Westinghouse Electric Corporation Power Systems

Box 355
Pittsburgh Pennsylvania 15230

December 5, 1978

NS-TMA-1999

Mr. John Stolz, Chief
Light Water Reactor Branch No. 1
Division of Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Reference: Westinghouse ECCS Evaluation Model, February 1978 Version
WCAP-9220, February 1978

Dear Mr. Stolz:

~~Enclosed are 40 copies of proprietary information and~~ 20 copies of non-proprietary information requested by the staff to assist in their review and approval of the above referenced report. Also enclosed are:

~~1.~~ One (1) copy of Application for Withholding, AW-78-85, (Non-Proprietary)
~~2.~~ One (1) copy of affidavit (Non-Proprietary)

This additional information includes:

1. Attachment 1 containing further information on the 15x15 FLECHT correlation requested by Mr. Wayne Hodges,

2. Microfiche copies of FLECHT data from the runs of the FLECHT Low Flooding Rate Cosine test series used to develop the subject evaluation model.

Attachment 1 addresses the behavior of the 6 ft. thermocouple in the 5G position. This information was requested by the staff following their review of Attachment 1 to NS-TMA-1834 dated 6/20/78.

The microfiche copies of the FLECHT data from the 31 runs of the Low Flooding Rate Cosine test series used to develop the subject evaluation model were requested by Mr. Wayne Hodges of the staff in a telecon with L. E. Hochreiter and R. C. Howard of Westinghouse Electric Corporation on 6/26/78. The information contained in the microfiche is described in Attachment 2. The microfiche film was packaged and sent to the NRC separately.



W003
S
20/20

This submittal contains proprietary information of Westinghouse Electric Corporation. In conformance with the requirements of 10CFR Section 2.790, as amended, of the Commission's regulations, we are enclosing with this submittal an application for withholding from public disclosure and an affidavit. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission.

Correspondence with respect to the affidavit or application for withholding should reference AW-78-48 and should be addressed to R. A. Wiesemann, Manager of Licensing Programs, Westinghouse Electric Corporation, P.O. Box 355, Pittsburgh, Pa. 15230.

The material in Attachment 1 will be added to WCAP-9220 when it is re-issued with the staff's approval letter.

If there are any further questions, please call us.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

T. M. Anderson, Manager
Nuclear Safety Department

TMA/EH/jb

Attachment

Attachment 1

At the request of the NRC, the February 1978 ECCS evaluation model described in WCAP-9220 was compared to individual hot rods from the low flooding rate cosine test series. This information was transmitted to the NRC in Attachment 1 to NS-TMA-1834 dated 6/20/78. The NRC has reviewed NS-TMA-1834 and asked why the 5G six foot heat transfer data shows up as the worst location in many of the test runs. This attachment addresses the behavior of the 5G 6 ft. heat transfer data in the low flooding rate cosine series.

It is postulated that the 5G-6 ft. thermocouple behavior may be due to either [ ] in the rod bundle or may be due to [ ] associated with the 5G-6 ft. thermocouple. To evaluate which hypothesis explains the 5G behavior, the following data was reviewed: the low flooding rate cosine test series (WCAP-8651), the low flooding rate skewed test data (WCAP-9108), test data from the previous FLECHT Test (WCAP-7931), a MOXY calculation of rod to rod radiation heat transfer, and the 5G heater rod inspection data. (A,C) (A,C)

In the 26 runs with 5G-6ft. data which the February 1978 ECCS model is compared against, the 5G thermocouple had [ ]. The 4G location was the next most frequent [ ]. The 8C location had the highest frequency for the highest heat transfer, repeating as the [ ]. (A,C) (A,C) (A,C)

To examine the rod location effect of rod 5G, the initial measured heat transfer coefficient (at the beginning of reflood) from the low flooding rate data (WCAP-8651) was reviewed. This review showed that [ ]. Also, the initial heat transfer coefficient for rod 5G was (A,C)

[ (A,C)

] The initial heat transfer was also calculated using the MOXY code. In the MOXY calculation, radiation is assumed to be the only heat transfer mechanism. The MOXY model includes rod to rod radiation between the heated and unheated rods for the 10x10 bundle used in the low flooding rate tests. The calculation applies to the initial heatup period prior to reflood and shows the [ (A,C)

] however, all hot rods had nearly the same temperature.

To further examine the effect of rod position, previous FLECHT cosine power shape data and the skewed power shape data was examined. The 10x10 rod bundle used in the FLECHT Supplement test series reported in WCAP-7931 has the same rod bundle geometry and radial power distribution as the low flooding rate cosine test series bundle (WCAP-8651). The skewed profile low flooding rate test series (wcap-9108) rod bundle is slightly larger than the 10x10 rod bundle but within the skewed bundle, an inner 6x6 rod array exists which has the same geometry and in selected tests, had the same radial power distribution as the cosine bundle. In each of these test series, [ (A,C)

] In 8 out of 9 supplement runs, with parameters close to the low flooding rate cosine test parameters, [ (A,C)

] In the skewed test series, in seven tests with the FLECHT radial power distribution, [ (A,C)

]

[ (A,C)

] Also the eight foot

(A,C)

data from [

] The

behavior of thermocouple 5G-6 ft. was also examined for those tests in which 5G-6 ft. showed the highest heat transfer data. Heat transfer plots of all instrumented rods at the six foot elevation were displayed

(A,C)

[

] The 5G- 6 ft.

data from low flooding rate test 04516 is shown in Figure 1. The high initial film coefficient and large heat transfer between 0-100 seconds are

[ (A,C)

The larger scatter in thermocouple quench time for 5G-6 ft. had been previously noted in a memo to Dr. Y. Y. Hsu (attached) further indicating that [ (A,C)

Finally the pretest rod inspection data for the 5G rod in the cosine test series was reviewed. All of the measured parameters for Rod 5G are within an acceptable tolerance, however, [ (A,C)

]

[ (A,C)

]

[ (A,C)

]

TABLE 1

Individual Rod Statistical Summary Data

Individual Rod

(1) N = No. of Data Points in Sample

$\overline{x}$ = Sample Average for Individual Rod Relative to the Average of All Rods at the Same Elevation

