ENCLOSURE 1

SONGS 1

HYDRAULIC CALCULATION FOR

AFW LINES

FLOW REQUIREMENTS

(For ICCNs Only)
DCP/MMP NO. 1-3587.01SM REV. A

Southern California Edison Company **INTERIM CALCULATION CHANGE NOTICE (ICCN)/ CALCULATION CHANGE NOTICE (CCN)**	ICCN NO./PRELIMINARY CCN NO.		CCN CONVERSION : CCN NO. CCN- C-1		CALC. REV. 5
	CALCULATION NO. DC-2836		REV. 4	UNIT 1	Q-CLASS SR
	CALCULATION TITLE : SONGS-1 HYDRAULIC CALC. FOR AFW LINES - FLOW REQUIREMENTS				
	ORIGINATOR Sharok Khabir		SYS. NO./STAT. SYS. DESIGNATOR AFW		
	PAX 51319	DATE 8-6-90	PAGE C-1 OF		

1.

REVISE CALC. DC-2836 TO INCLUDE ADDITIONAL SUPPLEMENT C. (ATTACHED.)

INITIATING DOCUMENT (NCR, SPR, OTHER)

2. OTHER AFFECTED DOCUMENTS (CHECK AS APPLICABLE):

☐ YES ☒ NO OTHER AFFECTED DOCUMENTS EXIST AND ARE IDENTIFIED ON ATTACHED183/184 FORMS.
THE APPLICABLE SOURCE DOCUMENT IS IDENTIFIED AS FOLLOWS:
☒ THIS CCN OR ☐ THE FOLLOWING DOCUMENT:

3. SCE DESIGN APPROVALS :

NUCLEAR GENERATION SITE DEPARTMENT		NES&L DEPARTMENT	
ORIGINATOR	DATE	ORIGINATOR [signature]	DATE 8/30/90
INDEPENDENT REVIEW ENGR.	DATE	INDEPENDENT REVIEW ENGR. [signature]	DATE 8/31/90
GROUP SUPERVISING ENGINEER	DATE	GROUP SUPERVISOR [signature]	DATE 9/7/90
DISCIPLINE MANAGER	DATE	DISCIPLINE MANAGER	DATE

4.

CONVERSION TO CCN DATE

SCE CDM-SONGS

SCE 26-122-1 NEW 3/90

CALCULATION TITLE PAGE

Sheet C1-1A

SONGS Unit 1 DCP/MMP No. & Rev. 1-3587.01SM Calc. No. DC-2836

Subject AFW FLOW REQUIREMENT VERIFICATION

Engineering System Number ____ Primary Station System Designator AFW Q-Class SR

Tech Spec Effecting [X] YES [ ] NO Section No. 3.4.3 Equipment Tag No. ____

Computer Program	STANDARD COMPUTER PROGRAM	PROGRAM NO.(S)	VERSION/RELEASE NO.
	[ ] YES [X] NO		

RECORD OF ISSUES

SCE DISC. or ESC	REV.	DESCRIPTION	TOTAL NO. of SHEETS	LAST SHEET NO.	ORIG.	IRE	GS	DM	DATE
MECH.	0	AFW Flow VERIFICATION-Suppl. 'C'	65	C1-65	SK	[illegible] 29AUG90	[illegible] 9/29	[illegible] 9/7/90	9/7/90

Space for RPE Stamp, reference alternate calc., and notes as applicable.

This calc. was prepared for the identified DCP/MMP. DCP completion and turnover acceptance to be verified by receipt of a memorandum directing DCN Conversion. Upon receipt, this calc. represents the as-built condition. Memo date ____ by ____.

SCE 26-121-1 REV 3/90

CALCULATION CROSS-INDEX

Subject Calculation No. DC-2836 Suppl. 'C'

Subject Calculation Revision No.	Superseded By Calc. No.	INPUTS These interfacing calculations and /or documents provide input to the subject calculation, and if revised may require revision of the subject calculation. Calc/ Document No.	Rev. No.	OUTPUTS Results and conclusions of the subject calculation are used in these interfacing calculations and/or documents. Calc/ Document No.	Rev. No.	Does the output interface calc/document require revision? YES / NO	Identify output interface calc/document CCN or DCN TCN/Rev.	Group Supervisor or Station Technical Group Supervising Engineer Signature/Date
0	N/A	DC-3414	0	IMPELLCALC. TH 1 DATED 4/22/85	1	YES	N/A	[signature]
		DC-2836 Suppl. A	5	SONGS-1 HYDRAULIC CALC. Suppl. A	–	NO	N/A	[signature]
	N/A	LETTER TO NRC ATWS MITIGATION SYSTEM DATED JULY 23, 1990	—	N/A	—	N/A	N/A	[signature]

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REV. INDICATOR

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REV. INDICATOR

1.0 PURPOSE

The purpose of this calculation is to determine if the auxiliary feedwater system can meet additional flow requirements that were not specified in the previous revision of this calculation.

Supplement "B" was performed to determine if the AFW system can meet the requirements for the following cases:

- Feedwater line Break Upstream of check valve
- Feedwater line Break Downstream of check valve
- Station Blackout
- Loss of Main Feedwater
- Pump Runout
- Water Hammer

This Supplement "C" covers the following additional conditions extracted from Ref.13:

- Small Break LOCA
- Steam Generator Tube Rupture
- Normal Plant Cooldown
- Steamline Break - Core Response
- Steamline Break - Containment Response
- Steamline Break - EQ Outside Containment
- ATWS
- Turbine Trip, Loss of Load, Loss of Condenser Vacuum
- Appendix 'R'

For completeness Supplement 'C' includes the results of supplement 'B' and the margins between the required and expected flows. For specific cases of supplement "B", which are superceded by this calc, the changes are identified in the results section. In addition, this supplement incorporates actual test results (preliminary issue) from the Permutit field tests to provide general agreement with expected field results. In addition, this calculation will form the basis for the test guidelines.

2.0 RESULTS/CONCLUSIONS AND RECOMMENDATIONS

2.1 The venturies will meet the AFW flow requirements specified in section 4.0 of this supplement.

Table 2.1 compares expected venturi flow rates with the AFW system flow requirements. It also compares the expected design values to the system design requirements. The difference expressed as margin is based on the use of 5532 and 5531 venturies for each design condition identified in Section 4.0 of this calculation.

2.2 The following events were previously evaluated in the calc. DC-2836 Supplement B and used in this Supplement to define the bounding conditions:

- Case 4.1 - Loss of Normal Feed (Supplement 'B' Case No. 3)
- Case 4.2 - Main Feedwater Line Break Upstream (Supplement 'B' Case No. 5)
- Case 4.3 - Main Feedwater Line Break Downstream (Supplement 'B' Case No. 2)
- Case 4.8 - Station Blackout (Supplement 'B' Case No. 4)
- Case 4.12 - Waterhammer (Supplement 'B' Case No. 1)
- Case 4.13 - Pump Run Out (Supplement 'B' Case No. 6)

2.3 Supplement "B" cases 4.1, 4.2, 4.3, 4.8 are re-evaluated due to the conservative results. Actual data available from the new venturi testing was incorporated.

2.4 Cases presented in this calculation identify bounding cases only. All other pumps and system configurations produce less limiting results and therefore, do not control the design.

2.5 Case 4.11- Appendix "R"

G10W pump curve intersects the most restrictive 5532 cavitation curve at 880 psig & 353 gpm. Since the venturies are cavitating, the flow rates through them cannot exceed 353 gpm. The margin associated with this flow rate is < 1%. This value is conservative because the calculated pressure drops are greater than the actual test data, thus, additional flow is expected during testing.

In addition, opening the bypass around the 4" venturi provides more flow margin. There is ample time during the event to open the bypass valve to allow more flow to the steam generators. G10W pump curve without 4" venturi is plotted on Fig. 7 and it intersects 5532 cavitating venturi curve at 363 gpm & 1010 psig. Additional margin is available if the bypass around the 3" venturies are also opened (opening the bypass valves has the potential to expose the system to water hammer and pump run out conditions). This action will require a revision to the operating proceedures.

This flow rate increases the margin from < 1% to 3.7%.

2.6 Case 4.7c Steamline Break Outside Containment.

Pump G10S provides the least flow rate of 315 gpm for this event and is considered the most limiting case with the margin of 12% . The margin is based on a preliminary Westinghouse analysis which determines that the Steamline Break concerns are satisfied with reduced AFW flow rate.

The results of all the cases are identified in Table 2.1.

