UNIVERSITY OF CALIFORNIA, IRVINE

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August 17, 2012

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 2011 through June 30th 2012. We regret that this report is delayed owing to our awaiting clarification on dosimetry results from the vendor.
Electronic copies are being provided as indicated below.
Thank you.

Sincerely,

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
*Greg Schoenebeck, US Nuclear Regulatory Commission
*Spyros Traiforos, Project Manager, US Nuclear Regulatory Commission
*Reactor Operations Committee Members, UCI

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NRR

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Nuclear Reactor Facility

Annual Report

for

July 1st, 2011 to June 30th, 2012

Facility License R-116

Docket 50-326

Prepared in Accordance with Part 6.7f

of the Facility Technical Specifications

by

Dr. George E. Miller, Reactor Supervisor
and
Jonathan Wallick, Staff Nuclear Science Engineer, SRO

Section 1. Operations Narrative Summary

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 2011 laboratory course in Radioisotope Techniques using the facility was 44 students with 3 graduate teaching assistants, who also learned these techniques. A three-week intensive summer course in reactor operations was offered in July, 2011 for 8 individuals. A two-week repeat of this course is planned for July 2012.

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. In this period, NSOP received no direct financial support.

A grant from the Department of Energy was awarded to enable refurbishment of some auxiliary equipment (continuous air monitor samplers, automatic sample changer) and construction of a sample irradiation loop for flowing liquids, and a burn-up fuel element monitor instrument.

Operations have continued at the increased level experienced last year. Criticality was achieved for 161.13 hours, and the total energy generated was equivalent to 85.1 hours at full steady state power. 129 separate experiments were performed, and over 2200 samples were irradiated (sometimes multiple samples are included in a single capsule and are not always separately logged). 5 moderate level mixed isotope shipments were made, all Yellow II category. Two low level test pulse operations have been performed to assess current instrumentation ability. Three 50.59 changes were approved this year: (i) shorting the terminals on relays 18 and 21 in the control console, (ii) reduction of the air pressure of the fast transient rod from 85 psig to 50 psig, (iii) replacement of a 220 ohm, 2 watt resistor, with 220 ohm, 5 watt resistor. In addition, a new pumping system for ground water adjacent to the reactor tank was installed. No unusual surveillance results/activities were conducted during this period.

A routine NRC inspection was carried out on December 12th to the 14th of 2011, resulting in two Notices of Violation, both of which have been corrected and reported to the NRC as having been corrected. An NRC non-routine inspection was carried out from March 14th-15th 2012. No Notices of Violation were received regarding anything at the facility. In 2011-12, Reactor Operations Committee meetings were held on Sept 7th 2011 and March 7th 2012 in accordance with Technical Specification schedule requirements.

No follow-ups or incidents have been forthcoming regarding security or emergency response. A review of the Emergency Plan was carried out by key personnel on May 4th 2012. As a result wording changes were made to upgrade the E-Plan according to changes made in the UCI Emergency Preparedness and Response Plan. UCI is now relying more on contractors to carry out recovery tasks. OCFA remains the primary response team with their HAXMAT group. A training exercise was conducted May 9th 2012 for the 4 SRO's on site to review procedures in response to a CAM alarm. A training exercise involving all qualified SROs was administered on June 11th, 2012, testing knowledge of high radiation casualty procedures. An exercise/training is scheduled to be held

July 25th, 2012 for the UCI EH&S radiological personnel, Orange County Fire Authority, and reactor operators related to response to a laboratory radiation spill event involving personnel injury.

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.

Operator examinations during the year (February 2012) resulted in the licensing of 1 new individual as an SRO, and 2 RO's. As of June 30th 2012, 5 SRO's and 2 RO's were active.

Section 2. Data Tabulations for the Period July 1st, 2011 to June 30th, 2012

TABLE I.

Experiment Approvals on file	3
Experiments performed (including repeats)	129
Samples irradiated	2264
Energy generated this period (Megawatt hours)	21.27
Total, 69 element core = 127.0	
>74 element core = 1391.0	
Total energy generated since initial criticality	1518.0 Mwh
Pulse operation this period	2
Total reactor pulses to 6/30/2012	980
Hours critical this period	161.13
Total hours critical to date	8851.3
Inadvertent scrams or unplanned shutdowns or events at power	7
Visitors to reactor - as individuals or in tour groups –	238
Maximum dosimeter recorded for visitors - all less than	0.2 mrem
Visiting researchers (Temporary Self Indicating Dosimeters)	28
Maximum exposure recorded at one visit	3.3 mrem
Visiting researchers (Thermoluminescent Dosimeters)	30
Students and teaching assistants in class, badged	47
Exposures reported for quarter (range: 0-10 mrem) average	0.25 mrem
Isotope Shipments this period (mixed act'n products = 0.9 μcuries total)	5

