fuel elements, the margin between the safety limit of 1000°C and the limiting safety system setting of 600°C in the B-RING was selected to assure that conditions would not arise which would allow the fuel element temperature to approach the safety limit. The safety margin of 400°C allows for differences between the measured peak temperature and calculated peak temperature encountered in pulse operation of TRIGA reactors and for uncertainty in temperature measurements. Power level, fuel physical dimensions and properties, and parameters of the coolant determine equilibrium temperature during steady-state operations. Because of the interrelationship of the fuel moderator temperature, the power level, and changes in reactivity required to increase or maintain a given power level, any unwarranted increase in the power level would result in relatively slow increase in the fuel moderator temperature. The margin between the maximum setting and safety limit would ensure reactor shut down before conditions could result that might damage the fuel elements.

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 reactor is capable of being made subcritical by a SHUTDOWN MARGIN more than \$0.50 under the following conditions: 1. Reference temperature and xenon conditions exist (i.e., cold, xenon-free condition) 2. The highest worth control rod is fully withdrawn 3. 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.
(2)	The maximum available core reactivity (excess reactivity) with all control rods fully withdrawn is less than \$4.00 when: 1. Reference conditions for temperature and xenon (i.e., cold, xenon-free condition) 2. No experiments that affect reactivity are in place

3.1.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
A. The reactor is not subcritical by more than $0.50 under specified conditions	A.1.a ENSURE control rods fully inserted AND A.1.b Secure electrical power to the control rod circuits AND A.1.c Secure all work on in-core experiments or installed control rod drives AND A.2 Configure reactor to meet LCO	A.1 IMMEDIATE A.2 Prior to continued operations
B. Reactivity with all control rods fully withdrawn exceeds $4.00	B.1 ENSURE REACTOR SHUTDOWN AND B.2 Configure reactor to meet LCO	B.1 IMMEDIATE B.2 Prior to continued operations

3.1.5 Bases

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.

The value for excess reactivity was used in establishing core conditions for calculations (Table 13.2.1.4) that demonstrate fuel temperature limits are met during potential accident scenarios under extremely conservative conditions of analysis. Analysis (Chapter 13) shows fuel temperature will not exceed 1,000°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.

3.2 STEADY STATE MODE Operation

3.2.1 Applicability

This specification applies to operation of the reactor in the STEADY STATE MODE.

3.2.2 Objectives

The objectives are to prevent the fuel temperature safety limit from being exceeded during steady-state operations and to prevent inadvertent pulse operation of the reactor while it is at high steady-state power level.

3.2.3 Specifications

(1)	The reactor SHALL NOT be operated in the STEADY STATE MODE at power levels above: (a) 500 kW with all stainless steel clad fuel elements (b) 250 kW if the core contains aluminum clad fuel elements
(2)	The reactor SHALL NOT be operated in the STEADY STATE MODE at power levels above 10 kW unless air is applied to the transient rod.

3.2.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
STEADY STATE MODE power level is greater than the LCO	Reduce reactor power to LCO	IMMEDIATE

Bases

The Kansas State University TRIGA Safety Analysis is based on power levels up to 500 kW. The K-State reactor was licensed in 1968 for operation at 250 kW with aluminum clad fuel elements

Calculations in Chapter 4 assuming 500 kW steady state operation and 81 fuel elements demonstrate fuel temperature limits are met. An 85-element core distributes the power over a larger volume of heat generating elements, and therefore results in a more favorable, more conservative, thermal hydraulic response. Design bases analysis (referenced in 4.2) indicates that steady state operation at up to 1900 kW (83 element core, 120°F inlet water temperature, natural convective flow) will not allow film boiling, and therefore high fuel and clad temperatures which could cause loss of clad integrity could not occur.

The value of 500 kW for maximum steady state power level with stainless steel clad fuel was used to establish core conditions for calculations (Table 13.2.1.4) that demonstrate fuel temperature limits are met during potential accident scenarios under extremely conservative conditions of analysis.

A 500 kW steady state-operating history is assumed to determine maximum fission product inventory available for release. The unrealistically conservative assumptions for maximum hypothetical release of fission products from fuel assume a complete release of all available inventory. Analysis in Chapter 13 demonstrates that even with these unrealistically conservative assumptions, limits of 10CFR20 for releases to unrestricted areas are not challenged, and although instantaneous releases to the reactor bay exceed limits for ALI for a few radionuclides if trapped within the reactor bay and not released, time averaged values are within limits.