$\sigma$ = Sample Standard Deviation

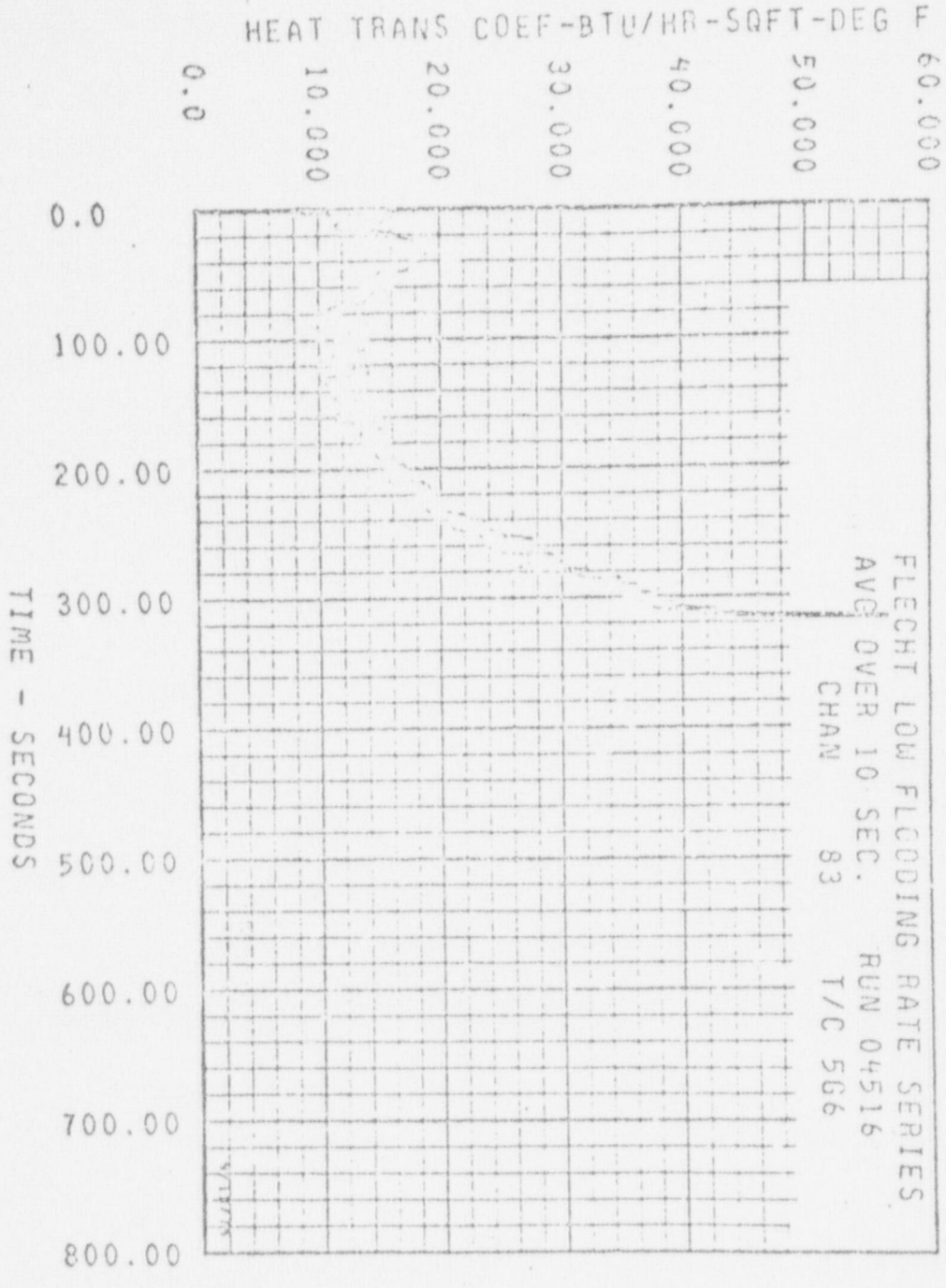



FIGURE 1

HEAT TRANS COEF-BTU/HR-SQFT-DEG F

ATTACHMENT 2

The microfiche data includes plots of the clad temperature, heat transfer coefficient and heat flux transients for each thermocouple in the heated bundle. The data is also presented in tabular form. The data tables include the thermocouple output, calculated clad surface temperature, heat transfer coefficient and heat flux versus time. Negative time values refer to the heatup period prior to initiation of reflood.

Following is a list of the run numbers for the attached FLECHT data.

| | | | |
|---|---|---|---|
| 0904 | 3447 | 5342 | 8037 |
| 1445 | 3709 | 5543 | |
| 1545 | 3946 | 5715 | |
| 1812 | 4019 | 5917 | |
| 1907 | 4516 | 6161 | |
| 2005 | 4641 | 6638 | |
| 2326 | 4748 | 7631 | |
| 2502 | 4831 | 7729 | |
| 2603 | 4930 | 7836 | |
| 2833 | 5132 | 7934 | |

ATTACHED TO SE-LEH-90

Westinghouse Electric Corporation
Power Systems Company

PWR Systems Division
Box 355
Pittsburgh Pennsylvania 15230

December 27, 1976

SE-SD-1229

Dr. Y. Y. Hsu
Office of Energy Research & Dev.
Mail Station 1130 SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Behavior of Rod 5G in FLECHT Low Flooding Rate Test Series

Dear Dr. Hsu:

We have examined rod 5G to see if it exhibited any abnormal behavior during the FLECHT Low Flooding Rate test series. The quench time of rod 5G was compared at the six foot elevation with the mean quench time of similar powered rods. On 11 of 49 cases, rod 5G showed a quench time which was different than one-standard deviation from the mean. These quench times were always shorter indicating better heat transfer for rod 5G. In comparison rod 8D was also examined and its quench time fell within the mean quench time, plus and minus the standard deviation, 48 of 49 cases. Also the deviations from the mean quench time were generally smaller for rod 8D than for rod 5G.

Both rods, 5G and 8D, were replacement rods which were installed into the FLECHT bundle at the same time. Both rods were 8 T/C rods with the T/C's covering the 6 to 12 foot elevations.

Therefore it is concluded that rod 8D represents the data mean more accurately than does rod 5G, however, there is at present no explanation for the different rod behaviors. The data generated for this study is attached and if there are any questions on this study, please contact me.

Very truly yours,

L. E. Hochreiter, Manager
Safeguards Development

cc: J. O. Cermak*
E. Davidson* - NRC-RSR
A. P. Suda

*w/o attachments

LEH:tmm

Attach.

WORK SHEET
WESTINGHOUSE FORM 8295 E

# QUENCH TIMES 1.1 ZONE US SG6

| RUN # | 1.1 MEAN | SG | ∇ | Δ | ∂∂ | Δ |
|---|---|---|---|---|---|---|
| 00208 | 86.7 | 100.3 | 18.5 | 13.6 | 70.9 | 4.2 |
| 00606 | 106.1 | 115.5 | 21.3 | 9.4 | 111.5 | 5.4 |
| 00904 | 175.3 | 186.5 | 27.6 | 11 | 183.0 | 7.7 |
| 01445 | 244.9 | 254.0 | 35.1 | 9.1 | 247.9 | 3 |
| 01545 | 239.5 | 256.0 | 39.1 | 16.5 | 250.8 | 11.3 |
| 01612 | 71.0 | 73.2 | 15.5 | 2.2 | 75.3 | 4.3 |
| 01707 | 90.2 | 102.3 | 22.1 | 12.1 | 96 | 4.8 |
| 02005 | 124.3 | 145 | 25.4 | 20.7 | 130.1 | 5.8 |
| 02223 | 272.8 | 284.0 | 39.3 | 16.2 | 280.7 | 7.9 |
| 02324 | 292.4 | 307.5 | 41.7 | 14.6 | 279.7 | 5.8 |
| 02414 | 327.1 | 341.9 | 46.7 | 14.8 | 331.7 | 4.6 |
| 02505 | 221.4 | 237.9 | 34.3 | 13.5 | 230.9 | 6.5 |
| 02603 | 286.8 | 305.8 | 49.3 | 19 | 295.5 | 8.7 |
| 02833 | 335.5 | 351.5 | 47.5 | 16 | 339.7 | 4.2 |
| 02928 | 212.3 | 213.3 | 27.5 | 1.0 | 225.0 | 12.7 |
| 03113 | 212.3 | 222.7 | 26.5 | 10.5 | 217 | 4.7 |
| 03325 | 231.1 | 127.8* | 46.0 | -103.3 | 244.5 | 13.4 |
| 03447 | 216.1 | 226 | 27.3 | 9.9 | 221 | 4.9 |
| 03610 | 140 | 75.3* | 58.1 | -64.1 | 185 | 45.1 |
| 03709 | 186.2 | 130.9* | 45.5 | -55.3 | 211.0 | 24.8 |
| 03811 | 89.9 | 52.1 | 42.5 | -37.8 | 137.4 | 47.5 |
| 03946 | 432.3 | 438.4 | 57.2 | 6.1 | 438.5 | 6.2 |
| 04019 | 193.3 | 192.9 | 25.7 | -0.4 | 200.7 | 7.4 |
| 04120 | 275.2 | 285.5 | 38.2 | 10.3 | 279.1 | 3.9 |
| 04144 | 63.1 | 59.1 | 7.7 | -4.0 | 69.7 | 6.6 |
| 04316 | 315.4 | 321.9 | 45.2 | 6.5 | 321.7 | 6.3 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 429.6 | 7.7 |

