GENERAL ATOMICS

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Non-Power Reactors & Decommissioning
Projects Directorate
Division of Reactor Projects III/IV/V
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Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: **Facility License R-67; Docket 50-163**
Submittal of TRIGA Mark F 1993 Annual Report (3 Copies)

Dear Mr. Adams:

Enclosed is the annual report for General Atomics' (GA's) TRIGA Mark F reactor (License R-67) prepared in the same format as that required for GA's Mark I (R-38). While the Technical Specification for Mark F require no annual report, the sections of the report are numbered consistent with the items of information referred to in Section 9.6e of the Technical Specifications for GA's Mark I TRIGA reactor (License R-38, Docket 50-89). This report covers the operation of the Mark I reactor for the calendar year 1993.

Should you desire additional information concerning the above, please contact me at (619) 455-2823 or Dr. Junaid Razvi at (619) 455-2441.

Very truly yours,

Keith E. Asmussen

Keith E. Asmussen, Director
Licensing, Safety and Nuclear Compliance

KEA:rmk

Enclosure - as above

xc: Mr. John B. Martin, Regional Administrator, NRC Region V

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TRIGA REACTORS FACILITY

TRIGA Mark F Reactor

ANNUAL REPORT

for

CALENDAR YEAR 1993

prepared to satisfy the requirements of
U.S. Nuclear Regulatory Commission
Facility License R-67
Docket No. 50-163

February 1994

GENERAL ATOMICS

TRIGA REACTORS FACILITY
TRIGA Mark F Reactor
ANNUAL REPORT for 1993

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INTRODUCTION

This report documents operation of the General Atomics (GA) TRIGA Mark F non-power reactor for the period January 1 - December 31, 1993. The Mark F reactor - one of two reactors operated by GA at its San Diego, California facilities - is a pulsing type reactor with a licensed steady state operating power of 1500 kilowatts, and maximum reactivity insertions during transient operations of $5.50. It is operated by GA under License No. R-67 granted by the U. S. Nuclear Regulatory Commission (Docket No. 50-163). The second reactor is a 250 Kw(t) GA Mark I reactor operated under license No. R-38. Both reactors are housed in GA's reactor building with their own independent reactor rooms and control rooms.

This report is presented in eight parts, consistent with the information required by Section 9.6(e) of the R-38 (Mark I) Technical Specifications, as amended. The administrative requirements in the R-67 (Mark F) Technical Specifications, as amended, do not have annual reporting requirements.

1. SUMMARY OF OPERATIONS.

1.1 Operating Experience. The TRIGA Mark F reactor was operated during calendar year 1993 in the steady-state mode only, primarily for in-core irradiations of direct conversion (thermionic) devices. Other irradiations of samples were carried out as necessary. Operations for the year were continuous through October 22, 1993, except for shutdowns - typically one to two weeks - as required for annual reactor related inspection and maintenance activities, neutron radiography inspection of the thermionic experimental devices and extended holiday periods. From the period October 22 through November 16 operations were performed for neutron radiography of thermionics devices, which concluded the in-core testing program for the thermionics devices at the TRIGA Reactors Facility. The following represents a summary of reactor operations conducted during this period:

1.1.1 The reactor generated a total of 8,329 MWh of energy. Total operating time was 6,181 hours during calendar year 1993. A total of 12,053 cumulative test hours were logged on three irradiation capsules with direct conversion (thermionic) devices during this period.

1.1.2 The reactor was not pulsed. Pulsing capability was removed in 1985 for the performance of continuous, in-core irradiations of direct conversion devices.

1.1.3 The reactor consumed 468.73 grams of U-235.

1.1.4 A total of 11 irradiation requests were processed during the period.

1.1.5 One new applications for facility modification under 10CFR50.59 was approved during the reporting period.

1.1.6 No special experiments, as defined in the R-67 Technical Specifications, were conducted during this period.

1.1.7 No license amendments were submitted or granted during this period.

1.1.8 One new irradiation capsule (6H1) with thermionic devices was fabricated and installed in-core during 1993.

1.1.9 All remaining irradiation capsules were removed from their Mark F in-core irradiation positions during 1993, and were stored in the reactor pool for transfer to a DOE site for destructive, post-irradiation examination.

