UCDAVIS
MNRC
McCLELLAN NUCLEAR RADIATION CENTER

5335 PRICE AVENUE
BUILDING 258
McCLELLAN, CA 95652
PHONE: (916) 614-6200
FAX: (916) 614-6250
WEB: http://ovcr.ucdavis.edu/mnrc

May 29, 2001

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
1 White Flint North
11555 Rockville Pike
Rockville MD 20852

Ref: University of California, Davis McClellan Nuclear Radiation Center (UCD/MNRC), Docket No. 50-607, Facility Operation License No. R-130

Subject: UCD/MNRC Annual Report for CY 2000

Gentlemen,

Attached is the UCD/MNRC Annual Report for CY 2000 as required by the UCD/MNRC Technical Specifications, Section 6.7.

Questions concerning this report should be directed to Dr. Wade J. Richards, 916-614-6200.

Sincerely

WADE J. RICHARDS, Ph.D.
Director
UCD/MNRC

Attachment:
UCD/MNRC Annual Report for CY 2000 (2 copies)

cc: Dr. W. Eresian, NRC (w/atch, 2 copies)

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MNRC

McCLELLAN NUCLEAR RADIATION CENTER

2000
ANNUAL REPORT

1.0 Introduction

The University of California, Davis McClellan Nuclear Radiation Center (MNRC) consists of a research reactor and associated radiography and positioning equipment. This MNRC 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 with pulsing capability.

It is the intent of this document to provide information relevant to the safe operation of the UCD/MNRC. A brief description of the MNRC facility and administration is followed by operational events and health physics information concerning this facility during CY 2000.

2.0 General Information

The United States Air Force (USAF) began building the reactor in 1988 and completed the project in 1990. The McClellan Nuclear Radiation Center (MNRC) achieved criticality on January 20, 1990. The reactor was operated at 1 MW from 1990 to 1997. The reactor was upgraded to 2 MW and the first 2 MW operation was done on April 14, 1997.

The USAF ran the reactor from 1990-1999 in support of their nondestructive inspection program. This program involved inspecting aircraft structures for signs of moisture and corrosion using neutron radiography.

McClellan Air Force Base is scheduled to close July 2001. Therefore, the MNRC was officially transferred to the University of California, Davis (UCD) on February 2, 2000. This transfer also included the Nuclear Regulatory Commission (NRC) operating license R-130 from the USAF to UCD.

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.

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

3.0 UCD/MNRC Facility Description

The UCD/MNRC facility is a three level 14,720 sq. ft. rectangular-shaped enclosure that surrounds a 2 MW research reactor. The UCD/MNRC provides four neutron beams and four bays for radiography. All four bays are capable of using radiography film techniques, but Bays 1 and 3 will normally use electronic imaging devices. Space, shielding and environmental controls are provided by the enclosure for neutron radiography operations performed on a variety of samples. Adequate room has been provided to handle the components in a safe manner.

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.

4.0 UCD/MNRC Programs

The year 2000 saw the official transfer of the USAF McClellan Nuclear Radiation Center (MNRC) to the University of California. The MNRC is now owned by the University of California (UC). The operating license (R-130) is administered by UC Davis (UCD).

UCD contracted with Science Applications International Corporation (SAIC) to operate the Center. The programmatic emphasis of the UCD/MNRC changed from the earlier work done by the USAF. The major program emphasis is now educations and research, with a commercial component to increase reactor utilization.

- Education Programs

-- Grants

(1) UCD Geology Department program to study the composition of rocks and soil utilizing the neutron tomography and film radiography systems.

(2) Oregon State University (OSU) program to develop a neutron activation analysis capability at the UCD/MNRC. In addition, classes have been developed at the graduate and undergraduate levels for the UCD/MNRC.

(3) Oregon State University (OSU) program to investigate soil remediation technology at the Hanford, Oregon site. This program utilizes the UCD/MNRC radiography and irradiation capabilities.

- Research

Working with UC Berkeley facility on the Cold Dark Matter program. Irradiating samples in the central facility.

- Commercial

-- Precision Casting Company (PCC). Performing neutron radiography on large investment castings.

-- White Sands Test Facility (WSTF). Performing neutron tomography and film radiography or values and pressure vessels.

-- ICI Tracer Company (ICI). Produced Argon-41 gas for industrial use.

-- New England Nuclear (NEN). Produced P-32 for commercial use.

5.0 UCD/MNRC Administration

UCD/MNRC Organization. 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 license of record.

UCD contracted with Science Applications International Corporation (SAIC) to operate the MNRC.

The UCD/MNRC is under the direction of the UCD/MNRC Director. The Director is a UCD employee that reports to the Vice Chancellor for Research.

A complete organization chart can be found in the UCD/MNRC Safety Analysis Report, Chapter 13.

6.0 Licensing and Regulatory Activities

6.1 Items sent to the NRC.

a. Changes to the Safety Analysis Report (SAR) reflecting the transfer from USAF to UC ownership.

b. Requested changes to the MNRC Technical Specifications reflecting the transfer from USAF to UC ownership.

c. Requested change to the MNRC Emergency Plan and Physical Security Plan reflecting the transfer from USAF to UC ownership.

6.2 Nuclear Safety Committee (UCD/NSC).

a. The annual NSC audit of the UCD/MNRC was conducted during the months of May, June and July 2000. The overall rating was satisfactory.

b. The NSC met twice during 2000.

(1) March, 2000
(2) September, 2000

6.3 The Nuclear Regulatory Commission performed two inspections during the year 2000.

(1) February 7-11, 2000, Reactor Operations
(2) October 24-27, 2000, Health Physics Program

7.0 OPERATIONS

A. OPERATING HISTORY:

7.1

TOTAL OPERATING HOURS THIS YEAR:	1,328.72
TOTAL OPERATING HOURS:	22,569.08
TOTAL MEGAWATT HOURS THIS YEAR:	2,192.63
TOTAL MEGAWATT HOURS:	27,116.88
TOTAL NUMBER OF PULSES PERFORMED THIS YEAR:	0
TOTAL NUMBER OF PULSES PERFORMED:	410
	425

7.2 UNSCHEDULED REACTOR SHUTDOWNS:

In 2000, there were twenty-eight (28) unscheduled scrams at the MNRC reactor Facility. Watchdog scrams are the largest contributor to the total number of unscheduled shutdowns (50%) followed by equipment failure/problems (25%), facility electrical power loss (11%), argon transfers (7%), and possible fuel element leak (7%). The following is a list of the unscheduled shutdowns:

DESCRIPTION OF UNSCHEDULED SHUTDOWNS	NUMBER OF REACTOR SHUTDOWNS
A. AUTOMATIC SCRAMS	
1. *CSC or DAC watchdog time-out scrams*	**14**
2. *NPP-1000 High Power*	
a. *Undetermined (04-12-00 and 04-17-00)*	**2**
3. *NM-1000 High Power*	
a. *Undetermined (07-07-00 and 10-09-00)*	**2**
4. *Control Rods Dropped Off During Reactor Operations*	
a. *Undetermined (06-13-00)*	**1**
5. *Loss of Building Power (08-03-00, 10-25-00, and 10-26-00)*	**3**
B. MANUAL SHUTDOWNS	
1. *Erratic Fuel Temperature Readings (07-21-00)*	**1**
2. *Loss of High Resolution Monitor (12-18-00)*	**1**
3. *Alarm on Reactor Room CAM*	
a. *Possible fuel element leak (10-20-00 and 10-26-00)*	**2**
b. *^{41}Ar Transfer (03-16-00 and 03-27-00)*	**2**
TOTAL NUMBER OF UNSCHEDULED SHUTDOWNS IN 2000	**28**

January

1. While operating, the reactor automatically scrammed three times during the month due to CSC watchdog circuit time outs. In all cases, operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

February

1. While operating, the reactor automatically scrammed once during the month due to CSC watchdog circuit time outs. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

March

1. While operating, the reactor automatically scrammed three times during the month due to CSC watchdog circuit time outs. In all cases, operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

2. On 03-16-00 at 1035 and again on 03-27-00 at 1407, the reactor operator manually scrammed the reactor when the reactor room cam alarmed during ^{41}A transfers. In both cases, there was not any release of ^{41}A to the reactor room or environment. During the finial steps of the ^{41}Ar, transfer procedure the operator vents the excess ^{41}A to a holding tank located in the overhead of the reactor room. The vent line passes on the same side of the reactor room that the reactor room cam is located. The increase in background radiation levels is causing the reactor room cam to alarm.

   Operations personnel will rerouted the vent line to the other side of the reactor room such that it does not pass the cam room. In the future, operations personnel will shutdown the reactor just prior to the transfer of ^{41}A until the relocation of the vent line is accomplished. Additional testing of the transfer system will be completed to ensure this is the only source of radiation affecting the reactor room cam during the transfer.

April

1. On 04-12-00 at 1206 and again on 04-17-00 at 1443, the reactor scrammed on NPP-1000 high power scram. The reactor was operating at a steady state of 2MWs with no other operations in progress. The Senior Reactor Operator upon entering the console's history playback mode noted that the indicated reactor power on the NPP-1000 was only 97 % (1.94 MWs) and 98% (1.96 MWs) at the times the automatic scrams occurred. There was not an actual high power level scram in either case.

   Operations personnel found all components acceptable after testing the NPP-1000. Pre-start tests and all scram checks of the NPP-1000 performed by

operations personnel were satisfactorily. No cause for the scrams could be determined other than electronic spikes. The Senior Reactor Operator granted the reactor operator to resume normal reactor operations at 2-MWs.

May

None

June

1. While operating, the reactor automatically scrammed once during the month due to CSC watchdog circuit time outs. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

2. On 13 June 2000 at 1026, the reactor was operating at 1.4 MW when all the control rods fell to the bottom with no scram indications. The electronics engineer was performing voltage checks in the DAC on the 1-KW interlock system at the time of the reactor scram. When the Senior Reactor Operator entered the history playback mode, all the conditions displayed were the normal operating conditions. No cause for the scram could be determined other then the electronics engineer causing an interruption of the magnet power supply while making voltage measurements. The Senior Reactor Operator performed all scram, interlocks check on the console, and tested all the control rods for operability. After the completion of these checks, normal reactor operations continued.

July

1. On July 07, 2000 at 1350, the reactor scrammed on NM-1000 high power scram. The reactor was operating at a steady state of 2MWs with no other operations in progress. The Senior Reactor Operator upon entering the console's history playback mode noted that the indicated reactor power on the NPP-1000 was only 100% (2.00 MWs) at the times the automatic scram occurred. There was no actual high power level scram.

   Operations personnel found all components acceptable after testing the NM-1000. Pre-start tests and all scram checks of the NM-1000 performed by operations personnel were satisfactorily. No cause for the scrams could be determined other than electronic spikes. The Senior Reactor Operator granted the reactor operator permission to resume normal reactor operations at 2-MWs.

2. On July 21, 2000 at 0900, operations personnel were performing a normal reactor startup. When reactor power was approaching 50%, the reactor operator noted that fuel temperature #1 indication was lagging behind the fuel temperature #2 indication. The normal expected indication is for fuel temperature #1 to be slightly higher than fuel temperature #2 once past the point of adding heat and all the way to full power. The Senior Reactor Operator held power at 70% to see if fuel temperatures would stabilize at the

expected levels with no further power increase. Fuel temperature #1 readings were consistently lower than expected and were becoming erratic. The Senior Reactor Operator directed the reactor to be shutdown.

