50-407

THE UNIVERSITY OF UTAH

10 April 1991

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Documentation Control Desk and
Alexander Adams, Jr. Project Manager
Standarization and Non-Power Reactors
Project Directorate
Office of Nuclear Reactor Regulation

Subject: Upgrade of TRIGA Reactor Console at University of Utah (R-126)

References: 10CFR50.59, NRC License R-126, Docket No. 50-407

Gentlemen:

The University intends to upgrade its existing TRIGA Reactor Console (NRC License R-126) employing the TRIGA Console that was formerly at the University of California, Berkeley and new equipment and supplies made available with a DOE Equipment Grant for modernizing and upgrading the control system. This upgrade of the Control Console System will be made in accordance with 10CFR50.59 and will entail no changes in the existing Technical Specifications for the facility nor instigate any unreviewed safety questions

The TRIGA Reactor operational staff at the University of Utah has planned and documented the proposed upgrade of the console and prepared a written safety evaluation which has been reviewed by the Reactor Safety Committee and been determined to require no Technical Specification changes nor involve any unreviewed safety questions.

The licensee will submit a description of the Console Upgrade Activities including tests, experiments, evaluations and audits in its annual report to the NRC.

Sincerely yours

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QUALITY ASSURANCE CHECKLIST
FOR INSTALLATION OF THE MARK III CONSOLE

I. Safety Systems

General Instructions

Place completion date in the "operable" column when the function satisfies scram requirements at the specified point. (See definition of "operable" in TS 1.4.)

Control Rod Drop Time Verification

Control rod drop times are measured by attaching relay inputs to the rod up/down microswitch signals. The relay output is directed to the Series/1 computer to measure relay timing.

Control Rod	Setpoint	Measured Time	Operable
A. Safety	< 2.0 seconds	_____ seconds	_____
B. Shim	< 2.0 seconds	_____ seconds	_____
C. Regulator	< 2.0 seconds	_____ seconds	_____

Scram Channel Verification

Scram channels are verified by initiating the scram with an artificial signal and observing scram enunciation, magnet current termination, and rod drop.

Scram Channel	Setpoint	Operable
A. Linear Power Channel Scram	Full Scale	_____
B. Percent Power Channel Scram	100 %	_____
C. Fuel Temperature Scram	200 °C	_____
D. Water Level Scram	< 1 Foot	_____
E. Manual Scram	initiated	_____
F. Magnet Key Scram	power off	_____
G. Console Power Supply Scram	power off	_____
H. Startup Count Rate Interlock	< 2 cps	_____
I. Control Rod Withdrawal Interlocks	one at a time	_____
J. Linear Switch Limit	300Kw/1Mw	_____

II. Control Systems

General Instructions

Place completion date in the appropriate column when the channel satisfies functional requirements specified in TS 1.4.

Control Rod Drive Verification

Control rod drives are verified by visually observing drive movement and indicator light operation.

Control Rod	Drive Up	Drive Down	Magnet Up	Magnet Down	Rod Down	Drive Operable
A. Safety						
B. Shim						
C. Regulator						

Measuring Channel Verification

Measuring channels are verified by observing meter indication after input of the appropriate signal. If a channel satisfies a higher level of performance, then all lower performance levels are considered satisfied.

Measuring Channel	Check	Test	Calibration	Operable
A. Linear Power				
B. Percent Power				
C. Log-n Power				
D. Startup				
E. Fuel Temperature				
F. Area Radiation				
G. Continuous Air Monitor				
H. Water Level Indicator				

III. Monitoring Systems

General Instructions

Place completion date in the appropriate column when the channel satisfies functional requirements specified in TS 1.4.

Auxiliary System Verification

Auxiliary systems are verified by observing drive movement and indicator light operation.

System	Function	Operable
A. Ventilation System	Dampers close on radiation scram	_____
	Vents reactor room >1800 cfm	_____
B. Recirculation System	Recirculates tank water	_____
C. Refrigeration System	Cools tank water	_____
D. pH Measurement	Tank water pH	_____
E. Conductivity Measurement	Tank water conductivity	_____
F. Area Radiation Monitors	Exposure calibrated	_____
	Dampers activate	_____
G. Continuous Air Monitor	Particulate/Ar-41 calibrated	_____
H. Reactor Room Negative Pressure	Measures pressure (inches water)	_____

IV. Completion

This form can only be completed by a staff member not involved with reactor operations or console installation and must be appointed by the RSC to perform this examination. Each function must be witnessed by the appointed individual and the results must satisfy the examiner. The examiner's signature indicates that the checklist has been fully completed and that he is satisfied that the console will safely operate the TRIGA reactor.

_____ _____

Examiner's Signature Date

Safety Review of
Upgrade for the Existing Mark I Console

This checklist summarizes the results of a review conducted by RSC safety subcommittee which examined the monitoring, control, and safety systems to assure that functional requirements of the upgraded console (Mark III) are met before operating staff begins the reactor upgrade process.

I. Monitoring Systems

General Instructions

Place completion date in the appropriate column when the channel satisfies functional requirements specified.

Auxiliary System Verification

Auxiliary systems are verified to function properly before installation of the up-grade.

System	Function	Operable (Dated and Initialed)
A. Ventilation System	Dampers close on radiation alarm	_____
	Vents reactor room ≈1800 cfm	_____
B. Recirculation System	Recirculates tank water	_____
C. Refrigeration System	Cools tank water	_____
D. pH Measurement	Tank water pH	_____
E. Conductivity Measurement	Tank water conductivity	_____
F. Area Radiation Monitors*	Exposure calibrated	_____
G. Continuous Air Monitor*	Particulate/Ar-41 calibrated	_____
H. Reactor Room Pressure	Negative pressure	_____

*- Expecting hardware upgrade to existing system

II. Control Systems

General Instructions

Place completion date in the appropriate column when the channel satisfies functional requirements specified in TS 1.4 for the upgraded console (Mark III).

Measuring Channel Verification

Measuring channels are verified by observing meter indication after input of the appropriate signal. If a channel satisfies a higher level of performance, then all lower performance levels are considered satisfied.

Measuring Channel	Check or Test	Operable (Dated and Initialed)
A. Linear Power	_____	_____
B. Percent Power	_____	_____
C. Log-n Power	_____	_____
D. Startup Channel	_____	_____
E. Fuel Temperature	_____	_____
F. Area Radiation Monitors*	_____	_____
G. Continuous Air Monitor*	_____	_____
H. Water Level Indicator	_____	_____

*- Expecting hardware upgrade to existing system

III. Safety Systems

General Instructions

Place completion date in the "operable" column when the function satisfies scram requirements at the specified point. (See definition of "operable" in TS 1.4.)

Scram Channel Verification

Scram channels are verified by initiating the scram with an artificial signal and observing scram enunciation and magnet current termination.

Scram Channel	Setpoint	Operable (Dated and Initialed)
A. Linear Power Channel Scram	Full Scale	See Note
B. Percent Power Channel Scram	Varible%	_____
C. Fuel Temperature Scram	200 °C	_____
D. Water Level Scram	< 1 Foot	_____
E. Manual Scram	initiated	_____
F. Magnet Key Scram	power off	_____
G. Ion Chamber Power Supply Scram (H.V. Scram Test)	power off	_____
H. Startup Count Rate Interlock	< 2 cps	_____
I. Control Rod Withdrawal Interlocks	one at a time	_____
J. Linear Switch Limit†	300Kw/1Mw	_____

Note: Not verified until recorder from Mark I console is installed in Mark III
†- Limit switch will be set to assure scram at (or before) 120 percent of full licensed power

IV. Completion

This form has been completed by the RSC subcommittee assigned to review the console upgrade. The members's signatures indicate that the checklist has been fully completed and that they are satisfied that the console functions as intended.

