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 SUBJECT: HRT DUMP TEST, Phase II
 TO: I. Spiewak
 FROM: C. H. Gabbard

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PURPOSE

The purpose of phase II of the HRT dump test was to evaluate the control system for maintaining a balance of the core and blanket pressures during a dump of the HRT and to make the necessary corrections to the system in order to maintain a pressure balance between the core and blanket of $\pm$ 50 psi.

EQUIPMENT

Figure 1 is a schematic diagram of the dump test equipment and the original control system. In order to duplicate the control requirements as closely as possible, the dump lines and valves were sized to give approximately the same dumping time as the HRT. It was impossible to obtain trim for the vent control valves to give the desired venting time, and therefore HRT size trim was used. Table 1 gives a comparison of volumes and dumping times of the dump test and HRT.

TABLE 1

	<u>Dump Test</u>	<u>HRT</u>
1. Core Volume (Liquid)	26.4 Liters	525 Liters
2. Blanket Volume (Liquid)	105 "	1785 "
3. Pressurizer Vapor Volume	4 "	74 "
4. Pressurizer Liquid Volume	1.5 "	33.4 "
5. Venting Time	20-30 Seconds	9-13 Minutes (CF-56-9-2)
6. Dumping Time (Liquid and Vapor)	8 Minutes	6 Minutes (CF-55-10-14)

The control system maintained a pressure balance between the core and blanket systems in the following manner. The dump was initiated by opening both pressurizer block valves and venting steam at a controlled rate through the vent control valves. After a predetermined time delay, the dump valves were opened and the bulk liquid and remaining steam were dumped. During the venting period, the pressure balance was maintained by the action of the vent control valves operating continuously from the output of the differential

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pressure cell and derivative control unit. During the remainder of the dump the pressure balance was maintained by the on-off action of the dump valves which were operated by pressure switches on the pneumatic output of the derivative control unit. The pressure switches were set to close the proper dump valve when the differential pressure became unbalanced by 40 psi, and to reopen the valve when the unbalance decreased to 10 psi.

The overall response time of the dump test and the HRT is determined mainly by the relatively large air volume in the valve operators. The response time of the dump test was found to be approximately one second, and the maximum time required to open the vent control valves of the HRT was about four seconds*. From the midposition, however, the valve would fully open or close in about two seconds. The other block and dump valves on the HRT required 1 1/2 to 2 1/2 seconds to open or close. Since the maximum rate of pressure decrease in the dump test system is approximately twice that of the HRT, the two systems should have similar control characteristics.

DISCUSSION

Since there are several possible conditions when the HRT might be dumped, it was impossible to duplicate the exact conditions in the dump test that might occur in the HRT. Therefore, the dump test was used to correct the difficulties in the control system and to assure that the pressure balance could be maintained under the most severe conditions that would exist in the HRT.

The initial runs of the dump test were used to determine the venting time, and to determine the limitations of the system. The venting time was found to be 15-20 seconds (2000-1250 psi) with the vent control valves 50% open, and therefore, the time delay relay was set at 30 seconds in order to prevent the dump valves from opening prematurely. The only serious limitation of the system was that it was impossible to run the bulk liquid of the core and blanket at different temperatures due to the heat transfer through the core wall during the heat up. This eliminated the possibility of running tests

*Verbal communication with P. N. Haubenreich, October 2, 1956.

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with the core and blanket at different saturation pressures as may occur in the HRT.

The early runs also indicated that the main difficulty was experienced during the venting period, and that little or no trouble was experienced during the remainder of the dump. Figures 2 and 3 are typical traces taken from the pneumatic and electric differential pressure cells respectively. Figure 2 shows the differential pressure for the entire dump and Figure 3 shows only the venting period which is the first 30 seconds. The run was made with the control system as shown in Figure 1 and the initial conditions being 2000 psia and 300°C bulk liquid temperature. The differential pressure oscillated during the venting period until the system pressures leveled out at 1250 psia with the maximum unbalance being approximately 120 psi. Several attempts to adjust the derivative control unit failed to produce satisfactory control, and the unit was removed from the system. The oscillations which occurred after 4 1/2 minutes on Figure 2 were under control, and the maximum unbalance at this time was 47 psi. These oscillations were caused by the action of the dump valves during the time the core was dumping the remaining steam and the blanket was still dumping liquid.

After the derivative unit was removed and the valves were actuated from the pneumatic differential pressure cell output, the differential pressure could be maintained within the desired ± 50 psi range as shown in Figure 4.

Since it was impossible to conduct tests with the core and blanket at different bulk liquid temperatures, a test was conducted with the blanket system charged as usual and with the core system charged with nitrogen at 2000 psia. This provided a potential vapor pressure difference during the entire run, and the control system was required to function during the dumping period as well as the venting period. During this test which was considerably more severe than the actual service conditions, the maximum differential pressure was 75 psi.

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CONCLUSIONS AND RECOMMENDATIONS

The derivative control unit as originally proposed for the control system was found to introduce an oscillatory effect on the differential pressure and was removed. Although the HRT control system may perform satisfactorily with derivative control unit, it should be removed in order to avoid unnecessary complication of the system.

With the exception of system oscillations as mentioned above, the basic requirement for adequate control is to have sufficiently fast response time for the particular control application. In the extreme case, the overall response time should be based on the maximum rate of pressure change occurring in either the core or blanket system. In the dump test, the maximum rate of pressure decrease was approximately 50 psi/sec, and therefore, to maintain a pressure balance within 50 psi, the control system should be capable of closing the control valve in one second or less.

The maximum rate of pressure decrease in the HRT will be approximately 25 psi/sec (Fig. 3, ORNL-CF-56-2-128), and therefore, the response time should be approximately two seconds. Since this is an extreme case, adequate control could probably be maintained with a somewhat slower response.

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FIGURE 1
DUMP TEST AND
PROPOSED CONTROL SYSTEM

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