

UNIVERSITY OF CALIFORNIA IRVINE (UCI)  
NUCLEAR REACTOR FACILITY (NRF)  
ANNUAL OPERATING REPORT (AOR)  
2024-2025

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## Section 1

# Operations, Personnel and Reviews Summary

The UCI Reactor Facility was used this year by campus and external users for training student operator license candidates, performing neutron activation and gamma irradiation, and teaching a Fall quarter radiation chemistry laboratory course.

### Personnel

Reactor Personnel this period have changed and are as follows:

Reactor Director: Professor A. J. Shaka (SRO)

Reactor Supervisor Emeritus: Professor George Miller

Reactor Supervisor/Facility Manager: Mr. John Keffer (SRO)

Reactor Operators: Mr. Alexander Bihun (RO)

Mr. Andrew Cho (RO)

Ms. Claudia Dewi (RO)

Ms. Jessica Granger-Jones (RO)

Ms. Marian Jardon Figueroa (RO)

Mr. Zach Jennison (RO)

Mr. Victor Klumper (RO)

Mr. John Proctor (RO)

Ms. Faye Saied (RO)

Mr. Max Zhang (RO)

Campus Radiation Safety Officer: Ms. Bridgette Neri (RSO)

### Operations

The facility has maintained open status for research and instruction and normal operations throughout the past year.

Operation of the facility supported UCI and visiting research, external users, and education programs in the Department of Chemistry (CHEM) and other UCI schools and departments. Research is being conducted in the application of radioisotopes as tracers and radiochemical analytical and separation techniques, including focused applications for medical isotope research, and nuclear waste separations. An associate professor appointed in Chemistry is using the facility for nuclear fuel related research.

Reactor utilization, apart from operator training and maintenance, is for analytical sample irradiation, production of isotopic tracers and medical isotopes, and neutron instrument testing. 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. Laboratory classes in September 2024 included work by undergraduates learning tracer and activation analysis techniques using small quantities of short-lived activated materials. The operator training class was held this Spring, 2025.

The operator training program continued with 23 new student participants (Chem 252). The students were selected from Chemistry, Physics, and Engineering departments and the class was open to graduates and undergraduates. Lectures and Discussions were in person, instructed by Professors Shaka. Lab sessions are continuing in facility for 14 students, led by Professor Shaka, through the Summer, 2025.

Seven new RO licenses were awarded to UCI students during the period following examinations administered by the NRC in January 2025.

Use was made of the facility by other educational institutions, using the reactor and the gamma irradiator. The tour program of the reactor facility has continued, attracting visitors from within the University and area schools as well as from the outside and professional community. In person tours were also available for potential graduate students.

Operations continued this year, with the reactor generating 23% less energy and the facility receiving 35% more visitors than last period.

Criticality was achieved for 188.5 hours, a 28% decrease from the previous year, and the total energy generated was equivalent to 91.8 hours at full steady state power. 129 experiments were performed this year, and 514 samples were irradiated. Use of the pneumatic transfer system continued, accounting for some of the facility's Ar-41 release. No pulse was performed this year. A few unusual maintenance/surveillance activities were conducted during this period and are noted in Section 4.

#### Inspections and Reviews

A routine annual NRC inspection was held January 22-24, 2025, with a focus on: (1) Procedures, (2) Experiments, (3) Health Physics, (4) Design Changes, (5) Committees, Audits, and Reviews, and (6) Transportation Activities. The U.S. Nuclear Regulatory Commission (NRC) staff examined activities at the facility as they relate to safety and compliance with NRC requirements. A written report was received March 7, 2024. No findings of significance were identified.

An Emergency/Security exercise was conducted on site in April 2025. On and off campus emergency response personnel were involved in the event and participants toured the reactor facility. In preparation for this event several Zoom planning meetings were held. A full follow-up after action report was prepared and issued by UCI Emergency Service personnel in May 2025.

In April 2025, the required annual Reactor Operations Committee meeting was held remotely via Zoom and Google drive. No significant issues were discussed.

Inspections/audits continue to be conducted monthly and quarterly by the Radiation Safety staff of EH&S at UCI. These have identified that surveillance frequency schedules have been properly maintained, and results continue to show absence of significant levels of contamination or personnel exposure.

