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NPR GRAPHITE AND FUEL TEMPERATURES

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NPR GRAPHITE AND FUEL TEMPERATURES

By

A. B. Carson

October 13, 1958

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October 13, 1958

NPR GRAPHITE AND FUEL TEMPERATURES

The Atomic Energy Commission has requested (reference 1) more detailed information regarding moderator and fuel temperatures expected for the NPR. Particular interest has been expressed in the methods for obtaining lower graphite temperatures at full power than were reported in HW-54664. The requested information has been collected and is summarized in the following paragraphs.

The detail design of the graphite blocks making up the moderator of the NPR is affected by two limiting criteria. First, adequate vent passages must be provided so that in event of a process tube rupture, the steam formed through release of pressurized primary coolant will not cause internal damage to the reactor such as shifting of the graphite stack. This problem is new to Hanford experience and, at the time of the NPR report, was receiving principal attention in the preliminary graphite design studies. The second limiting criterion is that of maximum graphite temperature which is, of course, familiar to Hanford. Maximum graphite temperature in existing Hanford reactors is set by oxidation considerations and is on the order of 650 C. Since provisions are being made in the NPR for maintaining closer control of graphite environment than is the case in the existing plants, it has been estimated that on the basis of oxidation rates only, maximum graphite temperatures on the order of 1200 C would be feasible. For these reasons, the moderator design presented in HW-54664 featured, in place of the conventional tube-bearing block, a tube supporting "saddle" of graphite, shown in Detail A, Figure 1, to ensure adequate steam venting but resulting in graphite temperatures near the oxidation limit.

Since issuance of the NPR report, two developments have led to departure from this particular method of tube support. First, it has been recognized that the variation in long-term graphite contraction rates as a function of temperature is not yet defined precisely enough for the conditions of interest to permit design for the maximum temperature which would be permitted from an oxidation point of view.

Also, it has been pointed out that process tube stress conditions are improved if a more nearly uniform tube to graphite contact is maintained. Therefore, the tube block detail design has been altered to feature a "three plane" venting system, more uniform process tube support, and a much more direct path for transfer of heat from areas of maximum graphite temperature to the process channels, as can be seen from Detail B, Figure 1. The Electrical Analogue Computer which is available here at Hanford for graphite temperature calculations was utilized in a rather extensive analysis of temperature distribution throughout the lattice for the various postulated operating conditions with the conclusion that the maximum graphite temperature

1. Letter, J. E. Travis to A. B. Greninger, "Graphite and Fuel Temperatures - NPR," dated October 8, 1958.

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during normal operation with this revised design would be on the order of 200 degrees lower than for the concept described in HW-54664 and that those portions of the stack relied on for structural support and process tube positioning would not exceed 950 C.

It is still recognized, however, that data on long-term contraction at these temperatures is very sparse and that additional information cannot be obtained until next spring. Therefore, careful attention is being given to other possible design provisions which would serve to ensure that the effects of maximum graphite temperature do not limit the useful life of the plant in case the additional contraction data are unfavorable. These include (1) further alterations of the graphite blocks to improve heat transfer conditions, (2) reduction in maximum specific power by increasing the active zone volume and/or by front-to-rear flux flattening, and (3) provision of a separate graphite cooling system. Feasibility of these approaches has been established and the extent of effectiveness as well as influence on cost and schedule are currently being evaluated.

Another design approach which is applicable to control of the high temperature contraction problem is that of vertical tube orientation. This concept has been studied as a potential method of reducing capital cost by drastic shortening of the primary loop pipe runs since, for this orientation, the heat exchangers can be located very close to the reactor in what would be the charge and discharge areas of a horizontal reactor. It has been noted that the long-term contraction effect is of much less concern for the vertical tube orientation since the graphite is not relied upon for positioning and support of the process tubes relative to the biological shield openings.

As indicated above, the primary objective of the studies to date has been development of all available and applicable information. As formal reactor scope design activity gets under way, selection of a specific course of action will be made with the additional possibility of alternate designs being carried forward until more definitive contraction data become available.

Reference 1 also contains questions regarding maximum fuel surface and core temperatures anticipated for the NPR. In general, the maximum cladding surface temperature considered has been about 330 C and the maximum uranium core temperature has been 630 C. With these limiting conditions, the concentric tube fuel design allows greater flexibility in flux distribution and maximum plant output than does the cluster geometry which has been used as a reference fuel design to date.

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Process Design Operation
FACILITIES ENGINEERING OPERATION

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DETAIL B

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