Once the reactor was shutdown, operations personnel performed the fuel temperature portions of the startup checklist to isolate the problem to the instrumentation or the detector. Satisfactory completion of the scram tests indicated that the problem was probably not in the DAC/CSC instrumentation or computers.

The Senior Reactor Operator checked the thermocouple connections under the north end of the bridge for tightness, and found no loose connections. Additional inspections performed on the fuel temperature Action Pac's determined they were properly seated, and properly installed. Operations personnel inspected the thermocouple wiring from the top of the stainless steel tubing that protects the thermocouple wires from moisture all the way to the first connectors in line. A small piece of black electrical tape was found on the fuel temperature #1 thermocouple wire just above the stainless steel tube. This piece of tape/insulation was starting to unravel. Personnel applied additional electrical tape to reseal the original tape repair and to further insulate the thermocouple wire a little above and below the suspected break in the thermocouple insulation.

Operations personnel repeated checks on fuel temperature channels 1 and 2. After the completion of these checks, operations personnel started the reactor and both fuel channels performed normally.

In addition, operations personnel encased the thermocouple wires in sheathing to protection the wires from chafing or anything accidentally snagging the wires.

August

1. While operating, the reactor automatically scrammed once during the month due to CSC watchdog circuit time out. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

2. On August 03, 2000 at 0942, operations personnel were operating the reactor at 2-MWs when incoming building power was lost for approximately two hours. After the restoration of building power, operations personnel performed the daily checks on the reactor and associated system and normal reactor operations continued.

September

1. While operating, the reactor automatically scrammed twice during the month due to CSC watchdog circuit time out. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

October

1. While operating, the reactor automatically scrammed once during the month due to a CSC watchdog circuit time out. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

2. ON October 09, 2000 at 0927, the reactor scrammed on NM-1000 high power scram. The reactor had just reached a steady state power level of 2-MWs with no other operations in progress. The Senior Reactor Operator upon entering the console's history playback mode noted that the indicated reactor power on the NM-1000 and NPP-1000 was only 99% (1.98 MWs) at the time the automatic scram occurred. There was no actual high power level scram.

   Operations personnel found all components acceptable after testing the NM-1000. Pre-start test and all scram checks of the NM-1000 performed by operations personnel were satisfactorily. The Senior Reactor Operator granted the reactor operator permission to resume normal reactor operations at 2-MWs.

3. On October 20 and 23, 2000 the Senior Reactor Operator had the reactor operator shutdown the reactor when the reactor room CAM was approaching the alarm set point (see Section E.1).

4. On October 25 and 26, 2000 operations personnel were operating the reactor at 2-MWs when the incoming building power was lost. After the restoration of building power, operations personnel performed the daily checks on the reactor and associated system and normal reactor operations continued.

November

1. While operating, the reactor automatically scrammed once during the month due to a CSC watchdog circuit time out. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

December

1. While operating, the reactor automatically scrammed once during the month due to a CSC watchdog circuit time out. Operation personnel rebooted the CSC computer and performed all weekly checks on the computer. All checks were satisfactory and normal operation of the reactor resumed.

7.3 ANOMALIES:

During 2000, there were fifteen (15) reported anomalies at the MNRC facility. Equipment failures accounted for five (5) of the anomalies (33%), followed by personnel called back five times (5) because of console shutdowns (33%), two personnel errors (13%), one security alarm (7%), one cooling tower high level alarm (7%), and suspected fuel element leak (7%).

DESCRIPTION OF ANOMALIES	NUMBER
A. Personnel called back to the facility during off hours	
1. Reactor console shutdown	5
2. High water level in cooling tower	1
3. Security alarm	1
B. Leak in demineralizer system (equipment failure)	1
C. HV-3 water level float failure (equipment failure)	1
D. Generator battery failure (equipment failure)	1
E. Transient rod stuck in down position (equipment failure)	1
F. UPS fault (undetermined)	1
G. Reactor room ventilation damper in wrong position (equipment failure and personnel error)	1
H. Low pressure in helium pressurization system (personnel error)	1
I. Suspected fuel element leak	1
TOTAL NUMBER OF ANOMALIES IN 2000	**15**

January

1. Operations personnel returned to work during non-duty hours three times this month upon receiving reactor alarm notifications from the Command Center. All the responses by operations personnel was due to CSC or DAC watchdog circuit time outs. Personnel rebooted the CSC and DAC computers and reset the reactor alarms to the Command Center.

2. On 01-19-2000 at approximately 1130, the Senior Reactor Operator (SRO) directed operations personnel to place the two (2) off service Demineralizer system resin bottles on service and the two (2) on service resin bottles out off service. Operations personnel placed the first resin bottle (North 1) on service by opening its inlet isolation valve (DV-14) and then opening the outlet isolation valve (DV-26). Personnel noted no leakage. When operations personnel placed the second resin bottle on service by opening its inlet isolation valve (DV-15) and outlet isolation valve (DV-27), they noted a small amount of leakage at both the inlet and outlet quick disconnects. The operator immediately shut DV-15, DV-27, and opened the high point vent (DV-23). These actions depressurized and vented the affected resin bottle to a 5-gallon sample container. Operations personnel wiped up the few drops of liquid at the quick disconnects and loose surface contamination surveys

revealed no contamination. Personnel immediately notified the SRO and Health Physics Technician (HP) on duty of the occurrence.

The SRO directed operations personnel to replace the effected quick disconnect O-rings. When operations personnel verified the North 2 resin bottle depressurized, they disconnected and bagged, the inlet quick disconnects. Personnel noted resin beads present at the top of the male portion of the quick disconnect on the North 2 resin bottle. Inspections of the female end of the quick disconnect revealed resin beads compacted up into the inlet flexible hose. Operations personnel reattached the quick disconnects. Wipe surveys performed by the HP found no loose surface contamination. Operations personnel notified the SRO and Operations Supervisor of the resin beads in the flexible hoses.

At approximately 1230, operations personnel assuming the source of the resin beads came from the North 2 resin bottle, attempted to flush the resin beads back into the resin bottle. As personnel placed, the North 2 resin bottle on service, excessive leakage from the quick disconnects prompted them to again isolate the resin bottle. They then proceeded to depressurize the resin bottle into a 5-gallon sample container using the high point vent. As the inlet quick disconnect was removed, operations personnel discovered resin beads around the O-ring thereby preventing the O-ring from properly seating inside the quick disconnects. Personnel attached a poly bag with absorbents wrapped around the female end of the quick disconnects and flex hose. Operation personnel used deionized water to flush and rinse the resin beads from the seating area of the O-ring into the poly bag. During disassembly of the quick disconnects, resin beads began to ooze up from the top of the resin bottle (North 2). Personnel collected the resin beads with absorbents and placed them in poly bags. After re-venting the resin bottle, personnel reconnected the quick disconnects to prevent more resin from escaping from the system. Radiation surveys of the two poly bags found levels of contamination approximately 400 counts above background. A wipe of the demineralizer area found no loose surface contamination. The Operations Supervisor suspended any further attempts at O-ring replacement until 01-20-2000 prior to reactor startup.

On 01-20-2000 at 0730, operations personnel pumped the North 2 resin bottle to the makeup water tank as per OMM 5120. During this procedure, the vent plug downstream of DV-19 must be removed. During the vent plug removal, operations personnel found resin beads (several hundred) in the small space between the plug and DV-19. Using the Radiological Vacuum (Rad Vac) cleaner, personnel removed these resin beads. Personnel also observed resin beads in the piping just below DV-15. The flex hose assembly was removed from the system, all resin beads were flushed out, and the O-ring replaced. Operations personnel also replaced the outlet quick disconnect O-ring and the female quick disconnect section resin bottle inlet when personnel noticed that one of the detent balls inside the QD was missing. When this bottle was placed on service along with the North 1 resin bottle (South 1 and 2 being isolated), it was noted that demineralizer system flow was significantly reduced (3 gpm vice 12 gpm). Operations personnel verified

the valve lineup to the on service bottles. Over several minutes, demineralizer system flow gradually increased to around 11 gpm.

At approximately 0930 Hrs, operations personnel observed leakage emulating from the outlet quick disconnect on the North 1 resin bottle. Between 0930 and 1130, operations personnel performed the same procedure on the North 1 resin bottle to replace both quick disconnect O-rings and to remove compacted resin beads from the inlet flex hose.

As a result, the following actions have been taken:

a. It appears that there is back flow through the demineralizer system, which probably occurs after the system has been shutdown. The resin columns take flow from the primary system and when this primary system is secured some of the water in the piping drains back to the reactor tank. To prevent back flow through the demineralizer operations personnel installed a check valve on the supply side of the resin columns.

b. O-rings received from the Air Force supply system do not work properly in the quick disconnect's that are installed in the demineralizer system. New O-rings have been procured from the quick disconnect vender and operations personnel removed the O-rings obtained from the Air Force supply system from spare parts.

February

1. Operations personnel returned to work during non-duty hours twice this month upon receiving reactor alarm notifications from the Command Center.

   a. The first response by operations personnel was due to a CSC watchdog circuit time out. The CSC and DAC computers were rebooted and the reactor alarms were reset to the Command Center.

   b. The second response by operations personnel was due to a high level in the secondary cooling tower. It had been raining over the weekend and eventually enough rain water accumulated in the sump to actuate the high level alarm. Operations personnel drained the sump below the high level alarm and secured the facility.

March

1. On 03-27-00 at approximately 07:15, while the reactor operator was touring the equipment space he observed that the pressure indication for all four-beam tube inserts, beam tubes were below 0.5 psig, and the helium bottle was empty. He notified the on-duty SRO that the helium system was depressurized and requested a work order to change helium bottle. The reactor operator change the helium bottle out immediately and restored normal pressure to helium system.

Operations personnel checked the helium system for obvious leakage and no valves were out of position. After operations personnel verified that the system was operational, the system was repressurized. After repressurizing the helium system, operations personnel verified the vent solenoids were closed. Operations personnel purged all the in-tank beam tubes satisfactorily.

At approximately 13:00, radiography personnel reported imaging problems with Bay 1. Operations personnel repeated Bay 1 beam tube insert purge. They observed only minimal water (2-3 ml) expelled from the purged line.

On 03-28-00, radiography personnel verified proper operation of the imaging equipment. In addition, two film radiographs confirmed insufficient neutrons were exiting the beam tube to create an image.

On 03-29-00 prior to reactor startup operations personnel purged of the insert, flange, and tank wall sections and produced no abnormal expelled water. Operations personnel performed a purge of each individual section in the reverse direction to ensure correct orientations of all the helium lime connections. This purge verified that no water was detected in the insert and flange sections, but that a significant amount of water was expelled from the tank wall section.

The investigation showed that at some point previously, operations personnel had inadvertently reversed the tank wall section's helium lines. Operations personnel successfully purged the tank wall section, redirected, and relabeled the helium manifold for the Bay 1 tank wall section to reflect the correct piping orientation. Radiography personnel later verified satisfactory imaging capability in Bay 1.

