W.S.U. NUCLEAR RADIATION CENTER

STANDARD OPERATING PROCEDURE NO. 5

Standard Procedure for Performing Preventive Maintenance on the Reactor and Associated Equipment

I. General

The Technical Specifications to Facility License R-76 specify that certain tests, measurements, and maintenance operations are to be performed routinely for the reactor to remain legally operable. Daily, weekly, monthly, semi-annual and annual tests, measurements, or maintenance must be performed if the reactor is operated at any time within that respective time period. In addition, the Nuclear Radiation Center requires additional maintenance not specified or required in the Technical Specifications.

All license-required daily and weekly tests are conducted in the performance of the Reactor Pre-Startup Checkoff which contains a record thereof. A Preventive Maintenance Check List, consisting of two log sheets, is the record of other required tests and measurements along with information taken from the daily Reactor Pre-Startup Checkoff.

This procedure outlines the methods to be utilized in the conduct of tests, measurements, and maintenance scheduled on the Preventive Maintenance Check List. References to other standard operating procedures are made where specific procedures have been prepared for particular items. A licensed Reactor Operator shall be present during all tests, measurements, or maintenance operations and shall date and sign the appropriate space in the Check List upon completion.

The Reactor Supervisor, or a Senior Reactor Operator performing the duties of the Reactor Supervisor, shall be immediately notified in the event of abnormalities during the performance of tests, measurements, or maintenance. In addition, the Reactor Supervisor shall be notified of the results of tests and measurements immediately upon completion.

II. License Required Tests, Measurements and Maintenance

A. Area Radiation Monitors

1. Alarm Operability - refer to S.O.P. No. 17.

2. Calibration - refer to S.O.P. No. 17.

B. Continuous Air Monitor

1. Alarm Operability - refer to S.O.P. No. 17

2. Calibration - refer to S.O.P. No. 17.

C. Control Element Calibration - refer to S.O.P. No. 16.

D. Control Element Drop Times

Scram time for the slowest scrammable control element shall not exceed 2 seconds and shall be measured annually not to exceed intervals of 15 months.

Equipment: Rod drop timer; drop time switchrod.

1. Complete a Reactor Pre-Startup Checkoff, leaving the cooling system secured.

2. With Control Element No. 1 rod drive fully run down, mount the switchrod foot on the first rod guide support and the reactor bridge frame.

3. Adjust the lower switch so that the switch contacts the connecting rod anvil and is closed when the blade is fully inserted in the core.

4. Record a full set of readings in the Reactor Log and enter "Operation for Control Element Drop Times" in the Comments section.
5. Raise the control element drive to the fully withdrawn position and enter the readings after withdrawal in the Reactor Log.
6. Adjust the top switch so that the switch opens immediately upon deenergization of the scram magnet.
7. Connect the timer leads and reset the clock.
8. Press the magnet current cutout switch on the No. 1 Trip Actuator Amplifier, obtain the drop time shown on the timer and enter "Dropped Blade #1 for Test" and the drop time in the Reactor Log.
9. Reset the timer and repeat steps 5. and 8. for two additional times. Average the three drop times and enter the result in the Preventive Maintenance Checklist.
10. Repeat the above procedure for Control Element 2 and 4.
11. Withdraw the pulse rod to the fully withdrawn position.
12. Using a stop watch, measure the drop time of the pulse rod as accurately as possible. Record the data in the Preventive Maintenance Checklist.
13. Run down the pulse rod cylinder to the fully inserted position.
14. Secure the Reactor.

E. Control Element Inspection

Control elements shall be visually inspected for deterioration at intervals not to exceed 2 years.

1. Move the reactor bridge to approximately the 7-foot position.
2. Complete a Reactor Pre-Startup Checkoff, leaving the cooling system secured. Station a Reactor Operator.

3. Raise control element No. 1 to the fully withdrawn position, leaving all other control elements fully inserted.
4. Using an underwater light to provide adequate visibility and binoculars, visually inspect the control element for scratches, warping, discolorations, and other external wear indications. Record findings in the Control Element Inspection Log.
5. Run down the control element drive unit to the fully inserted position. Maintain visual surveillance while the element is lowered to observe abnormalities in control element travel.
6. Repeat steps 3 through 5 for Control Elements 2 and 4. Secure the reactor.
7. Remove the transient rod in accordance with Standard Operating Procedure No. 8, "Standard Procedure for Control Element Maintenance, Removal and Replacement."
8. Visually inspect the transient rod for scratches, warping, discolorations and other external wear indications. Record findings in the Control Element Inspection Log.
9. Replace the transient rod in accordance with S.O.P. No. 8.

