The University of Utah TRIGA Reactor
Annual Operating Report
for the period
1 July 1990 through 30 June 1991

A. NARRATIVE.

1. Operating Experience.

The University of Utah Nuclear Engineering Laboratory (UUNEL) TRIGA Reactor, License No. R-126, Docket No. 50-407, was critical 117.6 hours and generated 6494.1 kilowatt-hours of thermal energy during this reporting year. The reactor was used for educational demonstrations, laboratory experiments, systems tests, power measurements and sample irradiations.

2. Changes in Facility Design.

On 9/21/89, UUNEL acquired the TRIGA control console from the recently decommissioned Berkeley Research Reactor (BRR, NRC License No. R-101) to replace the old control console in a comprehensive TRIGA Reactor Control System Upgrade Program. Authorization for the console exchange was approved by the Reactor Safety Committee (RSC). A Safety Analysis Report (SAR) was prepared for review by the RSC and subsequent inspection by the NRC. The SAR concluded that all operating license technical specifications were satisfied by the upgrade and that implementation of the BRR console did not adversely affect the safe operation of the facility. Console exchange commenced 15 April 1991 and was completed on 31 July 1991, after the end of the current reporting period. The TRIGA Control System Upgrade Program is still in progress as of this reporting date. Further discussion of the console exchange is presented in Section E of this report: Changes, Tests and Experiments Pursuant to 10 CFR 50.59.

3. Surveillance Tests.

(Documentation of all surveillance activities is retained and stored by the facility.)

a. Control Rod Worths.

Core Configuration #22	22 August 1990
Safety Rod	\$2.80
Shim-safety Rod	\$2.64
Regulating Rod	\$0.27
Excess Reactivity	\$1.98
Shutdown Margin	\$0.93

Core Configuration #22	6 February 1991
Safety Rod	\$2.35
Shim-safety Rod	\$2.21
Regulating Rod	\$0.27
Excess Reactivity	\$1.63
Shutdown Margin	\$0.85

b. Control Rod Inspection.

The Biennial Control Rod Inspection is scheduled for December, 1991. Rod drop times were measured on 8/22/90, 2/6/91 and 6/17/91. All rod drop times were less than 1.4 seconds.

c. Reactor Power Level Instrumentation.

Calorimetric power calibrations were performed on 8/7/90 and 2/13/91. The following results were obtained.

Date	Meter Reading	Calculated Power Level
08/07/90	90 kW	90.3 kW
02/13/91	95 kW	98.3 kW

d. Fuel Inspection.

The Biennial Fuel Inspection is scheduled for December 1991. The problem of leaking fuel elements was resolved by the identification and removal of defective fuel from the reactor core as reported in the 1988-89 and 1989-90 Annual Operating Reports. Pool water is sampled and analyzed periodically for evidence of fission product activity.

e. Fuel Temperature Calibration.

Fuel temperature circuits were calibrated on 8/31/90, 2/25/91 and 6/3/91. The circuits were calibrated to less than a 5 °C error over the range 20 °C to 500 °C.

f. Reactor Safety Committee Audits.

RSC member J. M. Byrne audited the maintenance and operational activities of the facility for the period 1 July 1990 through 31 December 1990.

University of Utah Radiation Safety Officer (RSO) and RSC member K. J. Schiager and Alternate RSO B. L. Hardy audited the maintenance and operational activities of the facility for the period 1 January 1991 through 10 March 1991.

K. J. Schiager and B. L. Hardy audited radiation safety and ALARA practices at the facility for the period1 January 1991 through 30 June 1991.

K. J. Schiager and B. L. Hardy reviewed radiation safety and monitoring at UUNEL for this reporting period.

No significant deviations from normal operating practices were identified by these audits.

g. Environmental Surveys.

RSO K. J. Schiager reported to the RSC a maximum total exposure of 45 millirem per quarter to environmental dosimeters located at various positions surrounding UUNEL for the period 1 July 1990 through 30 June 1991.

B. ENERGY OUTPUT.

The reactor was critical for 117.6 hours and produced 0.271 megawatt-days (6494.1 kilowatt-hours) of energy during this reporting period. Since initial criticality, the reactor has been operated for a total of 2,077.3 hours with an accumulated total energy output of 5.12 megawatt-days (122,862.5 kilowatt-hours).

C. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS.

There were no emergency (manually-activated) shutdowns of the reactor during operations this reporting period. On 26 September 1990, the reactor was intentionally shutdown during a demonstration run for NRC during a facility inspection. Inspectors asked the reactor operator to scram the reactor by manually depressing the float device of the water level alarm to demonstrate satisfactory operation of the system.

There were ten inadvertent (instrumental) scrams while the reactor was critical during this reporting period. The type, cause and action taken by the operations staff for each scram are outlined below:

Quantity	Type	Cause	Action
1	Linear Power Channel	Signal spike during switching power level.	Restart.
1	Hi-Log Power Channel	Signal spike during switching power level.	Restart.
1	High-Radiation Alarm	Hot samples removed from reactor without disabling radiation monitors.	Terminated Run.
2	Fuel Temperature	Signal spike caused by accidentally bumping console.	Cautioned personnel. Restart.
1	Magnet Current Failure	Signal spike caused by accidentally bumping console.	Cautioned personnel. Restart.
4	Magnet Current Failure	Loss of magnet current due to apparent power fluctuation.	Restart.

D. MAJOR MAINTENANCE.

The water pump of the pool recirculation/refrigeration system was serviced on 3/4/91 to correct excessive noise and overheating which caused premature shutdown. The nut securing the impeller blade to the pump shaft had loosened slightly, thereby increasing friction and vibration. Some minor scoring of the impeller blades and housing resulted. The nut was tightened and the pump was reassembled. Normal operation of the pump has been resumed without any adverse effects.

