REFUELING THE RPI REACTOR FACILITY WITH
LOW-ENRICHMENT FUEL*

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ABSTRACT

The RPI Critical Facility has operated since 1963 with a core of thin, highly enriched fuel plates in twenty-five fuel assembly boxes. A program is underway to refuel the reactor with 4.81 w/o enriched SPERT (F-1) fuel rods. Use of these fuel rods will upgrade the capabilities of the reactor and will eliminate a security risk. Adequate quantities of SPERT (F-1) fuel rods are available, and their use will result in a great cost saving relative to manufacturing new low-enrichment fuel plates. The SPERT fuel rods are 19 inches longer than are the present fuel plates, so a modified core support structure is required. It is planned to support and position the SPERT fuel pins by upper and lower lattice plates, thus avoiding the considerable cost of new fuel assembly boxes. The lattice plates will be secured to the existing top and bottom plates. The design permits the fabrication and use of other lattice plates for critical experiment research programs in support of long-lived full development for power reactors.

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INTRODUCTION

The critical facility at the L. David Walthousen Laboratory at Rensselaer Polytechnic Institute (RPI) includes a water-moderated reactor fueled by highly enriched uranium (HEU) in the form of $\text{U}_2\text{O}_2$ dispersed in stainless steel fuel plates. Since the beginning of its operation as an RPI facility in 1963, the reactor has operated in a highly satisfactory manner as a training and research facility. The reactor was reconfigured several years ago so as to reduce the U-235 inventory below 5kg. The reactor operating license was renewed recently to the year 2003.2,3

The research carried out at the RPI facility has included reactor noise and kinetic experiments as well as activation and reactivity worth measurements. In these low-neutron-flux research operations, there is no need to use HEU fuel with its attendant security problems. In fact, low-enrichment fuel (LEU) in the form of clad $\text{U}_2\text{O}_2$ rods would be advantageous because it would permit a variety of critical and other experiments in support of nuclear power programs. The training function at the RPI facility similarly would be enhanced by the use of LEU oxide rod-type fuel because this fuel would be more closely related to fuel used in the nuclear power industry.

A program is underway to refuel the RPI reactor with 4.81 w/o enriched SPERT (F-1) fuel rods clad in stainless steel 11.84 mm in outside diameter. The stainless steel cladding will be compatible with the remainder of the RPI reactor, which contains stainless steel components; thus the water purification system need not be upgraded. The proposed fuel rod configuration and support structure will be such that critical experiments can be carried out in support of light water power reactor programs, particularly for high exposure fuel development. The enrichment of the SPERT (F-1) fuel is somewhat higher than that currently used in light water power reactors, but it is typical of the higher enrichments which are required for high exposure fuel. The use of stainless steel clad rather than the Zircaloy clad commonly used in light water power reactors does not greatly affect such critical experiments, although it must be corrected for.

Adequate quantities of SPERT (F-1) fuel rods are available, and their use will result in a great cost savings compared with use of LEU fuel plates manufactured for the purpose. With present fuel element technology, it is not possible to achieve the uranium density required for simple replacement of HEU fuel plates by LEU fuel plates in the RPI reactor. It would be necessary instead to add numerous fuel plates and some fuel assemblies of low enrichment. In this case, there would be additional costs for core design and safety analysis although the basic core support structure and control system would remain unchanged. The new fuel plates would likely be uranium silicide in aluminum and would represent a
substantial cost. Care would be required to ensure chemical compatibility of the aluminum plates with the otherwise stainless steel system. The RPI Critical Facility will continue to operate at very low power with the SPERT (F-1) fuel in place so the SPERT (F-1) fuel rods can be reused later by the U.S. Government for other purposes. That is, the SPERT fuel will receive only very low exposure during the lifetime of the RPI reactor.

The refueling program has a number of components. These include (a) nuclear core design; (b) mechanical redesign of support structure; (c) safety analyses to verify new core design for license modification; (d) fabrication of new core support structure components; (e) disassembly of old core structure and peripherals; (f) assembly of new core structure and peripherals; (g) redesign, reconstruction, and criticality analysis for the fuel storage vault; (h) shipment of old fuel to designated facility; (i) shipment of new fuel to RPI and storage in vault; (j) reanalyses of instrument response, shielded doses, and other reactor parameters for license modification; (k) alteration of Technical Specifications and other documents for license modification; (l) loading of new core and experimental verification of reactor safety parameters; (m) reestablishment of instrument set points and other operational techniques.

The principal technical problem is the design of the new core support structure and control system within reasonable cost limitations. Figure 1 shows the present core structure. The integrity of the core support structure is maintained by four vertical tie bolts in tension and by the massive top plate, middle (support) plate, and lower (carrier) plate. These units are retained in the new design which should be at least as strong as that presently used.

The SPERT (F-1) fuel rods are 106.05 cm long, 19 inches longer than are the present fuel plates. Nuclear analyses indicate that about 500 fuel rods will be required on a square lattice pitch of about 1.4 cm. The roughly cylindrical array of fuel pins will extend out to a radius (see Figure 2) which contacts the present control rod locations to an extent which is estimated to be adequate to yield suitable control rod worths within the present Technical Specifications. The total fuel weight will be about one-half metric ton. The fuel rods will be supported and positioned on a new lower fuel pin support plate (see Figure 2) resting on and secured to the existing carrier plate. The lower fuel pin support plate will be drilled with 1/4" diameter holes in square array to accept the lower tips of the SPERT pins. A new upper fuel pin positioning plate (see Figure 2) resting on the top plate will be drilled through on the appropriate square pitch to position the upper ends of the fuel
Figure 1. Present Core Support Structure
pins. The lower fuel pin support plate and the upper fuel pin positioning plate will be secured by the present tie bolts. Such plates are used in many critical experiments and will be referred to here as upper and lower lattice plates. The use of lattice plates is much less expensive than new fuel assembly boxes and provides a regular fuel pin array unbroken by stainless steel box walls. The middle (support) plate will be retained for structural reasons and to support a plastic spacer plate, but its center will be machined out. Four new tie rod spacers will be required.

The present control rods and control rod drives will be retained, but the HEU fuel followers will be removed. Additional absorber sections (on hand) will be inserted both for enhanced control rod worth and to maintain the control rod weight. The present control rod hydraulic shock absorbers (see Figure 1) will be retained as fastened below the lower (carrier) plate. The control rod motion will be laterally constrained by cutouts in the upper lattice plate and by new, longer positioning rods passing through holes already present in the shock absorbers. There is adequate space below the carrier plate for these positioning rods when the control rods are fully inserted. There is also adequate travel on the control rod drive gears for the increased core height; however, minor modifications are required to the control rod height sensor mechanisms.

CONCLUSIONS

The use of LEU SPERT (F-1) fuel in the RPI Critical Facility reactor provides advantages in increased functional capabilities and in lessened security risk over the present HEU fuel plates. Moreover, the use of the existing SPERT (F-1) fuel is much less expensive than would be manufacture of new LEU fuel plates for the reactor. The lattice plate technique for positioning the fuel pins is considerably less expensive than would be fuel assembly boxes, and it permits the core to be a uniform array of fuel rods. The structural properties of the new core are expected to be similar to those for the present core. It is anticipated that the control rod system will be used with little modification except for replacement of fuel followers by absorber material.
REFERENCES


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