Operation with air supplied to the pulse rod couples the control rod to the rod drive, and therefore prevents an inadvertent or accidental pulse.

3.3 PULSE MODE Operation

3.3.1 Applicability

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

Objective

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

3.3.3 Specification

(1)	With all stainless steel clad fuel in the core, the transient rod drive is positioned for reactivity insertion (upon withdrawal) less than or equal to $3.00
(2)	With any aluminum clad fuel in the core, the transient rod drive is positioned for reactivity insertion (upon withdrawal) less than or equal to $2.00
(3)	The steady-state power level of the reactor is not greater then 10 kW.

3.3.4 Actions

CONDITON	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
B. With any aluminum clad fuel elements in the core, the worth of the pulse rod in the transient rod drive position is greater than $2.00 in the PULSE MODE	A.1 Position the transient rod drive for pulse rod worth less than or equal to $2.00 OR A.2 Place reactor in STEADY STATE MODE	A.1 IMMEDIATE OR A.2 IMMEDIATE
B. Steady state power is greater than 10 Kw in the PULSE MODE	B.1 Reduce reactor power to less than or equal to 10 kW OR B.2 Place reactor in STEADY STATE MODE	B.1 IMMEDIATE OR B.2 IMMEDIATE

3.3.5 Bases

The value for pulsed reactivity with all stainless steel elements in the core was used in establishing core conditions for calculations (Table 13.2.1.4) that demonstrate fuel temperature limits are met during potential accident scenarios under extremely conservative conditions of analysis.

The value for pulsed reactivity with aluminum-clad elements in the core was authorized under 250 kW steady state power license conditions. Analysis and a long history of pulsing operations demonstrates that fuel temperature limits are not challenged when pulsing to $2.00 reactivity insertions.

The limit for pulsing from a high steady-state power level ensures final peak temperature does not exceed the safety limit.

3.4 MEASURING CHANNELS

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

3.4.3 Specifications

(1)	The MEASURING CHANNELS specified in TABLE 1 SHALL be OPERATING
(2)	The neutron count rate on the startup channel is greater than 1 count per seconds.

TABLE 1: MINIMUM MEASURING CHANNEL COMPLEMENT

MEASURING CHANNEL	Minimum Number Operable	
	STEADY STATE MODE	PULSE MODE
Fuel element temperature	NA	1
Reactor power level	2	1
Startup count rate	1 (Startup)	NA
22 foot Area radiation monitor	1	1
0 or 12 foot Area monitor	1	1
Continuous air radiation monitor*	1	1
Exhaust plenum radiation monitor*	1	1

*In lieu of information display, high-level alarms audible in the control room may be used

3.2.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
A. Fuel element temperature channel is not OPERATING (PUSLE MODE)	A.1 Place reactor in STEADY STATE MODE OR A.2 ENSURE reactor is SHUTDOWN	A.1 IMMEDIATE A..2 IMMEDIATE
B. Reactor power channels not OPERATING (min 2 for STEADY STATE, 1 PULSE MODE)	B.1 Restore channel to operation OR B.2 ENSURE reactor is SHUTDOWN	B.1 IMMEDIATE B..2 IMMEDIATE
C. Startup Count rate channel is not OPERATING	C.1 Do not perform a reactor startup OR C.2 Terminate reactor startup	C.1 IMMEDIATE C..2 IMMEDIATE
D. 22 foot Area radiation monitor is not OPERATING	D.1 Restore MEASURING CHANNEL OR D.2 ENSURE reactor is shutdown OR D.3 ENSURE personnel are not on the 22 foot level OR D.4 ENSURE personnel on 22 foot level are using portable survey meters to monitor dose rates	D.1 IMMEDIATE D.2 IMMEDIATE D.3 IMMEDIATE D.4 IMMEDIATE

