U. C. IRVINE

Nuclear Reactor Facility

Annual Report

for

July 1st, 2012 to June 30th, 2013

Facility License R-116

Docket 50-326

Prepared in Accordance with Part 6.7f

of the Facility Technical Specifications

July, 2013

by

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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 2012 laboratory course in Radioisotope Techniques using the facility was 29 students with 2 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 made 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 uses have increased. Criticality was achieved for 241.77 hours, and the total energy generated was equivalent to 139.36 hours at full steady state power. 141 separate experiments were performed, and over 2853 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. No pulses were performed this year. Four 50.59 changes were approved this year: (i) security upgrades for the GTRI program, (ii) reinstallation into core of the former "cryogenic" facility with internals remodeled, (iii) installation of two additional fuel elements into the core, (iv) installation of an additional valve in the reactor cooling system. No unusual surveillance results/activities were conducted during this period. One new experiment has been approved (UC Davis) for placing a sealed tank of D_2O external to the core for NAA irradiations in a highly thermalized neutron flux.

A routine NRC inspection June 10th to the 13th of 2013, resulted in no Notices of Violation or follow-up items.. In 2012-2013, Reactor Operations Committee meetings were held on Sept 19th 2012 and February 28th 2013 in accordance with Technical Specification requirements.

No follow-ups or incidents have been forthcoming regarding security or emergency response. Two exercises were held this past year, one on July 25th, 2012 and the other one June 3rd, 2013 for the UCI EH&S radiological personnel, Orange County Fire Authority, UCI Police Department, Orange County Health Department, and reactor operators. The first exercise consisted of response to a laboratory radiation spill event also involving personnel injury and the second was a tabletop scenario of a bomb detonated at the reactor facility east wall. Both included debriefing and evaluation of all involved parties and after action reports were issued and after action items resolved.

The quinquennial fuel and control rod inspections were carried out in Oct-Nov, 2012 without incident. All core fuel elements and control rods were measured and/or inspected for change or wear. Fuel element serial numbers were veriftified. 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 in March 2012 resulted in the licensing of 4 new individuals as RO's. As of June 30th 2013, 4 SRO's and 6 RO's were active.

Section 2. Data Tabulations for the Period July 1st, 2012 to June 30th, 2013

TABLE I.

Experiment Approvals on file	4
Experiments performed (including repeats)	141
Samples irradiated	2853
Energy generated this period (Megawatt hours)	34.48
Total, 69 element core = 127.0	
>74 element core = 1425.5	
Total energy generated since initial criticality	1552.5 Mwh
Pulse operation this period	0
Total reactor pulses to 6/30/2013	981
Hours critical this period	241.8
Total hours critical to date	9093.1
Inadvertent scrams or unplanned shutdowns or events at power	16
Visitors to reactor - as individuals or in tour groups –	1158
Maximum dosimeter recorded for visitors - all less than	0.2 mrem
Visiting researchers (Temporary Self Indicating Dosimeters)	80
Maximum exposure recorded at one visit	2.5 mrem
Visiting researchers (Thermoluminescent Dosimeters)	30
Students and teaching assistants in class, badged	29
Exposures reported for quarter (range: 0-17 mrem) average	5.1 mrem
Isotope Shipments this period (mixed act'n products = 2.37 Ci total)	5

