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RECENT OPERATIONAL HISTORY OF THE NEW SANDIA PULSED REACTOR III (SPR III)*

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The Sandia Pulsed Reactor III (SPR III)[1] is a fast-pulse research reactor which was designed and built at Sandia Laboratories and achieved criticality in August 1975. The initial tests and operations were reported in an earlier paper[2]. The reactor is now characterized and is in an operational configuration. The core consists of 18 fuel plates (258 kg fuel mass) of fully enriched uranium alloyed with 10 wt. % molybdenum. It is arranged in an annular configuration with an inside diameter of 17.78 cm, an outside diameter of 29.72 cm, and a height of 35.9 cm. The reactor core uses reflectors of copper and aluminum for control and an external bolting arrangement to secure the fuel plates. SPR III and SPR II[3] are operated on an interchangeable basis using the same facility and control system. As of June 1977, SPR III has had over 240 operations with core temperatures up to 541^{o} C.

For a nominal 400^{o} C ΔT reactor pulse (reactivity insertion of $1.10), the total fluence in the cavity is 7.5×10^{14} n/cm^2 with a peak flux of 9.9×10^{18} n/cm^2 - sec and a pulse width at half maximum power of 76μsec. The ratio of pulse width to reactor period varies from 2.8 to 3.4 in this reactor. The gamma dose is 1.0×10^5 rads with a peak rate of 1.3×10^9 rad/sec. The neutron spectrum is a slightly softened fission spectrum with all of the neutrons having energies greater than 10 KeV. Approximately 10 percent of the neutrons have energies greater than 3 MEV.

*This work is sponsored by the U.S. Energy Research and Development Administration.

The reactivity worth of the pulse element is \$1.16 and the control element bank is \$9.74 with a control margin of \$7.12. The element worths have been decreased 13% from the as-built values.[4] The experiments conducted thus far have varied in reactivity worth from (+) \$3.60 to (-) \$4.34.

Initially, there was significant coupling between the experiments and the pulse element such that the pulse element worth varied from \$1.08 to \$1.21 depending on the type of experiment. This coupling was reduced by increasing th Boron-10 thickness in the shroud tube. In addition, this increased decoupling was needed to reduce the fission density and hence temperature peaking on the inside surface of the fuel caused by experiments containing neutron moderators. It also shifted the reactivity worth of moderating experiments to negative values. This is shown in Figure 1 giving the worths of various disk-shaped materials as a function of position in the experiment cavity. The results for polyethylene are with three different amounts of decoupler.

Increased decoupler also improves the kinetic performance of the reactor. Moderating experiments increase the neutron lifetime of the reactor as shown in Figure 2 where for a given yield the inverse reactor period is shorter. The effects of additional decoupling is evident in the two measurements with the nylon sample. The shift in data near an alpha of 2×10^4 sec^{-1} is caused by a dynamic thermal expansion effect which breaks a magnetic coupling supporting the lower core half. This permits the core halves to rapidly separate and reduces the heating produced in the tail of the pulse.

The neutron lifetime for the "free field" (no experiment) configuration is 14.6 nanosec. With some experimental polyethylene configurations, the lifetime is calculated to be as high as 32 nanosec. The bare cylinder of nylon, 7.62 cm diameter by 12.7 cm long, yielded a lifetime of 19.1 nanosec. With the additional B-10 decoupling, the lifetime was reduced to 15.5 nanosec. This shift in lifetime is in agreement with Monte Carlo calculations.[5]

Some minor mechanical changes have also been made to the reactor. The slotted inconel support plates at the center of the reactor were replaced with unslotted steel plates because of deformation caused by the dynamic fuel expansion. The steel plates have also deformed slightly, but this has not impacted the operability of the reactor. The nitrogen cooling system was modified in order to cool both halves of the core at the same rate. The upper core half support posts were redesigned to provide a built-in micrometer adjustment capability. This permits rapid alignment of the two core halves eliminating the use of shims and reducing personnel radiation exposures.

The control and plant protection system was placed into operation in 1974 and was used to operate SPR-II before SPR-III became operational. Hence, no changes have been required in the electrical systems.

In summary, SPR III satisfied the design criteria with a minimum of post-critical modifications. It is operating reliably in a predictable and repeatable fashion.