1.1.10 During the first two months of 1993, the facility noted a steady decrease in the concentration of "tramp uranium" fission products, reported in the 1992 TRIGA Mark F Annual report. The concentration of fission products in the reactor pool water and reactor room air continued to be monitored on an increased frequency. These activities had decreased markedly by the end of February 1993, and decreased further to near or below the level of detection by August 1993, at which time normal sampling frequencies were resumed.

Table I summarizes pertinent reactor operating parameters for 1993.

TABLE I

SUMMARY OF TRIGA MARK F OPERATING DATA

Operating Parameter	Annual Values January 1, 1993 through December 31, 1993
Mwh of energy produced	8,329
MWD of energy produced	347.0
Grams U-235 consumed	468.73
Number of fuel elements removed from core [1]	4
Number of fuel elements added to core [2]	4
Number of pulses	0
Hours reactor critical (steady state)	6,181
Number of start-up and shutdown checks	60
Number of irradiation requests processed	11
Number of facility modifications under 10CFR50.59	1
Number of direct conversion device capsules irradiated during calendar year[3]	3
Number of cumulative test hours on direct conversion device capsules	12,053

(1) The number of fuel elements (including FFCRs) removed from the core represents fuel removed as a result of bending or length changes, or otherwise determined to be damaged or otherwise deteriorated.

(2) The number of fuel elements (including FFCRs) added to the core represents fuel added to compensate for loss of reactivity, or to replace fuel removed from the core due to damage or deterioration.

(3) During the course of the year, one new capsule was installed in an in-core irradiation position, and one capsule was removed from it in-core position.

1.2 Facility Changes and Modifications. There were no major changes made in reactor performance characteristics or mechanical design during the reporting period. The facility continued to operate primarily as a thermionics test facility, an operating mode which has prevailed since early 1985. There was one change approved by the facility safety committee under the provisions of 10CFR50.59, described in section 5. Several changes to the reactor instrumentation and control system to upgrade and install state-of-the-art components and systems were made during the course of the year.

The modifications are described in Sections 4 and 5 of this report.

1.3 Surveillance Tests and Inspections. Surveillance tests and inspections were performed as required by Sections 4.0 (Reactor Pool), 5.0 (Reactor Core) and 6.0 (Control and Safety Systems) of the R-67 Technical Specifications. A summary of the results are presented below:

1.3.1 Pool Water. The pool water conductivity was measured continuously using a sensor installed in the input piping of the demineralizer system. Water conductivity was maintained well below the limit of 5 micro-mhos per centimeter averaged over one calendar month required by the Technical Specifications.

Water level sensors were used to ensure that the pool water level always was maintained at acceptable levels. In addition, a visual check of pool water level was made as part of the Daily Startup or Shift Change Checklists.

A water temperature monitor was used to ensure that bulk pool water temperature was maintained within acceptable limits. During continuous irradiations of thermionic fuel elements in-core, the bulk pool water temperature maintained at 36 ± 1°C.

1.3.2 Reactor Core. The reactor fuel was inspected for bending and length changes, as well as visually for deterioration and damage during March 1993. To perform these inspections each fuel element is removed from the core, inspected, and then replaced in the same location in the core from which it was removed. The inspection also included the use of a plate gage to check for swollen or deformed cladding, which helps to ensure that the elements can be removed and reinserted from the core grid plate without sticking. Additionally, all fuel elements were inspected for cladding deformities with an underwater color camera system, which was first used in 1991.