The mixed bed resin of the demineralizer system was replaced with new resin on 4/5/91. The spent resin is being stored in UUNEL pending transfer to the Radiological Health Department for disposal. The existing plumbing of the demineralizer circuit of the pool recirculation system was slightly altered to decrease pressure losses through the resin beds. New fittings were installed on the resin tanks to allow a larger diameter hose to be used in connecting the tanks in series. Additionally, extraneous sections of pipe and 90° elbows were removed from the circuit to reduce the overall length of flow through the channel.

The conductivity probes which monitor the quality of the pool water were cleaned on 4/8/91.

E. CHANGES, TESTS AND EXPERIMENTS PURSUANT TO 10 CFR 50.59.

As of the end of the reporting period, the current membership of the Reactor Safety Committee (RSC) as designated by the Licensee is as follows:

Dietrich K. Gehmlich, Reactor Administrator
Gary M. Sandquist, Nuclear Engineering Laboratory Director
Keith J. Schiager, Radiation Safety Officer
Kevan C. Crawford, Reactor Supervisor
John S. Bennion
James M. Byrne
Patrick S. Sheehan

The UUNEL has installed the TRIGA Mark III control console from the recently decommissioned Berkeley Research Reactor (BRR, NRC License No. R-101). Implementation of the Mark III console was accomplished according to approved written procedures under review of the Reactor Safety Committee. A copy of the Regulatory Analysis Report, Modification Authorization, changeover procedures and related documents are included in the Appendix. Installation of the Mark III console required that following significant changes: (1) control of the regulating control rod was removed from the Series/I computer and is now exclusively controlled from the Mark III console and (2) the Continuous Air Monitor display was moved to the Series/I computer screen.

The RSC has reviewed and approved several NEL procedures which were modified to update and correct any deficiencies. The NEL staff continues to review and update facility documentation to assure compliance with applicable regulations. The revised Standard Operating Procedures is nearly complete (to augment the Facility Operating Manual).

F. RADIOACTIVE EFFLUENTS.

1. Liquid Waste - Total Activity Released: Negligible.

   There was no liquid radioactive effluent this period.

2. Gaseous Waste - Total Estimated Activity Released: 1.25 mCi.

   The TRIGA Reactor was operated for 117.6 hours at power levels up to approximately 95 kW. At this power level argon-41 production is substantially below MPC values for unrestricted areas. The minimum detectable concentration of Ar-41 for the stack monitor has been found to be one-third of 10 CFR 20 appendix B limits for release to unrestricted areas. The average annual calculated concentration of Ar-41 generated during operations is estimated at 1.53 x 10^{-10} µCi/ml which is approximately 0.4% of the MPC for this radionuclide. The total amount of Ar-41 released was estimated at 50.3 µCi. In addition, during the months of July, August, October and December minute quantities of phosphorus-32 were released from UUNEL as the result of processing sulfur foil dosimeters used to measure the fast neutron fluence received during the irradiation of electronic components for the U.S. Air Force. The total amount of all gaseous radioactivity released was estimated at 1.25 mCi. A monthly summary of gaseous releases is given in Table I.

Table I.

Summary of Monthly Gaseous Radioactive Effluent
1 July 1990 through 30 June 1991

Month	Estimated Release (µCi) Ar-41	P-32 and all others	Total
July	2.7	240	243
August	5.9	240	246
September	2.3	0	2
October	6.2	480	486
November	3.8	0	4
December	3.7	240	244
January	10.0	0	10
February	6.8	0	7
March	2.7	0	3
April	2.9	0	3
May	0.0	0	0
June	3.3	0	3
Total activity of gaseous effluent (µCi):	50.3	1200	1251

3. Solid Waste - Total Activity: none

Approximately 1.0 cubic meter of solid waste consisting of low-level decontamination materials, debris removed from the reactor tank during cleaning, spent ion-exchange resin from the pool-water purification system and other wastes that have accumulated from past operations was generated by the facility during the reporting period. The waste is being stored in the Controlled Access Area of the facility pending characterization and subsequent transfer to the Radiological Health Department for disposal.

G. RADIATION EXPOSURES.

Personnel with duties in the reactor laboratory on either a regular or occasional basis have been issued a film-badge dosimeter by the University of Utah Radiological Health Department. The duty category and monitoring period of personnel are summarized below:

Name	Monitoring Period	Duty Category
Gary Sandquist	7/1/90-6/30/91	regular
Kevan Crawford	7/1/90-6/30/91	regular
John Bennion	7/1/90-6/30/91	regular
Todd Gansauge	7/1/90-6/30/91	regular
David Slaughter	7/1/90-6/30/91	regular
Byron Hardy	7/1/90-6/30/91	occasional
Cynthia Henderson	7/1/90-6/30/91	occasional
Sharon Packer	7/1/90-6/30/91	occasional
Medhi Taheri	7/1/90-6/30/91	occasional
Quyen Tang	7/1/90-6/30/91	occasional
Mary Jane Hale	7/1/90-6/30/91	terminated

Dose Equivalent summary for Reporting Period:

Measured Doses

7/1/90 - 6/30/91 Doses: 15 mrem average; 50 mrem highest measured.

Dose Equivalent Limits

Maximum Permissible Dose Equivalent = 5000 mrem/year (1250/quarter).
Minimum Detectable per Monthly Badge = 10 mrem.

Of the 510 visitors to the facility under the DOE Reactor Sharing Program for the reporting year, no visitor received a measurable dose. Therefore, the average and maximum doses are all within NRC guidelines. A summary of whole body exposures is presented in Table II.

Table I.

Summary of Whole Body Exposures
1 July 1990 through 30 June 1991

Estimated whole body exposure range (rem):	Number of individuals in each range:
No Measurable Dose	4
Less than 0.10	7
0.10 to 0.25	0
0.25 to 0.50	0
0.50 to 0.75	0
0.75 to 1.00	0
1.00 to 2.00	0
2.00 to 3.00	0
3.00 to 4.00	0
4.00 to 5.00	0
Greater than 5 rem	0
Total number of individuals reported:	11

H. LABORATORY SURVEYS.

Monthly surveys of the facility were conducted by the University of Utah Radiological Health Department during the reporting period. Some of these surveys have identified minor localized removable contamination sources which were immediately cleaned. The surveys have not indicated any unusual radiation levels over previous years. Records of surveys are retained by the facility.