Acknowledgment

We wish to thank J. A. Snyder, the SPR Facility Supervisor, and his staff for providing the data used in this paper.

References

1. J. A. Reuscher, T. R. Schmidt, R. L. Coats, D. J. Sasmor, D. N. Cox, "Design of Sandia Pulsed Reactor III (SPR III)" Trans. Am. Nucl. Soc, 23, 476 (1976).

2. J. A. Reuscher, B. F. Estes, J. S. Philbin, "Performance Characteristics of the Sandia Pulsed Reactor III"; Trans. Am. Nucl. Soc., 23, 476 (1976).

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4. T. R. Schmidt, R. L. Coats, "Neutronic Analysis for Sandia Pulsed Reactor III (SPR III)," Trans. Am. Nucl. Soc., 23, 560 (1976).

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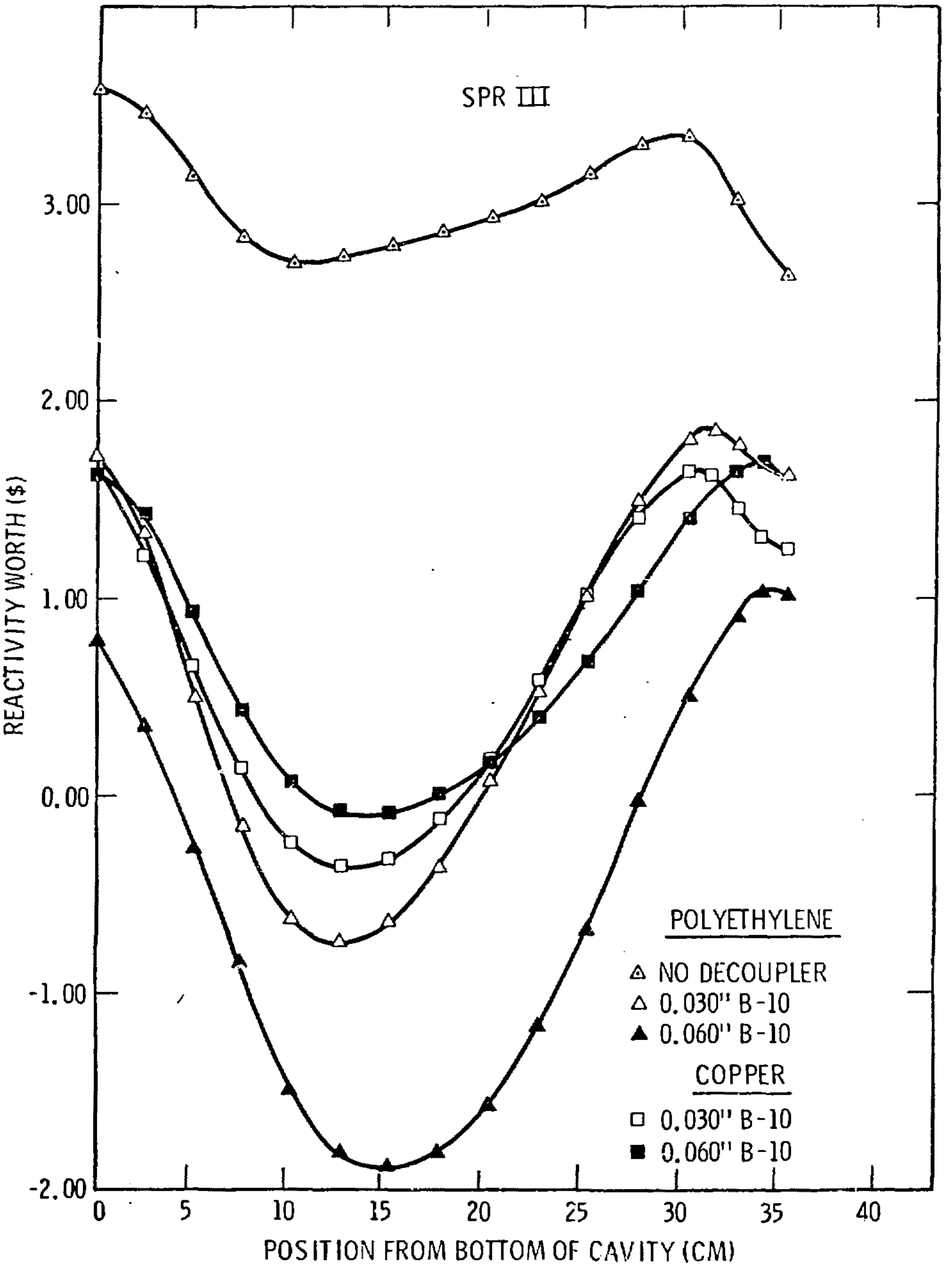