_____ _____
James Byrne Date

_____ _____
Byron Hardy Date

_____ _____
David Slaughter Date

SAFETY EVALUATION OF UNEL TRIGA REACTOR CONTROL BY MARK III CONSOLE

Scope of Authorization

This authorization addresses the installation of the Mark III console which will replace the Mark I console for operation of the TRIGA reactor. Rack and pinion drives for the safety and shim rods will accompany the installation of the Mark III console.

The Mark III is a newer console than the Mark I and is more reliable. Replacement parts for the Mark III are more easily acquired and has a more organized and documented meter and wiring layout. The console remains compliant with all general operating specifications and procedures.

This evaluation is performed in accordance with Technical Specification 6.5.4(5) and 10CFR50.59(a).

Description

The Mark III console has all of the required equipment and capabilities to safely control the reactor and to monitor safety systems. A diagram of the basic console layout is shown in Figure 1. The instrumentation is identified in the associated Table 1. Figures 2-4 show details of the console panels as installed from left to right. Generally, the left panel provides startup information, the right panel provides steady state power operation information, and the center panel provides safety system and control information as well as power level recording. Figure 5 shows the back panel layout with a few components identified in Table 2. A functional block diagram for the console is shown in Figure 6. Additional capabilities will be provided to the operator from nearby instrumentation to monitor and control the facility's auxiliary systems. A detailed description of the console can be found in the TRIGA Mark III Reactor Instrumentation Maintenance Manual.

Reactor Control System

The console is designed to accomodate for operation of up to five control rods; the regulator, shim, safety, spare, and transient. The TRIGA reactor has three of the drives, the shim, safety, and regulator. The two winch drives currently on the shim and safety will be replaced by rack and pinion drives shown in Figure 7. The regulator rod has already been converted to rack and pinion drive and operated as an approved experiment. Control of the regulator will be transferred from the computer to the Mark III console. Since a transient rod assembly is not available and license conditions do not permit transient operation, transient rod control will not be available to the operator.

Each control rod can be individually manipulated. Illumination of colored switches signify magnet up or down, magnet/rod contact, and magmet current on. The console monitors fives modes of operation; automatic, steady state, square wave, low and high

pulse. When in automatic mode, the console will control the regulator rod to maintain a preset power level. The square-wave and both pulsing modes will not be used because the TRIGA Reactor is not equipped with a transient rod.

The console monitors four power level channels; the linear power, log-n power, percent power, and count rate (startup channel). The linear and log-n channels receive their inputs via compensated ion chambers and have indicators from source strength to 1.0 Mwatt. The percent power channel operates from a uncompensated ion chamber and is adjusted to the correct licensed power during meter calibration. The startup channel receives input from a fission counter through a low noise preamplifier and cable driver. The startup channel provides a direct meter indication of neutron flux and a bistable output to prevent withdrawal of control rods when the count rate is below a preset value (source interlock).

Reactor Safety System

The Mark III console has six scram channels; percent power, linear power, period, high voltage, manual, and an external signal. The linear channel scram setpoint is adjustable to 100% power. The range switch for the linear channel is mechancially limited to 100 kWatts. The period signal will initiate a reactor scram for a preset period in the steady state mode and provides a signal for power regulation in the automatic mode. A meter relay connected to a fuel thermocouple will initiate a scram in the console at a preset temperature. The water level microswitch will be connected to an external scram input to provide a water level scram. An Eberline Area Radiation monitor will provide another signal to the external scram input for an another scram channel. Loss of the ion chamber high voltage will also scram the reactor. The reactor may also be scrammed through a manual scram and through a magnet key scram.

Monitoring System

Additional information is available to the operator. Parameter status and control switches for the reactor room ventilation system, tank water recirculation and refrigeration systems, continuous air monitor, and area radiation monitor will be provided at the console either through computer display, analog meters, or custom panels.

Safety Discussion

Reactivity Considerations

Limitations as described in T S 3.2 regarding control and reactivity shall continue to be applied to control by the Mark III console. The following analysis shown below demonstrates that the control mechanism will not present a safety hazard not previously analyzed. A sine squared model of the integral worth of the safety rod was assumed,

$$\rho^{\$} = A \sin^2 \frac{\pi x}{2H} ,$$

where x is the control rod position, H is the total control rod movement sweep , and A

is the total rod worth. The maximum differential worth is found by differentiating the integral worth curve and evaluating at x=H/2 where the curve is at a maximum. The following equation is produced.

$$\left(\frac{d\rho^{\$}}{dx}\right)_{max} = \frac{\pi A}{H} \sin\frac{\pi}{4}\cos\frac{\pi}{4}.$$

The maximum total worth of a control rod will be approximately $2.50. The control rod drive speed has been measured at 76 seconds for complete rod withdrawal. If the control rod drive speed in units per second is multiplied by the maximum differential reactivity per unit, then the maximum reactivity insertion rate can be calculated.

$$\frac{d\rho^{\$}}{dt} = \frac{d\rho^{\$}}{dx}\frac{dx}{dt} = \frac{\$.00393}{\text{unit}}\frac{1000\text{ units}}{76\text{ seconds}} = \frac{\$0.05167}{\text{second}}.$$

The maximum rate of reactivity insertion is determined to be $.052 per second. This is substantially less than the maximum of $.30 per second specified in TS 3.2(2).

Limitations as described in TS 3.3.3 regarding the startup count rate interlock shall continue to be applied to control by the Mark III console. The Mark III interlock is capable of preventing control rod withdrawal when the neutron count rate is less than 2 counts per second.

Fuel Cladding Considerations

Control of the reactor by the Mark III console does not increase the probability of fuel cladding failure because the Mark III console does not create additional mechanical, electrical, or neutronic failure mechanisms for the cladding which are not discussed in SAR 8.7.

A temperature scram will be operational on the Mark III console. This is done to remain in compliance with T.S. 2.2. Values set will have the same margin of safety and maximum temperature values, these are 800 degrees Celsius for stainless steal clad elements and 460 degrees Celsius for aluminum clad elements.

Personnel Exposure and Material Releases

Control of the reactor by the Mark III console does not increase the probability of personnel exposure hazards as discussed in SAR 8.3 nor does it increase the probability of radioactive material release because it does not introduce any new mechanisms or pathways for release as evaluated in SAR 8.4.

Pool Water Leakage

Control of the reactor by the Mark III console does not increase the probability of pool water leakage because there are no additional mechanisms or pathways for water leakage which are not discussed in SAR 8.6.

Conditions, Limitations, and Restrictions

The Mark I and Mark III consoles are both designed and built by General Atomic (San Diego). The Mark III is newer and is electronically and mechanically superior to the Mark I. No new limitations or procedures need to be integrated into the control of the TRIGA reactor for the Mark III console. Future modifications should not be limited by this analysis and they should be considered on an individual basis.

Conclusion

The Mark III console has been subjected to a quality assurance analysis as documented by General Atomic. It has been approved and licensed for TRIGA reactor control at The Univeristy of California (Berkeley). This model of console has been evaluated in several Safety Analysis Reports approved by the NRC and has been approved for operation in several foreign countries. The integrity of the system has been long established.

Installation of the Mark III console will not increase the probability or consequences of any accident previously analyzed in the Safety Analysis Report. It will not introduce any accident or malfunction not previously evaluated, and it will not reduce the margin of safety as defined in the basis for any Technical Specification. The Mark III console will be subjected to a quality assurance review before full operation. The new console will meet all the requirements of the original system and has equal or better performance and reliability.