Four FLIP fuel elements were removed from service during 1993 as a result of these inspections. In addition, 25 elements failed the 1/32" bend test but passed the 1/16" test and were returned to service. The elements removed from service were:

Element No.	Core Location	Reason for Removal
6318	D3	Growth > 100 mils
5877	D12	Swollen clad - difficult to remove from grid plate
5870	E10	Swollen clad - difficult to remove from grid plate
6319	G4	Swollen clad - difficult to remove from grid plate

One element was replaced by a FLIP fuel element which was in storage; the remaining elements were replaced with LEU stainless steel clad high hydride fuel elements (SSHH). The fuel in the Mark F core at the end of 1993 consisted of 63 FLIP elements, 19 30-20 elements, 9 SSHH elements, and 5 FLIP fuel follower control rods (FFCR).

1.3.3 Control Rods. All five fuel follower control rods were removed from the core and visually inspected for deterioration in March 1993. All were found to be in satisfactory condition.

1.3.4 Reactor Safety Systems. Surveillance and calibration of reactor safety systems was carried out as specified in the R-67 Technical Specifications and reactor operating procedures. The calibrations and checks on the scram functions of the required safety system scrams were verified on a routine basis, with the surveillance of power level, fuel temperature measuring channels and manual scram capability performed daily (except during continuous operations) prior to reactor startup. Daily checks ensure that the channels are operating as intended, and that the set points for these channels are within the limits specified in the Technical Specifications.

A calorimetric determination of reactor power is required at least semiannually, and is performed more often if dictated by the needs of the experiments being carried out. This procedure involves increasing reactor power to an indicated value of 1000 kW, and holding this power level for approximately one hour while the rise in pool temperature is recorded as a function of time. The ratio of the pool heat up rate to the pool constant gives the reactor thermal power. During the reporting period, six power calibrations were performed, and the calibration constants for each channel (amps/watt) used to convert detector current output to reactor power were recalculated and posted on each of the three power indicating/safety channels.

1.3.5 Radiation Monitoring. The primary instruments utilized during the reporting period for facility radiation monitoring were a continuous beta-gamma air monitor, radiation area monitors, water and air filter monitors, a thermionic cell top monitor, a control room monitor, and a variety of portable survey meters. Their use and calibration is described below:

Continuous Air Monitor (CAM). During 1993, a continuous air monitoring system was in use for monitoring the air above the reactor pool except for short periods of time necessary for calibration or repair, during which times the CAM was temporarily replaced by a Ludlum Model 300 portable monitor. The CAM alert and alarm set points were checked on a weekly basis by activating them with a check source. Calibration of the system was performed annually using two Sr-90/Y-90 sources with a calibration traceable to the National Institute of Standards and Technology (NIST). Two sources were used to allow calibration at low and high count rates.

Radiation Area Monitors (RAM). Two area monitors (Eberline Instrument Corp.) were used for monitoring area radiation levels in the reactor room. The low level monitor was used to provide an alarm when the area radiation levels exceeded 20 mR/hr; the high level monitor alarmed at levels exceeding 5000 mR/hr. The alarm set points were checked daily, with alarm testing performed biweekly using a check source. Calibration was performed annually using a 4 mCi Cs-137 source on a calibration range. All calibrations were traceable to NIST.

Water and Air Radiation Monitors. Separate radiation monitors were used to monitor the radiation levels in the reactor pool water and the reactor room air ventilation system. Their operation and alarm set points (50 mR/hr and 5 mR/hr respectively) were checked weekly. The monitors were calibrated annually using the calibration range; all calibrations were traceable to NIST.

Thermionic Cell Top Monitor. A radiation monitor is present above the reactor pool water level to indicate a gross leakage of fission products into the purgeable secondary containment of thermionic devices. The alarm set point was checked weekly, with NIST traceable calibrations performed annually. The thermionic cell top monitor, which is only required when thermionics devices are in the core, was removed from service after all thermionic cells were removed from the core at the end of the thermionics test program.

Control Room Monitor. A radiation monitor is located in the reactor control room to monitor dose rates at the control console. The alarm set point (2.5 mR/hr) was checked weekly, with calibrations performed annually.

