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In Reply
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Mr. Cecil O. Thomas, Chief
Standardization & Special Projects Branch
Division of Licensing
U.S. Nuclear Regulatory Com ssion
Washington, D.C. 20555

Subject: Facility License R-67; Docket 50-163
Submittal of Annual Report (3 copies)

Dear Mr. Thomas:

The following is an annual report for the TRIGA Mark F reactor prepared in the same format as that required for the Mark I (R-38). While the Technical Specifications for Mark F require no annual report, the numbered sections below are the sections referred to, for example, in Section 9.6e of the Technical Specifications of the R-38 (Docket 50-89) Mark I TRIGA reactor.

Part I

A brief narrative summary of (1) operating experience (including experiments performed), (2) changes in facility design, performance characteristics and operating procedures related to reactor safety occurring during the reporting period, and (3) results of surveillance tests and inspections.

1. Operating Experience

The Mark F reactor (R-67) was in operation during the year mainly to provide steady-state irradiation for experiments related to thermionic device tests. No pulses were performed. The steady-state operations included extended irradiations of thermionic devices, underwater neutron radiography of the thermionic devices and occasional out-of-core irradiation of samples.

During this year experience associated with the Mark F FLIP fuel tramp uranium reported first in 1978, then in successive years, is unchanged. This situation causes no problem but is, as before, under continuous scrutiny. Several indications of this effect were observed in 1985, but none were serious.

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After the reactor and facility modifications (described in detail in last year's Annual Report) were put into effect, the irradiation testing program for thermionic devices was initiated in mid January 1985 and continued throughout the year. Starting late in 1984 and continuing into January 1985, a thorough review was conducted by the TRIGA Safety Committee for the proposed thermionic testing program. After receiving satisfactory review and approval of the first three thermionic devices, the testing program started on a continuous basis (168 hours/wk). Late in the year, a fourth non-fueled device of a different type was installed, bringing to four (4) the number of devices tested simultaneously.

The operating schedule during essentially all of 1985 was the following. Typical irradiation runs lasted 1500 continuous hours, after which the reactor was shutdown and the several thermionic devices were removed from the core and inspected using the neutron radiography (NR) rig and the same Mark F reactor as neutron source. The NR inspection cycle took typically 5-7 days, after which the long term irradiation was continued. Typically, the reactor power for thermionic irradiation was selected in the range 1250 to 1500 KW.

In the course of the year, additional license amendments were sought to accommodate better the intent of the thermionic testing program:

a. One extended the period between reactor power calibrations to be consistent with other similar reactor facilities. The shorter time between power calibrations frequently required that the thermionic testing program be interrupted solely to perform a reactor power calibration. This amendment was granted.

b. One clarified the license intent that required, on the one hand, weekly checks of the continuous air monitor (CAM) and, on the other hand, continous scram capability from the same CAM. This amendment was also granted.

c. Late in the year we requested an amendment to extend the permissible tests from 10,000 hours to 20,000 hours duration. This amendment has not yet been granted but is pending.

Early in the year during the rainy season (1/20/85), a portion of the acoustic ceiling fell within the reactor room. The Safety Committee approved a carefully worked out cleanup operation by Plant Maintenance personnel while the thermionic test was running.

2. Changes in Facility Design, Performance Characteristics, and Operating Procedures

All of the essential facility design changes pursuant to the long term thermionic tests were incorporated in 1984 and discussed in that year's Annual Report. None of the operations during 1985 involved any changes in reactor performance characteristics. All of the operation was steady-state; no pulsing operations were involved.

The continuous operation (namely at 168 hours/wk) revealed several items that were best served by making changes in procedures. Certain of these procedure changes required license amendments; which were requested and granted. The procedural changes were the following:

a. At one point in the year, a rash of false alarms was generated by the monitoring thermionic computer because of electrical noise in the monitored units. A change was required in the reactor operator response to these alarms and such change was initiated. This change did not affect the safety of the thermionic components and resulted mostly in having the operator examine the purported cause of the alarm and take such action as directed by the thermionic engineer.

