THE UNIVERSITY OF ARIZONA
Nuclear Reactor Laboratory

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September 1, 2011

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

10 CFR 50.59

This is our Annual Report covering the period July 1, 2010, through August 31, 2011, for the activities of the TRIGA Mark I Reactor at the University of Arizona, Tucson, Arizona. This report is submitted in compliance with Section 6.7e of the Facility Technical Specifications and Section 50.59 of Title 10, Code of Federal Regulations, and will be the final report from this facility.

During the reporting period, we no longer operated our reactor. We defueled and decommissioned the facility. The attached historical chronology summarizes our activities.

We did not measure the Regulating, Shim, and Transient control rod worths, the control rod drop times, the reactor power during this reporting period because we no longer held an operating license.

We twice inspected the Transient control rod drive assembly during the reporting period. Both piston seals were found in satisfactory condition with no wear or rust present in the air cylinder. The biennial control rod inspection revealed no changes to the three control elements and fuel followers over the last two years.

Per existing procedures we calibrated the reactor console power channels, the area radiation monitors, the reactor pool activity monitor, and the pool conductivity meter during the reporting period.

The reactor was never critical during this reporting period. Our cumulative energy output since the facility was commissioned is 10.185 MW-days.

We performed no pulses or reactivity insertions during this reporting period. We have performed 2,567 pulses since 1958. We performed our five-year inspection and measurement of all fuel rods with the accompaniment of INEL on November 8-11, 2010.

The Reactor Committee met four times during this reporting period: July 28, November 4, and December 9 in 2010, and March 10 and May 5 in 2011.

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At its meetings and in individual reviews by members, the Committee reviewed operations and operational records of the facility as specified by the Committee charter. This included audits of preliminary check sheets, pulsing check sheets, approach to critical and termination check sheets, operations and maintenance log books, monthly and annual check sheets, irradiation records, and experiments performed with the reactor. The reactor committee approved five modified administrative and operational procedures, two new NRL plans and five new NRL procedures dealing with defueling and decommissioning, and conducted two 50.59 reviews involving these plans. The reactor committee also reviewed and adopted 16 plans submitted by defueling and decommissioning contractors and reviewed and commented upon ten contractor procedures. We had no changes to our facility that required 10 CFR 50.59 reviews.

We discharged no Argon-41 during the reporting period because we never operated the reactor.

During the reporting period and until we drained the reactor pool in June 2011 we replenished the reactor pool with 695 gallons of demineralized water from the campus micro-fabrication laboratory. The reactor pool water either: (a) evaporated directly from the pool, (b) was collected during maintenance and allowed to evaporate in Engineering Room 124A, or (c) declined as fuel and structures were removed and dried. The evaporated 695 gallons of tritiated pool water represents about 0.0074 milliCuries.

After analysis we discharged the entire 5,000 gallons of reactor pool water into the local sewer system during decommissioning. This entire amount corresponds to 0.053 milliCuries of tritium discharged.

Five (5) persons were issued film badges on a monthly basis for all or part of the reporting period in the Nuclear Reactor Laboratory. The persons receiving badges included all reactor operators and staff members and student employees using the reactor laboratory. The most any individual received was a 9 milliREM total effective dose equivalent (TEDE) exposure. The monitor badges distributed in NRL offices gave zero to 10 milliREM total effective dose equivalent (TEDE) for the year.

We admitted 318 non-badged persons to the Reactor Laboratory for inspections maintenance, defueling, decommissioning, or other official business during the twelve-month reporting period. The pocket dosimeters issued to all visitors indicated these persons received no exposure.

The University's Radiation Control Office conducted monthly direct measurement and wipe radiation surveys of the reactor room, control room, and experiment set-up room.

The results show little detectable activity except where expected (i.e., near radiological samples in storage areas and internal wall surfaces of the irradiation facilities).

