2021
ANNUAL REPORT

Docket Number 50-607
License Number R-130

UCDAVIS MNRC
McCLELLAN NUCLEAR RESEARCH CENTER

UCD/MNRC ANNUAL REPORT FOR 2021

1. Introduction

The University of California, Davis, McClellan Nuclear Research Center (UCD/MNRC) consists of a research reactor, associated radiography and positioning equipment, and a wide variety of equipment to support broad-based research activities. This Annual Report is published each year in support of the license provided by the United States Nuclear Regulatory Commission (NRC). The aforementioned license is for the operation of a steady-state TRIGA™ reactor.

The intent of this document is to provide information relevant to the operation and safety of the UCD/MNRC. A brief description of the UCD/MNRC facility and administration is followed by an operational summary and health physics information for this facility during CY 2021.

2. UCD/MNRC Facility Description

The UCD/MNRC is located on the McClellan Industrial Park site; the reactor is housed in Building 258. The McClellan Industrial Park site is approximately 2600 acres, located eight miles northeast of Sacramento, California.

The UCD/MNRC facility is a three-level ~18,000 sq. ft. rectangular-shaped enclosure that surrounds a 2 MW research reactor. The UCD/MNRC provides four neutron beams to four bays for radiography and other research and commercial activities. Space, shielding and environmental controls are provided by the enclosure for neutron radiography operations performed on a variety of samples.

In addition to the radiography bays, the UCD/MNRC reactor also has several in-core facilities ranging from a pneumatic tube system to a central irradiation facility.

For more detailed information on the UCD/MNRC project, the reader is referred to the UCD/MNRC Safety Analysis Report.

3. UCD/MNRC Administration

The UCD/MNRC is licensed by the Nuclear Regulatory commission (NRC) to operate under the provisions of operating license R-130. The University of California Regents have designated the Chancellor at UC Davis to be the license holder. The UCD Chancellor has in-turn delegated the Vice Chancellor for Research to be the licensee of record.

The UCD/MNRC is under the direction of the UCD/MNRC Director.

4. Operating Experiences

4.1 Experiments

No new experiments were approved this year, and no changes were made to existing experiments. Table 4.1 shows the number of experiments conducted in each experiment facility:

TABLE 4.1
2021 SUMMARY OF EXPERIMENTS

Experiment Facility	Number of Experiments	Typical Experiment Facility Utilization
Central Irradiation Facility	6	In-tank, in-core irradiations
Pneumatic Transfer System	0	
Neutron Irradiator	10	In-tank, out-of-core, fast neutron irradiations
Silicon Fixture	11	In-tank, out-of-core irradiations
Bay 1	964	Neutron radiography
Bay 2	1740	
Bay 3	94	
Bay 4	58	

4.2 Changes in Facility Design

There were no changes in the design of the UCD/MNRC facility.

4.3 Changes to Performance Characteristics and Operating Procedures

The latest thermal hydraulic analysis provided to the NRC concluded that a critical heat flux of 2.0 is reached with the current core configuration somewhere between 1.2 and 1.3 MW. As a result, the following changes have been made:

1. The annual reactor power calibration was performed at 800kW instead of 1600 kW.
2. The annual high-power scram tests were performed using the TRIGA prestart check routine and the console scram test functions for both power level safety channels instead of operating at the SCRAM setpoint (~2.14 MW).
3. As of November 5, 2021, the UCD/MNRC is administratively limited to steady state reactor operations at 1.0 MW or less. Reactor pulsing is not allowed and reactor power shall not exceed 1.2 MW for any reason.

These changes were analyzed through 50.59 Screening processes. It was determined that none of the changes qualified as facility modifications. 50.59 Screenings for the changes to the reactor power calibration and high-power SCRAM tests were approved on September 30, 2021, and the screening for the 1.0 MW administrative power limit was approved on November 5, 2021.

4.4 Surveillance Tests and Inspection Results

Surveillance tests and inspections were performed as required by the UCD/MNRC Technical Specifications with satisfactory results for all systems.

The annual reactor maintenance shutdown was completed during the month of August. During the shutdown, inspection of fuel elements and control rods was performed in accordance with the UCD/MNRC Technical specifications. All fuel element and control rod measurements were within the tolerances defined in the Technical Specifications, and there were no indications of deterioration or damage to any of the inspected elements or control rods systems.

Parametric values noted during testing were as follows:

Control Rod Worth:

Transient Rod:	$1.83
Regulating Rod:	$2.74
Shim 1:	$2.54
Shim 2:	$2.49
Shim 3:	$2.50
Shim 4:	$2.92

Control Rod Drop Times (in Seconds):

Transient Rod:	0.36
Regulating Rod:	0.41
Shim 1:	0.39
Shim 2:	0.37
Shim 3:	0.42
Shim 4:	0.40

Shutdown Margin: $6.78

Nuclear instrument calorimetric calibrations were performed during the annual reactor maintenance period. Minor adjustments were made to the NPP-1000 and NM-1000 detectors to match the measured calorimetric power.