b. After receiving the appropriate license amendment, the Written Procedures were changed to permit semiannual (rather than monthly) reactor power calibrations. Each temperature cycle of the thermionic devices (inherently associated with shutting down the reactor to perform a calibration) puts the devices at risk; therefore, this reduced frequency requirement to perform power calibrations improves the quality of the thermionic test program.

c. A license amendment was issued to clarify the intent, on the one hand, of periodic (weekly) surveillance tests on the performance of the CAM and, on the other hand, the license requirement for continuous scram capability should 50,000 CPM be generated by the CAM response. The written procedure was changed to permit carefully controlled bypass of the CAM scram during periodic on-line checking of the CAM with a radiation source.

d. The written procedures were changed to permit use of a carefully controlled bypass panel to allow checking, surveillance, replacement, and repair of any one of the license required safety circuits. This bypass capability can be invoked only with the direct knowledge of the facility Physicist-in-Charge (PIC) or Associate PIC who have in their personal possession the only two control keys. This bypass system, when used as described, improved the system safety by permitting the controlled and safe repair and/or replacement of a faulty safety channel. Its use is permitted only for redundant safety circuits so that there will always be in use the minimum number of safety systems required by the license (except for the specifically exempted CAM scram; see #3 above).

e. The written procedures for the Testing Program for the Thermionics devices were approved (1/23/85).

f. The Safety Committee approved (2/1/85) a revised SHIFT CHANGE Stamp and logbook entry.

3. Surveillance tests and inspections were performed as required by Sections 4.0, 5.0, and 6.0 of the Mark F Technical Specifications. A summary of results is presented below.

Fuel Surveillance

The FLIP fuel was inspected visually for bending and length changes in the period 7/11/85 to 7/16/85. One element (6327 FLIP) was removed from service because its cladding had swelled enough to prevent removal of the fuel element through the top grid plate. Another element (6324 FLIP) had a partially swelled clad that made it difficult to remove or insert this element in certain grid plate positions. Both elements passed the 1/16 bend test and the elongation test. They were removed from further service because of slight clad swelling. All other fuel elements in the core satisfactorily passed the license required fuel inspection tests; namely, bend and elongation.

The small number of fuel elements that show small surface wrinkles on their clad have been inspected closely. A special set of oversize ring gauges was constructed to check the surface diameter. The bend jig (1/16-inch oversize gauge) is not a sufficient test to locate localized surface wrinkles. The hole diameters in the top grid plate are about 0.032-inch oversize; thus a wrinkle that prevents a fuel element from being withdrawn through the top grid plate will not necessarily be detected in the 1/16-inch bend jig (which is about 0.060-inch oversize). Use of the ring gauges allowed us to determine more clearly the state of the fuel element surfaces. Most of the elements with wrinkles equal to or greater than 0.032-inch oversize continued to pass the 1/16-inch bend jig.

It must be noted carefully that none of the elements that have surface wrinkles (including those discussed in last year's Annual Report and those reported this year) released any fission products nor did they indicate any such likelihood. While they have been removed from further use, their use never constituted any danger to the public.

Control Rod Surveillance

The fuel follower control rods were inspected on 7/13/85 and were found all to satisfactorily pass the surveillance tests. In fact, all passed the 1/32-inch bend test, although they are required only to pass the 1/16-inch bend test.

Pulsing System Surveillance

Since the startup of the Thermionic test program in January 1985, no pulse assembly (rod, rod drive, piston, etc.) has been in the core. Only five control rods with standard control rod drives have been in use in 1985.

Reactor Safety Surveillance

As specified in the Technical Specifications, Channel Tests of the reactor safety system channels, Channel Calibrations of the Power Level monitoring channels, Calibration of the Temperature and Channel Checks of the fuel-element temperature-measuring channels were performed. The tests were performed at least as often as required, and the results were satisfactory. During this year, 10 power calibrations were made. In the early part of the year the power calibration was conducted monthly as required. Early in the year a license amendment reduced the frequency for this calibration to semiannually. A power calibration is required for operational reasons during each startup after the shutdown for neutron radiography (of thermionic devices). This occurs about every 1500 hours, or every 10 weeks. Because of the incore changes of the thermionic devices, the power calibrations usually required a change greater than 5 percent in at least one of the four power channels. In one case, a problem arose. Although there was no problem with the power calibration in this case, the documentation of the calibration for one channel was listed in error and the resulting scram was set too high in error. This caused no problems while two additional, correct channels were in use. When one of these latter channels failed and reliance was placed on the incorrectly set scram (to provide the two scram circuits required by the license), an abnormal occurrence was generated. This was reported to the Commission.