I. ENVIRONMENTAL SURVEYS.

The Air Monitoring Station, operated by the U.S. Environmental Protection Agency and located outside the reactor building, has indicated no unusual changes in radiation or radioactive material concentrations during the reporting period.

Environmental monitoring conducted by the University of Utah Radiological Health Department indicated no unusual dose rates in the areas surrounding the Merrill Engineering Building, which houses the reactor facility.

Prepared by: John S. Bennion, Sr. Reactor Engineer Date: 28 August 1991

Submitted by: [signature] Date: 19 Sept 91
Director, UUNEL

Approved by: [signature] Date: 20 Sept 91
Reactor Administrator

APPENDIX

1. Regulatory Analysis Report for the Installation of the TRIGA Mark III Console
2. Modification Authorization M-2: "Installation of the Mark III Console"
3. Report of the Reactor Safety Committee Subcommittee for the Upgrade of the TRIGA Reactor Console

REGULATORY ANALYSIS REPORT FOR INSTALLATION OF THE TRIGA MARK III CONSOLE

prepared by
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Salt Lake City, Utah
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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 4×10^{-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 5×10^{-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.

<u>Limiting Conditions for Operation</u>

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 deviation to the procedures by the installation of the Mark III console, nor will the procedure char 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 ^{o}C under any conditions of operation and 530 ^{o}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 15 April 1991

Reactor Safety Committee
Subcommittee for Upgrade of the TRIGA Reactor Console

Summary

The University of Utah (UU) Reactor Safety Committee (RSC) had appointed a subcommittee to review 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 the Regulatory Analysis Report and the Modification Authorization on 19 December 1990 submitted by operations staff. The Report and the Authorization were found satisfactory with minor modifications. At that time, a subcommittee composed of the following personnel

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

was selected to act in behalf of the RSC to review the proposed modification procedures for console upgrade and perform independent equipment checks pertaining to issues regarding NRC license, regulation, safety, Technical Specifications, CFR requirements, etc. Documents resulting from the review and checks are attached.

UPGRADE IMPLEMENTATION PROCEDURE SCHEDULE

		DAY
I.	**Remove fuel from the core.**	1

A. Complete NEL-014 to step 3

II.	**Disconnect the Mark I Console.**	1

A. Disconnect Line Power.
B. Disconnect all Rod drive cables.
C. Disconnect all thermocouples.
D. Disconnect all Power Channels.
E. Disconnect all External SCRAM signals.
F. Disconnect CAM and ARM.

III.	**Remove the Mark I console.**	1

A. Disassemble the Mark I console.
B. Remove the Mark I console from the control room.

IV.	**Transfer the Mark III console to the control room.**	2

A. Short out the window tape sensor.
B. Remove glass from the window.
C. Move the Mark III console into the control room.
D. Replace the window glass.
E. Re-enable the window glass tape sensor.

V. **Installation of the Mark III console.**

A.	Connect console to Line power.	3
B.	Disconnect REG. rod drive.	3

1. Disconnect computer control capability.
2. Replace existing rod drive with Mark III compatible drive.

C.	Connect rod drives to the Mark III console.	3

1. Connect rod drives to the console by using adapter cable.
2. Remove control rods per NEL-014.
3. Connect absorbers.
4. Install new rod drive assemblies per NEL-014 as applicable.
5. Complete the <u>Rod Drive Verification</u> section of the QA Checklist.

D.	Connect and install Auxiliary Systems to the Mark III console.	4-5

1. Install the Ventilation switches and indicators in the Mark III console.
2. Connect the Area Radiation Monitor to the damper solenoids.

3. Connect the Continuous Air Monitor to the Series/1 computer.
4. Complete the Auxiliary System Verification portion of the QA Checklist.

E. Connect and Test all Measuring Channels to the Mark III console. 6

1. Check and Test the following Channels after connecting.

   a. Linear Power Channel (Install recorder)
   b. Linear channel switch limits (300 Kw and 1 Mw)
   c. Percent Power Channel.
   d. Log-n Channel (Install recorder)
   e. Startup Channel
   f. Fuel Temperature
   g. Area Radiation Monitor
   h. Continuous Air Monitor.
   i. Water Level Indicator

2. Verify calibration on items e-h.
3. Complete the Measuring Channel Verification portion of the Quality Assurance Checklist. (Except calibration of Power Channels.)

F. Test all SCRAM systems. 7

1. The following SCRAM Channels will be tested:

   a. Linear Power Channel
   b. Percent Power Channel
   c. Fuel Temperature SCRAM.
   d. Water Level SCRAM.
   e. Manual SCRAM.
   f. Magnet Key SCRAM.
   g. Console Power Supply SCRAM.
   h. Startup Channel Interlock.
   i. Control Rod Withdrawal Interlocks.

2. Initiate a SCRAM condition for each Safety Channel by applying an artificial signal.
3. Note reaction on Indicator Panel.
4. Repeat process for all Safety Channels.
5. Complete the SCRAM Channel Verification portion of the Quality Assurance Checklist.

G. Control Rod Drop Time Evaluation. 7

1. Connect manual SCRAM buttons and rod down switches to the computer.
2. Initiate Drop Time Program on the computer.
3. Initiate a manual SCRAM.
4. Note Drop Time on the computer monitor.
5. Repeat procedure for all three rod drives.
6. Complete the Control Rod Drop Time Verification portion of the QA Checklist.

H. Reload fuel per NEL-014. 8

I. Calibration of the Power Channels. 8

1. The calibration of the Power Channels will be done in accordance with the Thermal Calibration procedure of Power Channels (NEL 012).
2. Calibration Verification will be preformed at 70 C for a period of three hours.