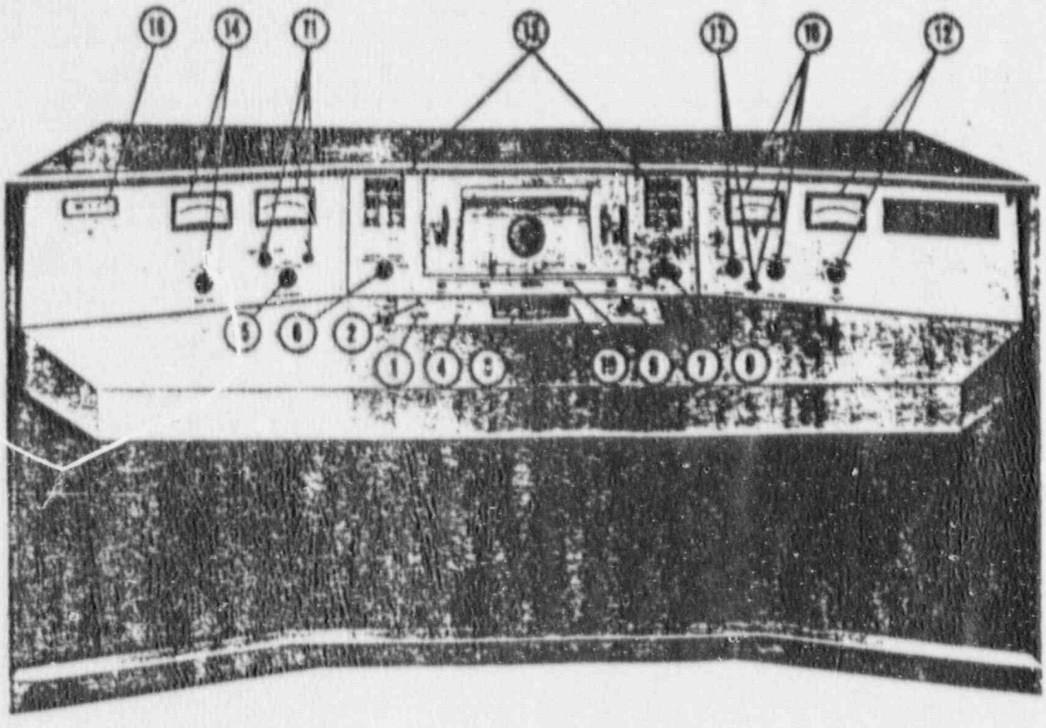

Figure 1. Console Front View.

1	Power Botton	7	Linear Range Switch	13	Scram Enunciators
2	Key Switch	8	Power Recorder	14	Startup Channel
3	Rod Drive Switchs	9	Auto Control Set	15	Log Channel
4	Transient Rod Fire	10	Scram Button	16	Percent Channel
5	Rod Position Indicator	11	Log Recorder	17	Linear Channel
6	Mode Slection Switch	12	Fuel Temperature	18	Time

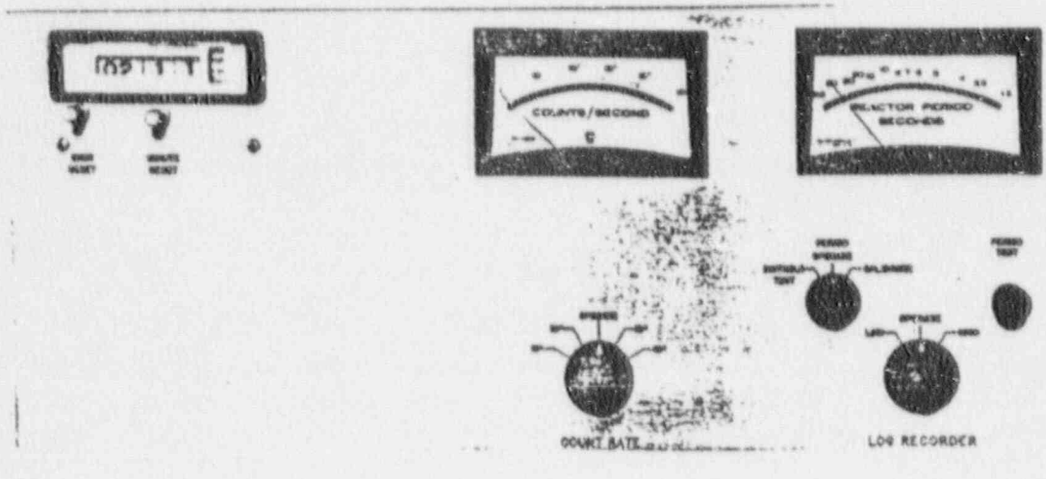

Figure 2. Console Left Panel.

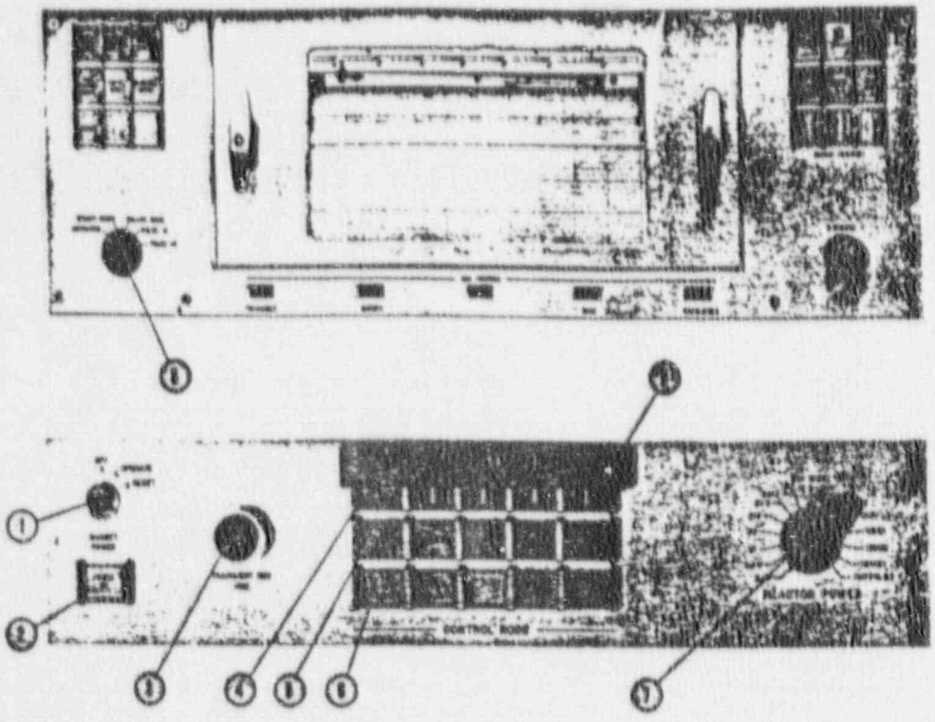

Figure 3. Console Center Panel.