Three environmental TLD monitors on the roof of the Engineering Building and environmental TLD monitor sites on the roofs of ten additional buildings provide a radio-dosimetry perimeter around the Engineering Building where the UARR is located. Two control TLD monitors are maintained in the Radiation Control Office to give a campus background. For calendar year 2010-the period for which RCO data exists-the dose rate, after subtraction of the average background reading for 10 of these 13 TLDs was zero milliREM/yr. The TLD atop the Art Building read 8.5 milliREM/yr, down from 10 milliREM/yr in 2009. The TLD atop the Computer Center showed 3.5 milliREM/yr, up from 2.0 milliREM/yr in 2009. The TLD atop the Arizona Health Science Center-Drachman Hall read 5.5 milliREM/yr in 2010, anomalous since this location has normally given a zero reading.

Radiation exposures in the vicinity of the reactor remain normal. Eight TLD monitors placed at the periphery of the restricted area provide the annual dose rate. Two TLDs in an office area far removed from the restricted area provide a baseline reference for the Engineering Building background. The background-subtracted exposures recorded by TLDs on the periphery of the NRL ranged from 6 to 95 milliREM/yr. The areas where the uncorrected monitors exceeded 100 milliREM/yr are surveyed using a calibrated ion chamber quarterly by the Radiation Control Office with the reactor operating at 100 kW. Our Radiation Control Office detected no radiation levels exceeding background level (<0.01 mR/hr).

Two background monitors are in Room 111 of the Engineering Building. The minimum detectable dose for these monitors is 1.0 milliREM/qtr for photon radiation. Area monitors are placed in and around the Reactor Room to monitor the beta dose.

Environmental TLD monitors at three locations on the roof of the Engineering Building showed no radiation level exceeding background (0.01 mR/hr.). Additionally these areas are not continuously occupied, and instrument dose rates demonstrate exposure rates to be <0.01 mR/hr.

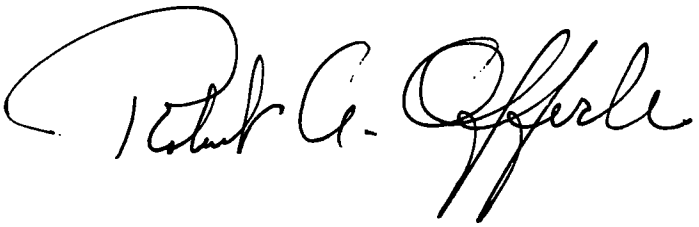
10CFR20.1301 mandates the total effective dose to the public must not exceed 100 milliREM/year or 2.0 milliREM/hr. With the reactor operating at maximum power (100kW), all survey instruments read under 0.01 milliREM/hr. To estimate the radiation dose from external and internal radiation sources, the highest environmental monitor reading is summed with the ^{41}Ar estimated dose and multiplied by an occupancy factor (0.25). The dose in Room 124A, the middle of the North wall, adjacent to the secured electrical transformer enclosure is 95 milliREM/year. Our COMPLY Code estimated the

dose of 0.055 milliREM/year. These are summed and multiplied by the occupancy factor (0.25) to yield an estimate dose to the public of 23.8 milliREM/year. This meets the requirements as stated above.

Furthermore, microStar® radiation badges affixed to perimeter chainlink fencing during defueling (December 2010) and decommissioning (May-August 2011) showed no exposure to the population from these evolutions.

In writing this report, I have tried to be both complete and as brief as is reasonable, and still satisfy the requirements of 10CFR50.59, our Technical Specifications, and the needs of the Commission. If other or more detailed information is needed, please contact me at your convenience.

Cordially,



Robert A. Offerle, Acting Director
Nuclear Reactor Laboratory

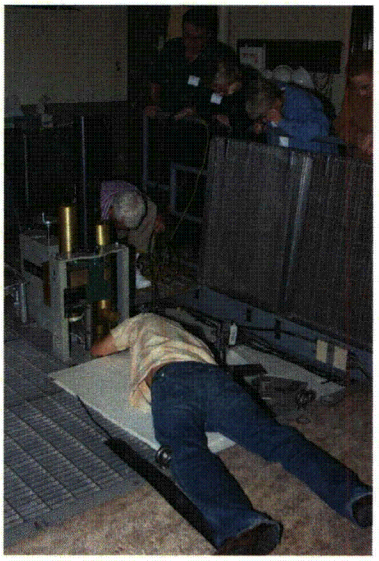
Enclosure
University of Arizona's Defueling & Decommissioning Chronology

cc:
Mr. John Hickman, U.S. Nuclear Regulatory Commission
Dr. Leslie Tolbert, Vice President for Research, University of Arizona