5. Energy Generated by the Reactor

TOTAL OPERATING HOURS THIS YEAR:	1527.48
TOTAL OPERATING HOURS:	57714.21
TOTAL MEGAWATT HOURS THIS YEAR:	1445.30
TOTAL MEGAWATT HOURS:	71929.29
TOTAL NUMBER OF PULSES PERFORMED THIS YEAR:	0
TOTAL NUMBER OF PULSES PERFORMED:	484

6. Unscheduled Reactor Shutdowns

There were three SCRAMs and one unscheduled shutdown in 2021. Each event is described in Table 6.1:

TABLE 6.1
2021 SUMMARY OF UNSCHEDULED REACTOR SHUTDOWNS

Date	Event	Description of Event
2/18/2021	Silent SCRAM	At 16:22, the reactor was operating at 1.0 MW steady-state power in the automatic mode when it was observed that all of the control rods had separated from their electromagnets and were fully inserted into the reactor core. The electromagnets were still energized, but all other indications of reactor power, reactor period, and fuel element temperatures confirmed the reactor was subcritical with a negative period. There was no visual, audible, or recorded cause of the control rod separations, and there was no obvious external event that could explain the silent SCRAM, which is believed to have been caused by a momentary loss of electromagnet power. After de-energizing the electromagnets by initiating a manual SCRAM, control rod operability and SCRAM time checks were performed for each control rod. All checks were completed satisfactorily. Normal operations were resumed. The problem did not reoccur.
3/11/2021	Unscheduled Shutdown	At 12:49, the reactor was shut down to look for a possible item dropped in the reactor tank. A pen was found at the bottom of the tank.
4/15/2021	Database Timeout SCRAM	At 12:26, a reactor SCRAM was initiated by a Database Timeout. The error cleared on acknowledgement.
11/17/2021	Manual SCRAM	At 13:10, a reactor SCRAM was initiated by the inadvertent operation of the Reactor Room Manual SCRAM Button.

7. Maintenance Operations

Scheduled preventative maintenance items were conducted throughout the year with satisfactory results and no major issues. The annual reactor maintenance shutdown was completed in August. During the shutdown, preventative maintenance was performed on the control rod drives and radiography bay shielding doors. No significant issues were identified. Control rod, nuclear instrument, and fuel temperature calibrations were also performed satisfactorily during the shutdown. Preventative maintenance on the cooling tower was performed satisfactorily in December.

Non-routine maintenance items related to systems that may be associated with reactor safety are described in the Table 7.1.

TABLE 7.1
2021 SUMMARY OF NON-ROUTINE MAINTENANCE

Open date	Close date	Description
5/14/2021	5/17/2021	An air leak was repaired in the Bay 3 fast shutter actuation system. This shutter is used for radiography, not biological shielding. There was no impact on safety.
6/23/2021	6/23/2021	The Reactor Room Continuous Air Monitor's motor power switch was replaced. It was hot to the touch. There was no impact on reactor safety.
7/20/2021	7/20/2021	The Reactor Room Continuous Air Monitor's fuse holder was replaced. It was getting hot during operation. There was no impact on reactor safety.
9/30/2021	1/28/2022	A leak in the fire sprinkler system was repaired and a few sprinkler heads were replaced. The leak was not significant enough to render the system inoperable. There was no impact on reactor safety.
11/1/2021	11/5/2021	Dedicated ground conductor bars and tandem collectors were installed on Bay 2 & 3 Staging Area, Bay 4 Staging Area, and Equipment Room cranes to conform with current crane requirements. There was no impact on reactor safety.
11/4/2021	11/4/2021	A leak was repaired in the helium line leading to the Bay 4 beam tube. The leak was in the reactor room. It was identified and repaired before the helium supply was depleted. There was no impact on reactor safety.
12/2/2021	12/2/2021	The depleted inlet deionizing resin bottles to the reactor makeup water tank were replaced. There was no impact on reactor safety.
12/1/2021	12/1/2021	The reactor room's air conditioner (AC-1) was not providing heating service and was repaired. There was no impact on reactor safety.
12/16/2021	Repairs in Progress	The primary cooling system's ultrasonic flow sensor stopped reporting flow measurements. It has been taken out of service. A replacement system has been identified and will be installed when it arrives. The loss of the flow sensor does not impact reactor safety. Primary coolant flow is still monitored and reported to the reactor operator by the primary flow proof switch, and the failed sensor is not required by the UCD/MNRC Technical Specifications.