The area monitor and survey system were under suveillance during this reporting period. The frequency of calibration was as indicated below.

Continuous Air Monitor

Alarm setpoints were checked daily when there was reactor operation. The system was calibrated semiannually with three U-235 sources in front of the detector (600 cts/min, 1500 cts/min, and 5000 ct/min).

Eberline Area Monitors

Operation was checked daily; alarms were activated in response to a source every two weeks; calibration was performed semiannually with a 4mCi Cs-137 source.

Portable Survey Monitors

The Eberline RO2 and RO2a meters, the Ludlum pancake GM meters (Model 3), and the LFE SNOOPY (neutron) meters were calibrated semiannually in the GA Technologies calibration facility.

Part II

A tabulation showing the energy generated by the reactor (in megawatt-hours).

The energy generated in 1985 by the Mark F was 10,325.961 megawatt-hours.

Part III

The number of emergency shutdowns and inadvertent scrams, including the effect, if any, on the safe operation of the reactor, and the reasons for any corrective maintenance required, if any.

1. 1/10/85. During a series of manipulations of the neutron radiographic facility for a survey of thermionic devices, three scrams were caused. The scrams caused no problems for the experiment and were part of the learning process of how to operate the reactor smoothly while performing neutron radiography.

2. 1/14/85. An inadvertent reactor scram was caused by accidentally shorting the thermocouple leads to the T2 temperature scram while calibrating the T2 channel (on-line) using a Digital Multi Meter on the wrong range. Subsequently a scram bypass panel has been installed to prevent this and similar unplanned, inadvertent scrams.

3. 2/17/85. A power channel (K1) scram caused by range shifting due to operator error while reducing reactor power on a programmed shutdown.

4. 2/21/85. The K1 power channel caused a scram when the operator operated the range switch in the wrong direction. Operator error.

5. 4/23/85. The reactor was scrammed due to an accidental CAM signal caused when the operator accidentally broke the detector window with the filter canister. The canister had come loose in its mounting and pierced the thin GM window when the shield plug was inserted. All operators were instructed on the proper technique to insert the plug properly.

6. 5/6/85. Loss of site power caused a scram. The power grid to the whole GA Technologies site was lost due to a short to ground.

7. 5/23/85. Two K1 power channel scrams during startup and range switching. Operator error.

8. 5/24/85. K2 power channel scram. Operator error.

9. 7/2/85. Scram due to partial failure of #5 control rod magnet which was overheated. Returned to power after an air conditioner was used to blow cold air onto all magnets of the 5 control rods. Maintaining the magnet assembly at the lowered temperature has controlled the problem.

10. 8/8/85. External scram from low cell current and voltage on thermionic cells simultaeously with a K3 power channel scram. Thermionics checked all their circuitry; the TRIGA group bench tested the K3 Keithley for stability for several days. Conclusion was that this was induced by the Thermionic experiment.

    The TRIGA facility has subsequently built and bench tested a <u>first</u> scram indicator but has not had an opportunity to install it on the Mark F console. When this device is installed, its rapid response (a few microseconds) will latch onto the first scram so that the operator will be able to state with certainty which of several scram indications occurred first.

11. 9/2/85. External scram from thermionics. The indication was a low coolant flow in the bus bar cooling but the scram was probably caused by entrained air bubbles in the coolant, the bubbles causing a scram in the optical viewing system. By venting the closed cooling system, the entrapped air was removed. Adequate cell cooling system was never in question.

12. 10/14/85. External scram by low coolant flow indication in bus bar cooling for thermionic cells. Caused by entrapped air bubbles; cooling system vented to remove entrapped air; cooling was never in question.

13. 10/15/85. External scram; same as above.

14. 10/16/85. External scram; same as above.

15. 10/24/85. External scram; same as above. To eliminate the unnecessary scram indication, a second optical system was installed in each line and a coincident no flow indication was required from each system. Since the air bubbles could not affect each optical system simultaneously, and there was never a lack of cooling due solely to air bubbles in the system, the coincidence requirement provided a method to eliminate the false scrams and provide a safe, reliable indication if the coolant flow really should be lowered or interrupted.

