UNCLASSIFIED

CLASSIFICATION LEVEL
(S, C, OR U)

ATOMICS INTERNATIONAL
A Division of North American Aviation, Inc.

NAA-SR-MEMO -3556

This document contains 30 pages

This is copy _____ of _____ series _____

Do not remove
this sheet

~~Facsimile Price \$ 1.64~~
~~Microfilm Price \$ 1.64~~
~~Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.~~

MASTER

CLASSIFICATION TYPE
(RD OR DI)

*NAA-SR-MEMOs are working papers and may be expanded,
modified, or withdrawn at any time,
and are intended for internal use only.*

This report may not be published without the approval of the Patent Branch, AEC.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNCLASSIFIED

CLASSIFICATION LEVEL
(S, C, OR U)

WRITTEN BY P. Legendre <i>PL</i>		<h1 style="text-align: center;">ATOMICS INTERNATIONAL</h1> <p style="text-align: center;">A Division of North American Aviation, Inc.</p> <h2 style="text-align: center;">TECHNICAL DATA RECORD</h2>	TDR NO. X
SECTION Engineering			3556
GROUP General Engineering			GO 7518
UNIT Shielding			LEDGER ACCT. 3621
APPROVED BY: (SUPERVISOR) R.L. Ashley <i>RLA</i>		PROGRAM HNPF	SUB-ACCT. 9961
OTHER	S. Berger <i>SB</i>	PROJECT	TWR 5109
		REACTOR STRUCTURE	DATE March 27, 1959
			PAGE 1 OF 30

TO:

J. F. Stolz

COPIES TO: E. B. Ash J. W. Cochran M. P. Heisler D. McGee M. Slater
R. L. Ashley J. Dillon H. B. Holz W. T. Morgan H. Sujata
S. Berger L. M. Flower W. D. Leonard M. Meuller J. Susnir
C. J. Brous R. C. Gerber J. E. Mahlmeister I. E. Randall G. L. Wegmann
D. F. Casey W. V. Haberer E. Matlin H. Ross-Clunis D. Zweng

SUBJECT: Analysis of the Heat Generation in the Primary Sodium Pipe Tunnels, Intermediate Heat Exchanger Cells, and the Primary Sodium Fill Tank Vault for the Hallam Nuclear Power Facility (HNPF)

CONTENTS:

- I STATEMENT OF PROBLEM PAGE 1
- II SUMMARY OF RESULTS AND RECOMMENDATIONS PAGE 1
- III METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS . . . PAGE 2
- IV REFERENCES AND APPENDICES PAGE 9

I STATEMENT OF PROBLEM

- A. To determine an adequate method for calculating the heat generation in the primary sodium pipe tunnels.
- B. To determine the heat generation in all areas containing parts of the primary sodium system.

II. SUMMARY OF RESULTS AND RECOMMENDATIONS

A. Summary of Results

1. An adequate and conservative calculational method for evaluation of the heat generation distribution in the primary sodium system sub-structural areas has been developed. The Applied Mathematics Unit has programmed⁽¹⁾ this method for the IBM 704 and the IBM 709.
2. The results obtained from analysis of the gamma-ray heat generation in the primary sodium pipe tunnels and intermediate heat exchanger cells are presented in Figures 1 through 17. Each figure has either a sketch of the particular location in the reactor system to which it refers, or an appropriate reference drawing is cited.
 - a. The peak heat generation in the north reactor cavity wall (see Figure 8) occurs in the area just opposite to the sodium nozzles and is 0.028 watts/cm²; that for the south reactor cavity wall (see Figure 9) is 0.024 watts/cm².
 - b. The peak heat generation in the intermediate heat exchanger cells

is located on the floor under the 16 in. O. D. primary sodium pipe (see Figure 16) and is 0.014 watts/cm².

3. The results for the gamma-ray heat generation in the primary sodium fill tank cavity are listed in Table II.

- a. The peak heat generation in the primary sodium fill tank cavity is 0.0448 watts/cm² and is located on the east cavity wall opposite the disc end (see Table II).

B. Recommendations

The results obtained in this study are based on a sodium specific activity of 0.325 curies/cc. However, this value was obtained (3) from an analysis for the reference core design. Since the design of the fuel assemblies has changed considerably since that time, it is recommended that the results obtained in this report be corrected when final calculations of the sodium specific activity for the moly and carbide fueled cores are completed. The results obtained in this report are directly proportional to the specific activity. In addition, it is recommended that all primary piping layout drawings which are issued be reviewed and analyzed to insure that no serious hot spots occur in any of the primary coolant substructure areas.