| RUN # | 1.1 MEAN | SG | ∇ | Δ | ∂∂ | Δ | |
|---|---|---|---|---|---|---|---|
| 04748 | 206.9 | 187.4 | 27.2 | -19.2 | 219.9 | 13 | |
| 04831 | 210.0 | 187.6 | 26.5 | -22.5 | 217.7 | 7.7 | |
| 04930 | 239.4 | 234.6 | 27 | -4.8 | 245.9 | 6.5 | |
| 05029 | 277.3 | 278.8 | 34.8 | 1.5 | 283.9 | 6.6 | |
| 05132 | 280.9 | 282.9 | 36.0 | 2.0 | 288.9 | 8.0 | |
| 05342 | 449.4 | 454.9 | 59.7 | 5.1 | 453.4 | 4.0 | |
| 05548 | 380.5 | 368.7 | 50.1 | -11.8 | 387.7 | 7.2 | |
| 05617 | 353.4 | 341.7 | 43.7 | -11.7 | 357.9 | 4.4 | |
| 05715 | 247.2 | 241.9 | 38.4 | -5.3 | 260.9 | 13.7 | |
| 05821 | 46.3 | 119* | 23.7 | -34.4 | 37.2 | -9.1 | |
| 05917 | 329.1 | 299.6 | 44.6 | -29.5 | 336.9 | 7.8 | 26/49 |
| 06022 | 221.1 | 193.4 | 32.7 | -27.7 | 250.6 | 29.5 | |
| 06161 | 288.5 | 243.6* | 36.6 | -39.9 | 275.3 | -8.2 | |
| 06218 | 295.7 | 331.4* | 28.0 | 35.7 | 303.6 | 7.9 | |
| 06357 | 55.5 | 43.3 | 17.0 | -12.2 | 54.3 | 1.2 | |
| 06458 | 91.2 | 64.3* | 15.1 | -26.9 | 95.6 | 4.4 | |
| 06554 | 116.4 | 54.3* | 47.0 | -62.1 | 129.7 | 13.3 | |
| 06638 | 500.8 | 462.3 | 140.0 | -38.2 | 540.9 | 40.1 | |
| 06751 | 77.4 | 34.5* | 28.3 | -42.9 | 73.9 | 4.5 | |
| 06850 | 110.4 | 71.5* | 25.9 | -38.9 | 111.9 | 1.5 | |
| 07151 | 84.9 | 57.5 | 24.8 | -27.8 | 101.9 | 17.0 | |
| 07252 | 115.4 | 71.9 | 50.6 | -43.5 | 139.7 | 24.3 | |

1 RUN, ∂∂ DO NOT

12 RUNS, SG DO NOT

INFO ± 1∇ FROM MEAN TIMES (17 %)

1.1 QUENCH

WORK SHEET
WESTINGHOUSE FORM 8295 E

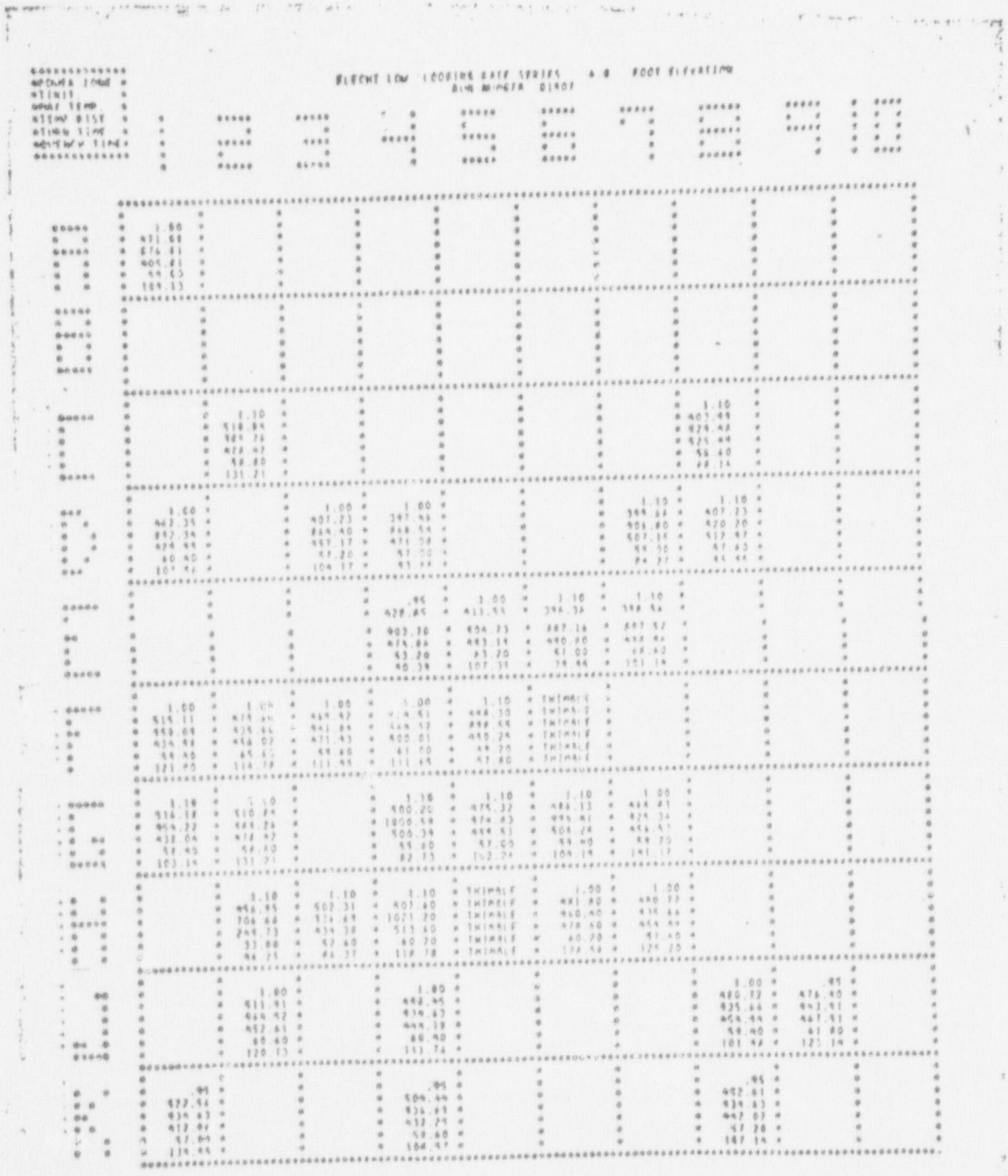
2

AFANS ± 5.0 FOR 1.1 ZONE

| RUN | ROD | | | 6' | 6.5 | 7 | 8 | | 6 | 6.5 | 7 | 8 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01907 | SG | | | 102.3 | 96.7 | 124.4 | 145 | M | 90.2 | 105.8 | 129.6 | 142.4 | | | |
| | GE | | | 80 | 107.6 | 127.6 | 153 | | | | | | | | |
| | SD | | | 96 | 112.9 | 137.1 | 166 | SD | 22.9 | 6.74 | 5.74 | 42.99 | | | |
| 02005 | SG | | | 145 | 128.7 | 158 | 195 | M | 124.3 | 140.7 | 167.3 | 176.8 | | | |
| | GE | | | 115.1 | 145.7 | 169 | 172 | | | | | | | | |
| | SD | | | 130.1 | 147.8 | 175 | 195 | SD | 25.44 | 8.53 | 7.03 | 58.5 | | | |
| 03709 | SG | | | 130.9 | 63.1 | 150 | 245.9 | M | 186.2 | 183 | 233.0 | 226.7 | | | |
| | GE | | | 233 | 241.5 | 278 | 327 | | | | | | | | |
| | SD | | | 211.0 | 221.9 | 278 | 324 | SD | 45.46 | 81.91 | 58.75 | 52.01 | | | |
| 04444 | SG | | | 59.1 | 49.1 | 64.4 | 77.3 | M | 63.1 | 66.9 | 76.6 | 74.0 | | | |
| | GE | | | 64 | 75.1 | 78.7 | 93.8 | | | | | | | | |
| | SD | | | 69.7 | 76.3 | 81.7 | 91 | SD | 7.74 | 12.56 | 5.25 | 25.63 | | | |
| 05521 | SG | | | 11.9 | 32.2 | 12.5 | 12.5 | M | 46.3 | 37.4 | 20.5 | 27.3 | | | |
| | GE | | | 24.6 | 34.8 | 33.4 | 52.3 | | | | | | | | |
| | SD | | | 37.2 | 45.2 | 15.2 | 14.1 | SD | 23.65 | 5.61 | 9.54 | 23.37 | | | |
| 06458 | SG | | | 64.3 | 74.4 | 71.1 | 91.3 | M | 91.2 | 89.0 | 89.7 | 97.3 | | | |
| | GE | | | 64.3/88 | 77.7 | 88.1 | 124.1 | | | | | | | | |
| | SD | | | 95.6 | 112.9 | 109.9 | 73.7 | SD | 15.1 | 17.05 | 15.85 | 18.54 | | | |