TABLE II

Reactor Core Status 6/30/13 (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			3
Experimental facilities in core positions			5
Non-fuel control rods			2
Total core positions accounted for			127
Core excess, cold, no xenon (as of 6/28/2013)			$2.85
Control rod worths (calibrated 11/10/2012)	REG	$2.80	
	SHIM	$3.55	
	ATR	$1.75	
	FTR	$0.62	
	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
2012			
07/09	09:31	250 kw	Percent power scram. Jump in the Power range monitor indicated jump in power level but not on linear or logarithmic indications of reactor power. Checked connections to instrument, reseated connections. Restart authorized by SRO.
	09:58	200 kw	Manual Scram. Indications of Power range monitor and linear range and logarithmic range monitors disagreed by 15, later determined to be caused by a blown OPAMP in the instrument that happened while at full power during the previous operation. Fixed and returned to normal operation on 7/13/2013.
07/16	15:20	2.5 w	A series of period scrams are occurring while at shutdown levels, interrupting a startup. Suspected to be signal noise from the detector. Restart authorized by SRO. Later determined to be reproducible, definitive interference from Verizon wireless cell phones of a particular generation.
08/17	08:17	25 w	Linear scram. Auto ranging feature failed to function when switching from the 25 w range to the 75 w range. Restart authorized by SRO.
	10:40	250 kw	Linear scram. Minor contact with cabinet containing linear power range instrument resulted in a linear power scram. Checked connections to instrument, verified to be not reproducible, trainee operator, restart authorized by SRO.
08/28	08:39	250 kw	Manual scram. Cooling pump was determined to be malfunctioning based on lack of cooling of reactor pool water and cavitation noises. Troubleshooting revealed the casing clamp was too tight, causing friction between the pump rotor and casing. Restart authorized by SRO after verification that cooling flow was no longer obstructed.
10/11	16:45	150 mw	Period scram. While at 150 mw steady state, a period scram was initiated. Suspected to be signal noise from the detector. Restart authorized by SRO. Later determined to be reproducible, definitive interference from Verizon wireless cell phones of a particular generation.
11/08	11:00	1.5w	Period scram. While stabilizing power at 1.5w for a control rod calibration, a period scram was initiated. Suspected to be signal noise from the detector. Console left on with key removed overnight to determine nature of cause. No scram found to be locked in next day, but when an operator with a Verizon wireless cell phone approached to console, spurious spikes in logarithmic power levels began happening, and would disappear when the phone was removed from the room. Determined to be reproducible, definitive interference from Verizon

			wireless cell phones of a particular generation. Continued operation authorized with restriction on cell phones near the console.
11/09	15:38	25 w	Linear scram. Auto ranging feature failed to function when switching from the 25 w range to the 75 w range. Restart authorized by SRO.
11/10	21:42	200 kw	Linear scram. Adjustment of the full power gain adjust potentiometer during a reactor power calibration resulted in a linear power scram. Common occurrence during power calibration.
11/27	14:28	1.5 w	Period scram. A period scram occurred during a routine start up to 1.5 watts due to operator error of a first time operator. Trainee operator counseled on proper start up procedure, restart authorized by SRO.

2013

01/31	13:19	250 kw	Manual scram. A sample was reported stuck in the pneumatic transfer system and a manual scram was initiated per the standard operating procedures. The sample was retrieved using another sample tube with adhesive material on the end. All parts of the stuck sample were verified to be retrieved. Restart authorized by SRO.
03/09	11:50	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.
04/23	10:34	250 kw	Linear scram. A linear power scram was initiated during an irradiation when a pneumatic transfer sample was injected into the core. The sample was removed from the core and gamma spectroscopy was performed on it. The results were inconclusive due to the short irradiation time and the sample had be irradiated previously without incident. Determined to be a spurious event. Restart authorized by SRO.
06/05	13:26	75 w	Linear scram. Auto ranging feature failed to function when switching from the 75 w range to the 250 w range. 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.

2012

Jul 9th — On July 9th, 2012, a failure occurred in the Power Range Monitor instrument, causing indications to be high off scale for the Peak Power indication at all times and the Power Level indication to be 15% higher than actual when compared with the Wide Linear and Logarithmic Range Monitors. Root cause was determined to be a dysfunctional integrated circuit operational amplifier, U10, on the Linear Amplifier card. When replaced with an identical part supplied from the Power Range Monitor's manufacturer, function was completely restored and verified to be functional.

