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MODIFICATIONS TO THE NRAD REACTOR

(1977 to Present)

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ABSTRACT

Argonne National Laboratory-West, operated by the University of Chicago, is located near Idaho Falls, ID, on the Idaho National Engineering Laboratory Site. ANL-West performs work in support of the Liquid Metal Fast Breeder Reactor Program (LMFBR) sponsored by the United States Department of Energy.

The NRAD reactor is located at the Argonne Site within the Hot Fuel Examination Facility/North, a large hot cell facility where both non-destructive and destructive examinations are performed on highly irradiated reactor fuels and materials in support of the LMFBR program. The NRAD facility utilizes a 250-kW TRIGA reactor and is completely dedicated to neutron radiography and the development of radiography techniques.

Criticality was first achieved at the NRAD reactor in October of 1977. Since that time, a number of modifications have been implemented to improve operational efficiency and radiography production. This paper describes the modifications and changes that significantly improved operational efficiency and reliability of the reactor and the essential auxiliary reactor systems.

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Criticality was first achieved at the NRAD reactor in October of 1977. Since that time, a number of modifications have been implemented to improve operational efficiency and radiography production. The modifications to the NRAD reactor are categorized as either "operational improvements", which have increased operational efficiency and reliability, or as "production improvements", which have reduced the number of unscheduled shutdowns due to instrument malfunctions or mechanical failures. A brief synopsis of the significant reactor modifications in both categories is presented in the following paragraphs.

A. Operational Improvements

1. Modifications to the Auxiliary Console

The installation of a new beam tube for additional neutron radiography production in 1981 created the need for space on the auxiliary console for the new North Radiography Station instrumentation. It was also desirable to add secondary flow instrumentation to the auxiliary console at this time. Therefore, the existing auxiliary console instrumentation was consolidated and relocated using state-of-the-art components and techniques. Changes to the auxiliary console included:

Relocation of: digital temperature indicator,
clock and rod drop timer,
radiation monitor readouts,
primary and demineralizer flow meters,
conductivity meters, and
uninterruptible power supply.

Installation of: new alarm annunciator panel with audible alarm,
primary and demineralizer pump controls,
neutron shutter indication,
two television monitors, and
secondary flow meter and pump indicator.

All of the preceding listed components are currently located on the auxiliary console except for the uninterruptible power supply, which was removed from the auxiliary console and installed at a remote location behind the main console.

2. Modification of Main Console Annunciator Power Supply Input

Certain plant parameters require continuous monitoring, even when the reactor is shutdown, such as tank water level. These parameters are annunciated on the main console. Until July of 1979, the main console was kept energized at all times to provide this continuous monitoring. Since the control rod drive system is also energized whenever the main console is energized, the control rod drive motors were receiving excessive wear due to the heat generated by their dynamic braking. Therefore, the annunciator power supply input was changed to permit deenergization of the control rod circuits while still maintaining power to the annunciators.

3. Modification of Reactor Tank Liquid Level Switches

The NRAD reactor tank contains two liquid level detectors: a high level detector and a low level detector. Prior to November of 1978, the liquid level switches used in conjunction with the detectors would alarm only if the tank water level increased or decreased beyond prescribed limits. These switches were removed and replaced with fail-safe switches that alarm upon loss of power or detector failure in addition to the prescribed water level limits.

4. Modification to the Silicon Control Rectifier Circuits

From May 1979 to September 1979, a large number of false water level alarms were received. These false alarms were traced to instabilities in the silicon control rectifier (SCR) circuits. Because the SCR circuits are highly susceptible to noise, they were replaced with a 12-volt relay circuit utilizing a latch contact to maintain an alarm indication. Thus, the false water level alarms were eliminated.

5. Modification to the Uninterruptible Power Supply (UPS)

In August 1979 the Nuclear Quality Assurance Program Office, DOE/NPD, issued a bulletin concerning the usage of uninterruptible power supplies as a source of continuous power for reactor instrumentation and other components essential to safe operation and shutdown. The bulletin indicated that there had been a small but repeating number of incidents in which the UPS had been compromised when non-operating personnel (e.g., instrument technicians, janitors, etc.) plugged test instruments, electric drills, vacuum cleaners, etc., into the "convenience outlet" receptacles of the UPS. The NRAD UPS was equipped with two such common "household type" receptacles. These were replaced with "specific purpose" amphenol connectors, preventing general equipment from being plugged into the power supply.