Although some water probably leaked into the Bay 1 insert there appears to not present a problem at this time. Operations personnel will continue to monitor the bay 1 insert and helium supply pressure for abnormal losses.

April

1. On 04-11-00 at approximately 0700, while the reactor operator was performing the startup checklist he observed the UPS FAULT alarm on the reactor console. The Senior Reactor Operator noted that the following alarms were illuminated on the UPS:

   a. Battery Low
   b. Bypass On
   c. UPS Overload

   Operations personnel checked the UPS and could not determine any causes for the UPS shutting down. The Senior Reactor Operator secured the UPS and performed an operational restart of the unit. The UPS returned to normal operation with all alarms cleared. Normal reactor operations continued.

May

1. On 16 May 2000 at 0700, the reactor was in a shutdown condition and operations personnel were performing the normal daily pre-startup checks prior to starting the reactor. During the checks, the reactor operator notified the Senior Reactor operator that the transient rod would not stay latched to the rod drive magnet. The Senior Reactor Operator investigated and found that the transient rod appeared to be stuck in the down position. The Senior Reactor Operator immediately notified the Reactor Manager that the transient rod would not elevate during pre-startup checks

During the Reactor Manager's investigation, he ascertained that the Senior Reactor Operator was correct; something was jamming the transient rod mechanism. He directed operations personnel to start disassembling the transient rod.
Operations personnel attempted to remove the pneumatic cylinder, it could not be raised enough to remove it from the connecting rod. They attempted to rotate the pneumatic cylinder's shaft and found that it could only be rotated in the counter clockwise direction. As they rotated the pneumatic cylinders shaft in the counter clockwise direction the connecting rod became free and could be raised. By feeling the weight of the connecting rod, it was determined that the transient rod was no longer attached to the connecting rod. Operations personnel removed the pneumatic cylinder from the connecting rod and determined that the cylinder operated smoothly with no binding.

Connecting the transient rod (Figure 7) to the rod drive mechanism are two primary connecting rods (upper and lower) and a ¼ inch connecting rod (threaded on either end). The ¼ inch connecting rod allows the assembly to pass through the snubber assembly. The Reactor Manager ascertained that the ¼ inch threaded connecting rod had unscrewed causing the connecting rod assembly the disconnect at either to upper or lower connecting rods. At this time, it could not be determined where the ¼ inch threaded connecting rod had unscrewed.

Interconnected shroud tubes extend from the reactor room bridge and terminate at a snubber assembly. The snubber assembly decelerates the transient rod when it is pulsed. The snubber assembly captures the guide tube but does not rest on it. As operations personnel attempted to remove the shroud tubes and snubber assembly from the top of the guide tube the snubber assembly appeared to be stuck on the guide tube. By rotating the shroud tube operations personnel could raise the shroud tubes and snubber assembly in small increments. Operations personnel continued to do this until the shroud tubes and snubber assembly broke free of the guide tube. During the visual inspection of the bottom of the snubber assembly the ¼ inch connecting rod could be seen protruding out the bottom of snubber assembly when the snubber was clear of the guide tube. In addition, the top several inches of the guide tube appeared bent.

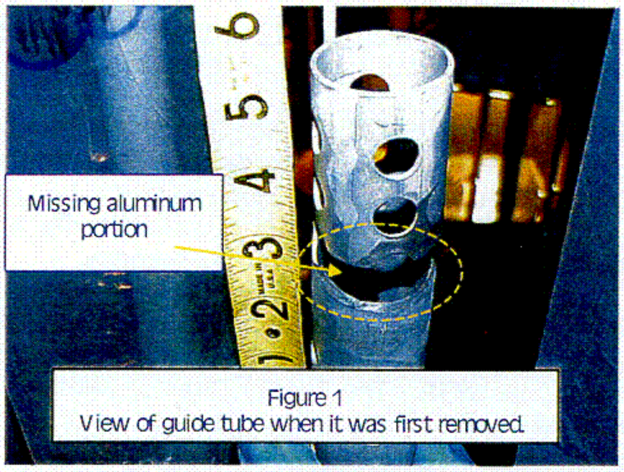

Figure 1
View of guide tube when it was first removed

Personnel could see the transient rod's lower connecting rod and Teflon piston in the guide tube. They appeared to be in the full down position. Operations personnel unscrewed and removed the guide tube from the safety plate. The guide tube and transient rod were removed from the reactor core area. Operations personnel continued to raise the guide tube and transient rod to the surface of the reactor tank for visual inspection and to remove the transient rod from the guide tube. Operations personnel noticed that a segment of the guide tube was missing (Figure 1). The missing segment is approximately two inches from the top; ½ inches wide and extended approximately half way around the circumference of the guide tube.

Operations personnel attached a ¼ inch threaded rod through the Teflon piston and into the lower connecting rod. As they attempted to remove the transient rod from the guide tube, it became apparent the transient rod was stuck in the guide tube. The Reactor Manager instructed operations personnel to cut the guide tube approximately two inches below the Teflon piston and insert a fiber optics camera down the guide tube to see if anything was jamming the transient rod in the guide tube.

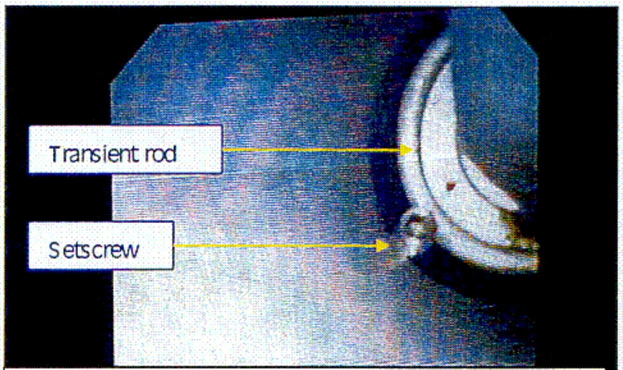

Figure 2
Set screw lodged between transient rod and guide tube.

When operations personnel cut and removed the upper portion of the guide tube they discovered that two setscrews were missing. One setscrew secures the ¼ inch threaded connecting rod to the lower connecting rod and the other setscrew secures the Teflon piston to the top of the lower connecting rod. Operations personnel inserted the fiber optics camera down the guide tube and discovered a setscrew lodged between the guide tube and the transient rod (Figure 2).

The Reactor Manager instructed operations personnel to cut the guide tube approximately four inches above the top of the transient rod. During the cutting process, the setscrew dislodged freeing the transient rod.

Operations personnel slowly raised the transient rod by hand and recovered the setscrew. Closer examination of the setscrew revealed that this one secured the

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¼ inch threaded connecting rod to the lower connecting rod. The setscrew that secures the Teflon piston to the top of the lower connecting rod could not be located.

After removing the transient rod from the guide tube, operations personnel visually inspected the transient rod and found no defects. Operations personnel replaced the guide tube, installed a new Teflon piston, and replaced the setscrews. They reassembled the transient rod and satisfactorily performed all operability checks. The transient rod scrammed in 0.37 seconds.

On 17 May 2000, operations personnel performed a rod calibration on the transient rod. The worth of the transient rod is within two cents of the previous calibration performed in August 1999. The Facility Director released the reactor for normal reactor operations.

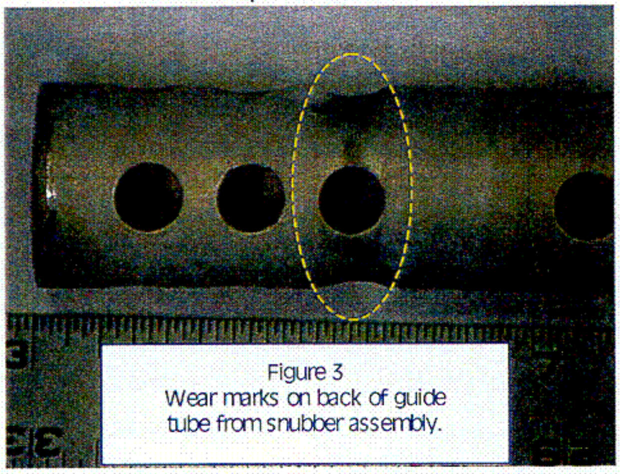


Figure 3
Wear marks on back of guide tube from snubber assembly.

On a closer inspection of the guide tube, the back (Figure 3) shows wear marks that closely match the inlet bevel of the snubber. On the left side, view (Figure 4) one can observe a beveled line on the cut through the guide tube. This appears to be caused by vibration between the guide tube and the snubber assembly. The vibrations are either from the natural harmonics of the reactor structure or water from the ^{16}N diffuser causing lateral movement between the guide tube and snubber. The latter seems more likely as the guide tube bent towards one of the ^{16}N diffuser discharge nozzles and the missing section of guide tube is on the opposite side as one of the ^{16}N diffuser discharge nozzles.

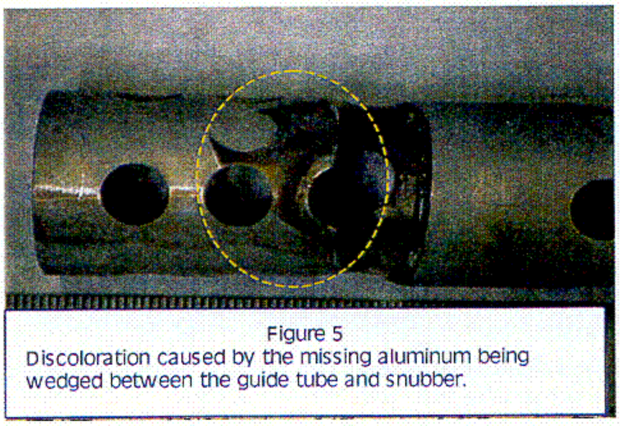


Figure 5
Discoloration caused by the missing aluminum being wedged between the guide tube and snubber.

Figures 5 and 6 (front and right sides of guide tube) clearly show the missing piece of aluminum. This piece of aluminum could not be located in the reactor tank. Discoloration on the guide tube shows where the missing aluminum had, at some point in time, peeled in an upward direction and lodged between the guide tube and the snubber. This could be a result of the August 1999 fuel inspection when operations personnel inspected the transient rod and reassembled the snubber over the guide tube. During the reassembly of the

C02

transient rod, operations personnel experienced some difficulty getting the snubber to slide over the guide tube.

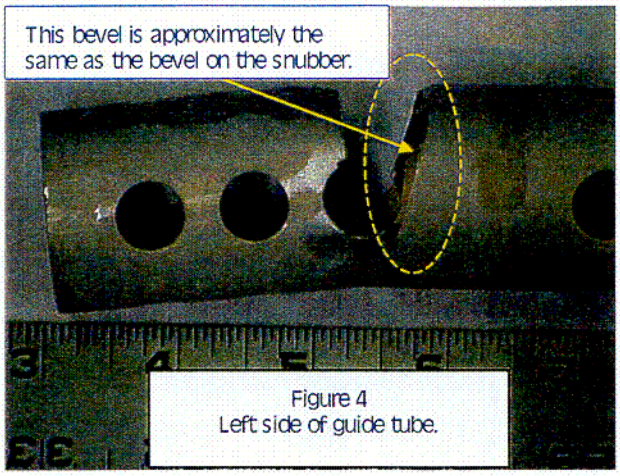


Figure 4
Left side of guide tube.

