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US Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Re: Docket 50-326; License R-116
Annual Report Submittal, Tech Spec 6.7f

Gentlemen:

Please find enclosed three (3) copies of the annual report for the UCI Nuclear Reactor Facility, covering the period July 1st 2013 through June 30th 2014.
Electronic copies are being provided as indicated below.

Thank you.

Sincerely,

G.E.Miller

George E. Miller
Reactor Supervisor

Cc.,w/enc (*electronic copies)

American Nuclear Insurance, 95 Glastonbury Blvd, Glastonbury CT 06033, Policy NF-176
Dean of Physical Sciences, Ken Janda
*Johnny Eads, US Nuclear Regulatory Commission
*Jason Lising, Project Manager, US Nuclear Regulatory Commission
*Reactor Operations Committee Members, UCI

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Nuclear Reactor Facility

Annual Report

for

July 1st, 2013 to June 30th, 2014

Facility License R-116

Docket 50-326

Prepared in Accordance with Part 6.7f

of the Facility Technical Specifications

July, 2014

by

Dr. George E. Miller, Reactor Supervisor
Jonathan Wallick, Associate Nuclear Engineer

Section 1. Operations Summary (additional details given below)

Operation of this facility supports UCI research and education programs in the Department of Chemistry (CHEM) and the Department of Chemical Engineering and Material Science (ChEMS). Research is being conducted in application of radioisotopes as tracers and radiochemical analytical and separation techniques including applications to nuclear waste separations (ChEMS).

Reactor utilization, apart from operator training and maintenance, is for analytical sample irradiation and production of isotopic tracers. Analysis samples come from diverse origins related to forensic science, fossil fuels, geochemistry, art, and archaeological studies, chemical separations in nuclear fuel cycle experiments, chemical synthesis, industrial quality control, enzyme studies, trace element pollution studies, etc. The reactor is also used in class work by undergraduates learning tracer and activation analysis techniques using small quantities of short-lived activated materials. Enrollment in the Fall Quarter 2013 laboratory course in Radioisotope Techniques using the facility was 34 students with 3 graduate teaching assistants, who also learned these techniques.

Support for UCI faculty and students includes grants from NRC and DOE (NEUP and NSSA), and partnerships with national laboratories (PNNL, LLNL, LANL, and INL. Security upgrades are in the process of being finalized, which have been funded by the DOE GTRI program.

Use is also made of the facility by other educational institutions, both for research and for visits/tours. A modest Nuclear Science Outreach program (NSOP) using UCI students to present talks and a laboratory to middle and high school classes has been continued. This program has also involved tours, class demonstrations, and analyses of samples submitted by faculty.

Operations have continued to increase as student use has increased. Criticality was achieved for 255.45 hours, and the total energy generated was equivalent to 180.66 hours at full steady state power. 191 separate experiments were performed, and over 3695 samples were irradiated (sometimes multiple samples are included in a single capsule and are not always separately logged). 6 moderate level mixed isotope shipments were made, all Yellow II category, totaling 22.17 GBq of activity. Four relatively low power pulses were performed this year, all without incident. Four 50.59 changes were approved this year: (i) a new fuel temperature meter, (ii) new area radiation monitors, (iii) adding a UPS to the Continuous Air Monitor power supply, (iv) modifications to the start up check list. No unusual surveillance results/activities were noted/conducted during this period. One new experiment has been approved (UCI) for use of the Flow Loop Terminus, installed last year, by a current researcher in the Nilsson lab, specifically for research using Szilard-Chalmers reactions that might be used for producing medical isotopes.

A routine NRC inspection June 9th to the 12th of 2014, resulted in no Notices of Violation or follow-up items. In 2013-2014, Reactor Operations Committee meetings were held on Sept 30th, 2013 and April 21st, 2014 in accordance with Technical Specification requirements.

No follow-ups or incidents have been forthcoming regarding security or emergency response. No exercise has been held this past year, but is planned shortly for the UCI EH&S radiological personnel, Orange County Fire Authority, UCI Police Department, Orange County Health Department, and reactor operators using lessons learned in GTRI training at the Y-12 site.

