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STATUS OF THE UNIVERSITY OF MISSOURI-COLUMBIA RESEARCH REACTOR UPGRADE

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ABSTRACT

The University of Missouri-Columbia (MU) Research Reactor Facility staff is in the process of upgrading the operational and research capabilities of the reactor and associated facilities. The upgrades include an extended life aluminide fuel element, a power increase, improved instrumentation and control equipment, a cold neutron source, a building addition, and improved research instrumentation and equipment. These upgrades will greatly enhance the capabilities of the facility and the research programs. This paper discusses the parts of the upgrade and current status of implementation.

I. INTRODUCTION

The MU Research Reactor (MURR), the highest steady state power university research reactor, is enhancing the research, education, and service capabilities of the facility through a five part upgrade. The existing reactor is a 10 MW, pressurized loop type, already operating at a greater than 90 percent availability to support demand from researchers and industry. The upgrade is focused to meet the increasing demand for more neutrons and higher specific activity radioisotopes, especially for the biomedical community, cold neutrons, and expanded laboratory and office space. This kind of upgrade is especially important at a university research reactor to help meet the need for increased education and training in the nuclear sciences in the USA. The upgrade includes an extended life fuel element, power increase, instrument and control and electrical system upgrade, cold neutron source (CNS), building addition, and modernization of research instrumentation and equipment.

MURR has been working on this upgrade since 1983, when work started on the fuel element conceptual design and power upgrade feasibility study. The fuel design and safety analyses were performed by the MURR staff. They are also working on the power upgrade safety analyses with support from the MU Nuclear Engineering Program faculty and students. Stone and Webster Engineering Corporation was architect/engineer for the conceptual design, completed in 1987, of the fluid system modifications for power increase, instrumentation and control, and electrical package and the building addition. Stone and Webster acted as MU's agent in determining the CNS options. In March 1989, Sverdrup Corporation was selected architect/engineer for the detail design of the building addition with the design to be completed after a new MURR Director is hired.

II. DISCUSSION

Extended Life Fuel Element

MURR based the new fuel element design on the extended life aluminide fuel (ELAF)[1] with the goal of reducing the fuel cycle cost and providing a core capable of operating at a higher power level. The ELAF is aluminide fuel with UAl_2 the primary constituent in the UAl_x powder with 50 volume percent UAl_x powder in the fuel meat. This gives a loading density of 3 gm/cm^3 of high enriched uranium (HEU). The advantage of the ELAF is the coupling of the high uranium loading with the ability to maintain good fuel plate integrity in high burnup conditions. Test plates were run in the Advanced Test Reactor (ATR) in Idaho with peak burnups of 3.0×10^{21} $fissions/cm^3$.[2]

The uranium loading per unit volume is varied to flatten the radial power density, with a total element loading of 1.244 kg of U-235. Boron carbide is used in some of the inner and outer plates as a burnable poison. The combination of heavy uranium loading, high burnup limit, and flattened power density provide the characteristics needed to more than double the megawatt days (MWD) of energy obtained per element to 300 MWD.[3-4]

Since submitting the fuel license amendment in September 1986, MURR has answered three sets of questions concerning the requested license amendment to cover the ELAF fuel. The last set (submitted February 1989) was strictly concerning reactivity transient analysis and some clarification of wording in previous submittals. The Nuclear Regulatory Commission (NRC) asked four more question in November 1989 requesting MURR modify the requested license amendment to better fit the analysis completed for the first three NRC question sets. Response to these latest questions will be completed in March 1990, and the NRC's approval for use of ELAF may be given shortly thereafter. If the DOE university fuel budget can support the startup cost for fabrication of a new fuel design, the MURR ELAF fuel element will be used starting in 1990.

Power Increase

The goal of the power upgrade is to operate the reactor at the maximum safe technical limit as is often done in European reactors. With its flattened power distribution, the new fuel element design provides the greatest increase in the safe technical limits. The physical dimensions are identical to the current fuel element, requiring no change in the geometry of the reactor core.

The only modifications planned for operating at a higher power are the slight increases in operating pressure and primary coolant flow rate, and installation of new heat removal equipment. The upgrade power level has been targeted at 30 MW. The safety analyses performed have shown no problem operating at 30 MW.[5-9] However, the loss of coolant accident results are very sensitive to changes in power level around 30 MW.[10] To show confidence in the RELAP5/M0D2 analysis for a low pressure/low temperature fuel plate type research reactor, MU's NE department and MURR submitted a proposal to DOE for a benchmark experiment. This was funded in November 1988 and the work is in progress.[11]

Reactor Instrumentation & Control and Electrical System Upgrade

The reactor instrumentation and control (I&C) system was reviewed to determine necessary modifications and recommendations for equipment replacement and improvements. An evaluation was performed both for reliability/availability improvements and for reactor upgrade requirements.