THE UNIVERSITY OF ARIZONA

Nuclear Reactor Laboratory

Defueling & Decommissioning Chronology

Date	Event(s)	Photograph
May 18, 2010	Our final criticality and shutdown. Aaron Farber, an Aerospace Engineering graduate student, is the reactor operator for the irradiation of LLNL[1] and LPL[2] samples in the 'Lazy Susan' rotary specimen rack.	
May 19	We removed all the fuel rods from the B- and C-rings and placed these fuel elements in the southwest storage holster. This ensured no possibility for an inadvertent criticality existed. We left the fuel-followed SHIM and REGULATING control rods in place.	
May 21	Our NRC operating license expired at midnight.	
May 24	We removed all irradiation samples from the rotary specimen rack and then verified all forty rotary specimen rack positions were empty.	
May 25 to June 1	We performed the: • Annual control console calibrations, • Biennial control rod inspections, • Semi-annual transient rod drive cylinder and air supply inspection, • Control rod drop time verification, and • Low water level detector test.	

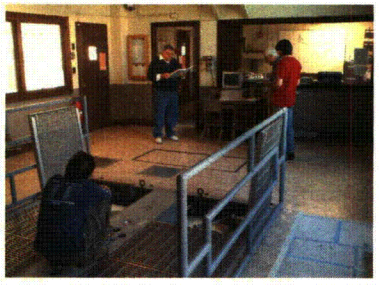
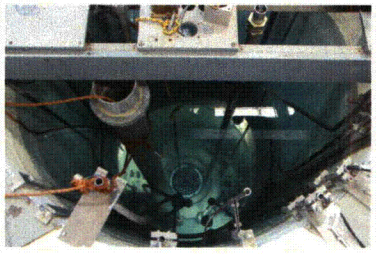
[1] Lawrence Livermore National Laboratory, Livermore, California 94550
[2] Lunar and Planetary Laboratory, Department of Planetary Sciences, University of Arizona, Tucson, Arizona 85721

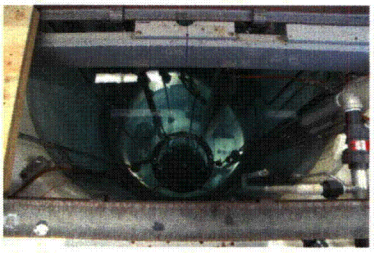
Defueling & Decommissioning Chronology

Date	Event(s)	Photograph
July 1	Removed three gallons of water from the Subcritical Assembly (SCA) tank for analysis by RCO[3]. The results would show the water activity well below limits.	
July 14	Removed 4 liters of reactor pool water for analysis by RCO. This routine quarterly analysis would show our reactor pool water activity about 1% of EPA limits.	
August 3	We cored into the soil surrounding the reactor tank to determine the level of soil activation, if any, and complete site characterization.	
August 4	Today's coring hit an unmarked, un-blueprinted, active sewer line running north-south and located 2 feet west of the outer reactor tank wall. Water shutoff throughout half the Engineering Building. All site characterization activities suspended. Drilling contractors depart the next day.	
August 11	The University completed re-lining the sewer pipe. Engineering Building returned to normal use. All sewer line samples (yuck!), fractured pieces of sewer pipe, equipment wipes, and corings show no elevated radioactivity.	
October 12	Characterized and measured the neutron radiography tube in preparation for disassembly and eventual removal from the reactor pool.	