1	Console Key Switch	4	Microswitch Indicators	7	Linear Range Switch
2	Power Switch	5	Drive Up Switches	8	Mode Switch
3	Transient Rod Fire	6	Drive Down Switches	9	Scram Button

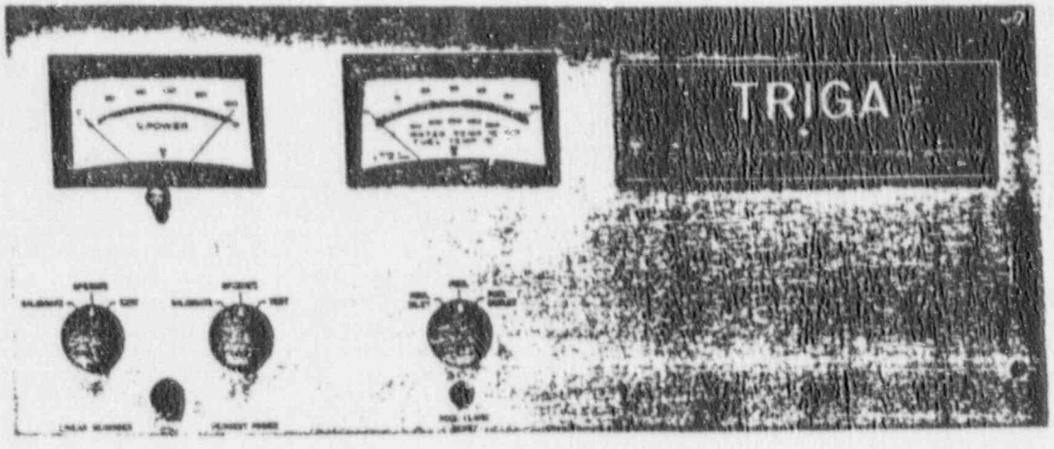

Figure 4. Console Right Panel.

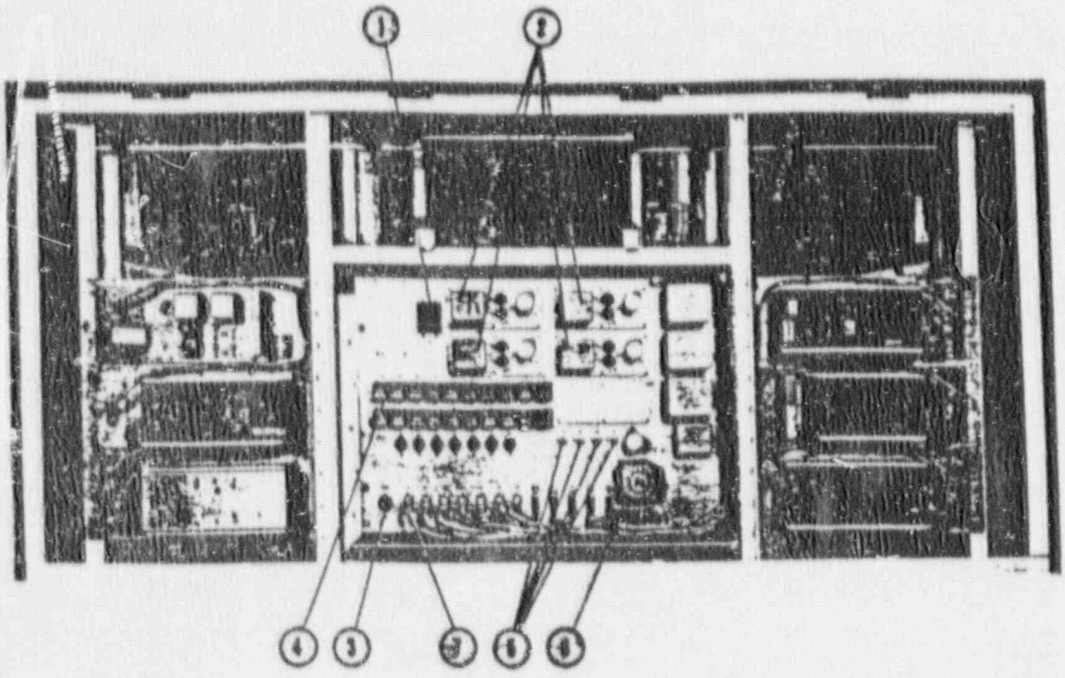

Figure 5. Console Back Panel.

1 Breaker Switch
2 Magnet Power Supplies
3 Line Power Connector
4 Scram Relay Array
5 Magnet Current Adjust
6 Time Delay Relay
7 Rod Drive Connectors

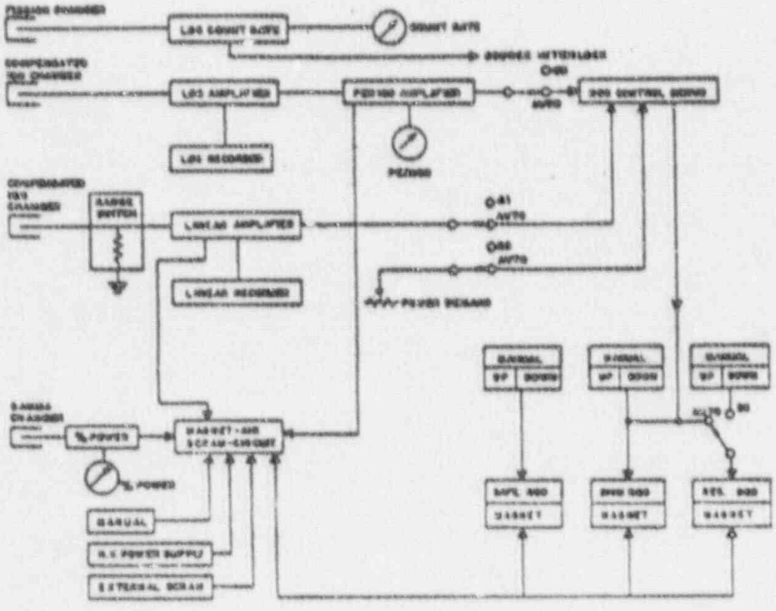

Figure 6. Functional Block Diagram.