TABLE 2.1

AFW REQUIREMENTS,EXPECTED FLOWS AND MARGINS

Design Condition		Required Flows (GPM)	Expected Flows (GPM)	Margin	Bounding Case	Remarks
4.1 Loss of Normal Feed		>185	G10W=255	37%	this Suppl. 'C'	To 3 S/GS @ 1015 psig
4.2 MFW Line Break Upstream of Check Valve		>100	G10W=140	40%	this Suppl. 'C'	To 2 S/GS @ 1015 psig
4.3 MFW Line Break Down-Stream of Check Valve		>175	G10S=210	20%	Case 2 Suppl. 'B' G10S Cavitate	To 2 S/GS @ 15 psia
4.4 Small Break LOCA		>185	G10W=255	37%	Bound by Case 4.1 Supplement 'C'	To 3 S/GS @1015 psig
4.5 S/G Tube Rupture	a)	>120	G10W=312	160%	this suppl.'C'	To 2 S/GS @ 250-750 psia.G10S cavitate @ @319 gpm & 730 psig
	b)	>120	G10S=242	101%	Ditto	Ditto
4.6 Normal Plant Cooldown	a)	>185	G10W=295	59%	Case 4.6 this calc. Suppl. 'C'	To 3 S/GS @ 125-923 psia
	b)	>185	G10S=319	72%		G10S controls @ < 500 psig
4.7 Steamline Break Outside Containment	a)	>150	G10W=255	70%	Case 4.1 above	To 3 S/GS @ 1015 psig
	b)	>280	G10W=352	26%	this suppl.'C'	To S/GS @ 700 psia
	c)	>280	G10S=319	14%	this supll.'C'	To 3 S/GS @ 15-700 psia, G10S controls* @ < 500 psig
	d)	>215	G10+G10S=393	82%	Ditto	To 3 S/GS @ 875 psia cavitate
	e)	>215	G10W=310	44%	Ditto	To 3 S/GS @ 875 psia

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TABLE 2.1

AFW REQUIREMENTS, EXPECTED FLOWS AND MARGINS

Design Condition	Required Flows (GPM)	Expected Flows (GPM)	Margin	Bounding Case	Remarks
4.8 Station Blackout	>185	G10=300	62%	Case 8.6 above	To 3 S/GS @ 923 psia
	>185	G10W=295	59%	Case 8.6 above	To 3 S/GS @ 923 psia
4.9 ATWS	>185	G10W=255	37%	Case 8.1 above	To 3 S/GS @ 1015 psig
4.10 Turbine Trip Loss of Load, Loss of condenser vacuum	>185	a) G10W=295	59%	Case 4.6 above Suppl. 'C'	To 3 S/GS @ 125-923 psia. Both pumps cavitate as press. decreases.
		b) G10S=319	72%	Case 4.6 above	G10S controls @ < 500 psig
4.11 Appendix 'R'	>185	G10W=295	59%	This suppl. C	To 3 S/GS @ 923 psia
a) 4" venturi bypass closed	>350	G10W=353	<1%	This suppl. 'C'	To 3 S/Gs @ 15 psia
b) 4" venturi bypass open	>350	G10W=363	3.7%	Case 4.11 above	To 3 S/GS @ 15 psia
c) 3" venturi bypass also open	>350	G10W=450	28%	this suppl. 'C'	To 3 S/Gs @ 15 psia
4.12 Water Hammer	<450	G10+G10S +G10W=397	-	This Suppl. 'C'	To 3 S/GS @ 15-1030 cavitate @less than 450 gpm
4.13 Pump Runout	<420	G10S=319	-	Case 6 Suppl. 'B'	To 3 S/GS @ 15-1030 psia. Cavitate @ less than 420 gpm
4.14 Steamline Break Core Response	<1419	G10W=352	-	Case 3 Suppl. 'B'	To 3 S/GS @ 15 psia cavitate @ less than 420 gpm

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TABLE 2.1

AFW REQUIREMENTS,EXPECTED FLOWS AND MARGINS

Design Condition	Required Flows (GPM)	Expected Flows (GPM)	Margin	Bounding Case	Remarks
4.15 Steamline Break Inside Containment	<500	G10W=352	-	Case 3 Suppl. 'B'	To 3 S/GS @ 15 psia cavitate @ less than 500 gpm

*Shown as point in time when G10 not available, however, above S/G pressure at 500 psig G10 is available.
Note: Where pressure ranges are shown the highest pressure was used to establish flow & margins.

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REV. INDICATOR

3.0 ASSUMPTIONS

1. Auxiliary Feedwater temperature is 70°F.

2. Venturi recovery factors will be the same as those reported during the calibration testing of the new AFW venturi.

3. Line losses and flow coefficients for the three venturies are assumed equal for stating that the flows through each branch are the same.

4. Flow requirements identified in this Supplement are in addition to the cases identified as limiting in the DC-2836 Supplement B.

5. Flow around cavitating venturies is assumed zero. The bypass around the 3″ venturies will be closed. For the Appendix 'R' Case 4.11b the bypass around the 4″ venturi will be opened when needed.

6. The pumps system pressure curves at inlet to venturies are based on the original manufacture curves, which are assumed correct.

7. Pressure drop in suction piping is negligible.

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REV. INDICATOR

4.0 DESIGN INPUTS

Venturies are sized to meet the following parameters:

4.1 Loss of Normal Feed
AFW Flow >185 GPM to 3 S/Gs @1030 psia.
Bound by Case No. 3 Ref. 1

4.2 Main Feedline Break- Upstream of check valve
AFW Flow >100 GPM to 2 S/GS @ 1030 psia.
Bound by Case No. 5 Ref. 1

4.3 Main Feedline Break- Downstream of check valve
AFW Flow >175 GPM to 2 S/G @ 15 psia.
Bound by Case No. 2 Ref. 1

4.4 Small Break LOCA
AFW Flow >185 GPM to 3 S/GS @ 1030 psia (Ref. 6)

4.5 Steam Generator Tube Rupture
AFW >120 GPM to 2 S/GS @ 250-750 psia (Ref. 7)

4.6 Normal Plant Cooldown
AFW Flow >185 GPM to 3 S/GS @ 125-923 psia
(Ref. UFSAR 9.2 and 6.5)

4.7 Steam Line Break Outside Containment (Ref. 9)
G10W Flow >165 GPM to 3 S/GS @ 1030 psia
G10W Flow >280 GPM to 3 S/GS @ 700 psia
G10W Flow >280 GPM to 2 S/GS @ 15 - 700 psia
G10W Flow >215 GPM to 3 S/GS @ 875 psia

4.8 Station Blackout
G10W Flow >185 GPM to 3 S/GS @ 923 psia (Ref. 8)
G10 Flow >185 GPM to 3 S/GS @ 923 psia (Ref. 8)
Bound by Case No. 4 Ref. 1

4.9 ATWS
AFW FLow >185 GPM to 3 S/G @ 1030 psia (Ref. 12)

4.10 Turbine Trip, Loss of Load, Loss of Condenser Vacuum
G10W Flow >185 GPM to 3 S/GS @ 125-923 psia
Bound by Case No. 4 Ref. 1

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4.11 Appendix 'R'
AFW Flow >185 GPM to 3 S/GS @ 923 psia Bound by Case No. 3 Ref. 1
AFW Flow> 350 GPM to 3 S/GS @ 15 psia (Ref. 11)

4.12 Water Hammer (Ref. UFSAR 8.5)
AFW Flow <450 GPM (total) to 3 S/GS @ 15-1030 psia
Bound by Case No. 1 Ref. 1

4.13 Pump Runout
GIOS Flow <420 GPM to 3 S/GS @ 15-1030 psia
Bound by Case No. 6 Ref. 1

4.14 Steamline Break - Core Response (Ref. 11)
AFW Flow <1419 GPM to 3 S/GS @ 15 psia
Bound by Case No. 3 Ref. 1

4.15 Steamline Break Inside Containment
AFW Flow <500 GPM to 3 S/GS @ 15 psia
Bound by Case No. 1 Ref. 1

AFW pump system curves (based on manufacturers curves and field test) and permutit venturi curves have been used to determine the margins available above the system design requirements. (Ref. 1, 2 and 6).

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0	SK	8/28/93	[illegible]	29AUG93					

REV. INDICATOR

5.0 METHODOLOGY

Calculate AFW flow rates for each of the design conditions, Section 4.0, for the new venturies by using the following steps.

5.1 Identify AFW conditions covered by the calculation DC-2836 Supplement B.

5.2 Identify AFW conditions bound by the existing analyses. This is accomplished by a comparison between the additional AFW flow requirements and those AFW flows in the Supplement B at the same steam generator pressures.

5.3 The remaining conditions are analyzed per the following steps:

5.3.1 Plot pumps G10S and G10W curves using Ref. 2

5.3.2 Plot cavitating venturi curves using Wyle test results (attachment B)

5.3.3 Calculate system coefficient (K_{sys}) from Ref. 1 & 2.per the following steps:

5.3.3.1 Calculate the highest line losses from the pump through the discharge control valve to the steam generator venturi. (line losses from the pump to the first branch to other FCV's are based on the longest pipe run and full flow)

5.3.3.2 Calculate pressure drop across pump discharge valve and flow control valve using full flow through pump discharge valve and third through FCV.(branch piping downstream of the pump discharge valve to the FCV's are assumed to have the same pressure drop to the steam generators)

5.3.4 Calculate total system pressure drop using the equation $\Delta P = Ppsig + K_{sys}.*Q^2 + Elev.$ Difference for various flows (Q values are chosen from pump curves to plot ΔP).

5.3.5 Plot new system curves using ΔP above.

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5.3.6 Determine flow rates from intersections of the system curves with either the bounding pump curve or the cavitating venturi curve.