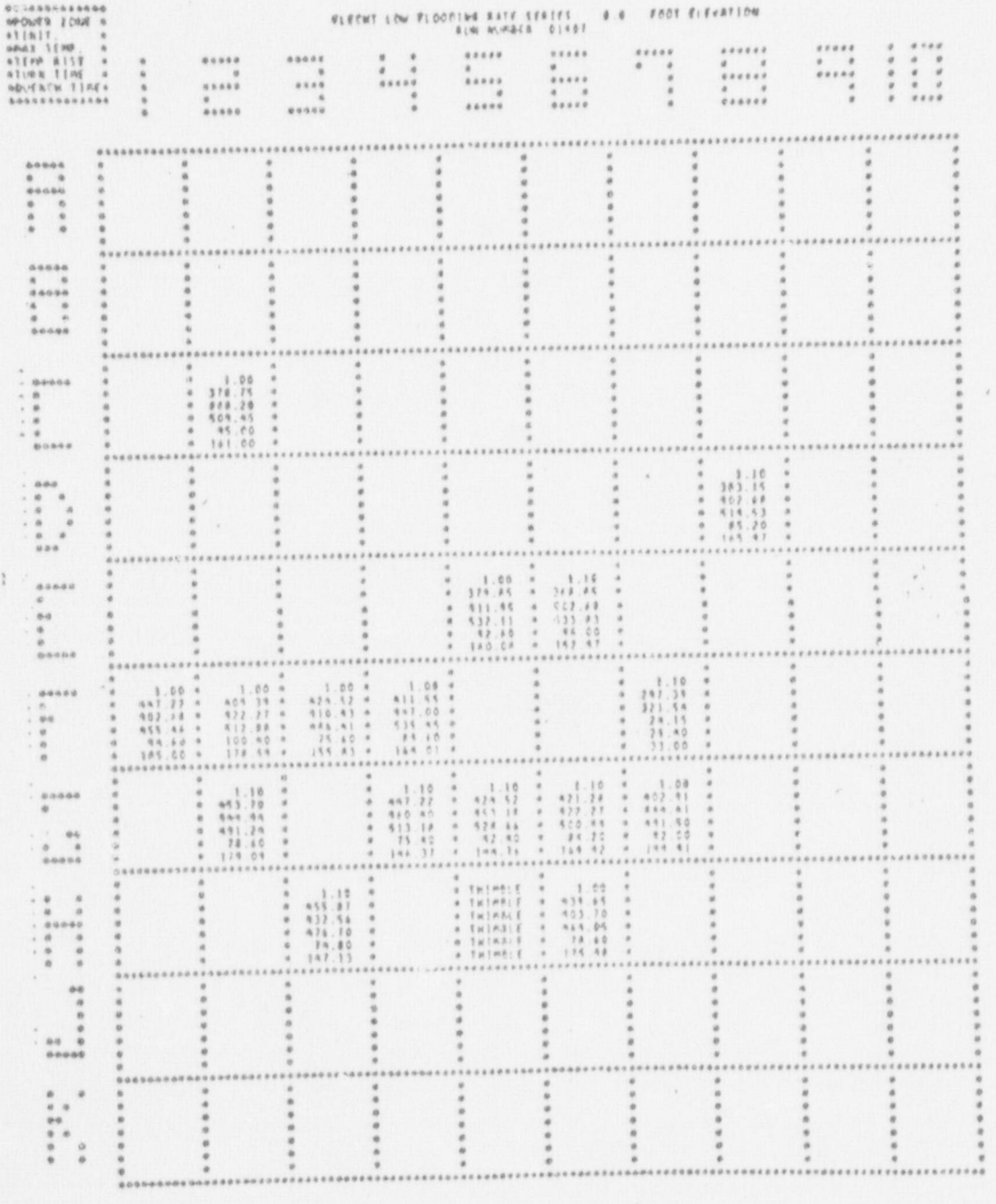
FLECHT

COSINE SERIES RUN 01907 6'



FLECHT

COSINE SERIES RUN 01907 8'