To detect and monitor this problem in the future, additional preventive maintenance measures (other than just visually inspecting the transient rod) shall be added to the annual inspection. Operations personnel will perform these additional annual preventive maintenance items:

1. Visually inspect the Teflon piston.
2. Tighten the setscrew on the Teflon piston.
3. Tighten the ¼ inch threaded connecting rod.
4. Tighten the setscrews on the ¼ inch threaded connecting rod.
5. Remove and inspect the guide tube for abnormal wear.

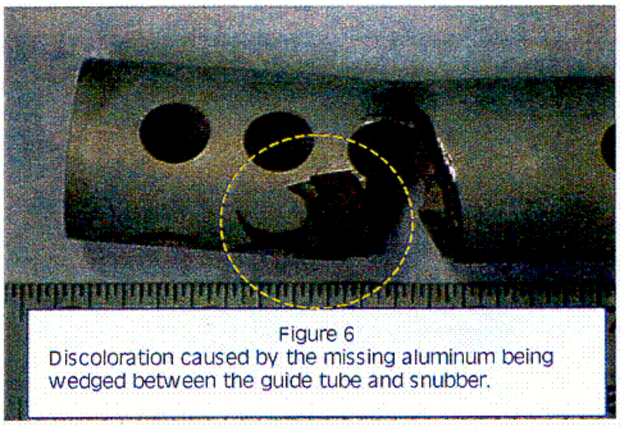
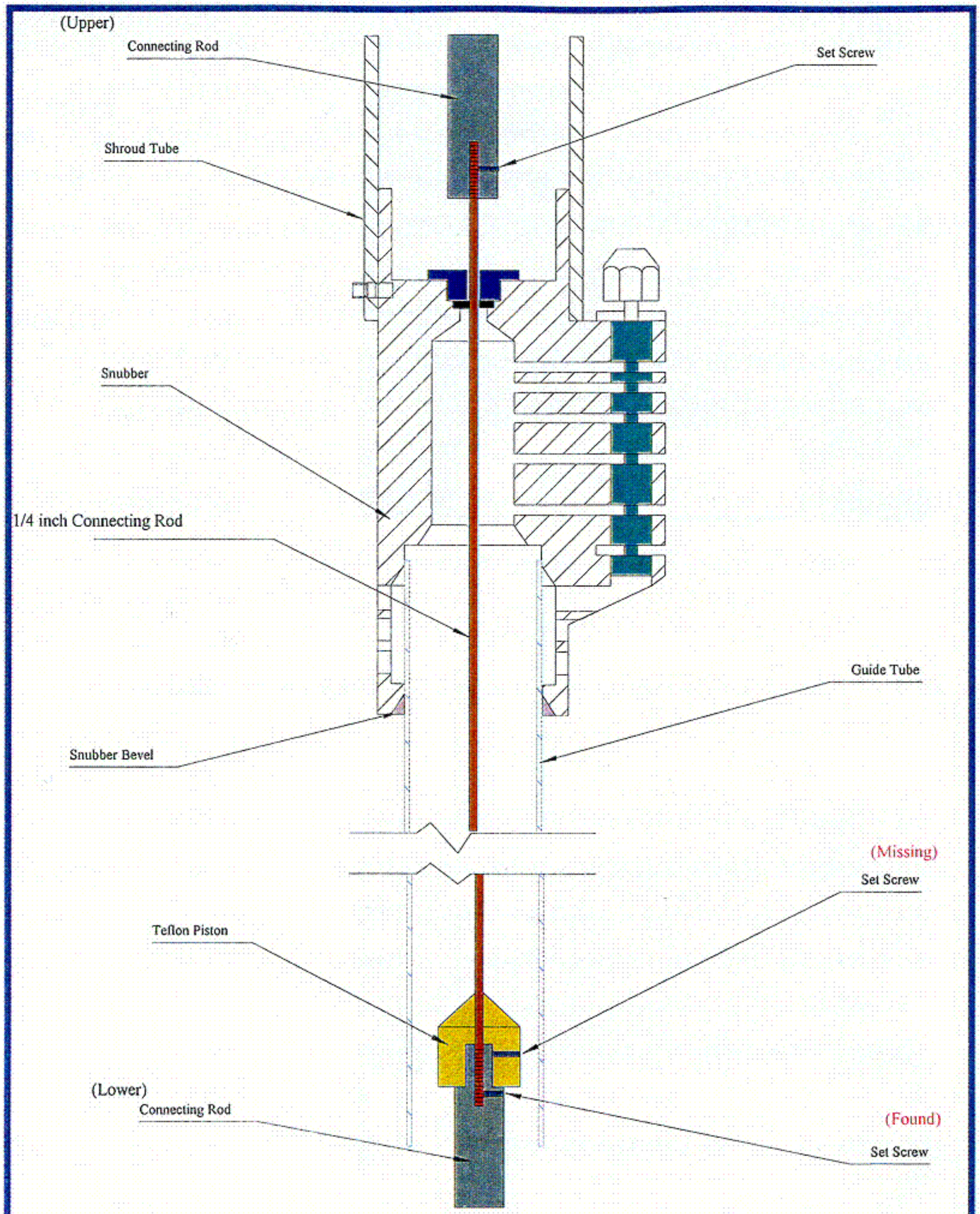


Figure 6
Discoloration caused by the missing aluminum being wedged between the guide tube and snubber.

C03



TRANSIENT ROD

FIGURE 7

C04

June

1. On 12 June 2000 at 0530, the reactor was in a shutdown condition and secured for the weekend. Upon returning to work, one of the operations personnel noted water coming below the Bay 4 staging area rollup door. When he entered the Bay 4 staging area, water was on the deck and overhead, under the false floor in the Bay 4 control room, in the shield door troughs for Bay 2 and Bay 4. When operations personnel went upstairs to find the source of the water, they found the float valve for HV-3 had broken and the valve had failed open. This caused the sump to overflow into the HV unit and to run down the heating and cooling air ducts. Operations personnel secured the water to the HV unit.

   Additional investigation by operations personnel found the water overflowed into Bays 1, 2, and 3. There was an approximately ½ inch of water in the Bay 4 staging area, 2 inches of water under the false floor in the Bay 4 control room, both of the shield door troughs for Bay 2 and Bay 4 were full and overflowing into their respective bays. Additionally there was 3 inches of water in the bottom of Bay 4, approximately 60 gallons of water in Bay 2, and 40 gallons of water in Bay 1.

   Health Physics personnel performed contamination and obtained water samples in the affected areas. All area surveys showed there was no contamination in the affected areas or activity in the water. All personnel removed the water from the Bay 4 staging area, under the false floor in the Bay 4 control room, and both of the shield door troughs for Bay 2 and Bay 4 by pumping, vacuuming and wiping. Bays 2 drained into Bay 1 through the inter-connecting drain line and by using the installed sump pump; operations personnel evacuated the water from Bay 1 to the holding tank. Bay 4 did not drain to Bay 1 because shielding placed in the Bay 5 cutout had blocked the drain line. Operations personnel pumped the water out of the bottom of Bay 4.

   The water damage to the area was limited to wetting of the drywall in the Bay 4 staging area and flooding of the Bay 4 hand and foot monitor. Health Physics personnel dried the hand and foot monitor and it was returned to a normal operating status. Operations personnel repaired to the float valve assembly in HV-3 by installing a new float valve shaft.

   It appears that the float valve shaft broke due to repeated flexing. This seems to be caused by a lower than normal building water pressure, exacerbated by sharing a common line with the cooling tower. Low header pressure prevents positive seating of the float valve, causing an oscillation effect within the HV sump. Oscillations in the sump area cause large pressure surges as the float valve starts and stops flow. These pressure surges within the sump and resulting wave actions in the sump area caused a large amount of stress on the float valve's connecting rod causing it to fail. Operations personnel did not notice similar problems on the other two HV units, which are located on another section of the roof. A common building water header supplies all HV units but individual feeder lines separates them.

Operations personnel are now required to isolate the water supply to HV-3 sump at the close of business each day. Additionally, HV-1 and HV-2, are periodically monitored to ensure similar oscillation do not occur. Personnel are investigating the installation of a larger sump overflow line or installing a drain line in the housing surrounding the HV's return air plenum.

July

1. On July 17, 2000 at 0600, a reactor operator observed that the battery for the emergency generator was broken and fluid was on the ground. Operations personnel determined that the battery had undergone an exothermic reaction that exceeded the ultimate yield strength of the battery casing.

   The Senior Reactor Operator directed operations personnel to clean the surrounding area of all battery fluid and notified the Reactor Manager. Contractor personnel looked at the battery and decided that a low water level in the "maintenance free" battery and the call for load on the battery (i.e. starting the generator) caused the exothermic reaction. The contractor personnel ordered a replacement battery

   On July 24, 2000, contractor personnel checked the charging system and replaced the broken battery with a maintenance free gel cell battery. Operations personnel started the emergency generator and it operated normally. The generator was returned to normal service.

2. Operations personnel returned to work during non-duty hours once this month upon receiving a security alarm notification from Security Police. An inspection of the facility by Security Police and operations personnel could not determine the cause for the alarm annunciation.

August

None

September

None

October

1. Operations personnel returned to work during non-duty hours on November 13, 2000, upon receiving reactor alarm notifications from the Command Center.

   A CSC watchdog circuit time out had occurred on the control console. Operations personnel rebooted the CSC and DAC computers. Personnel reset the reactor alarms to the Command Center.

November

1. On 11-13-00 at 1450, the reactor was operating at 2-Mw; all facility indications were normal. The Day Shift SRO was present in the control room when the oncoming Swing Shift Duty SRO stated the Reactor room manometer was indicating a slight positive pressure. The Day Shift SRO notified the duty RO to help investigate the problem. The oncoming Duty SRO remained in the control room.

   Throughout the day the reactor room, manometer had been reading a negative 0.12 to -0.17 inches of water as verified by the duty RO and SRO. The Day Shift SRO wanted to verify that the reactor room was indeed at a positive pressure and that the manometer was not malfunctioning from an obstruction in one of the ports prior to taking any action with the reactor. The SRO verified the manometer was indicating a pressure from zero to 0.01. AC-1, Reactor room AC unit, AC-2, Equipment area AC unit, EF1, Reactor Room Exhaust Fan, and EF2, Facility Exhaust Fan were all operating normal. Operations personnel inspected the positions of all the dampers in the reactor room ventilation system and determined they were in what appeared to be normal positions. By obtaining the nominal differential readings on various pressure gauges, operations personnel determined that the reactor room manometer was not malfunctioning and the damper on the inlet to the normal HEPA filter was shut. Personnel immediately repositioned the damper by manually rotating the shaft and repositioned the damper to its normal operating position. Upon repositioning the damper, a negative pressure was restored to the reactor room.

   From the time of notification, 1450 hrs to restoring the damper to its correct position was approximately 15 minutes. The Reactor Manager was notified of the situation after the anomaly had been corrected. The Reactor Manager notified the Facility Director.

