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Production New Reactor

Richland, Washington
October 24, 1951

This document consists of 4 pages, No. [redacted]

Mr. J. R. Wolcott, Chairman
Working Committee - Project C-431-B
RICHLAND

INSULATING WEBBING BETWEEN THERMAL SHIELD AND GRAPHITE REFLECTOR

Introduction:

It has been proposed that insulating webbing be placed between the thermal shield and the graphite in "C". The purpose is to minimize heat flow from graphite to thermal shield and thereby increase graphite temperatures in order to reduce pile graphite growth. Several meetings were held by the Working Committee and calculations on temperatures and growth were presented by R. K. Andersen, G. M. Roy and M. Altman. A letter summarizing these calculations was written to the Working Committee by Altman and Roy.

Purpose:

The purpose of this document is to present the bases and calculations which resulted in the conclusion given in the letter of October 17. Also, the original calculations were made on the basis that the webbing face thickness is equal to 1/2 inch, which is no longer the case. The new thickness is 3/4 inch. This alters the condition of heat generation. Consideration is given to the heat generation in the legs.

Bases of Calculations:

The estimate of the heat generation in the thermal shield was based on calculations which were made using the source of data given below:

Source of Data	Power Level	Data Used	Calculated* Heat Generation per sq./ft. of Shield Faced (Btu/hr)
HW-15153 and Tech. Manual	275	Flux: 2.6×10^{11} thermal 2.6×10^{11} primary gammas $2. \times 10^{10}$ fast neutrons	835

[redacted]

Source of Data	Power Level	Data Used	Calculated* Heat Generation per sq/ft. of Shield Faced (Btu/hr)
Tech. Manual	250	Enthalpy gain in thermal loop = 375 KW	680
HW-17396	275	Thermal loop data: Inlet T = 19.5°C. Outlet T = 24.5°C. GPM = 260	650

* At the place of maximum flux

At 275 MW the heat generation is taken as 700 Btu/hr/ft^2. The heat generation @ 1200 MW and high enrichment would be $\frac{1200}{275}$ (2). Had the power been increased to 1200 MW while maintaining the same flux distribution, the ratio would have been 1200/275. The factor of 2 is to allow for the increase shield load due to enrichment flattening.

A conservative estimate of the heat generation in the 3/4 inch thick section of the webbing is 30% of the value generated in the thermal shield. The heat generation in the webbing is then $\frac{1200}{275} \times 2 \times (.3)\ (700) = 1830$ Btu/hr/ft^2. In addition, the heat generation in the legs of the webbing is about 10% of the total heat or 610 Btu/hr/ft^2 (conservative)

Condition I (not realistic)

Assumptions:

1. Perfect insulation between base thermal shield and webbing. That is, no conduction, convection, or radiation.
2. Conductivity of graphite in reflector = 6 Btu/hr/ft^2 per °F. per ft. of length.
3. Contact resistance between graphite blocks = 300 Btu/hr/ft.
4. Resistance at gap = 1/KA = 0.151

$$R_t = \Sigma R \text{ contacts} + R \text{ graphite} + R \text{ core}$$

$$R_t = (6 \text{ contact}) \frac{1}{300} + \frac{2 \text{ ft}}{6} + \frac{.030''/12}{.03\ (.55)}^{*}$$

* Core gap 0.030"

$$R_T = 0.02 + 0.333 + 0.151$$

$$R_T = .504$$

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ΔT (due to webbing along) = (.504) (1810 + 610) = 1230°F. This is ΔT from webbing face to process tube. With consideration of heat generation in the graphite the temperature at the web would definitely be excessive (~1600°F.).

Condition II

Infinite contact resistance between Thermal Shield and Webbing is assumed. Consideration is given to radiation and convection.

Temperature Base Cast Iron	Temperature Drop from Webbing to C.I.	Temperature of Face of Webbing	$h_r \epsilon$	h_c	Remarks
350°F*	400°F	750°F	4.5	1.5	No heat to graphite

* HDC-2274, Table IIA and IIB page 6, Case I gives maximum as 524°F.
Case II gives maximum as 430°F.

Using two tube/slot it is expected this will drop to 350°F. maximum.

ϵ = overall emissivity coefficient = 0.6

The above calculation did not allow for the increase in area from the webbing legs.

Condition III (Believed to be the most realistic case considered)

Allowance for radiation, convection and contact between cast iron webbing was made. No heat is transferred to the graphite from the webbing. The aluminum foils are assumed to be left out.

Assumptions:

Case I

1. The h (contact) equals 100 btu/hr/sq. ft./°F.
2. The sketch shown in Figure 1.
3. The temperature of the base cast iron is 350°F. This is based on calculations in HDC-2274.

Case II

As above, except with h = 300

	ΔT	T Cast Iron	T web	$h_r \epsilon$	h_c
Case I	250°F.	350°F.	600°F.	3.4	1.3
Case II	165°F.	350°F.	515°F.	3.0	1.1

Sample Calculation:

Case I: Heat transfer by radiation and convection:

$(250)(3.4 + 1.3) = 1170$ per ft.^{2}

Heat transfer by conduct $= 1830 - 1170 = 660$ per ft^2.

Heat which must be transferred per web is:

$\left[(8\ 3/8)^2/144\right](1830) = 891$

$(891)\dfrac{660}{1830} =$ 320 Btu/hr per web which must be transferred by conduction.

ΔT drop conduction: Resistance contact = .275
Resistance of legs = .159
.434

$\Delta T = (.434)(320) = 139°F$.
Superimposed on this is the drop caused by heat generation in the legs.
Generation = 10% of total = 297 Btu/hr per web.

$\Delta T = 115°F$. (This is conservative in that it neglects any radiation from the legs.)

Total $= 139 + 115 = 254$, which is near 250°F. assumed.

Conclusions and Recommendations:

Without the use of the aluminum foil underneath the webbing the temperature of the graphite in contact with the webbing will be less than 380°C. (present graphite limitation). The assumption of $h = 100$ Btu/hr/ft^2 - °F. is conservative.

Since the insulating layer gives a reduction in sideward graphite expansion (HDC-2267) it is recommended that it be installed. It is also recommended that the aluminum foil not be installed, as it does little good at low power levels and its absence insures safe operating temperatures at high levels.

If the heat generation is less than 30% of the total (which would have been produced in the thermal shield) then graphite conditions are definitely below the 380°C. limit even with infinite contact resistance.

If, when operating at high power levels and high enrichment, the temperature of the webbing were to exceed permissible limits, it would only be necessary to reduce the enriched loading in the center of the lowest layers to decrease the webbing temperatures to safe operating values.

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