5.3.7 Determine the lowest flow from step 5.3.7 above. Calculate the AFW flow margins by comparing calculated and required flows for a venturi 5531 or 5532.(Wyle numbers)

5.3.9 Enter AFW flow rates and margins in Table 2-1.

5.3.10 Based on engineering judgement, determine if the margin is acceptable for this system.

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6.0 REFERENCES

1. Calculation DC-2836 Supplement 'B' dated 5/9/90.
2. Calculation DC-2836 Supplement 'A' dated 3/22/90.
3. Westinghouse Feedline break reanalysis with reduced auxiliary feed flow dated 5/9/90 (SCE-90-578).
4. UFSAR chapters 6, 15 and 16 are used to identify additional AFW flow requirements.
5. Impell calc. TH1 "Dedicated Safe Shutdown System" Job No. 0310-007-1372. Dated 4/22/85.
6. SONGS 1 Small Break LOCA WCAP-9600, W NSSS Small Break Report 6/1979.
7. Letter to NRC Emergency Procedure Upgrade, May 20, 1982.
8. Station Blackout, SCE Doc. 90050 Rev. 1.
9. Steamline Break Outside Containment WCAP.11294.
10. Appendix 'R' Letter to NRC, Fire Protection Program, dated May 21, 1985.
11. Steamline Break Core Response UFSAR 6.2.
12. ATWS, Letter to NRC, ATWS Mitigation System, July 1990.
13. Design Calculation DC-3414 Rev. 0 "AFW Flow Requirements"
14. Preliminary Engineering Package 1-3587.01SM
15. DC-2836 Rev 5.
16. Crane Technical paper 410.

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REV. INDICATOR

7.0 NOMENCLATURE

GPM - Gallons Per Minute

K_{sys} - System Pressure Loss Coefficient

K_v - Pressure Loss Coefficient for Venturi (Non cavitating)

PD - Pump Discharge Pressure psig

$P_{S/G}$ - Static Pressure psig Steam Generator

S/G - Steam Generator

ΔP - Pressure Drop for System

Q - Flow (GPM)

$P_{discharge}$ - Pump discharge pressure (psig)

P_S - Pump suction pressure (psig)

P_L - Piping pressure loss (psi)

additional nomenclature is identified in the in the body of the calculation.

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8.0 COMPUTATIONS

The pump and system curves used in the previous revisions of this calculation are further corrected for the actual venturi test data from Wyle labs. The reference point of the pump and system curves is moved to the venturi inlet to provide direct reading of the cavitation curves.

To reference the pump curves at the venturi inlet, the pressure drops due to the elevation changes and line losses between the pump discharge and the venturi inlet have to be subtracted from the discharge pressure for the design flow rates.

A. Calculate the pressure drop ΔP due to elevation changes:

Pipe elevation at venturi	23.17 Ft @ FE 3066 (highest venturi)
Discharge pump elevation	16.83 Ft @ G10s (lowest pump)
	ΔH= 6.34 Ft (Maximum height)

Convert Δ H to psi, ΔP = 6.34 Ft * 0.4328 psi/Ft = 2.74 psi

B. Calculate line losses to the venturi

Compare calculated line losses to the field data from the cycle 10 return the service testing.

The field test data indicated a pressure drop of;

26 psi @ 325 gpm (from pump discharge to control valves)

C. Compare the above field data to calculate line losses by determining the line losses from control valves to venturies. Use the below simplified sketch for calculating ΔP from one pump to one of the venturies. The Pump G-10 flow path the Steam Generator B was selected because it has the highest resistance (The calc will be conservative for cases sensitive to lower pump curves).

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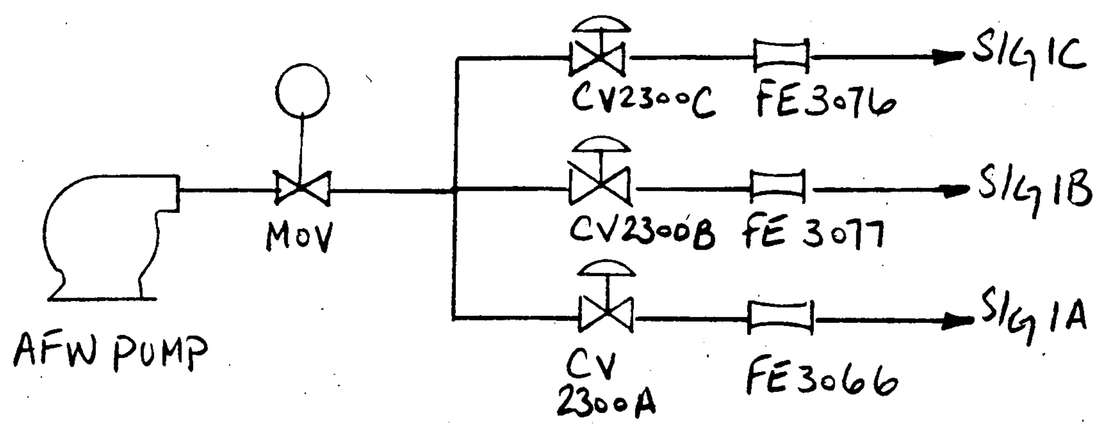
REV. INDICATOR

FIGURE 1

SYSTEM SCHEMATIC



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D. . Calculate ΔP from pump discharge to the control valve inlets at 325 gpm. 325 gpm was selected to provide a direct comparison with the test data.

Convert C_v values of the motor operated and control valves to K values:

$K_{control\ valve} = 891\ d^4/C_v^2$ (Ref. 16) Eq. 1
where C_v = 28.8 (Ref.15 page 11) and d= 3″

$K_{control\ valve} = 87$

$K_{MOV} = 8.72$, where C_v = 91 (Ref. 15 page 11)

E. . Convert line losses to K values:

K = f L/D (Ref.16) Eq. 2 , where f=0.018, D=0.25 Ft
L= 221 Ft, K= 16 and,
L= 327 Ft, K= 23.5

F. . Determine total K:

$K_{total} = K_{line} + K_{mov} = 16 + 8.72 = 24.72$

$K_{total} = K_{control\ valve} + K_{line\ to\ venturi} = 23.5 + 87 = 110.5$

G. . Calculate ΔP = pump to control valve inlet (K control valve not included based on Ref. 16).

$\Delta P = 0.00001799 * K * B * Q^2 / d^4$ Eq. 3

ΔP pump to branch:

Solve the above equation for the following;

B = 62.35 lb/ft^3 , Q = 325 gpm, d = 3″

$K_{total} = 24.72$

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ΔP = 36.15 psi

ΔP branch to Control Valve inlet:

B = 62.35 lb/ft^3 , Q = 108.33 gpm, d = 3"

K_{total} =23.5

ΔP = 3.8 psi

Therefore; the pressure drop from the pump discharge to the inlet to the venturies at 325 gpm is;

  36.15 psi
+ 3.8 psi

39.95 psi

H. Comparing the field data to the calculated values;

(39.95/25) = 59.8% difference

This difference indicates that the calculation will be conservative for the cases sensitive to lower pump curves. Cases that are not conservative will be identified and corrected for higher expected pressures. It can be expected that the test results will be 15 psi higher at the inlet to the control valve for this flow rate.

I. The ΔP for the control valve is calculated to determine the pressure venturi inlet.

ΔP = 14.14 from eq. 2

where B= 62.35 lb/ft^3 , Q= (325/3)=108 gpm, d=3", K=87

Therefore, line losses to the venturi inlet are;

ΔP= 39.95 + 14.14 = 54 psi @ 325 gpm.

J. Create a pressure loss table, 8-1, as a function of pump flow: Based on the above formula,

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REV. INDICATOR

Line Loss Table 8-1

Pump Flow (gpm)	ΔP pump to branch	ΔP branch to Venturi	Total Loss
50	0.86	0.42	1.3
100	3.4	1.7	5.1
150	7.7	3.82	11.5
200	13.7	6.8	20.5
250	21.4	10.6	32
300	30.8	15.3	46.1
350	41.9	20.82	62.7
400	54.8	27.82	82
450	69.3	34.4	103.7
500	85.6	42.5	128.1

Based on the above values in table 8-1 revise the pump curves to show the venturi as a function of pump flow.
The table is created by reducing the pressure at the pump discharge by the values in the table 8-1.

K. The revised system pressure curves at inlet to venturi are shown on:

Table 8-2 G10W
Table 8-3 G10S
Table 8-4 G10

G10 + G10S curves were generated graphically by adding the resultant pump curves of G10 and G10S.

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REV. INDICATOR

G10W system pressure curve at inlet to venturi: Table 8-2

System Flow (gpm)	Disch.Press. (psig)*	Line Loss to Venturi	Δelev pump to venturi	Pump press. @ venturi (psig)
0	1315	-	2.7	1312.3
50	1310	1.3	2.7	1306
100	1290	1.3	2.7	1286
150	1260	11.5	2.7	1246
200	1200	20.5	2.7	1177
250	1130	32	2.7	1095
300	1050	46.1	2.7	1001
350	590	62.7	2.7	885
400	830	82	2.7	745
450	705	103.7	2.7	599

* Discharge pressure were extracted from Fig.9 Page 57 of Reference 2.

