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**RE-EVALUATION OF SAVANNAH RIVER REACTOR  
TRANSIENT REACTIVITY COEFFICIENT TESTS:  
THE EFFECT OF DELAYED NEUTRON CONSTANTS  
AND SPATIAL VARIATIONS (U)**

by

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# RE-EVALUATION OF SAVANNAH RIVER REACTOR TRANSIENT REACTIVITY COEFFICIENT TESTS: THE EFFECT OF DELAYED NEUTRON CONSTANTS AND SPATIAL VARIATIONS

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## ABSTRACT

Transient reactivity tests conducted in one of the Savannah River production reactors in 1962 have been re-evaluated. A significantly lower (more negative) coolant temperature coefficient is now ascribed to that test;  $-1$  pcm/Deg-C vs the previously obtained  $+2$  pcm/Deg-C. The change from the previous value is because of revisions to delayed neutron constants and accounting for spatial effects. The new value is in reasonable agreement with the currently calculated value of  $-2$  pcm/Deg-C, considering measurement and calculational uncertainties. Therefore, we conclude that the current analytic models for physics and transient analysis are fully consistent with the 1962 test observation, and that there is no basis for assigning a calculational bias or increasing uncertainty allowances.

## INTRODUCTION

In 1962, transient reactivity tests were conducted in one of the Savannah River Production reactors containing a uniform lattice tritium producing charge. In these tests, special "delta-k rods" were used to introduce a small, rapid reactivity perturbation (about 30 pcm in 75 milliseconds). The change in measured flux was used to infer a set of reactivity coefficients. At the lowest reactor exposure, a  $+2$  pcm/Deg-C prompt feedback coefficient (from the coolant channel), when combined with the point kinetics and thermal kinetics models in use at the time, gave the closest fit to the observed flux response in the first few seconds after the reactivity perturbation. Because of the design of the SRS reactors, isothermal coefficients are neither meaningful nor easy to measure, so this 1962 test has been considered to be the only reactor measurement of the prompt reactivity coefficient in a tritium producing reactor.

As part of establishing the reactor physics and safety analysis methodology in 1989-90 for reactor restart, Westinghouse Savannah River Company committed to revisit this 1962 test with current calculational methods used for physics and for transient analysis, for the purpose of justifying the uncertainty assigned to current calculations of reactivity coefficients.

Current physics methods calculated an effective prompt coefficient at low exposure of -2.3 pcm/Deg-C (fuel, coolant, and target were computed as 0.0, -2.2, and -0.1 pcm/Deg-C, respectively), with a uncertainty in the range of 1 to 1.5 pcm/Deg-C. The discrepancy of 4 pcm/Deg-C from the 1962 observation required investigation and explanation.

## DISCUSSION

We must emphasize that the 1962 tests did NOT measure reactivity coefficients. The test measured the transient response to a reactivity perturbation of unknown magnitude. Reactivity coefficients can be inferred from the test results, based on analytic models for the transient response and spatial effects. Errors in these models -- as well as errors in the test measurements -- would cause error in the inferred coefficient.

Our re-evaluation of the 1962 test data found the best fit for a prompt coefficient of -1.3 pcm/Deg-C, or about 1 pcm/Deg-C more positive than the current calculated coefficient. The current prompt coefficient inferred from the test data is 3 pcm/Deg-C more negative than historic inferred values. The more negative value is caused by:

- Revised delayed neutron constants<sup>(1)</sup>. Estimated delayed neutron parameters have shifted considerably in the last two decades. In particular, the shortest delayed neutron group fraction has increased four-fold, compared to the Keepin data<sup>(2)</sup> used in the earlier analysis, affecting the very short-term response to a step reactivity change. This has little effect on safety analysis, but has a marked effect on estimating the feedback effects from a reactivity step of unknown magnitude. The change in delayed neutron constants alone decreases (makes more negative) the inferred prompt coefficient by 2 pcm/Deg-C.
- Spatial effects. Prior evaluations of the 1962 tests assumed that the detector response was proportional to core power. That's not strictly true. The delta-k perturbation was near the center of the core, changing the relation between detector and core average power by about 0.7%. That's a far bigger effect than it appears. For example, where the detector reported a 4.3% increase, the core average power probably increased 4.3% plus 0.7%, or 5.0% -- at least a 15% larger change than previously considered. This effect decreases the inferred prompt coefficient by about 1 pcm/Deg-C.