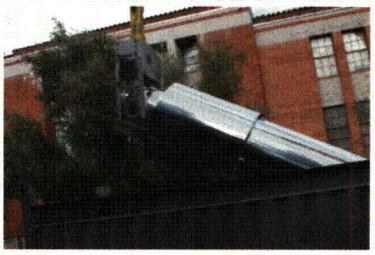
[3] Radiation Control Office, University of Arizona, P.O. Box 245101, Tucson, AZ 85724

Defueling & Decommissioning Chronology

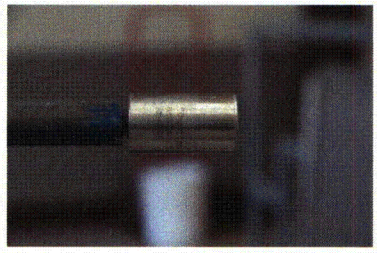
Date	Event(s)	Photograph
October 21	Removed just over a gallon of reactor pool water for analysis by RCO. This routine quarterly analysis continues to show our water activity remains well below EPA limits.	
November 8 to 11	INEL fuel inspection. We did see the pinhole puncture in fuel element #4058, a failed fuel element removed from service in 1976 and placed into inactive storage ever since.	
November 12 to 23	Nuclear Reactor Laboratory (NRL) staff remove from the bridge or from pool storage: • Three control rod drives. The control elements remained submerged in the pool on rope lanyards. • Pneumatic transfer system (the "rabbit"). • Fast irradiation facility (FIr). • Rotary specimen rack ("lazy Susan") drive. • Air accumulator. • Pneumatic tubing. • Reactivity adjustment system, rotary (RASR) experiment. We cut the upper 4 feet off the neutron radiography tube (NRT). The NRT now floats in the reactor pool. We pass it beneath the bridge and gently secure it to the northwest side of the pool. These activities made for more working space within the confines of reactor tank for the upcoming defueling.	 

Date	Event(s)	Photograph
December 12	We cut (cropped) the three instrumented fuel elements (IFEs) and the two fuel-followed control rods (FFCRs) installing bailing loops atop each of them. We packaged failed element #4058 in an INEL-provided vacuum storage canister and placed the package in storage pit #2.	
December 14	The University's Facilities Management Plumbing Shop repositions the pool water intake, exhaust, and skimmer pipes.	
December 15	We installed inner shield holder (ISH) in the reactor pool. The ISH is a specially constructed basket designed to suspend the two-ton NAC Inner Shield above the reactor structure. Our reactor pool had no extra space to place the NAC Inner Shield or an internal structure which could support the NAC Inner Shield. We suspended the ISH from 8-inch I-beams via four clamps, shackles, and turnbuckles. The apparatus worked perfectly. We had just enough clearance to get the NAC Inner Shield passed the north edge of the bridge and fit into the ISH without bumping the cooling coils.	

Date	Event(s)	Photograph
December 18	NRL staff practice moving the failed fuel element container from storage pit #2 back into the reactor pool. The University's Key Shop removes all but two locks to Engineering Building's outer doors. The Engineering Building's handicap entrance (the SE door) and northwest door on the first floor have new locks. Two keys are made. The UAPD dispatchers have one key and the second one resides with the on-site police supervisor. INEL purges the canister containing element #4058 with helium. We move the canister from storage pit #2 to the reactor pool. The University Police sweep the Engineering Building to ensure no one, except reactor-associated personnel, remain within the building.	
December 19	University Police conduct another sweep within the Engineering Building. University Facilities Management installs I-beam floor supports to build a trolley for rolling the NAC Inner Shield in and out of the Reactor Room. Amid overcast, but not rainy, wintry skies NAC equipment arrives and gets set up. Temporary chain-link perimeter fencing installed. James E. Rogers Way is closed to traffic. Installed a 3-ton gantry crane over the reactor pool. RCO badges all personnel.	

Date	Event(s)	Photograph
December 20	The weather remains overcast and cool. We move our reactor fuel into the NAC Inner Shield. The University of Arizona Police Department (UAPD) provides continuous guard of the Engineering Building and the surrounding north side.	
December 21	We placed the last of our reactor fuel into the NAC Inner Shield. This final basket holds our demountable fuel element (#2898), the canister containing failed element #4058, two thermocouple instrumented fuel elements (#10211 and #7879), and the fuel-follower portions of our SHIM and REGULATING control rods (#6606 and #6608).	
December 22	DOE along with STS and NAC contractors load the transport trailer and pack their equipment up. Tucson receives on and off drizzle.	
December 23	Brief drizzle. Arizona's nuclear fuel leaves Tucson for INEL then for further transfer to Reed College in Portland, Oregon. NRL staff goes home to celebrate Christmas and the University closes until after New Years.	