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	3/27/91 Dws [illegible] 3/27/91
	Vents reactor room ≈1800 cfm	Bldg. Design Spec. Dw
B. Recirculation System	Recirculates tank water	3/21/91 Dws [illegible] 3/21/91
C. Refrigeration System	Cools tank water	3/21/91 Dws [illegible] 3/21/91
D. pH Measurement	Tank water pH	3/27/91 Dws [illegible] 3/21/91
E. Conductivity Measurement	Tank water conductivity	3/27/91 Dws [illegible] 3/27/91
F. Area Radiation Monitors*	Exposure calibrated	3/27/91 Dws [illegible] 3/27/91
G. Continuous Air Monitor*	Particulate/Ar-41 calibrated	3/27/91 Dws [illegible] 3/27/91
H. Reactor Room Pressure	Negative pressure	3/27/91 Dws [illegible] 3/27/91

*- 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	Check	3/21/91 DWS BJH 3/21/91
B. Percent Power	Check (see note)	3/21/91 DWS
C. Log-n Power	Check	3/21/91 DWS BJH 3/21/91
D. Startup Channel	Test	3/21/91 DWS BJH 3/21/91
E. Fuel Temperature	Check	3/21/91 DWS BJH 3/21/91
F. Area Radiation Monitors*	Test	3/27/91 DWS BJH 3/27/91
G. Continuous Air Monitor*	Test	3/27/91 DWS BJH 3/27/91
H. Water Level Indicator	Check	3/27/91 DWS BJH 3/27/91

* - Expecting hardware upgrade to existing system

Note: % Power channel did not operate during initial checks. Operating staff located the problem and repaired it.

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%	3/21/91 Dws DJH 3/21/91
C. Fuel Temperature Scram	200 °C	3/21/9 Dws DJH 3/21/91
D. Water Level Scram	< 1 Foot	3/21/91 Dws 3/27/91 Dws DJH 3/21/91
E. Manual Scram	initiated	3/21/91 DJH 3/21/91
F. Magnet Key Scram	power off	3/21/91 Dws DJH 3/21/91
G. Ion Chamber Power Supply Scram (H.V. Scram Test)	power off	3/21/91 Dws DJH 3/21/91
H. Startup Count Rate Interlock	< 2 cps	3/21/91 Dws DJH 3/21/91
I. Control Rod Withdrawal Interlocks	one at a time	3/21/91 Dws DJH 3/21/91
J. Linear Switch Limit†	300Kw/1Mw	3/21/91 Dws DJH 3/21/91

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 M Byrne — 4/15/91
James Byrne — Date

Byron Hardy — 4/15/91
Byron Hardy — Date

D. M. Slaughter — 4/15/91
David Slaughter — Date

Modification Authorization

Identification: MA-?

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: 20 Mar 91

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: 7-26-91

3. Implementation Procedure Review

Member, RSC Subcommittee — Date: 7-26-91

4. Implementation Procedure Approval

Kevan Crawford
Reactor Supervisor, UNEL — Date: 7/2/91

Director, UNEL — Date: 26 Jul 91

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 provide 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. 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,

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

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.

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

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.

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.

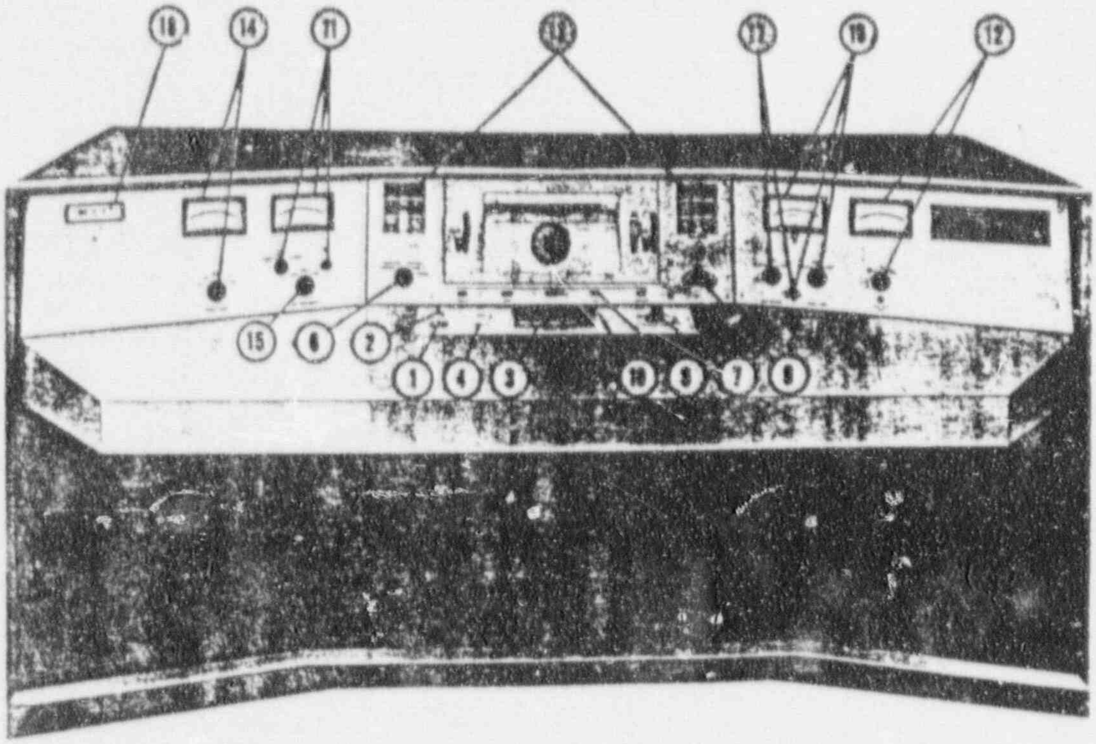


Figure 1. Console Front View.