   In September, the damper's motor actuator had failed and operations personnel were waiting for the replacement to arrive. Until the actuator could be replaced, the damper was physically disconnected from the shaft and placed in the open position. Nothing was placed on the damper to prevent it from closing. In the event of an airborne release in the reactor room the Reactor room exhaust damper just prior to exhausting to the stack (Attachment 1), closes preventing a release to the atmosphere. This situation or line up was not the cause of the damper closing. The oncoming Duty Reactor Operator had taken non-facility maintenance personnel to the roof to look at a malfunctioning AC unit. While they were there, they looked at the failed motor actuator and noticed that the U-bolt around the shaft was loose and tightened it. During this evolution, the damper closed creating the slight positive pressure in the reactor room.

   The duty SRO was not notified that any personnel would be working on any of the reactor facility equipment/systems, especially the Reactor Room exhaust.

   On 16 November 2000, the Facility Director notified the Nuclear Safety Committee Chairman and the Nuclear Regulatory Commission's Project Manager

of a possible Technical Specification violation (Section 3.4). At no time was there any safety impact to the facility staff or the public. The Project Manager and Facility Director concluded that this was not a Technical Specification violation and should be treated as an anomaly.

Corrective actions:

a. All personnel were reminded that the duty SRO shall be notified of any personnel working on any facility systems.

b. The new motor actuator is on order, and shall be replaced when received.

c. A physical inspection of the damper was inconclusive in trying to determine why it closed during the process of tightening the nuts on the U-bolt.

December

1. On 12-18-00 at 1523, the reactor was operating at 2-Mw; all facility indications were normal. The reactor operator noticed that the high-resolution monitor blinked off and as it came back on, the CSC attempted to redraw the display with limited success. The reactor operator shutdown the reactor and notified the Senior Reactor Operator.

   The Senior Reactor Operator secured the CSC and DAC computers and then rebooted both computers. The high-resolution monitor returned to a normal display during the reboot operations. The electronic engineer checked the high-resolution monitor and could not find any problems but he suspected that the monitor experienced a momentary loss of its power supply. Operations personnel tested the high-resolution monitor and found all indications acceptable. All pre-start and scram checks performed by operations personnel were satisfactorily. No definitive cause for the loss of the high-resolution monitor could be determined other than momentary loss of the power supply. The Senior Reactor Operator granted the reactor operator permission to resume normal reactor operations at 2-MWs.

7.4 MAINTENANCE OTHER THAN PREVENTIVE:

January

1. Operations personnel replaced the demineralizer filters when the differential pressure reached 15 psig. After replacement, the differential pressure was 4-psig.

2. Operations personnel completed the following items on North 1 and 2 resin columns:[1]

    a. Disassembled and cleaned resin from flexible hoses.
    b. Replaced O-rings in all quick disconnects.
    c. Replaced female quick disconnect on the inlet of North 2 resin column.

3. After shifting the resin columns to North 1 and 2, operations personnel replaced South 1 and 2 resin columns.

4. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.68 μmho/cm^2
Outlet Conductivity	0.42 μmho/cm^2

5. During a normal startup of the secondary system, the motor operated pump discharge valve (SC-4) failed to open. Operations personnel noted that the breaker for SC-4's motor had tripped. Upon further investigation, operations personnel found the motor housing to be full of water. The water accumulated in the motor housing during several hard rainstorms over the preceding weekend. Personnel drained the motor housing, blew excess water out of the motor housing, and resealed the housing. The motor operated valve operated properly upon completion of this maintenance.

February

1. During normal startup checks of the reactor, the reactor operator noted that the helium supply solenoid valve to the beam tubes was sticking open. Operations personnel replaced the internal spring, magnetic core, and the valve disk. Operational checks on the solenoid valve motor were satisfactory.

2. Operations personnel adjusted the foot switch on the regulating rod by adjusting the limit switch actuator. Regulating control rod scram time is 0.40 seconds and all operability checks were satisfactory performed.

[1] Refer to Anomaly on 01-19-00.

3. Operations personnel performed control rod drop times with the following results:

CONTROL ROD	DROP TIME (Limit < 1.0 seconds)
Transient	0.39
Regulating	0.38
Shim 1	0.40
Shim 2	0.40
Shim 3	0.40
Shim 4	0.39

4. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.4 μmho/cm^2
Outlet Conductivity	0.3 μmho/cm^2

5. While performing routine maintenance on AC-3, operations personnel replaced the blower fan belt.

6. Operations personnel noted that AC-10 was not cooling properly. Personnel cleaned the evaporator coils, disassembled, cleaned, and reassembled the fan motor.

March

1. Operations personnel installed new conduit, wires, and a new breaker from the UPS to the new DAC (FM-I-97-11).

2. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.55 μmho/cm^2
Outlet Conductivity	0.43 μmho/cm^2

3. While performing routine maintenance on AC-7, operations personnel replaced the blower fan belt.

4. Operations personnel noted that AC-6 was not cooling properly. Personnel cleaned the evaporator coils, and replace the fan motor and capacitor unit.

5. Operations personnel adjusted the foot switch on the regulating rod by adjusting the limit switch actuator. Regulating control rod scram time is 0.40 seconds and all operability checks were satisfactory performed.

April

6. Operations personnel replaced pin #12 on Shim #2's multi-pin connector. Operability checks on Shim #2 were satisfactory with a rod scram time of 0.39 seconds.

7. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.70 μmho/cm^2
Outlet Conductivity	0.50 μmho/cm^2

8. Operations personnel installed new control wiring from the new DAC (Data Acquisition Cabinet) (JB-1) to the reactor room for the control rods (FM-I-97-11). They added piggyback wires from the new DAC junction box to the old DAC for the transient rod. After the installation of the wires, they tested the limit switch signals and rod positions on the new display console with satisfactory results. After completion, personnel tested and checked the transient rod for operability. All operability checks on the transient rod were satisfactory with a rod scram time of 0.39 seconds.

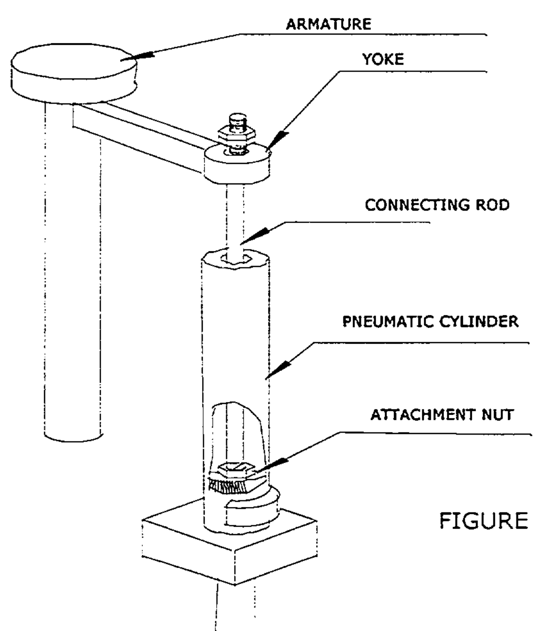


FIGURE 8

9. Operations personnel install a modified beam tube mask in the bay 4-beam tube (SOP 00-03).

10. During square wave testing and training, the transient rod's air cylinder connecting rod started to unthread and became loose. The connecting rod (**Figure 8**) attaches to the top of the pneumatic cylinder's piston and allows the control rod drive to raise the transient rod through a yoke assembly. This allows the transient rod to utilize the same rod drive mechanism as the other five control rods and still maintaining the capability of pulsing and square waving. Operations personnel disassembled the pneumatic cylinder and installed a lock washer at the attachment point of the connecting rod and the pneumatic cylinder piston. After reassembling the transient rod, operations personnel

performed transient rod operability checks. All operability checks were satisfactory with a rod scram time of 0.47 seconds.

May

1. Operations personnel installed a calibrated NPP-1000 (SN T1087043) as part of the annual channel calibration. Personnel performed a reactor tank calometric to verify the proper operation of the NPP-1000.

2. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.62 μmho/cm^2
Outlet Conductivity	0.39 μmho/cm^2

3. Operations personnel installed new piggyback wires from the new DAC junction box to the old DAC for the control rods (FM-I-97-11). After the installation of the wires, they tested the limit switch signals and rod positions on the new display console with satisfactory results. After completion, personnel tested and checked all control rods for operability. All control rods operability checks were satisfactory. The table below list the actual rod scram times.

CONTROL ROD	DROP TIME (Limit < 1.0 seconds)
Transient	0.38
Regulating	0.38
Shim 1	0.41
Shim 2	0.40
Shim 3	0.52
Shim 4	0.40

4. During a normal prestart-up checklist, operations personnel noted that HV-2 did not have air flow indication on the temperature control panel. When operation personnel investigated, they found that HV-2 was not operating. They found a scorched terminal block and the fuses blown across the secondary transformed. They replaced the fuses, removed the terminal block. They wired the unit directly across the terminal block location until a new terminal block can be obtained. HV-2 was returned to normal service.

5. During a normal prestart-up check list, operations personnel noted that one of the reactor room ventilation dampers did not return to its normal open position after an operational test of the recirculation function. Personnel remove the motor actuator and found no problems. When they manually cycled the damper it appeared to be sticking in the shut position. After lubricating the damper shaft and manually cycling the damper numerous times, it operated smoothly. The motor actuator was reinstalled and personnel electrically cycled the damper

numerous times to verify proper operation. The system was returned to normal service.

6. Operations personnel replaced the reactor tank water level alarm float switches when the high level alarm switch would not actuate every time. The alarm functions (high and low) and the make-up water pump shutoff tested satisfactory after the replacement.

June

1. After installing some new wiring to the new DAC, operations personnel noted that the transient rod position indication was not working. Investigation revealed that there was no voltage to the ten-turn potentiometer. This potentiometer provides rod position indication. Personnel had been wiring to the new DAC in the area of an amphenol connector for the transient rod. When personnel removed the amphenol the retaining ring fell off. After installation of the retaining ring and reconnecting the amphenol, all voltages returned to normal. Personnel checked the transient rod for operability and the transient rod drop time was measured at 0.36 seconds.

2. Operations personnel changed the resin in the auxiliary makeup water system (AMUWS) and sampled with the following results:

Conductivity	Limit 5.0 μmho/ cm²
Inlet Conductivity	0.62 μmho/cm²
Outlet Conductivity	0.45 μmho/cm²

3. During normal maintenance activities, operations personnel pulled the NPP-1000 signal out of the BNC connector. The signal cable had caught on the drawer below the NPP-1000 drawer and when the operator slid the drawer open, it caused the cable to pull out of the connector. Personnel installed a new BNC connector. All weekly and daily operations checks on the NPP-1000 were satisfactorily performed. The Reactor Manager gave the Senior Reactor Operator permission to resume normal reactor operations.

4. Contractor personnel (Boeing) found and repaired a Freon leak on AC-2.

July

1. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm²
Inlet Conductivity	0.72 μmho/cm²
Outlet Conductivity	0.48 μmho/cm²

2. Contractor personnel (Boeing) found and repaired a Freon leak on AC-11.

3. Operations personnel replaced a faulty helium pressure regulator.

August

1. During normal routine maintenance, operations personnel replaced the fan belt on EF-2.

2. Operations personnel removed the Bay #1 insert and installed the spare 20-degree insert (SOP-00-16). The Bay #1 insert has had a helium leak around the bellows section for several years. Management personnel decided to replace the insert during the normal annual reactor shutdown.