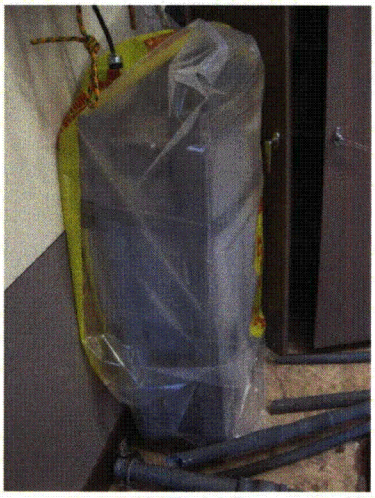
Defueling & Decommissioning Chronology

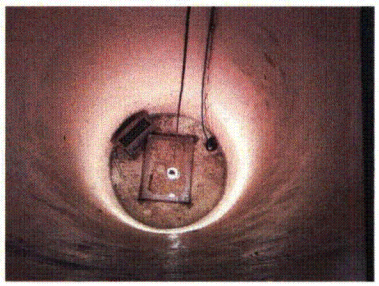
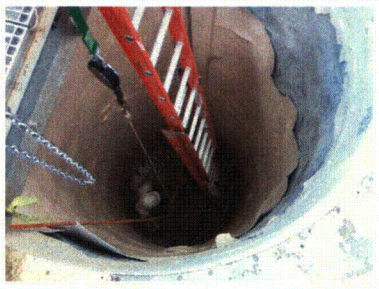
Date	Event(s)	Photograph
Early January 2011	The University of Arizona selects the LVI Services Inc. and ENERCON Services Inc. consortium to decommission our reactor.	
January 20, 2011	We removed the ISH from the reactor pool. This equipment remains available for other reactors where space constraints prohibit placing the NAC Inner Shield on the reactor tank structure directly.	
Early February	LVI and ENERCON sign the decommissioning contract.	
March 23	We removed the AmBe reactor startup neutron source from the reactor pool and transferred it to the University's Radioactive Waste Storage Facility.	
May 11 & 12	The Nuclear Reactor Laboratory (NRL), the University's Radiation Control Office (RCO), and the decommissioning contractors conduct RadHaz, worker safety, and program timetable training at the University's Radiation Control Office training facility.	

Defueling & Decommissioning Chronology

Date	Event(s)	Photograph
May 17	We conducted our reactor annual emergency drill with the ENERCON and LVI personnel. The drill examined decommissioning planning and exercised the emergency notification and emergency reporting portions of our Nuclear Reactor Laboratory's Emergency Plan. LVI commenced coring the reactor room (Engineering 124) floor for building support system footers.	
May 18 to 23	LVI removed reactor power instrumentation, conductivity sensors, water thermometers, experiment apparatus, and irradiation facilities. We find tubing three feet or more above the core is "free release." We cut tubing there releasing the non-activated portions as scrap. The lower activated portions go into radwaste containers.	
May 24	John Hickman and Bruce Watson from NRC Headquarters and Dr. Blair Spitzberg from the NRC Region IV Office visit our facility.	
May 25 to June 3	LVI dismantled the exterior water chiller unit and removed the cooling coils from the reactor pool. Neither the Freon compressor unit nor the expansion coils are activated or contaminated. Removed rabbit tubing and associated pneumatic equipment.	

Defueling & Decommissioning Chronology

Date	Event(s)	Photograph
June 7	LVI removes and cocoons the thermalizer.	
June 8	Four liters of reactor pool water given to RCO for analysis. LVI hoists the core from the pool	
June 9	After drying the reactor core overnight, we place the core into a blue, custom-made, steel container and move it to the University's Secured Radwaste Storage Facility with UAPD escort. We remove another four liters of reactor pool water for RCO to analyze. This way we have our routine quarterly pool water analyses, a sample taken just before we removed the core, and a sample just after the core removal.	