6. Modification to the Demineralizer System

The NRAD reactor demineralizer system utilizes canisters of nuclear grade deionizing resin. The resin canisters come from the factory with a PVC screen to prevent exit of the resin on the outlet side only. If a canister were inadvertently installed backwards in the system, the resin would be flushed out of the canister and into the reactor tank. Therefore, in April of 1981, 149-micron Y-type stainless steel strainers were installed on the outlet side of the canisters to prevent the resin from exiting the demineralizer system in such an event.

7. Modification to the Reactor Room Doors and Ventilation System

Until July of 1984 the air supply for the NRAD reactor room was provided by leakage around the reactor room doors from the HFEF/North cask tunnel area. If a containment brea should have occurred during cask operations, the radioactivity would have been swept through the reactor room, since it was negative with respect to the cask tunnel. Therefore, a leakproof seal door was installed at the entrance to the reactor room, preventing the cask tunnel air from being pulled through the reactor room while the reactor room doors are shut. In addition, ventilation supply to the reactor room was provided from the north corridor (exterior and adjacent to the reactor room) in lieu of the cask tunnel. The addition of the seal door and the modification to the ventilation system also enable the reactor to be isolated from the outside environment in case of a release of activity from the reactor.

B. Production Improvements

1. Modification of the Dual Pen Recorder

In April of 1978 electronic noise generated by the chart-drive motor in the dual pen recorder was causing the rod withdrawal prohibit (RWP) bistable on the log channel of the nuclear instrumentation to trip during reactor startup, necessitating a manual scram. Placing a line filter in the power supply to the dual pen recorder successfully removed the chart-drive motor electronic noise without affecting the nuclear instrumentation.

2. Modification of Individual Control Rod ON Lamp Sockets

By July of 1978, the NRAD reactor had experienced four unscheduled shutdowns due to failures in the individual rod scram circuitry. These failures were caused by a loss of electrical contact between individual rod ON lamps and their bayonet-type sockets due to a build-up of iron oxide on the base of the loosely-fitting lamps. The lamps were in series with the control rod electromagnets. Therefore, loss of contact to one of these lamps would cause the applicable control rod to drop, necessitating scramming the reactor. The bayonet-type sockets were replaced with standard screw-in type sockets, providing good area contact with the lamps.

3. Relocation of the High Voltage Test Switches

During the first year of operation at NRAD, there were six unscheduled scrams caused by the linear power level safety channel power supply circuit board becoming loose from the connector. The circuit board was coming loose as the result of opening and closing the console drawers during performance of the Weekly Checklist. This problem was resolved by relocating the high voltage test switches to the front of each console drawer, eliminating the need to open the drawers regularly.

4. Replacement of the ±15-Volt Power Supplies

In September 1980 the reactor scrammed from steady-state operation at 250-kW. The CIRCUIT TROUBLE, POWER LEVEL ONE and HIGH VOLTAGE annunciators were activated. The POWER LEVEL ONE and HIGH VOLTAGE annunciators cleared when reset. The high voltage monitor chart recorder indicated that a high voltage transit had occurred. After extensive monitoring of the safety channel high voltage circuitry, two changes were made. First, the isolation transformer which supplies power to the nuclear instrumentation was replaced with a Faraday shield isolation transformer, effectively reducing high frequency noise from the power line; and second, the ±15-volt power supplies in the nuclear instrumentation were replaced with new state-of-the-art G.A. power supplies. To date, no further unscheduled scrams of this nature have occurred.

5. Removal of Control Rod ON Lamps

The modification that changed the sockets of the individual control rod ON lamps did not solve all the problems encountered. The control rod ON lamps indicate that magnet power is being supplied, and the circuit is complete. Whenever a lamp burned out, the circuit would be broken, and the applicable control rod would drop, necessitating scramming the reactor. In June of 1984, the control rod ON lamps were removed and replaced with resistors. A single relay was placed in parallel with the control rod electromagnets to provide power to an indicator lamp whenever power is available to the control rod electromagnets.

CONCLUSION

Many changes have been made to the NRAD reactor since first achieving criticality in 1977. Because the reactor is used primarily for production neutron radiography, the majority of modifications have been made to increase reliability and operational efficiency. Upcoming additional modifications are currently under consideration and review, and are expected to further enhance production at the NRAD facility.

Fig. 1 NRAD Reactor