Inspections/audits continue to be conducted quarterly by the Radiation Protection staff of EH&S at UCI. These have identified that frequency schedules have been properly maintained, and results continue to show absence of significant levels of contamination or personnel exposure. A new Radiation Safety Officer has joined UCI's EH&S team upon the retirement of our previous RSO.

No NRC operator examinations have taken place this year, as no new trainees had been identified. As of June 30th 2014, 4 SRO's and 6 RO's were active. 1 SRO is dormant.

Section 2. Data Tabulations for the Period July 1st, 2013 to June 30th, 2014

TABLE I.

Experiment Approvals on file	5
Experiments performed (including repeats)	191
Samples irradiated	3695
Energy generated this period (Megawatt hours)	45.17
Total, 69 element core = 127.0	
>74 element core = 1470.67	
Total energy generated since initial criticality	1597.67 Mwh
Pulse operation this period	4
Total reactor pulses to 6/30/2014	985
Hours critical this period	255.45
Total hours critical to date	9348.55
Inadvertent scrams or unplanned shutdowns or events at power	3
Visitors to reactor - as individuals or in tour groups –	838
Maximum dosimeter recorded for visitors - all less than	0.2 mrem
Visiting researchers (Temporary Self Indicating Dosimeters)	32
Maximum exposure recorded at one visit	3.7 mrem
Visiting researchers (Thermoluminescent Dosimeters)	28
Students and teaching assistants in class, badged	37
Exposures reported for quarter (range: 0-22 mrem) average	14.7 mrem
Isotope Shipments this period (mixed act'n products = 0.59 Ci total)	5

TABLE II

Reactor Core Status 6/30/14 (core configuration changed as of 11/6/12)

Fuel elements in core (including 2 fuel followers)			84
Fuel elements in storage (reactor tank - used)			23
Fuel elements unused (4 instrumented elements + 1 element + 1 FFCR)			6
Graphite reflector elements in core			34
Graphite reflector elements in reactor tank storage			0
Water filled fuel element positions			2
Experimental facilities in core positions			5
Non-fuel control rods			2
Total core positions accounted for			127
Core excess, cold, no xenon (as of 6/28/2014)			$2.88
Control rod worths (calibrated 12/4/2013)	REG	$2.99	
	SHIM	$3.52	
	ATR	$1.75	
	FTR	$0.68	
	Total:	$8.64	
Maximum possible pulse insertion (calculated)			$2.43
Maximum peak power recorded ($1.75 insertion)			218 Mw
Maximum peak temperature recorded in pulse (B-ring)			212.9^{o}C

Section 3.

Inadvertent Scrams, Unplanned Shutdowns, Events at Power

TABLE III.

Date	Time	Power	Type and Cause
2013			
07/12	09:45	25 mw	Linear scram. The Linear power monitor was left in the manual mode of range changing operation due to operator error during the start up. The operator was counseled on proper start up procedures. Restart authorized by SRO.
08/21	10:00	75 mw	Period scram. Mounting screws on amphenol connector on back of instrument had loosened, disrupting ground / common contact of scram connections. Amphenol screws tightened and condition cleared and was no longer reproducible. Restart authorized by SRO after verification.
2014			
01/14	09:42	250 kw	Linear scram. The UP button for the Regulating control rod became stuck in the depressed position. Operator did not respond quickly enough to prevent high power condition. Button was removed and cleaned and verified to operate correctly. Restart authorized by SRO.

Section 4
Maintenance and Surveillance and Other Incidents

The following non-routine maintenance/surveillance activities were carried out during this period. Any reactor operation related items have been included above and are not repeated here.

