Hw-35794

AD 17 104

OSTI

**Cover Sheet for a Hanford
Historical Document
Released for Public Availability**

Released 1994

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DECLASSIFIED

GENERAL ELECTRIC
COMPANY

RECORD CENTER FILE

HW-35794
Page 1

This document consists of
16 pages. Copy ~~14~~ of
~~24~~ copies Series ~~1~~

TIME RESPONSE OF A PROCESS TUBE TEMPERATURE MONITOR COPY 1 OF 1

by

M. E. Forsman

Classification Cancelled and Changed To

DECLASSIFIED

March 16, 1955

By Authority of CG-PR-2
DS. Lewis 8-20-92
By PN Eck 4-25-94
Verified By J. H. Wells-4-25-94

RECEIVED

JUL 9 1955

300 AREA
CLASSIFIED FILES

REACTOR DESIGN AND DEVELOPMENT
DESIGN SECTION
ENGINEERING DEPARTMENT

~~RESTRICTED DATA~~

~~This document contains restricted data as defined by Atomic Energy Act of 1954. Its transmission or disclosure in any form to an unauthorized person is prohibited.~~

This document classified by

R. Andersen

THIS DOCUMENT IS PUBLICLY
AVAILABLE

REFERENCE COPY

DECLASSIFIED

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DECLASSIFIED

DISTRIBUTION

1. R. K. Andersen	13. R. O. Mehann
2. R. H. Beaton	14. O. H. Pilkey
3. M. W. Carbon	15. E. L. Reed
4. A. B. Carson	16. P. H. Reinker
5. R. D. Carter	17. O. C. Schroeder
6. E. S. Day/W. A. Richards	18. H. P. Shaw
7. R. A. Farran	19. M. T. Slind
8. W. M. Harty	20. D. G. Toyoda
9. I. M. Jacobs	21. H. T. Wells
10. J. P. Langan	22. M. E. Forsman
11. D. S. Lewis	23. 300 Files
12. L. H. McEwen	24. Yellow File

ACKNOWLEDGEMENT

The assistance given by those listed below
is acknowledged.

R. D. Carter
R. R. Cone
R. A. Farran

C. E. Huck
R. F. Recht
D. G. Toyoda

DECLASSIFIED

DECLASSIFIED

HW-35724
Page 3

PURPOSE

During the design of the 100-K reactors, it was requested that tests be performed which would provide data concerning the temperature monitor time response to variations in cooling water flow rate in a single tube. These tests have been completed and the results are published for information purposes.

INTRODUCTION

The effluent water temperature of each process tube of a reactor is indicative of the operating conditions internal to that tube. A temperature monitor which will provide individual tube effluent water temperature on demand has been in use for many years in reactor operation. However, the primary sensing element, as well as other parts of the system, were not suited for installation in the #2 safety circuit. During the design of the K reactors, it was shown that a continuous temperature monitor could provide protection during single tube failures⁽¹⁾, except those cases wherein the flow through the tube was diminished to a very low value, provided a primary sensing element with a very short time response could be obtained. A resistance type sensing element was designed by a vendor and the continuous temperature monitor was included in the scoping of the K reactors.

Although the continuous temperature monitor was approved, there were no data which showed the protection provided by such a continuous monitor. It was known that such a device would react to flow changes considerably later than the front face pressure monitor (Panellit Gages) and there was considerable doubt about the protection provided during major changes in flow (flow reduced to less than 50 per cent). In order to obtain the data required to determine the rate of response of the temperature monitor, a test was authorized.

This document consists of a review of the data obtained and a prediction of the K reactor response time.

SUMMARY

The temperature-time response of the "C" type process tube in the 189-D heat transfer test facility was determined using the "K" type resistance bulb and crossheader fitting. The first set of data was obtained with an aluminum heater tube and is shown in Figures 5 and 6. The input power to the tube was about 600 KW and the flow about 29 gpm. The time to indicate a 5C and a 10C rise in temperature after a flow reduction is shown in Figures 6 and 10.

- (1) HW-26950, "An Evaluation Of Continuous Temperature Monitoring Of The Process Water At The 100-K Area," M. E. Forsman.

DECLASSIFIED

DECLASSIFIED

HW-35794
Page 4

The second set of data was obtained using a solid Cupro-Nickel rod for the heater tube instead of the aluminum tube and is shown in Figures 3 and 7. The input power in the tube was about 500 KW and the flow was about 26 gpm. The time to indicate a 5C and a 10C rise in temperature is shown in Figures 4 and 8. The increase in response time using the Cupro-Nickel rod in place of the aluminum tube is due primarily to the difference in the heat capacities, the capacity of aluminum tube being less than 20 per cent of that of the Cupro-Nickel rod which, in turn, has a heat capacity about 50 per cent greater than the uranium fuel elements.