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

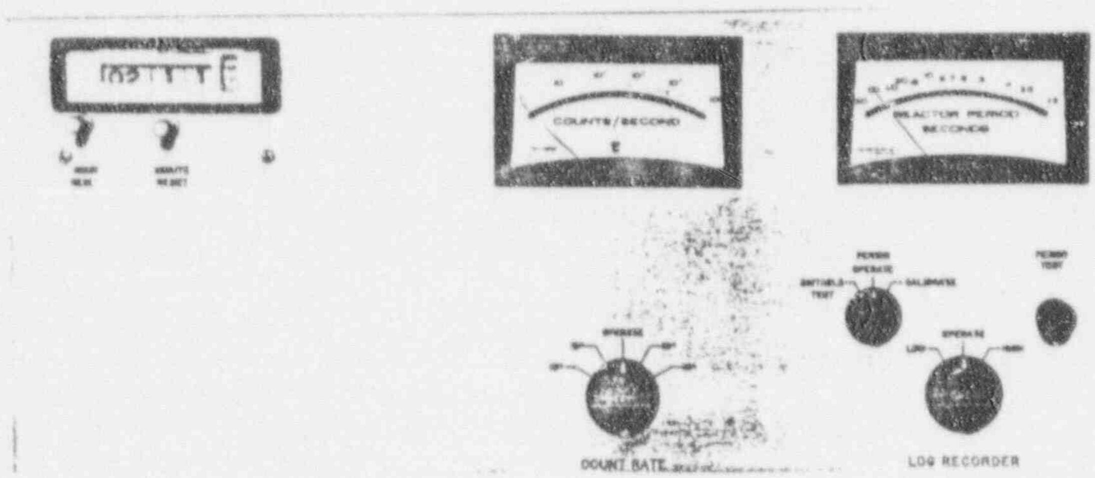


Figure 2. Console Left Panel.

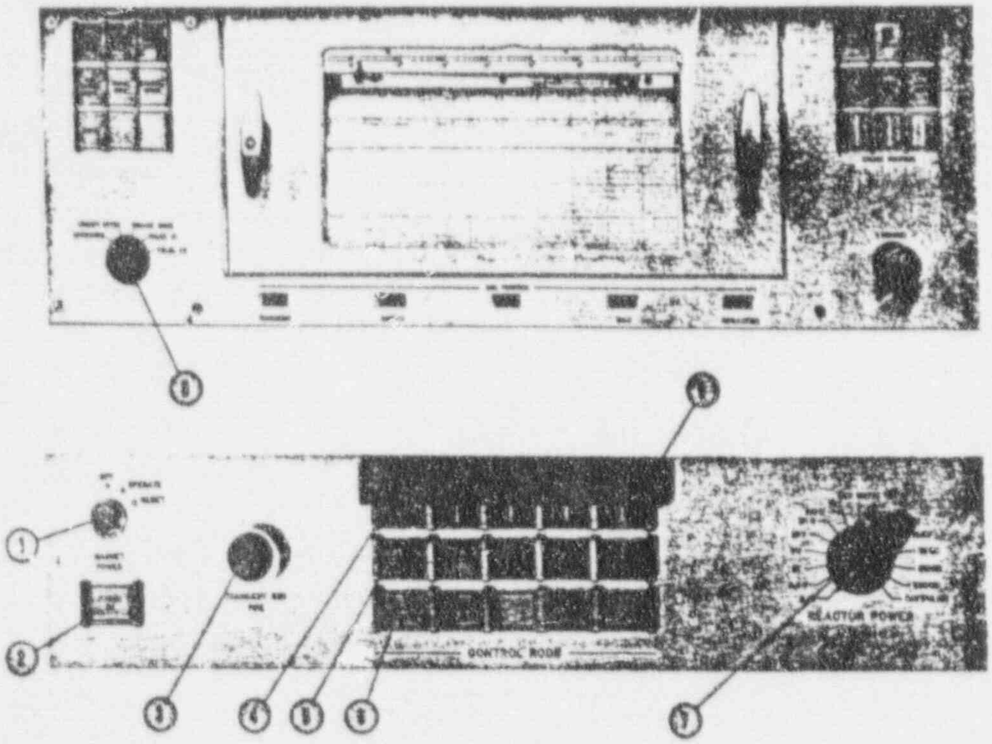


Figure 3. Console Center Panel.

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

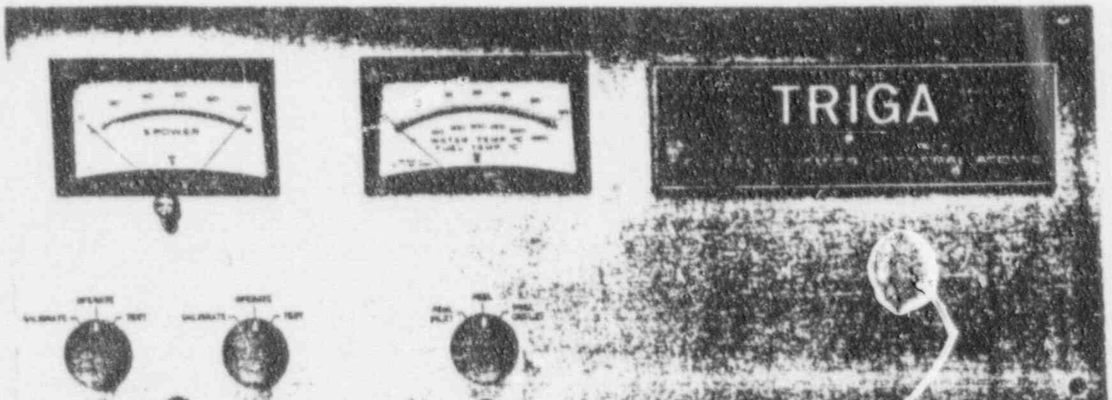


Figure 4. Console Right Panel.