FLEET

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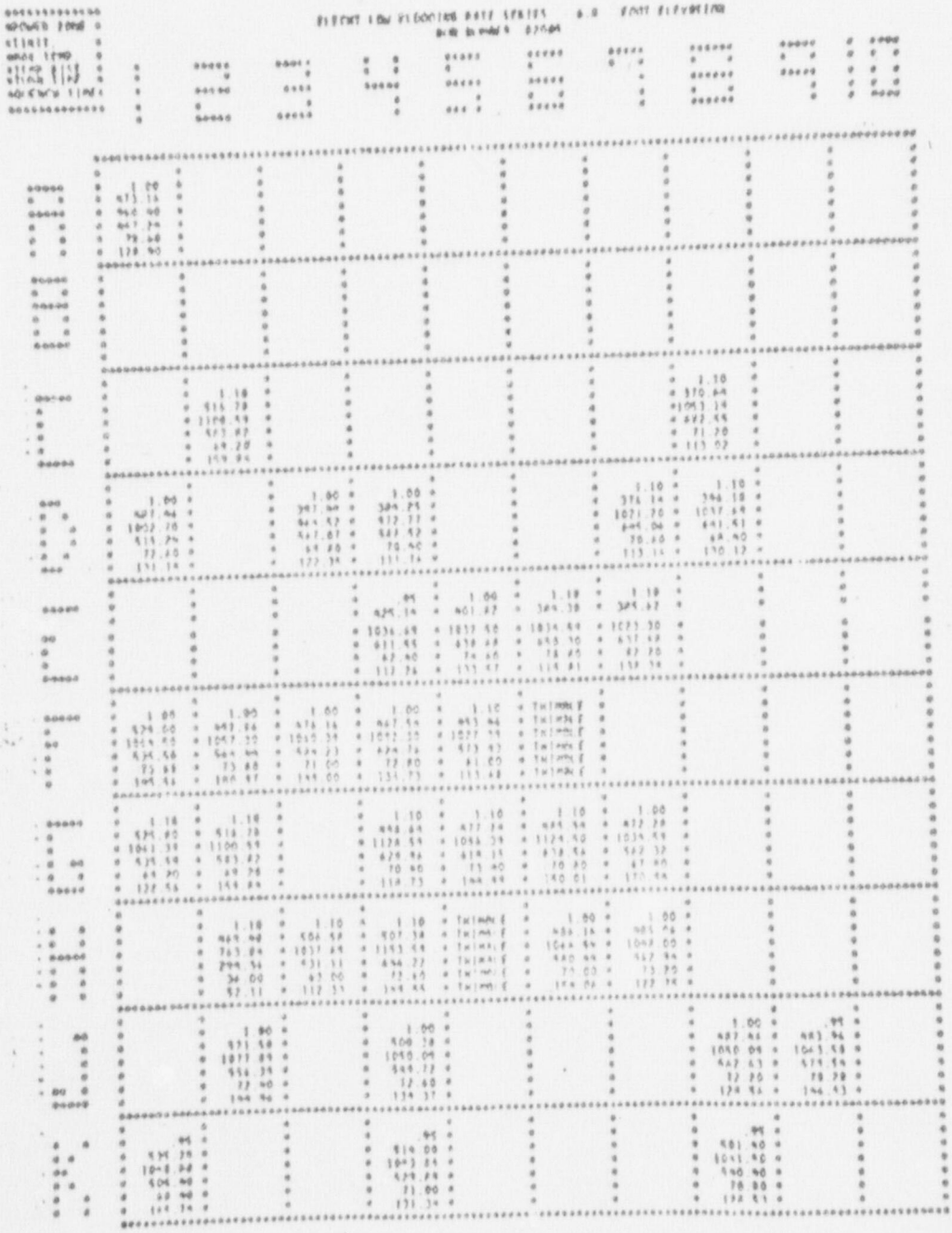
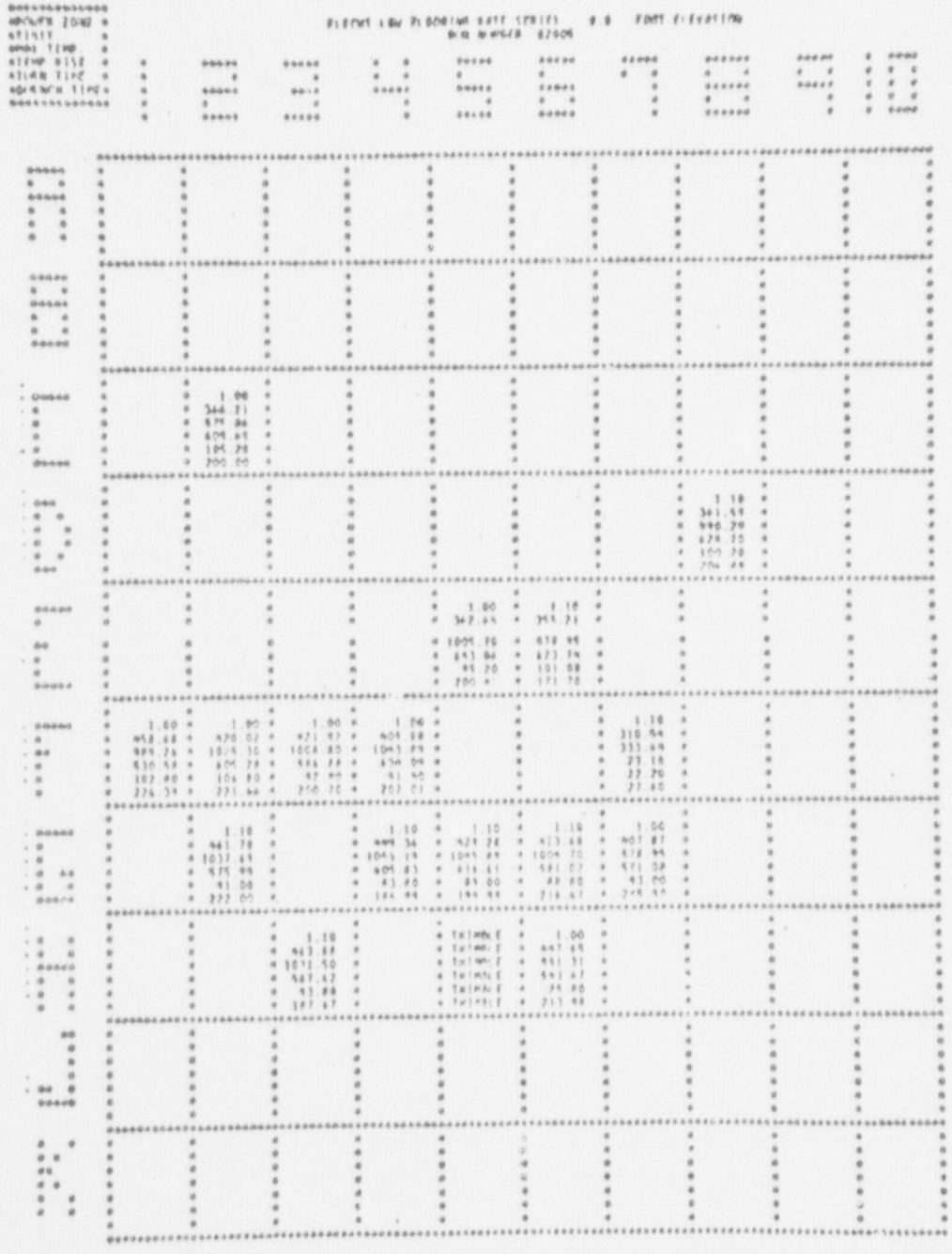


FLECHT

COSINE SERIES RUN 02005 81



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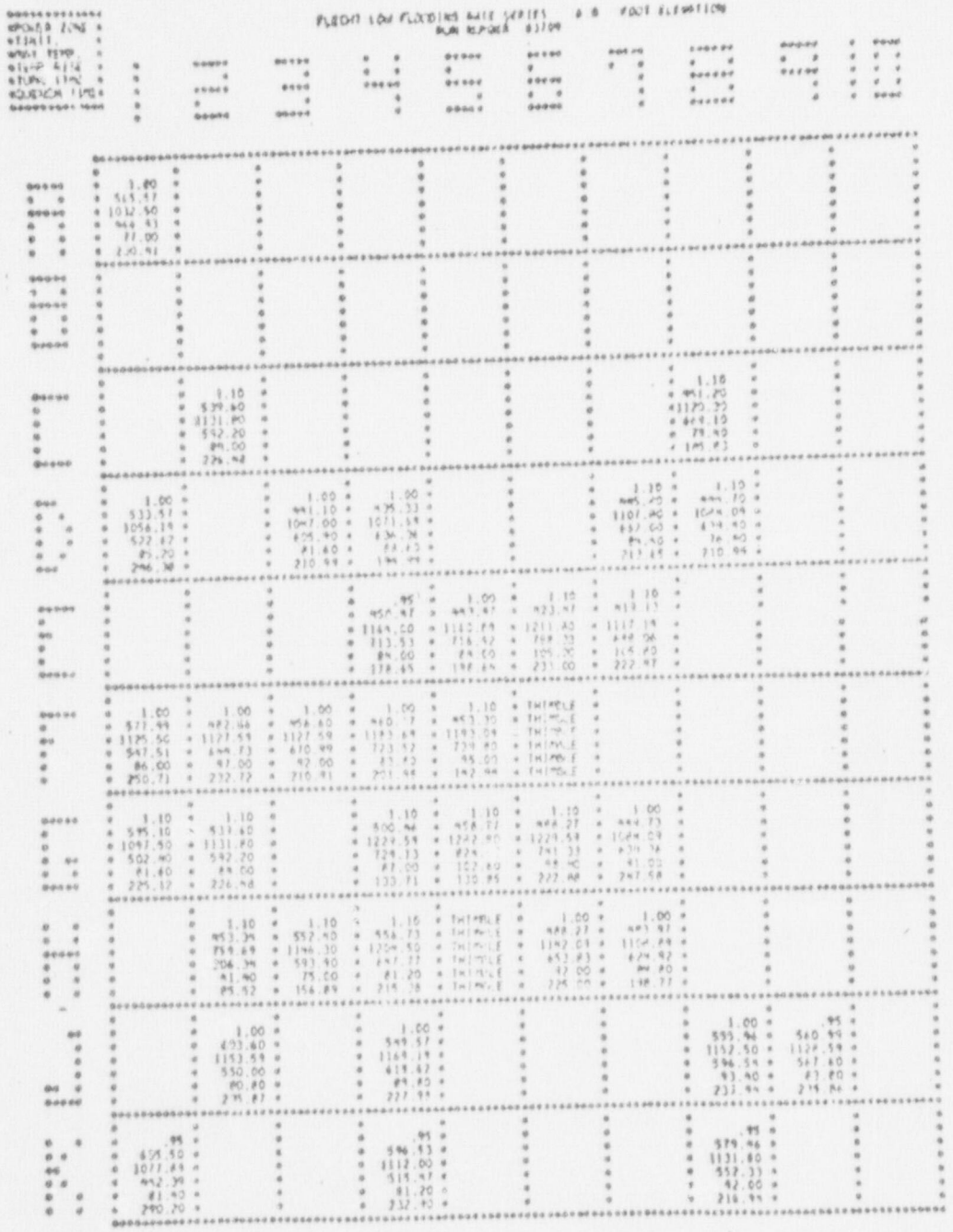

