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AUTH.NAME AUTHOR AFFILIATION
MALONEY,G.P. IN & MI PWR
RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. OFFICE OF NUCLEAR REACTOR REGULATION

SUBJECT: Forwards response to questions in 781107 ltr from A Schwencer re addl info on containment sumptest.Sump mod is tentatively sched for first & fourth refueling outage for Unit 2 & Unit 1,respectively.

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INDIANA & MICHIGAN POWER COMPANY

P. O. BOX 18
BOWLING GREEN STATION
NEW YORK, N. Y. 10004

December 29, 1978
AEP:NRC:00110

Donald C. Cook Nuclear Plant Unit 1 and 2
Docket Nos. 50-315 and 50-316
License DPR Nos. 58 and 74

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

Enclosed please find our response to the questions contained in the Attachment to Mr. A. Schwencer's letter dated November 7, 1978 regarding additional information on the containment sump test. Modifications to the sump, as recommended in the Alden Research Laboratory test report (submitted to the NRC via AEP:NRC:00112), are tentatively scheduled to be completed during the first and the fourth refueling outage for Unit 2 and Unit 1 respectively. Detailed schedule will be sent to you as it is finalized.

The attached information is being submitted at the request of the NRC staff and provides experimental and analytical verification of the adequacy of a previously reviewed and approved sump design. In light of the above, AEPSC interprets 10 CFR 170.22 as requiring that no fee accompany this submittal. (Reference: 10 CFR Part 170.22, footnote (2).)

Very truly yours,

G. P. Maloney
Vice President

GPM:em

Sworn and subscribed to before me
this 29th day of December, 1978 in
New York County, New York

Susan Gay Stoner
Notary Public

SUSAN GAY STONER
NOTARY PUBLIC, State of New York
No. 31-4577878
Qualified in New York County
Certificate filed in New York County
Commission Expires March 30, 1980

cc: (Attached)

A005
S 1/1

cc: R. C. Callen
P. W. Steketee
G. Charnoff
R. Walsh
R. W. Jurgensen
D. V. Shaller-Bridgman

ATTACHMENT TO

AEP:NRC:00110

RESPONSES TO NRC REQUEST FOR ADDITIONAL INFORMATION ON CONTAINMENT SUMP DESIGN AND TESTING

RESPONSE TO ITEMS 1, 5 AND 6 :

Alden Research Laboratory (ARL) has made several suggestions for design improvements of the containment sump. Based on their model tests, AEP is planning to implement the ARL Recommendations. Specifically,

a) Modification of the vent pipe design to insure that air will not be trapped in the sump.

b) Removal of the horizontal perforated plate located below the sump suction.

c) Installation of a vertical fine mesh screen behind the vertical grating at the sump inlet.

d) Provide holes in the sump roof for additional venting.

e) Extend the existing vent pipe beyond the maximum water elevation to avoid the water flow through the vent pipe.

All these modifications will be implemented in the plant during the first refueling outage of Unit 2 in the Fall of 1979 and the fourth refueling outage of Unit 1 in the Spring of 1980.

RESPONSE TO ITEM 2:

Model tests will be conducted to insure the sump design is not susceptible to air entrainment due to liquid effluent from the ice condenser drains and to the pipe breaks striking the water surface in the containment. Once the tests are complete they will be submitted to the NRC.

RESPONSE TO ITEM 3:

Model tests will be conducted to demonstrate that pipe breaks in the vicinity of the sump will not create flow conditions which adversely affect the sump performance. The results of the tests will be submitted to the NRC.

RESPONSE TO ITEM 4:

Attached is an analysis based on preoperational data and model tests which demonstrate that adequate NPSH margin is available under runout conditions for the containment spray and residual heat removal pumps.

RESPONSE TO NRC QUESTION NO. 4.

OBJECT

Demonstrate that adequate NPSH margin is available under runout conditions for the Containment Spray (CTS) pumps and the Residual Heat Removal (RHR) pumps. Entrance losses based on model tests and pipe friction losses based on preoperational tests will be utilized.

BASIS

1. Active Containment Sump water temperature - 190°F (Section 5.3.8, page 5.3-25, Unit 1 Appendix N of the D.C. Cook Plant FSAR and Response to Question 212.29, Unit 2, Appendix Q of the D.C. Cook Plant FSAR).

2. Containment Pressure - 13.2 psia (Lowest allowable in D.C. Cook Technical Specifications Section 3.6.1.4 page 3/4 6-6).