2013

July 29th	On July 29th, 2013, a failure of the radiation monitoring system had occurred and been consequently repaired. The failure was traced to a faulty voltage regulator internal to the high voltage power supply in the unit. The system is in process of being replaced with the GTRI security upgrades and should be a less problematic and reliable system.
Aug 21st	On August 21st, 2013, spurious reactor period scrams from the Wide Range Logarithmic Monitor prevented reactor startup. It was quickly discovered that the Amphenol plug on the back of the monitor which transmits the scram signals was slightly loose in mounting. After tightening the mounting screws, the condition cleared and reactor operation was restored to normal function.
Oct 7th	On October 7th, 2013, the NFT-1000 fuel temperature meter was replaced by three independent thermocouple reading meters manufactured by Laurel Electronics. The units had been connected in parallel with the NFT-1000 for two months prior to the replacement to verify reliability of the new units. The unit has been operating without incident since the replacement and functions far more reliably than the previous NFT-1000. A 50.59 review is on file for this replacement. No safety issues are involved at this time. The Technical Specifications are satisfied by this new unit.
Dec 16th	On December 16th, 2013, the water purification filters were rotated to correct an excessive differential pressure across the component due to particulate accumulation. Initial differential pressure was 14 psid, and after rotating it was observed to be 9 psid. The radiation level of the used filters was measured to be less than 0.01 mr/hr on contact. The filters were scheduled to be replaced when additional filters were acquired.
Dec 4th	On December 4th, 2013, the SHIM, REG, ATR, and FTR rod calibrations were performed. A new preliminary core excess of $2.94 was found. Final results for rod worths were: SHIM $3.52 REG $2.99, ATR $1.75, FTR $0.68 for a total of $8.94. On December 4th, power calibrations were also performed. 80.67% actual power was found for the previous setting of 80.0%, requiring slight adjustment of balance potentiometers on the channels. All instrumentation is now in correct alignment for calculated power level values.

2014

Jan 8th	On January 8th, 2014, the water purification filters were replaced to correct an excessive differential pressure across the component due to particulate accumulation. Initial differential pressure was 11 psid, and after replacement it was observed to be <1 psid. The radiation level of the used filters was measured to be less than 0.01 mr/hr on contact. The filters were stored for drying and later gamma spectrometry assessment. No unexpected radioisotopes (e.g., fission products) were found upon gamma spectrometry of the filters.
Jan 14th	On January 14th, 2014, the wide range linear monitor output a linear power scram during a routine startup. This was due to the SHIM rod control up button sticking in the actuated position. The reactor operator did not respond quickly enough to this condition and reactor power was allowed to rise to the Linear Power Scram set point. The instrument promptly scrammed the reactor. The cause was determined immediately and the SRO authorized restart of the reactor following cleaning of the button's immediately accessible internals. Operations returned to normal.
Feb 12th	On February 12th, 2014, the Continuous Air Monitoring (CAM) system was switched to be on the emergency power supply to the reactor room. During emergency generator testing performed the weekend prior to the change, a false High Airborne Contamination alarm and Air Monitor Failure alarm were sent in to the police department automatically. It was surmised that the root cause was a loss in power to the CAM, and therefore would be powered from an uninterruptable power supply connected to emergency power circuits provided to the reactor. A 50.59 review is on file for this change. No safety issues are involved at this time.
Mar 3rd	On March 3rd, 2014, the radiation monitoring system was completely replaced with the new Horizon system provided by Canberra through the Global Threat Reduction Initiative program. Canberra provided a physical output from the system via 3rd party electronics consisting of USB communication and relays. System has been completely functional and without incident since installation. A 50.59 review is on file for this replacement. No safety issues are involved at this time. The technical specifications are satisfied by these new units.
Apr 22nd	On Apr 22nd, 2014, the water purification filters were changed due to low flow rates in the purification system. All radiological controls were in place and no contamination of personnel or equipment occurred.
May 29th	On May 29th, 2014, the differential pressure between the reactor room and outside atmosphere was noted to be low and out of spec at -0.08" WC, failing to meet the minimum requirement of -0.10" WC. This was observed as an intermittent issue and only occurred later in the afternoon, possibly due to outside temperature changing or building ventilation changes. A trouble call to facilities was placed and the condition was corrected on June 12th, 2014.

Section 5
Facility Changes and Special Experiments Approved

Four 10 CFR 50.59 changes have been implemented during the course of the last year.

(1) Replacement of the trouble-prone (during start-up testing) fuel temperature meter by multiple small modules. Each of the modules performs the functions of the previous module and can be switched to at any time. Redundancy of the system has been improved immeasurably with this change and each module is technically identical to the NFT-1000 that was replaced.