Figure 1 - Reactivity worths of 2.54 cm thick disc samples versus axial position in the experiment cavity.

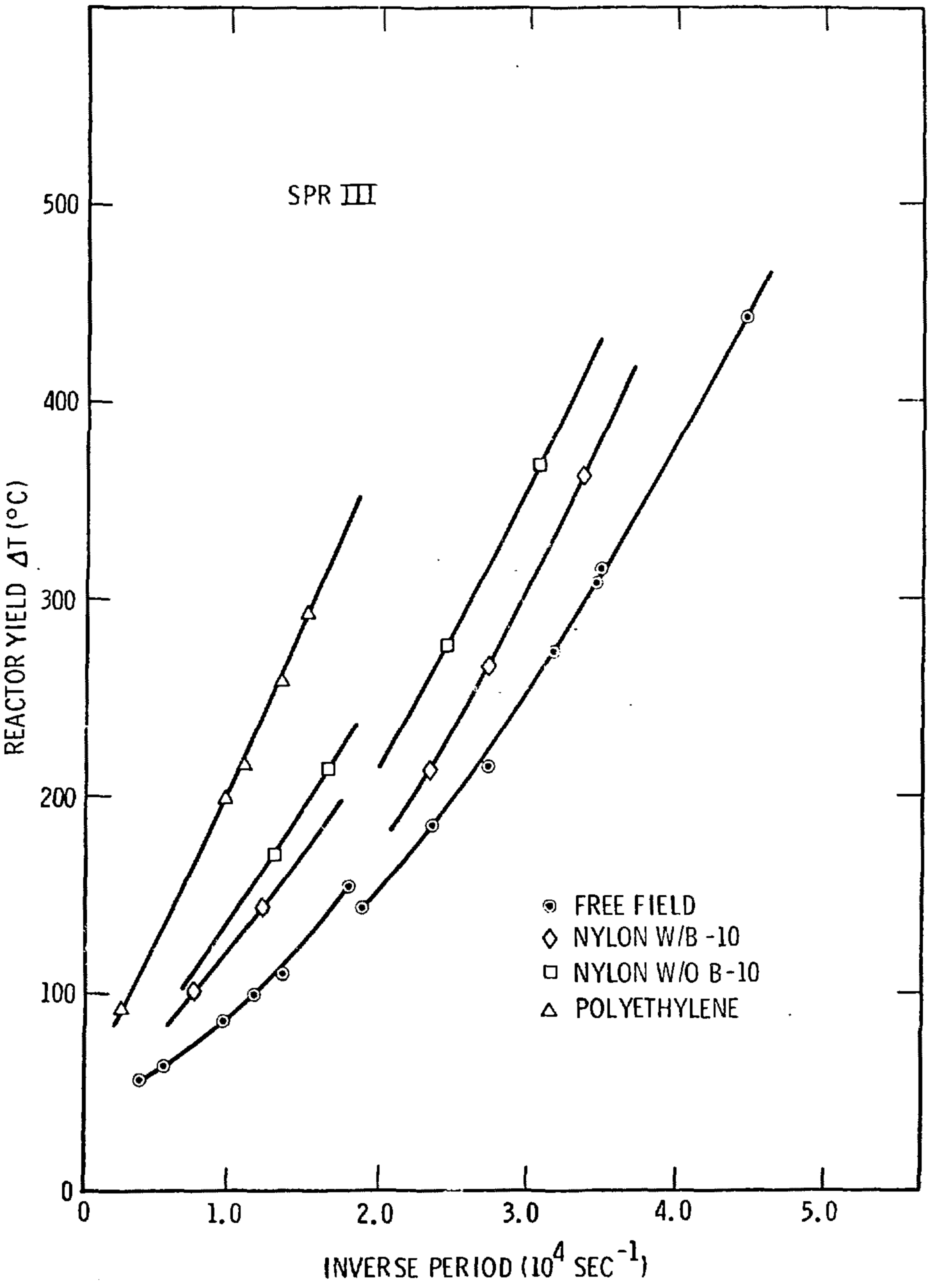

Figure 2. Inverse reactor period versus reactor yield with various moderating experiments.