8. Facility and Procedure Changes

8.1 Facility Modifications

One class III facility modification, FMIII-21-001: Removal of Bay 3 "SAIC Plug" Beamline Insert, was performed in 2021. The goal of the modification was to remove a plug at the end of the Bay 3 beamline and increase the size of the neutron beam so that the bay could better support neutron radiography. An evaluation of the proposed modification was performed prior to starting work on the project. It was concluded

that the change did not meet any of the 10 CFR 50.59 criteria, and therefore, no license amendment or change to the Technical Specifications was required. Special Operating Procedure, SOP 21-01, was created for the modification. Work was successfully completed on May 10, 2021. A radiological survey was performed after the modification was completed. Radiation levels remained in compliance with pre-modification radiation postings and all other applicable provisions of 10 CFR Part 20.

8.2 Procedure Changes

Some preventative maintenance and surveillance frequencies were adjusted in 2021. All surveillance items remain in compliance with the requirements of the UCD/MNRC Technical Specifications. These changes were evaluated in a 50.59 screening on December 3, 2021. Table 8.1 provides details on changes that are associated with systems related to reactor safety.

TABLE 8.1
2021 SUMMARY OF CHANGES TO PROCEDURE FREQUENCIES

Item	Frequency Change*	Reason for Change
CALIBRATION - BAY CAM	A → Remove	Bay CAM is no longer in service
BAY CAM - Oil change and greasing	Q → Remove	
Sample Secondary Water	M → Remove	Secondary water conductivity and pH are continuously monitored by the secondary cooling system's chemical addition system
Cycle Demineralizer Valves	M → S	Frequent valve operation may lead to leaks or premature failure
Cycle Primary Valves	M → S	
Cycle Secondary Valves	M → S	
Check the Tell-Tale Drain	M → Remove	There are no penetrations in the reactor tank, no history of tank leaks, and tank water level is monitored regularly as part of reactor startup and shutdown procedures
Drain and Clean Cooling Tower	Q → A	Sediment and contaminant levels do not warrant quarterly cleaning
Calibrate ECCS Supply Pressure gauge.	S → Suspend	The 1 MW administrative restriction placed on reactor operations as of November 5, 2021 suspends the need perform surveillance items on the ECCS, AMUWS, and Generator systems.
Perform flow test of ECCS supply.	S → Suspend	
Flow test in-tank ECCS flow nozzle	S → Suspend	
Change Generator Crankcase Oil and Oil Filter	A → Suspend	
Sample AMUWS for Activity	S → Suspend	

Exercise Generator set	W → Suspend	The 1 MW administrative restriction placed on reactor operations as of November 5, 2021 suspends the need perform surveillance items on the ECCS, AMUWS, and Generator systems.
Sample AMUWS System	M → Suspend	
Clean AMUWS Demin FM batt. Terminals	A → Suspend	
Calibrate AMUWS pressure gauges	A → Suspend	
Clean and Inspect Power Transfer Switch	A → Suspend	
Clean Propane Generator Air Cleaner	B → Suspend	
Leak Check the Helium Pressurization System Mechanical Joints	M → Remove	Leaks in the helium system are effectively identified by routine observation of helium tank pressure

* M = Monthly, Q = Quarterly, S = Semi-Annually, A = Annually
Remove = Item completely removed from Preventative Maintenance Management System
Suspend = Item temporarily suspended while not required

9. Radioactive Effluents

A summary of the nature and amount of radioactive effluents released or discharged to the environment beyond the effective control of the MNRC, as measured at or prior to the point of such release or discharge, include the following:

9.1 Liquid Effluents

No liquid effluents were released during 2021.

9.2 Airborne Effluents

Airborne radioactivity discharged during 2021 is tabulated in Table 9.1 below.

TABLE 9.1
2021 SUMMARY OF AIRBORNE EFFLUENTS

MONTH	TOTAL MEASURED Ar-41 RELEASED (Ci)	CALCULATED AVG. CONC. OF Ar-41 IN UNRESTRICTED AREA [1] (uCi/ml)	CALCULATED DOSE FROM Ar-41 IN UNRESTRICTED AREA (mrem)	FRACTION OF 10 CFR 20 DOSE LIMIT (%)	RELEASED PARTICULATE FORM WITH HALF-LIFE >8 DAYS (Ci)	RELEASED PART. ACT. RELEASED WITH HALF-LIFE > 8 DAYS (uCi/ml)
JAN	2.81	2.82E-10	0.12	1.2	NONE	NONE
FEB	2.86	2.87E-10	0.12	1.2	NONE	NONE
MAR	3.29	3.30E-10	0.14	1.4	NONE	NONE
APR	3.08	3.09E-10	0.13	1.3	NONE	NONE
MAY	2.31	2.32E-10	0.10	1.0	NONE	NONE
JUN	2.32	2.33E-10	0.10	1.0	NONE	NONE
JUL	2.59	2.60E-10	0.11	1.1	NONE	NONE
AUG	1.62	1.63E-10	0.07	0.7	NONE	NONE
SEP	2.43	2.44E-10	0.10	1.0	NONE	NONE
OCT	2.60	2.61E-10	0.11	1.1	NONE	NONE
NOV	2.17	2.18E-10	0.09	0.9	NONE	NONE
DEC	1.93	1.94E-10	0.08	0.8	NONE	NONE
TOT	30.02		1.25	12.5	NONE	NONE
AVG	2.50	2.51E-10				

