SCHOOL

OF

NUCLEAR ENGINEERING

Purdue University

West Lafayette, Indiana 47907

REPORT ON REACTOR OPERATIONS

For the Period

January 1, 1978 to December 31, 1978

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PURDUE UNIVERSITY REACTOR-1

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West Lafayette, Indiana 47907

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Prepared by

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Reactor Supervisor

1. INTRODUCTION

This report describes the operation of the Purdue University Reactor (PUR-1) for the period from January 1 to December 31, 1978. The report is to meet the requirements set forth in 10CFR50.59 and in the Technical Specifications.

During 1978 the reactor has continued its mission of assisting with the research and educational programs of the University. It is available to all Schools and Departments of Purdue as well as industrial organizations for neutron irradiations or educational purposes. Laboratory classes use the reactor for sample irradiations, reactor operation, and reactor experiments.

As part of a continuing public educational program tours and demonstrations are provided for students from junior high to the university level and to the public at large. During 1978, 522 persons visited the reactor and 41 groups were conducted on tours or demonstrations.

2. PLANT DESIGN AND OPERATIONAL CHANGES

Reactor operations during the year consisted of research, sample irradiations, instruction in reactor operation and surveillance checks.

2.1 Facility Design Changes

No changes in the facility design were made during the year.

2.2 Performance Characteristics

The reactor instrumentation is of a type designed in the mid 1950's using vacuum tube technology, and it has been in use in the PUR-1 since 1962. Replacement parts are difficult to obtain since some are no longer made. Preventative maintenance has minimized the problems but the type and age of the instrumentation has been an ongoing problem for several years. Modern state-of-the-art instrumentation is on hand. Since the technical specifications were approved in late 1978 the installation of the new instrumentation should move forward in the future.

In all cases the instrumentation problems have been such as to fail in a safe manner, causing inconvenience, but no safety problems.

Fuel performance continued satisfactory as indicated by an inspection completed June 19, 1978. No significant change was observed in the aluminum cladding of the fuel plates by either visual inspection or by measurements taken with a micrometer.

2.3 Changes in Operating Procedures Concerning Safety of Facility Operations

Conservation measures put into effect by Purdue due to the power restrictions during the coal strike included shutting down all unnecessary pumps and exhaust systems. In an effort to comply with University policy the water process system was operated only during working hours and the exhaust system only during reactor runs from February 6, 1978 to April 3, 1978. After this period normal continuous operation was resumed.

2.4 Results of Surveillance Tests and Inspections

2.4.1 Reactivity Limits. The reactivity worths of the control rods were measured as follows:

Shim-safety #1 - 5.2% $\frac{\Delta k}{k}$

Shim-safety #2 - 2.6% $\frac{\Delta k}{k}$

Regulating Rod - .28% $\frac{\Delta k}{k}$

With an excess of .47% $\frac{\Delta k}{k}$ the shutdown margin was calculated to be 7.6% $\frac{\Delta k}{k}$.

The annual inspection of the control rods was completed on May 15, 1978 with no noticeable change observed.

No new experiment was placed in the PUR-1 that required a determination of its reactivity worth.

2.4.2 Reactor Safety System. A channel test is performed on each safety system channel during the prestartup check. This is done for each reactor run that follows a shutdown of 8 hours or more.

A channel check of each reactor safety channel was performed at least once every four hours when the reactor is operating.

An electronic calibration was performed on all the safety channels on January 5, 1978. The results are in close agreement with previous checks which indicated a non-linearity in the last decade. This non-linearity is on the conservative side (i.e. 1 kilowatt indicated on Log N vs. 680 watts by foil activation). A recheck by foil activation on

December 8, 1978 reconfirmed these readings.

Verification that the radiation monitoring equipment is operational is completed during the prestartup procedure that preceeds each reactor run.

Shim-safety rod drop times continued to be measured on a quarterly basis until the Technical Specifications were approved. All drop times fell between 563 and 593 milliseconds which is below the 600 millisecond maximum and continues to show no significant change in the drop times.

2.4.3 Primary Coolant System. In an attempt to minimize any variables the pH of the primary coolant is measured each Monday before the weekend flow system is revalved. This has produced values between 5.2 and 5.9. On June 12, 1978 a digital pH meter replaced litmus paper as the means of measuring the pH, a change which gives more reliable results.

Conductivity of the primary coolant is recorded each Monday and has never exceeded 1.24 micromho-cm during the year. This value corresponds to a resistivity greater than 806,000 ohm/cm.

The level of the primary coolant is recorded as part of the prestartup check list which preceeds each reactor run. It has been maintained at or above the 13 foot level during the entire year.

2.4.4 Containment. The negative pressure in the reactor room is included on the weekly check list. Readings from 0.05 to 0.13 inches of water were recorded.

The operation of the inlet and outlet dampers of the exhaust system and the air conditioner are checked at the same time since they are controlled from the same toggle switch. Both systems were cycled in April and October, demonstrating correct operation.

Three representative fuel plates were inspected on June 19, 1978. No evidence of deterioration of the fuel cladding was revealed by the visual inspection or micrometer measurements that were taken. In addition fuel plate number 4-3-73, incorporated as the ninth fuel plate in fuel assembly F-4, showed no visible change in the surface defect that has been inspected annually since its discovery in 1967.