III. METHOD USED

A. Introduction

When the evaluation of this problem was initiated, two items became apparent, namely that the amount of calculations to be performed would be very extensive and that there was a very strict deadline to meet. In order to accomplish this task, it was necessary to develop a quick and somewhat conservative calculational method. The normal method used in the evaluation of heating in shields, and which is discussed in this report, is slow and very tedious when calculated by hand. However, J. Dillon of the Applied Mathematics Unit has recently programmed (1) this method for the IBM 704 and 709 computers and, as a result, calculations which formerly took man-weeks to solve by hand computational techniques now require only minutes to solve by machine. A large part of the results in this report was calculated by hand while the code was being developed; the remaining results, mainly for the areas outside of the reactor cavity, were obtained by machine computational methods.

It should be pointed out that both during the course of this analysis, and in the weeks which followed, many of the reference drawings which were used became obsolete. At the time, however, they constituted the "latest" available information. Therefore, particular note should be taken of the reference drawings listed on each figure.

B. Outline of the Calculations

1. Cylindrical Source

The gamma-ray energy flux, $\phi(E)$ in watts/cm², at a detector location for a given source strength was determined by the following equation (2,4) for an infinitely long cylindrical source:

$$\phi(E) = \frac{KBS_v R_o^2 F(\theta, b_2)}{2(a + \bar{z})} \quad (1)$$

where R_o = radius of the cylindrical source (cm)
 B = energy buildup factor, taken as = 1 for this application due to the thin steel regions in the piping.
 a = distance from the surface of the source to the detector (cm)
 $\bar{z}$ = effective self-attenuation distance (cm)
 K = $1.60 \times 10^{-13} \frac{\text{watt-sec}}{\text{Mev}}$

$$F(\theta, b_2) = \int_0^\theta e^{-b_2 \sec \phi} d\phi \quad (2)$$

θ = $\pi/2$ for the infinite source length

$$b_2 = b_1 + \mu_s \bar{z} \quad (3)$$

μ_s = linear absorption coefficient of the source (cm⁻¹)

$$b_1 = \sum_{i=1}^n \mu_i t_i \quad (4)$$

where $\mu_1, \mu_2, \dots, \mu_n$ = linear absorption coefficients of shields 1, 2, ..., n; (cm⁻¹)

t_1 = thickness of the 1-th shield, (cm)

The gamma-ray volumetric source strength of energy E , S_v , in Mev/cc-sec, was obtained as follows:

$$S_v = CkE \quad (5)$$

where C = sodium activity = 0.325 curie/cc⁽³⁾

$$k = 3.7 \times 10^{10} \text{ dis/curie-sec}$$

$$E = \text{gamma-ray energy, Mev}$$

The energy gamma-ray flux from an infinitely long cylinder, as obtained in Equation (1), must be corrected for the finite size of the source. This is accomplished by using a general line-source geometric factor⁽²⁾, GF, based on the definition:

$$GF = \frac{F(b, \phi)}{F(b, \pi/2)} \quad (6)$$

where ϕ = subtended angle of the pipe extremities
 b = b_1 as defined in Equation (4)

GF is obtained from Figure 4.11, page 112 of reference 2. Therefore, the gamma-ray heat generation, $H(E)$ in watts/cm², due to a given source strength at energy E , from a finite cylindrical source, is given by Equation (1) which is modified as follows:

$$H(E) = \phi(E) GF \quad (7)$$

$$H(E) = \frac{KBS_v R_o^2 GF F(\pi/2, b_2)}{2(a + z)} \quad (8)$$

The total heat generation at a particular detector point, H_r , is then obtained by simply summing over all source energies:

$$H_r = \sum_{E=1}^{10} H(E) \quad (9)$$

where H_r = heat generation at detector point r , watts/cm².
Equation (9) can now be written out in its final form

$$H_r = \sum_{E=1}^{10} \frac{KBS_v R_o^2 (GF) F(\pi/2, b_2)}{2(a + z)} \quad (10)$$

In the calculations involving Equation (10), H_r was evaluated using a single gamma-ray source energy of 2 Mev. This was used for reasons discussed in section C.