TABLE II

Reactor Core Status 6/30/12 (core configuration unchanged from 6/30/10)

Fuel elements in core (including 2 fuel followers)			82
Fuel elements in storage (reactor tank - used)			25
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			5
Experimental facilities in core positions			4
Non-fuel control rods			2
Total core positions accounted for			127
Core excess, cold, no xenon (as of 6/28/2012)			\$2.42
Control rod worths (calibrated 10/4/2011)	REG	\$2.70	
	SHIM	\$3.55	
	ATR	\$1.72	
	FTR	\$0.65	
	Total:	\$8.62	
Maximum possible pulse insertion (calculated)			\$2.37
Maximum peak power recorded (no pulse operation during this period)			- Mw
Maximum peak temperature recorded in pulse (B-ring)			-.°C

Section 3.

Inadvertent Scrams, Unplanned Shutdowns, Events at Power

TABLE III.

Date	Time	Power	Type and Cause
2011			
07/18	16:39	~2.5 w	Linear scram. Auto ranging malfunctioned while switching down, skipping past the proper range and resulting in a 106% scram in the 750 mW range. Trainee operator. Restart authorized by SRO.
07/19	16:55	~25 w	Linear scram. Auto ranging feature failed to operate in time to keep up with rate of power increase. Operators warned to use longer periods. SRO operator. Restart authorized by alternate SRO.
07/28	14:42	2.5 kw	Linear scram. Auto ranging feature failed to operate in time to keep up with rate of slowed rate of power increase. SRO Operator. Restart authorized by SRO.
10/04	15:50	~25 mw	Linear scram. Instrument left in Manual mode in the 25 mw range. Operator error. Trainee operator. Restart authorized by SRO.
10/06	17:04	191 kw	During power calibration, unexpected Linear scram. Adjustment made to WRLM instrument resulted in second scram at 17:19. Additional adjustment remedied problem. SRO Operator. Restart authorized by SRO.
2012			
3/15	9:07	~25 kw	Linear scram. Auto ranging feature failed to function when switching from the 25 kw range to the 75 kw range. Trainee operator. 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.

2011

October 5th — Power calibration run at 200 kilowatts indicated power (WRLM). Several SCRAMs occurred while making adjustments to the Full Power Gain Adjust on the WRLM instrument. Proper calibration was achieved and the spurious SCRAM behavior was negated.

2012

February 13th — Reactor Control Console Key switch had maintenance performed to alleviate problems maintaining proper contact. A different set of contacts in better condition on the same wafer of the switch was placed in used and proper contact was achieved.

February 21st — Fast Transient Rod failed to withdraw from the core. Upon further inspection, connecting rod attached to the control rod had uncoupled from the connector located on the rod's drive due to a shearing and stripping of the threads. The connections were re-machined to previous specifications and operating pressure of the FTR in steady state mode was reduced to 50 ± 5 psig, as documented in a 50.59 change. The repair was successful and performance has been verified to meet previous operational and technical requirements.

February 27th — Shim rod failed to move upon initial start up of the day. Troubleshooting revealed a 220Ω 2W resistor had developed an open fault in the rod drive circuitry. Replacement was made with a 220Ω, 5W resistor, documented in a 50.59 change. Another rod drive had the same failure in 1987 and underwent the same repair. Rod drive was repaired and reinstalled successfully, meeting previous operational and technical requirements.

May 17th — A sample being irradiated in the Delayed Neutron System (Fast Transfer System) broke open on the counting station side of the system. Sample contained 400 mL solution of 320 μg of Uranium-238, resulting in contamination of the DNS/FTS. Decontamination was carried out by disassembling all parts of the DNS/FTS, including the core terminus that had been in use at the time of contamination, and proceeding to decontaminate with deionized water. Decontamination successful and repair affected to the DNS/FTS, preventing further sample breaches in the future. Performance evaluated to put back in operation.

Section 5
Facility Changes and Special Experiments Approved

Three 10 CFR 50.59 changes have been implemented during the course of the last year. The first change involved shorting the terminals on relays 18 and 21 in the reactor control console in order to make them available as spares, as they had served no purpose in the console beforehand.

