Final Report

DE-FG02-90ER-12966 Breazeale Reactor Modernization Program

DOE Patent Clearance Granted

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6.6.03

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The Pennsylvania State University
Breazeale Reactor Modernization Program, DE-FG0290ER12966
Phase II-V

Date: September 7, 1990 - March 29, 1996

Total U.S. Department of Energy Funding: \$196,576.00

The Penn State Breazeale Nuclear Reactor is the longest operating licensed research reactor facility in the nation. The facility has played a key role in educating scientists, engineers and in providing facilities and services to researchers of many different disciplines. In order to remain a viable and effective research and educational institution, a multi-phase modernization project was proposed. Phase I was the replacement of the 25-year-old reactor control and safety system along with associated wiring and hardware. This phase was fully funded by non-federal funds. Tasks identified in Phases II - V expand upon and complement the work done in Phase I to strategically implement state-of-the-art technologies focusing on identified national needs and priorities of the future.

This report provides information about the DOE funded portion of Phase II-V of the grant indicated. The total project funding included matching funds and cost sharing on the part of the University. A change in reactor management occurred at the end of the project thus delaying the preparation of the report.

Phase II - Amount funded \$72,800

Task 1: Reactor Bridge and Neutron Beam Laboratory Change

Task 2: Adding an Additional Power Monitor

Task 3: Adding a Neutron Diffractometer

Task 1 and 2 were funded.

Phase III - Amount funded \$39,123

Task 1: Radiation Monitoring and Spectroscopy

Task 2: Reactor Control and Safety System Spare Parts

Task 3: Local area Network (LAN) for RCCS

Task 1 was funded

Phase IV - Amount funded \$44,036

Task 1: Reactor Control and Safety System (RCSS) Spare Parts and Facility Upgrade

Task 2: New Personnel Dosimetry System and Emergency Equipment

Task 3: RCSS Console Software Upgrade

Task 4: Distributed Auxiliary Smart Alarm and Control Panel

Task 5: Local Area Network for RCSS

Task 6: Reactor Control and Safety System Spare Parts

Task 1 and 4 were funded

Phase 5 - Amount funded \$40,617

Task 1: Upgrade Health Physics and Emergency Equipment

Task 2: Computer Equipment to support controls and Neutron Radiography research

Task 3: Reactor Pool maintenance

Task 1 and 2 were partially funded.

Description

Phase II

Task 1: Reactor Bridge and Neutron Beam Laboratory Change

- The bridge structure and support for the reactor core was redesigned and built to provide lateral and rotational movement. Prior to this modification the core was only able to move in a longitudinal manner within the pool. A detailed progress report on this part of the project was completed November 15, 1994. Specific details are not included in this report due to security concerns.
 - Rotational movement of the core provides the ability to interface with all experiments at just one core face. This core face is flat which allows for better coupling with experimental apparatus. Single face interfacing allows for the placement of reactor instrumentation at a location to minimize power degradation due to the experiment-instrumentation interaction.
 - Lateral movement of the core allows coupling with several additional permanent experimental facilities and better access to the beam tubes. This greatly enhances the research capabilities since there are fewer limitations placed on the size of the experiment and set-up time is minimized.
- A new D₂O thermal column was designed and constructed to improve beam quality. The new design provides for a tangentially coupled reactor to the NBL.
 - A tangentially coupled neutron beam improves the neutron beam quality by increasing the neutron to gamma ratio. This enhances the contrast of radiography therefore expanding the utility of the beam for research.
- New shielding was designed and constructed for the beam tubes and for the beam target area in the NBL. The challenge of the shielding is to provide for potentially large and small experiments while allowing access to experimenters. Movable shielding was included to accommodate the variety of uses and size of experiments. This follows the ALARA principle for the personnel radiation exposure of those working in the NBL.