(2) Replacement of the Eberline area radiation monitoring system (RMSII) with Canberra's Horizon system with EcoGamma and iR7040/GP100 units. The new system has 8 units, two more than the previous and function has been without problem. System is functionally similar, however it is now computer based as opposed to completely analog, but alarm contacts and relays are maintained functional.

(3) Inclusion of an uninterruptable power supply for the Continuous Air Monitors. This was determined to be necessary to prevent false alarms due to momentary drop outs of power during emergency diesel generator testing. Reliability of the system has been vastly improved.

(4) Documentation of the changes made to the start up check list. These changes were made to accommodate the new area radiation monitoring system and make minor changes to the layout of the list.

One new experiment was approved this year. A researcher from the UCI chemical engineering department under Dr. Mikael Nilsson has begun an experiment involving the modified cryogenic irradiation facility, now termed the flow loop terminus. The purpose of this experiment is to irradiate samples in the reactor utilizing a Szilard-Chalmers reaction, collecting recoiling nuclei from a target by passing a collecting fluid by the target sample. Irradiations using this system began in August. A 50.59 document for installation of this loop was filed in a prior year.

Section 6. Radioactive Effluent Release.

(a) Gases.

The major direct release to the environs is Argon-41 produced during normal operations. Very small amounts of other gases may be released from irradiated materials in experiments.

Releases are computed based on original measurements at point of origin within the facility and taking only dilution into account. Since much of the release is from operation of the pneumatic transfer system for samples, this is a conservative estimate in that assumption is made that all use of the PT is at full steady state power level (250 kW) when, in fact, considerable use is with the reactor at a lower power level. In view of the small numbers involved, and the fact that an integrated dose check is provided by an environmental dosimeter ($CaSO_4$-Dy) hanging directly against the three exhausts as they enter final dilution and discharge, it is considered unnecessary to provide further checks of these estimates. The dosimeter data confirm that an individual standing directly against the exhaust flow for one year would receive an additional submersion dose from the exhaust less than the reliability limit of the dosimeters, or less than 20 mrem per year. The dosimeter data are presented separately in Section 7, Table IV. Over the years that data have been collected, the accumulated exposure at the exhaust locations have been lower than for "control" points because of lower masses of concrete structures in the vicinity. In fact the data have been consistently at 20-25 mrem per year below background level, so confidence of exposure less than 5 mrem over background seems possible.

Release estimates based on operational parameters are as follows:

(1) Operation of pneumatic transfer system (7/1/13-6/30/14):

a. Minutes of operation:	317.3 minutes
b. Release rate assumed:	6.0×10^{-8} microcuries/mL
c. Flow rate of exhaust air:	1.2×10^{8} mL/min
d. Dilution factor:	0.01
Total release computed: (a x b x c x d) =	2.28×10^{1} microcuries

(2) Release from pool surface (7/1/13-6/30/14):

a. Total hours of operation at full power (Effective Full Power Hours) = 180.66 hours

b. Release rate assumed:	1.0×10^{-8} microcuries/mL
c. Flow rate of exhaust air:	1.2×10^{8} mL/min
d. Dilution factor:	0.01
Total release computed: (a x 60 x b x c x d)	= 1.30×10^{2} microcuries
e. Total of (1) and (2) emission in 1 year	**= 1.52×10^{2} microcuries**

f. Total effluent released in 1 year (525960 minutes/yr. x c x d) = 6.3×10^{11} mL

Concentration averaged over 12 months (e/f) = ~< 2.42×10^{-10} microcuries/mL
Since 2×10^{-9} microcuries/mL provides an annual exposure for constant immersion of 10 mrem, this corresponds to < 1.0 mrem potential additional radiation exposure to an individual standing breathing in the effluent stack for the entire year.

Exhaust is diluted by a factor of 100 before release and the mixed plume is released at ~100 feet above the roof level (200 feet above surrounding ground).

(b) Liquids and Solids.

