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May 19, 1947

TO: P. F. GAST

FROM: U. M. STAEHLER

TEMPERATURE MOMENTS VS. POISON MOMENTS

Introduction

The excess reactivity available in an operating pile is absorbed in poison columns and horizontal rods. The temperature distribution of the pile is determined by the relative strengths and locations of the poison columns and the configuration of control rods used. A method for adjusting poison columns and rods to improve upon the pile's temperature distribution is given in Document #7-2654, "Procedure for Improving Temperature Distribution via Rods and Columns", Wheeler and Menegus to Jordan, September 9, 1945. A relationship between poison moment (inhour lattice units) and temperature moments (per cent) was theoretically derived in the above document and has since been measured on several occasions on the basis of operating experience. A survey of recent operating data for the F Pile has been made by H. A. Gauper, Jr. with the intent of improving the method for obtaining the temperature and poison moments and relating changes in the two. This study was concerned with only the horizontal and vertical dipole moments. The results of Mr. Gauper's investigation are summarized in this memorandum.

Summary

A rather large number of tubes in the central portion of the pile now contain material other than uranium and in some cases this interferes with the use of tubes listed in Document #7-2654 for calculating temperature moments. This condition is improved by expanding by one lattice unit the radius of the ring of tubes considered in the calculation.

The value of control rods in terms of inhour lattice units of poison moment has been estimated on the basis of the most recent rod calibrations. This correction is given in Figure 1.

Since the poison moment of the rods is based on effective poisoning value it seems reasonable to correct the nominal values of individual poison columns for the effect of shadowing and express their strengths in terms of effective inhours in calculating the "inhour lattice unit" value of the poison moment.

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U. M. Staebler to P. F. Gast, 5/19/47, Page 2

A plot of the effective poison moment vs. the observed temperature moment is shown in Figure 2 for the horizontal dipole and in Figure 3 for the vertical dipole. The following points of interest are noted from Figures 2 and 3.

1. A change of about 25 inhour lattice units in the effective poison moment will produce a change of one per cent in the corresponding temperature moment.
2. Neither graph passes through the origin; the horizontal dipole is displaced by 80 inhour lattice units while the vertical dipole is displaced by 180 inhour lattice units.

Details

Temperature Moment

The temperature moments used in this study were obtained by taking the temperature rise in each of 40 tubes on a radius of $12\frac{1}{2}$ lattice units from the center of the pile. This represents a revision of Table I of Document #7-2654. The tubes used are listed below.

NORTHWEST

3163
3264
3366
3466

NORTH

3672
3673
3674
3675
3676

NORTHEAST

3184
3285
3382
3481

WEST

2161
2261
2361
2461
2561

CENTRAL

2174
2273
2372
2476

EAST

3186
3286
3386
3486
3586

SOUTHWEST

1366
1466
1564
1663

SOUTH

1172
1173
1174
1175
1176

SOUTHEAST

1381
1482
1583
1684

The horizontal and vertical dipole temperature moments were calculated according to the form given in Table II of Document #7-2654.

Correction for Rods

An effort was made to determine the effect of control rods on the temperature moments by comparison of observed moments with a given poison pattern but under different rod conditions. It was not possible to obtain any satisfactory results from the available data.

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U. M. Staebler to P. F. Gast, 5/19/47, Page 3

In order to compare poison moments with temperature moments it was necessary to express all poison in the pile in terms of inhour lattice units, including the rods as well as the poison columns. Curves for interpreting the rods in terms of inhour lattice units of poison were determined by using the corrected rod calibrations of January 27, 1947, and numerically integrating the product of local strength with the horizontal and vertical distances from the center of the pile. These curves are given in Figure 1.

Poison Moments

The basis for calculating the moment of a poison column in terms of inhour lattice units is given on page 7 of Document #7-2654. There is only one deviation from this procedure to be mentioned in connection with the present study. Inasmuch as the values assigned to various lengths of the rods are based on the effective poison strength of that amount of rod it seemed reasonable to use effective rather than nominal poison strengths in calculating poison moments due to columns containing materials other than uranium. The correction for shadowing was made by means of the equation reported in Document #7-2318, "Effectiveness of Poison Columns", Menegus to Jordan, August 11, 1945.

Poison Moments vs. Temperature Moments

The horizontal and vertical dipole temperature moment of the P Pile was calculated for 63 different times from September, 1946 to February, 1947. The pile was operating with the xenon poison at equilibrium at the time each point was taken. These values were plotted as a function of the net effective poison moment, including rods and columns. The resulting graphs are shown in Figures 2 and 3. There is a great deal of scattering among the points plotted but at least part of that is due to the fact that the temperatures for calculating the temperature moments were taken from temperature maps which record the outlet tube temperatures only to the nearest degree, centigrade. The range covered is so large however that the slope of each graph is rather well defined.

For purposes of comparison the following summary of previously determined relationships between poison and temperature moments is given.

Date	Document #	Horizontal	Vertical	Remarks
9-27-46	7-2654	11 in 1 u/%	11 in 1 u/%	Theoretical
1 -46	7-3320	.20 "	20 "	Experimental
4-24-46	7-3983	28 " •	—	3 Columns
10 -46	7-5324	35 " •	17 " •	Experimental

No definite reason can be given for the observation that neither of the graphs passes through the origin. Several possible explanations can be offered. The quality of material making up the pile may not be symmetrical about the center due to original construction or due to local effects that have developed with operation. The correction allowed for the effect of control rods may be in error due to the calibration curve used or to the method of integrating along the length of the rod. The average shadowing correction applied to each column may not be a good value for the local shadowing on an individual

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U. M. Staebler to P. F. Gast, 8/19/47, Page 4.

column due to the proximity of other columns or control rods. The method of treating the bismuth column is subject to question because of the observation that these columns cause a slight increase in the temperature rise in surrounding tubes and because some of the columns are located slightly beyond the central flattened region of the pile.

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WATER LEVEL (FEET)

TIME (DAYS)

CHANGE IN WATER LEVEL

EFFECTIVE POISON MOMENT • INHUF LATTICE UNITS

CRITICAL ANALYSIS

RF-1 240

DATE

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8/12/94

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