JC02616

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

RECEIVED

FEB 25 1975

1 Copy

1975 FEB 25 PM 1 17

U.S. ATOMIC ENERGY COMM.
ADVISORY COMMITTEE ON
REACTOR SAFEGUARDS

J. C. McKinley, Senior Staff Assistant
Advisory Committee on Reactor Safeguards

BOILING WATER REACTOR PROTECTION SYSTEM RESPONSE TIME AND PERFORMANCE

You forwarded an ACRS consultant's report on BWR protection system performance to the staff for comments on November 29, 1973.

Enclosed is the staff's evaluation of this report. It should be noted that, after writing the evaluation, an amendment to GESSAR was received which referred to the use of higher rod insertion speed rather than prompt relief valve trip as a solution to less than needed reactivity insertion rates for the turbine trip class of transient. Details regarding the higher insertion rates have not been received. The conclusions of the evaluation are still valid.

We are treating this material as intra-agency for internal use only.

Voss A. Moore

Voss A. Moore, Assistant Director
for Light Water Reactors, Group 2
Division of Reactor Licensing

Enclosure:
As stated

ACRS Ltr 3/14/75 - Stern
ACRS Office Copy

EVALUATION OF ACRS CONSULTANT'S REPORT
ON
BWR PROTECTION SYSTEM

An ACRS Consultant's Report on BWR protection system performance, dated October 2, 1973, and transmitted with a letter from J. C. McKinley to V. A. Moore, dated November 29, 1973, proposes an "upgrading" of the control rod system. The discussion and proposals are directed primarily to three areas. These can be summarized as follows:

1. Group Withdrawal. Control rods should be withdrawn as a group, rather than individually, to about the 20 percent power level in order to minimize the effects of a postulated rod drop accident by (a) maintaining (automatically by virtue of the configuration) lower individual rod reactivity worth relative to those which might occur with single rod full withdrawal and by (b) improving effective scram reactivity insertion rates by having the withdrawn rods not fully withdrawn and thus closer to the regions of importance if called upon to scram in this regime. (Note: 20% power is about the level above which the rod drop accident even with an erroneous rod configuration no longer approaches limiting criteria.)
2. Faster Startup. Existing operational restrictions on rate of insertion of reactivity, allowed periods, IRM scram ranges and setpoints and operator checks and procedures should be reexamined with the aim of achieving more rapid rod removal and thus faster startups in conjunction with the group withdrawal scheme.
3. Diverse and Faster Scram. A fraction (on the order of 10%) of the control rods should be replaced with a redesigned system which is diverse and capable of more rapid insertion response to a scram demand, for example, a 1g acceleration over an initial travel range,

in order to improve the reactivity insertion rate for such transients as the turbine trip and to provide a diverse system for ATWS.

Areas 1 and 2 are apparently envisioned in the report as being accomplished primarily by programming changes and without major physical changes to the rod system, although they evidently would require programming assistance by way of a computer or mechanical programmer. Area 3 would require system redesign and physical changes, however, specific suggestions as to how this could be accomplished are not given.

The group withdrawal scheme as proposed, if suitably maintained (except for the case of an assumed uncoupled rod left behind, then dropped to the insertion level of the mechanism), would indeed assure low individual dropped rod reactivity worth and more rapidly effective scram. (A rod moving in an otherwise unrodded region of the core generally has relatively low worth.) However, there are also potentially severe operational problems associated with a direct application of the scheme. These result from the very large differential reactivity worth near full insertion of a large total worth bank, especially at low power in an axially-shaped burnable poison core (or any core beyond first cycle) with a relatively large k_∞ at the top of the core. To reach the order of 20% power in a typical reactor would require in excess of 50% of the rods withdrawn. Depending on time in cycle and xenon content from previous operation, withdrawal could be from 60% to beyond 80%. Assuming (1) that on the order of 60% of the rods would be withdrawn as a group and (2) the characteristics on scram bank reactivity worth as a function of position in the core as given in recent SARs (e.g., GESSAR), differential worths of as much as 8% Δk per stable notch position (6 inches) might be achieved near initial withdrawal. If the reactor were near cold, xenon-free conditions, there would be little reactivity gain by the first stable notch position, but there would be sufficient reactivity addition (about 8% Δk) by the second stable notch to achieve criticality or beyond and by the third notch (a foot and a half withdrawn) the reactor could be several percent supercritical (assuming no feedback). The reactor would, of course, be much more subcritical, if restarted from hot, xenon conditions rather than cold clean, and the operational problem of rapid insertion would be less severe. Nevertheless, this illustrates the kind of operational problems which would have to be examined carefully when dealing with a configuration which inserts a large fraction of the total reactivity in a small fraction of the total travel (e.g., 90% of the reactivity within 25% of the travel).

