DECLASSIFIED

HW-23861

RECORD CENTER FILE

RECEIVED

JUN 19 1956

300 AREA
CLASSIFIED FILES

Classification Cancelled and Changed To

DECLASSIFIED

By Authority of CG-PR-2

C.H. HENAGER 3-24-92

By T.J. KEATON 6-22-94

Verified By PM Eick 6-22-94

1. WK Alexander
2. JT Baker
3. MW Carbon
4. RG Clough
5. EJ Filip
6. OH Greager
7. JA Haaga
8. RB Hamilton
9. TW Hauff
10. EP Lee
11. DS Lewis
12. JE Maider
13. GE McCullough-WR Lewis
14. LE McEwen
15. RO Mehamn-CW Botsford
16. EB Montgomery
17. SL Nelson
18. RL Olsen
19. PH Reinker
20. JE Robb
21. JH Warren
22. CW Wheelock
23. EC Wood
24. WK Woods
25. RG Vanderwater
26. 700 Files
27. 300 Files
28. Yellow Copy
29. Pink Copy

This document contains information that is exempt from public release. Its transmission or the disclosure of its contents is prohibited.

March 26, 1952

COPY 1 OF 1, SERIES MA

This document consists of

1 page. No. 28

27 copies. Series 4

TUBE TEMPERATURE RISE LIMITS - BOILING CONSIDERATIONS

Introduction

A revision of tube power limits based on boiling considerations was presented in Document HW-23251.* The limits were given on a basis of tube power versus header pressure. However, for convenience of operation, the limits have been converted from tube power to permissible water temperature rise. The permissible Δt 's are given in this document.

Summary

Boiling of the water in a process tube, if permitted to continue, would cause excessive temperatures and thus damage the slugs, tube, and possibly the adjacent graphite. To avoid this situation the tube temperature rises should not exceed the limits given in Figures 1 through 4.

*Vanderwater, R. G., "Boiling Limits", January 22, 1952

DECLASSIFIED MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

870

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

- 2 -

HW-23861

The limits presented here vary with the film build-up, inlet water temperature, header pressure, orifice size, and the vertical location of the tube in the pile. They are directed toward efficient utilization of the header pressure as well as operational safety.

These limits are expected to permit an increase in the average power level of H and DR piles of about 3 to 4%. However, B, D, and F piles are limited by graphite temperatures at present and hence they are not expected to be affected immediately by the change in limits. The daily effect on the power level of H and DR piles is expected to vary from a reduction of about 2% to an increase of about 7% compared to the limits that have been in use.

Discussion

Boiling of the water in a tube would cause large increases in tube temperatures and result in damage to the slugs, tube, and possibly the adjacent graphite. Thus, it is desirable to provide sufficient header pressure to sweep steam from a tube should a momentary change cause boiling to begin. The limits set up in HW-23251 are intended to provide this protection.

Figures 1 and 2 give Δt limits for tubes with the following conditions: (a) water inlet temperature of 20°C, (b) tube elevation equal to that of the top tube row in the pile, and (c) a tube loading as follows, beginning at the rear end of the tube: one 5-inch perforated dummy slug, eleven 8-inch perforated dummy slugs, four 8-inch solid dummy slugs, and sixty-four 4.35-inch uranium slugs (no upstream dummy slugs). Figure 1 applies to tubes at B, D, and F piles, and Figure 2 to tubes at H and DR piles. The difference between the limits for B, D, and F and for H and DR is caused by the fact that B, D, and F piles have a slightly different inlet nozzle from that on H and DR piles. The two types of nozzles have different pressure drop characteristics. Thus, they affect the flow rate as measured by the Panellit System and hence the Δt limit.

In Figures 1 and 2 the Δt limits are plotted vs. the header pressure. A series of constant Panellit pressure curves is given for each orifice to take into account the effect of build-up of film in the tubes. As the film builds up, it causes an increase in the Panellit pressure. Since it also reduces the allowable tube power and the water flow through the tube, it affects the Δt limit. For this reason the Δt limit is given as a function of the Panellit pressure. The limits might have been given for a conservative amount of film build-up, thus reducing them to a single curve for each orifice. However, in order to permit a higher Δt for tubes with smaller amounts of film, this was not done. As an example, consider a tube at B, D, or F pile with a 0.240" orifice, a 380 psig header pressure, and a 230 psig Panellit pressure. From Figure 1 it is found that the Δt limit for this tube would be 64.6°C.