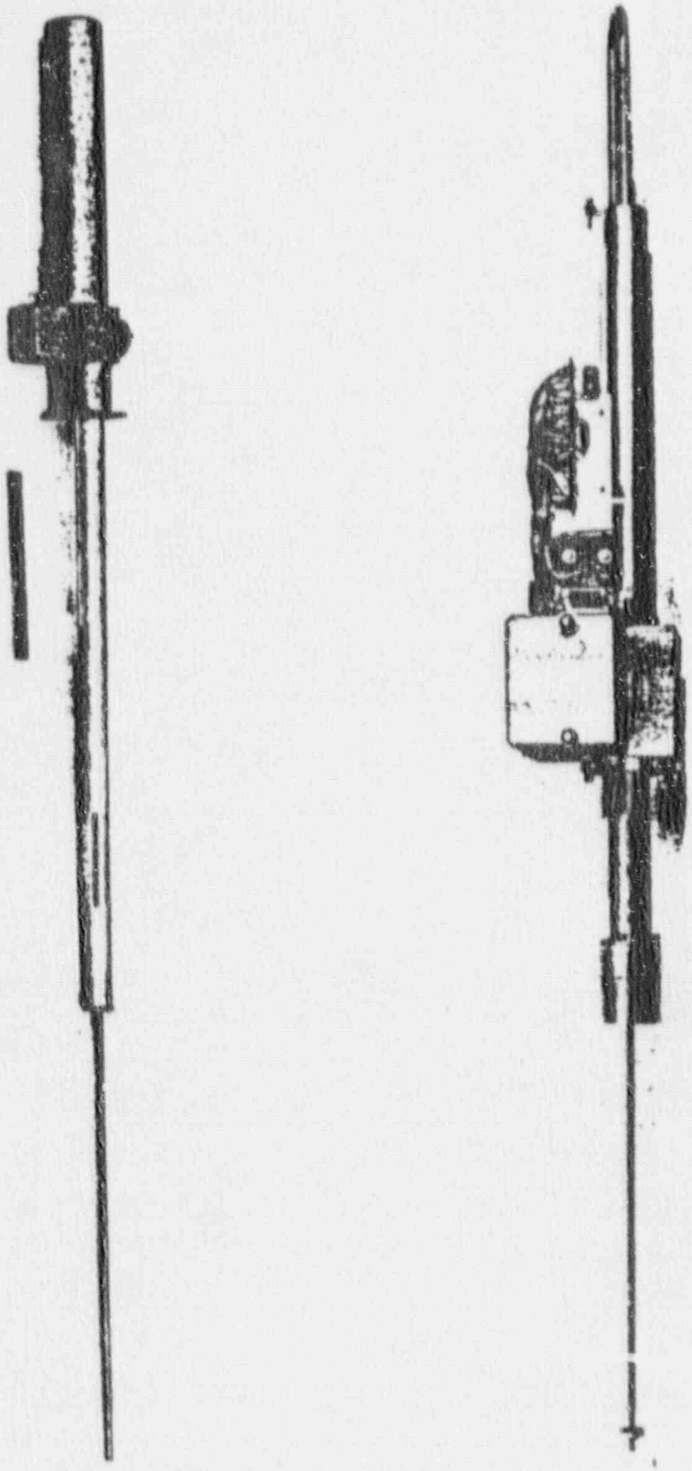

Figure 7. Rack and Pinion Drives.

REGULATORY ANALYSIS REPORT FOR INSTALLATION OF THE TRIGA MARK III CONSOLE

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Salt Lake City, Utah
December 17, 1990

TABLE OF CONTENTS

I. Introduction

The University of California (Berkeley) recently decommissioned a TRIGA nuclear reactor. The console from that system was given to the University of Utah for use with the Utah TRIGA reactor. Along with the console came compatible rod drivers. This console is the last version of the analog reactor control consoles produced by General Atomic and is known as the Mark III console. It is the intention of the staff and management of the University of Utah Nuclear Engineering Laboratory (UNEL) to install this console and compatible rod drivers on the existing TRIGA reactor.

The UNEL reactor is a modified TRIGA Mark I. Most of the components were obtained from the University of Arizona after they upgraded their reactor control capabilities. The console was decommissioned from Arizona in 1971 and recommissioned at Utah in 1975. The Mark I console was designed and built in 1958 as General Atomic's first commercial console. The Mark I uses winch type rod drives with submersible electromagnets. This system has received considerable use and wear over the 32 years of operation in two facilities.

The age of the Mark I console presents problems for operation and maintenance of the UNEL reactor. With many of the Mark I console components reaching the upper limit of their designed lifetime, the reliability of the system has been in doubt. Once a component has failed, the replacement of such a component becomes a major task. Therefore, much effort has been put forth to obtain and adapt the Mark III console. The Mark III console will simplify training, operation and maintenance.

This report is an analysis of the impact regulations governing the UNEL reactor have on installation of the Mark III console. The following chapters evaluate the UNEL TRIGA Technical Specifications, the Operations Manual, and 10CFR50.59. This report will provide information to the Reactor Safety Committee to assist in completing the review and approval process for installation of the Mark III console.

II. Technical Specifications

The Technical Specifications and Bases for the University of Utah TRIGA Reactor (Docket No. 50-407, Facility Licence No. R -126, March 1985) give the limitations and operating requirements for the UNEL TRIGA reactor. This section will address each section of the technical specifications as it pertains to the installation of the Mark III console. Potential problems with installation or operation of the Mark III console will be denoted through the use of italics.

Chapter 1. Definitions

The first chapter provides definitions for the reactor. The definitions will not change because of the installation of the Mark III console, nor will the definitions affect the way the console is installed or operated.

Chapter 2. Safety Limits and Limiting Safety System Settings

Safety Limit - Fuel Element Temperature

This section establishes limits for the maximum fuel temperatures allowed without concern for fuel integrity. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Limiting Safety System Settings

The section establishes setpoints for scram activation by the fuel temperature measuring channel for instrumented elements in various core locations and various cladding compositions. For the Mark III console, the levels are manually set on the fuel temperature meter relay. Since the meter relay is capable of activating the safety systems at all temperatures between 0 and 1000 °C, this specification presents no problem to installation or operation.

Chapter 3. Limiting Conditions of Operation

Normal Operation

This section establishes the maximum power generated in the reactor during normal operation at 100 kW. The Mark III console shall be calibrated to match metered power with core thermal power. The operator will reference these channels to to ensure that the core power is not deliberately raised above 100 kW.

Reactivity Limitations

This specification applies with the reactivity condition of the reactor and the reactivity worth of the control elements and experiments, the purpose of which is to ensure that

reactor can be shut down and that the fuel temperature safety limit will not be exceeded. The following conditions must be met:

(a) The shutdown margin is greater than $0.50.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(b) The rate of reactivity insertion by control rod motion shall not exceed $0.30 per second.

An analysis of this specification is performed in the Safety Evaluation of the Modification Authorization (MA-2) for the console. The maximum reactivity insertion rate is determined to be $.052 per second. This is significantly less than the specified maximum of $.30 per second.

(c) Any experiment with a reactivity worth greater than $1.00 is securely fastened.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(d) The excess reactivity is less than $2.80.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(e) The reactivity worth of an individual experiment is not more than $2.80.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Control and Safety System

Scram Time

The scram time from the instant that the slowest scrammable control rod reaches its fully inserted position shall not exceed 2 seconds. The Mark III console and control drives are not likely to be in violation of this specification as they are standard General Atomic design, which have been in use for many years at many facilities, and are not capable of exceeding this requirement. In addition, experience with the regulator rod at UNEL has demonstrated that this design is satisfactory in meeting this specification.

Reactor Control System

The specification states that the reactor shall not be operated unless the measuring channels listed in the following table are operable.

Measuring Channel	Minimum Number Operable
Fuel Temperature	1
Reactor Power	2
Startup Count Rate	1
Tank Water Level	1
Area Radiation Monitor	1
Continuous Air Radiation Monitor	1

The Mark III console has one fuel temperature scram channel and one fuel temperature backup channel. This console also has one startup count rate channel and three power channels including percent power, linear power, and log-n channel. The first three requirements are met by the console without modification.

The Mark III console does not have specific channels for water level, area radiation, and continuous air monitor. However, these systems may be retained from the present control system. The indicators for the four Eberline Area Radiation Monitors and the Continuous Air Monitor will be visible from the reactor control console. The tank water level is monitored with a microswitch activated by a float. While the Mark III does not have a channel specifically for water level, this signal may be routed through the external scram channel.

Reactor Safety System

The reactor shall not be operated unless the safety channels described in the following table are operable.

Safety System or Measuring Channel	Minimum Number Operable	Scram Setpoint
Fuel Temperature	1	At or below Limiting Safety System Setting
Reactor Power	2	At 120% of full power
Manual Scram	1	Manual activation
Key Switch	1	Manual activation
Console Power Supply	1	Loss of power
Tank Water Level	1	1 foot low
Startup Count Rate	1	<2 cps
Rod Withdrawal	1	prevent simultaneous withdrawal

The Mark III console has specific functions for all of the specifications above except for the water level scram capability. The problem is solved by routing the water level

microswitch signal through the external scram connector. When activated, the console will provide a scram with the indication of external scram.