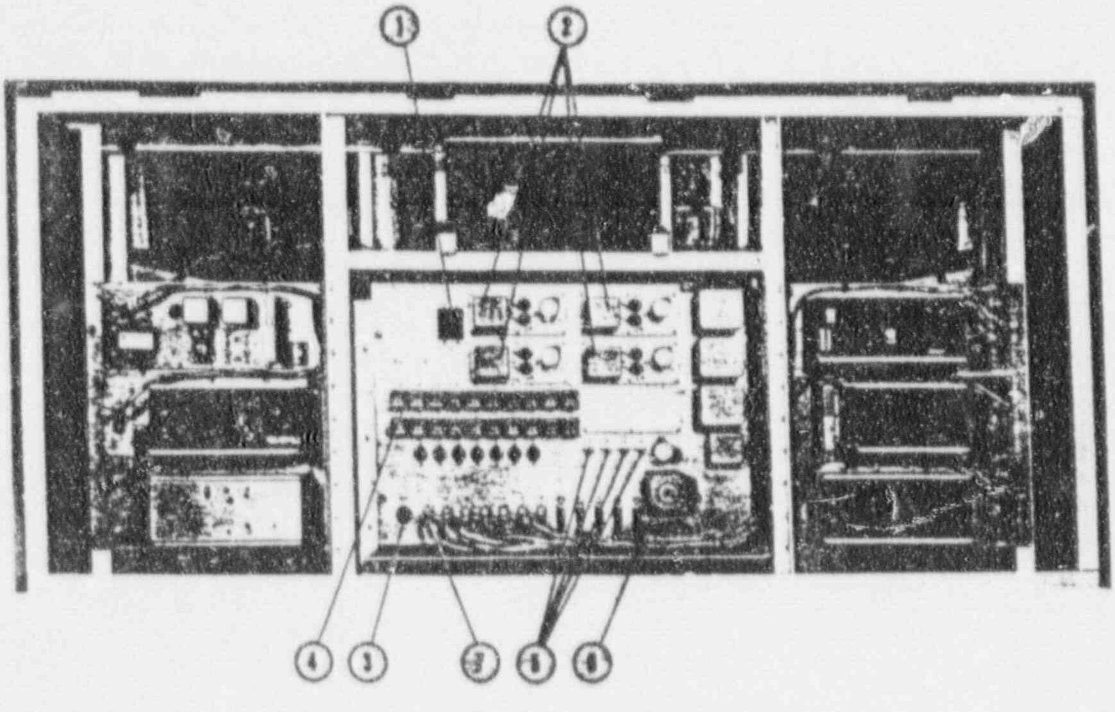


Figure 5. Console Back Panel.

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

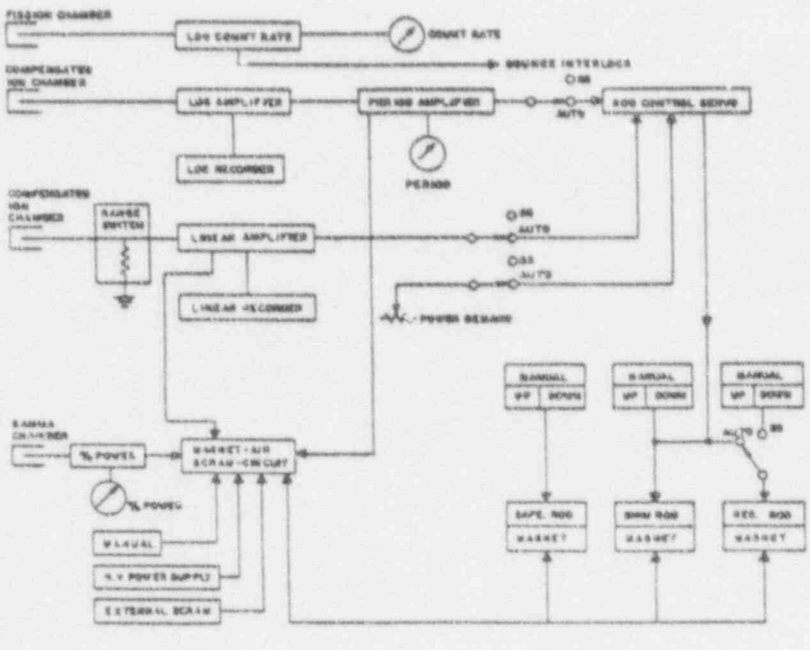


Figure 6. Functional Block Diagram.