2. Disc Source

The primary sodium fill tank is represented by two source geometries: 1) a cylindrical geometry for the tank body and 2) a disc geometry for the large tank ends.

A disc source was also considered for the headers of the intermediate heat exchangers, but the magnitude of the heat generation from this portion of the source was negligible compared to that from the cylindrical pipe sources.

The gamma-ray heat generation flux, $H(E)$ in watts/cm², at energy E from a disc source, is given by the following equation: (2,4)

$$H(E) = \frac{KBS_A}{2} [E_1(b_1) - E_1(b_1 \sec \theta)] \times K \left[\frac{d}{R_o}, \frac{a}{R_o}, \mu R_o \right] \quad (11)$$

where $E = 2$ Mev for these calculations (see section C)

d = the radial distance from the axis of the disc source to the detector point in the plane of the dose point

$$E_n(b) = b^{n-1} \int_0^b \frac{e^{-t}}{t^n} dt \quad n \geq 0 \quad (2,4), \text{ and is tabulated in reference 2.} \quad (12)$$

$$K \left[\frac{d}{R_o}, \frac{a}{R_o}, \mu R_o \right] \text{ is plotted on pp. 349-352, reference 2.}$$

$$\theta = \tan^{-1} \frac{R_o}{a} \quad (13)$$

B, K, b_1, a and R_o were previously defined.

The source strength of a plane source, S_A , in Mev/cm²-sec, is defined as

$$S_A = \frac{S_v}{\mu_s} = 1.33 \times 10^{10} \quad (14)$$

where $\mu_s = 0.036 \text{ cm}^{-1}$ for 2 Mev gamma-rays and S_v was previously defined.

The average linear absorption coefficient of the shield regions, $\bar{\mu}$, in cm⁻¹, is determined by

$$\bar{\mu} = \frac{\sum_i \mu_i t_i}{\sum_i t_i} = 0.343 \quad (15)$$

where μ_1 and t_1 were previously defined. In this case, $\bar{\mu}$ equals the μ for iron at 2.0 Mev.

Finally, the heat generation at the detector point is summed over all source energies, as it is in Equation (9), to get the following for a disc source:

$$H_r = \sum_{E=1}^{10} \frac{KBS_A}{2} \left[E_1(b_1) - E_1(b_1 \sec \theta) \right] \quad (16)$$

In this case, and as previously, H was calculated only for a single gamma-ray energy of $E = 2$ Mev.

C. Source Constants

The sodium 24 decays by emitting a 1.38 Mev gamma-ray and a 2.78 Mev gamma-ray for each disintegration. Since these calculations were initially hand computed, it was necessary, in order to save time, to make an assumption that the sodium 24 decayed by emitting two, 2 Mev gamma-rays per disintegration. This assumption would permit a reduction in the calculational time by about a factor of two. Due to this assumption, the results vary from between 10 and 20 percent conservative, depending on the source size. In general, the values obtained for the heat generation from the pipe sources will be about 10% conservative, whereas the primary fill tank sources will give heat generation distributions which are about 17% conservative.

The sodium source strength is determined from Equation (5), which, for the specific activity of 0.325 curies/cc,

$$S_v(2 \text{ Mev}) = 4.8 \times 10^{10} \text{ Mev/cc-sec.}$$

The constants used in evaluating the cylindrical source geometry of the primary sodium piping, intermediate heat exchangers, and primary sodium fill tanks are listed in Table I. It should be noted that there are guard pipes positioned around some of the primary sodium piping. However, due to the lack of data concerning the guard pipe thicknesses at the time the calculations were performed, their presence was neglected in the determination of the cylindrical source geometry constants. The effect of not including this additional attenuation in the guard pipes is that the results for these areas are conservative.

The source for the IHX was assumed to be comprised of a homogenized region consisting of sodium and stainless steel.