3. Active Containment Sump water level - Elevation 602'-10" based on the water inventory from the RWST during the injection phase from "min" level to "lo" level. When credit is taken for the water inventory to the "lo-lo" level in the RWST, the active containment sump level would rise to elevation 606'-2". A further increase in level would occur if ice meltdown was included.

4. Preoperational Test Suction Pressure Data (2PO-050-537A).

5. Sump Model Data (Alden Research Laboratory Report).

REFERENCES

1) Crane Technical Paper No. 410, "Flow of Fluids Through Valves, Fittings and Pipes".

2) ASME Steam Tables, 1967 Edition.

3) Hydraulics Institute Standards (pgs 57, 58, 88, 89, 90, 91).

4) "Hydraulic Model Investigation of Vortexing and Swirl Within a Reactor Containment Recirculation Sump", Alden Research Laboratory.

5) Appendix N and Q of the D.C. Cook Plant FSAR.

METHOD OF CALCULATION

The Containment Spray pump flow was varied up to runout with the Residual Heat Removal pump constantly at its runout condition. Data was taken at various points and is presented along with calculated values in the tables on pages seven and eight. Curves were constructed based upon these tables and graphically show the relationship between $NPSH_a$ and $NPSH_r$.

A similar method was used to generate data for the Residual Heat Removal pump. Data is presented on pages nine and ten.

SUBJECT CONTAINMENT SUMP - NPSH MARGIN.

METHOD OF CALCULATION

SYMBOLS

- A — PIPE CROSS SECTIONAL AREA ($FT.^2$)
- C_L — LOSS COEFFICIENT FROM WATER SURFACE IN THE CONTAINMENT TO THE OUTLET OF THE SUMP
- H_A — CONTAINMENT PRESSURE (FT. H_2O)
- H_{VPA} — VAPOR PRESSURE OF THE LIQUID (FT. H_2O)
- H_S — STATIC HEAD ABOVE PUMP CENTERLINE (FT. H_2O)
- H_{VH} — VELOCITY HEAD AT PUMP INLET (FT. H_2O)
- H_L — FRICTION LOSSES (FT. H_2O)
- P — PUMP SUCTION PRESSURE (FT. H_2O)
- P_{SAT} — SATURATION PRESSURE (FT. H_2O)
- V — FLUID VELOCITY (FT/SEC)
- v_{SAT} — SPECIFIC VOLUME ($FT.^3/lb_m$)

1) $NPSH_A$

$$NPSH_A = H_{A_{ACCIDENT}} + H_{VH} \pm H_{S_{ACCIDENT}} - H_{VPA_{ACCIDENT}} - H_L$$

2) $H_L = H_{S_{TEST}} - P +$ SUMP LOSSES

3) $H_{VH} = \frac{V^2}{2g}$

4) SUMP LOSSES $= C_L \frac{V^2}{2g}$

FROM THE ALDEN RESEARCH LABORATORY REPORT (PG. 26): $C_L = .27$

5) $H_{S_{TEST}}$ = TEST SUMP LEVEL - PUMP CENTERLINE ELEVATION

$H_{S_{ACCIDENT}}$ = ACCIDENT SUMP LEVEL - PUMP CENTERLINE ELEVATION

CTS PUMP CENTERLINE ELEVATION = 574'-6"
RHR PUMP CENTERLINE ELEVATION = 575'-0"

SUBJECT CONTAINMENT SUMP - NPSH MARGIN

6) H_{VPA} = 22.29 FT H_2O AT 190°F

7) H_A = 14.7 PSI − 1.5 PSI = 13.2 PSI = 31.5 FT. H_2O

8) CORRECTION OF CTS DATA:

THE MAXIMUM RHR FLOW OBTAINABLE DURING THE TEST WAS 3837 gpm for the "WEST" RHR pump AND 3751 gpm FOR THE "EAST" RHR pump. CORRECTIONS MUST THERFORE BE MADE SINCE THE DATA FOR THE CTS NPSHA SHOULD REFLECT THE RHR FLOW OF 5050 gpm WHICH WOULD OCCURE DURING RUNOUT.

THE EXCESS FLOW WILL INCREASE THE FRICTION LOSSES AND INCREASE THE VELOCITY HEAD. IT WAS ASSUMED THAT THE FRICTION LOSSES WERE DIVIDED BETWEEN THE COMMON PIPE AND THE INDIVIDUAL PIPE TO THE CTS PUMP IN THE SAME RATIO AS THE THEORETICAL CALCULATIONS PRESENTED IN THE D.C. Cook PLANT FSAR.

The AFFINITY LAW WAS USED TO MAKE THE CORRECTION IN THE FRICTION LOSSES.