CONDITON	REQUIRED ACTION	COMPLETION TIME
E. 0 or 12 foot Area monitor is not OPERATING	E.1 Restore MEASURING CHANNEL OR E.2 ENSURE reactor is shutdown OR E.3 ENSURE personnel are not in the reactor bay OR E.4 ENSURE personnel entering reactor bay are using portable survey meters to monitor dose rates	E.1 IMMEDIATE E.2 IMMEDAITE E.3 IMMEDAITE E.4 IMMEDAITE
F. Continuous air radiation monitor is not OPERATING	F.1 Restore MEASURING CHANNEL OR F.2 ENSURE reactor is shutdown OR F.3.a ENSURE exhaust plenum radiation monitor is OPERATING AND F.3.b Restore MEASURING CHANNEL	E.1 IMMEDIATE E.2. IMMEDIATE E.3.a. IMMEDIATE E.3.b Within 30 days

CONDITON	REQUIRED ACTION	COMPLETION TIME
G. Exhaust plenum radiation monitor is not OPERATING	G.1 Restore MEASURING CHANNEL OR G.2 ENSURE reactor is shutdown OR G.3.a ENSURE continuous air radiation monitor is OPERATING AND G.3.b Restore MEASURING CHANNEL	G.1 IMMEDIATE G.2. IMMEDIATE G.3.a. IMMEDIATE G.3.b Within 30 days

3.2.5 Bases

The fuel temperature displayed in the control room provides information on the process variable ensuring the safety limit (1,000°C) is met. Chapter 3 discusses fuel design. Chapters 4 and 13 discuss fuel performance in normal and accident scenarios.

Maximum steady state power level is 500 kW. The neutron detectors ensure measurement of the reactor power level. Chapter 4 and 13 discuss heat removal capabilities in normal and accident scenarios. Chapter 7 discusses neutron and power level detection systems.

The specification on the startup channel count rate assures the startup channel is operating during approaches to criticality. The specification of 2 cps requires sufficient neutrons be available in the core to provide a minimum signal above channel sensitivity. Chapter 7 discusses neutron and power level detection systems.

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. Chapter 7 discusses radiation detection and monitoring systems.

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.

3.5 Safety Channel and Control Rod Operability

3.5.1 Applicability

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

3.5.2 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.

3.5.3 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: REQURIED SAFETY SYSTEM CHANNELS

Safety System Channel or Interlock	Minimum Number Operable	Function	Required OPERATING Mode	
			STEADY STATE MODE	PULSE MODE
Fuel element temperature	1	Scram	NA	YES
Reactor power level	2	Scram	YES	NA
Manual scram bar	1	Scram	YES	YES
Startup count rate interlock	1	Prevent control rod withdrawal when neutron count rate is less than 1/sec.	YES (Startup)	NA
CONTROL ROD (STANDARD) position interlock	1	Prevent withdrawal of transient rod in the PULSE MODE	NA	YES

3.5.4 Actions

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

CONDITON	REQUIRED ACTION	COMPLETION TIME
B. Startup Count rate channel is not OPERABLE	B.1 Do not perform a reactor startup OR B.2 Terminate reactor startup	B.1. IMMEDIATE B.2. IMMEDIATE
C. TRANSIENT CONTOL ROD interlock	C.1 Restore interlock function OR C.2 ENSURE reactor is SHUTDOWN OR C.3 Go to STEADY STATE	C.1. IMMEDIATE C.2. IMMEDIATE C.2. IMMEDIATE

3.5.5 Bases

The fuel temperature scram provides the protection to ensure that if a condition results in which the limiting safety system setting is exceeded, a shutdown will occur to keep the fuel temperature below the safety limit of 1,000°C. The fuel temperature scram is not credited in analysis (Chapter 13), but provides defense in depth by causing a reactor shutdown at levels lower than the safety limit.

The power level scram is provided as added protection to ensure that reactor operation stays within the licensed limits of 500 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 interlock ensures a neutron detection channel is operating prior to startup by preventing startup of the reactor with less than l count/sec. indicated on the startup channel.

The control rod position interlock will prevent air from being applied to the transient rod drive when it is withdrawn and disconnected form the control rod to prevent inadvertent pulses. The control rod interlock is not credited in the accident analysis, (Section 13.2.3) which assumes the interlock does not function, and is a defense in depth measure to ensure the accidental or inadvertent pulse does not occur.

3.6 Gaseous Effluent Control

3.6.1 Applicability

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

3.6.2 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.

3.6.3 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.