F. Exhaust Gas Monitor

1. Operability - refer to S.O.P. No. 18.
2. Calibration - refer to S.O.P. No. 18.

G. Fuel Temperature Calibration - refer to S.O.P. No. 15.

H. Fuel Temperature Scram Time

Scram time using the slowest scrammable control element shall not exceed 2 seconds and shall be measured annually not to exceed intervals of 15 months.

Equipment Needed: Pulse Generator; Blade Drop Switch Unit; Scram Time Test Box; BIN Mounted Scaler.

1. Select the control blade with the longest drop time as measured by the control element drop time procedure.
2. Install the blade drop switch unit on the selected blade. Connect the S.T. Test Box drop switch leads to the bottom drop switch. Connect the 15V DC power supply to the S.T. Test Box and energize.
3. Remove the thermocouple wires from the fuel temperature Thermocouple Transmitter Input. Connect the S.T. Test Box Yellow and Red wires to the Thermocouple Transmitter Input.
4. Install the pulse generator with connections to the scaler and the timer. Set for 1000 Hz. Disconnect timer and connect S.T. Test Box to the scaler.
5. Initiate the trip signal and determine the scram time from the Scaler in mSeconds.
6. Repeat drop twice more. Average the three drops and record this value in the Preventive Maintenance Checklist.
7. Restore Fuel Temperature system.

I. Low Count Rate Inhibit Calibration

This calibration is performed to correlate Log-N % power to CPS. Low Count Rate Inhibit operability check shall be performed semi-annually not to exceed intervals of 7-1/2 months.

Equipment Needed: Pulse Generator; L.C.R. Test Box; Scaler.

1. Deenergize the Log Power Channel.
2. Remove the signal input from J6 and replace with the pulse generator and the L.C.R. Test Box. Terminate the pre-amp signal output on a 50 OHM terminator.

3. Connect the scaler to the Scaler CR/2 output on the Log-N.
4. Reenergize the Log-N and generate a signal from the pulse generator that achieves an output on the log power meter of 10^{-7}% N.
5. Take a one-minute count on the scaler to determine the CPS equivalent of an indicated power of 10^{-7}% N.
6. Repeat steps 4 and 5 for power level indications of both 10^{-6}% N and 10^{-5}% N.
7. Determine the average relationship between % N and CPS for the three data points.
8. Using the value determined in step 7, calculate the % N equivalent of 2 CPS and adjust the Low Count Rate Inhibit trip point to that level or greater.

J. Pool Level Alarm Operability

Pool Level Alarm check shall be conducted semi-annually not to exceed 7-1/2 month intervals.

1. Move the reactor bridge to approximately the 5'0" position.
2. Place the Console Mode Switch in the TEST position and turn on the Control Power.
3. Manually depress the lower float switch and ensure that the console Pool Level Alarm functions and the annunciator sounds.
4. Manually raise the upper float switch and ensure that the console Pool Level Alarm functions and the annunciator sounds.
5. Ensure that the pool fill solenoid opens and closes the feedwater valve when the middle float switch is depressed and released.

6. Place the Control Power Switch in the OFF position, remove the key and return the reactor bridge to the initial position.

K. Power Calibration

Power Level Monitoring Channels shall be calibrated annually not to exceed 15 month intervals.

1. Perform a calibration check of the Linear Power Indication Channel in accordance with the procedure outlined in the Linear Indication Channel equipment log (Equipment Book 4). If calibration is required, utilize the calibration procedure in Book 4.
2. Perform a calibration check of the Linear Safety Channels in accordance with the procedure outlined in the Linear Safety Channels equipment log (Equipment Book 3). If calibration is required, utilize the calibration procedure in Book 3.
3. Check the calibration of the Log-N Channel. The power meter scale is marked with red marks corresponding to the six calibration positions. If the alignment is not correct, complete the calibration procedure in the GA Wide Range Log-N Manual, Section 4.2.5, pp. 25-31.
4. Check the intercalibration of both the Linear Power Recorder and Linear Power Channel, and the Log-N Recorder and Log-N Channel.
5. Perform the procedure of S.O.P. No. 13, "Standard Procedure for Performing Power Calibrations."