## Section 2

### Data Tabulations for the Period July 1st, 2024 to June 30th, 2025

**TABLE I – General Information**

Experiment Approvals on file (active)	3
Experiments performed (including repeats)	129
Samples irradiated	514
Energy generated this period (Megawatt hours)	22.94
Total, 69 element core	127.00
>74 element core	1792.51
Total energy generated since initial criticality (Megawatt hours)	1919.51
Pulse operation this period	0
Total reactor pulses to 6/30/2025	1115
Hours critical this period	188.5
Total hours critical to date	11654.9
Inadvertent scrams or unplanned shutdowns	19
Non-research personnel visits to reactor – logged and PRM issued (incl. tours)	1128
Maximum dosimeter recorded for visits - all less than 1 mrem (non-researchers)	0.2
Visiting researchers (Temporary PRM, incl. repeats)	63
Maximum exposure recorded at one visit (mrem, Temp PRM, researcher)	0.6
Staff and researchers badged with Thermoluminescent Dosimeters (TLD)	17
Students and assistant, or operators training – (TLD badged)	24
Exposures reported for radiochemistry class (2024-25), deep mrem ave.	3
Isotope Shipments off campus this period	4

**TABLE II – Reactor Core Status**

**2025-06-30 (Core Configuration last Changed 2024-01-10)**

Fuel elements in core (including 2 fuel followers)	88
Fuel elements in storage (reactor tank - used)	19
Fuel elements unused (4 instrumented elements + 1 element + 1 FFCR)	6
Graphite reflector elements in core	29
Graphite reflector elements in reactor tank storage	5
Water filled fuel element positions	3
Experimental facilities in core positions	8
Non-fueled control rods	2
Total core positions accounted for	127
Core excess, cold, no xenon (as of 6/24/2025)	\$2.69
Control Rod Worths (Calibrated 02/06/2025)	
REG	\$2.07
SHIM	\$3.62
ATR	\$1.71
FTR	\$0.75
Total	\$8.15
Maximum possible pulse insertion (calculated)	\$2.46
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

TABLE III – Scrams, Unplanned Shutdowns			
2024-07-10		<1.5W	WRM period scram, noise when firing rods, air scram PB reset
2024-08-08		SD	WRLM HV scram, noise on key insert/reset, console power off/on reset
2024-08-08		<1.5W	WRLM HV scram, noise, cleared after ATR drive inserted
2024-08-09		<1.5W	WRM period scram, noise when starting SHIM withdraw
2024-08-12		<1.5W	WRM period scram, noise when starting ATR withdraw
2024-08-12		<1.5W	HV scram, console power off/on reset
2024-08-14		<1.5W	HV scram, noise when starting ATR withdraw, key switch reset
2024-08-29		50kW	PRM HV scram, inadvertent CAL PB depressed
2024-11-05		SD	WRM period scram, noise during ARM/DISARM SUCL
2024-11-07		250kW	WRLM 110% scram, during power ascension, pulling rods too quickly
2024-12-11		<1.5W	WRM period scram, noise when firing rods, console power off/on reset
2025-01-14		<1.5W	WRM period scram when FIRE, AIR PB reset to release FIRE relay
2025-01-16		<1.5W	FT scram, IFE test/cal switch
2025-02-04		200kW	WRLM scram during gain adjust (expected)
2025-03-03		<1.5W	WRM period scram when FIRE, AIR PB reset to release FIRE relay
2025-03-10		<1.5W	WRLM scram, ranging in MANUAL
2025-04-23		250kW	WRLM scram, pulling rods too fast
2025-04-24		250kW	Seismic scram, bumped back panel test PB
2025-05-23		250kW	WRLM scram, pulling rods too fast

One of the scrams was expected during gain adjustment calibration of the WRLM. Eleven of the scrams were attributed to circuit noise when moving rods, especially transient rod arming/firing, or powering the console. Four were inadvertent calibration switch/push-button motion or not ranging automatically. Three were due to withdrawing rods too quickly during power ascension.

## Section 4

### Non-Routine Maintenance and Surveillance and Other Incidents

The following non-routine maintenance/surveillance activities were carried out during this period. As noted earlier, routine surveillance and operations were established as of the start of this review period.

**TABLE IV – Maintenance, Surveillance, and Other Incidents**

2024-07-31	The ground water sump pump that draws subterraneous water from beneath and away from the outside of the reactor pool liner was replaced.
2024-09-10	Building supply damper causing high air pressure outside facility was repaired.
2024-10-25	The remote low pool water level alarm to UCIPD was temporarily inoperable.
2025-06-05	Adjusted set screw on SHIM rod drive pull rod to resolve rod withdrawal issues.
2025-06-11	Replaced WRLM Output Signal Isolation Relay to Yokogawa Chart recorder. Resolved intermittent noise issues with blue pen chart trace.