The linear absorption coefficient for 2 Mev gamma-rays, μ_s in cm^{-1} , was calculated as follows:

$$\mu_s = \rho_{ss} \left[\frac{\mu}{\rho} \right]_{ss} + \rho_{Na} \left[\frac{\mu}{\rho} \right]_{Na} = 0.0565 \quad (17)$$

where $\left[\frac{\mu}{\rho} \right]_{ss}$ and $\left[\frac{\mu}{\rho} \right]_{Na}$ are the mass absorption coefficients (14) at 2 Mev for stainless steel and sodium, respectively.

$$\left[\frac{\mu}{\rho} \right]_{Na} = .0428 \text{ cm}^2/\text{gm}$$

$$\left[\frac{\mu}{\rho} \right]_{ss} = .0422 \text{ cm}^2/\text{gm}$$

The densities of the stainless steel and sodium were calculated as follows:

$$\rho_{ss} = \frac{W_{ss}}{V_x}, \text{ gm/cc} \quad (18)$$

$$\rho_{Na} = \frac{W_{Na}}{V_x}, \text{ gm/cc} \quad (19)$$

where V_x = volume of the IHX, $2.39 \times 10^6 \text{ cc}$ (13)

W_{ss} = weight of the stainless steel in the IHX, $0.85 \times 10^6 \text{ gm}$ (13)

W_{Na} = total weight of the sodium in the IHX, $1.90 \times 10^6 \text{ gm}$ (13)

The sodium source strength of the IHX, S_{ve} in Mev/cc-sec, was obtained as follows:

$$S_{ve} = \frac{W_{PNa}}{W_{Na}} S_v = 2.37 \times 10^{10} \quad (20)$$

where S_v = source strength of the primary sodium,
 4.8×10^{10} Mev/cc-sec

W_{PNa} = weight of the primary sodium in the
IHX, 0.965×10^6 gm (13)

W_{Na} was previously defined.

D. Results and Discussion

The results obtained for the gamma-ray heat generation distribution in the primary sodium pipe tunnels and IHX cells are presented in Figures 1 through 17. Each of these figures contain either a sketch of the location in the reactor system to which it refers or an appropriate reference drawing is given.

Figures 18 and 19 list the gamma-ray attenuation coefficients, both linear and mass, respectively, for sodium, steel, and concrete at gamma-ray energies of 1.38, 2 and 2.76 Mev; they also give the corresponding attenuations as a function of thickness.

The calculations for the primary sodium fill tanks considered three situations: 1) the maximum case where one tank is filled, 2) the case where two primary sodium coolant loops have been emptied into one tank, and 3) the case where one primary sodium coolant loop has been emptied into one tank. The results are listed in Table II.

IV. REFERENCES AND APPENDICES

1. J. Dillon, "Gamma Flux Heat Generation," NAA Program Description, Deck No. W3-326, (to be published).
2. T. Rockwell III, editor, Reactor Shield Design Manual (New York: McGraw-Hill Book Co., 1956), pp. 360-365 and pp. 108-118.
3. F. D. Anderson, "Analysis of the Equilibrium Specific Activity of the Primary Sodium in the Hallam Nuclear Power Facility (HNPF) and the Sodium Reactor Experiment (SRE)," TDR 2592, August 8, 1958.
4. A. Foderaro and F. Obenshain, "Fluxes from Regular Geometric Sources," WAPD-TN-508, June, 1955.
5. "Reactor and Primary Pipe Tunnel Layout-Plan, Hallam Nuclear Power Facility," AI Drawing No. 7508-D73006, May 8, 1958.
6. "Reactor and Primary Pipe Tunnel Layout - Sections, Hallam Nuclear Power Facility," AI Drawing No. 7508-D73007, May 8, 1958.
7. "Process Piping-Area 4-Plan Below Ground Floor, Hallam Nuclear Power Facility," Bechtel Drawing No. D-730542, August 13, 1958.
8. "Process Piping - Area 4-Section 41-41, Hallam Nuclear Power Facility," Bechtel Drawing No. D-730543, August 13, 1958.
9. "Primary Sodium Fill Tanks Piping, Plan and Section, Hallam Nuclear Power Facility," Bechtel Drawing No. 2933-SK-14, December 19, 1958.
10. Personal Communication, G. Landler, Design Group, Atomics International.
11. L. S. Marks, Mechanical Engineer's Handbook, (New York: McGraw-Hill Book Co., 1951), page 1013.
12. Personal Communication, F. W. Poucher, Engineering Design Group, Atomics International.
13. "Intermediate Heat Exchanger," Kellogg Drawing No. 301B1, June 6, 1958.
14. R. L. Ashley, "Preliminary Draft of a Shielding Data Manual," NAA-SR-Memo - 1187, Revised, December 9, 1954.
15. P. J. Legendre, "Radial Thermal and Fast Neutron Flux Distributions in the Sodium Reactor Experiment (SRE) and in the Title I Configuration of the Hallam Nuclear Facility (HNPF)," TDR 3352, to be published.