L. Pulse Rod System Inspection

The Pulse Rod System shall be cleaned and inspected semiannually at intervals not to exceed 7-1/2 months.

1. Station a Reactor Operator.

2. Place the reactor control power switch in the ON position and the mode switch in the TEST position.
3. Raise the pulse rod cylinder to the fully withdrawn position.
4. On the bridge, unscrew the shock absorber from the top of the cylinder.
5. Visually inspect the inside of the cylinder utilizing a flashlight. If excessive wear, corrosion, or foreign particle accumulation is found, notify the Reactor Supervisor who will initiate corrective action.
6. Run a clean rag or tissue up and down the cylinder to clean the cylinder walls and remove built-up lubricant.
7. With a fresh rag or tissue, apply a light coat of Silicon Vacuum grease to the walls of the cylinder. Exercise caution to eliminate excessive lubrication.
8. Raise and lower the cylinder several times, leaving it in the fully withdrawn position.
9. Check the cylinder for adequate distribution of lubrication.
10. Reassemble the shock absorber.
11. With a clean rag or tissue, wipe the threaded portion of the cylinder and relubricate with a light film of Lubriplate or equivalent.
12. Bleed off any moisture or particles which may have accumulated in the surge tank.
13. Check condition of electrical connections, hoses, mechanical drive, and air filters. Replace air filter cartridges if necessary.

14. Lower the cylinder to the fully inserted position, place the Mode Switch in the MANUAL position.

15. "FIRE" the pulse rod and check for seal integrity.

16. Secure the reactor.

M. Shutdown Margin

Equipment Needed: Current Control Element Worth Curves.

The minimum Shutdown Margin shall be $0.25 with the highest worth Control Element fully withdrawn. For administrative purposes, minimum shutdown margin will be $0.50.

NOTE: This procedure is to be conducted following a shutdown period of at least 60 hours to allow significant decay of Xe^{135} generated during previous operations.

1. Following the specifications of S.O.P. No. 4, take the reactor critical and proceed to a power level of 1 KW.

2. Once power is stabilized at 1 KW, take a full set of readings as required by S.O.P. No. 4.

3. Proceed to required operating power level.

4. Using the control element reactivity worth curves and the position readings obtained in Step 2. above, determine the reactivity added to the core for each control element. The reactivity added is the integral worth of the control element for the withdrawal position.

5. For each control element, subtract the reactivity added determined in Step 4. above, from the total element reactivity worth. Sum the results. This value is the excess reactivity.

6. Sum the total reactivity worths of Blades 1, 2, and 3. From this sum, subtract the excess reactivity calculated in Step 5. above. The result is the shutdown margin.

N. Test Pulse

A test pulse shall be conducted semiannually to compare Fuel Temperature and Peak Power to previous Test Pulses.

1. Calibrate the pulse power measuring equipment in accordance with S.O.P. No. 14, "Standard Procedure for Calibration of Pulse Instrumentation."
2. Calibrate the fuel temperature indicator-recorder system in accordance with S.O.P. No. 15, "Standard Procedure for Alignment of Fuel Temperature System."
3. Using the current transient rod calibration, determine the withdrawal distance equivalent to a $2.00 reactivity insertion.
4. Check out and start up the reactor for pulsing operations in accordance with S.O.P. No. 4, "Standard Startup and Operating Procedure."
5. Fire a pulse using the cylinder height determined in Step 3 above. Record the pulse data in the Reactor Log and the Pulsing Summary Log, noting completion and the pulse number in the Preventive Maintenance Checklist.
6. Proceed with shutdown in accordance with S.O.P. No. 4.

O. Ventilation System Operability and Filter D/P Check

Ventilation system operation shall be checked monthly, not to exceed 6-week intervals. Pressure drop across the absolute filters shall be measured every 2 years. Filters shall be changed every 2 years and whenever D/P across the filters exceeds 1 inch of water.