Date	Event(s)	Photograph
June 14	RCO gives us the 'okay' to pump out the reactor pool water. The water activity is down to ½% of the EPA maximums. We begin pumping the pool water through a submersible pump into the reactor water filtration system, though the filter and the demineralizer, and into the sink in Engineering Room 124A.	
June 15	The submersible pump can no longer adequately supply the pool filtration system. The reactor pool pump cavitates. We disconnect the submersible from the pool filtration system and pump the remaining water directly to the sink in Room 124A.	
June 16	The submersible pump cannot remove any more reactor pool water. ENERCON's Frank Brown descends into the empty tank and reports one inch of water remains, and the exposure rate is 300 $^{\mu REM}/_{hr}$. We mop-up and remove the remaining water and commenced coring the tank.	
June 20 to 24	We continued taking cores from the reactor tank walls and bottom for analysis. Annual U.S. NRC inspection by Region IV Office's Robert Evans.	

Defueling & Decommissioning Chronology

Date	Event(s)	Photograph
June 27 to 29	Build dust barrier above pool in preparation for gunite removal.	
June 30 to July 20	Chipped all gunite off the walls and floor of reactor pool. Contractors find the entire steel liner intact. No rust, no evidence of any leakage.	
July 21 to 25	Moved the uranium slugs from the subcritical assembly into surplus wooden ammunition boxes. The uranium within our subcritical assembly elevates the radiation background within Engineering Room 124A. The SCA must go before we can conduct the final status survey. We commence removing the lower six feet of the steel reactor liner. The contractor first uses a portable electric abrasive saw. This proves too slow due to the blade also sawing the concrete beneath the liner. The contractor switches to an oxy-acetylene cutting torch.	

Date	Event(s)	Photograph
July 26 and 27	Continue to cut and remove the lower six feet of the steel liner. We discover a compartment filled with bricks behind the steel liner on the west side behind the thermalizer location.	
July 28	Contractors commence removing the lower six feet of concrete to a depth of 4-inches from the tank wall and floor.	
July 29	RCO informs us the SCA tank water is "less than background."	
August 1 and 2	We pump the SCA tank water into the sink in Engineering Room 124A, and continue chipping away the activated concrete tank.	
August 3	Disassembled the dust containment structure over the reactor pool. Returned the removed soil to the floor excavations about storage pits #1, #5 and #6.	
August 4	We transported three flexbags of removed activated tank concrete and all remaining ammo boxes of subcritical assembly uranium slugs to RCO's Radwaste Storage Facility. Receive a "good to go" for pumping two 55-gallon drums of 'dust mitigation' spray water into the sink in Engineering Room 124A.	 

Date	Event(s)	Photograph
August 5 to 11	RCO surveyed all material, tools, and contractor equipment. Removed all equipment, material, and tools from reactor area. Remediated all rooms within the reactor area. Built fence around open reactor pool.	
August 23 to 25	ENERCON's Corey DeWitt and Dustin Miller and AECOM's Kevin Taylor conduct our Final Status Survey.	

What lies ahead for the remainder of 2011.

Date	Event(s)	Photograph
September 7 and 8, 2011	NRC/ORISE team performs the confirmatory survey.	
Late September	We receive permission from the NRC to backfill the reactor tank.	
September 23 to 26	Foss Therapy Services removes our two remaining cobalt-60 irradiation sources.	
After October 1	We ship the subcritical assembly uranium slugs from RCO's Radwaste Storage Facility to: • Savannah River Site, • Oak Ridge, or • NTS/NNSS.	
Early October	ENERCON Services drafts the Final Status Survey Report and submits the FSS to the University for approval. LVI backfills and caps the reactor tank and floor penetrations.	
Mid-October	We submit the Final Status Survey Report to the U.S. NRC.	

Date	Event(s)	Photograph
December	NRC terminates our facility license. All reactor laboratory related spaces reassigned to the College of Engineering, and all staff retired.	