TABLE I
GEOMETRY CONSTANTS FOR THE SOURCE

(5,6,7,8,9) Nominal Pipe Diameter, inches	Pipe Schedule	Pipe Wall Thickness, inches	Inside Diameter, inches	Insulation Thickness, inches	b	$\frac{KBS_v R_o^2}{2}$	Length
16	10(11)	0.25(10)	15.50	4.0(10)	0.623	1.5	
14	10(11)	0.25(10)	13.50	4.0(10)	0.523	1.125	
10	20(11)	0.25(10)	9.50	4.0(10)	0.364	0.556	
6	40(10)	0.280(11)	6.065	4.0(10)	0.269	2.24×10^{-1}	
3	40(10)	0.216(11)	3.068	4.0(10)	0.212	4.73×10^{-2}	
IHX	-	1.0(13)	33(13)	-	0.871	3.33	$10^{1-11-3/4}$ (13)
PFT	-	0.375(12)	144(9)	-	0.327	1.29×10^2	$18^{(9)}$

MATERIAL CONSTANTS⁽¹⁵⁾

Material	Density (gm/cc)
Stainless steel	7.85
Sodium	0.82
Insulation	0.176

TABLE II

Heat Generation in the Primary Sodium Fill
Tank Cavity for One Tank

A: Sketch

B: Results

Side Location	Na Level	Heat Generation (watts/cm ²)		
		One Loop	Two Loops	Full
A		.0287	.0287	.0287
B		.0134	.0269	.0448
C		.0287	.0287	.0287
D		.00833	.0166	.0278

Two Dimensional Heat Generation Profile for Southeast Na Tunnel

Figure 1

C.F.A.I. Dwg. No. 7508-D73006

$D, \text{ watts/cm}^2$

1cm = 1 ft.

$D = \text{Heat Generation}$

Two Dimensional Heat Generation Profile for the Northwest Na Tunnel

Figure 2

C.F.A.I. Dwg. No. 1508-D13006

D Watts/cm²
 8×10^{-3}
 6×10^{-3}
 4×10^{-3}
 2×10^{-3}
 0

1 cm = 1 ft

D = Heat Generation

Two Dimensional Heat Generation Profile for The Southwest Na Tunnel Figure 3

C.F.A.I. Dwg. No. 7506-D73006

N ← S

$D, \text{ Watts/cm}^2$
 8×10^{-3}
 6×10^{-3}
 4×10^{-3}
 2×10^{-3}
 0

1 cm = 1 ft

D = Heat Generation

Two Dimensional Heat Generation Profile for the Northeast Na Pipe Tunnel

Figure 4

C.F.A.I. Dwg No. 7508-D73006

Y-axis label: $D, \text{ Watts/cm}$
 Scale: 8×10^{-3} , 6×10^{-3} , 4×10^{-3} , 2×10^{-3} , 0

1 cm = 1 ft

D = Heat Generation

Two Dimensional Heat Generation Profile for The Southeast NA Pipe Tunnel

Figure 5

C. S. A. J. Doc. No. 7508-D73006

Two Dimensional Heat Generation Profile for The Northwest Na Pipe Tunnel Figure 6

C.F.A.I. Draw No. 7508-D73006

N ← S

Dispers/cm²
 8×10^{-3}
 6×10^{-3}
 4×10^{-3}
 2×10^{-3}
 0

1cm = 1ft.

D = Heat Generation

Two Dimensional Heat Generation Profile for the Southwest Na Tunnel Figure 7

C.G.I.T. Dwg. No. 7502-D73006

N ← S

Watts/cm.
 2×10^{-3}
 4×10^{-3}
 6×10^{-3}
 8×10^{-3}

1cm = 1ft.

D = Heat Generation

Heat Generation Profile in The North Reactor Cavity Wall Opposite the Na Inlets Figure 8

C.F.A.I. Dwg. No. 7508-D73007

A - Contribution from the reactor to the
 surface of the cavity liner
 B - Contribution from the external sodium piping
 $C = \text{Total} = A + B$

Heat Generation as a function of Distance
 Along the Vertical Wall of the South Na Nozzle Cavity
 Figure 9

Heat Generation, as a Function of Distance
 Along the Horizontal Wall of the South Na
 Nozzle Cavity (24 ft. from reactor top)
 Figure 10

Two-Dimensional Heat Generation
Profile for the West Outlet of the
Reactor Cavity.