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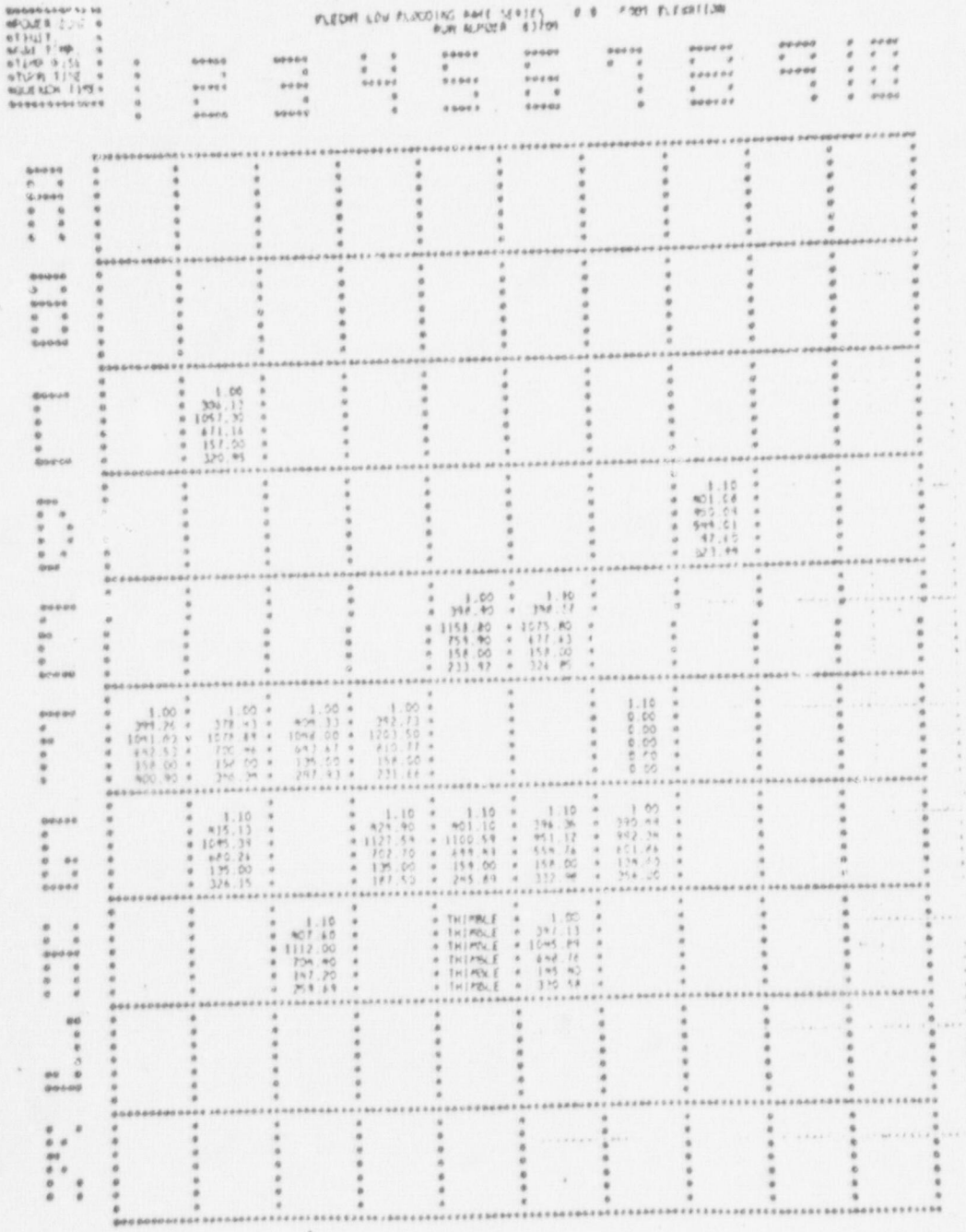

FLECHT

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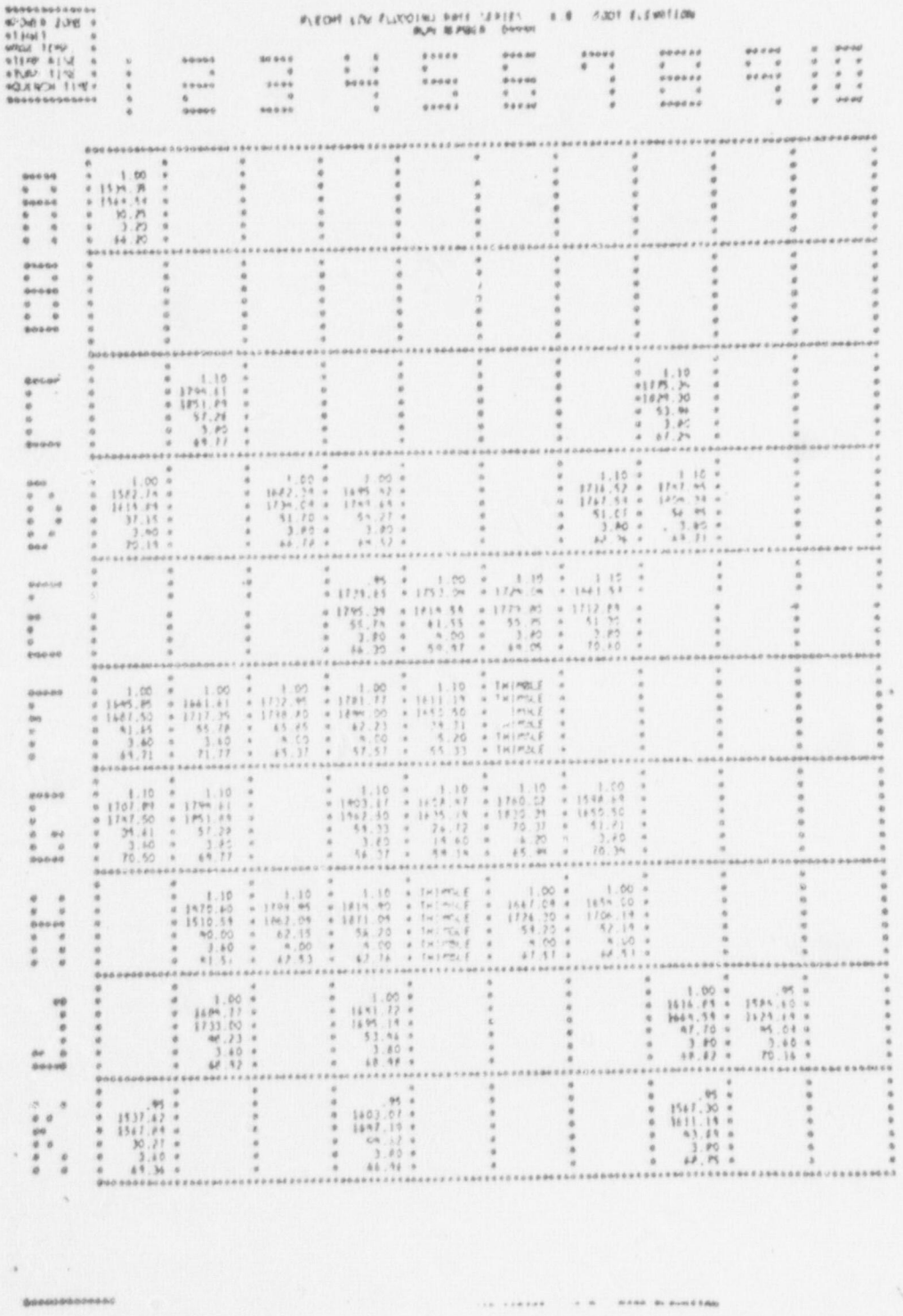