AFFINITY LAW: $\frac{H_{L_1}}{H_{L_2}} = \frac{gpm_1^2}{gpm_2^2}$

THE NEW FRICTION LOSS VALUE WAS THEN USED IN THE $NPSH_A$ CALCULATION.

9) EXTRAPOLATION OF RHR DATA:

SINCE THE MAXIMUM OBTAINABLE RHR FLOW WAS considerably less THAN THE RUNOUT FLOW (see "8" above) A DATA POINT WAS NEEDED IN THE AREA OF RUNOUT FLOW. THIS POINT WAS OBTAINED USING THE SAME METHOD DESCRIBED ABOVE IN "8".

10) RUNOUT CONDITIONS:

CTS PUMP − 3600 gpm
RHR PUMP − 5050 gpm

THESE ARE CALCULATED VALUES BASED ON MANUFACTURERS CURVES AND THE ACTUAL PIPE LAYOUT.

SUBJECT CONTAINMENT SUMP - NPSH MARGIN

SAMPLE CALCULATION:

WEST CTS PUMP AT 1801 gpm WITH RHR pump at 5050 gpm

1) STATIC HEAD (TEST):

$$H_{S_{TEST}} = 599.42 - 574.5 = 24.92 \text{ FT. } H_2O$$

2) VELOCITY HEAD:

$$H_{VH} = \frac{V^2}{2g}$$

VOLUME FLOW = $1801 \text{ gpm} (.13368 \frac{ft^3}{gal} \times .0167 \frac{sec}{min}) = 4.01 \frac{ft^3}{sec}$.

PIPE AREA $A = .7773 \text{ FT.}^2$

$$V = 4.01/A = 5.16 \text{ FT/SEC}$$

$$H_{VH} = .41 \text{ FT. } H_2O$$

3) SUMP FRICTION LOSSES:

$$H_{L_{sump}} = C_L \frac{V^2}{2g} = .27(.41) = .11 \text{ FT. } H_2O$$

4) PIPE FRICTION LOSSES:

$$H_{L_{PIPE}} = 24.92 - 22.16 = 2.76 \text{ FT } H_2O$$

5) FRICTION LOSSES:

$$H_L = 2.76 + .11 = 2.87 \text{ FT. } H_2O$$

6) STATIC HEAD (ACCIDENT):

$$H_S = 602.83 - 574.5 = 28.33 \text{ FT. } H_2O$$

7) CORRECTED FRICTION LOSS:

FROM FSAR: LOSS IN COMMON PIPE = 4.25 FT H_2O

LOSS IN PIPE TO CTS PUMP = 5.27 FT. H_2O

RATIO = $\frac{5.27}{9.52} = .55$

LOSS IN COMMON PIPE = $.55 \times 2.87 = 1.59$ FT H_2O

CORRECTION: $H_2 = [(1801 + 5050)^2/(1801 + 3837)^2] \times 1.59 = 2.35$ FT. H_2O

SUBJECT CONTAINMENT SUMP- NPSH MARGIN.

TOTAL FRICTION LOSS = $2.35 + (2.87 - 1.59) = 3.63$ FT. H_2O

8) $NPSH_A$:

$$NPSH_A = 31.5 + .41 + 28.33 - 22.29 - 3.63 = 34.32 \text{ FT. } H_2O$$

CONCLUSION:

IN ALL CASES THE $NPSH_A$ EXCEEDS THE $NPSH_R$. AS IS SHOWN ON THE TABLES AND GRAPHS ON THE FOLLOWING PAGES.

FORM GE-8

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
2 BROADWAY
NEW YORK

SHEET 7 OF 10
DATE _____ BY EB CK _____
COMPANY _____ G.O. _____
PLANT _____

SUBJECT EAST CTS PUMP WITH RHR PUMP

DATA POINT	SUMP ELEVATION (TEST)	STATIC HEAD (TEST)	SUCTION PRESSURE	VELOCITY HEAD	FRICTION LOSSES	SUMP ELEVATION (ACCIDENT)	STATIC HEAD (ACCIDENT)
	FT.	FT. H_2O	FT. H_2O	FT. H_2O	FT. H_2O	FT.	FT. H_2O
1	597.50	23.00	18.00	.47	5.13	602.83	28.33
2	597.58	23.08	17.00	.73	6.19	602.83	28.33
3	597.58	23.08	16.50	1.16	6.89	602.83	28.33
4	597.83	23.33	16.00	1.33	7.69	602.83	28.33
5	597.92	23.42	13.50	1.68	10.37	602.83	28.33