Portable Radiation Monitors. Several types of portable radiation monitors were in use at the facility. Examples are the Eberline RO2 and RO2-A beta-gamma survey meters, Ludlum pancake probes, Ludlum MicroR meter and LFE SNOOPY neutron survey meter. All portable radiation monitors were calibrated semiannually, with the exception of the SNOOPY neutron survey meter, which was calibrated annually.

2. ENERGY GENERATION

The total energy generated during calendar year 1993 as a result of Mark F operations was 8,329 megawatt-hours. Figure 1 is a bargraph showing the reactor operation on a monthly basis during the year. The relatively lower energy generation during the months of November and December reflects the termination of the thermionics irradiation program.

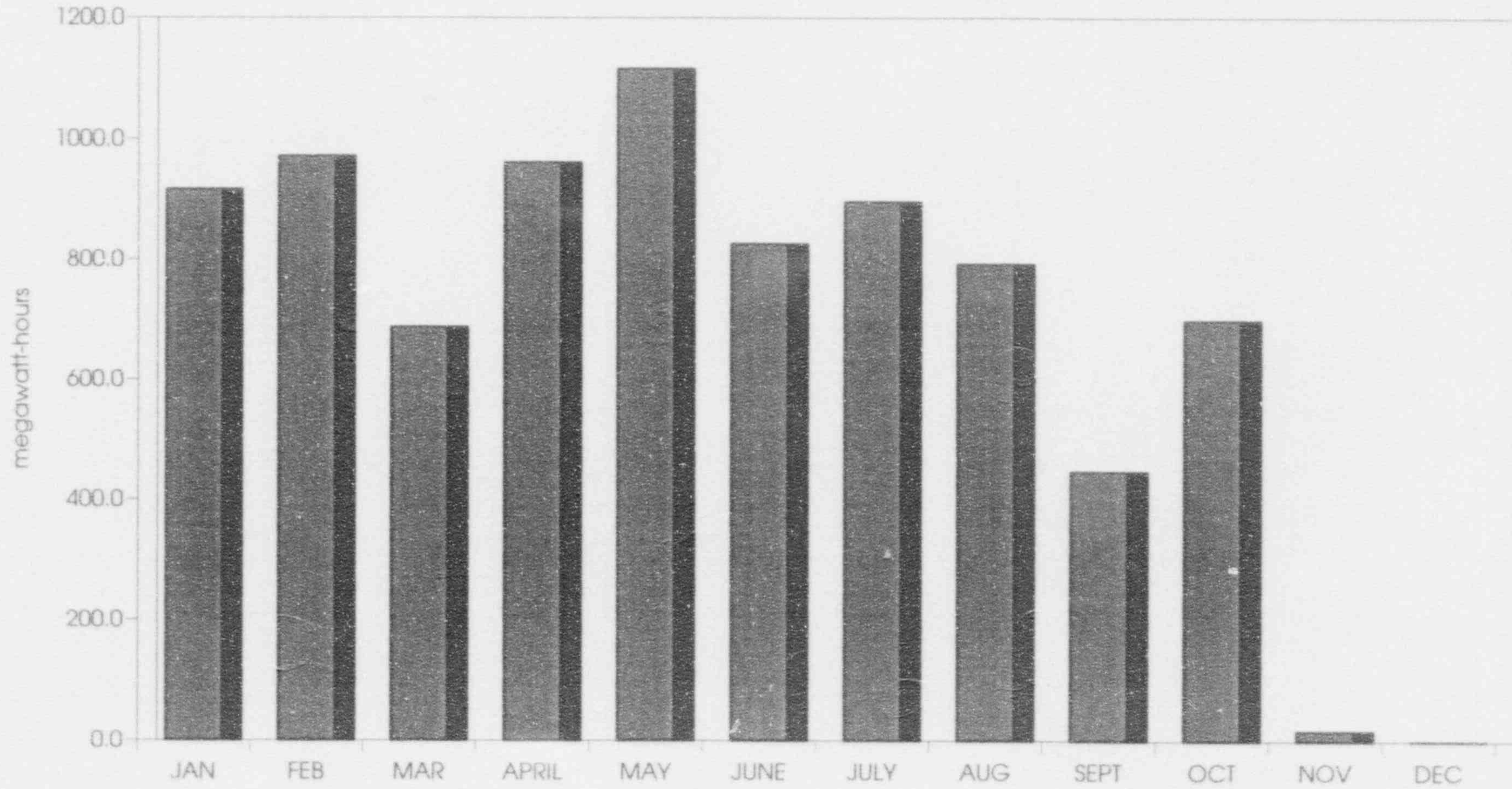

Figure 1. TRIGA Mark F Energy Production for 1993

3. EMERGENCY SHUTDOWNS AND INADVERTENT SCRAMS

The total number of unscheduled scrams during 1993 operations was 6. *None of the scrams experienced in 1993 had any effect on, or consequence for, the safe operation of the Mark F reactor.* In fact, all safety systems functioned as intended in shutting down the reactor when trip setpoints were reached, or an error condition was otherwise detected in the reactor operating or experimental systems. The causes of the scrams are summarized below:

Scram Channel	Cause	Number
External	Loss of site power	1
External	Thermionics Engineer error	1
Percent Power	Scram while up-ranging power channels	1
External	Thermionic device low voltage	2
External	Backup secondary containment temperature	1

4. MAINTENANCE ACTIVITIES

Maintenance activities performed during the year generally fall into three categories: (i) routine preventative maintenance, (ii) routine calibration activities and (iii) ongoing upgrade activities associated with replacement of older components and systems with state-of-the-art technology, or simply due to normal wear and tear from years of use. Significant activities in this area are described below:

4.1 Reactor, Mechanical and Auxiliary Systems.

March 1993	The continuous air monitor air pump was replaced due to noisy bearings.