## Section 5

### Facility Changes and Special Experiments Approved

Four (4) 10 CFR 50.59 change screenings were initiated and completed during the year:

2024-03	7/11/2024	Removed Westronics Paper Chart Recorder from Service.
2025-01	4/15/2025	UCI SOP Changes and Updates, rev 3.3c.
2025-02	5/12/2025	BOSCH Alarm Panel Update.
2025-03	6/12/2025	WRLM Isolated Output Relay replacement.

No new experiments involving the reactor were approved during the period.

## 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 the 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 hanging on the side of the exhausts at the point of entry to the fan creating the 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. 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 consistent at about 20 mrem per year below control level, and >30 mrem below a distant check level (5<sup>th</sup> floor library) so confidence of exposure less than 5 mrem over background seems plausible.

Release estimates based on operational parameters are as follows:

<b>TABLE V – Radioactive Effluent Release Estimates</b>	
Operation of pneumatic transfer system - 07/01/2024 - 06/30/2025:	
A. Minutes of Operation (minutes):	353
B. Release Rate Assumed ( $\mu\text{Ci}/\text{mL}$ ):	6.0 E-08
C. Flow Rate of Exhaust Air ( $\text{mL}/\text{min}$ ):	1.2 E+08
D. Dilution Factor (unitless):	0.01
E. PT System Release Computed ( $\mu\text{Ci}$ ): $A*B*C*D = E$ :	25.42
Release from pool surface – 07/01/2024 – 06/30/2025:	
F. Total Hours of Operation at Full Power (EFPH):	91.78
G. Release Rate Assumed ( $\mu\text{Ci}/\text{mL}$ ):	1.0 E-08
H. Flow Rate of Exhaust Air ( $\text{mL}/\text{min}$ ):	1.2 E+08
I. Dilution Factor (unitless):	0.01
J. Pool Surface Release Computed ( $\mu\text{Ci}$ ): $F*G*H*I*60 = J$ :	66.08
Total Emissions from PT and Pool ( $\mu\text{Ci}$ ): $E + J$ :	91.50
Total Effluent Released in One Year ( $\text{mL}$ ): $525960 \text{ min} / \text{year} * H * I$	6.31 E+11
Average Concentration Released ( $\mu\text{Ci}/\text{mL}$ ): Total Emissions / Total Effluent	14.5 E-11

Since  $2.0 \text{ E-}09 \mu\text{Ci}/\text{mL}$  provides an annual exposure for constant immersion of 10 mrem, the above corresponds to < 1 mrem potential additional radiation exposure to an individual standing in and breathing in the effluent stack for the entire year, a zero-likelihood event. *Note:* Minutes of operation includes PT air blower minutes and CT minutes with  $\text{N}_2/\text{air}$  cooling. *Additional note:* the mixed and diluted exhaust plume is discharged to approximately 100 feet above the roof level (200 feet above surrounding ground), granting even greater dilution.

## (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. 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 including  $^3\text{H}$  from  $^6\text{Li}$  irradiation and purchased materials (exclusively  $^{14}\text{C}$ ). During this period, a campus program to dispose of additional legacy radioisotope materials continued including decayed sealed sources and measurement samples, mostly not UCI reactor related.

Production of radioactive waste materials has been minimal during this period.

### Liquid Waste:

One liquid waste transfer was made this period.

1. 1 container, 0.34 gal (about 280 4ml vials of hydrocarbon distillates and 40 4 ml vials of waters) of waste from sample disposal following activation analysis, activity  $^{76}\text{As}$  (<0.1uCi).
2. 1 container, <5 gal of waste of liquid scintillation cocktail vials in bag lined bucket, with  $^{122/124}\text{Sb}$  (<1uCi); ( $^3\text{H}$  and  $^{14}\text{C}$  activity, <200dps)

### Solid, Dry Waste:

Two solid dry waste transfers were made this period.