3. Removed the west silicon compensator (SOP-00-14) and installed the neutron irradiator's conditioning well (SOP-00-15) in the west silicon position.

4. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.62 μmho/cm^2
Outlet Conductivity	0.45 μmho/cm^2

5. Operations personnel performed control rod drop times with the following results:

CONTROL ROD	DROP TIME (Limit < 1.0 seconds)
Transient	0.46
Regulating	0.38
Shim 1	0.40
Shim 2	0.40
Shim 3	0.39
Shim 4	0.40

September

1. While performing the reactor startup checklist, the reactor operator noted that Shim #1 was not changing color on the CSC (i.e. going from black to green) when raising the control rod. Investigation by operations personnel noted that the actuating bracket for the rod down limit switch had come loose. The bracket's setscrew was replaced and the bracket reinstalled. After adjusting the control rod down limit switch Shim #1 passed all operability checks. Shim #1 rod drop time is 0.39 seconds.

2. Contractor personnel installed conduit, wiring, and two 208-volt outlets in the Bay #1 staging area (RM-III-00-02).

3. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 µmho/ cm^2
Inlet Conductivity	0.80 µmho/cm^2
Outlet Conductivity	0.70 µmho/cm^2

October

1. Operations personnel installed new piggyback wires (FM-I-97-11) from the new DAC junction box to the old DAC for the continuous air monitors and the radiation area monitors (SOP 00-21). After the installation of the wires, they tested the new display console with satisfactory results.

2. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 µmho/ cm^2
Inlet Conductivity	0.96 µmho/cm^2
Outlet Conductivity	0.69 µmho/cm^2

3. AC-1 air conditioning unit Contractor personnel replaced the condenser fan motor on AC-1.

4. During a normal prestart-up checklist, operations personnel noted HV-3 was abnormally noisy. Investigation by operations personnel noted deterioration of the fan belt. Personnel replaced the fan belt and changed the air filters on HV-3.

5. Operations personnel replaced the prefilter on rabbit hood's HEPA filter because the differential pressure across the filter was greater than 1.0 inches of water.

6. During a power outage, personnel noted one of the emergency lights did not come on. Contractor personnel replaced the battery in the emergency light.

November

1. Operations personnel noted that AC-10 (reactor control room) was not operating. Investigation by operations personnel determined that the 20-amp breaker for the unit had tripped and would not reset. Operations personnel replaced the breaker and returned AC-10 to normal operations.

2. Contractor personnel installed new magnetic door locks, request to exit buttons, wiring for console alarms to UCD, and security cameras (FM-III-00-01) to meet the new security requirements.

3. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	0.52 μmho/cm^2
Outlet Conductivity	0.41 μmho/cm^2

4. Operations personnel replaced the makeup water resin bottles.

5. Operations personnel replaced the cooling fan in the CSC computer and the power supply on the high-resolution monitor.

6. While performing the reactor startup checklist, the reactor operator noted that Shim #3 was not changing color on the CSC (i.e. going from black to green) when raising the control rod. Investigation by operations personnel noted that the actuating bracket for the rod down limit switch had come loose. The bracket was adjusted and the setscrew tightened. After adjusting the control rod down limit switch Shim #3 passed all operability checks. Shim #3 rod drop time is 0.39 seconds.

December

1. Operations personnel replaced the CSC DISO64 board after numerous reactor shutdowns involving loss of switch control. This situation occurred when the reactor control room temperature increased above 60 °F. After replacement of the board, operations personnel check all control functions associated with the DISO64. Since the replacement of the board, the reactor control room temperature is normal (70 °F) and operations personnel have not experienced any temperature related problems with the reactor console.

2. Operations personnel sampled the auxiliary makeup water system (AMUWS) with the following results:

Conductivity	Limit 5.0 μmho/ cm^2
Inlet Conductivity	2.15 μmho/cm^2
Outlet Conductivity	0.30 μmho/cm^2

3. Contractor personnel installed a new emergency light in Staging Area 1 when the light failed to pass the monthly operational test.

4. Operations personnel shifted to the south set of primary resin columns.

5. Operations personnel replaced failed reactor room damper actuator (Nov-00 Anomaly). After replacement, operations personnel verified proper operations of the damper during normal closure from the temperature control panel and closure during a reactor room CAM alarm. All damper operations were satisfactorily.

7.5 PROBLEM AREAS:

1. SUSPECTED LEAKING FUEL ELEMENT

A suspected fuel element leak occurred on 09-13-99. Since then, operations personnel attempted numerous fuel movements to isolate the suspected leaking fuel element. The fuel element leakage is sporadic (i.e. the reactor can operate at several hours or days without a problem) and occurs at higher fuel temperatures. Normally the particulate channel on the reactor room CAM reaches the alert level with a peak slightly above the alert level followed by a decreasing activity level. Occasionally the particulate level approaches the alarm level at which time operations personnel decrease the reactor power level to 1 MW. This prevents the particulate level from reaching the alarm set point but restricts reactor operations. Presently, personnel are moving fuel elements one or two at a time followed by reactor operations at 2 MWs for extended periods in an attempt to isolate the leaking fuel element.

Listed below is a chronological table on the efforts to isolate the suspected leaking fuel element:

Suspected Leaking Fuel Element

Date	Action
09-13-99	The reactor operator shutdown the reactor when the reactor CAM increased from 300 to 3000 counts per minute and reached the alert level on the particulate channel. The health physics personnel obtained an air sample and reported that there were fission products on the air filter. Operations personnel visually inspected all the fuel elements twice during the months of September and October.
09-14-99	Started replacing 20 fuel elements at a time to find leak.
09-23-99	Returned core to original core configuration.
09-27-99	Started removing individual FFCRs and instrumented fuel element.
09-28-99	Replaced instrumented fuel element with new-instrumented fuel element.
09-30-99	Continued removing individual FFCRs.
10-07-99	Started second iteration of replacing 20 fuel elements at a time.
12-01-99	Moved 8.5 % fuel from C-hex to E-hex and moved 8.5 % fuel from E-hex to C-hex.
12-20-99	Replaced five-fuel elements from C-hex.

Suspected Leaking Fuel Element

Date	Action
02-07-00	Eight of the 8.5-wt % fuel elements were visually inspected as part of routine normal surveillance. The sequential reactor startup produced a spike in the fission product activity. On the following days' reactor operation, the increase was noticeably less in magnitude. This continued to be the pattern for the next couple of weeks.
02-28-00	The same 8.5-wt % fuel elements were visually re-inspected by operations personnel. Two of the eight fuel elements, 5303 and 5319, had noticeable dark bands horizontally around the fuel elements and some vertical streaking/blotching. There is no evidence of any damage or noticeable deformity to these fuel elements other than the color disparity between them and the other six fuel elements. Operations personnel returned the fuel elements to service to allow additional data to be acquired.
03-01-00	The same 8.5-wt % fuel elements were visually re-inspected by Reactor Manager.
03-03-00	Removed fuel element 5319 from the reactor core and replaced it with a graphite dummy element.
03-09-00	Returned fuel element 5319 to the reactor core. Removed fuel element 5303 from the reactor core and replaced it with a graphite dummy element.
03-30-00	Removed fuel element 5319 and the graphite dummy element. Replaced the fuel element and graphite element with fuel elements from the fuel storage racks.
06-19-00	To further investigate the possible leaking fuel element, the investigation will centered on the last 8.5-wt % elements received from GA. The fuel element that failed in November 1998 (#10730) was one of those fuel elements. Each element will be removed and replaced one at a time. Operations personnel removed fuel element 10743 from the reactor and replaced it with fuel element 5319.
08-14-00	Operations personnel removed element 10665 from the reactor core. This element would not successfully pass through the straightness gauge. This element is considered bowed and is removed from service.
10-12-00	Since the removal of element 10665, the reactor room particulate channel has not approached the alarm set point. On a couple of occasions, the particulate channel reached the alert set point and quickly dropped to approximately 1000 cpm (normal for 2 MW operations). Operations personnel will continue to monitor the particulate channel to obtain additional data.
10-24-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10748 from the reactor and moved fuel element 10749 back into the reactor.

Suspected Leaking Fuel Element

Date	Action
10-26-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10746 from the reactor and moved fuel element 10748 back into the reactor.
11-02-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10735 from the reactor and moved fuel element 10746 back into the reactor.
11-03-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10732 from the reactor and moved fuel element 10735 back into the reactor.
11-06-00	During the normal quarterly inspection of the 8.5 wt. % fuel elements, fuel element 10279 exhibited different horizontal markings on the element. The Reactor Manager had this fuel element removed from service and replaced it with fuel element 5331.
11-21-00	Operations personnel removed all new style 8.5 wt. % fuel elements from the reactor core. Fuel element numbers: 10177, 10175, 10180, and 10281. Placed fuel elements 5266, 5261 5306, and 5339 in the reactor.
11-28-00	Operations personnel moved all the new style 8.5 wt. % fuel elements removed from the reactor core on 11-21-00 back into the reactor. Fuel element numbers into core: 10177, 10175, 10180, and 10281. Fuel element numbers removed from core: 5266, 5261, 5306, and 5339. Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10739 from the reactor and moved fuel element 10732 back into the reactor.
12-08-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10747 from the reactor and moved fuel element 10739 back into the reactor.
12-11-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel element 10738 and from the reactor and moved fuel element 10747 back into the reactor.
12-12-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel elements 10745 and 10736 from the reactor and moved fuel elements 5261 and 10738 back into the reactor.
12-20-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel elements 10734 and 10741 from the reactor and moved fuel elements 10745 and 10736 back into the reactor.

Suspected Leaking Fuel Element

Date	Action
12-26-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel elements 10731 and 10733 from the reactor and moved fuel elements 10734 and 10741 back into the reactor.
12-27-00	Due to reactor room particulate levels, approaching the alarm set point operations personnel removed fuel elements 10740 and 10737 from the reactor and moved fuel elements 10731 and 10733 back into the reactor.

2. Bowed Fuel Element

On August 14, 2000 at 0900, reactor operations personnel were performing fuel measurements for the annual fuel inspection. Upon completion of the first length measurement on fuel element #10665, a lead element adjacent to the transient rod (position D-05), the dial indicator did not return to its normal unloaded position with the indexing tool removed.

The Senior Reactor Operator directed operations personnel to move the element up and down in the inspection jig to verify no foreign objects were impeding the movement of the inspection jig's actuating rod. Operations personnel noted that the fuel element seemed to have more than the normal resistance when passing through the straightness gauge. The fuel element was removed and the standard inserted in the inspection jig to verify the operability of the inspection jig. The inspection jig operated satisfactorily and the dial indicator read correctly. Operations personnel placed the fuel element back in the inspection jig and noted the same problems experienced earlier. The Senior Reactor Operator notified the Reactor Manager.