16. 11/14/85. A K1 power channel scram and an external scram occurred when a malfunctioning control UP switch failed. This caused the control rod to run to the full up position and caused a power level scram. On a random basis, the switch stuck in the closed UP position even though the operator had released the switch. Immediately after the scram, on 11/14/85, the Electronics Department personnel replaced the offending switch and the reactor was returned to service. Although destructive analysis of the switch revealed no evident source of problem, the fact is that the problem (which had been previously experienced by several operators) has not returned.

Part IV

Discussion of the major maintenance operations performed during the period, including the effect (if any) on the safe operation of the reactor, and the reasons for any corrective maintenance required.

1. 1/7/85. Replaced the pump shaft coupling for the water treatment pump. No safety consequence.

2. 1/8/85. Sent K1 power channel out for repairs because it was greater than 20% out of calibration. No reactor safety consequence because two other power channels were available.

3. 1/13/85. In a maintenance operation on 12/5/84, the control rod assembly dash pot was adjusted which had the effect of raising slightly the control rod and its fueled follower. In normal cases, when the rod and its fuel follower are properly mounted, the bottom of the fuel follower will extend through the bottom grid plate when the rod is full UP. Because of the 12/5/84 maintenance, the Facility management chose to lengthen the connecting rod for the control rod to assure that the lower end of the rod could never pull up above the bottom grid plate.

4. 1/13/85 & 1/14/85. The T2 temperature indication failed on TC6950 during thermionic startup. Adequate redundant TC readings were available to satisfy the license requirement. On second day, we found a problem in TC patch panel, so the problem was not with TC6950. Problem resolved and fuel temperature readings restored to normal.

5. 1/28/85. The water cooling system slowly became air bound during a 15 day period. The trouble was traced to the water treatment system which dumped its treated water into the INLET rather than into the OUTLET of the main cooling line. Although this was an original plumbing error, it had been this way since 1960 without incident. The plumbing was changed to the correct arrangement and the air binding problems vanished. Since TRIGA is convectively cooled, there was no safety problem related to reactor cooling.

6. 2/3/85. During long term full power operation, the K3 power channel failed up scale. The operator caught the problem and prevented a power scram. At the next shutdown, we found the compensated ion chamber (CIC) had failed. It was replaced and again the K3 channel worked normally.

7. 2/17/85. All the instrumentation for K1, K2, and K3 power channels was reworked to prevent accidental power outage from front panel AC switches. A coax signal connection was also added for easier test operation.

8. 2/18/85. Replaced all valves in the water treatment system with rebuilt ones.

9. 2/19/85. Replaced all 5 connecting rods for the 5 control rods with shafts that are smooth (without bolts and nuts) in the region where thermionic cell wiring and plumbing is located. This will allow eventual installation of 4 thermionic devices without interfering with the smooth travel of control rods.

10. 1/19/85 & 2/20/85. Replaced Rod Drive #2 and #4 with spare drives because of their tendency to drift down slowly. Added a blocking capacitor to other circuits to eliminate problem.

11. 2/21/85. K1 power channel gave a shutdown power reading that indicated trouble. This was traced to a bad BNC connector on the signal cable. The connector was replaced and the channel returned to satisfactory service.

12. 3/3/85. The water treatment system was overhauled with new filter cartridges, flow bypass valves, and remount of circulating pump to prevent water flooding in rainy weather.

13. 3/14/85. Installed an isolation filter and radio frequency filter in the input of the stack monitor instrumentation. This reduced transient AC line noise in stack monitor readings.

14. 4/23/85. The CAM air particulate filter holder became loose and fell apart causing the G-M thin window to break. The resulting scram shut down the reactor and thermionic test. The holder was refitted to reduce the likelihood of this recurrence.

15. 6/10/85. The top TC of TC 6950 fuel element failed. During the next reactor shutdown, another of the three TC 6950 thermocouples will be connected to the console T1 safety channel. The two remaining TC channels were sufficient to meet the license requirements.