DATA POINT	CONTAINMENT PRESSURE	VAPOR PRESSURE	CORRECTED FRICTION LOSSES	FLOW	$NPSH_A$	$NPSH_R$	EXCESS NPSH
	FT H_2O	FT. H_2O	FT. H_2O.	GPM	FT. H_2O	FT. H_2O	FT H_2O
1	31.50	22.29	6.62	1910	31.39	5.5	25.89
2	31.50	22.29	7.84	2385	30.43	6.5	23.93
3	31.50	22.29	8.54	3009	30.16	8.3	21.86
4	31.50	22.29	9.47	3228	29.40	8.9	20.50
5	31.50	22.29	12.63	3627	26.59	10.0	16.59

FORM GE-8

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
2 BROADWAY
NEW YORK

SHEET 8 OF 10
DATE _____ BY EB CK _____
COMPANY _____ G.O. _____
PLANT _____

SUBJECT WEST CTS PUMP WITH RHR PUMP

DATA POINT	SUMP ELEVATION (TEST)	STATIC HEAD (TEST)	SUCTION PRESSURE	VELOCITY HEAD	FRICTION LOSSES	SUMP ELEVATION (ACCIDENT)	STATIC HEAD (ACCIDENT)
	FT.	FT H_2O	FT. H_2O	FT. H_2O	FT H_2O	FT.	FT. H_2O
1	599.42	24.92	22.16	.41	2.87	602.83	28.33
2	599.42	24.92	21.50	.78	3.63	602.83	28.33
3	599.50	25.00	20.16	1.33	5.12	602.83	28.33
4	599.50	25.00	18.67	1.78	6.73	602.83	28.33
5							

DATA POINT	CONTAINMENT PRESSURE	VAPOR PRESSURE	CORRECTED FRICTION LOSSES	FLOW	$NPSH_A$	$NPSH_R$	EXCESS NPSH
	FT. H_2O	FT. H_2O	FT. H_2O	GPM	FT. H_2O	FT. H_2O	FT. H_2O
1	31.50	22.29	3.63	1801	34.32	5.2	29.12
2	31.50	22.29	4.47	2473	33.85	6.8	27.05
3	31.50	22.29	6.13	3228	32.74	9.0	23.74
4	31.50	22.29	8.01	3741	31.31	10.6	20.71
5							

FORM GE-8.

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
2 BROADWAY
NEW YORK

SHEET 9 OF 10
DATE _____ BY EB CK _____
COMPANY _____ G.O. _____
PLANT _____

SUBJECT West RHR Pump with CTS pump

DATA POINT	SUMP ELEVATION (TEST)	STATIC HEAD (TEST)	SUCTION PRESSURE	VELOCITY HEAD	FRICTION LOSSES	SUMP ELEVATION (ACCIDENT)	STATIC HEAD (ACCIDENT)
	FT.	FT. H_2O	FT. H_2O	FT. H_2O	FT. H_2O	FT.	FT. H_2O
1	599.58	24.58	21.83	.52	2.89	602.83	27.83
2	599.50	24.50	21.42	.77	3.29	602.83	27.83
3	599.50	24.50	20.67	1.06	4.12	602.83	27.83
4	599.50	24.50	19.50	1.29	5.35	602.83	27.83
5	—	—	—	2.23	—	602.83	27.83

DATA POINT	CONTAINMENT PRESSURE	VAPOR PRESSURE	CORRECTED FRICTION LOSSES	FLOW	NPSH$_A$	NPSH$_R$	EXCESS NPSH
	FT. H_2O	FT. H_2O	FT. H_2O	GPM	FT. H_2O	FT. H_2O	FT. H_2O
1	31.5	22.29	2.89	2427	34.67	9.0	25.67
2	31.5	22.29	3.29	2972	34.52	10.4	24.12
3	31.5	22.29	4.12	3479	33.98	12.5	21.48
4	31.5	22.29	5.35	3837	32.98	14.4	18.58
5	31.5	22.29	7.94	5050	31.33	25.0	6.83