The second change was the reduction in operating pressure of the Fast Transient Rod to reduce the mechanical stresses placed on the rod, which is suspected to be a root cause of the rod's failure earlier in the year.

The third change was for the SHIM rod's electrical control system, which had a failed 220 ohm, 2 watt resistor. The resistor was replaced with a 220 ohm, 5 watt resistor. An identical replacement had been successfully performed on another rod drive in 1987.

No special or unusual experiments were approved or carried out.

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 in the exhaust at the point of stack discharge, it is considered unnecessary to provide further checks of these estimates. The dosimeter data confirm that an individual standing directly in 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 (7/1/11-6/30/12):

a. Minutes of operation:	329 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) =	2.4×10^{1} microcuries

(2) Release from pool surface (7/1/11-6/30/12):

a. Total hours of operation at full power (Effective Full Power Hours) = 85.1 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)	$= 1.6 \times 10^{0}$ microcuries
e. Total of (1) and (2) emission in 1 year	**$= 1.2 \times 10^{2}$ 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 (d/e) = ~< 1.9×10^{-10} microcuries/mL
Since 2×10^{-9} microcuries/mL provides an annual exposure for <u>constant immersion</u> of 10 mrem, this corresponds to < 1.0 mrem potential additional radiation exposure to an individual standing breathing in the effluent stack <u>for the entire year</u>.

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 techniques) may be a mixture of reactor generated byproducts and purchased materials (exclusively ^{14}C and ^{3}H).

DRY WASTES:

Three transfers of 2 cubic foot containers of dry waste were disposed during this period (7/1/11 through 6/30/12) estimated at a total quantity in 6 cu ft of 8.72 microcuries of mixed activation products (measured as ^{60}Co equivalent at time of transfer).

LIQUIDS:

One transfer of 500 mL of liquid waste was made this year. Content of the transfer was 320 μg of U-238 dissolved in 500 mL of deionized water. No ^{14}C was disposed or purchased this year.

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), 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. An additional dosimeter has been located in Engineering Tower, Room 521 (#12), 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. Reactor Facility Main Air Exhaust
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. Reactor Facility Emergency Exhaust Duct
10. On-campus Housing
11. Rowland Hall Building Fume Hood Exhaust Duct
12. Engineering Tower Room 521

TABLE IV.

Environmental Dosimetry Data.
2011-2012
Average Total Exposures in mrem (including "control background")

Location.	Quarter				Annual	Prior year	Excess(11-12) over control
	2/11	3/11	4/11	1/12	Total 2011/12	Totals 2010/11	mr ANNUAL
1. S. Facility perimeter	24	35	26	28	113	110	+2
2. W. Facility perimeter	22	29	24	29	104	109	-7
3. N Facility perimeter	23	32	27	31	113	115	+2
4. Facility main air exhaust	19	25	21	26	91	101	-20
5. Hallway over facility	19	27	23	27	96	97	-15
6. McGaugh Hall top floor	21	28	24	28	101	107	-10
7. Langson Library top floor	26	33	28	33	120	122	+9
8. Reines Hall top floor	24	30	26	30	110	113	-1
9. Facility emer .exh.	18	24	21	25	88	100	-23
10. On-campus housing	18	26	21	27	92	100	-19
11 Facility fume hood exh.	16	24	22	26	89	-	-22
12 Engineering Tower 521	18	28	22	26	84	-	-27
Background control (GDS)	23	31	25	32	111	117	0

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.
- Location 3 is on a heavy concrete wall.
- Location 1 is a hallway with an extremely low occupancy rate. (See additional note below).
- In spite of increased operations, levels remain statistically within range of previous year.

Exposure estimated to a single individual in an uncontrolled area at this facility is still very minimal. Locations 1 and 2 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 to individuals with building keys). The rooms overhead (location 4) 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 #5, #6 and #7) 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 9 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.

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. TLD's are read quarterly by Global Dosimetry Solutions, and results are presented in Table Va. Data are for 4 quarters of operations since April 1, 2011. 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 Vb. 30 persons were issued TLD badges on a continual basis; 9 were also issued with finger TLDs. 44 students and 3 teaching assistants in a Radioisotope Techniques class were TLC badged. Reported exposures fell in a narrow range averaging 0.25 mrem each person for the quarter.

Table Vb. 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 Va.