2.4.5 Experiments. The singly encapsulated samples were of such small quantity and both the reactor flux and irradiation time so small that the complete release of all gaseous, particulate, or volatile components of the sample are below 10% of the equivalent annual doses stated in 10CFR20. The maximum activity was for a one gram sample of manganese sulphate which was calculated to be 0.19 mCi after irradiation.

No doubly encapsulated samples were irradiated.

A meteorite sample of unknown material weighed 0.2 gram which is well below the 10 gram limit for samples of unknown composition.

2.5 Changes, Tests, and Experiments Requiring Commission Authorization

No changes, tests, or experiments which required authorization from the Commission pursuant to 10CFR50.59(a) were performed.

3. POWER GENERATION

Operation of the PUR-1 during 1978 consisted of 71 runs which generated 1,034,426 watt-minutes of energy covering an integrated running time of 139.2 hours.

4. UNSCHEDULED SHUTDOWNS

During the year a total of 20 unscheduled shutdowns occurred. They were distributed as follows:

13 composite safety amplifier trouble

5 instrument noise

1 operator error

4.1 Composite Safety Amplifier Trouble

The safety channel portion of the composite safety amplifier (CSA) was originally designed for the trip point to be at 150% of the licensed power level. As reactor power increases the magnet current drops very slightly until the power level approaches the trip point. In the range between 120-150% power, the magnet current drops sharply. Calibration of the fast scram-high level trip point consists of adjusting the magnet current so that the safety rods would drop at 150% power. This operating range would permit the magnet current to be near its maximum value when the reactor was operating at 100% of power.

The specifications for the PUR-1 call for the trip point to be set at 120% of power which means that when operating at 100% power the magnet current has dropped much more than the design intended at this power level and operation is much closer to the trip point on the curve. The random nature of the alignment of the magnet and control rod or the accumulation of a bit of dust between the magnet and the control rod introduces changes in the magnet current drop point following each rod drop. When an unscheduled shutdown is caused by such a shift in the magnet current drop point the only indication on the annunciator panel is CSA TROUBLE. The most conservative setting of the magnet currents requires both accurate alignment and a clean innerface between the magnet and control rod and any change in these parameters will shift the drop point in the direction of an earlier and safer shut down. The short term solution to reducing the frequency of this type of unplanned shutdown is to keep magnets and control rods as properly aligned and dust free as possible. The long term solution that is being pursued is a change in the design of the CAS's which will maintain the magnet power well above the drop point until the trip point is reached. At this time the magnet current will be quickly reduced by electronic or relay action. Both the short and long term solutions are being pursued.

4.2 Instrument Noise

Maintenance of existing instruments is the immediate solution to noise induced shutdowns. For a more permanent solution to this problem solid state instrumentation is being accumulated to replace the vacuum tube design. The sequence for replacement first requires changing the CSA's because some of the new instrumentation is not compatible with the present models. These changes will be completed as soon as practical.

4.3 Operator Error

This unscheduled shutdown occurred when the reactor operator turned the range switch the wrong direction on the linear channel. This produced a high level reading on the lower range.

The necessity for alert operation was impressed upon the operator responsible for the unplanned shutdown and it is felt this will be sufficient to prevent a repetition.

5. MAINTENANCE

No major maintenance was required during the year. The replacement of components that failed, such as vacuum tubes o~ resistors, accounted for the work beyond the preventative maintenance.

PURDUE UNIVERSITY inter office memorandum

To Committee On Reactor Operations
From E. R. Stansberry
Date August 28, 1980
Subject Correction to Annual Report

The worths of the shim-safety rods were inadvertently reported incorrectly in the annual report. Please exchange the enclosed page 2 for the one in your copy of REPORT ON REACTOR OPERATIONS For the Period January 1, 1979 to December 31, 1979.

We are sorry for any inconvenience this may have caused.

ERS/sab

Enclosure as noted

Fuel performance continued satisfactory as indicated by an inspection completed June 29, 1979. Neither visual inspection nor measurements taken with a micrometer indicated any significant change in the fuel plates.

2.3 Changes in Operating Procedures Concerning Safety of Facility Operations

No change in operating procedures concerning the safety of facility operations was made during the year.

2.4 Results of Surveillance Tests and Inspections

2.4.1 Reactivity Limits. The reactivity worths of the control rods are as follows:

Shim-safety #1 - 5.03% $\frac{\Delta k}{k}$

Shim-safety #2 - 2.81% $\frac{\Delta k}{k}$

Regulating Rod - .28% $\frac{\Delta k}{k}$

With an excess of .47% $\frac{\Delta k}{k}$ the shutdown margin was calculated to be 7.65% $\frac{\Delta k}{k}$.

The annual inspection of the control rods was completed on June 21, 1979 with no noticeable change observed.

No new experiment was placed in the PUR-1 that required a determination of its reactivity worth.

2.4.2 Reactor Safety System. A channel test was performed on each safety system channel during the prestartup check. This was done for each reactor run that follows a shutdown of 8 hours or more.

A channel check of each reactor safety channel was performed at least once every four hours when the reactor was critical.