Task 2: Adding an Additional Power Monitor

An additional wide range power monitor was purchased and installed. The computer-based control and monitoring system only had one wide-range fission chamber instrument. This instrument functions as a safety

channel and as an input to the automatic power control. This channel is needed to satisfy technical specification requirements and maintain power calibration. The addition of a spare wide range power monitor provided for a necessary back-up of a critical component, which was recommended by the bid specifications of the replacement control system. This additional detector provided the ability to study various detector locations to determine placement for adequate and predictable power monitoring. This improved the reproducibility of power level, allowed safe manipulation of the flux profile to optimize the beam and core face flux, and increased reactor safety and reliability.

Phase III

Task 1: Radiation Monitoring and Spectroscopy

New radiation monitoring and spectroscopy equipment was purchased and installed. A high purity germanium detector with a 45 percent efficiency rating was purchased along with new software to interface with the detector. The new spectroscopy system is more sensitive and reliable than the older system, which frequently failed and contained hard-to-find replacement parts. The new system with "user friendly software" improved the ability for the analysis of activated samples and air monitor filters. As part of this project another detector was located in the reactor bay for immediate analysis of samples released from the reactor. This remote means of analysis improved assessment capability.

Phase IV

Task 1: Reactor Control and Safety System (RCSS) Spare Parts and Facility Upgrade

The RCSS consists of hardwired reactor instrumentation and a redundant computer system. This redundancy comes about due to the fact that all operational interlocks and safety system scrams are duplicated in software in the control computer DCC-X. The spare parts required to maintain operations without extended periods of downtime can be divided into two categories; the hardwired reactor safety system and the digital control computer system. Spare parts from the digital control system technical manual were evaluated and purchased. These items were chosen because they are long lead time items, or items that would be difficult to obtain. I/O cards and assemblies needed to maintain an operable, reliable control system were purchased along with equipment to improve the thermal power calibration of the reactor.

Task 4: Distributed Auxiliary Smart Alarm and Control Panel

Rather than continually change the computer software as facility changes occurred it was determined that most of the parameters could be monitored using an auxiliary Smart Alarm and Control panel. All of the necessary equipment was purchased and training for reactor engineers was

conducted on this system. However, as implementation of the system progressed there was a concern for validation and verification issues. The U.S. Nuclear Regulatory Commission brought up these issues. After an analysis of addressing and documenting V&V issues with the Smart panel system - it was determined that the personnel time would exceed any benefit of the proposed system. Funds that were not expended on this part of the project were then used to implement Task 5, which was not originally funded. A synopsis of Task 5 follows.

Task 5: Local Area Network for RCSS

This task utilized the funding originally intended for the smart panel. The RCSS LAN system was extended to other parts of the facility and to the Emergency Support Center. Three microcomputer systems were purchased along with associated hardware needed to extend the network. This network development enhanced the capability to evaluate reactor events and provided for greater utilization of the capabilities of the new control system. One component of the new system was implemented in the west stairwell of the reactor building replacing an old lighted indicator for radiation alarms. This not only gives an indication of which alarms were tripped, but a trend of the alarm parameter can be accessed providing valuable input to determining possible cause and mitigating actions that might be taken. The computer in the Emergency Support Center provides for real-time and historical monitoring of reactor and facility parameters from a distant location. This improved emergency response and support capabilities. It also allows the Emergency Director and emergency support teams to understand the conditions of the reactor facility without the necessity to enter the building or reactor bay. An additional station was initially implemented in the neutron beam laboratory to provide better communication with researchers about information on reactor power levels and other parameters as needed. This station was moved to the reactor classroom as an educational and training tool for students and staff.

Phase V

Task 1: Upgrade Health Physics and Emergency Equipment

Several new radiation detectors along with a high-volume air sampler were purchased for the Emergency Support Center to improve the dose assessment capability. Speakers and cables were purchased to upgrade existing radiation monitoring equipment - providing an audible feedback of radiation activity along with the meter indication. Powered air-purifying respirators were purchased for the re-entry team.

Task 2: Computer Equipment to support controls research and Neutron Radiography research

Computer equipment for data acquisition and controllers were purchased for research on advanced reactor control and optimization. A SPARCstation 10 Model 54 with four 45 MHz processors plus SuperCache was purchased for this research. Image processing equipment and software was purchased for neutron radiography research. The funding of the equipment greatly enhanced data acquisition providing for more detailed imaging capabilities.