G10S system pressure curve at inlet to venturi Table 8-3

System Flow (gpm)	Disch.Press. (psig)**	Line Loss to Venturi	Δelev pump to venturi	Pump press. @ venturi (psig)
0	1225	-	2.7	1222.3
50	1205	1.3	2.7	1201
100	1170	5.1	2.7	1162.2
150	1110	11.5	2.7	1095.8
200	1010	20.5	2.7	986.8
250	900	32	2.7	865.3
300	780	46.1	2.7	771.2
350	640	62.7	2.7	574.6
400	480	82	2.7	395.3

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REV. INDICATOR

** Discharge pressures were extracted from Fig.3 Page 51 of Reference 2.

G10 system pressure curve at inlet to venturi Table 8-4

System Flow (gpm)	Disch.Press. (psig)*	Line Loss to Venturi	Δelev pump to venturi	Pump press. @ venturi (psig)
0	1305	-	2.7	1302.3
50	1280	1.3	2.7	1276.4
100	1245	5.1	2.7	1237.2
150	1210	11.5	2.7	1195.8
200	1170	20.5	2.7	1146.8
250	1130	32	2.7	1095.3
300	1070	46.1	2.7	1021.2
350	1000	62.7	2.7	935
400	930	82	2.7	845.3

* Discharge pressure were extracted from Fig. 3 page 51 of Ref. 2.

G10 + G10S system pressure curve at inlet to venturi Table 8-5

System Flow (gpm)	Disch.Press. (psig)**	Line Loss to Venturi	Δelev pump to venturi	Pump press. @ venturi (psig)
200	1210	6.8	2.7	1200
300	1175	15.3	2.7	1152
400	1120	27.8	2.7	1089

** Discharge pressure were extracted from Fig. 3 page 51 of Ref. 2.

Line losses were based on 1/2 the flow through the branch and 1/3 through the Venturi piping.

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REV. INDICATOR

- Calculate the elevation change from 3″ venturi to the steam generators.

  The elevation of the steam generator = 41.37 Ft
  Elevation of the lowest venturi(FE 3076) = 21.67 Ft

  ΔH = 19.7 Ft

  Convert to psi = 19.7 ft * 0.4329 psi/ft = 8.53

M. • Determine the pressure drop from the venturi outlet to the steam generator:

  L = 174.5 Elev. to steam generator B

  convert L to K:

  K = f L/D , where f = 0.018 and D = 0.25 Ft

  K = 12.56

N. • Calculate ΔP for pump flow of 325 gpm from Eq.3:

  ΔP = 2.04 per single flow branch
  where B = 62.35 lb/ft^3, Q = 325/3 = 108 gpm, D = 3″

O. • Calculate the ΔP for the venturies.

  Refine the venturi test data and determine the K_v values for each venturi.

  $K_v = \Delta P/Q^2$

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REV. INDICATOR

From the test data (see attachment A):

Table 8-6

ΔP	Q_{test}	K_v	Venturi
86.9	106.8	7.62E-3	5530
55.6	84.2	7.84E-3	
32.2	61.4	8.54E-3	
27.3	55	9.03E-3	
		$\overline{K_{v,ave}}$=8.26E-3	
100.1	101.5	9.7E-3	5531
67.3	82.3	9.94E-3	
39.4	62.4	1.01E-2	
29.9	54.4	1.01E-2	
		$\overline{K_{v,ave}}$=9.96E-3	
73.6	105.1	6.67E-3	5532
47	84.7	6.55E-3	
29	62.9	7.33E-3	
21.5	54.5	7.24E-3	
		$\overline{K_{v,ave}}$=6.95E-3	

P. • Based on the above K_v values create a system loss table for the maximum and minimum loss from the venturi outlet to the steam generator.

Convert K_v to ΔP using $K_v = \Delta P/Q^2$ solving for ΔP;
$\Delta P = K_v * Q^2$

$\Delta P = \Delta P_{venturi} + \Delta P_{piping}$

$K_v = 9.96 * 10^{-3}$ (5531)

$K_v = 6.95 * 10^{-3}$ (5532)

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REV. INDICATOR

System Loss Table 8-7

Pump Flow rate(gpm)	Single Venturi Flow(gpm)	ΔP line Loss(psi)	Max.ΔP (psi)	Min.ΔP (psi)
50	16.6	0.043	2.7	1.9
100	33.3	0.19	11	7.72
150	50	0.43	24.75	17.37
200	66.6	0.77	44	30.88
250	83.7	1.2	68.75	48.26
300	100	1.7	99	69.5
350	116	2.4	134.75	94.59
400	133.33	3.1	176	123.5
450	150	3.9	222.7	156.37

8.1 Case 4.1. Loss of Normal Feed (@ S/G pressure of 1030 psia)

This case is identified in the calc. DC-2835 Supplement "B" as case number 3. (Ref. 1).

- Calculate the system losses as a function of flow.

Calculated ΔP for the system curves have to be adjusted for elevation changes from the venturies to steam generators.

Loss due to elevation = 8.5 psid

ΔP Max. and Min. venturi (Table 8-5)

$P = P_{S/G} + \Delta P + \text{Elev. Loss}$

$P = 1015.3 + 8.5 + \Delta P = 1023.8 + \Delta P$

Qcurve	System Curves Ppsig Max.	Min.	GlOW	Based on Figure 2 % Margin
150	1052	1044	252-265	39%
250	1097	1077		
350	1164	1123		
450	1254	1187		

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REV. INDICATOR

Ppsig = System pressure based on (Qcurve/3) per steam generator

Psig = Ps/g + ΔP + Elev. loss

% Margin = % calculated based on the ratio of the minimum flow rate requirements and the Qcalc.

PS/G = 1030 psia = 1015.3 psig

% margins of 36% is based on pump GlOW.

8.2 Case 4.2 Main Feedwater Line Break Upstream.

At the time of break flow out of the broken line increases until it reaches cavitation flow rate. By using attachment "A" cavitating K_v can be determined as follow:

$Q^2 = K_v * \Delta P$

ΔP= 1168.5 psid, Q= 136.3 gpm, K_v= 15.9

Using Ref. 1 method obtain the following:

$Q_T = 2 * Q_{unaffected\ S/G} + Q_{throughout\ the\ break}$

$Q_T = 2 * Q_1 + Q_2$

$Q_T = 2 * K_{1,2} * (P_D - P_{S/G} - \Delta P_{EL})^{1/2} + K_{CAVITATION} * (P_D + (14.7 - P_v)^{1/2}$

$K_{1,2} = 1/(K_{sys})^{1/2}$ =9.8, where $K_{sys} = K_v + K_{sys\ without\ venturi}$

$K_{1,2} = 1/(5.12E-4 + 9.96E-3)^{1/2}$ = 9.8 , K_{sys} = 5.12E-4

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REV. INDICATOR

Venturi	ΔP(psid)	Q(gpm)	$K_{cavitation}$
5530	1168.5	136.3	3.99
5531	1175.7	139.7	4.07
5532	1178.2	136.5	3.98

Use $K_{cavitation}$ =4

$K_{CAVITATION} = (K_v)^{1/2} = 4$, where $K_v = 15.9$

ΔP	2* Q_1	Q_2	Q_T
1200	259	139	398
1190	250	139	389
1180	243	138	381
1170	235	138	373
1160	227	137	364
1140	209	136	345
1100	168.5	133.5	302
1050	96.5	130.5	227
1026	0	129	129

- Plot above ΔP and Q_T.

This curve intersects with pump G10W at 270 gpm @ 1075 psig. Extending this point to the 5532 venturi curve at 390 gpm & 1075 psig. One third (out the break) of this value subtracted from 270 equals to 140 gpm (to 2 S/Gs). Therefore AFW flow to 2 S/Gs is 140 gpm with a margin of 40%.

8.3 Case 4.3 MFW Break Downstream

This case is identified in the calc. DC-2835 Supplement 'B' as Case No. 2 (Ref. 1).

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0	SK	8/28/90	[illegible]	29AUG90					

REV. INDICATOR

Venturi	ΔP(psid)	Q(gpm)	$K_{cavitation}$
5530	1168.5	136.3	3.99
5531	1175.7	139.7	4.07
5532	1178.2	136.5	3.98

Use $K_{cavitation}$ =4

$K_{CAVITATION} = (K_v)^{1/2} = 4$, where $K_v = 15.9$

ΔP	2* Q_1	Q_2	Q_T
1200	259	139	398
1190	250	139	389
1180	243	138	381
1170	235	138	373
1160	227	137	364
1140	209	136	345
1100	168.5	133.5	302
1050	96.5	130.5	227
1026	0	129	129

- Plot above ΔP and Q_T.

This curve intersects with pump G10W at 267 gpm.

G10+G10S cavitate at 393 gpm .

Margin for this case for G10W is 167%.

8.3 Case 4.3 MFW Break Downstream

This case is identified in the calc. DC-2835 Supplement 'B' as Case No. 2 (Ref. 1).

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REV. INDICATOR

By inspection of Fig.1, it is evident that pump G10S is the limiting pump at steam generator pressure of 15 psia. The maximum flow expected can be determined from the intersection of G10S reduced pump curve and the 5532 venturi cavitation curve. Total flow of 315 gpm or 210 gpm to 2 steam generators with a margin of 20%. Adding more pressure to the pump curve will allow more flow to pass through the break and less flow is available to the steam generators. However, this change is very small not calculated.