Argon-41 Discharge Limit

The concentration of argon-41 releaseed to the environment shall not exceed 4 x 10^{-8} µCi/ml averaged over one year. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Engineered Safety Feature - Ventilation System

With an exception, the reactor shall not be operated unless the facility ventilation system is operable. The ventilation system is an auxiliary system. *The panel controlling the system will be moved from the Mark I console to the Mark III console.*

Limitations on Experiments

This specification applies to experiments installed in the reactor and the experimental facilities. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

As Low As Reasonable Achievable (ALARA) Radioactive Effluent Releases

This specification applies to the measurements required to ensure that the radioactive effluents released from the facility are in accordance with ALARA criteria. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Primary Coolant Conditions

This specification applies to the quality of the primary coolant in contact with the fuel cladding. The conductivity of the pool water shall be no higher than 5 x 10^{-6} mhos/cm and the pH of the pool water shall be between 5.0 and 8.0. These parameters are read by the computer and displayed on the CRT in the control room. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Chapter 4. Surveillance Requirements

General

This specification requires that all additions or modifications be made and tested in accordance with the specifications to which the systems were originally designed and fabricated. *This specification is fulfilled through this report and the Modification Authorization including the Safety Evaluation and the QA test.*

Safety Limit - Fuel Element Temperature

This specification applies to the surveillance requirements of the fuel element

temperature measuring channel.

(a) Whenever a reactor scram caused by high fuel element temperature occurs, the peak indicated fuel temperature shall be examined to determine whether the fuel element temperature safety limit was exceeded.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(b) The fuel element temperature measuring channel shall be calibrated semi-annually or at an interval not to exceed 8 months by the substitution of a known signal in place of the instrumented fuel element thermocouple.

Fuel temperature channel tests can be performed on the Mark III console. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(c) A channel check of the fuel element measurement channel shall be made each time the reactor is operated by comparing the indicated instrumented fuel element temperature with previous values for the core configuration and power level.

This specification is accomplished on the Preliminary Checklist. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Limiting Conditions for Operation

Reactivity Requirements

This specification applies to the surveillance requirements for reactivity control.

(1) The reactivity worth of each control rod and the shutdown margin shall be determined annually but at intervals not to exceed 15 months.

The Mark III provides for independent scram of each control to determine rod worth. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(2) The controls rods shall be visually inspected for deterioration at intervals not to exceed 2 years.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Control and Safety System

This specification applies to the surveillance requirements for measurements, tests, and calibrations of the control and safety systems.

(1) The scram time shall be measured annually but at intervals not to exceed 15 months.

Scram times can be measured using the same procedure as for the Mark I console. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(2) A channel check of each of the reactor's safety system channels shall be performed before each day's operation or before each operation extending more that 1 day, except for the pool level channel which shall be tested monthly.

Assuming installation of the water level safety channel as described previously, the console provides the ability to test each safety channel independently. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Radiation Monitoring System

The Area Radiation Monitoring System and the Continuous Air Monitoring System shall be calibrated biennially and shall be verified to be operable at monthly intervals. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Ventilation System

The reactor shall not be operated unless the reactor room ventilation system is in operation. This specification is not violated by the installation of the Mark III console, nor will the specification affect how the console is installed. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Experiment and Irradiation Limits

This specification applies to the surveillance requirements for experiments installed in the reactor and its experimental facilities and for irradiations performed in the irradiation facilities. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Reactor Fuel Elements

This specification applies to the surveillance requirements for the fuel elements. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Primary Coolant Conditions

This specification applies to the surveillance of the primary water quality. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Chapter 5. Design Features

Reactor Fuel

This specification applies to the design of fuel elements used in the reactor core. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Reactor Core

This specification applies to the configuration of the fuel and in core experiments. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Control Elements

This specification applies to the design and operation control elements used in the reactor core. The specification allows for the regulator rod to be nonscrammable. Since the regulator rod is scrammable, the Mark III is more conservative than the specification allows. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Radiation Monitoring System

This specification describes the functions and essential components of the area radiation monitoring equipment and the systems for continuously monitoring airborne radioactivity.

(1) Function of Area Radiation Monitor (gamma -sensitive instruments): Monitor radiation fields in key locations, alarm and readout at control console.

(2) Function of Continuous Air Radiation Monitor (beta -, gamma-sensitive detector with particulate collection capability): Monitor concentration of radioactive particulate activity in the pool room, alarm and readout at control console.

(3) Function of Argon-41 Stack Monitor (gamma-sensitive detector): Monitors the concentration of radioactive gases including argon-41 in the building exhaust, alarm and readout at console.

These systems are auxiliary systems. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Fuel Storage

This specification applies to the storage of reactor fuel at times when it is not in the reactor core. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Reactor Building and Ventilation System

This specification applies to the building that houses the reactor. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

Reactor Pool Water Systems

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

(1) The reactor core shall be cooled by natural convection water flow.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(2) All piping extending more than 5 ft below the surface of the pool shall have adequate provisions to prevent inadvertent siphoning of the pool.

Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

(3) A pool level alarm shall be provide to indicate a loss of coolant if the pool level drops more than 2 ft below the normal level.

The Mark III provides for this capability as described previously.

(4) The reactor shall not be operated with less than 18 ft of water above the top of the core.

With the water level scram installed as described previously, this specification will not be violated.

Chapter 6. Administrative Control

This section describes the administrative control functions including responsibility, organization, facility staff qualifications, training, the reactor safety committee, quality assurance, actions to be taken in the event a safety limit is exceeded, operating procedures, facility operating records, and reporting requirements. The only sections applicable to the Mark III console are the sections on QA and Reporting.

Quality Assurance

This specification deals with the review of replacement, modifications, and changes to systems having a safety related functions. This specification applies to the Mark III console, since the change in consoles can be deemed a replacement/modification of safety related functions. The change in consoles will be subjected to a QA review. The changes are required to be documented, and to have equal or better performance or reliability as compared to the original system. *This specification is satisfied with completion of the Modification Authorization (MA-2).*

Reporting Requirements

This specification requires that a brief description, including a summary of the safety evaluations of changes in the facility pursuant to 10CFR50.59. Since this specification is under administrative control, it will not be violated by the installation of the Mark III console, nor will the specification affect how the console is installed.

III. Conditions for Licensing (10CFR50.59)

The Code of Federal Regulations (CFR) applies to all federally regulated facilities. Because of the nuclear fuel, which is loaned to UNEL under contract from DOE (the fuel owner), the UNEL is a federally controlled facility. Title 10 of CFR provides regulations for energy related facilities. Part 50 outlines license conditions for nuclear facilities. Section 59 provides conditions for changes, tests and experiments that are to be made regarding a licensed nuclear reactor.

Specifically, 10CFR50.59(a)(1) states: "The holder of a license authorizing operation of a production or utilization facility may (i) make changes in the facility as described in the safety analysis report . . . without prior commission approval, unless the proposed change, test or experiment involves a change in the technical specifications incorporated in the license or an unreviewed safety question." Further, 10CFR50.59(c) states: "The holder of a license authorizing operation of a production or utilization facility who desires . . . to make a change in the facility . . . which involve(s) an unreviewed safety question . . . shall submit an application for amendment of his license pursuant to § 50.90."

Installation of the Mark III console does constitute a change in the facility. However, this change will not require a change in the Technical Specifications for the UNEL TRIGA reactor. The Modification Authorization (MA-2) which is to be reviewed and approved by the Reactor Safety Committee, includes the safety evaluation required by 10CFR50.59(a)(1) and (c) for installation of the Mark III console. The safety evaluation should conclude that there are no unreviewed safety questions. Therefore, no amendments to the R-126 license need be submitted. However, it will be necessary to modify the Mark III console such that it will meet the Technical Specifications as noted in the Recommendations section of this report.