For tubes below the top tube row of the pile, or with an inlet water temperature below 20°C, a slightly higher Δt than that read from Figures 1 and 2 may be permitted. Figures 3 and 4 give the additional Δt permitted for lower inlet temperatures, and for lower tube rows, respectively. Assume that in the previous example, the tube was in row 23 and the inlet temperature was 10°C. In Figure 3 a 10°C inlet temperature is shown to give a +2°C Δt correction. For a 0.240" orificed tube in row 23, Figure 4 shows a correction of +1.3°C in the Δt limit. Thus the total Δt in this case would be 64.6 plus 2.0 plus 1.3, or 67.9°C.

DECLASSIFIED

DECLASSIFIED

- 3 -

HW-23861

The 0.140" orifice was omitted from Figures 1 and 2 because the minimum Δt limit for this orifice is about 85°C. Thus, outlet temperatures rather than Δt 's will limit the power of tubes with 0.140" orifices.

For tubes with solid dummy slugs in the upstream end of the tube somewhat larger Δt 's may be permitted. Although the permissible power is decreased 1 per cent by the presence of the upstream dummy slugs, the greater decrease in the water flow makes a net increase in the Δt limit. With the entire upstream end of the tube (about 8.6 feet) filled with solid dummy slugs, the following corrections may be made to the Δt limits as determined above:

<u>Orifice</u>	<u>Δt Limit Correction</u>
0.285	+ 4.5°C
0.240	4.6
0.200	5.6
0.175	6.7

For instance, if the tube in the previous example had had upstream dummy slugs in addition to the normal loading, an additional Δt of 4.6°C would be permitted. This is the correction for a tube with a 0.240" orifice. Thus the Δt limit of 67.9°C found previously for this example would be increased to 67.9 plus 4.6 or 72.5°C.

R. G. Vanderwater
R. G. Vanderwater
PILE TECHNOLOGY UNIT
Engineering Department

RGV:djs

DECLASSIFIED

DECLASSIFIED

HW-25861

- 4 -

APPENDIXMethod of Calculation of Δt Limits

Tube temperature rise limits may be calculated from the allowable tube power, Q , and the flow rate in the tube, F , as follows:

$$\Delta t = 3.79 (Q/F)$$

In this equation the power, Q , is in KW; the flow rate, F , is in gallons per minute; and Δt is in degrees centigrade.

The allowable power, Q , was determined from the data in HW-23251. Corrections were made for film build-up, tube elevation, and inlet temperatures.

The tube flow rate, F , may be calculated from the difference between the inlet cross-header pressure and the panellit pressure (ΔP_o) by the following equation:

$$F = \sqrt{C \Delta P_o} = \sqrt{C (P_h - P_p)}$$

Here C is a constant depending upon the orifice diameter and the type of inlet nozzle. The type of nozzle effects the flow calibration because the size and location of the panellit pressure tap openings differ slightly on the two nozzles. Table I gives the coefficients for the orifices used at present.

©

TABLE I - ORIFICE COEFFICIENTS

Orifice Diameter (Inches)	Coefficient (C)	
	B, D, and F Piles (Aluminum Inlet Nozzles)	H and DR Piles (Galvanized Inlet Nozzles)
0.285	5.68	4.93
0.240	2.89	2.64
0.200	1.49	1.30
0.175	0.862	0.813
0.140	0.344	0.331

NOMENCLATURE

- C = orifice coefficient
 F = flow rate, gallons per minute
 P_h = header pressure, psig as measured in the control room
 P_p = panellit pressure, psig as measured in the control room
 ΔP_o = orifice pressure drop ($= P_h - P_p$)
 Q = power, KW per tube
 Δt = tube temperature rise, degrees centigrade

DECLASSIFIED

FIGURE 1
 Δt LIMITS FOR R, S, AND T PILES
 DOWNSTREAM DUMMY SLUGS.

TOP ROW TUBE: FOUR 8" SOLID ALUMINUM
 20° INLET TEMPERATURE ELEVEN 8" PERFORATED DUMMIES
 NO UPSTREAM DUMMY SLUGS ONE 5" PERFORATED DUMMY

DECLASSIFIED

- 6 -

ΔT LIMITS FOR DR AND II PILES

DOWNSTREAM DUMMY SLUGS:

TOP ROW TUBE:	FOUR 8" SOLID ALUMINUM
20 INLET TEMPERATURE	ELEVEN 8" PERFORATED DUMMIES
NO UPSTREAM DUMMY SLUGS	ONE 5" PERFORATED DUMMY

DECLASSIFIED

DECLASSIFIED

INW-23861

-7-

FIGURE 3
TEMPERATURE CORRECTION
FOR INLET WATER TEMPERATURE

FIGURE 4
TEMPERATURE CORRECTION FOR
VERTICAL LOCATION OF PROCESS TUBE

DECLASSIFIED