The change in the shape was found to be accurately fit by the equation,  $Tilt(t) = A * [1 - B * F(t)]$ , where A is the steady state tilt (1.007 in this case), B is the fraction delayed (.098 in this case), and F(t) is the delayed neutron relaxation function, or  $\text{Sum}\{ \text{Beta}(i) * \text{Exp}[-\text{Lambda}(i)*t] \} / \text{Sum}\{ \text{Beta}(i) \}$ .

- Improved transient models. Current transient models permit explicit modeling of each tube in the fuel assembly, and also a more accurate representation of flow patterns in the moderator tank. Because the fuel temperature changes both more and faster than does the coolant temperature, explicit modeling of fuel temperature feedback has been found necessary. In this particular instance, however, these improvements had no effect. The calculated fuel coefficient is zero for the 1962 core at beginning of cycle, and the calculated target coefficient is very small (-0.1 pcm/Deg-C). Also, attention is limited to the first few seconds, when potential error in the moderator flow patterns will have little influence.

Both the size of the reactivity insertion, dk, and the feedback effects are unknowns that must be inferred from the test observations. The current inferred results, compared to the 1962 inferences, are tabulated below for the size of the reactivity insertion and the prompt coefficients:

Exposure (MWD)	dk, pcm		Prompt Coef, pcm/Deg-C	
	Prior	Present	Prior	Present
14,000	28.5	36.8	+1.7	-1.3
91,000	28.5	35.7	+0.5	-2.4
199,000	32.5	39.7	-2.0	-5.0

Figure 1 shows the measured detector response, and the calculated response for the "old" and "new" evaluations. The "old" evaluation included the old delayed neutron constants, had no spatial correction, and was fit with a dk of 28.0 pcm and a prompt coefficient of +1.6 pcm/Deg-C. The "new" evaluation included current delayed neutron constants<sup>(1)</sup>, the spatial correction to core average power, and was fit with a dk of 36.8 pcm and a prompt coefficient of -1.27 Deg-C. The curves labeled "reactivity" are the total reactivity as a function of time that are consistent with the two power curves shown. The difference in the shape of the reactivity curve is quite pronounced in the first two seconds.

## UNCERTAINTIES

Measurement uncertainties include: (a) scatter in data points; (b) uncertainty in timing and shape of reactivity insertion; (c) uncertainty in initial test conditions; and (d) uncertainty in detector location. The error due to those four components is estimated (at the 95% confidence level) to be in the range of 0.5 to 1 pcm/Deg-C.

Uncertainties in delayed neutron constants are still significant despite advancements over the years. In addition to basic uncertainties, the shape of neutron flux within the first few seconds may not be adequately described by the conventional six collapsed groups. The uncertainties tend to increase for the shorter-lived precursors, which are important within the first few seconds. Uncertainties in delayed neutron constants, as they would affect the shape of the flux response curve in the first few seconds are considered to contribute an uncertainty of perhaps 1 pcm/Deg-C to inferred temperature coefficients.

In both of the areas just discussed, the effective uncertainties would have been smaller if measurements had been made at zero power as well as at power. In that case, much of these uncertainties would have cancelled in comparing the cases. If future measurements of this sort are made, this will certainly be done.

Calculated temperature coefficients use a lattice physics code with associated cross section libraries. Uncertainties in the calculation and cross sections, combined with uncertainties in material contents in the charge, are expected to be in the range 1-1.5 pcm/Deg-C.