Jul 16th — As mentioned above, there had been a recurring problem with period scrams occurring at low power levels and during startups. The first such incident occurred on July 16th, 2012 and was written off as a spurious event. Second incident was on October 11th during the Thermo-Fisher detector testing. A third incident occurred on November 8th, causing reason for serious investigation. To this point, the connections to the instrument and detector had been cleaned, re-soldered, insulated, and otherwise made to protect against possible grounding / shorting / electromagnetic interference. During a training session in the control room with the reactor shutdown, just days after the third incident, it was noted that the period scram was intermittently indicating tripped. The phenomenon was determined to be associated with a particular trainee's cellular phone. This trainee had been present with the cellular phone in question in the control room or seated near the instrument every time that the phenomenon occurred. In keeping the cellular phone near the instrument, it would periodically trigger the Reactor Period scram, indicating the a signal being emitted from the phone (possibly a data update request or similar transmission) was interfering with the signal to the instrument. In trying to reproduce the event with all cell phones available, only those of a certain service carrier (Verizon Wireless) would induce the signal, indicating that the frequency used for transmission was in a band that was interfering with our instrument. As a result, cellular phones of that carrier are required to be turned off or in "Airplane mode" during reactor startup. We have seen no further incidents of this sort since instituting this policy.

Aug 10th — On August 10th, 2012, difficulty was found in trying to get the reactor cooling pump to maintain proper suction and severe cavitation was noted during pump operation. To remedy the problem of initially acquiring suction when starting the pump, a permanent priming solution was installed and later, the pump's seals were replaced with an OEM kit from the manufacturer. All suction and cavitation problems have been resolved and the pump is fully functional.

Sep 17th — On September 17th, 2012, the cryogenic tube facility modified for working at ambient temperatures was re-inserted into core position G28 where it had been installed a few years earlier. It has be renamed Flow Loop Test facility (FLT) as it eventually will be used to test samples irradiated while fluids are passed over them.

A 50.59 review is on file for this re-installation. No safety issues are involved at this time. The reactivity change as measured was less than $0.01.
After insertion, however, it was noted that the REG rod failed to rise from its lower limit. In installing the FLT facility, the FTS system terminus piping had been rotated, resulting in the delivery tubes resting against the REG rod connecting rod. The drag induced was sufficient enough to cause the magnet not to be able to pick up the rod. The FTS terminus piping was maneuvered into a more optimal location, restoring normal operation of the REG rod.

Oct 4th — October 4th, 2012, the SHIM drive down micro-switch needed minor adjustment to correct operation, as the drive was no longer automatically tracking the scrammed control rod. Proper operation and function was restored and verified.

Oct 10th — On October 10th, 2012, the FLT was removed once again as part of preparation for experiments that needed approach to core side at that location and for the upcoming fuel measurement checks. Again a reactivity change of less than $0.01 was measured. Thermo-Fisher (Gamma-Metrics) testing of a neutron detection system was conducted adjacent to core but outside the reflector. This causes no perturbation of core fluxes and therefore analysis for such effects is not required. A number of small scale power changes at low reactor power levels were used during these tests, all at less than 1 kW. At one point an unexplained period scram at about 250 mW presumed to be an electronic "glitch" occurred; as the event was not reproducible, operations were resumed with no further incident.

Oct 29th — On October 29th, the two FTS and the PT terminuses were removed in preparation for quinquennial fuel measurements. The measured core excess was $2.99 after FTS with Cd liner was removed, which showed this to be worth - $0.59. but license TS limits on shutdown were still obtained. The AmBe neutron source and IFE were removed at which time no further operation is possible and reactor core excess is far below $3.00. The 6 B ring elements were next removed to temporary storage racks, at which time the core reactivity is estimated to be -$8.00. With the SHIM rod removed, the core reactivity is -$5.03 to meet all required margins. A full crew then removed one element at a time, measured it and returned it to its original location, performing surface observations and serial number checks using our underwater camera.
This continued for 2 days, during which each control rod was serially removed, measured, inspected, and returned to its' original position. As the fuel measurement tool was adapted for control rod measurement, an internal swipe of the tool was made. 3600 dpm per 100 cm^2 of removable was determined to be present, so all was treated and bagged carefully as radioactive material. Gamma spectrometry of the swipe revealed Co, Ni and Cr isotopes, all of which are expected from friction of the stainless steel cladding of the fuel elements with the measurement tool. No fission products were observed, confirming the absence of leakage and the integrity of all the fuel elements.
The REG and SHIM were examined by camera under water as they both have fuel followers. The ATR and FTR were completely removed from the pool, serially again, onto adsorbent paper for close visual inspection. All portions of the rods were intact and in similar condition as when last inspected. Special attention was paid to the FTR in view of the need earlier in the year to repair it. The highest rad level

