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PROPOSED POWER UPGRADE OF THE HOT FUEL EXAMINATION FACILITY'S NEUTRON RADIOGRAPHY REACTOR

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Argonne National Laboratory-West is located near Idaho Falls, Idaho, and is operated by the University of Chicago for the United States Department of Energy in support of the Liquid Metal Fast Breeder Reactor Program, LMFBR.

The Hot Fuel Examination Facility, HFEF, is one of several facilities located at the Argonne Site. HFEF comprises a large hot cell where both non-destructive and destructive examination of highly-irradiated reactor fuels are conducted in support of the LMFBR program. One of the non-destructive examination techniques utilized at HFEF is neutron radiography.

Neutron radiography is provided by the NRAD reactor facility, which is located beneath the HFEF hot cell. The NRAD reactor is a TRIGA reactor and is operated at a steady state power level of 250 kw solely for neutron radiography and the development of radiography techniques.

When the NRAD facility was designed and constructed, an operating power level of 250 kw was considered to be adequate for obtaining radiographs of the type of specimens envisaged at that time. A typical radiograph required approximately a twenty-minute exposure time. Specimens were typically single fuel rods placed in an aluminum tray.

Since that time, however, several things have occurred that have tended to increase radiography exposure times to as much as 90 minutes each. First, a new beam tube was installed for the purpose of radiographing specimens outside of the hot cell. The flux at the plane of radiography is one-half that of the original beam tube, resulting in exposure times twice as long as required on the original beam tube. Second, the development of the radiography technique known as "computed axial tomography" has led to the desire by scientists to radiograph reactor fuel subassemblies prior to dismantling them. Tomography at just one elevation along a subassembly can require as many as 90 exposures. Finally, the thickness of the specimens being radiographed is greater than was initially envisaged. Radiography of subassemblies as thick as 12.5 inches is presently being planned. A typical exposure time for such a subassembly is 90 minutes.

In order to decrease exposure times, the reactor power level is to be increased from 250 kw to 1 Mw. This increase in power will necessitate several engineering and design changes. For instance, the primary cooling system will have to be completely replaced. Presently the system consists of 2.5-inch aluminum piping and a ten horsepower pump, which results in a primary flow rate of 120 gpm. The upgraded system will consist of 4-inch stainless steel piping and a 40 horsepower pump in order to provide a flow rate of 480 gpm. Also, the primary cooling system delay loop, which is presently located within the reactor tank, will be increased in capacity and relocated to a position external to the reactor tank[1].

Due to the increased primary cooling system flow rate, the primary flow meter will require replacement with one of appropriate range. The nuclear detectors will be relocated from their present positions near the core to positions adjacent to the tank wall. The nuclear instrumentation amplifiers will be modified to increase their operating ranges.

For the most part, the present facility radiation shielding should be adequate for the upgraded reactor. Some additional shielding will be required on the reactor room doors and some additional neutron shielding may be required for the north beam tube. The east beam collimator and shielding are being redesigned. A new beam stop will be necessary for the east beam and plans are to incorporate the upgraded primary cooling system delay loop into its construction.

The only changes that will be required for the purification system will be to relocate the system delay loop from its position within the reactor tank to a location external to the tank and to provide shielding for the resin bottles.

The secondary cooling system changes will be major. Presently the secondary cooling system is a branch of the HFEF facility cooling system, which does not have the cooling capacity required for the upgraded core. Present plans call for divorcing from the HFEF facility system completely. Therefore, a new pump and cooling tower will be required.

The present primary-to-secondary heat exchanger is designed for 300 kw operation. A used 3 Mw heat exchanger has been acquired from the Lawrence Livermore National Laboratory.

The most major changes required will be to the reactor core itself. The Exterminator III computer code, which is a U. S. Nuclear Regulatory Commission accepted code, was used in designing the upgraded reactor core. The present core contains 61 FLIP fuel elements, three boron-carbide control rods, and 10 rectangular graphite elements. The average power per fuel element is 2.02 kw, and the maximum fuel element power is 5.95 kw.

The upgraded core will be a mixed core similar to the one at Texas A&M University and will contain 61 70%-enriched FLIP fuel elements and 39 20%-enriched standard fuel elements. The upgraded core will also have four fuel-follower type control rods. The use of fuel-follower type control rods will require a new grid plate with holes for the fuel-followers. The upgraded core will require 24 graphite elements that will have to be fabricated. The average power per fuel element will be 9.6 kw and the maximum fuel element power will be 17.00 kw.

The upgraded core will also contain instrumented fuel elements and a rabbit system.

The standard fuel elements, fuel-follower control rods, and instrumented fuel elements required for the upgraded core have been obtained from Texas A&M University. A shielded box with two master-slave manipulators for use as the rabbit terminal has been obtained from another Argonne organization.

The proposed upgrade of the NRAD facility will increase the neutron flux available in the beam tubes appreciably. The increased flux will enable NRAD to continue to meet its operational commitments in a timely manner and to develop state-of-the-art techniques in the future as it has in the past.

REFERENCES

1. C. C. Heidel, W. J. Richards and D. P. Pruett, Reconfiguration of the NRAD Delay Loop for Proposed 1 Mw Operation, Ninth U. S. TRIGA User's Conference, Anaheim, California, March, 1984.