The total of the above contributors to uncertainty appears to be in the neighborhood of 2 pcm/Deg-C. Since the difference between the current inferred and calculated prompt temperature coefficients is only about 1 pcm/Deg-C, (comparable to the uncertainty allowance in the calculated coefficient alone), the discrepancy does not appear to be significant.

## CONCLUSIONS

We conclude that the current analytic models - the combination of physics and transient methodology - are fully consistent with the 1962 test observations, and that there is no basis for assigning a calculational bias or increasing uncertainty allowances.

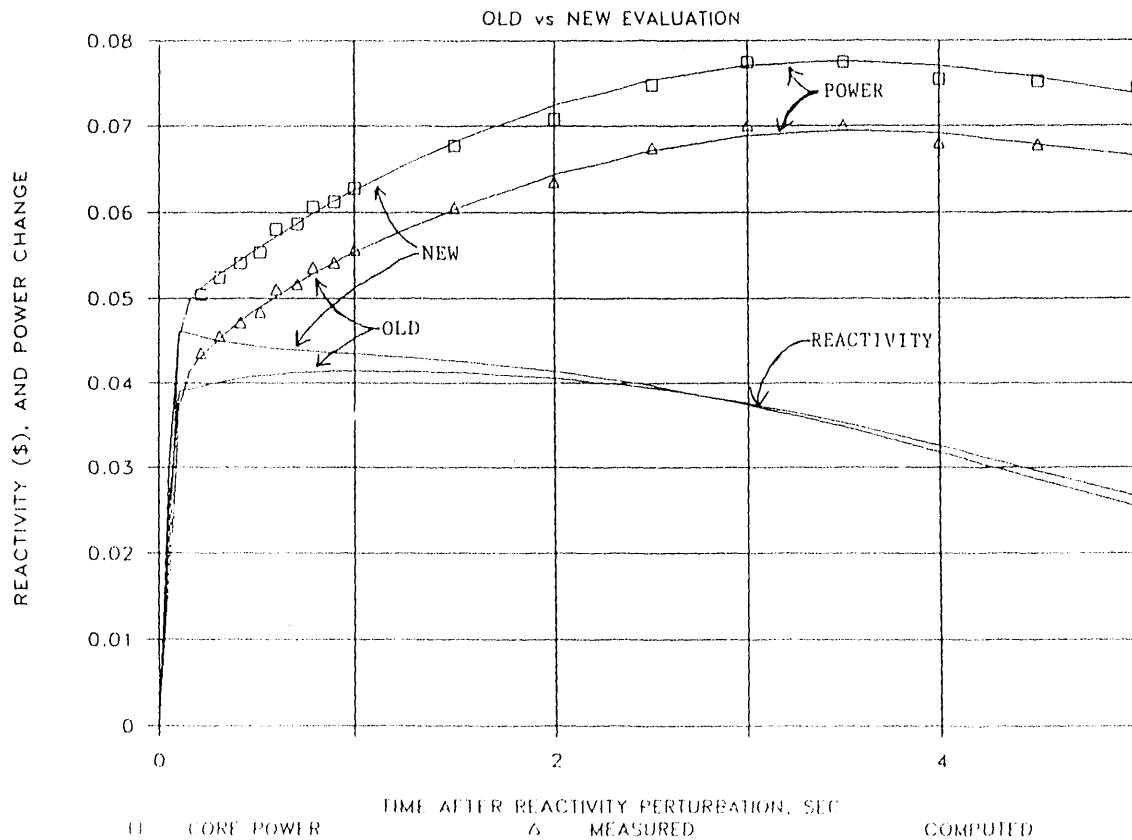
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## REFERENCES

1. M.C. Brady and T. R. England, Delayed Neutron Data and Group Parameters for 43 Fissioning Systems, Nuclear Science and Engineering 103, 129-149 (1989).
2. G.R. Keepin, Physics of Nuclear Kinetics, Addison-Wesley Publishing Company, Reading, Massachusetts (1956).

FIGURE 1: POWER & REACTIVITY, 1962 dk TEST



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