Since the K reactors may operate at about 1000 KW tube power and 50 gpm coolant flow, the data obtained did not apply directly. Extrapolations to the K reactor conditions are not correct for minor differences but are conservative and indicate a response time which is long. The main difference in the response times is the difference in rates of coolant flow through the dummy section and pigtail. The curves of Figure 1, showing the response time for the K reactor, were obtained by correcting for this difference in flow rates. The time to indicate a 5C and 10C rise in temperature is shown in Figure 2.

DISCUSSION

It is frequently impossible to perform tests under operating conditions because the test may involve destruction of the equipment used. Such is the case in determining the time response of the temperature monitor on the process tube when the coolant flow is varied. Attempting to obtain the data from a process tube in the reactor is not only expensive but dangerous. To obtain the necessary data the process tube heat transfer test set up in the 189-D Building was used.

The heat transfer equipment consists of a process tube the length of the active zone, an aluminum tube which simulates the slug column inside the process tube, a simulated dummy section on the effluent end, pumps and associated piping and valving to supply coolant, and associated control and instrumentation. The flow sensing element was a Potter rotating type flow meter and the temperature sensing element was a K type resistance bulb. The output from each of these was recorded on a Sanborn two-channel, strip-chart recorder. A solid Cupro-Nickel rod was also used to simulate the column of slugs inside the process tube. This rod had a heat capacity about 50 per cent in excess of that of a standard slug column.

The data were obtained by adjusting the power level and coolant flow rate to provide 90C effluent water temperature with a power level of 600 KW for the aluminum heater tube and 500 KW for the Cupro-Nickel rod and then decreasing the flow as fast as possible to some predetermined level. Both the flow rate and the effluent water temperature were recorded as functions of time. The data obtained are plotted in Figures 3, 5, 7, and 9 for both simulated obstruction upstream of the active zone and a simulated ruptured front face pigtail. Figures 4, 6, 8, and 10 were obtained from the above data and show the time required for 5C and 10C rise in temperature as a function of the flow rate after reduction.

DECLASSIFIED

The calculated temperature response time for the K reactors is shown on Figure 1 for an upstream obstruction. These curves indicate that the more severe the flow reduction, the faster will be the response of the temperature monitor. This decrease in response time at low flows is due to the generation of steam in the process tube. At 50 gpm, the pressure drop from the effluent end of the active zone to the crossheader is about 40 psi and only a relatively small amount of steam generation is necessary in order to supply this pressure requirement. The curves indicate that there is a relatively constant time lag between the instant of the flow reduction and the first indication of a temperature rise. The rate of rise of temperature after the first indication is a function of the flow, with the lower apparent flow giving a quicker response.

Although the response of the temperature monitor is more rapid for zero flow than any other condition, the probability of tube damage when the tube is subjected to full power for a few seconds after the water flow has been reduced to zero is high. At the present time, it is not known that an instantaneous scram, i.e., at the instant of flow reduction, under full power would prevent damage to the process tube. The amount of damage would, of course, increase as the duration of operation under full power after the flow reduction is increased.

Figure 2 is a plot of the time required for the temperature monitor to indicate a 5C and 10C temperature rise after the flow reduction. Although the exact shape of this curve was not determined, the errors in shape would cause only a small discrepancy in the time and this is probably at the higher flow rates. (See Figure 6 for comparison.) The rather unusual shape of the curves in the neighborhood of 60 per cent flow is partially due to the formation of steam in the process tube. The location of the unusual hump in the curve is probably dependent on the ratio of tube power to water flow through the tube which also affects the amount of flow reduction necessary to start boiling.

EXTRAPOLATION TO K REACTOR

The equipment used to obtain the data did not correspond to the K reactor's configuration nor flow conditions. The differences are listed below:

1. Process tube dimensions and active zone length correspond to the C reactor. The K-type Y-fitting was used on the rear crossheader.
2. Heater rod was Cu Ni instead of U slugs. The heat capacity of the rod is about 150 per cent that of the slugs.
3. Flow through process tube was about 50 per cent that of K, i.e., 26 gpm.
4. Heat generation was about 50 per cent that of K, i.e., 500 KW.
5. Heat generation was uniform along the rod instead of a cosine distribution.

DECLASSIFIED

HW-35794
Page 6

6. The higher velocity in the K-type will increase the heat transfer coefficient and therefore decrease the response time.