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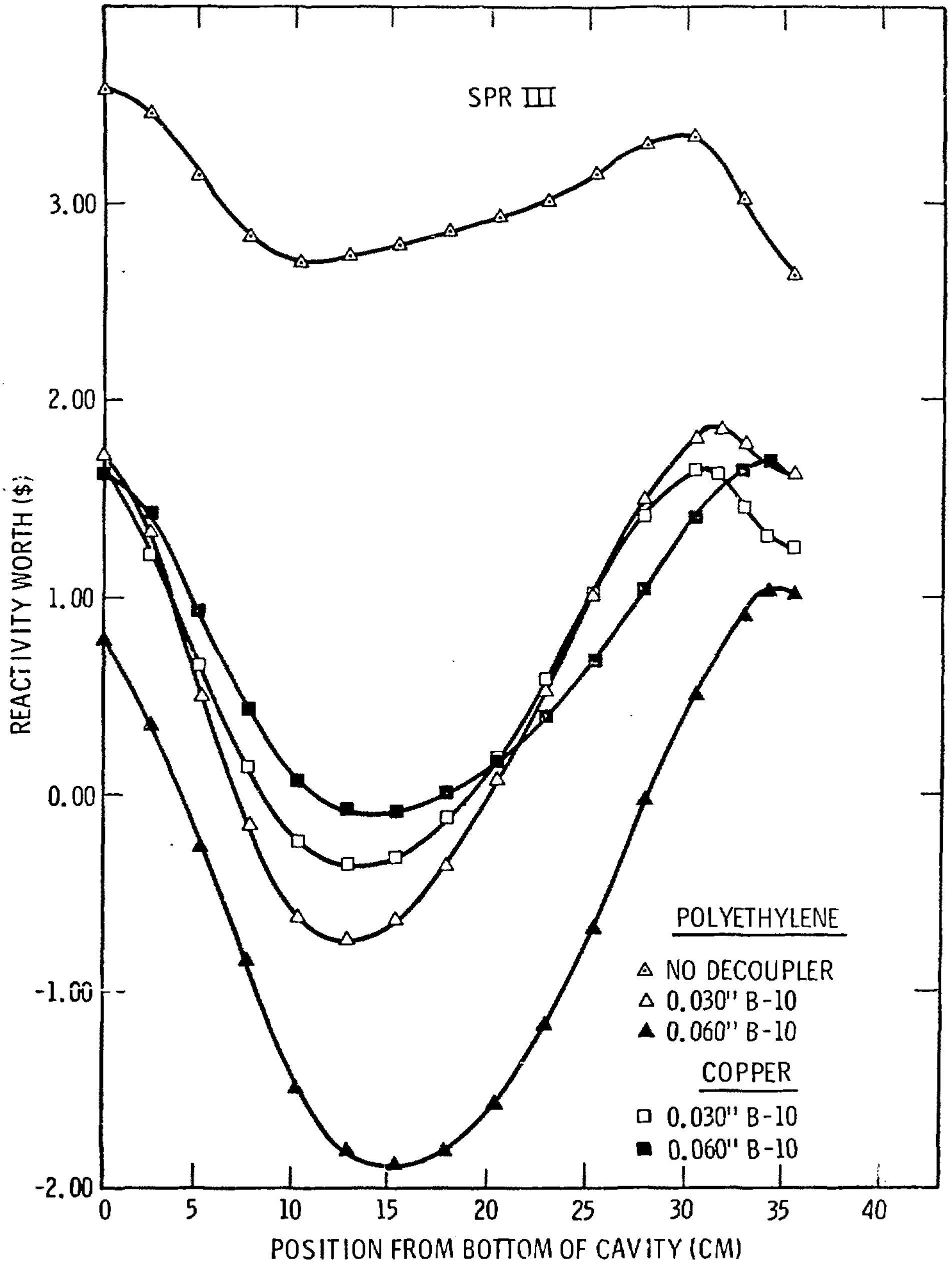