3.6.4 Actions

CONDITON	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 OPEABLE	A.2.d Within 30 days

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

3.6.5 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 Appendix A demonstrates an exposure rate of 1.84×10^{-4} µCi h/mL, 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-iodines 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 no more than 2 mrem annual exposure to any person in unrestricted areas. At 2% of the allowable releases that would meet 10 CFR 20 requirements, there is a significant margin of safety.

3.7 Limitations on Experiments

3.7.1 Applicability

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

3.7.2 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

3.7.3 Specifications

(1)	If all fuel elements are stainless steel clad, the reactivity worth of any individual EXPERIMENT SHALL NOT exceed $2.00
(2)	If aluminum clad fuel elements are used in the reactor core during EXPERIMENT operations, the reactivity worth of any individual EXPERIMENT SHALL NOT exceed $1.00
(3)	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.
(4)	Irradiation holders ands vials SHALL prevent release of encapsulated material in the reactor pool and core area

3.7.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
A. INDEPENDENT EXPERIMENT worth is greater than $2.00 for stainless steel fuel, $1.00 if aluminum clad fuel in the core	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

3.7.5 Bases

Specifications 3.7(1) through 3.7(3) are conservatively chosen to limit reactivity additions to maximum values that are less than an addition that could cause the fuel temperature to rise above the limiting safety system set point (LSSS) value. The temperature rise for a $2.00 insertion is known from previous license conditions and operations and is known not to exceed the LSSS.

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 mateiral with potential for challenging the fuel cladding or pool wall, the facility will be inspected to ensure that continued operation is acceptable.

3.8 Fuel Integrity

3.8.1 Applicability

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

3.8.2 Objective

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

3.8.3 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.

3.8.4 Actions

CONDITON	REQUIRED ACTION	COMPLETION TIME
Any fuel element is elongated greater than 1/8 in. over manufactured length, or bent laterally greater than 1/8 in.	Do not insert the fuel element into the upper core grid plate.	IMMEDIATE

3.8.5 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 the TRIGA reactor.

3.9 Reactor Pool Water

3.9.1 Applicability

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

3.9.2 Objective

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

3.9.3 Specifications

(1)	Water temperature at the exit of the reactor pool SHALL NOT exceed 130°F
(2)	Water conductivity SHALL be greater than 5 μmho/cm
(3)	Water level above the core SHALL be at least 16 ft from the top of the core

3.9.4 Actions

CONDITON	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 ASAP
B. Water conductivity SHALL be greater than 5 μmho/cm	B.1 ENSURE the reactor is SHUTDOWN AND B.2 Restore conductivity to greater than 5 μmho/cm	B.1 IMMEDIATE B.2 Within 4 weeks

CONDITON	REQUIRED ACTION	COMPLETION TIME
C. Water level above the core SHALL be at least 16 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 ASAP

3.9.5 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.

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.

A reactor pool level of 16 ft is adequate to provide shielding during power operations, as required to meet design requirement indicated in Section 3.5.2.

3.10 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

CONDITON	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 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 3.2 are met.

4.1.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SHUTDOWN MARGIN Determination	SEMIANNUAL
Excess Reactivity Determination	SEMIANNUAL
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 STEADY STATE MODE

4.2.1 Objectives

This surveillance assures that the high power level trips function at the required setpoint values.

4.2.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
CHANNEL TEST of Per-Cent Power Safety Circuit scram	SEMIANNUAL
CHANNEL TEST of Linear Power Safety Circuit scram	SEMIANNUAL

4.2.3 Basis

The histories of the reactor power level instruments at the K-State reactor are exceptionally stable over time. The SEMIANNUAL checks of power level trip are adequate to ensure the trip set points meet requirements.

4.3 PULSE MODE

4.3.1 Objectives

The CHANNEL CHECK of the pulse rod interlock provides assurance that the reactor cannot be operated in the PULSE MODE at power levels higher than the required limiting conditions for operation.

4.3.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
CHANNEL TEST Transient Pulse Rod Interlock	Prior to pulsing operations

4.3.3 Basis

Testing the power level interlock prior to pulsing operation provides a high confidence the interlock will work as designed.

4.4 MEASURING CHANNELS

4.4.1 Objectives

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

4.4.2 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Fuel element temperature MEASURING CHANNEL, CHANNEL CHECK	
CHANNEL CHECK	DAILY
CHANNEL CALIBRATION	ANNUAL
Reactor power level MEASURING CHANNEL	
CHANNEL TEST	DAILY
Calorimetric calibration	ANNUAL
Startup Count Rate	DAILY
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

4.4.3 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.