1. Check that the ventilation system status board indicates the system is in AUTO/DILUTE mode.

2. In the penthouse, ensure that: Fans 1 and 4 are operating; the Inlet and Exhaust Dampers D1 and D4 are open; Damper D4 (S.P. control) is operating; Fan 3 is off; and Dampers D2, D3, and D6 are closed.
3. Trip the CAM alarm by lowering the alarm setpoint and ensure that the ventilation system switches to DILUTE mode.
4. Check the Magnehelic Gauge for filter D/P on the ventilation Control Panel. Record the reading in the Preventive Maintenance Checklist Log.
5. In the penthouse, check that Fan 3 is operating, that Dampers D2 and D3 are open, that Damper D6 (S.P. control) is operating, that all other fans are off and all other automatic dampers are closed.
6. Place the ventilation system mode switch in ISOLATE and check that all fans are off and all automatic dampers are closed.
7. Place the mode switch in AUTO. Reset DILUTE MODE.
8. Place the console Control Power Switch in the ON position, the Mode Switch in MANUAL and reset the scram condition.
9. Depress the manual scram button and check that the ventilation system is switched to ISOLATE. Reset the scram condition and ensure that the ventilation system returns to AUTO.
10. Place the console Master Switch in the OFF position and remove the key.

    NOTE: This procedure is for the Ventilation System Auxiliary Panel located in the Front Office.

11. Place the AUTO/ISOLATE switch in the ISOLATE position, then return it to AUTO.

12. Verify that the Ventilation System Main Panel indicates ISOLATE.

13. Using Reset Key located in the Security Safe, reset ISOLATE mode.

14. Place the AUTO/DILUTE switch in the DILUTE position. Return it to AUTO.

15. Verify that the Main Panel indicates DILUTE. Reset Ventilation System to AUTO from the Control Room.

P. Pool Water Conductivity

Pool water conductivity shall be measured at least once every two weeks. Conductivity shall be maintained less than 5×10^{-6} mhos/cm.

1. Check the calibration of the conductivity meter by rotating the METER RANGE knob to the CHK position. The meter should indicate full scale, or 2 micromhos/cm. If not, complete the calibration procedure:

   a. Rotate the METER RANGE knob to the OFF position. Check the zero alignment of the meter needle to the meter scale. If required, rotate the zero adjustment screw (located under the meter face) until the meter needle is aligned with the zero mark on the meter scale.

   b. Rotate the METER RANGE knob to the CHK position. If the meter does not indicate full scale, rotate the calibration adjustment until the meter needle is properly aligned. The calibration adjustment is located on the circuit board inside the meter case. There is a hole in the top of the case to provide access to the calibration adjustment.

2. Place the Conductivity Cell Selector knob in position 3, heat exchange outlet. The meter indication is the conductivity value. Record the value in the Preventive Maintenance Checklist Log.

Q. Pool Water pH

Primary Coolant Water pH shall be measured at least once every two weeks. pH shall be maintained between 5.0 and 7.5.

Equipment Needed: pH meter; DI water; 250 ml beaker; pH 7 buffer or lower.

1. Collect a 200 ml sample of pool water from directly in front of the pool skimmer.
2. On the pH meter, check BATTERY condition.
3. Switch to pH NORMAL, lower electrodes in buffer.
4. Adjust TEMPERATURE knob to temperature of buffer.
5. Adjust CALIBRATION knob so meter reads exact pH of buffer.
6. Raise electrodes and rinse with DI water.
7. Lower electrodes into pool water sample and read pH.
8. Raise electrodes and rinse with DI water.
9. Store electrodes in buffer of pH 7 or lower.
10. Switch pH meter to OFF.
11. Record the value in the Preventive Maintenance Checklist Log.

III. Non-License Required Tests, Measurements, and Maintenance

A. Area Radiation Monitor Set Point - refer to S.O.P. No. 17.

B. Building Evacuation Alarm Operability

This test may be conducted either at the end of an operating day or during the maintenance shutdown period. Preferably, the test should be conducted upon completion of operations.