8.4 Case 4.4 Small Break LOCA

This case is in addition to the cases identified in the Supplement B of calc. DC-2836 (Ref. 1).

The AFW flow requirement for this case is bound by the case number 4.1 of this Supplement 'C' with AFW flow rate of 255 gpm with a margin of 37%.

8.5 Case 4.5 Steam Generator Tube Rupture

Afw flow is manually terminated to one steam generators because of a postulated failure.
For this case, the Max. K for one path to the steam generator is $K = 9.9E-3$.

Determine the system curve when 1/2 of the flow goes through the branch.

From the Table 8-7 create ΔP + line losses column based on the 1/2 of the pump flow.

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REV. INDICATOR

pump gpm	flow gpm	flow each psi	ΔP Max. psi	Δ line Total psi	S/G press.
100	80	24.75	0.43	25.2	768.7
200	100	99	1.7	100.7	844.2
300	150	222.7	3.9	226.6	970.1
400	200	396	6.8	402.8	1146.3

System curve is plotted based on the above data and it intersects G10W and G10S at 312 gpm and 255 gpm respectively. These correspond to 160% and 101% margins.

8.6 Case 4.6 Normal Plant Cooldown

This case is bound by the AFW flow rate assumed tin the LONF at an AFW flow rate of 185 GPM. Pump G10W expected flow is calculated below:

$P = P_{S/G} + \Delta P + \text{elev. loss} = 923-14.7 + 8.5 + \Delta P$

Ps/g = 923 psia

$P = 916.8 + \Delta P$ from Table 8-7

Qcurve	Ppsig Max.	Ppsig Min.	G10W	G10S*	Margins
150	945	938	305-295	319	59%-72%
250	990	970			
350	1058	1017			
450	1148	1080			

* G10S controls @ < 500 psig

Ppsig = System pressure based on (Qcurve/3) per steam generator

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REV. INDICATOR

Psig = Ps/g + K_{sys}*Q^2curve + Elev. loss

% Margin = % calculated based on the ratio between the minimum flow rate requirements and Qcalc.

PS/G = 923 psia = 908 psig

% margins of 72% & 59% are used for pumps G10S and G10W respectively.

8.7 Case 4.7 Steamline Break Outside Containment

- The AFW flow rate for this case at steam generator pressure of 1030 psia is bound by the existing LONF analysis (Case No. 4.1 of this Suppl. C) except AFW minimum flow is 150 gpm with expected G10W flow of 255 gpm with 70% margin).
- The minimum AFW flow rate for this case at steam generator pressure of 685 psig is 280 gpm per Ref. 14 Section 2. The pump G10W expected flow is as follow: (Ref. 1 Case 2)

DATA: P = Ps/g + ΔP + Elev. loss, P = 685 + ΔP, ΔP from Table 8-5
P = 693.5 + ΔP

	System Curve		From Figure 6		
Qcurve	Ppsig		G10W	G10S	Margin
	Max.	Min.		*	
150	718	710.8	352	319	72%-26%
250	762	742			
350	828	788			
450	916	850			

* G10S controls @ < 500 psig
G10 + G10S and G10W pumps cavitate @ this pressure range.

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REV. INDICATOR

Ppsig = System pressure based on (Qcurve/3) per steam generator

Psig = Ps/g + K_{sys} * Q^2curve + Elev. loss

% Margin = % calculated based on the difference between the minimum flow rate requirements and Qcalc.

PS/G = 700 psia = 685 psig

% margins of 72% & 26% are used for pumps G10S and G10W respectively.

- AFW flow >215 GPM to 3 S/GS @ 875 psia

P = $P_{S/G}$ + Elev. loss + ΔP, ΔP from Table 8-5

P = 875 - 14.7 + ΔP + 8.5

P = 868.6 + ΔP

Qcurve	Ppsig Max.	Ppsig Min.	G10W	G10 + G10S *	Margin
150	893	886	310-323	393	44%-82%
250	937	917			
350	1003	963			
450	1091	1025			

* Value is taken from G10 +G10S pump curve with the 5532 cavitating venturi curve.

Ppsig = System pressure based on (Qcurve/3) per steam generator

Psig = Ps/g + K_{sys} * Q^2curve + Elev. loss

% Margin = % calculated based on the difference between the minimum flow rate requirements and Qcalc.

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0	SK	8/29/90	[illegible]	24 AUG 90						

PS/G = 875 psia = 860 psig

% margins of 44% and 82% are used for pumps G10S + G10 and G10W respectively.

8.8 Case 4.8 Station Blackout

This case is similar to case 8.6, except that flows are adjusted for the steam generator pressure of 923 psia and determined by intersection of the new system curve with G10 pump curve. G10W flow rate is 295 gpm and G10 flow rate is 300 gpm with margins of 59% - 62% respectively.

8.9 Case 4.9 ATWS

This case is bound by the case 4.1 of this Supplement 'C'. The expected G10W flow rate is 255 with a 37% margin.

8.10 Case 4.10 - Turbine Trip, Loss of Load and Loss of Condenser Vacuum

This case is covered by case 4.6 in Section 8.6.

The G10W flow rate is 295 gpm with a margin of 59%. Pump G10S flow rate is 205 gpm with a 10% margin.

8.11 Case 4.11 Appendix 'R'

- Flow rate of >185 GPM to 3 S/Gs @ 923 psia is bound by Case 4.6 of this Supplement 'C'. The AFW flow rate expected from G10W is 295 gpm with a margin of 59%.

- Flow rate of >350 GPM to S/GS @ 15 psia.

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REV. INDICATOR

- Flow rate of >350 GPM to S/GS @ 15 psia.

Steam generators are used as once through heat exchangers in the Appendix 'R' analysis. For this scenario the required AFW is 350 GPM. (G10W powered from DSS diesel Ref. 5).

W new analysis requires a minimum of 350 GPM to achieve a cold shutdown at the steam generator pressures of 15 psia (Ref. 11).

G10W pump curve intersects the 5532 cavitation curve at the pump discharge pressure of 870 psig and flow rate of 367 gpm. The margin associated with this flow rate is < 1%.

With the AFW venturi bypass valves open this margin will be increased from < 1% to 8.6 %. (See Fig 7 for the intersection of the 5532 cavitating venturi and the G10W pump curve without venturi, @ AFW flow rate of 380 GPM)

8.12 Case 4.12 waterhammer (G10 + G10S + G10W) to 3 steam generators (G10W partial flow of <57 GPM).

This case is identified as a case number 1 in calc, DC-2836 Supplement 'B' (Ref. 1).

By definition (Ref. 1) AFW venturies were designed to deliver flows not to exceed 140 + 0/-5 GPM per steam generator. However, pumps G10 + G10S are expected to cavitate @ 402 gpm Max. which would be below 420 gpm Max.

8.13 Case 4.13 Pump Runout

This case is identified as a case number 6 in calc. DC-2836 Supplement 'B' Figure 2-1. (Ref. 1)

The expected AFW pump G10S cavitating flow rate is 315 GPM for the 5532 venturi and 321 gpm for the 5531 venturi.

8.14 & Cases 4.14 & 4.15 Steamline Break - Core Response and Steamline Break - Inside Containment.

NES&L DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE C1 OF 35
	CCN CONVERSION: CCN NO. CCN-- C-1

Project or DCP/MMP 1-3587.01SM Calc No. DC-2638 Suppl. C

Subject AFW FLOW VERIFICATION Sheet No.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	SIL	8/28/90	[illegible]	29 Aug 90					

REV. INDICATOR

The AFW flow requirements for steamline break core response are bound by those assumed in the feedline break events as discussed in the PEP 1-3587.01SM Safety Evaluation (Ref. 14).

Steamline break analysis assumes an AFW flow rate of 500 GPM initiated at time zero to maximize of secondary side inventory that is released. The AFW flow rate is then reduced at 10 minutes to 250 GPM by operator action. Therefore, a reduction in AFW flow rate due to resized venturies are bound by the LONF event. The 500 GPM limit is bound by the 450 GPM water hammer limit (Ref. 1).

PRESSURE AT VENTURI INLET AND CAVITATION LIMIT CURVES.