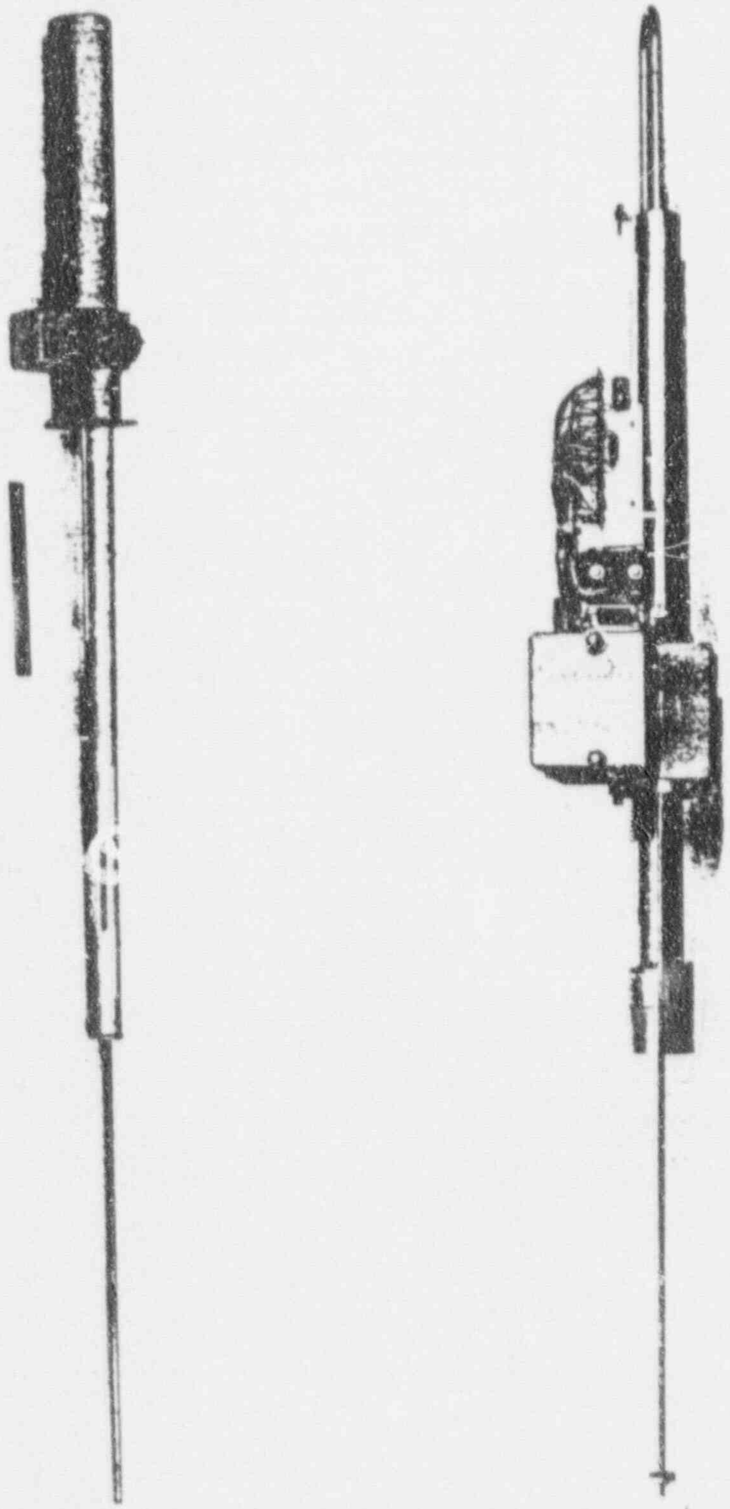


Figure 7. Rack and Pinion Drives.

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	0.68 seconds	Dws 6/10/91
B. Shim	< 2.0 seconds	0.79 seconds	Dws 6/10/91
C. Regulator	< 2.0 seconds	0.75 seconds	Dws 6/10/91

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	6/6/91 Dws
B. Percent Power Channel Scram	100 %	6/5/91 Dws
C. Fuel Temperature Scram	200 °C	6/5/91 Dws
D. Water Level Scram	< 1 Foot	6/6/91 Dws
E. Manual Scram	initiated	6/5/91 Dws
F. Magnet Key Scram	power off	6/5/91 Dws
G. Console Power Supply Scr.	power off	6/6/91 Dws
H. Startup Count Rate Interlock	< 2 cps	6/6/91 Dws
I. Control Rod Withdrawal Interlocks	one at a time	6/6/91 Dws
J. Linear Switch Limit	300Kw/1Mw	6/6/91 Dws

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	4/16/91 Dwo	4/16/91	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo.
B. Shim	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91	4/16/91 Dwo
C. Regulator	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo	4/16/91 Dwo

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	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo
B. Percent Power	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo
C. Log-n Power	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo	7/2/91 Dwo
D. Startup	6/4/91 Dwo	6/4/91/Dwo	6/4/91 Dwo	6/4/91 Dwo
E. Fuel Temperature	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo
F. Area Radiation	6/4/91 Dwo	6/4/91/Dwo	6/4/91 Dwo	6/4/91 Dwo
G. Continuous Air Monitor	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo
H. Water Level Indicator	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo	6/4/91 Dwo

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	DWS 5/22/91
	Vents reactor room >1800 cfm	5/22/91 DWS
B. Recirculation System	Recirculates tank water	5/22/91 DWS
C. Refrigeration System	Cools tank water	5/22/91 DWS
D. pH Measurement	Tank water pH	5/22/91 DWS
E. Conductivity Measurement	Tank water conductivity	5/22/91 DWS
F. Area Radiation Monitors	Exposure calibrated	5/22/91 DWS
	Dampers activate	5/22/91 DWS
G. Continuous Air Monitor	Particulate/Ar-41 calibrated	5/22/91 DWS
H. Reactor Room Negative Pressure	Measures pressure (inches water)	5/22/91 DWS

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.

[signature] 7/2/91

Examiner's Signature   Date

UPGRADE IMPLEMENTATION PROCEDURE
VERIFICATION CHECKLIST

TASK	COMPLETE	DATE	INITIAL
I. Remove fuel from the core.			
A. Complete NEL-014 to step 3.	[✓]	4/15/9	K.C.
II. Disconnect the Mark I Console.			
A. Disconnect Line Power.	[✓]	4/15/91	K.C.
B. Disconnect all Rod drive cables.	[✓]	4/15/91	K.C.
C. Disconnect all thermocouples.	[✓]	4/15/91	K.C.
D. Disconnect all Power Channels.	[✓]	4/15/91	K.C.
E. Disconnect all External SCRAM signals.	[✓]	4/15/91	K.C.
F. Disconnect CAM and ARM.	[✓]	4/15/91	K.C.
III. Remove the Mark I console.			
A. Disassemble the Mark I console.	[✓]	4/15/91	K.C.
B. Remove the Mark I console from the control room.	[✓]	4/15/91	K.C.
IV. Transfer the Mark III console to the control room.			
A. Short out the window tape sensor.	[✓]	4/16/91	K.C.
B. Remove glass from the window.	[✓]	4/16/91	K.C.
C. Move the Mark III console into the control room.	[✓]	4/16/91	K.C.
D. Replace the window glass.	[✓]	4/16/91	K.C.
E. Re-enable the window glass tape sensor.	[✓]	4/16/91	K.C.
V. Installation of the Mark III console.			
A. Connect console to Line power.	[✓]	4/16/91	K.C.
B. Disconnect REG rod drive.			
1. Disconnect computer control capability.	[✓]	4/16/91	K.C.
2. Replace rod drive with compatible drive.	[✓]	4/16/91	K.C.
C. Connect rod drives to the console.			
1. Connect rod drives to the console.	[✓]	4/16/91	K.C.
2. Remove control rods per NEL-014.	[✓]	4/16/91	K.C.
3. Connect absorbers.	[✓]	4/16/91	K.C.
4. Install new control assemblies per NEL-014 as applies.	[✓]	4/16/91	K.C.
5. Complete Rod Drive Verification of QA Checks.	[✓]	4/16/91	K.C.
D. Connect Auxiliary Systems to the console.			
1. Install Ventilation switch and indicators in the console.	[✓]	5/13/91	K.C.