observed on either of these rods was about 40 mr/hr at close range. The air systems of both the FTR and ATR were inspected, and the solenoid valves dismantled, cleaned and lubricated, per the required planned maintenance.
On November 2nd, B ring elements, including the IFE, were reinserted, then the PT and DNS system terminuses and finally the neutron source.

Nov 4th — On November 4th, a low pool alarm trip was received by UCIPD at a setting of 17.4 instead of 0. Somehow, the alarm set point had become changed during testing. It was reset to zero and water added to clear the condition and correct the aberrant behavior of the instrument. System was determined to be functional and returned to proper operation.

Nov 6th — On November 6th, 2012, all control rod functions were verified prior to further core modification operations. Owing to the last low core excess (re-measured to be about $2.40) it was planned to add 1 or 2 elements to come closer to the allowed $3.00. To accommodate additional elements and meet the "close packed array" guideline, it was necessary to move any graphite elements from the F ring to the G ring. This was predicted to result in a small loss of reactivity as water replaced the graphite. Adding fuel from storage to the F ring would then modestly increase core reactivity.
On November 7th, the following core movements were made, in order, as follows (exact locations are recorded in reactor log):

1. Moved one graphite element from F ring to G ring and verified serial number.
2. Added one element from storage to F ring and verified serial number; measured change was +$0.13
3. Moved one graphite element from F ring to G ring and verified serial number.
4. Added one element from storage to F ring and verified serial number; measured change was +$0.22

Following these additions, a new core excess was measured based on the former rod worth measurements, resulting in a core excess of $2.75 to $2.86, depending on rod positions. Both were well within license limit of $3.00.
During the monthly surveillance, the water purification filters were changed to correct an excessive differential pressure across the component due to clogging during the fuel measurements. Initial differential pressure was 8 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 were found upon gamma spectrometry of the filters.

Nov 8th — On November 8th, 2012, following the fuel measurements and element additions to the core, control rod worth calibrations were commenced. During SHIM calibration, an unexpected period scram occurred. An investigation of the WRM unit, including reseating the circuit boards, was found to improve reliability and no further scram interruptions were observed. A new preliminary excess of $2.99 was found.
On November 9th, 2012, the REG rod calibration was performed, during which, a single failure of the automatic range adjustment caused a WRLM scram at low power (25 watts). No repeat of this was observed. The core excess as determined was now $2.86, in better agreement with older values. ATR and FTR were also recalibrated. Final results for total worths were:

SHIM $3.55 REG $2.80, ATR $1.75, FTR $0.62 for a total of $8.72. Thus the extra fuel increased the rod worth from $8.04 to $8.72, or by $0.68.
On November 10th, 2012, power calibrations were performed. 81.65% 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.
On November 13th, 2012, the reactor was declared available for routine operations with a new core excess of $2.86, and a complement of 82 fuel elements in place of the former 80.

Dec 22nd — On December 22nd, 2012, a security alarm from a motion sensor (PIR) in control room occurred at night (left) no obvious cause. No signs of intrusion or forced entry were evident and this has been attributed to shifting equipment or possibly excessive vibration of the doors exiting to the Rowland Hall loading dock from the hallway. No earthquakes were reported by USGS at the time of the alarm.

2013

Jan 7th — On January 7th, 2013, the new grid system being installed over the formerly "open" part of the pool renders it difficult to operate the valve in the cooling water system at the top of the pool. Therefore, on January 24th, 2013, a new valve closer to the cooling water pump was installed to make operation simpler. The valve installed was selected to be compatible with the cooling system's current materials and piping requirements. It is necessary to close this valve when coolant flow is off in order to conserve priming water in the pump. Functionality of the system was verified and returned to normal service on the same day.