FORM GE-8

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
2 BROADWAY
NEW YORK

SHEET 10 OF 10
DATE _____ BY EB CK _____
COMPANY _____ G.O. _____
PLANT _____

SUBJECT EAST RHR PUMP WITH CTS PUMP

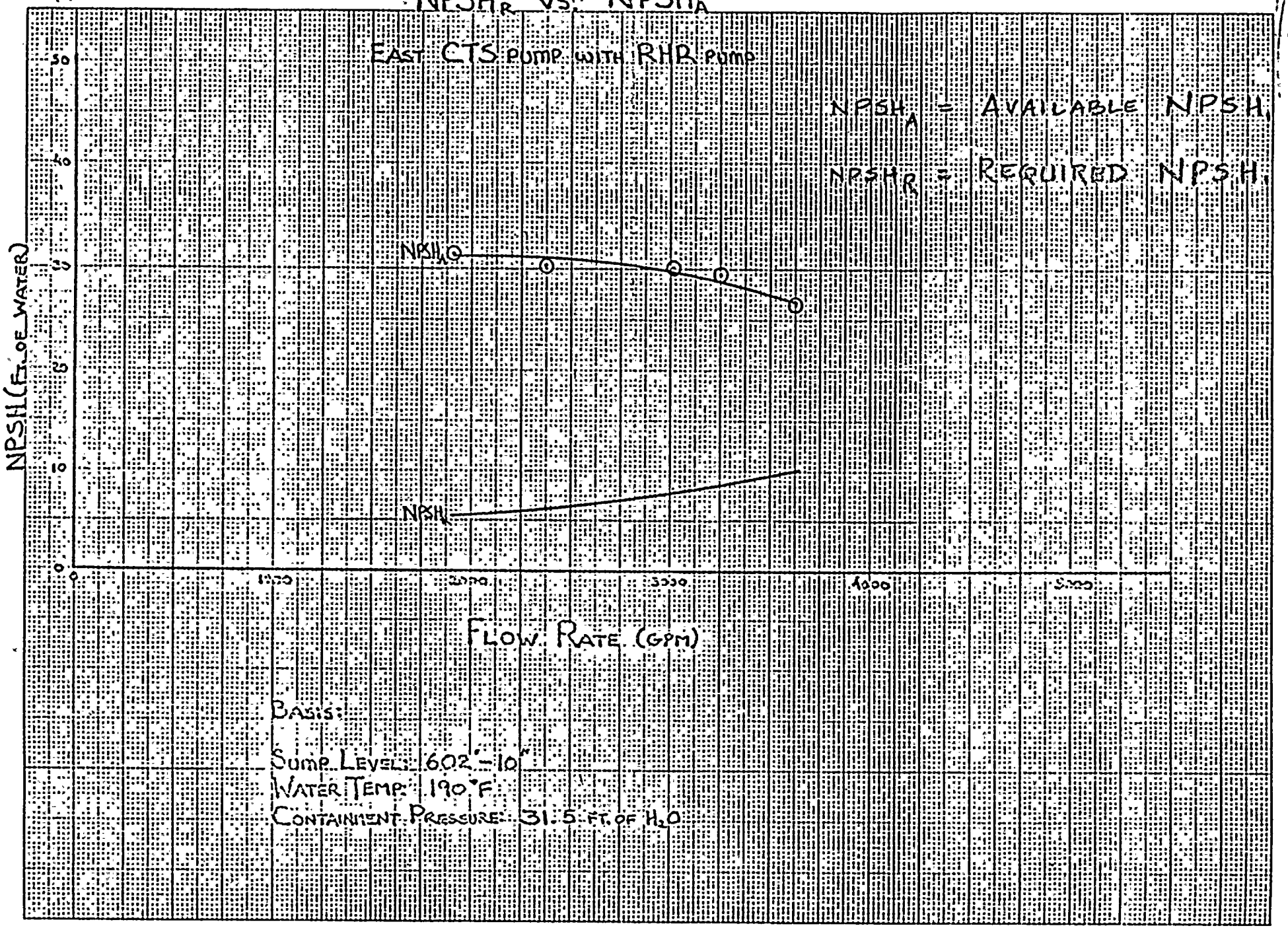
DATA POINT	SUMP ELEVATION (TEST)	STATIC HEAD (TEST)	SUCTION PRESSURE	VELOCITY HEAD	FRICTION LOSSES	SUMP ELEVATION (ACCIDENT)	STATIC HEAD (ACCIDENT)
	FT.	FT. H_2O	FT. H_2O	FT. H_2O	FT. H_2O	FT.	FT. H_2O
1	597.50	22.50	20.50	.34	2.09	602.83	27.83
2	597.83	22.83	20.17	.77	2.87	602.83	27.83
3	597.83	22.83	20.00	1.06	3.12	602.83	27.83
4	597.50	22.50	19.83	1.23	3.00	602.83	27.83
5	—	—	—	2.23	—	602.83	27.83