	Three upper grid plate triad adapters (1.507 inch inside diameter) were replaced with 1.515 inch inside diameter triads to facilitate the insertion and removal of thermionics cells.
May 1993	In order to facilitate calibrations, the ventilation system magnehelic pressure monitoring gages were replaced with manometers.
June 1993	The ventilation system was re-sealed to minimize air leakage in the Mark F reactor room.
July 1993	The continuous air monitor air pump was found to be overheating and was replaced (the cooling fan had come free from the motor shaft). The air pump was repaired and returned to service.
September 1993	The water treatment system filter cartridge were replaced.
	A 1.5 inch hole was bored in the center of the B6, C10, C11 triad position of the lower grid plate to allow thermionic cells to be lowered through the lower grid plate. This change was made under the provisions of 10CFR50.59 and is described in section 5.

October 1993	The water treatment system demineralizer resin was changed.
	The cooling tower damper arm ball joint failed and was repaired.

4.2 Instrumentation and Control System.

February 1993	The BNC connector on self powered detector #2 was replaced due to an intermittent contact.
March 1993	Ion chambers for percent power channels K1 and K2 were relocated to allow a new fission chamber to be installed in the old K1 position.
	The radiation area monitors were upgraded to improve low level response. The replacement monitors utilize GM detectors (scale 0.1 to 10,000 mR/hr); the original monitors used ion chambers (scale 1 to 10,000 mR/hr).
April 1993	The safety channel optical relay lamps were replaced.
	A new pool temperature sensor was calibrated an placed in service.
	A new wide range log channel (General Atomics model NLW-1000) and a new fission chamber were installed and calibrated. The NLW-1000 replaces the existing NLW-2 wide range log channel, which was removed from service.
June 1993	The NLW-1000 fission chamber installed in April failed and was removed from service. The NLW-2 wide range log channel was reinstalled pending replacement of the fission chamber for the new channel.
	Fuel temperature channels were calibrated, and thermocouple wires were re-insulated with shrink tubing.