IV. Operating Procedures

This section gives the details of the operating procedures for the UNEL reactor, and examines how the planned operating procedures will be affected by the installation of the Mark III console. As in the previous section, any potential problems will be denoted through the use of italics.

The Procedures are divided into 10 chapters. The subject matter of each chapter is reasonably described by the chapter title. The chapters are defined as follows:

Chapter 1	Organization and Responsibilities
Chapter 2	Reactor Operations
Chapter 3	Reactor Calibration, Surveillance, and Maintenance
Chapter 4	Experiment Procedures
Chapter 5	Support Systems
Chapter 6	Maintenance and Surveillance of Support Systems
Chapter 7	Health Physics Procedures
Chapter 8	Emergency Plan and Procedures
Chapter 9	Physical Security Plan and Procures
Chapter 10	Requalification Training

A detailed examination of the Procedures will demonstrate that the only chapters which could possibly be affected are Chapters 2 and 3. Therefore, a brief outline of these chapters follows. As for the other chapters, there will be no deviations to the procedures by the installation of the Mark III console, nor will the procedures change how the console is installed.

Chapter 2. Reactor Operations

Facility Access

This section describes and defines the persons responsible for controlling access to the Nuclear Engineering Laboratory, as well as who has access to which sections of the facility. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Operations Record

This section describes and defines the records and logs that must be kept concerning the operations processes of the Nuclear Engineering Laboratory. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Reactor Startup

General

This section describes the general requirements for start up of the reactor. This section also states that the reactor "shall be checked out according to the Prestart Checklist, For

NEL-001, prior to the initial startup each day." There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Prestart Checklist

This section states that the Prestart Checklist, Form NEL-001, be completed in its entirety prior to the initial start up each day. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed. *However, it should be noted that the Prestart Checklist, Form NEL-001, may require some minor revisions to accommodate the Mark III console.*

Startup

This section describes the procedure concerning the approach to critical for the reactor. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed. *However, it should be noted that the TRIGA Critical Approach, Form NEL-001, Sheet 3, may require some revisions to accommodate the Mark III console.*

Startup Following a Scheduled Shutdown

This section describes the procedure for starting up the reactor following a scheduled shutdown. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Startup Following an Unscheduled Shutdown

This section describes the procedure to be followed in order to restart the reactor following an unscheduled shutdown. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Steady State Operation

General

This section describes the modes of operation of the reactor and gives the restrictions imposed by the Technical Specifications governing the reactor as follows:

a. "Limiting safety systems setting for stainless steel clad fuel is 1000 °C under any conditions of operation and 530 °C for aluminum clad fuel. (TS 2.1 and TS 2.2)" There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

b. "The reactor power level shall not deliberately be raised above 100 kilowatts under any conditions of operation(TS 3.1)" The Mark I console was set for normal operation of 100 kW (max). The Mark III console power is adjustable for full power of 0.1 W to 1 MW in steps of 3X and 10X. The last three settings are: 100 kW, 300 kW and 1 MW. The last two settings violate this section. *It should therefore be recommended that the 300 kW and 1 MW settings on the linear power setting switch be mechanically disabled so as to prevent anyone from deliberately or accidentally raising the reactor power above 100 kW.*

c. This section specifies that the reactor shall not be operated unless the Reactor Control System measuring channels described in TS 3.3.2 are operational. Recommended steps to eliminate a deviation from this procedure are previously noted in the Technical Specification chapter.

Log Entries

This section describes information to be contained in the log books. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Sample Movements

This section describes the requirements for the movement of radioactive samples used in experiments. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Reactor Shutdown

General

This section describes the requirements and definitions for the reactor to be in the state of shutdown. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Shutdown Procedures

This section describes the general procedures for shutting down the reactor, as well as making the appropriate log book entries. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Fuel Movement, Control Rod Movement and Core Changes

This section describes and defines the requirements for the movement and adjustment of fuel elements, the use of the tools that are used for fuel element movement, changing the core structure, and adjusting reactivity. Also described are the procedures and requirements for the removal and installation of the control rods for maintenance, repair, inspection or experimental procedures. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Response to Alarms

This section describes the alarms that can be sounded in the Nuclear Engineering Laboratory, as well as the possible causes and actions to be taken in response to them. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Response to Abnormal Reactivity Changes

This section describes and defines what is considered to be a reportable occurrence of change in reactivity and the procedure to follow in the event that a reportable occurrence

happens. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

Chapter 3. Reactor Calibration, Surveillance, and Maintenance

This chapter describes the frequency for the various surveillance requirements to be performed. *The only procedure to be affected is the Prestart Checklist which has been noted before*. There will be no deviations to the procedures by the installation of the Mark III console, nor will the procedure change how the console is installed.

V. Conclusions and Recommendations

All of the regulatory documentation pertaining to reactor safety and control systems for the R-126 license has been examined. Review details for the license conditions (Technical Specifications), Code of Federal Regulations (CFR), and the Operating Procedures have been included in this report. The Safety Analysis Report for R-126 is augmented by the Modification Authorization which contains a Safety Evaluation for installation of the console. This authorization determines that while installation of the console will deviate from certain descriptive aspects of the Safety Analysis Report, no new types of failure are introduced and the possibility of failures examined in the Safety Analysis Report are not increased.

The American National Standards Institute in cooperation with the American Nuclear Society provide guidelines for reactor safety and control systems. This console meets all of the recommendations of the ANSI/ANS standards. Installation of the console should follow the Quality Assurance guideline which suggests independent oversight of the work. To satisfy this recommendation, the Modification Authorization provides for an independent test of all systems prior to final approval for normal operations. This procedure will ensure that the following recommendations are completed before final staff authorization for normal reactor operations.

This review identified several areas of potential problems during installation of the Mark III console. Assuming all safety and control channels explicitly designed into the Mark III console will be properly operating, the recommendations are as follows:

1. The Mark III console linear range switch should be modified to mechanically limit the 300 kW and 1 MW selections.

2. The tank water level indicator should be connected to an "external scram" input.

3. At least one area radiation monitor from the Mark I console should be made available to the Mark III console.

4. The continuous air monitor from the Mark I console should be made available to the Mark III console.

5. The ventilation system control from the Mark I console should be made available to the Mark III console.

6. All safety systems should be tested for operation.

7. Safety and control measuring channels should be calibrated, including fuel temperature, power level, control rod position, rod drop time, and rod worth.

8. The Modification Authorization (MA-2) should be reviewed and approved by the Reactor Safety Committee.

9. The console installation should be reported to the NRC via the Annual Operating Report as a 10CFR50.59 change.

10. The Prestart Checklist should be modified to accommodate the Mark III console.

University of Utah Nuclear Engineering Laboratory 21 March 1991

Reactor Safety Committee
Subcommittee for Upgrade of the TRIGA Reactor Console

Summary

The University of Utah (UU) Reactor Safety Committee (RSC) has appointed a subcommittee to review, audit, evaluate and recommend certain operations, procedures and activities associated with the safety and regulatory aspects of implementing an upgrade for the present TRIGA Nuclear Reactor Console at the University of Utah Nuclear Engineering Laboratory (UUNEL). The RSC reviewed and approved the proposed upgrade program on 19 December 1990 and delegated the operational review and auditing to a subcommittee composed of the following personnel

- James M. Byrne - member RSC
- Dr. David M. Slaughter - Research Professor in Mechanical Engineering
- Byron L. Hardy - Alternate Radiation Safety Officer

This subcommittee was charged with acting in behalf of the RSC in the operational review and audit of all issues regarding NRC license, regulation, safety reviews, Technical Specifications, CFR requirements, etc associated with the TRIGA Console Upgrade Program. Documentation of individual tests, audits, recommendations and evaluations performed by this subcommittee are attached.