Personnel Exposure Report Summary for 12 months: 4/1/10 to 3/30/11 (in millirem)

Individuals	Whole Body			Finger Ring
	DEEP	EYE	SHALLOW	(Shallow)
1[1]	0	26	43	351
10[2]	0	0	0	0
20[3]	0	0	0	0
Totals	0	26	43	351
47[4]	Range 0-16 (mean <1)	Range 0-16 (mean <1)	Range 0-16 (mean <1)	not issued
class total	28	28	28	-
Totals	28 (78 individuals)	54 (78 individuals)	71 (78 individuals)	351 (9 persons)

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)
1[1]	4	6.4
70 other visitors logged	2 each on average	1.2
167 in tour groups[5]	1 each	0.0 to 0.1 each monitor
Total 238 persons	Total 320	Total 11.6 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 Jan-Mar 2011. 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 > 0.1 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.

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No special or unusual experiments were approved or carried out.

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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 in the exhaust at the point of stack discharge, it is considered unnecessary to provide further checks of these estimates. The dosimeter data confirm that an individual standing directly in 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 (7/1/11-6/30/12):

a. Minutes of operation:	329 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) =	2.4×10^{1} microcuries

(2) Release from pool surface (7/1/11-6/30/12):

a. Total hours of operation at full power (Effective Full Power Hours) = 85.1 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)	= 1.6×10^{0} microcuries
e. Total of (1) and (2) emission in 1 year	**= 1.2×10^{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 (d/e) = ~< 1.9×10^{-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).

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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 techniques) may be a mixture of reactor generated byproducts and purchased materials (exclusively ^{14}C and ^{3}H).

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Three transfers of 2 cubic foot containers of dry waste were disposed during this period (7/1/11 through 6/30/12) estimated at a total quantity in 6 cu ft of 8.72 microcuries of mixed activation products (measured as ^{60}Co equivalent at time of transfer).

LIQUIDS:

One transfer of 500 mL of liquid waste was made this year. Content of the transfer was 320 μg of U-238 dissolved in 500 mL of deionized water. No ^{14}C was disposed or purchased this year.

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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), 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. An additional dosimeter has been located in Engineering Tower, Room 521 (#12), for a total of 12.

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2. West Reactor Facility Perimeter
3. North Reactor Facility Perimeter
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9. Reactor Facility Emergency Exhaust Duct
10. On-campus Housing
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TABLE IV.

Environmental Dosimetry Data.
2011-2012
Average Total Exposures in mrem (including "control background")

Location.	Quarter				Annual	Prior year	Excess(11-12) over control
	2/11	3/11	4/11	1/12	Total 2011/12	Totals 2010/11	mr ANNUAL
1. S. Facility perimeter	24	35	26	28	113	110	+2
2. W. Facility perimeter	22	29	24	29	104	109	-7
3. N Facility perimeter	23	32	27	31	113	115	+2
4. Facility main air exhaust	19	25	21	26	91	101	-20
5. Hallway over facility	19	27	23	27	96	97	-15
6. McGaugh Hall top floor	21	28	24	28	101	107	-10
7. Langson Library top floor	26	33	28	33	120	122	+9
8. Reines Hall top floor	24	30	26	30	110	113	-1
9. Facility emer .exh.	18	24	21	25	88	100	-23
10. On-campus housing	18	26	21	27	92	100	-19
11 Facility fume hood exh.	16	24	22	26	89	-	-22
12 Engineering Tower 521	18	28	22	26	84	-	-27
Background control (GDS)	23	31	25	32	111	117	0

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.
- Location 3 is on a heavy concrete wall.
- Location 1 is a hallway with an extremely low occupancy rate. (See additional note below).
- In spite of increased operations, levels remain statistically within range of previous year.

Exposure estimated to a single individual in an uncontrolled area at this facility is still very minimal. Locations 1 and 2 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 to individuals with building keys). The rooms overhead (location 4) 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 #5, #6 and #7) 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 9 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.

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. TLD's are read quarterly by Global Dosimetry Solutions, and results are presented in Table Va. Data are for 4 quarters of operations since April 1, 2011. 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 Vb. 30 persons were issued TLD badges on a continual basis; 9 were also issued with finger TLDs. 44 students and 3 teaching assistants in a Radioisotope Techniques class were TLC badged. Reported exposures fell in a narrow range averaging 0.25 mrem each person for the quarter.

Table Vb. 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 Va.