(1) This location is 100 meters downwind which is the point of maximum expected concentration of Ar-41 based on an average wind speed of 2 m/s and atmospheric stability class B.

9.3 Solid Waste

No solid radioactive waste was shipped this year.

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10. Radiation Exposure

Radiation exposure received by facility operations personnel, facility users, and visitors during 2021 is summarized in Table 10.1 below.

TABLE 10.1
2021 SUMMARY OF PERSONNEL RADIATION EXPOSURES

	NUMBER OF INDIVIDUALS	*AVERAGE TEDE PER INDIVIDUAL (mrem)*	*GREATEST INDIVIDUAL TEDE (mrem)*	*AVERAGE EXTREMITY (1) (mrem)*	*GREATEST EXTREMITY (mrem)*
FACILITY PERSONNEL	10	38	110	170	420
FACILITY USERS	143	<1.0	2.0	*	*
VISITORS	462	<1.0	1.0	*	*

(1) Only 3 individuals received extremity exposure

***** Extremity monitoring was not required.

11. Radiation Levels and Levels of Contamination

Radiation levels and levels of contamination observed during routine surveys performed at the MNRC during 2021 are summarized in Table 11.1 below.

TABLE 11.1
2021 SUMMARY OF RADIATION LEVELS AND CONTAMINATION LEVELS DURING ROUTINE SURVEYS

	AVERAGE (mrem/hr)	HIGHEST (mrem/hr)	AVERAGE (dpm/100cm²)	HIGHEST (dpm/100cm²)
OFFICE SPACES	<0.1	<0.1	<5000(1)	<5000(1)
REACTOR CONTROL RM	<0.1	<0.1	<5000(1)	<5000(1)
RADIOGRAPHY CONTROL RM	<0.1	<0.1	<5000(1)	<5000(1)
COUNTING LAB	<0.1	<0.1	<5000(1)	<5000(1)
STAGING AREA	<0.1	<0.1	<5000(1)	<5000(1)
FACILITY (Fenceline)	<0.1	<0.1	<5000(1)	<5000(1)
EQUIPMENT RM	0.6 (4)	70 (5)	<800(2)	<800(2)
DEMINERALIZER AREA	13(4)	220(5)	<800(2)	<800(2)
REACTOR RM	4.0(4)	590(5)	<800(2)	<800(2)
RADIOGRAPHY BAYS	0.5(3)	215	<800(2)	<800(2)

(1) <5000 dpm/100 cm² = Less than the lower limit of detection for a scanning survey.

(2) <800 dpm/100 cm2 = Less than the lower limit of detection for a swipe survey.

(3) Due to Bay 1 Storage Areas; all other areas and bays are significantly lower (typically <0.1 mrem/hr).

(4) General area dose rate.

(5) Maximum contact dose rate.

12. Environmental Surveys

Environmental surveys performed outside of the MNRC during 2021 are summarized in Tables 12.1 & 12.2 below. The environmental survey program is described in the UCD/MNRC Safety Analysis Report.

TABLE 12.1
2021 SUMMARY OF ENVIRONMENTAL TLD RESULTS
(WITH NATURAL BACKGROUND(1) SUBTRACTED)

	AVERAGE (mrem)	HIGHEST (mrem)
ON SITE (SITES 50 – 61 & 65-71)	15	27

(1) Natural background assumed to be the off park (Sites 27-42) average of 57 mrem.
(2) This report no longer includes the "on base" sites as has not been relevant since 2000.

TABLE 12.2
2021 SUMMARY OF RADIOACTIVITY IN WELL WATER

	ALPHA (pCi/l)	BETA (pCi/l)	TRITIUM (pCi/l)	Cs-137 (pCi/l)
AVERAGE	<MDA	1.07	<MDA	<MDA
HIGHEST	<MDA	1.92	<MDA	<MDA

MDA is the minimum detectable activity at the 95% confidence level.

The MDA range for the analyzed radionuclides (pCi/L).

	MIN	MAX
Alpha	2.50	4.09
Beta	1.70	1.92
Tritium	169	230
Cs-137	16.9	23.0