During FY89, the first phase of I&C/electrical upgrade began. A small building addition adjoined to the facility houses the new 275 KW Cummins diesel emergency generator. It includes an empty bay sized for the future installation of a 2500 KW electrical substation required for the power upgrade, CNS, and expansion of facilities. The electrical upgrade also included the installation of a Solidstate Controls Inc. (SCI) uninterruptable power supply (UPS) to handle the reactor I&C system. The emergency generator was put in service in August 1989, the UPS in November 1989. Upgrade of two I&C subsystems was started during Spring 1989--the area radiation monitoring system (ARMS) and the exhaust stack radiation monitor. The installation of an Eberline analog ARMS will be completed in March 1990 and of a Nuclear Measurements Corporation (NMC) stack monitor in May 1990. MURR is planning to complete the next task in the I&C upgrade during 1990 by replacing the nuclear instrumentation systems (replace six 1960 model channels with three 1990 model channels).

Cold Neutron Source

To meet the rapidly increasing demand for long wavelength neutrons, the MURR upgrade includes adding a cold neutron source (CNS) facility. The CNS will be in the reflector near the core, and this section of the reflector will be modified to enhance the CNS effectiveness. With the reactor operating at 30 MW, the thermal flux around the CNS would be approximately 3×10^{14} neutrons/cm^2 sec with gamma heating of 3.6 watts/gram. A small part of the analyses have been completed to evaluate what combination of reflector materials (beryllium, D_2O, bismuth, etc.) and which CNS design will give the optimal combination of long wavelength neutron beam intensity, capital and operating costs, and minimum impact on other users of the reactor.(12) With 30 MW reactor power, a lower core position, and a CNS, the intensity of 8 Å (8×10^{-10}m) wavelength neutrons could increase by a factor of 80.

The MURR staff also evaluated CNS designs from three suppliers of this equipment, Technicatome, Interatom, and AECL. As part of this evaluation, Stone and Webster assisted MU in obtaining conceptual design information and cost data from the three vendors. The design information requested was for a total package including cryogenic and control systems that would be applicable to installation and operation of a CNS at MURR's beamport "E" position. The information was to be based on previous experience, and to include the design parameters and estimate of the expected capability and performance characteristics.

Facilities Expansion

The MURR upgrade includes a 44,000 sq ft (4087 m^2) building addition, the conceptual design of which was completed in January 1987. The addition centers around a cold neutron guide hall that allows a 60 m flight path for experiments using the CNS. Several electronics laboratories will be relocated in the new addition, freeing up their current location (laboratories with fume hoods) for expanding the radioisotope applications research. The building will also contain a 1600 sq ft (148 m^2) counting room, a clean room, culture room and sample preparation laboratory for neutron activation analysis (NAA).

The State of Missouri appropriated $250,000 for planning of the new addition. Sverdrup Corporation was selected to work on the detail design of this facility in March 1989, but the design will be worked after the new MURR Director is hired. With the July 1989 administrative shift of MURR to the MU campus from the University of Missouri System level, the 1987 conceptual design will be restudied to see if it provides for the best coupling of the combined strengths of MURR and the research strengths of other MU departments.

III. CONCLUSIONS

MURR has designed a fuel element that will cut the fuel cycle cost at least in half and provide a flatter power distribution allowing for a power increase up to 30 MW. A power increase to 30 MW will provide a peak thermal flux of 1.8×10^{15} neutrons/cm^2 sec in the flux trap and a beam port flux of 3.5×10^{14} neutrons/cm^2 sec.

The cold neutron source coupled with other improvements will provide an increase up to a factor of 80 in 8 Å wavelength neutrons, which are needed for the fastest growing area of neutron scattering research. The laboratory space available to radioisotope applications for finding ways to cure cancer will at least double. The NAA group will have a major increase in facilities to aid in their trace element research in areas such as nutrition studies, epidemiology studies, archaeometry studies, etc. The 44,000 sq ft (4087 m^2) building addition will provide a guide hall and new research facilities to meet the demand for increased utilization of the reactor. Estimated to cost $23,000,000 in FY88 dollars, the total project will take four to five years to complete.[13-14] Missouri Governor Ashcroft has pledged the State will provide one-third of the project cost when the matching two-thirds are obtained. The upgrade will expand the world-class capabilities of the best research reactor located on a university campus, and will enable the USA to educate and train the researchers needed by national laboratories and the proposed Advanced Neutron Source.

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