Personnel Exposure Report Summary for 12 months: 4/1/10 to 3/30/11 (in millirem)

Individuals	Whole Body			Finger Ring
	DEEP	EYE	SHALLOW	(Shallow)
1[1]	0	26	43	351
10[2]	0	0	0	0
20[3]	0	0	0	0
Totals	0	26	43	351
47[4]	Range 0-16 (mean <1)	Range 0-16 (mean <1)	Range 0-16 (mean <1)	not issued
class total	28	28	28	-
Totals	28 (78 individuals)	54 (78 individuals)	71 (78 individuals)	351 (9 persons)

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)
1[1]	4	6.4
70 other visitors logged	2 each on average	1.2
167 in tour groups[5]	1 each	0.0 to 0.1 each monitor
Total 238 persons	Total 320	Total 11.6 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 Jan-Mar 2011. 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 > 0.1 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.

U. C. IRVINE

Nuclear Reactor Facility

Annual Report

for

July 1st, 2011 to June 30th, 2012

Facility License R-116

Docket 50-326

Prepared in Accordance with Part 6.7f

of the Facility Technical Specifications

by

Dr. George E. Miller, Reactor Supervisor
and
Jonathan Wallick, Staff Nuclear Science Engineer, SRO

Section 1. Operations Narrative Summary

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 2011 laboratory course in Radioisotope Techniques using the facility was 44 students with 3 graduate teaching assistants, who also learned these techniques. A three-week intensive summer course in reactor operations was offered in July, 2011 for 8 individuals. A two-week repeat of this course is planned for July 2012.

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. In this period, NSOP received no direct financial support.

A grant from the Department of Energy was awarded to enable refurbishment of some auxiliary equipment (continuous air monitor samplers, automatic sample changer) and construction of a sample irradiation loop for flowing liquids, and a burn-up fuel element monitor instrument.

Operations have continued at the increased level experienced last year. Criticality was achieved for 161.13 hours, and the total energy generated was equivalent to 85.1 hours at full steady state power. 129 separate experiments were performed, and over 2200 samples were irradiated (sometimes multiple samples are included in a single capsule and are not always separately logged). 5 moderate level mixed isotope shipments were made, all Yellow II category. Two low level test pulse operations have been performed to assess current instrumentation ability. Three 50.59 changes were approved this year: (i) shorting the terminals on relays 18 and 21 in the control console, (ii) reduction of the air pressure of the fast transient rod from 85 psig to 50 psig, (iii) replacement of a 220 ohm, 2 watt resistor, with 220 ohm, 5 watt resistor. In addition, a new pumping system for ground water adjacent to the reactor tank was installed. No unusual surveillance results/activities were conducted during this period.

A routine NRC inspection was carried out on December 12th to the 14th of 2011, resulting in two Notices of Violation, both of which have been corrected and reported to the NRC as having been corrected. An NRC non-routine inspection was carried out from March 14th-15th 2012. No Notices of Violation were received regarding anything at the facility. In 2011-12, Reactor Operations Committee meetings were held on Sept 7th 2011 and March 7th 2012 in accordance with Technical Specification schedule requirements.

No follow-ups or incidents have been forthcoming regarding security or emergency response. A review of the Emergency Plan was carried out by key personnel on May 4th 2012. As a result wording changes were made to upgrade the E-Plan according to changes made in the UCI Emergency Preparedness and Response Plan. UCI is now relying more on contractors to carry out recovery tasks. OCFA remains the primary response team with their HAXMAT group. A training exercise was conducted May 9th 2012 for the 4 SRO's on site to review procedures in response to a CAM alarm. A training exercise involving all qualified SROs was administered on June 11th, 2012, testing knowledge of high radiation casualty procedures. An exercise/training is scheduled to be held

July 25th, 2012 for the UCI EH&S radiological personnel, Orange County Fire Authority, and reactor operators related to response to a laboratory radiation spill event involving personnel injury.

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.

Operator examinations during the year (February 2012) resulted in the licensing of 1 new individual as an SRO, and 2 RO's. As of June 30th 2012, 5 SRO's and 2 RO's were active.

Section 2. Data Tabulations for the Period July 1st. 2011 to June 30th. 2012

TABLE I.