The Reactor Manager also noted the higher-than-normal resistance when placing the fuel element through the straightness gauge. The Reactor Manager considered the element bowed and directed the Senior Reactor Operator to remove it from service. Operations personnel placed fuel element #10665 in the fuel storage rack and put fuel element #10676 in position D-05.

7.6 TRAINING:

January

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

	TRAINING
1.	Design and Operating Characteristics -- Class II

2. All licensed Senior Reactor Operators and Reactor Operator passed the following exam as part of the licensing program:

	Examination
1.	Design and Operating Characteristics

3. All Reactor Operator Trainees attended the following classes as part of the initial licensing program:

	TRAINING
1.	MNRC TRIGA Fuel
2.	Building Cranes
3.	Fuel Handling

4. All Reactor Operator Trainees passed the following exam as part of the initial licensing program:

	Examination
1.	Emergency Plan and Procedures

February

1. All licensed Senior Reactor Operators and Reactor Operators attended the following class as part of the licensing program:

	TRAINING
1.	All personnel are attending CPR and First Aid Class (completion expected in March 00).
2.	Results of the Routine Industrial Survey
3.	Reactor Protective System
4.	HAZCOM Briefing

March

1. All licensed Senior Reactor Operators and Reactors Operators attended the following classes as part of the licensing program:

	TRAINING
1.	Fitness for Duty Briefing
2.	Radiation Safety -- Class 2
3.	Radiation Safety -- Class 3
4.	Radiation Safety -- Class 4
5.	Title 10CFR – Class 1
6.	ALARA Training
7.	Primary Cooling System – Revision 05
8.	Bay Ventilation – Revision 03
9.	Quality Assurance Plan – Revision 01

2. All licensed Senior Reactor Operators and Reactors Operators passed an examination in as part of the licensing program.

	Examination
1.	Radiation Safety

3. All Reactor Operator Trainees attended the following classes as part of the initial licensing program:

	TRAINING
1.	Fitness for Duty Briefing
2.	Radiation Safety -- Class 2
3.	Radiation Safety -- Class 3
4.	Radiation Safety -- Class 4
5.	Title 10CFR – Class 1
6.	ALARA Training
7.	Primary Cooling System – Revision 05
8.	Bay Ventilation – Revision 03
9.	Quality Assurance Plan – Revision 01
10.	Utilization Document
11.	Technical Specifications – Class 1
12.	Technical Specifications – Class 2
13.	Technical Specifications – Class 3
14.	Technical Specifications – Class 4

4. All Reactor Operator Trainees passed an examination in as part of the initial licensing program.

	Examination
1.	Technical Specifications

April

1. All licensed Senior Reactor Operators and Reactors Operators attended the following classes as part of the licensing program:

TRAINING	
1.	Building Ventilation – Revision 03
2.	Selection and Training Plan – Revision 04

2. All Reactor Operator Trainees took the NRC initial licensing examination.

3. Two reactor operators took the Senior Reactor Operator licensing upgrade examination.

May

1. All licensed Senior Reactor Operators and Reactors Operators attended the following classes as part of the licensing program:

TRAINING	
1.	Fuel Handling
2.	Overhead Cranes
3.	Pneumatic Transfer System – Revision 04
4.	Tag Out Procedure – Revision 04
5.	Emergency Procedures – Revision 04
6.	Experiment Review and Authorization – Revision 04
7.	Utilization Document – Revision 07

2. All licensed Senior Reactor Operators and Reactors Operators passed the and as part of the licensing program.

Examination	
1.	Annual operating examination
2.	Annual oral board
3.	Fuel and fuel handling
4.	Overhead cranes

June

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

TRAINING	
1.	Annual Security Training
2.	Overhead Cranes Daily Checklist

July

1. As part of re-licensing requirements, all Senior Reactor Operators and Reactors Operators passed a written examination on the following subject:

	Examination
1.	Biennial Operator License Requalification Exam

August

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

	TRAINING
1.	Remedial training on Technical Specifications – Revision 10
2.	Personnel contamination briefing (RIR 00-01)

September

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

	TRAINING
1.	Health Physics Procedures – Revision 08
2.	Facility Modification Procedures – Revision 03
3.	Demineralizer System OMM – Revision 05
4.	Secondary Cooling System OMM – Revision 04
5.	NRC Emergency Classification System
6.	Initial QA Orientation
7.	ISO-9000 and Quality Program

October

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

	TRAINING
1.	Normal, Abnormal and Emergency Procedures (Class 1)
2.	Normal, Abnormal and Emergency Procedures (Class 2)
3.	UCD Reactor Console Alarm Line Procedures

2. As part of re-licensing requirements, all Senior Reactor Operators and Reactors Operators passed a written examination on the following subject:

	Examination
1.	Normal, Abnormal and Emergency Procedures

November

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

TRAINING
1. Experiment Coordination Checklist
2. Revision 5, Changes to the FSAR
3. New Security Procedures

December

1. All licensed Senior Reactor Operators and Reactors Operators attended training on the following subjects:

TRAINING
1. Health Physics Procedures (Revision 09)
2. Nuclear Theory (Class 1)
3. Quality System Procedures (Classes 1, 2, and 3)

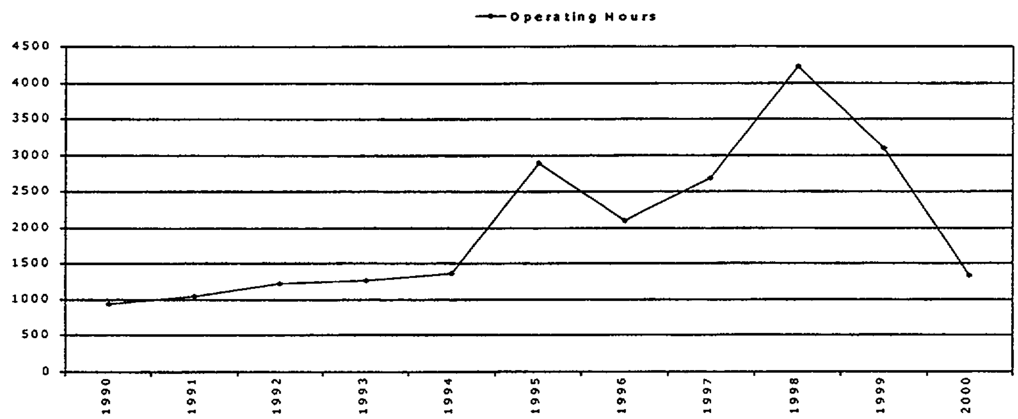
7.7 OTHER:

1. In August, Operations personnel completed the annual fuel inspections, control rods calibrations, and shutdown margin calculation.

Control Rod	*Old Control Rod Worth*	*New Control Rod Worth*
Transient rod	$ 2.21	$2.32
Regulating rod	$ 2.43	$2.48
Shim rod #1	$ 2.64	$2.61
Shim rod #2	$ 2.42	$2.59
Shim rod #3	$ 2.45	$2.58
Shim rod #4	$ 2.46	$2.51

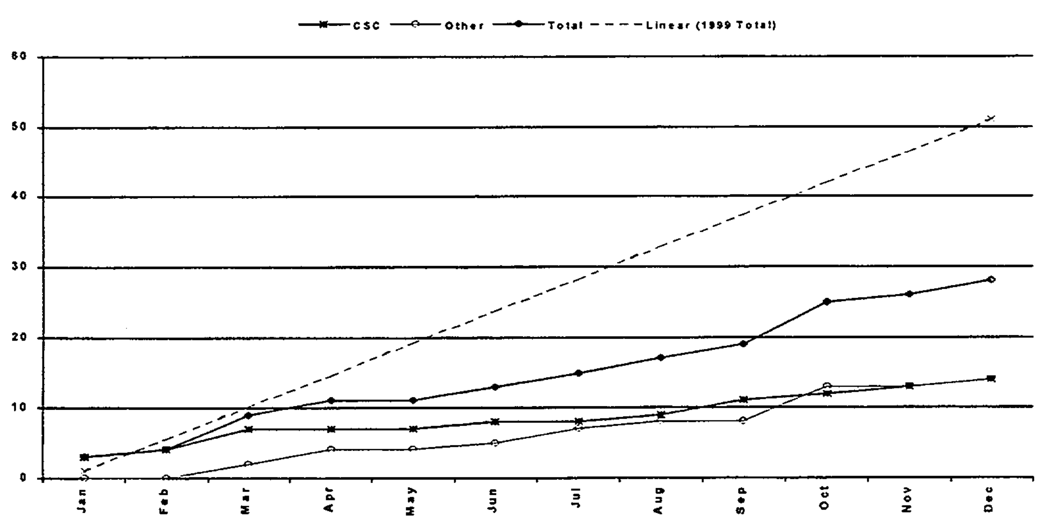
Old Shutdown Margin	$3.67
New Shutdown Margin	$4.45

UCD/MNRC Operating History



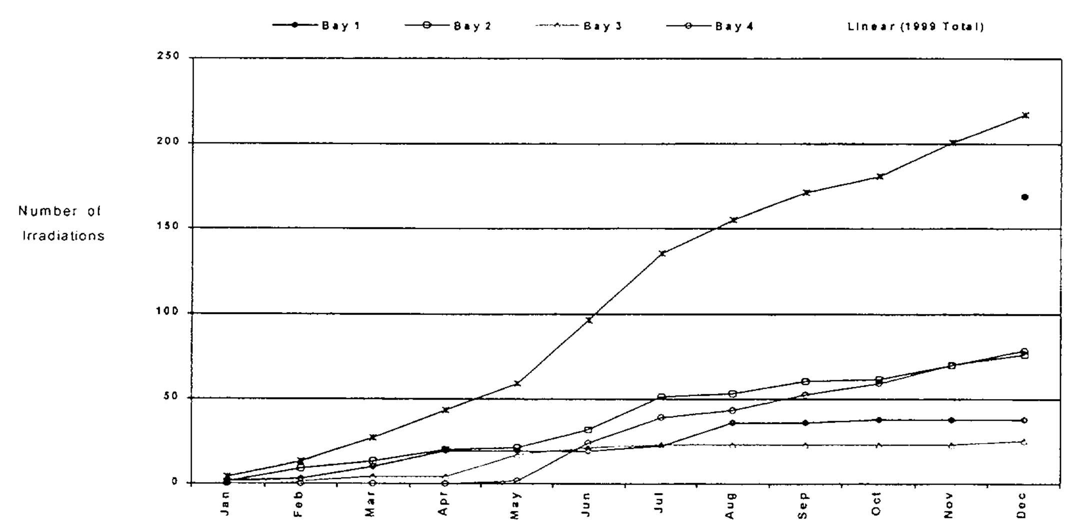
UCD/MNRC Annual Report For 2000

Unscheduled Reactor Shutdowns Total -- 2000



UCD/MNRC Annual Report For 2000

Bay Irradiations Completed (2000)