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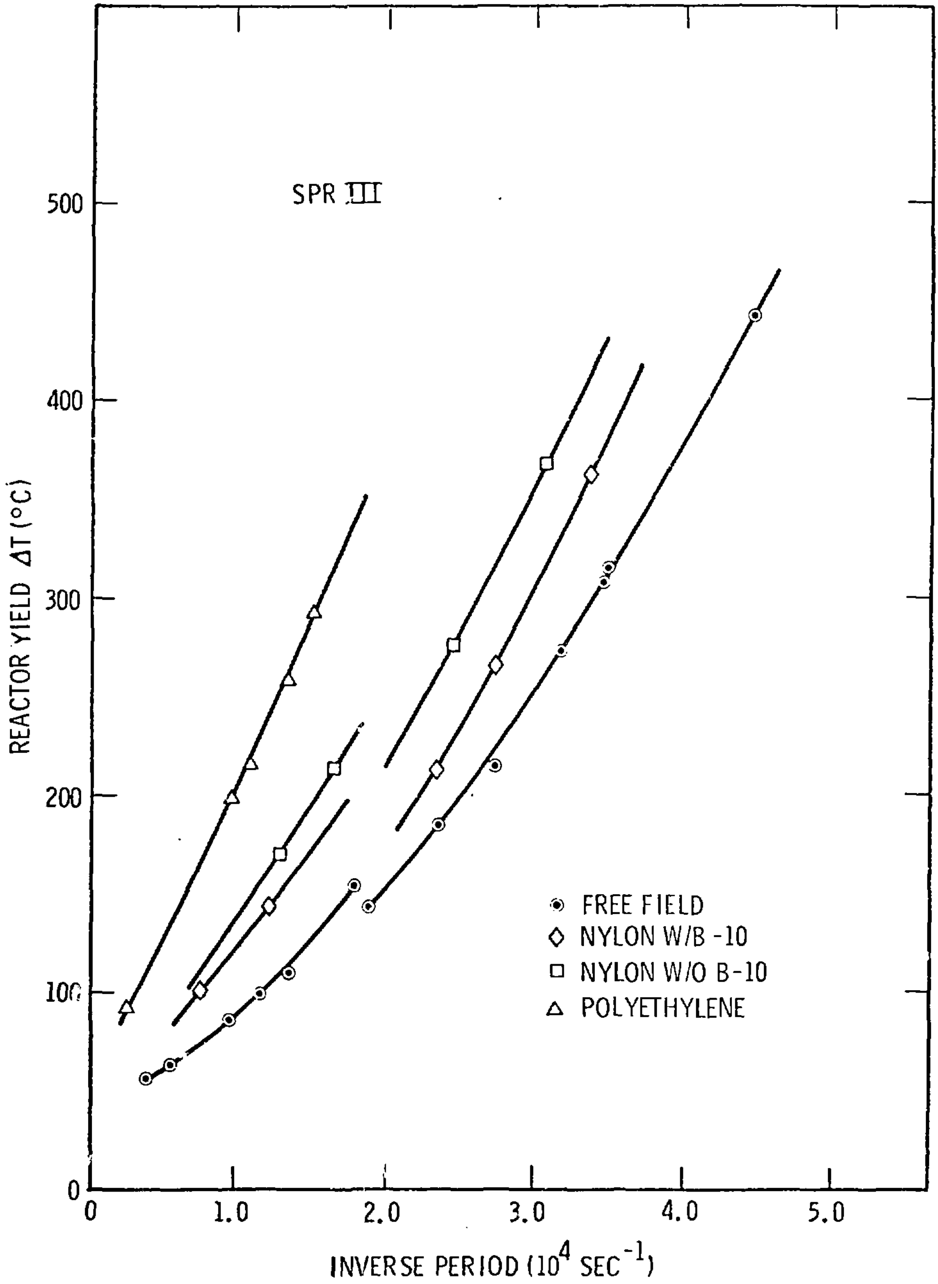

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