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TO: W. E. JULE, 773-A

FROM: W. E. GRAVES, 773-41A

REVISED MARK 22 COOLANT TEMPERATURE COEFFICIENTS

INTRODUCTION

Coolant temperature coefficients for the Mark 22 charge published previously[1] are non-conservative because of the neglect of a significant mechanism which has a positive contribution to reactivity. Even after correcting for this effect, dynamic tests made on a Mark VIB charge in the early 60's suggest the results are still non-conservative. This memorandum takes both of these sources of information into account in making a best estimate of the prompt (coolant plus metal) temperature coefficient.

Although no safety issues arise from this work (the overall temperature coefficient still strongly contributes to reactor stability), it is obviously desirable to use best estimates for prompt coefficients in limits and other calculations.

SUMMARY

Best estimates of the prompt coefficient for the Mark 22 charge are zero at beginning of life and $-3 \times 10^{-5}/^{\circ}C$ coolant at end of life.

DISCUSSION

Calculations with GLASS gave good agreement with isothermal temperature coefficients measured in zero power experimental facilities with a Mark 22 lattice.[1] GLASS calculated coolant and moderator temperature coefficients were therefore recommended for general use with Mark 22 charges.[1] Reactor Technology concurred with these results[2] and provided a specific procedure for associating a fuel temperature change with a given average coolant temperature change.

Recent work on the physics of a Mark 22 type charge in a double plenum NPR[3] focussed on the coolant temperature coefficient alone, since there would be no significant moderator coefficient acting. It was realized that isothermal temperature coefficient measurements are not a good basis for confidence in the coolant coefficient alone. The best experimental tests that permit inferring a separate coolant coefficient are dynamic tests with "ΔK rods" in the 100 areas. No such tests were run for Mark 22 charges, but results of carefully conducted tests on a Mark VI-B charge were available.[4] The two charges are so similar in physics characteristics that it was thought that these data would provide a suitable test for calculations.

Applying the recommended calculation methods[1] to the Mark VI-B charge revealed a significant discrepancy with the 100 area dynamic results for coolant temperature coefficients.[3] The calculations were non-conservative with the most important discrepancy at beginning of life. The calculated prompt coefficient was $-2.2 \times 10^{-5}/^{o}C$ coolant compared with $+(2.1 \pm 0.5) \times 10^{-5}/^{o}C$ coolant inferred from the dynamic tests.

A mechanism has been identified which explains about half of the discrepancy. Expansion of the fuel tubes relative to the target tubes (on an increase in power) provides a positive component to the prompt coefficient which has previously been neglected. The reactivity effect of this expansion can be calculated with GLASS, if special precautions are used.[3]

The conclusions of reference 3, as applied to the Mark 22 charge, are

- Modify the previously calculated[1 2] prompt (coolant and fuel) temperature coefficients by the calculated effect of the dimension changes.
- Apply an additional (additive) bias of $+2.4 \times 10^{-5}/^{o}C$ coolant to take into account small known qualitative effects in this direction and other unknown effects to get the best match with the VI-B dynamic test results.
- Moderator temperature coefficients have not been addressed, and are presumed to be unchanged from the normal calculation.[1 2]

Results for the Mark 22 prompt coefficients are given below (in $\Delta k_{eff}/^{o}C$ coolant $\times 10^{-5}$)

Exposure MWD/ft	Published[1]	Expansion Effect Correction	VIB bias[3] Correction	Revised Prompt Coefficient
0	-4.0	+1.6	+2.4	0.0
40	-5.3	+1.1	+2.4	-1.8
80	-6.2	+0.8	+2.4	-3.0

RECOMMENDATIONS

It is recommended that the revised coefficients given in the table be used in future limits calculations and transient analyses.

WEG:elr

References

1. W. E. Graves, Mark 22 Temperature Coefficients, DPST-85-542, June 1985.

2. M. A. Rosser, Analysis of Mark 22 Temperature Coefficients, RTR-2417, October 1986.

3. W. E. Graves, Coolant Temperature Coefficients in the NPR, DPST-87-237, January 1987.

4. C. E. Bailey, Mark VIB Temperature Coefficients, DPST-62-419, October 1962 (Declassified).