DATA POINT	CONTAINMENT PRESSURE	VAPOR PRESSURE	CORRECTED FRICTION LOSSES	FLOW	NPSH$_A$	NPSH$_R$	EXCESS NPSH
	FT. H_2O	FT. H_2O	FT. H_2O	GPM	FT. H_2O	FT. H_2O	FT. H_2O
1	31.50	22.29	2.09	1981	35.29	8.0	27.29
2	31.50	22.29	2.87	2972	34.94	10.4	24.54
3	31.50	22.29	3.12	3479	34.98	12.5	22.48
4	31.50	22.29	3.00	3751	35.27	13.7	21.57
5	31.50	22.29	5.29	5050	39.98	25.0	8.98

D. C. Cook Plant

$NPSH_R$ vs. $NPSH_A$

East CTS pump with RHR pump



$NPSH_A$ = Available NPSH

$NPSH_R$ = Required NPSH

Basis:

Sump Level: 602'-10"

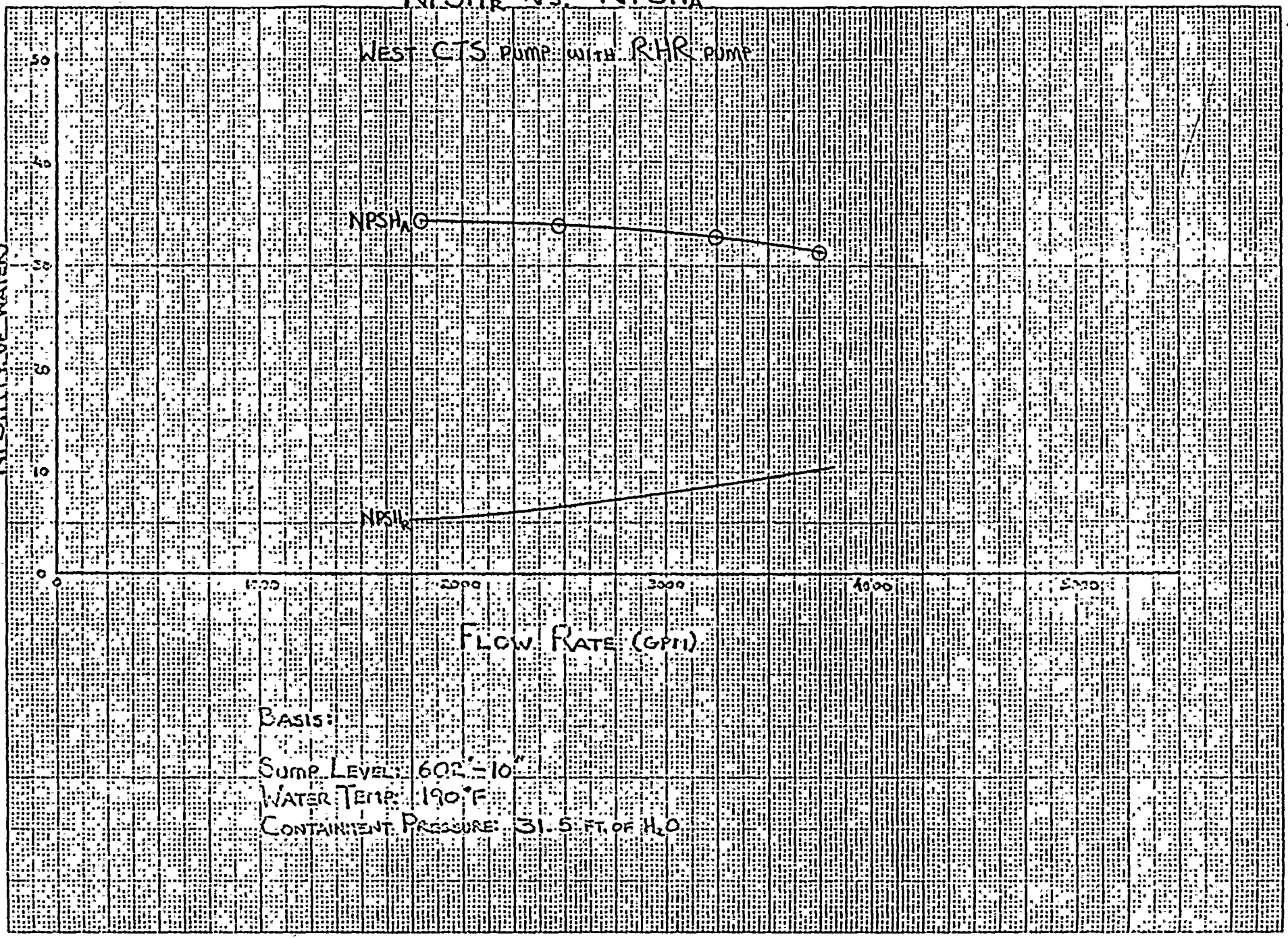
Water Temp: 190°F

Containment Pressure: 31.5 ft. of H_2O

EB 12/26/79

D. C. Cook Plant

$NPSH_R$ vs. $NPSH_A$



BASIS:

SUMP LEVEL: 602'-10"

WATER TEMP: 190°F

CONTAINMENT PRESSURE: 31.5 FT. OF H_2O

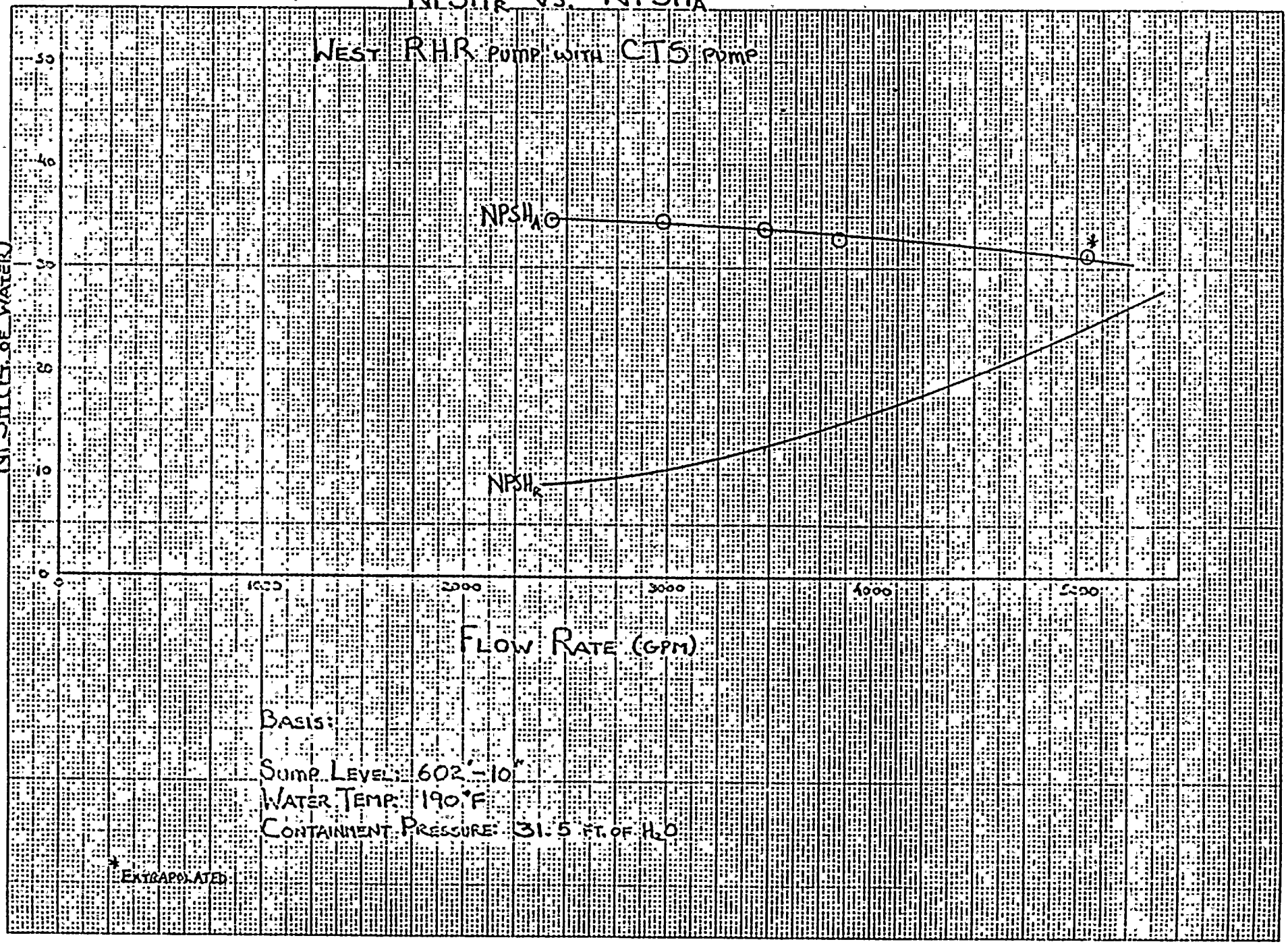
EB 12/24/19

MILLIMETER MADE IN U.S.A.