Since the conditions under which the test was made are so different from the actual conditions, it was decided to account for the difference in the flows through the dummy sections only. All of the differences affect the data in such a way that the time response obtained is conservative, i.e., longer than would exist in K for the same per cent flow reduction except for the uniform heat generation which would shorten the time slightly. After accounting for the difference in time required to flow through the dummy section, the result would still be conservative.

Under the test conditions, 1.32 seconds were required for the water to flow through the dummy section at 25.75 gpm while the K reactor required only 0.77 second at 50 gpm flow. The difference in time may be computed as $\frac{1.32 - 0.77}{W}$ where W is per unit flow. The equation is not valid for flows

which allow boiling. For this report it was assumed that flow reduced to less than 50 per cent would cause boiling before the temperature element would respond, although the exact point is unknown.

Using this approximation, curves for K reactor were plotted from the test results down to the 50 per cent flow point and extrapolated to zero flow. These curves are shown in Figures 1 and 2 for the case of flow reduction due to an obstruction in the inlet end of the tube. Since the data obtained indicated only a slight difference between the upstream obstruction and the ruptured front-face pigtail, the one set of curves is a good indication of the time response for either condition.

M.E. Forsman

Reactor Design & Development Unit
Design Section
ENGINEERING DEPARTMENT

DECLASSIFIED

DECLASSIFIED

BY 3570K
Page 7

TEMPERATURE VS TIME AFTER FLOW REDUCTION
UPSTREAM OBSTRUCTION K-REACTORS
Tube Power: 1000 KW Flow Rate: 50 GPM

FIGURE 1

DECLASSIFIED

25-11 CLOUTIER & ELLER CO
16 X 10 to 100 lb. 5th floor
BOSTON U.S.A.

DECLASSIFIED

HW-35794
Page 8

TIME AFTER FLOW REDUCTION FOR TEMPERATURE
MONITOR TO INDICATE 5° AND 10° C RISE
K-REACTORS
TUBE POWER 1000 KW
UPSTREAM OBSTRUCTION
FLOW RATE 50 GPM

FIGURE 2

DECLASSIFIED

DECLASSIFIED

EN-35794
Page 9

TEMPERATURE VS. TIME AFTER FLOW REDUCTION
UPSTREAM OBSTRUCTION
CUPRO-NICKEL HEATER ROD
TUBE POWER 500 KW FLOW RATE 25.8 GPM

FIGURE 3

DECLASSIFIED

NY-35794
Page 10

TIME AFTER FLOW REDUCTION FOR TEMPERATURE MONITOR
TO INDICATE 5 AND 10 °C RISE
CUPRO-NICKEL HEATER ROD
UPSTREAM OBSTRUCTION
TUBE POWER 500 KW FLOW RATE 25.8 GPM

FIGURE 4

DECLASSIFIED

HW-3579A
Page 11

FIGURE 5

DECLASSIFIED

DECLASSIFIED

HW-30794
Page 12

TIME AFTER FLOW REDUCTION TEMPERATURE MONITOR
TO INDICATE 5 AND 10 C RISE
ALUMINUM HEATER TUBE
UPSTREAM OBSTRUCTION

TUBE POWER 600 KW FLOW RATE 28.8 GPM

FIGURE 6

DECLASSIFIED

DECLASSIFIED

MM-33754
Page 13

TEMPERATURE VS TIME AFTER FLOW REDUCTION
RUPTURED FRONT-FACE PIGTAIL
CUMERO-NICKEL HEATER ROD
TUBE POWER 500 KW FLOW RATE 25.8 GPM

FIGURE 7

DECLASSIFIED

[REDACTED]

TIME AFTER FLOW REDUCTION FOR TEMPERATURE
MONITOR TO INDICATE 5 AND 10 C RISE
CUPRO-NICKEL HEATER ROD
RUPTURED FRONT-FACE PIGTAIL
TUBE POWER 500 KW FLOW RATE 25.8 GPM

DECLASSIFIED

10. A 10 ton log jack. The time required
will be 8 or 9.

DECLASSIFIED

EW-35724
Page 15

FIGURE 9

DECLASSIFIED

DECLASSIFIED

17-57794
Page 16

TIME AFTER FLOW REDUCTION FOR TEMPERATURE
MONITOR TO INDICATE 5 AND 10 C RISE
ALUMINUM HEATER TUBE
RUPTURED FRONT-FACE PIGTAIL
TUBE POWER 600 KW FLOW RATE 28.8 GPM

FIGURE 10

DECLASSIFIED