4.5 Safety Channel and Control Rod Operability

4.5.1 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.

4.5.2 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
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

4.5.3 Basis

Manual and automatic scrams are not credited in accident analysis. The systems do 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 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.

The functional checks of the control rod drive system assure the control rod drive system operates as intended for any pulsing operations.

4.6 Gaseous Effluent Control

4.6.1 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.

4.6.2 Specification

SURVIELLANCE REQUIREMENTS

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

4.6.3 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. .

4.7 Limitations on Experiments

4.7.1 Objectives

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

4.7.2 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 estimated worth is greater than $0.40).	Initial insertion of a new experiment where estimated worth is greater than $0.40

4.7.3 Basis

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

Experiments with an estimated significant reactivity worth (greater than $0.40) will be measured to assure that maximum experiment reactivity worths are met. If an 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).

4.8 Fuel Integrity

4.8.1 Objective

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

4.8.2 Applicability

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

4.8.3 Specification

SURVIELLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
The standard fuel elements SHALL be visually inspected for corrosion and mechanical damage, 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
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

4.8.4 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.

4.9 Reactor Pool Water

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

4.9.1 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.

4.9.2 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 SHALL be measured	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 dily 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.

4.10 Maintenance Retest Requirements

4.10.1 Objective

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

4.10.2 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 requirments	Prior to resumption of normal operations

4.10.3 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.

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.

(3) The low-hydride aluminum-clad thermocouple element (that can be used only within specific power and reactivity restrictions) shall contain uranium-zirconium hydride, clad in 0.030 in. of aluminum. It shall contain a maximum of 8.5 weight percent of uranium which has a maximum enrichment of 20%. There shall be a ratio of approximately 1.0 hydrogen atoms to each 1.0 zirconium atom

5.1.4 Bases

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

5.2 Reactor Building

5.2.1 Applicability

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

5.2.2 Objective

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

5.2.3 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 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.

5.2.4 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.

5.3 Experiments

5.3.1 Applicability

This specification applies to the design of experiments.

5.3.2 Objective

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

5.3.3 Specifications

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

(2) The design rate of planned reactivity addition in any EXPERIMENT SHALL be less than 0.07$/sec, except that if the total associated reactivity addition is less than 0.40$, no limit on the rate shell be imposed.

(3) Design shall ensure that failure of an EXPERIMET 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.

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

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

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

(7) 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.

(8) 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.

(9) 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 130°F 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.

5.3.4 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) The KSU TRIGA Reactor, located in the KSU Nuclear Reactor Facility in Ward Hall on the campus of Kansas State University shall be operated by the Department of Mechanical and Nuclear Engineering. The reactor organization is related to the University structure as shown in Chart I.

b) 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.

c) 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.

d) 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.

e) 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.

f) The University Radiation Safety Officer (RSO), or a deputy, 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 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 Chart I.

g) 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.

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. Determination of whether a proposed change, test, or EXPERIMENT would constitute an unreviewed safety question or change in the Technical Specifications (Ref. 10 CFR 50.59);
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.

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.

e) 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, and

   (b) 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 6.2b 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 therefor 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 6.3b above. Recorded affirmative votes on proposed new or revised experiments or procedures must indicated that the Committee determines that proposed actions do not involve unreviewed safety questions, changes in the facility as designed, or changes in Technical Specifications, 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 fall within the limitations given in Section 3.8.

2. It must not involve violation of any condition of the facility license or of Federal, State, University, or Facility regulations and procedures. The possibility of an unreviewed safety question (10 CFR 50.59) must be examined.

3. 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

A physical security plan 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 Director, Division of Reactor Licensing, 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 $0.50;

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, with a copy to the Regional Administrator, Region IV.

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 Operation Center and 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 1.1 of these specifications.

b) A report within 10 days in writing to the NRC Operation Center and 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; 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.

d) A report within 30 days in writing to the Director, Non-Power Reactors and Decommissioning Project Directorate, US. Nuclear Regulatory Commission, Washington, D.C. 205 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.

d) A report within 60 days after criticality of the reactor in writing to the NRC Operation Center and Region I, 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, Document Control Desk, Washington, DC 20555 and Region IV, within 60 days after completion of