Jan 24th — On January 24th, 2013, the LS unload radiation monitor indicated failure. The detector from the PT lab was installed in its place temporarily while the original unit underwent troubleshooting and corrective maintenance. On January 25th, 2013, a new GM tube and diode were installed and the repaired unit returned to service on January 26th.

Jan 31st — On January 31st, 2013, a PT rabbit tube base failed, stranding the contained sample in the terminus. The reactor was scrammed immediately, and the sample removed using a "sticky" rabbit. The run was resumed, and the radiation level from the over-exposed sample was appreciably low.

Feb 4th — On February 4th, 2013, the fuel temperature channel module was dismantled and internal units re-seated in an effort to improve an irregularity found during start-up testing. The results of this corrective maintenance have thus far proven effective.

Feb 6th — On February 6th, 2013, the ground water level meter was observed to be non-functional. However the pump was still operational and functioning every half hour via the associated motor controller, pumping the ground water well dry. The failure was of the water depth (pressure) sensor. A new sensor was ordered, as the manufacturer indicated this cannot be repaired, and was just out of warranty period. After an extended period due to a shipping error on the manufacturer's part, the

defective detector was replaced and the system was verified to be functional and placed back into service on March 7th, 2013.

Feb 11th — On February 11th, 2013, a trip of panic alarm was accidentally initiated by security upgrade installers. Since this is a silent alarm, it was not noted until PD officers arrived in less than 5 minutes after the installers had begun work on the panic alarm reporting system, indicating the effectiveness of our system and the attentiveness and responsiveness of the UCIPD with regards to our facility.

Mar 4th — On March 4th, 2013, the cryogenic tube facility modified for working at ambient temperatures was re-inserted into core position G28 where it had been installed a few months earlier. It has be renamed Flow Loop Test facility (FLT) as it eventually will be used to test samples irradiated while fluids are passed over them.
A 50.59 review is on file for this re-installation. No safety issues are involved at this time. The reactivity change as measured was less than $0.01.

Apr 10th — On April 10th, 2013, an all aluminum construction experiment holding apparatus was lowered into the pool outside the reflector of the core to aid in determining neutron flux levels exterior to the core. After a two hour irradiation, the samples were removed from the apparatus and the apparatus itself was allowed to decay under the water of the reactor pool. On April 11th, 2013, the apparatus was removed from the pool where radiation levels of less than 1 mr/hr were detected at the most active point of the apparatus. The apparatus was dried and stored for later use.

Apr 29th — On April 29th, 2013, Area Radiation Monitor (ARM) #5 was found to be inoperable. Troubleshooting revealed that water had leaked into the detector due to an old, cracked seal. Replacement of the seal and a high voltage rectifier diode inside made the unit operable once again. Placed back into operation the same day.

May 29th — On May 29th, 2013, an all aluminum construction tank designed for an experiment by UC Davis filled with water was lowered into the pool near the reflector of the core. The aluminum apparatus lowered previously on April 10th, 2013, was also lowered into the pool. After a 6 hour irradiation, the samples were removed from the apparatus , which was then lowered back down into the pool to decay. The tank, however, had radiation levels too high to permit removal of its samples and was left overnight to decay in the pool. On May 30th, 2013, the radiation levels of the tank had lowered enough to permit removal of the samples and store the tank in dry storage.

Jun 25th — On June 25th, 2013, the water purification filters were changed due to low flow rates in the purification system. All radiological controls were in place and nocontamination of personnel or equipment occurred.

Section 5
Facility Changes and Special Experiments Approved

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

The first change was a general change written for the in progress Global Threat Reduction Initiative security upgrades. These upgrades will be in progress throughout the entire year covering many parts of the security system. Completion is scheduled for October, 2013/

The second change was the reinstallation of former cryogenic irradiation facility with the interior portions removed. The change details the new intended use of the facility and impacts on the reactor safety criteria.

The third change was for the fuel element addition that took place in November of 2012, detailed above in the maintenance / surveillance portions of this report.