Liquid and solid wastes from utilization of by-product materials are disposed through a university contract. Waste is transferred to the custody of UCI Environmental Health and Safety (EH&S). Disposals to this custody are given below. It is important to note that activity values are estimated at the time of transfer to EH&S control. Since few shipments are being made from campus, decay to negligible levels occurs for all medium-lived radionuclides. Teaching course items (used for training in liquid scintillation counting and isotope dilution analysis techniques) may be a mixture of reactor generated byproducts and purchased materials (exclusively ^{14}C and ^{3}H).

DRY WASTES:

Four transfers of 2 cubic foot containers of dry waste were disposed during this period (7/1/13 through 6/30/14), estimated at a total quantity in 8 cu ft of 35.1 microcuries of mixed activation products (measured as ^{60}Co equivalent at time of transfer).

LIQUIDS:

One transfer of a 2.5 gallon liquid constituent was made this year. The contents of the container included 8.253 microcuries of ^{3}H along with 0.05% traces of (non-radioactive) NaF.

Section 7.

Environmental Surveillance.

Calcium Sulfate/Dysprosium thermoluminescent dosimeters are in place at 12 locations around the UCI Campus for environmental monitoring purposes. Starting July 1 2004, these are provided by Global Dosimetry Solutions (GDS), a division of Mirion Technologies, Costa Mesa, California. The GDS packs have three chips in each pack which are averaged for exposure recording. GDS runs multiple control samples in addition to the locations listed below. All dosimeters are housed in small metal lock-boxes (except for locations 10 and 12). The table below lists the locations. The locations on exhaust ducts have been changed following upgrade of Rowland Hall (and facility) ventilation systems. An additional dosimeter has been located in Engineering Tower, Room 521 (#12), where irradiated materials from the reactor may be further handled, for a total of 12.

Routine contamination surveys consisting of wipe tests and G-M surveys have shown mostly a "clean" facility with significant, removable contamination only in areas coming into direct contact with samples removed from the reactor, and on sample handling tools. Trash is surveyed before disposal and not disposed unless found to be free of removable and fixed contamination.

Table of Locations for Environmental Dosimeter Packs.

1. South Reactor Facility Perimeter
2. West Reactor Facility Perimeter
3. North Reactor Facility Perimeter
4. Rowland Hall Main Air Exhaust Fan 1
5. Rowland Hall, First Floor Hallway Over Reactor Facility
6. McGaugh Hall Top Floor
7. Langson Library Top Floor
8. Reines Hall Top Floor
9. Rowland Hall Main Air Exhaust Fan 2
10. On-Campus Faculty Housing
11. Rowland Hall Main Air Exhaust Fan 3
12. Engineering Tower Room 521

TABLE IV.

Environmental Dosimetry Data.
2013-2014
Average Total Exposures in mrem (including "control background")

Location.	Quarter				Annual	Prior year	Excess(13-14) over control
	2/13	3/13	4/13	1/14	Total 2013/14	Totals 2012/13	mr ANNUAL
1. S. Facility perimeter	28	32	26	37	123	122	+8
2. W. Facility perimeter	43	77	34	38	192	127	+77
3. N Facility perimeter	31	35	29	38	133	125	+18
4. Rowland exhaust fan 1	23	26	20	31	100	94	-15
5. Hallway over facility	24	28	22	33	107	100	-8
6. McGaugh Hall top floor	26	29	23	33	111	102	-4
7. Langson Library top floor	30	35	30	39	134	125	+19
8. Reines Hall top floor	27	32	25	35	119	112	+4
9. Rowland exhaust fan 2	23	26	21	32	102	95	-13
10. Faculty housing	26	29	21	33	109	96	-6
11.Rowland exhaust fan 3	23	28	21	32	104	93	-11
12 Engineering Tower 521	24	27	21	33	105	111	-10
Background control (GDS)	25	29	24	37	115	112	+3

Discussion
Raw data is presented here, along with controls and prior year comparisons. Within this range, the data vary with significant consistency. Locations 1, 3, and 9 are usually the highest, 10 the lowest. Data for this year reflects several issues:

- Location 7 is on the top floor of a large building and may experience greater cosmic flux, as well as concrete releases.
- Locations 1, 2, and 3 can be attributed to the increased usage of the reactor for this time period (almost double the value of last year).
- Location 1 is a hallway with an extremely low occupancy rate. (See additional note below).
- Location 2 is on the other side of a location in the reactor facility temporarily used for source storage.
- Location 3 is on a heavy concrete wall.