16. 7/16/85. Installed the much needed SCRAM BYPASS panel. With the Safety Committee approval for PIC and associate PIC control of this panel, it now becomes possible to check or replace anyone of several safety channels while still at full power.

17. 8/8/85 & 8/9/85. Replaced the Keithley K3 channel with a spare Keithley and optical scram circuit. On second day, during reactor morning checkout, the scram time response was observed to be slower than desirable. Replaced the optical meter relay with a spare and obtained acceptably rapid scram response time.

18. 9/1/85 & 9/17/85. K1 Keithley became erratic in readout, fluctuating around the expected power reading. Its output was disabled. Prior to the shutdown on 9/17/85 it was again enabled and demonstrated smooth response without fluctuation. At the next shutdown all the cable connectors were cleaned.

19. 10/15/85 & 10/16/85. Installed an audible scram alarm on the control console.

20. 10/30/85. K2 power channel now shows some of the glitching exhibited earlier by K1 (see 9/1/85 above). It was bypassed. Subsequently, the erratic behavior ceased. The source of this problem was not clearly identified.

21. 11/14/85. Control Rod #1 UP switch was replaced since it intermittently was sticking in the on position. On this day, it stuck and caused a power scram (see 11/14/85 under Scrams above).

22. 12/22/85. Plant Maintenance disassembled the parallel plate heat exchanger to search for any avenue for unexplained water loss. None of the exposed piping or heat exchanger was the cause. The cause may lie in a leak in the buried sections of cooling pipes. The loss of cooling water is negligible except when the flow is throttled back to control cooling rates. Then the loss is significant being ~290 gal/day makeup water instead of the usual 50-100 gal/day.

23. 12/29/85. The cell top monitor unit failed in service. It was replaced within 10 minutes with a spare RM-14. The temprorary loss of the license-required cell top monitor was reported to the U.S. Nuclear Regulatory Commission as an unusual occurrence.

Part V

A summary of each change to the facility or procedures, tests, and experiments carried out under the conditions of 10 CFR 50.59 is presented below.

1. 1/31/85. A request to the Safety Committee to approve a redundant scram circuit for the 1000°C Prime Emitter Temperature. After approval, the second circuit for scram was activated.

2. 5/18/85. The Safety Committee reviewed the Thermionic Insulator Test Cell Experiment and approved it. Thus, the fourth test device, was constructed and installed toward the end of 1985.

3. 5/28/85. A 50.59 review was conducted for the Scram Bypass Panel for the Mark F console. It was approved and has been installed.

Part VI

A summary of the nature and amount of radioactive effluents released or discharged to the environs beyond the effective control of the licenses as measured at or prior to the point of such release or discharge.

During the calendar year 1985, 19.475 curies of Argon-41 were released from the facility to the atmosphere.

All liquid and solid wastes are transferred to GA's SNM-696 Licensed Waste Processing Facility for ultimate disposal by an authorized waste disposal vendor.

Part VII

A description of any environmental surveys performed outside the facility.

There have been no significant changes to the Environmental Surveillance Program during 1985.

Part VIII

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

Facility Personnel Whole Body Exposures for the Year 1985 (Rem):

Number of Employees Monitored	High	Low	Average
18	0.485	0.025	0.228

Nonfacility GA Personnel Whole Body Exposures for the Year 1985(Rem):

Number of Employees Monitored	High	Low	Average
81	0.700	0.000	0.019

The majority of these exposures were received at other facilities on the GA site.

Contractor/Customer Personnel Whole Body Exposures for the Year 1985 (Rem):

Number of Persons Monitored	High	Low	Average
96	0.760	0.000	0.053

Visitor Whole Body Exposures for the Year 1985 (Rem):

Number of Persons Monitored	High	Low	Average
7	0.000	0.000	0.000

Routine Wipe Surveys

High Wipe	4359	β dpm/100 cm^2
Average Wipe	34	β dpm/100 cm^2
Low Wipe	<25	β dpm/100 cm^2

Routine Radiation Measurements

High	1600 mR/hr @ 1 foot
Average	5 mR/hr @ 1 foot
Low	0 mR/hr @ 1 foot

Should you desire additional information concerning the above, please contact me at:

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Very truly yours,

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KEA:hc

cc: John B. Martin, U.S. NRC, Region V