The scheme could be modified to withdraw several smaller groups of rods. This then would approach, however, the Group Notch Control RSCS system developed by GE and reviewed and approved by the staff as a satisfactory means for assuring suitable control rod worths. This system permits withdrawal of rods only in small groups (4 to 8 rods) beyond the 50% rod withdrawal density (i.e., checkerboard pattern). It presumably could, if required, also provide for (small) group withdrawal below 50% rod withdrawal density, but there is no Regulatory safety requirement to do so and operational slowdown would result from multiple operator action unless physical changes were made to the system to provide for automatic multiple selection and energizing with adequate assurance of error-free operation. (Note: The Rod Pattern Control System (RPCS), a more advanced system developed for the BWR-6 but with single and group withdrawal characteristics similar to that for the Group Notch RSCS is presently under review.)

Physical changes to present systems would also be involved in the implementation of item 2, faster startup. Present systems can only energize one rod at a time and then move it at about 3 inches/sec. Thus, about 2 hours are required at a minimum in a large core to withdraw rods rods to the hot low power range. In practice, restart from hot conditions following scram generally takes about 4 to 6 hours in order to comply with procedures. Cold startup takes 10 to 12 hours to meet heatup rate requirements. With the present system, the fastest startup from hot conditions would result from using the single rod, fully withdrawn mode, since this involves minimum operator action. To improve on this would require changes to produce multiple simultaneous withdrawal. If small group, simultaneous withdrawal in the 0 to 50% withdrawal density range, leading to somewhat faster startup from hot conditions were proposed by GE, it would be considered and reviewed on its merits. (Note: The RPCS apparently will move the rods in a group simultaneously in the above 50% withdrawn density, group withdrawal mode.)

It is generally recognized that improvements to the scram system to provide more rapid response and diversity are desirable. Two problem areas related to these aspects of the scram system are currently under review. The extreme ranges of the turbine trip class of transient approaches thermal limits for some reactors during some parts of the fuel cycle primarily because of less-than-needed reactivity insertion rate response of the scram system. This could be alleviated by sufficiently rapid movement of the rods. To date, however, solutions that have been presented by GE are partial derating and prompt relief valve trip (PRT).

The potential for significantly improved scram has not been indicated. The ATWS review is considering a variety of improvements of reactivity control systems to provide for increase scram reliability. Among potential solutions is a diverse control rod system. Thus far, no specific indication has been given by GE that a diverse rod system will be presented as an ultimate ATWS solution. Whether to improve response or add diversity, a design would have to be conceived developed, tested, and intensively investigated in order to be offered as a satisfactory solution without introducing new pitfalls. If this were done, it too would be considered and reviewed as a viable possibility. Unfortunately, the report only suggests the obvious desirability of such system improvements. It does not present designs or design concepts.

As is noted in the report, these proposed changes are suggestions for improvements and are not mandated by unresolved safety problems or unmet Regulatory requirements. While from a Regulatory viewpoint they are interesting to discuss, they do not provoke fresh insights about safety. The suggested changes do not stem from unreviewed safety questions nor do they represent sole solutions to known problems which have been or will be under review.