Experiment Approvals on file	3
Experiments performed (including repeats)	129
Samples irradiated	2264
Energy generated this period (Megawatt hours)	21.27
Total, 69 element core = 127.0	
>74 element core = 1391.0	
Total energy generated since initial criticality	1518.0 Mwh
Pulse operation this period	2
Total reactor pulses to 6/30/2012	980
Hours critical this period	161.13
Total hours critical to date	8851.3
Inadvertent scrams or unplanned shutdowns or events at power	7
Visitors to reactor - as individuals or in tour groups –	238
Maximum dosimeter recorded for visitors - all less than	0.2 mrem
Visiting researchers (Temporary Self Indicating Dosimeters)	28
Maximum exposure recorded at one visit	3.3 mrem
Visiting researchers (Thermoluminescent Dosimeters)	30
Students and teaching assistants in class, badged	47
Exposures reported for quarter (range: 0-10 mrem) average	0.25 mrem
Isotope Shipments this period (mixed act'n products = 0.9 μcuries total)	5

TABLE II

Reactor Core Status 6/30/12 (core configuration unchanged from 6/30/10)

Fuel elements in core (including 2 fuel followers)			82
Fuel elements in storage (reactor tank - used)			25
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			5
Experimental facilities in core positions			4
Non-fuel control rods			2
Total core positions accounted for			127
Core excess, cold, no xenon (as of 6/28/2012)			$2.42
Control rod worths (calibrated 10/4/2011)	REG	$2.70	
	SHIM	$3.55	
	ATR	$1.72	
	FTR	$0.65	
	Total:	$8.62	
Maximum possible pulse insertion (calculated)			$2.37
Maximum peak power recorded (no pulse operation during this period)			- Mw
Maximum peak temperature recorded in pulse (B-ring)			-.^{o}C

Section 3.

Inadvertent Scrams, Unplanned Shutdowns, Events at Power

TABLE III.

Date	Time	Power	Type and Cause
2011			
07/18	16:39	~2.5 w	Linear scram. Auto ranging malfunctioned while switching down, skipping past the proper range and resulting in a 106% scram in the 750 mW range. Trainee operator. Restart authorized by SRO.
07/19	16:55	~25 w	Linear scram. Auto ranging feature failed to operate in time to keep up with rate of power increase. Operators warned to use longer periods. SRO operator. Restart authorized by alternate SRO.
07/28	14:42	2.5 kw	Linear scram. Auto ranging feature failed to operate in time to keep up with rate of slowed rate of power increase. SRO Operator. Restart authorized by SRO.
10/04	15:50	~25 mw	Linear scram. Instrument left in Manual mode in the 25 mw range. Operator error. Trainee operator. Restart authorized by SRO.
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6. McGaugh Hall top floor	21	28	24	28	101	107	-10
7. Langson Library top floor	26	33	28	33	120	122	+9
8. Reines Hall top floor	24	30	26	30	110	113	-1
9. Facility emer .exh.	18	24	21	25	88	100	-23
10. On-campus housing	18	26	21	27	92	100	-19
11 Facility fume hood exh.	16	24	22	26	89	-	-22
12 Engineering Tower 521	18	28	22	26	84	-	-27
Background control (GDS)	23	31	25	32	111	117	0

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.
- Location 3 is on a heavy concrete wall.
- Location 1 is a hallway with an extremely low occupancy rate. (See additional note below).
- In spite of increased operations, levels remain statistically within range of previous year.

Exposure estimated to a single individual in an uncontrolled area at this facility is still very minimal. Locations 1 and 2 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 to individuals with building keys). The rooms overhead (location 4) 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 #5, #6 and #7) 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 9 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.

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. TLD's are read quarterly by Global Dosimetry Solutions, and results are presented in Table Va. Data are for 4 quarters of operations since April 1, 2011. 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 Vb. 30 persons were issued TLD badges on a continual basis; 9 were also issued with finger TLDs. 44 students and 3 teaching assistants in a Radioisotope Techniques class were TLC badged. Reported exposures fell in a narrow range averaging 0.25 mrem each person for the quarter.

Table Vb. 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 Va.

Personnel Exposure Report Summary for 12 months: 4/1/10 to 3/30/11 (in millirem)

Individuals	Whole Body			Finger Ring
	DEEP	EYE	SHALLOW	(Shallow)
1[1]	0	26	43	351
10[2]	0	0	0	0
20[3]	0	0	0	0
Totals	0	26	43	351
47[4]	Range 0-16 (mean <1)	Range 0-16 (mean <1)	Range 0-16 (mean <1)	not issued
class total	28	28	28	-
Totals	28 (78 individuals)	54 (78 individuals)	71 (78 individuals)	351 (9 persons)

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)
1[1]	4	6.4
70 other visitors logged	2 each on average	1.2
167 in tour groups[5]	1 each	0.0 to 0.1 each monitor
Total 238 persons	Total 320	Total 11.6 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 Jan-Mar 2011. 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 > 0.1 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.