1. Completion of Operations

a. No more than three minutes prior to scheduled shutdown, announce over the building address system: "This is a drill."

b. At the moment the reactor is scheduled to the shut down, press the console Building Evacuation button.

c. In the Reactor Log, note the time of shutdown as normally required, writing in the "Comments" section, "Shut down by Building Evacuation test."

d. Ensure that a reactor scram occurs and that the evacuation siren sounds for 15 seconds. Announce, "This is a drill; evacuate the building."

e. Proceed with shutdown procedure of S.O.P. No. 4.

f. Check the personnel check-in board and ensure that all personnel have evacuated the building.

g. Announce over the address system: "All testing of the building evacuation alarm system is completed."

2. Shutdown Period

a. Turn on the console power and reset the scram condition.

b. Raise a control element approximately one inch and announce over the building address system: "This is a drill, the building evacuation siren will sound. This is a drill."

c. Press the Building Evacuation button and ensure that the reactor scrams and the evacuation siren sounds for 15 seconds. Announce, "This is a drill; evacuate the building."

d. Secure the reactor.

e. Check the personnel check-in board and ensure that all personnel have evacuated the building.

f. Announce over the address system, "All testing of the building evacuation alarm system is completed."

C. Console Auxiliary Equipment

The following items shall constitute the required monthly maintenance of the Console Auxiliary Equipment.

1. Check that all lights are operable; replace weak or inoperable bulbs.
2. Check all rod drive readouts by depressing the readout test button on the console, and raise and lower each rod drive. Repair readouts as necessary.
3. Check operation of switches, push buttons, etc.; repair or replace as required.
4. Perform a calibration check of the Radiochem Lab Stack Monitor.
   a. Place the Radium needle check source on point X marked on the stack and compare the observed count rate with count rate obtained during the calibration most recently performed.
   b. If a variation of 75% of last calibrated count rate, compensated for source decay, is observed, perform a complete calibration. Calibration of the R.C. Stack Monitor is identical to Continuous Air Monitor calibrations (S.O.P. No. 17) for both parts a. and b. with the exception of step a. (7). For the R.C. Stack Gas Monitor, substitute:
      a. (7) Place the Radium needle check source on point X marked on the stack. Record the observed count rate in the Maintenance Record section of the R.C. Stack Gas Monitor book.

D. Continuous Air Monitor Filter

1. Remove the filter holder from inside the cave.

2. Remove the "O" ring seal, pull off the old filter, and replace with an unused filter (the filters are normally stored inside the C.A.M. cave). Replace the "O" ring seal and reinstall the filter holder.

E. Continuous Air Monitor Set Point - refer to S.O.P. No. 17.

F. Exhaust Gas Monitor Set Point - refer to S.O.P. No. 18.

G. Intrusion Alarm Operability

1. Inform the Police Department that an operability check of the intrusion alarm will be performed.

2. With the intrusion alarm activated, open one of the doors connected to the system.

3. Check that an audible and visual alarm occurs at the intr usion alarm status board and that the visual room indication correlates with the door that was opened.

4. De-energize the intrusion alarm, notify the Police Department that the test is completed and obtain verification that the alarm at the station switchboard had activated.

H. Operating Records Completion

1. Complete the Operations Summary Log for the month required. This will normally be completed in the beginning of the month immediately after, and the date in the Preventive Maintenance Log shall reflect such delay.

2. Check the Scram Summary for completeness.

3. Check the Pulsing Summary for completeness.

I. Reactor Auxiliary Equipment

The following items shall constitute the required monthly maintenance of Reactor Auxiliary Equipment.

1. Flush the Exhaust Gas Monitor and C.A.M. pump with solvent.
   a. Remove the inlet and outlet lines to the pump and the inlet and outlet filters and cannisters.
   b. With the pump running, pour solvent into inlet and allow the pump to run for several minutes. Repeat.
   c. Clean the felt filters and reinstall the filters and cannisters. Replace the filters annually.
   d. Reconnect the inlet and outlet lines to the pump.
2. Perform a calibration check of the Exhaust Gas monitoring system using the procedure outlined in S.O.P. No. 18.
3. Check cooling tower sump for debris and sediment collection. Clean if necessary using caution to ensure that debris does not enter the secondary intake.
4. Check the operability of the cooling tower fan for both Low and High speeds.
5. Check all pumping equipment including diffuser, primary and secondary pumps, and purification pumps for seal integrity.
6. Clean the pool purification system strainers and skimmer basket.
7. Check that the water level in the H-1 Neutron Radiography Beam Catcher is within at least one inch of the top of the reservoir. Fill, if necessary, with deionized water.
8. Cycle the H-1 beam port shutter several times. Check for proper operation.
9. Perform an operational check of the hand monitors. Annually, perform a calibration check of the monitors and calibrate if required. The hand monitors are to be calibrated using the same procedure as outlined for the C.A.M. in S.O.P. No. 17, with the

exception that the sources must be held in contact with the detector cover screens.