1. 1 container, 2 ft<sup>3</sup>, glove waste,  $^{122/124}\text{Sb}$  (<1uCi).
2. 1 container, 2 ft<sup>3</sup>, filters, poly tubes,  $^{54}\text{Mn}$  (0.2uCi),  $^{60}\text{Co}$  (1.0uCi)
3. 1 container, 2 ft<sup>3</sup>, dry solids,  $^{60}\text{Co}$ ,  $^{65}\text{Zn}$ ,  $^{153}\text{Gd}$  (<2uCi ea),  $^{46}\text{Sc}$  (<6uCi),  $^{226}\text{Ra}$  (10uCi), <23uCi total

## Section 7

### Environmental Surveillance

Environmental dosimeters are in place at 12 locations around the UCI Campus for environmental monitoring purposes. These are provided by Mirion Technologies, Oak Ridge, TN (formerly in Irvine, CA). The environmental packs have three chips in each pack which are averaged for exposure recording. Mirion runs multiple control samples in addition to the locations listed below. All dosimeters are housed in small metal locked boxes (except for locations 10 and 12). The tables below list the locations. As work in Engineering Tower 521 had ceased, the dosimeter there was redeployed to the storage closet across the hall from the east side of the reactor facility. Other locations have been renamed to agree with the locations in the revised ventilation system provided for Rowland Hall, and a new laboratory constructed on the former loading dock adjacent to the north side of the facility.

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 of unless found to be free of removable and fixed contamination.

<b>Table VI - Locations for Environmental Dosimeters</b>
1. South Reactor Facility Perimeter
2. West Reactor Facility Perimeter
3. North Reactor Facility Perimeter in adjacent lab of Atmospheric Chemistry group
4. Rowland Hall Roof Air Exhaust Duct to Fan 1
5. Rowland Hall, First Floor Hallway Over Reactor Facility
6. McGaugh Hall Top (5 <sup>th</sup> ) Floor
7. Langson Library Top Floor
8. Reines Hall Top (5 <sup>th</sup> ) Floor
9. Rowland Hall Roof Air Exhaust Duct to Fan 2
10. On-campus Faculty Housing
11. Rowland Hall Roof Air Exhaust Duct to Fan 3
12. Reactor Storage Closet Rowland Hall East side of facility

**Table VII – Environmental Dosimetry Data**

## Average Total Exposures in mrem (Including Control Background)

<u>Location</u>	<u>Quarter</u>				<u>Annual</u>	<u>Prior Year</u>	<u>Above Control</u>
	2024 Q2	2024 Q3	2024 Q4	2025 Q1			
1. S. Facility Perimeter	26	29	26	26	107	115	-1
2. W. Facility Perimeter	30	33	29	28	120	120	12
3. N. Facility Perimeter	28	32	28	29	117	124	9
4. Facility Air Exhaust Fan 1	20	24	20	21	85	86	-23
5. Hallway Over Facility	23	26	24	23	96	98	-12
6. McGaugh Hall Top Floor	25	27	24	24	100	105	-8
7. Langson Library Top Floor	30	35	32	31	128	128	20
8. Reines Hall Top Floor	26	28	26	26	106	109	-2
9. Facility Air Exhaust Fan 2	21	24	20	22	87	90	-21
10. On-Campus Housing	21	25	21	21	88	88	-20
11 Facility Air Exhaust Fan 3	20	24	19	22	85	89	-23
12 E. Facility Closet	23	29	22	25	99	105	-9
Background Control	26	30	26	26	108	109	0

Discussion

Raw data is presented here, along with controls and prior year comparisons. Within this range, the data sets vary relatively little. Locations on walls bordering the facility, such as 1, 2, 3, are usually the highest, whereas remote locations, such as 10, 5, 6, 12, and 8, aside from the diluted facility exhausts, are 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. This has been a result continuing for many years.
- Location 1 is near the facility's gamma irradiator, as well as a lead cave which continues to store a higher activity load.
- Location 2 is on the other side of a location in the reactor facility temporarily used for source storage.
- Location 3 is on the other side of a concrete wall from the ion exchange resin tanks and a second lead storage cave which have moderate levels of activity. This location is also in a radiation use laboratory, which may be contributing to the higher dose readings but more likely due to TNORM in the concrete wall and floor.

Conclusion

Exposure estimated to a single individual in any uncontrolled area at this facility is minimal. With the exception of two locations nearest the facility, all dosimetry associated with exposures from the facility indicates at or lower than control levels. 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), and location 3 is in an adjacent radiation use laboratory. The hallway overhead (location 5) is only casually occupied and not close to a main building entrance. 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 within statistical error of zero of potential (full 24/7 occupancy) public exposure over normal background levels.