Figure 11

U.S. A.I. Dwg. No. 7508-D73006

A.I. Dwg. No. 7508-D73007 Sec. B-B

D = Heat Generation

Two-Dimensional Heat Generation
Profile for the East Outlet of the
Reactor Cavity.

Figure 1B

C.F.A.I. Draw. No. 7502-D73006

Draw. No. 7502-D73007 Sec. D-D

D = Heat Generation

Two-Dimensional Heat Generation
Profile for the Sodium Pipe Tunnels
Running East-west which Lead
To the JHX Cells.
Figure 14

C.F.I. Div. No. 7508-D73006

D in 10^{-3}

8×10^{-3}
 6×10^{-3}
 4×10^{-3}
 2×10^{-3}
0

91

14

1600-14

10m-162

D = Heat Generation

Two Dimensional Heat Generation Profile for the Sodium Pipe
 Tunnel's Leading into the
 JHX Cells

C.F. Bechtel, Dwg. No.'s
 D-730542
 and D-730543

Figure 15

D = Heat Generation

Two-Dimensional Heat Generation Profile for
 Intermediate Heat Exchanger Cell 3
 G.F. Bechtel Draw Nos D-730542 and D-730543
 Figure 16

Two-Dimensional Heat Generation Profile for Intermediate
 Heat Exchanger Cell 3
 of Bechtel Dwg No's D-730542 and D-730543
 Figure 17

KE 10X10 TO THE CM. 359-14
 KEUFFEL & ESSER CO. MADE IN U.S.A.

1.02×10^{-3}

1 cm = 2 ft

D Watts/cm²

2×10^{-3}
 4×10^{-3}
 6×10^{-3}
 8×10^{-3}

D = Heat Generation

Gamma Ray Attenuation vs. Penetration
 Figure 18

Gamma Ray Attenuation vs Penetration in Steel

Figure 19

$\mu/p(1.38) = 0.0506 \text{ cm}^2/\text{gm}$
 $\mu/p(2.10) = 0.0422 \text{ cm}^2/\text{gm}$
 $\mu/p(2.76) = 0.0370 \text{ cm}^2/\text{gm}$

APR 30 1963

UNCLASSIFIED

CLASSIFICATION LEVEL

(S, C, OR U)

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

Do not remove
this sheet

NAA-SR-MEMO -3556 Addendum

This document contains 12 pages

This is copy _____ of _____ series _____

MASTER

CLASSIFICATION TYPE

(RD OR DI)

*NAA-SR-MEMOs are working papers and may be expanded,
modified, or withdrawn at any time,
and are intended for internal use only.*

This report may not be published without the approval of the Patent Branch, AEC.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNCLASSIFIED

CLASSIFICATION LEVEL

(S, C, OR U)

WRITTEN BY P. J. Legendre		ATOMICS INTERNATIONAL A Division of North American Aviation, Inc.		TDR NO. 3556 Addendum 1	
SECTION Engineering				GO 7518	
GROUP Analytical Engineering		TECHNICAL DATA RECORD		LEDGER ACCT. 3621	
UNIT Radiation Analysis				SUB-ACCT. 9961	
APPROVED BY: (SUPERVISOR) R. L. Ashley		PROGRAM HNPF		TWR 5109	
OTHER S. Berger		PROJECT Reactor Structure		DATE April 25, 1959	
				PAGE 1 OF 12	

TO: **J. F. Stolz**

COPIES TO:

E. B. Ash	J. W. Cochran	M. P. Heisler	M. Slater
R. L. Ashley	J. Dillon	H. B. Holz	P. Spiegler
S. Berger	L. M. Flower	W. D. Leonard	H. L. Sujata
C. J. Brous	R. C. Gerber	J. E. Mahlmeister	J. Susnir
D. F. Casey	W. V. Haberer	E. Matlin	G. L. Wegmann
		H. A. Ross-Clunis	D. Zweng

SUBJECT: **Analysis of the Heat Generation in the Primary Sodium Pipe Tunnels, Intermediate Heat Exchanger Cells, and the Primary Sodium Fill Tank Vault**

CONTENTS:

I	STATEMENT OF PROBLEM	PAGE 1
II	SUMMARY OF RESULTS AND RECOMMENDATIONS	PAGE
III	METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS . . .	PAGE
IV	REFERENCES AND APPENDICES	PAGE

I STATEMENT OF PROBLEM

To determine the heat generation in areas where the primary sodium system piping layout has changed from that analyzed in TDR 3556.