D. C. Cook Plant

$NPSH_R$ vs. $NPSH_A$

West RHR pump with CTS pump



Basis:

Sump Level: 602'-10"

Water Temp: 190°F

Containment Pressure: 31.5 ft. of H_2O

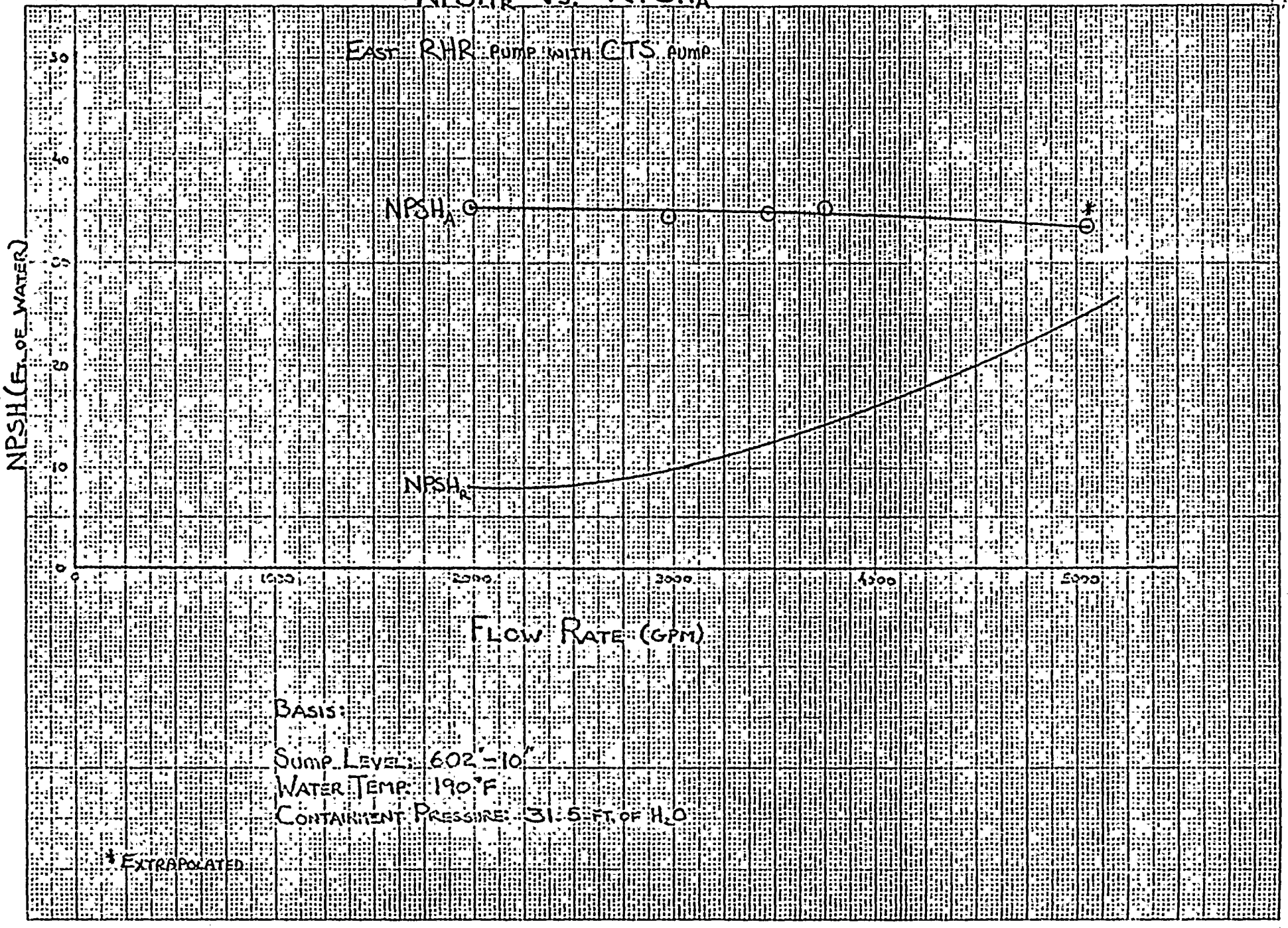
* Extrapolated

EB 12/26/79

D. C. COOK PLANT

NPSH$_R$ VS. NPSH$_A$

EAST RHR PUMP WITH C.T.S. PUMP



BASIS:

SUMP LEVEL: 602'-10"

WATER TEMP: 190°F

CONTAINMENT PRESSURE: 31.5 FT. OF H_2O

* EXTRAPOLATED

EB 12/26/78