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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DOCUMENT NO.

HW-63160

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ISOTOPE-PRODUCING CONTROL RODS

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ISOTOPE-PRODUCING CONTROL RODS

D. E. Simpson

December 21, 1959

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December 21, 1959

A. B. Carson, Manager
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ISOTOPE-PRODUCING CONTROL RODS

INTRODUCTION

In accordance with the NPR technical criteria which require that provisions be made for useful isotope production in the control rods, both isotope-producing and non-production rods have been designed. Design Analysis has been requested by Reactor Plant Design to specify the number and location of the isotope rods for the initial installation. This choice, however, cannot be made without knowledge of the fuel element characteristics and a prediction of the reactor operating techniques. Some of the factors affecting the use of isotope-producing rods are discussed in this letter, and the following recommendation is made.

RECOMMENDATION

It is recommended that no full scale pattern of isotope-producing control rods be included in the initial NPR installation. Installation of two isotope-producing rods, if considered worthwhile for demonstration purposes, is within the intent of this recommendation.

SUMMARY

The NPR control system capacity will be reduced by the installation of isotope-producing control rods. The control system is designed to be no more than adequate (with a reasonable safety factor) under the most severe reactivity transient conditions considered in design; these most severe conditions occur with a 25 lb/ft tube-in-tube fuel element. To date, the fuel element has not been specified, but it appears that the choice may be a tube-in-tube of 24-25 lb/ft. There is no indication, then, that any appreciable number of isotope-producing rods can be installed within the control capacity requirement.

If some isotope-producing rods could be installed, any choice of location, with no basis of operating experience, would be little more than an educated guess. It must be assumed that a fair percentage of any of these rods installed initially would have to be relocated later in order to serve their purpose.

These factors lead to the conclusion that installation of a full scale pattern of isotope-producing rods should await the results of initial loading experiments and some operational experience.

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DISCUSSION

The NPR technical criteria⁽¹⁾ require that provisions be made in the reactor design for production of useful isotopes in the control rods. This requirement was not interpreted as requiring excess control capacity specifically to permit isotope production, and the design bases⁽²⁾ state that isotope-producing control rods may be used only if the control system strength is not reduced below the required level. Since the isotope-producing rods are individually 20-25 percent less effective than the non-productive rods, the number of isotope rods which may be installed depends upon the control requirement and the control system strength in the reactor; both of these factors are dependent upon the lattice characteristics which in turn depend upon the reactor fuel element design.

As has been shown in references (2) and (3), both the maximum control strength requirement and the capacity of the designed control rod system vary considerably over the range of fuel types and sizes considered in the NPR design. For the most severe conditions, with a 25 lb/ft tube-in-tube fuel element, the calculated control strength (with a reasonable safety factor) is not appreciably more than the control requirement. At the other end of the scale, with a 20 lb/ft cluster fuel, the control strength exceeds the requirement by 10-15 percent of the installed capacity. The fuel element to be used during NPR operation has not been specified, but appearances to date indicate that the choice will be a tube-in-tube which may weigh 24 lb/ft or more. Thus, there is no indication that any significant number of isotope-producing control rods can be installed initially.

The time is approaching when the number of isotope rods must be specified if reactor design and procurement schedules are not to be affected; this information has already been requested by Reactor Plant Design. For this reason alone, the present status of fuel element design appears sufficient to rule out the initial installation of isotope-producing rods except for perhaps two for testing and demonstration purposes. There are other factors related to the isotope rods which are less important from timing considerations but which also point to the same conclusion.

As stated above, the control strength with a 25 lb/ft tube-in-tube fuel element is not appreciably greater than the control requirement. This conclusion is based on extensive calculations of lattice characteristics and control strength, with a safety factor of 15 percent having been included in control strength values and no safety factor in control requirement values. Since there is a reasonably large safety factor here, there is a fair chance that some isotope rods could be used even with the heavy fuel element. Experiments during the initial NPR loading should determine the number of these rods permissible. If isotope rods can be installed within control strength limitations, the choice of location of these rods requires a rather specific prediction of operating techniques. There are some 40 rods located within a reasonable equilibrium control zone and about one-third of these will be inserted half-way or more during equilibrium operation. The choice of the particular rods will be made by the area physicist and operating

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personnel on the basis of operational experience; any prediction of the rod configuration now would be little more than an educated guess. Thus, it might be expected that if 10-20 isotope rods were installed initially that several of these would have to be relocated later in order to serve their purpose. Since the outer rod sheaths are interchangeable between the two types of rods, the cost of installing isotope rods and discarding the insides of non-productive rods would not be much greater than the cost of exchanging rod positions and might, in fact, be less.

While I would be willing to make the educated guess as to isotope rod locations if a fuel element were specified which indicated that some of these rods could be used, consideration of the present lack of knowledge of experimentally determined control strength and requirement of operational conditions indicates to me that the substantial potential value of isotope rods would be better left for later exploitation.

On the basis of all the factors presented in this discussion, it is recommended that no full scale pattern of isotope-producing control rods be included in the initial NPR control rod installation. Two isotope rods would have no significant effect upon the control system capacity and could be installed for testing and demonstration purposes. No definite recommendation is made with respect to two such rods; it is felt that testing to determine the reactivity strength is not necessary and therefore the installation should be made only if the demonstration of isotope-production capability is considered worth the cost.

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