II. SUMMARY OF RESULTS AND RECOMMENDATIONS

The results obtained from analysis of the gamma-ray heat generation in the primary sodium pipe tunnels and the intermediate heat exchanger cells are presented in Figures 1 through 9. Each figure contains a notation to an appropriate reference drawing.

The following specific results point out the major changes in magnitude of the hot spot heat generation due to the change in primary sodium piping layout:

1. The peak heat generation in the diaphragm seal at the east end of the reactor cavity (see Figure 1) is 0.011 watts/cm². Previous calculations¹ gave 0.0084 watts/cm².
2. The peak heat generation in the intermediate heat exchanger cells is located on the wall opposite pipe 239-14" A (see Figure 9) and is 0.031 watts/cm². The previous peak heat generation in the IHX cell, 0.013 watts/cm², was located on the cell floor beneath the 16 inch primary sodium pipe.

III. METHOD USED

The addendum presents the heat generation in areas where the primary sodium piping layout has changed from that analyzed in TDR 3556.

The method used to perform the analysis reported in this addendum is the same as that presented in TDR 3556 with one exception. In TDR 3556, the two Na^{24} gamma-ray energies, 1.38 and 2.75 Mev, were lumped into one energy, 2 Mev, whereas in this addendum, the heat generation values were calculated for both energies, and summed to yield the total. This change results in heat generation values which are 10% less conservative than those in TDR 3556 (for the same source configuration).

On Figure 9, it will be noted that there are only six points plotted, and that these points are not connected to form a profile. Although Figures 5 through 8 presented the heat generation profiles in the IHX cells in detail, additional points were required due to the proximity of certain primary sodium pipes to the IHX cell walls. These additional points were plotted on Figure 9. If a complete profile had been presented in Figure 9, it would be similar to the right-hand profile on Figure 8.

IV. REFERENCES AND APPENDICES

1. P. J. Legendre, "Analysis of the Heat Generation in the Primary Sodium Pipe Tunnels, Intermediate Heat Exchanger Cells, and the Primary Sodium Fill Tank Vault for the Hallam Nuclear Power Facility (HNPF)," TDR 3556, March 27, 1959.
2. "Process Piping Area 6 - Plan Below Ground Floor," Bechtel Drawing No. D-730612, February 17, 1959.
3. "Process Piping Area 4 - Plan Below Ground Floor," Bechtel Drawing No. D-730573, February 17, 1959.
4. "Process Piping Area 4 - Section 576," Bechtel Drawing No. D-730576, February 17, 1959.
5. "Reactor Cavity Pipe Seal to Pipe Gallery - Design Layout," AI Drawing No. 7508-D971215, March 9, 1959.

Heat Generation for the Diaphragm Seal
East End of the Reactor Cavity

Figure 1

C.F. A.I. Dwg. No. 7508-D971215

HNPF - Reactor Structure

Heat Generation for the Diaphragm Seal
West End of the Reactor Cavity

Figure 2

C.F. A.I. Dwg. No. 7508-D971215

ENPF - Reactor Structure
 North-South Profile in the West Hot Tunnel

Figure 3

c.f. Bechtel Draw No. D-730612

HNPF - Reactor Structure

East-West Profile in the West Hot Tunnel

Figure 4

c.f. Bechtel Dwg. No. D-73061R

Profile View of the IHX Cell No. 3

Figure 5

c.f. Bechtel Dwg. No's D-730376
D-730573

Scale: 1 cm = 4 ft

HNPF - Reactor Structure

Front View Section of IHX Cell No. 3
 thru IHX No. 3A

Figure 6

Heat Generation, watts/cm^2

C. F. Bechtel Dwg. No's D-730376
 D-730573

Scale: 1 cm = 4 ft.

Front View Section of IHX Cell No. 3
Thru 239-14" A

Figure 7

Cf. Bechtel Drawings D-7303-76
D-7305-23

Scale: 1 cm = 4 ft

Figure 8

C. F. Bechtel Div. No. D-730376
D-730373

Scale: Km = 4 ft

HNPF - Reactor Structure

Front View Section of IHX Cell No. 3
 thru a Point 12 ft. back of 239-14"-A

Figure 9

C.F. Bechtel Draw No's D-730376
 D-730573

Scale: 1cm = 4ft.