July 1993	A spare fission chamber from the Mark I reactor was installed for use with the NLW-1000 log channel. The NLW-1000 was recalibrated and returned to service. The NLW-2 log channel was removed from service.
	The picoammeter on percent power channel K2 was replaced with a spare unit due to a faulty range switch.
August 1993	The faulty range switch on the percent power channel picoammeter removed from service in July was repaired and returned to service.
September 1993	The NLW-1000 wide range log channel preamp was relocated to the reactor shroud to minimize noise pick up due to log cable runs.

5. 10CFR50.59 FACILITY MODIFICATIONS AND SPECIAL EXPERIMENTS

One application was submitted, approved and implemented for a facility modification under the provisions of 10CFR50.59 during the 1993 reporting period. In the implementation of facility modifications, the application for the proposed change to the R-67 facility is reviewed by the TRIGA Reactors Facility Safety Committee, among others. It can be approved only after the safety committee has determined that the proposed change (a) does not involve a change to the R-67 Technical Specifications, or (b) does not create any unreviewed safety questions as defined in 10CFR50.59.

5.1 Modification to Mark F Bottom Grid Plate to Allow Longer Thermionics Fuel Element (TFE) Devices

5.1.1 Description. During the in-core irradiation testing program for thermionics devices, several different TFE designs have been utilized. One TFE (6H1), installed in 1993, is configured with a longer active fuel length, which places the device fuel centerline above the core fuel centerline. As a result, the bottom of the TFE 6H1 runs hot and the top runs cold.

To minimize the temperature differential between the top and bottom of TFE 6H1, it was proposed to drill a 1.50" hole through the lower grid plate. This will allow the TFE to be lowered through the grid plate, aligning the TFE fuel centerline with the core fuel centerline.

This change was proposed to be made with the upper and lower gridplates in place, unloading fuel as required to meet shutdown requirements and to gain access to the area of interest.

The position selected for the new hole is located in the center of "triad" position A1, consisting of fuel element locations B6, C10 and C11 (a triad consists of a segment of the reactor core from which three fuel elements and an upper grid plate fuel/experiment centering device may be remove to gain access to a larger irradiation facility).

The lower gridplate is fabricated from 1.25" thick 6061-T6 aluminum, with 1.25" positioning holes below each fuel element position. These positioning holes support/locate the lower triflute of each fuel element, and allow coolant flow through the lower grid plate. The A1 triad position also includes a 0.28" hole located at the center of the A1 position, in addition to the three 1.25" fuel positioning holes. The upper grid plate A1 triad position consists of a three element cutout, with special adapters to locate fuel or experiments.

The procedure to drill the 1.50" hole in the lower grid plate utilized a drill motor positioned on the top of the reactor shroud; an A1 adaptor with a 2.00" central hole (for drill shaft bearing positioning); a 1.50" counter bore tool with a 0.25" pilot pin, and a long drill shaft with integral top grid plate support bearing to rest in the 2.00" A1 triad adaptor.

After approval of the 10CFR50.59, an out-of-core mock up of the lower grid plate was used to verify the integrity of the drilling procedure.

5.1.2 Safety Evaluation. The application for the modification was reviewed, and it was concluded that this modification **does not** involve either changes to the R-67 Technical Specifications, or any unreviewed safety questions.

The primary concern involved in the review of the 10CFR50.59 was: Will the enlarged hole weaken the bottom grid plate to the point that it will no longer support the weight of the fuel elements? Analysis showed that with the 1.50" hole the stress level in the bottom grid plate is 594 psi, which is well below the ASME code allowable stress of 9,500 psi for 6061-T6 aluminum. Thus, the larger hole will **not** affect the load carrying ability of the lower grid plate.

The second concern was: Will the larger hole affect the core cooling? Analysis shows that operation of the TFE in the A1 triad position, with the TFE plugged into the new 1.50" center hole, is no different than routine operation of the core with a flux trap around the TFE (R-67 Technical Specifications allow flux traps with adjacent fuel positions monitored with a thermocouple instrumented fuel element). Thus, the finding of the review committee was that the proposed modification **does not** involve an unreviewed safety question.