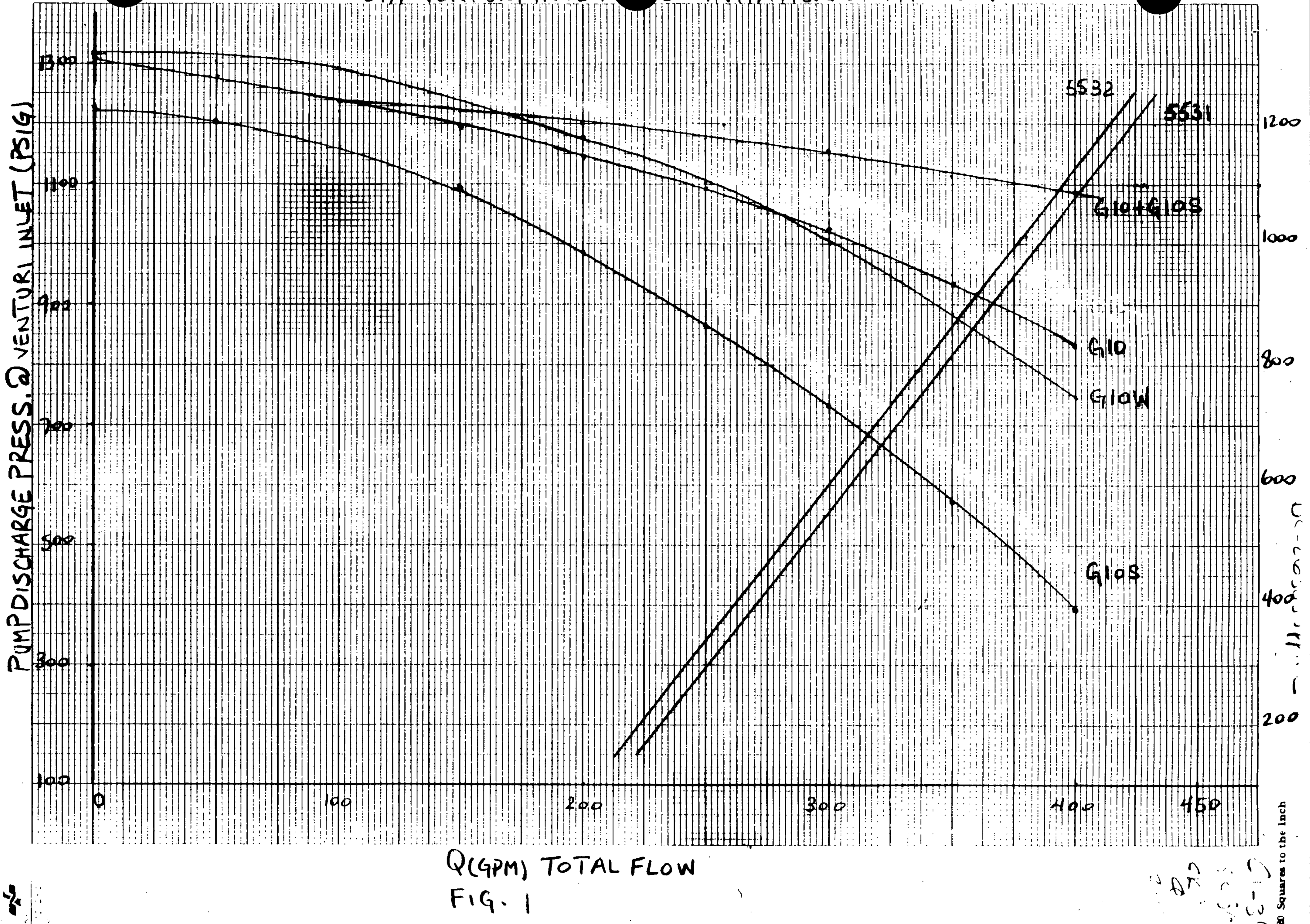
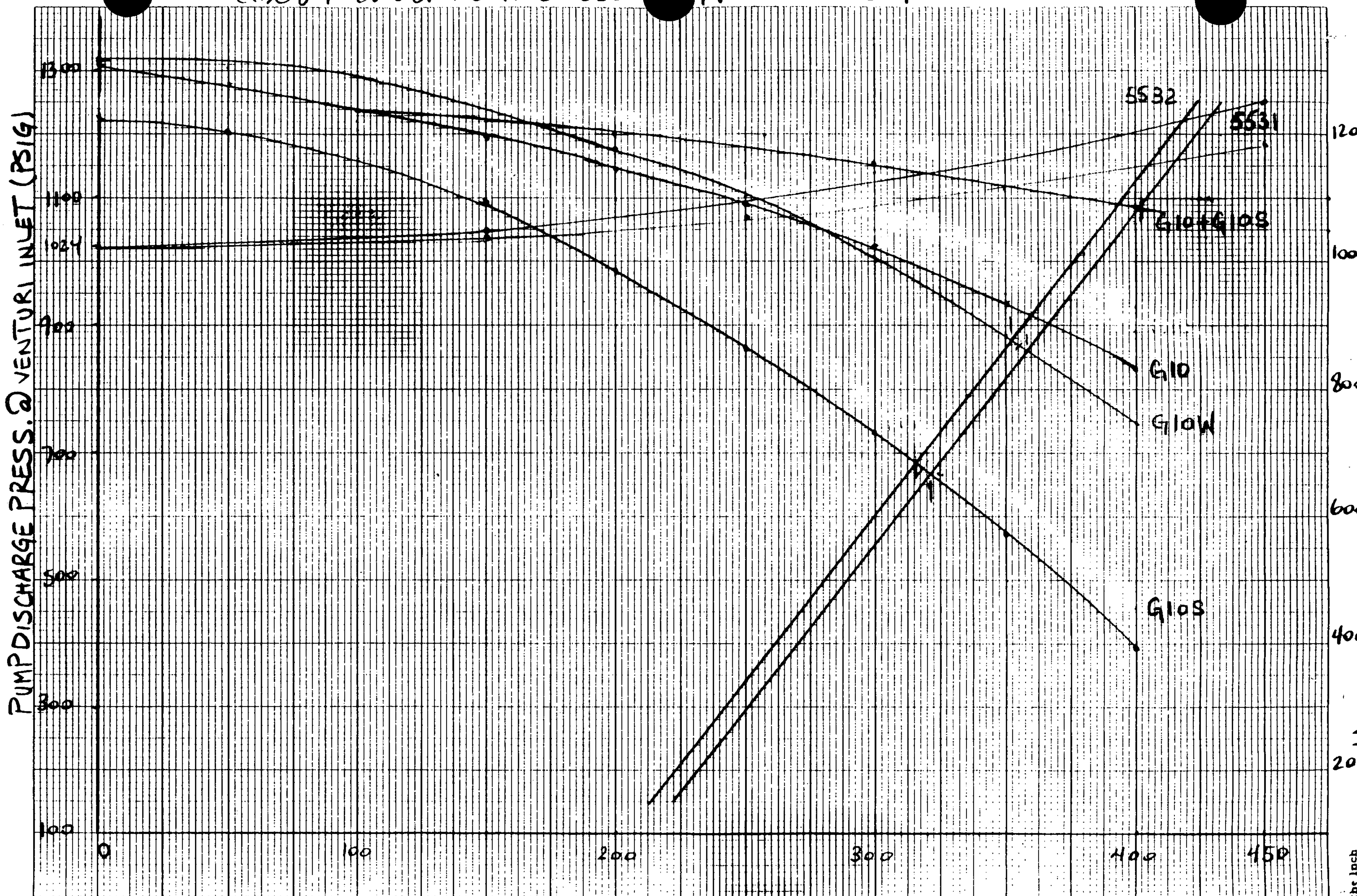


FIG. 1

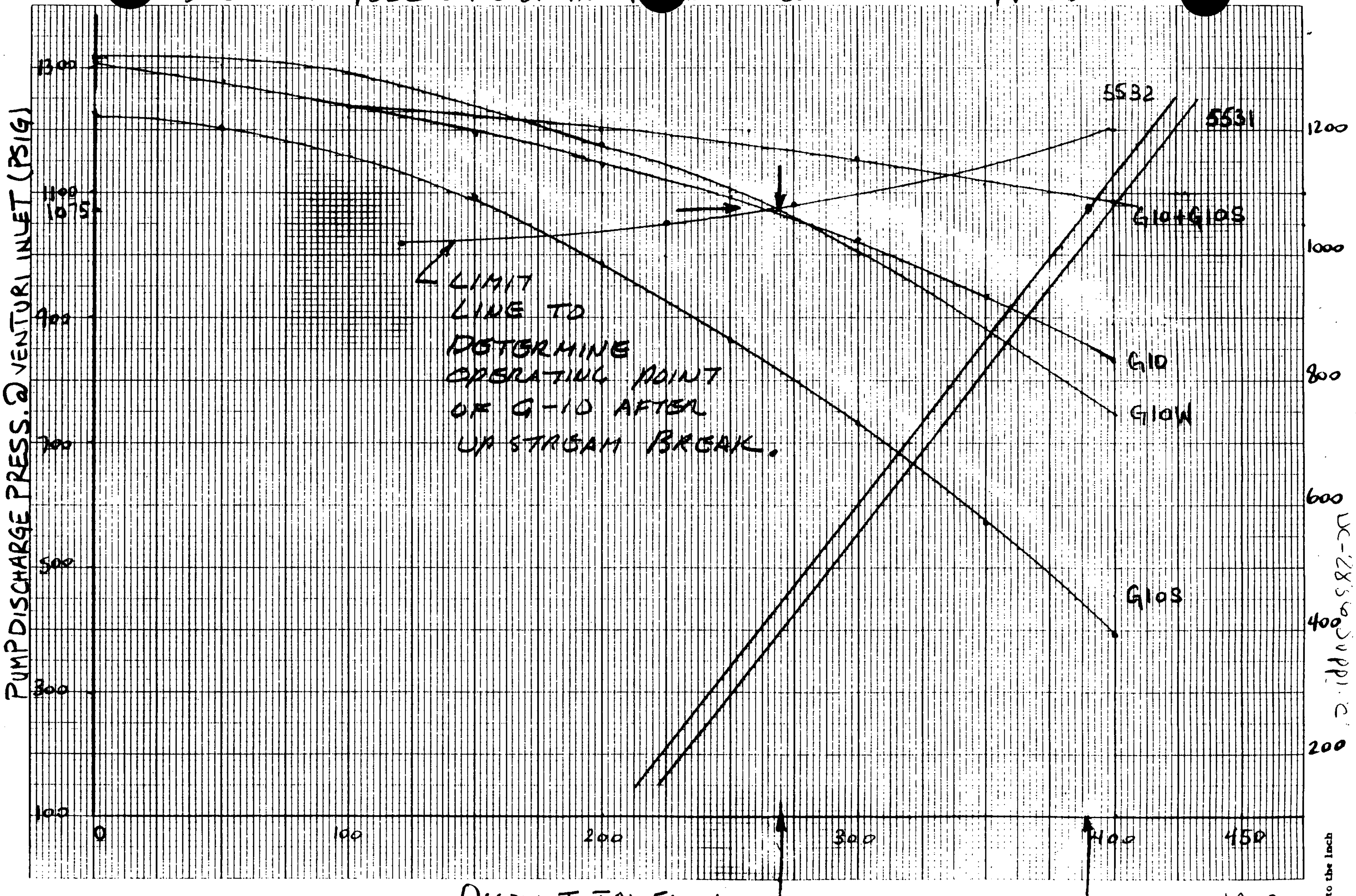
CASE 8.1 - LOSS OF NORMAL FEED @ [illegible] PRESS. of 1030 PSIA