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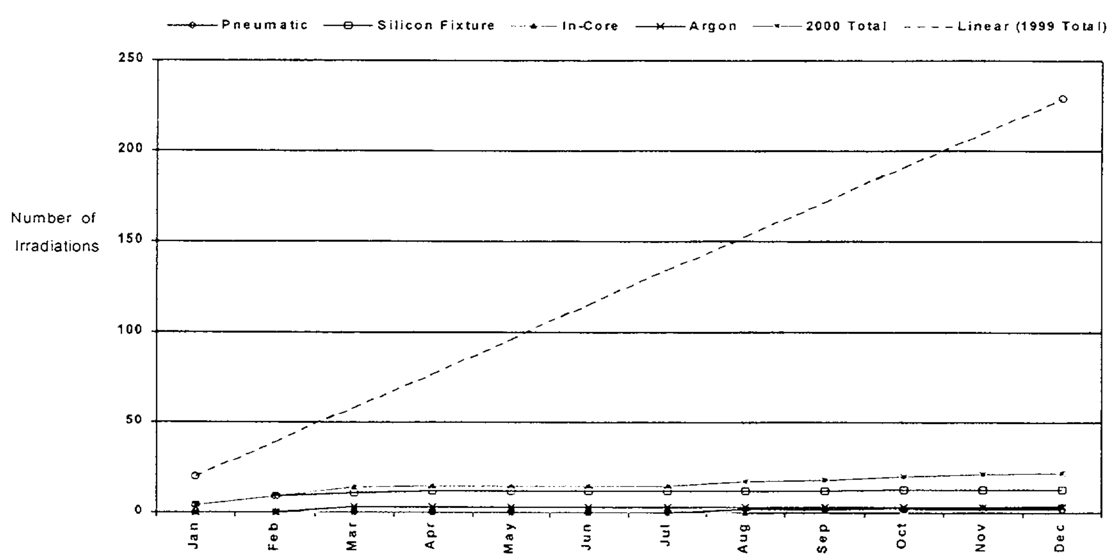
Reactor Tank Irradiation Facilities
Total Number of Irradiations Completed (2000)



UCD MNRC Annual Report For 2000

8.0 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:

8.1 Liquid Effluents

Liquid effluents released during 2000 are summarized on a monthly basis in Table 1 below. No liquid effluent releases were made in 2000.

TABLE 1
2000 SUMMARY OF LIQUID EFFLUENTS

MONTH	TOTAL ACT. RELEASED (Ci)	DETECTABLE RADIO-NUCLIDE (S)	SPECIFIC ACT. OF EACH DETECT-ABLE RADIO-NUCLIDE (uCi/ml)	TOTAL ACT. OF EACH DETECT-ABLE RADIO-NUCLIDE (Ci)	AVG. CONC. OF RAD. MATL. AT POINT OF RELEASE (uCi/ml)	FRACTION OF 10CFR20 LIMIT	TOTAL VOL. OF EFFLUENT WATER (INCLUDING DILUENT) RELEASED (gal)
JAN	0	NONE					
FEB	0	NONE					
MAR	0	NONE					
APR	0	NONE					
MAY	0	NONE					
JUN	0	NONE					
JUL	0	NONE					
AUG	0	NONE					
SEP	0	NONE					
OCT	0	NONE					
NOV	0	NONE					
DEC	0	NONE					

8.2 Airborne Effluents

Airborne radioactivity discharged during 2000 is tabulated in Table 2 below.

TABLE 2
2000 SUMMARY OF AIRBORNE EFFLUENTS

MONTH	TOTAL EST. ACT. RELEASED (Ci)	TOTAL EST. QUAN. Ar-41 RELEASED (Ci)	EST.MAX AVG. CONC. OF Ar-41 IN UNRESTRICTED AREA [1] (uCi/ml)	FRACTION OF APPLICABLE 10CFR20 CONC. LIMIT FOR UNRESTRICTED AREA [1] (%)	EST. DOSE [2] FOR UNRESTRICTED AREA [1] (mrem)	FRACTION OF APPLICABLE 10CFR20 DOSE LIMIT FOR UNRESTRICTED AREA [1] (%)	TOT. EST. QUANTITY OF ACT. IN PART. FORM WITH HALF-LIFE >8 DAYS (Ci)	AVERAGE CONC. OF PART. ACT. RELEASED WITH HALF-LIFE > 8 DAYS (uCi/ml)
JAN	7.83	7.83	2.41E-10	2.4	1.22E-01	0.12	NONE	NONE
FEB	6.44	6.44	2.12E-10	2.1	1.07E-01	0.11	NONE	NONE
MAR	7.34	7.34	2.26E-10	2.3	1.15E-01	0.11	NONE	NONE
APR	4.39	4.39	1.40E-10	1.4	7.08E-02	0.07	NONE	NONE
MAY	4.26	4.26	1.31E-10	1.3	6.65E-02	0.07	NONE	NONE
JUN	3.83	3.83	1.17E-10	1.2	5.94E-02	0.06	NONE	NONE
JUL	4.66	4.66	1.31E-10	1.3	6.65E-02	0.07	NONE	NONE
AUG	1.73	1.73	4.86E-11	0.5	2.47E-02	0.02	NONE	NONE
SEP	3.27	3.27	9.51E-11	1.0	4.83E-02	0.05	NONE	NONE
OCT	5.74	5.74	1.62E-10	1.6	8.19E-02	0.08	NONE	NONE
NOV	8.50	8.50	2.47E-10	2.5	1.25E-01	0.13	NONE	NONE
DEC	3.29	3.29	1.07E-10	1.1	5.44E-02	0.05	NONE	NONE
TOT	61.29	61.29	1.86E-09		0.94	0.94	NONE	NONE
AVG			1.55E-10	1.5				

(1) This location is 240 meters downwind, which is the point of maximum expected concentration based on the worst-case atmospheric conditions (see MNRC SAR Chapter 11).
(2) Based on continuous occupancy and the calculation techniques used in Appendix A of the MNRC SAR (2.3E-10 uCi/ml continuous for one year equals 1.4 mrem).

8.3 Solid Waste

Solid waste packaged and transferred for disposal during 2000 is summarized in Table 3 below.

TABLE 3
2000 SUMMARY OF SOLID WASTE

TOTAL VOL. (cu. ft.)	TOTAL ACTIVITY (Ci)	DATE OF SHIPMENT	
0	0	NA	NA

9.0 Radiation Exposure

Radiation exposure received by facility operations personnel, facility users, and visitors during 2000 is summarized in Table 4 below.

TABLE 4
2000 SUMMARY OF PERSONNEL RADIATION EXPOSURES

	NUMBER OF INDIVIDUALS	AVERAGE TEDE PER INDIVIDUAL (mrem)	GREATEST INDIVIDUAL TEDE (mrem)	AVERAGE EXTREMITY (mrem)	GREATEST EXTREMITY (mrem)
FACILITY PERSONNEL	21	262	552	709	3074
FACILITY USERS	0	0	0	*	*
VISITORS	792	0.4	20	*	*

* Extremity monitoring was not required.

10.0 Radiation Levels and Levels of Contamination

Radiation levels and levels of contamination observed during routine surveys performed at the MNRC during 2000 are summarized in Table 5 below.

TABLE 5
2000 SUMMARY OF RADIATION LEVELS AND CONTAMINATION LEVELS DURING ROUTINE SURVEYS

	AVERAGE mrem/hr	HIGHEST mrem/hr	AVERAGE dpm/100cm^2	HIGHEST dpm/100cm^2
OFFICE SPACES	<0.1	<0.1	<800[1]	<800[1]
REACTOR CONTROL RM	<0.1	<0.1	<800[1]	<800[1]
RADIOGRAPHY CONTROL RM	<0.1	<0.1	<800[1]	<800[1]
COUNTING LAB	<0.1	0.4	<800[1]	<800[1]
STAGING AREA	<0.1	12	<800[1]	<800[1]
COMPOUND	<0.1	1.4	<800[1]	<800[1]
EQUIPMENT RM	0.5	35	<800[1]	<800[1]
DEMINERALIZER AREA	30	700	<800[1]	<800[1]
REACTOR RM	10	120	<800[1]	<800[1]
ROOF	<0.1	0.5	<800[1]	<800[1]
SILICON STORAGE SHED	<0.1	1.3	<800[1]	<800[1]
RADIOGRAPHY BAYS	1	2800	<800[1]	<800[1]

(1) <800 dpm/100 cm^2 = Less than the lower limit of detection for the portable survey instruments used.

11.0 Environmental Surveys

Environmental surveys performed outside of the MNRC during 2000 are summarized in Tables 6-11 below. The environmental survey program is described in the MNRC Facility Safety Analysis Report.

TABLE 6
2000 SUMMARY OF PROJECTED ANNUAL DOSE
(WITH NATURAL BACKGROUND (1) SUBTRACTED)
BASED ON DIRECT
MICROROENTGEN PER HOUR MEASURMENTS

	AVERAGE (mrem)	HIGHEST (mrem)
ON BASE (OFF SITE 1-20 & 64)	5	29
ON SITE (SITES 50 - 61 & 65-69)	16	53

(1) Natural background assumed to be the off base (Sites 27-42) average of 55 mrem
*Projected for continuous occupancy.

TABLE 7
2000 SUMMARY OF ENVIRONMENTAL TLD RESULTS
(WITH NATURAL BACKGROUND (1) SUBTRACTED)

	AVERAGE (mrem)	HIGHEST (mrem)
ON BASE (OFF SITE 1-20 & 64)	3	11
ON SITE (SITES 50 - 66 & 65-69)	9	28

(1) Natural background assumed to be the off base (Sites 27-42) average of 22 mrem.

TABLE 8
2000 SUMMARY OF RADIOACTIVITY IN SOIL SAMPLES

	BETA (pCi/gm)	Cs-137 (pCi/gm)	K-40 (pCi/gm)	Ra-226 (pCi/gm)	Th-232 (pCi/gm)
AVERAGE	21.19	0.24	13.10	0.68	0.82
HIGHEST	24.80	0.30	14.80	1.29	1.00

MDA is the minimum detectable activity at the 95% confidence level.
The MDA range for the analyzed radio nuclides (pCi/gm).

	MIN	MAX
Beta	4.52	5.21
Cs-137	0.05	0.06
K-40	0.32	0.61
Ra-226	0.09	0.20
Th-232	0.26	0.33

TABLE 9
2000 SUMMARY OF RADIOACTIVITY IN VEGETATION SAMPLES

	BETA (pCi/gm)	Cs-137 (pCi/gm)	K-40 (pCi/gm)
AVERAGE	19.58	<MDA	17.47
HIGHEST	28.30	<MDA	27.50

MDA is the minimum detectable activity at the 95% confidence level.
The MDA range for the analyzed radio nuclides (pCi/gm).

	MIN	MAX
Beta	4.40	4.65
Cs-137	0.10	0.17
K-40	0.89	1.75

TABLE 10
2000 SUMMARY OF RADIOACTIVITY IN WELL WATER

	ALPHA (pCi/l)	BETA (pCi/l)	TRITIUM (pCi/l)	GAMMA (pCi/l)
AVERAGE	<MDA	<MDA	2.5E+04[1]	<MDA
HIGHEST	<MDA	<MDA	2.5E+04[1]	<MDA

[1] This was the only measurement greater than the MDA

MDA is the minimum detectable activity at the 95% confidence level.
The MDA range for the analyzed radio nuclides (pCi/L).

	MIN	MAX
Alpha	1.6	2.2
Beta	2.5	3.1
Tritium	314	1200
Cs-137	7.7	78.0