Detailed RSC Verification of Performance, Safety Requirements, Limiting Conditions and Other Factors Associated with Upgrade of the UUNEL TRIGA Console

The following specific UUNEL TRIGA Technical Specifications were reviewed, audited and evaluated by the RSC Upgrade Subcommittee regarding implementation of the Upgrade TRICA Console Program (i.e., utilization of the former University of California Berkeley TRIGA Console to upgrade the current console system) planned for upgrade of the TRIGA Reactor System by the operational staff of the UUNEL. The Upgrade console was demonstrated in a avariety of operational modes including single subsystem operation and independent and parallel critical and subcritical operation with the existing console.

UUNEL Technical Specification 3.3.2 Reactor Control System

Technical Specification (TS) 3.3.2 requires that certain minimum number of measuring channels be operational a specified in the Table in TS 3.3.2.

Measuring Channel - Minimum Number Operable — Upgrade Status / Reviewed by / date

a) Fuel element temperature - 1 _____

b) Reactor Count rate - 2 _____

c) Startup Count rate - 1 _____

d) Reactor tank water level - 1 _____

e) Area radiation monitor - 1 _____

f) Continuous Air radiation monitor - 1 _____

Comments_____

UUNEL Technical Specification 3.3.3 Reactor Safety System

Technical Specification 3.3.3 requires that a certain minimum number of reactor safety system channels be operational a specified in the Table in TS 3.3.3

Safety-Measuring Channel - Minimum Number Operable Upgrade Status / Reviewed by / date

a) Fuel element temperature - 1 _____

b) Reactor power level - 2 _____

c) Manual console scram button - 1 _____

d) Magnet current key switch - 1 _____

e) Console power supply - 1 _____

f) Reactor tank water level - 1 _____

g) Startup count rate interlock - 1 _____

h) Control rod withdrawal interlocks - all rods _____

Comments_____

UUNEL Technical Specification 2.1 Safety Limit - Fuel Element Temperature

Technical Specification 2.1 specifies the maximum fuel temperature that can be permitted with confidence that a fuel cladding failure will not occur

Fuel Temperature Specification	Upgrade Status / Reviewed by / date
1) Temperature in SS clad, high hydride fuel element not exceed 1000 °C	
2) Temperature in Al clad, low hydride fuel element not exceed 530 °C	

Comments

UUNEL Technical Specification 2.2 Limit Safety System Settings

Technical Specification 2.2 specifies settings that will prevent the safety limit from being reached. Specifications for Safety Limit Settings are as follows:

1) For a core composed entirely of SS clad, high hydride fuel elements or a core compose do SS clad, high hydride fuel elements with low hydride fuel elements in the F or G hexagonal ring only, the safety system setting must be as follows:

Location of instrumented fuel rod - temperature setting Upgrade Status / Reviewed by / date

B- hexagonal ring - 800 °C _____

C- hexagonal ring - 755 °C _____

D - hexagonal ring - 680 °C _____

E- hexagonal ring - 580 °C _____

2) For a core with low hydride fuel elements in other than the F or G hexagonal ring, the safety system setting must be as follows:

Location of instrumented fuel rod - temperature setting Upgrade Status / Reviewed by / date

B- hexagonal ring - 460 °C _____

C- hexagonal ring - 435 °C _____

D - hexagonal ring - 390 °C _____

E- hexagonal ring - 340 °C _____

3) For a core containing flux traps, the limiting settings must be applied to the hottest fuel element in the core.

Comments_____ _____

_____

_____

_____

UUNEL Technical Specification 3.1 Normal Operation

Technical Specification 3.1 specifies that maximum reactor power level for any condition of operation which is **100 kilowatts (thermal)**

Upgrade Status / Reviewed by / date

Comments

UUNEL Technical Specification 3.2 Reactivity Limitations

Technical Specification 3.2 requires that certain reactivity conditions and limitations be satisfied

Specification	Upgrade Status / Reviewed by / date
1) Shutdown margin > $.50	_____
2) Rate of reactivity insertion < $.30/sec	_____
3) Experiments > $1.00 securely fixed	_____
4) Excess reactivity < $2.80	_____
5) No individual experiment > $2.80	_____

Comments_____

UUNEL Technical Specification 3.3.1 Reactor Scram Time

Technical Specification 3.3.1 requires that the scram time from the instant a safety system setting is exceeded to the instant the slowest scrammable control rod reaches its fully inserted position shall not exceed 2 seconds.

Upgrade Status / Reviewed by / date

Comments

UUNEL Technical Specifications - General Review and Audit

The UUNEL Technical Specifications define and control the technical operation of the UUNEL TRIGA Nuclear Reactor and must be reviewed and satisfied by the TRIGA Console Upgrade Program. Each of the individual specifications pertinent to the Upgrade Program were reviewed by the RSC Subcommittee and endorsed by the RSC.

Specific Condition in UUNEL TRIGA TS Upgrade Status / Reviewed by / date

1.0 Definitions

1.1 Reactor Operating Conditions _____

1.2 Reactor Experiment and Irradiations _____

1.3 Reactor Components _____

2.0 Safety Limits and Limiting Safety System Settings

2.1 Safety Limit - fuel element temperature _____

2.2 Limit Safety System Setting _____

3.0 Limiting Conditions of Operation

3.1 Steady State Operation _____

3.2 Reactivity Limitations _____

3.3 Control and Safety System _____

3.4 Argon-41 Discharge Limit _____

3.5 Ventilation System _____

3.6 Limitations on Experiments _____

3.7 ALARA Radioactive Effluent Releases _____

3.8 Primary Coolant Conditions _____

4.0 Surveillance Requirements

4.1 General _____

4.2 Safety Limit - fuel element temperature _____

4.3 Limiting Conditions for Operations _____

4.4 Reactor Fuel Elements _____

4.5 Primary Coolant Conditions _____

5.0 Design Features

5.1 Reactor Fuel _____

5.2 Reactor Core _____

5.3 Control Elements _____

5.4 Radiation Monitoring System _____

5.5 Fuel Storage _____

5.6 Reactor Building & Ventilation System _____

5.7 Reactor Pool Water System _____

5.8 Physical Security _____

6.0 Administrative Control _____

Comments

_____

_____

_____

_____

_____

_____

_____

Modification Authorization

Identification: MA-2

Title: Implementation of the Reactor Console Upgrade

1. Staff Review of Safety Evaluation

The hazards associated with this proposed modification have been reviewed by the Operations Staff. It is determined that this modification does not increase the probability of occurrence or consequences of any accident previously analyzed in the Safety Analysis Report and does not introduce any accident, malfunction, or safety issue not previously evaluated.

_____ _____

Director, UNEL Date

2. Reactor Safety Committee Review of Safety Evaluation

The hazards associated with this proposed modification have been reviewed by the RSC. It is determined that this modification does not increase the probability of occurrence or consequences of any accident previously analyzed in the Safety Analysis Report and does not introduce any accident, malfunction, or safety issue not previously evaluated.

_____ _____

Chairman, RSC Date

3. Implementation Procedure Review

_____ _____

Member, RSC Subcommittee Date

4. Implementation Procedure Approval

_____ _____

Reactor Supervisor, UNEL Date

_____ _____

Director, UNEL Date