FLECHT

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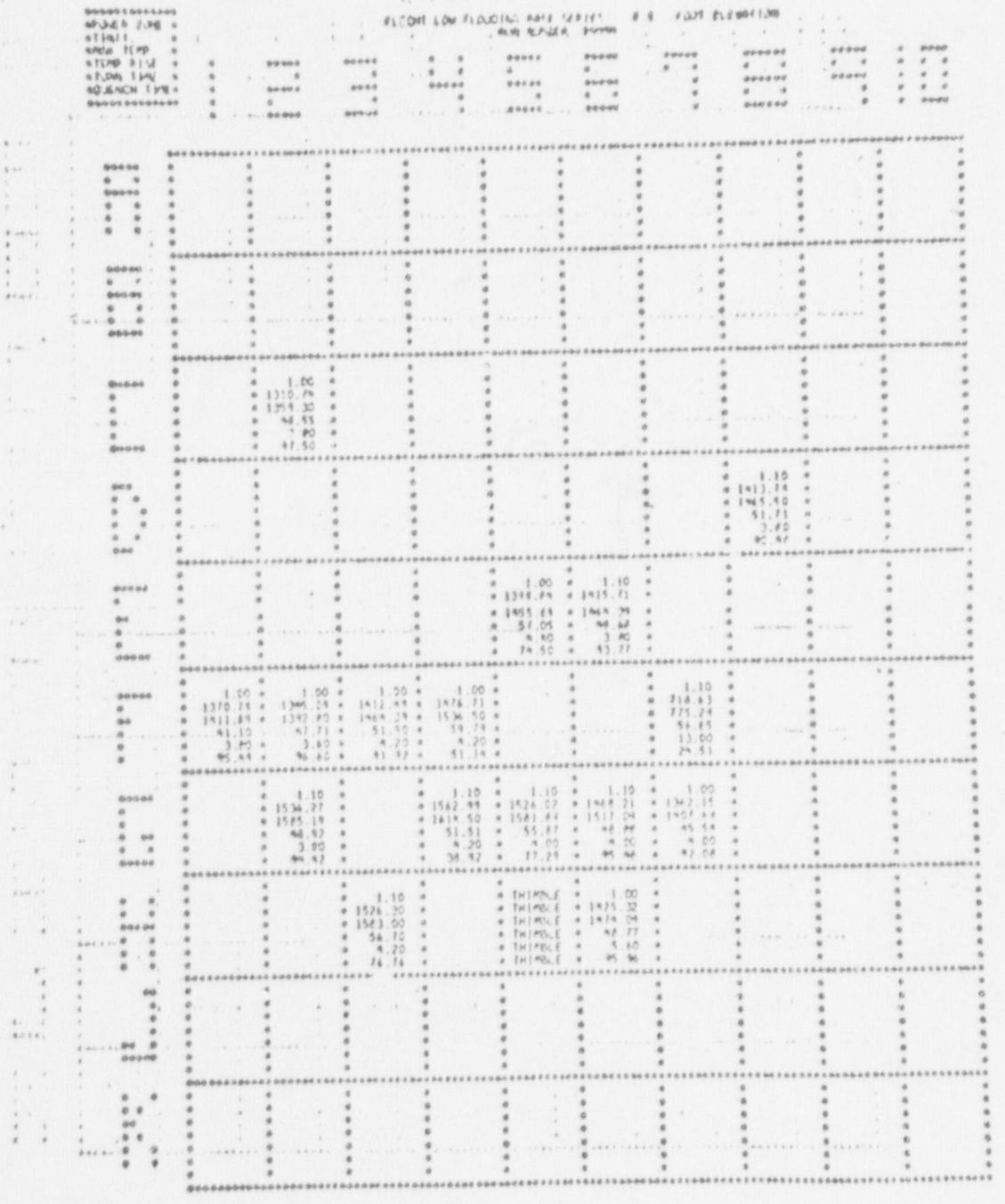
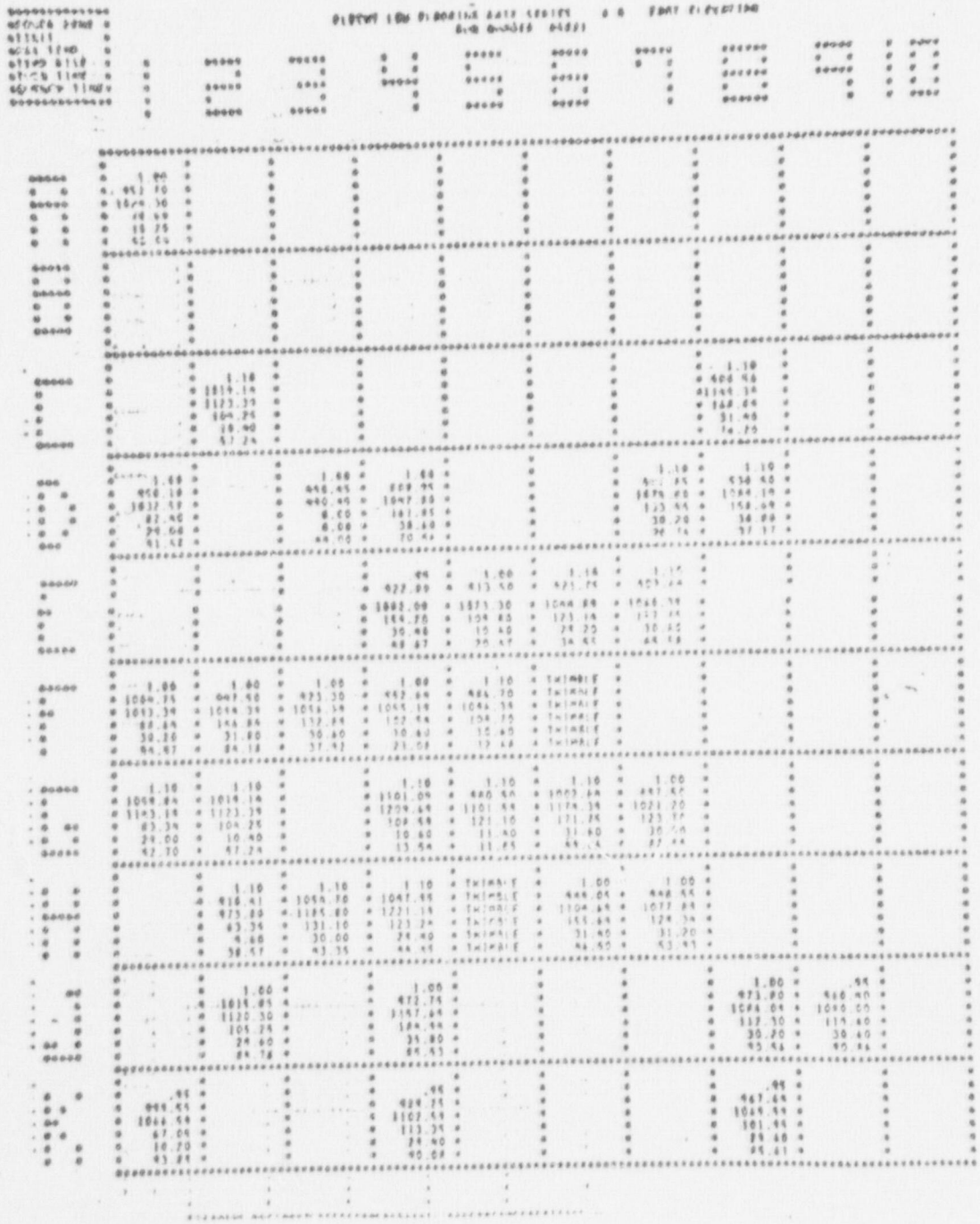