6. RADIOACTIVE EFFLUENTS DISCHARGED TO THE ENVIRONMENT

During the calendar year 1993, 3.42 curies of Argon-41 were discharged from the Mark F reactor facility to the atmosphere.

All low level radioactive wastes were transferred to GA's Nuclear Waste Processing Facility - which operates under NRC license SNM696 and GA's California Radioactive Materials License - for disposal. All waste was measured at the facility for specific radionuclide activity using high resolution gamma-ray spectroscopy prior to the transfer. Solid wastes were then repackaged as necessary and shipped to an authorized disposal facility by GA's waste processing facility. Liquid waste was first subjected to volume reduction by evaporation, and the residue waste was packaged for disposal as solid waste. Trace quantities of liquid low level waste may also be released into the municipal sewer system, if such waste is found to be within the limits and criteria specified by applicable local, state and NRC regulations.

During calendar year 1993, GA's TRIGA Reactors Facility (R-38 and R-67 licenses) shipped 150 cu. ft. of compacted as well as noncompactable low level radioactive waste to an authorized disposal facility.

7. ENVIRONMENTAL MONITORING

There were no significant changes in the GA Environmental Surveillance Program during 1993.

The environmental monitoring program for the TRIGA Reactors Facility included the following during 1993:

- Five emergency air samplers situated on the roof and around the reactor building.
- Fifteen environmental air samples adjacent to, and near the GA site in accordance with GA's SNM-696 license.
- Daily liquid effluent monitoring from GA's main pump house, for gross alpha and beta concentrations.
- Annual soil, vegetation, and water sampling at sixteen stations on the GA site, including stations around the GA reactor building.
- External radiation monitoring of the reactor facilities using four area dosimeters (26 locations around the entire GA site), as well as radiation meter surveys conducted periodically.
- Air samplers located in the reactor room to routinely sample room air for airborne radioactivity.
- Additional radiation monitors as described in Section 1.3.5 of this report.

8. SUMMARY OF RADIATION EXPOSURES AND RADIOLOGICAL SURVEYS

The following data summarizes personnel radiation exposures (rem) and radiological surveys of the facility during 1993.

8.1 TRIGA Reactors Facility Staff Whole Body Exposures[1]

Number of employees monitored:	20
High Exposure:	0.180
Low Exposure:	0.000
Average Exposure:	0.031

8.2 Nonfacility GA Staff Whole Body Exposures[2]

Number of employees monitored:	19
High Exposure:	0.325
Low Exposure:	0.000
Average Exposure:	0.034

8.3 Contractor and Reactor Users Whole Body Exposures[3]

Number of persons monitored:	61
High Exposure:	0.230
Low Exposure:	0.000
Average Exposure:	0.010

8.4 Visitor Whole Body Exposures[4]

Number of persons monitored:	124
High Exposure:	0.170
Low Exposure:	0.000
Average Exposure:	0.003

8.5 Routine Wipe Surveys of Mark I Reactor Facility

High Wipe:	86 Beta dpm/100 cm^2
Low Wipe:	<1 Beta dpm/100 cm^2
Average Wipe	2.2 Beta dpm/100 cm^2

8.6 Routine Radiation Measurements of Mark I Reactor Facility

High Measurement:	48 mRem/hr @ 1 foot
Low Measurement:	<0.1 mRem/hr @ 1 foot
Average Level:	2.8 mRem/hr @ 1 foot

(1) Includes reactor operations staff facility support staff and experimenters assigned to work full-time or near full-time at the reactor facility.

(2) Includes GA support staff and experimenters who were granted periodic access to the reactor facility for the performance of work.

(3) Includes non-GA personnel who were granted periodic access to the facility for the performance of work.

(4) Includes GA staff who routinely work in other GA radiation facilities, and who were granted visitor access to the reactor facility. Most if not all, of the radiation exposure received by the GA staff was from these other radiation facilities.

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