10. Check conductivity insertion cells for seal integrity and leakage.
11. Check the operability of the rotator motors and the rotator motor cooling fans.
12. Check condition of rotator hoses. Repair or replace as necessary to ensure integrity.
13. Check pool and beam room emergency lighting for charging rate, water level, and operability.
14. Conduct a complete system check of the reactor intrusion alarm. This shall be conducted as follows:
    a. Deenergize the system by placing key switch in the DAY position.
    b. Open and close each door connected to the alarm and check that the door ajar indications operate for each.
    c. Simulate a power failure by switching off power to the alarm system in the Beam Room, and check that the system operates off the battery. Reconnect the system to the building power.
    d. Notify the Police Department that tests will be conducted on the alarm system.
    e. Energize the system by placing the key switch in the NIGHT position. Ensure that the energize indication light located directly above the key switch is on.
    f. Remove main control panel cover from unit in the Beam Room.
    g. Using Test Tool, test alarms 3 through 16 ensuring appropriate alarm is displayed on event recorder. Replace panel cover.

h. Deenergize the system and notify the police that all testing of the intrusion alarm system has been completed.

15. Conduct a complete check of the rabbit system. The test shall be conducted as follows:

a. Clean or replace the air line filters as necessary.

b. Open the filter bleed valves and allow the line to blow down, then shut the bleed valves.

c. Disassemble and clean the switching valves thoroughly, using a very slight amount of silicon vacuum grease on the "O" rings. Reassemble.

d. Disconnect the rabbit hoses at the ball valves on the bridge, check that the valves are in the closed position and ensure that the red lights are lit for each valve operator.

e. Depress the POWER switch on the rabbit controller located on the reactor console.

f. Check that the ball valves are completely open and that the green light is lit for each operator. Reconnect the rabbit hoses.

g. Energize the system by opening the air line valve. Check that the pressure in the system is between 20 and 30 psig.

h. Test fire a blank rabbit for 1 minute or less, using the manual return, utilizing the drop-out end in Room 101. Check that the system functions properly and that all indications at the reactor console and master control are correct.

i. Test fire a blank rabbit for 1 minute or less using the automatic timed return, utilizing the drop-out in Room 101.

Check that the time period is correct, the system functions properly, and that all indications at the reactor console and master control are correct.

j. Close the air supply valve and deenergize the system by depressing the POWER switch on the rabbit controller located on the reactor console.

16. Low Pulse Air Alarm Operability

NOTE: This procedure requires the participation of two persons at least one of whom shall be a licensed operator.

a. Locate one person in Pool Room at the Pulse Rod Air Supply gauge.

b. Turn off the air supply to the transient rod in the Pool Room.

c. While the person in the Pool Room observes the pulse rod air pressure gauge, the second person shall open the drain valve to the pulse air surge tank so that the air is released very slowly.

d. Release the air from the system until the Low Pulse Air alarm sounds at the reactor console. Note the pressure at which the alarm sounds. The alarm should sound at 70 ± 2 psi. If not within this range, adjust the setpoint of the pressure switch to 70 psi.

J. Seismic Trip Operability

Seismic trip operability shall be tested during a Reactor Pre-Startup Checkoff while performing Part M, "Scram Circuits."

1. Upon completion of Step P, "Fuel Temperature Scram", raise a control element approximately one inch.

2. Introduce the Seismic Trip Scram Signal by lightly touching the pendulum on the seismometer with a wire. (The wire shall normally be stored behind the seismometer case.)
3. Check that a scram has occurred in accordance with the scram check "NOTE:" under part N of the Pre-Startup Checkoff.
4. Continue the Pre-Startup Checkoff, beginning with Part O., "Manual Air Scram."