Exposure estimated to a single individual in an uncontrolled area at this facility is minimal. Locations 1, 2, and 3 are in hallways with extremely minimal occupancy or travel, especially since security policy is to maintain permanently locked doors to the hallways on this floor level (access only with building keys). The rooms overhead (location 5) are casually occupied by very few individuals (one or two at the most) in the space above the reactor core. The air released from the facility/building (measured by locations 4, 9, and 11) continues to give no detectable exposure above background. Over many years, the data at each specific location has shown remarkable consistency. The net conclusion is that, within precision of measurement, and compared to distant control areas (numbers 7 and 10), we are operating with very minimal levels (within statistical error of zero) of potential (full 24/7 occupancy) public exposure over normal background levels.

Section 8. Radiation Exposure to Personnel.

Personnel exposure data are summarized in Table V-I.

UCI issued TLD badges to UCI students or researchers regularly utilizing radiation. Finger dosimetry (TLD) rings are also issued to personnel who might be regularly handling radioactive sources. TLDs are read quarterly by Mirion (GDS), and results are presented in Table V-I. Data are for 4 quarters of operations since April 1, 2013. Reporting categories are DEEP, EYE, and SHALLOW. Other individuals visiting or casually working in the facility were issued DOSIMAN/R for which results are shown in Table V-II. 40 persons were issued TLD badges on a continual basis; 39 were also issued with finger TLDs. 34 students and 3 teaching assistants in a Radioisotope Techniques class were TLD badged. The lab component met for 40 hours during the quarter. Reported exposures fell in a narrow range averaging 14.7 mrem each person for the quarter.

Table V-II. also lists all visiting individuals that were issued with DOSIMAN/R monitors that record in units of 0.1 mR. In the course of a few hours, a worker can accumulate 0.2 mr. A tour visitor accumulates 0.0 or 0.1 mR during a 45 minute visit to the facility. Any reading above 0.2 is thus tabulated separately.

TABLE V-I.

Personnel Exposure Report Summary for 12 months: 4/1/13 to 3/30/14 (in millirem)

Individuals	Whole Body			Finger Ring
	DEEP	EYE	SHALLOW	(Shallow)
2[1]	15	45	79	609
9[2]	10	10	10	118
29[3]	0	0	0	349
Totals	25	55	89	1076
37[4]	Range 0-22 (mean 14.7)	Range 0-22 (mean 14.7)	Range 0-22 (mean 14.7)	not issued
class total	544	544	544	-
Totals	569 (77 individuals)	599 (77 individuals)	633 (77 individuals)	1076 (39 persons)

TABLE V-II

Aggregated non-zero data from self-reading dosimeters issued to researchers or visitors in addition to TLD badges are:

Persons	Admissions (per person)	Total Accumulation (mrem)
32[1]	3 each on average	14.4
132 other visitors logged	3 each on average	8.6
706 in tour groups[5]	1 each	0.0 to 0.1 each monitor
Total 870 persons	Total 1081	Total 23.0 mrem

1. Individuals doing extensive or casual activation analysis and radiochemical work at the facility. Most of the exposure is a result of Cl-38 or Al-28 radioactivity production.
2. Individuals receiving exposure as a result of shipping isotopes, and/or calibration activities in the facility.
3. Individuals who did enter but not carry out radiation related activities during this period, so any exposure reported is an indication of range of general background/precision where the badges are stored when not in use.
4. Reported for students and teaching assistants in Radioisotope Techniques class Sep-Dec 2013. Note badges kept 24/7 in laboratory room. All also ran samples by NAA as well as working with sealed sources.
5. Issuing 1 dosimeter each for groups up to 10 and 10 randomly for larger groups. No readings > 0.2 mrem were recorded.

Personnel exposures continue to be very low at this facility in keeping with ALARA efforts. Fewer isotope shipments have been made this year, so exposure from that activity is lower.