The fourth and final 50.59 change of this year was for the installation of an additional ball valve in the suction piping of the cooling pump to accommodate the GTRI security upgrades, as the previously installed valve was made inaccessible by these upgrades.

One new experiment was approved this year. A group from the UC Davis physics department under Dr. Robert Svoboda has begun an experiment involving an all aluminum construction tank intended to be filled with heavy water and undergo irradiations of 4-8 hours long. The purpose of this experiment is to irradiate samples under highly thermalized neutron flux conditions for more precise activation analysis. Irradiations are set to being in July.

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 (7/1/12-6/30/13):

a. Minutes of operation:	444 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) =	3.2×10^{1} microcuries

(2) Release from pool surface (7/1/12-6/30/13):

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)	= 1.0×10^{2} microcuries
e. Total of (1) and (2) emission in 1 year	**= 1.31×10^{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) = ~< 1.73×10^{-11} 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 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 (7/1/12 through 6/30/13) estimated at a total quantity in 6 cu ft of 4.22 millicuries of mixed activation products (measured as ^{60}Co equivalent at time of transfer).

LIQUIDS:

One transfer of a 2 cubic foot container of used scintillation vials was made this year. Contents of the container were scintillation cocktail containing 0.001 millicuries of H-3 and 0.001 millicuries ^{14}C. No ^{14}C was purchased this year.

One transfer of a 2.5 gallon liquid constituent was made this year. The contents of the container included 0.030 millicuries of ^{3}H along with 0.0% trace elements of 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), 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.
2012-2013
Average Total Exposures in mrem (including "control background")

Location.	Quarter				Annual	Prior year	Excess(12-13) over control
	2/12	3/12	4/12	1/13	Total 2012/13	Totals 2011/12	mr ANNUAL
1. S. Facility perimeter	25	29	29	39	122	113	+9
2. W. Facility perimeter	26	30	31	40	127	104	+23
3. N Facility perimeter	27	34	32	32	125	115	+10
4. Facility main air exhaust	20	25	25	24	94	91	+3
5. Hallway over facility	22	26	27	25	100	96	+4
6. McGaugh Hall top floor	22	26	28	26	102	101	+1
7. Langson Library top floor	27	32	34	32	125	120	+5
8. Reines Hall top floor	24	29	31	28	112	110	+2
9. Facility emer. exhaust	20	25	26	24	95	88	+7
10. On-campus housing	21	25	26	24	96	92	+4
11 Facility fume hood exh.	20	24	25	24	93	89	+4
12 Engineering Tower 521	32*	26	29	24	111	84	+27
Background control (GDS)	24	29	31	28	112	111	+1

* Element left in place for 6 months in error.

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 3 is on a heavy concrete wall.
- Location 1 is a hallway with an extremely low occupancy rate. (See additional note below).
- Location 12 levels can be attributed to the increased usage of the Gas Chromatograph with radioactive materials.

Exposure estimated to a single individual in an uncontrolled area at this facility is 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 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, 2012. 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; 30 were also issued with finger TLDs. 29 students and 2 teaching assistants in a Radioisotope Techniques class were TLD badged. Reported exposures fell in a narrow range averaging 5.1mrem 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: 4/1/12 to 3/30/13 (in millirem)

Individuals	Whole Body			Finger Ring
	DEEP	EYE	SHALLOW	(Shallow)
1[1]	36	79	134	479
9[2]	53	55	63	168
20[3]	11	11	11	217
Totals	100	112	208	864
31[4]	Range 0-17 (mean 5.1)	Range 0-17 (mean 5.1)	Range 0-17 (mean 5.1)	not issued
class total	159	159	159	-
Totals	259 (61 individuals)	271 (61 individuals)	367 (61 individuals)	864 (30 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)
8[1]	4	26.2
182 other visitors logged	3-4 each on average	24.3
451 in tour groups[5]	1 each	0.0 to 0.1 each monitor
Total 641 persons	Total 1174	Total 50.5 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 2012. 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.