Q(GPM) TOTAL FLOW

FIG. 2

CASE 8-2 _MAINFEED LINE BREAK U[illegible]EAM CHECK VALVE @ S/G PRESS. OF 103[illegible].A



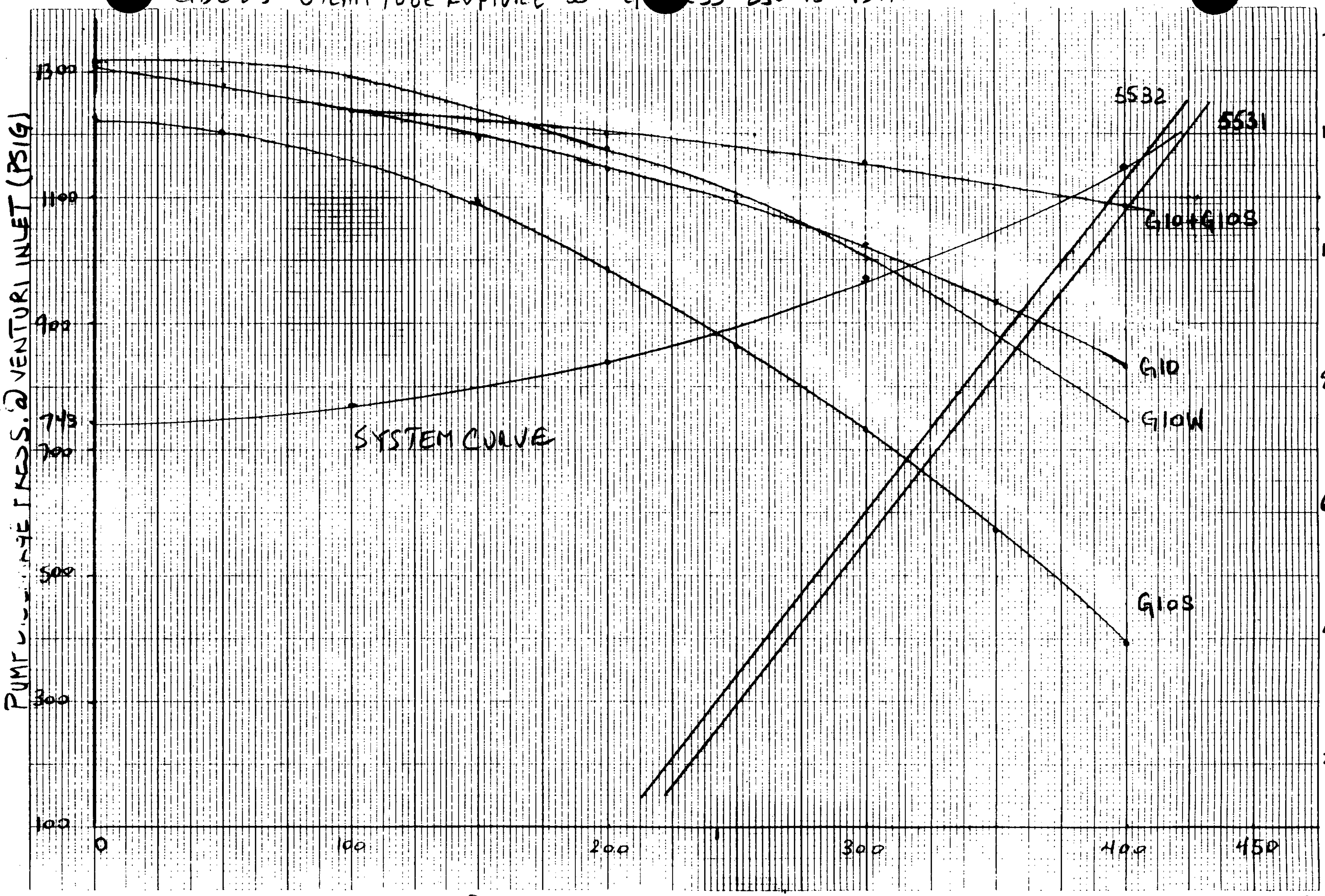
Q(GPM) TOTAL FLOW

270

390

FIG. 3

CASE 8.5- STEAM TUBE RUPTURE @ S/G [illegible]ESS. 250-750 PSIA



Q(GPM) TOTAL FLOW

FIG. 4

DC-2856 Supp.1 C

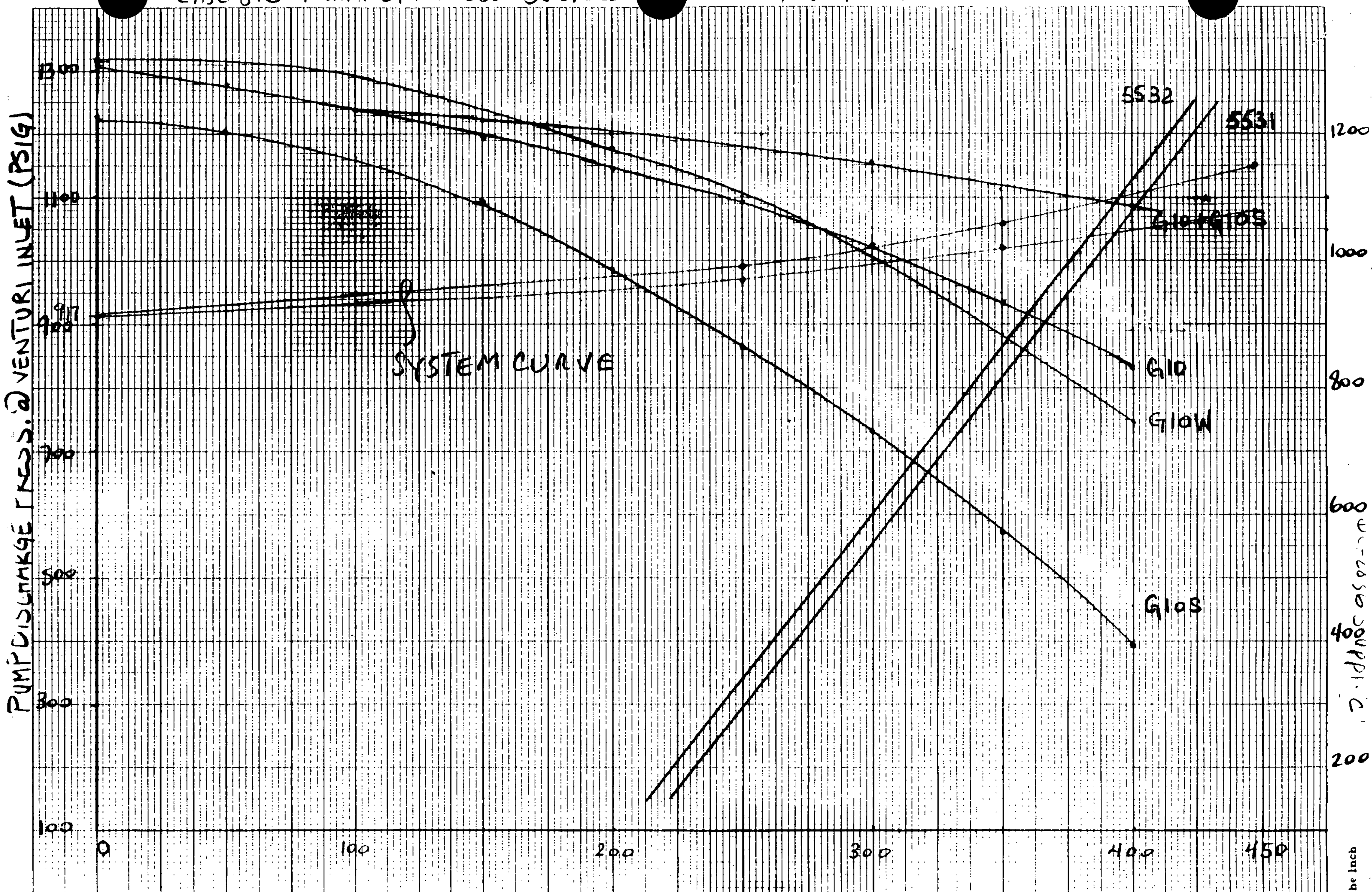
C1-39

C-1

5/8/81

12/8/81

CASE 8.6 - NORMAL PLANT COOL DOWN @ [illegible] PRESS. 125 - 923 PSIA



Q(GPM) TOTAL FLOW