2. Connect Area Radiation Monitor to damper solenoids.	[✓]	5/17/91	K.C.
3. Connect the Continuous Air Monitor to the computer.	[✓]	5/17/91	K.C.
4. Complete <u>Auxiliary System Verification</u> of QA Checks.	[✓]	5/22/91	K.C.

E. Connect and Test all Measuring Channels to the console.

1. Check and Test the following channels after connecting.

a. Linear Power Channel (Install recorder)	[✓]	5/23/91	K.C.
b. Linear channel switch limits (300 Kw and 1 Mw)	[✓]	5/24/91	K.C.
c. Percent Power Channel	[✓]	5/24/91	K.C.
d. Log-n Channel (Install recorder)	[✓]	5/24/91	K.C.
e. Startup Channel	[✓]	5/24/91	K.C.
f. Fuel Temperature	[✓]	6/3/91	K.C.
g. Area Radiation Monitor	[✓]	6/3/91	K.C.
h. Continuous Air Monitor	[✓]	6/3/91	K.C.
i. Water Level Indicator	[✓]	6/4/91	K.C.

2. Verify calibration on items e-h.	[✓]	6/5/91	K.C.
3. Complete <u>Measuring Channel Verification</u> of QA Checks. (Except calibration of Power Channels.)	[✓]	6/5/91	K.C.

F. Test all ~~SCRAM~~ SAFETY systems.

1. The following ~~SCRAM~~ SAFETY Channels will be tested:

a. Linear Power Channel	[✓]	6/6/91	K.C.
b. Percent Power Channel	[✓]	6/5/91	K.C.
c. Fuel Temperature SCRAM	[✓]	6/5/91	K.C.
d. Water Level SCRAM	[✓]	6/6/91	K.C.
e. Manual SCRAM	[✓]	6/5/91	K.C.
f. Magnet Key SCRAM	[✓]	6/5/91	K.C.
g. Console Power Supply SCRAM	[✓]	6/6/91	K.C.
h. Startup Channel Interlock	[✓]	6/6/91	K.C.
i. Control Rod Withdrawal Interlocks	[✓]	6/6/91	K.C.

2. Initiate a SCRAM condition for each Safety Channel.	[✓]	6/6/91	K.C.
3. Note reaction on Indicator Panel.	[✓]	6/6/91	K.C.
4. Repeat process for all Safety Channels.	[✓]	6/6/91	K.C.
5. Complete <u>SCRAM Channel Verification</u> of QA Checks.	[✓]	6/6/91	K.C.

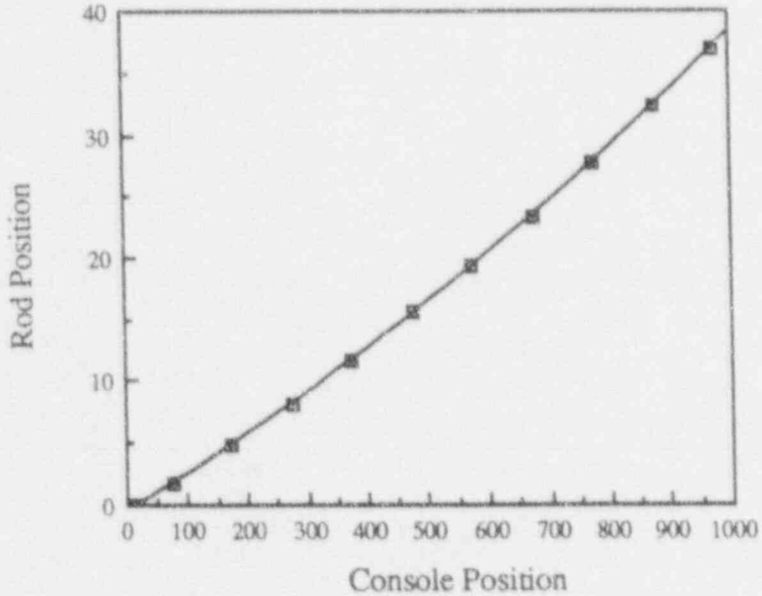
G. Control Rod Drop Time Evaluation.

1. Connect manual SCRAM buttons and rod down switches to computer.	[✓]	6/10/91	K.C.
2. Initiate Drop Time Program on the computer.	[✓]	6/10/91	K.C.
3. Initiate a manual SCRAM.	[✓]	6/10/91	K.C.
4. Note Drop Time on the computer monitor.	[✓]	6/10/91	K.C.
5. Repeat procedure for all three rod drives.	[✓]	6/10/91	K.C.
6. Complete <u>Control Rod Drop Time Verification</u> of QA Checks.	[✓]	6/10/91	K.C.

H. Reload fuel per NEL-014. 14 6/17/91 K.C.

I. Calibration of the Power Channels.

1. Calibrate Power Channels per NEL 012. 14 7/2/91 K.C.
(Calibration Verification will be preformed at 70 C for a period of three hours.)



y = - 0.49121 + 2.9377e-2x + 7.9871e-6x^2 + 1.3581e-9x^3   R^2 = 1.000

Shim Rod Plot