## Section 8

### Radiation Exposure to Personnel

UCI issues TLD badges to students or researchers regularly utilizing radiation within the facility. Finger dosimetry (TLD) rings were also issued to all those personnel, as there is a strong likelihood of regularly handling radioactive sources. TLDs were read quarterly by Mirion Technologies, and results are presented in Table VIII. Data are for 4 quarters of operations since April 1, 2024. Reporting categories are deep, eye, shallow, and ring shallow. Neutron dosimetry badging was discontinued owing to absence of any recorded exposure greater than zero after many years. Other individuals visiting or casually working in the facility were issued Personal Radiation Monitors (PRM) DMC 3000s (aka EPDs) for which results are shown in Table IX. 17 persons were issued TLD badges and finger TLDs on a continual basis. Researchers, operator trainees, and radiochemistry lab students have also been issued TLDs.

Table IX also lists all visiting individuals that were issued DMC 3000s (PRM) that record in units of 0.1 mrem. Over the span of a few hours, a typical worker could accumulate 0.2 mrem background. A tour visitor usually accumulates 0.0 or 0.1 mrem during a 45-minute visit to the facility.

**TABLE VIII**  
**Aggregate Personnel Exposure from TLD (mrem) 2024-04-01 to 2025-04-01**

Group	Individuals	Whole Body			Ring
		Deep	Eye	Shallow	Shallow
A	8	8	8	8	202
B	4	0	0	0	45
C	5	2	2	3	0
D	24	71	77	81	0
<b>Total</b>	<b>41</b>	<b>81</b>	<b>87</b>	<b>92</b>	<b>247</b>

**TABLE IX**  
**Data from EPDs for Workers and Visitors**

Group	Persons Admitted*	Max Dose (mrem)	Total Dose (mrem)
A	29	0.6	3.8
B	6	0.1	0.1
C	110	0.1	0.2
D	96	0.1	0.5
E	950	0.2	8.6
<b>Total</b>	<b>1191</b>		<b>13.2</b>

\* Multiple admissions of the same individual are separately counted. 1050 unique individuals were logged in.

**Group A:** Activation Analysis Personnel: individuals doing extensive or casual activation analysis and radiochemical work at the facility. Most of the exposure is a result of  $^{38}\text{Cl}$ ,  $^{28}\text{Al}$ , or  $^{226}\text{Ra}$  radioactivity production/handling.

**Group B:** Workers: individuals receiving exposure from the handling isotopes for shipment, and/or sources used for calibration activities in the facility.

**Group C:** Inactive / Other: individuals who did enter but not directly carry out radiation related activities during this period, therefore any exposure reported is an indication of range of general background (for PRM) or background and precision where the TLDs are stored when not in use. This group includes visiting researchers admitted to review facilities for potential experiments, those bringing and taking away samples exposed in the cesium gamma irradiator in the facility and maintenance workers NOT doing work on radiation related systems all of whom are always issued EPD. [Note: Operation of the gamma irradiator is restricted to badged staff personnel].

**Group D:** Class Students: Radiochemistry Lab (Chem 133L) and Operator Training (Chem 252).

**Group E:** Tourists: includes tour groups that entered the facility this period.

Personnel exposures continue to be very low at this facility in keeping with ALARA efforts and the low degree of operations experienced. 12 individuals performed activation analysis activities this period. Handling activities of  $^{38}\text{Cl}$ ,  $^{24}\text{Na}$ , and  $^{226}\text{Ra}$  containing samples leads to some exposure. No radiation exposures received were greater than 25% of that allowed.

## Section 9

### Closing Remarks

The facility has seen increased numbers of visitors and a decrease in the operating hours of use for instruction and research from last year. Key personnel departure and retirement are being addressed to ensure continued function. Waste generation and disposal has remained at its traditionally low values, given the low power of the reactor and the capacity for short term storage of materials. Some activated hardware from SPND testing and medical isotope development have been generated and stored for later disposal. Radiation exposure to personnel also remains low, attributing most dose absorbed per person to the activation analysis activities of the facility or to handling of calibration sources.

The increase in facility activities has been supported by increased involvement of the Reactor Director, Supervisor Emeritus, and Radiochemistry faculty. Licensed operator status and new candidate training has received increased focus.

An Associate Professor of Chemistry has assumed teaching roles within the radiochemistry program and implemented a radiochemistry and nuclear fuel-oriented research program with growing research group membership and summer student participants.

It is anticipated that reactor operations including laboratory classes, tours and research, and selected improvements to the facility will continue in the coming year.