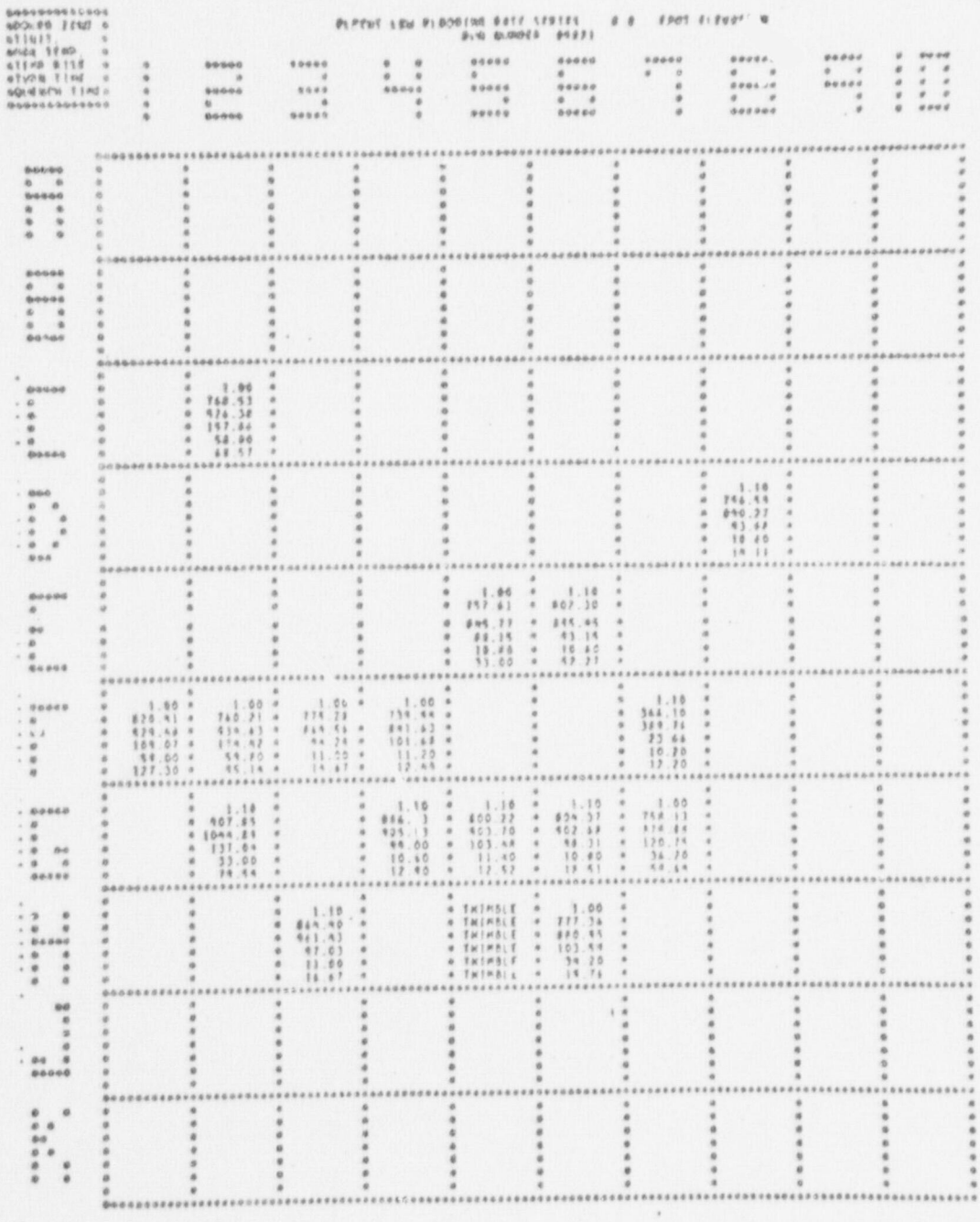
FLECHT

COSINE SERIES RUN 05821 0'



FLIGHT

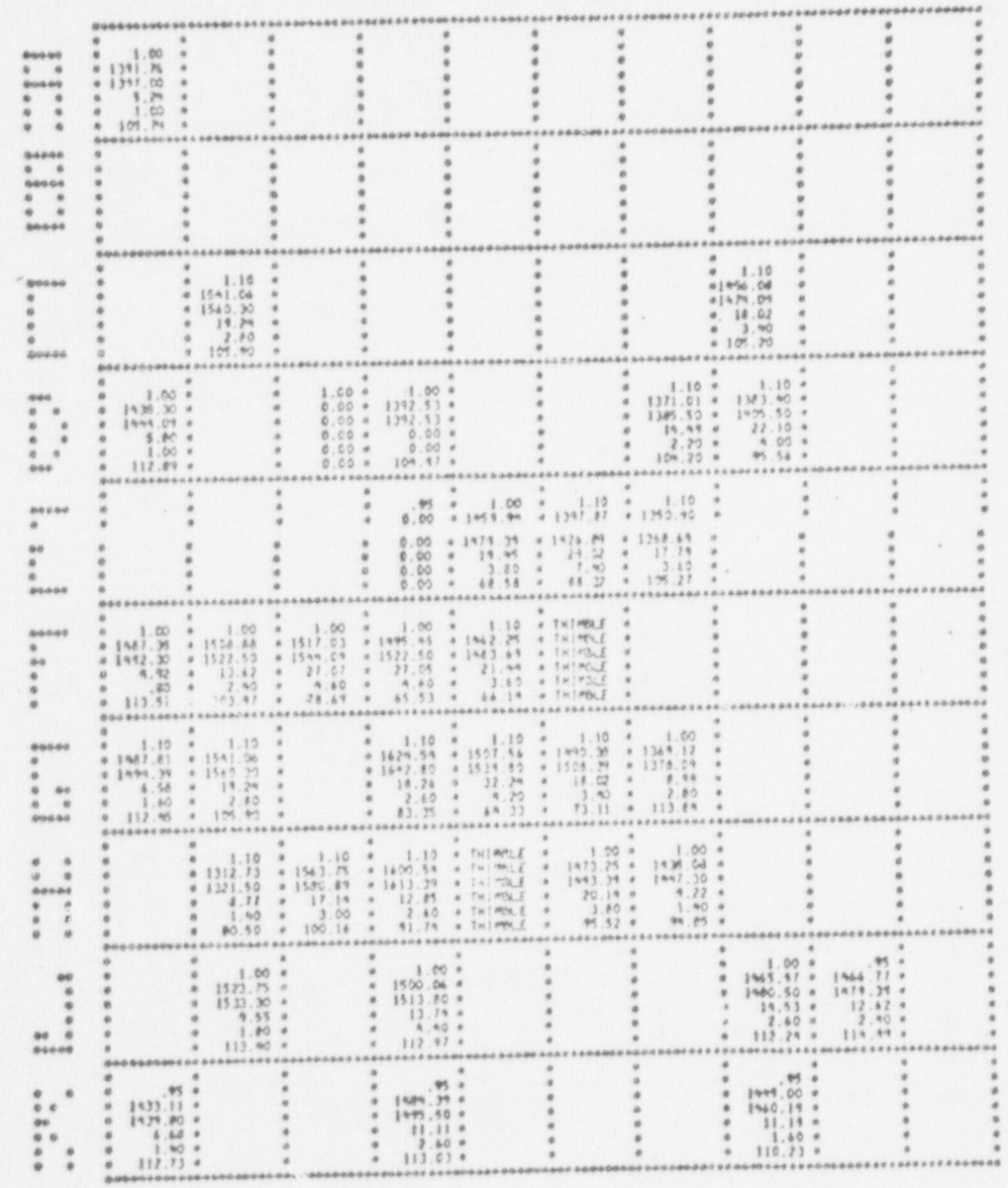
COSINE SERIES RUN 05821 3'



FLEIGHT

COSHIB SERIES RUN 06458 6'

FLEIGHT LOW FLOODING RATE SERIES 0.0 FOOT ELEVATION
RUN NUMBER 06458



FLECHT

COSINE SERIES RUN 06458 8'