FIG. 5

CASE 8.7. STEAMLINE BREAK OUTSIDE CONTAINMENT @ S/G PRESS. 700-875

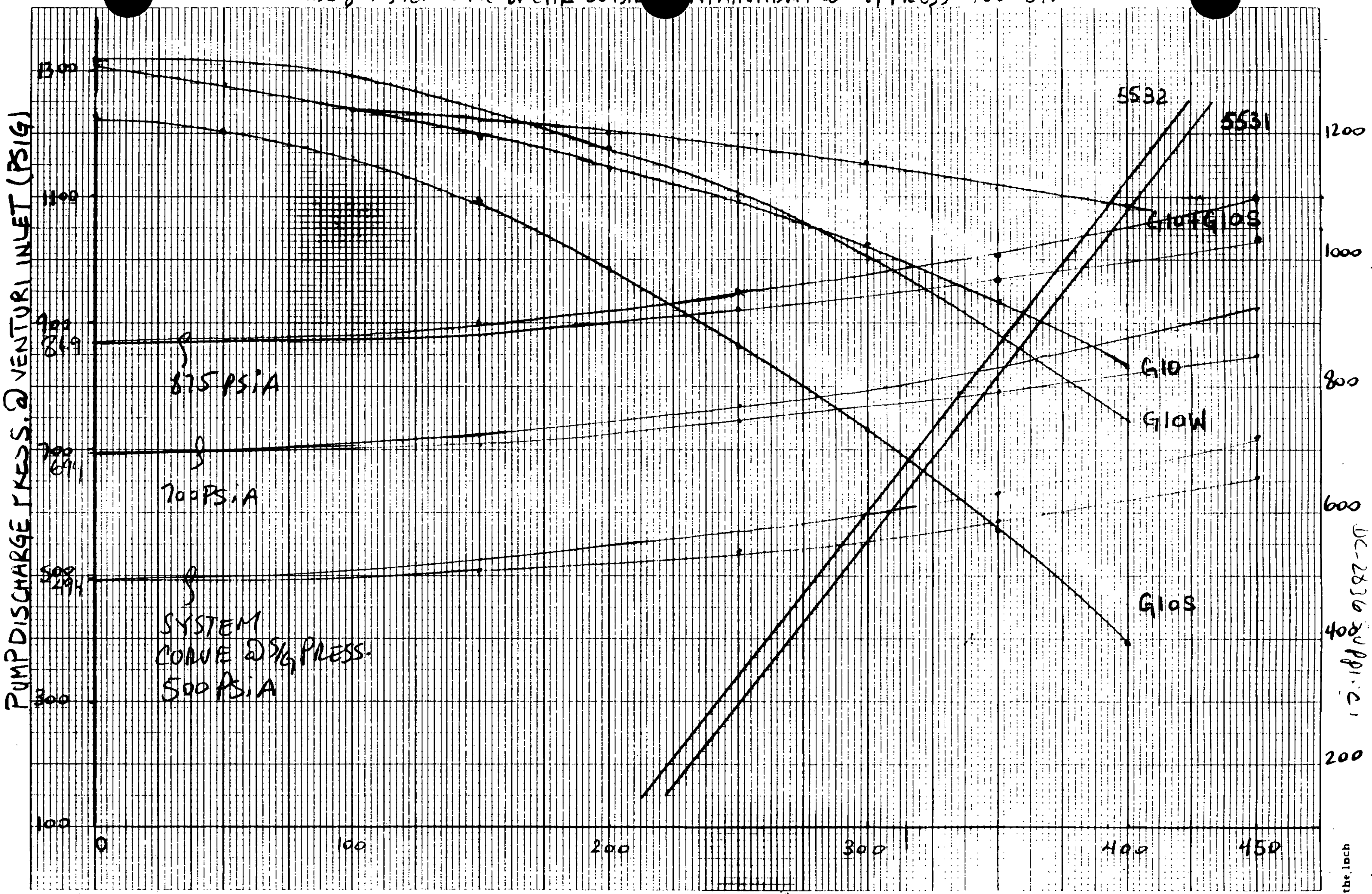


FIG. 6

DC-2836 Suppl. C
C1-41

CASE 8·11 APPENDIX 'R'

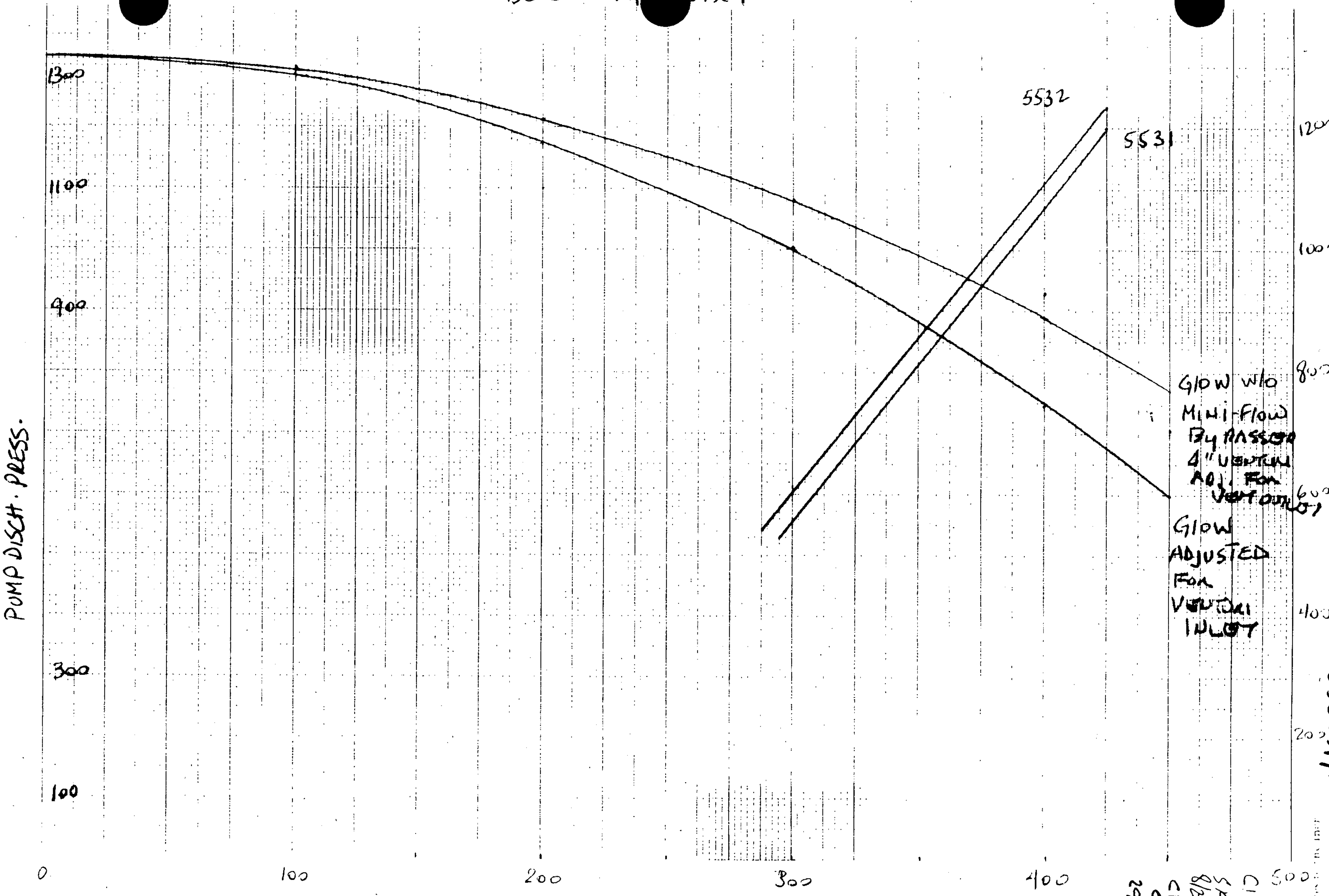


FIG. 7.

UC-2836 SUPPL. C

CI-42

NES&L DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE C143 OF
	CCN CONVERSION: CCN NO. CCN-- C-1

Project or DCP/MMP 1-3587.015M Calc No. DC-2836 Suppl. 'C'

Subject AFW FLOW REQUIREMENT VERIFICATION Sheet No.

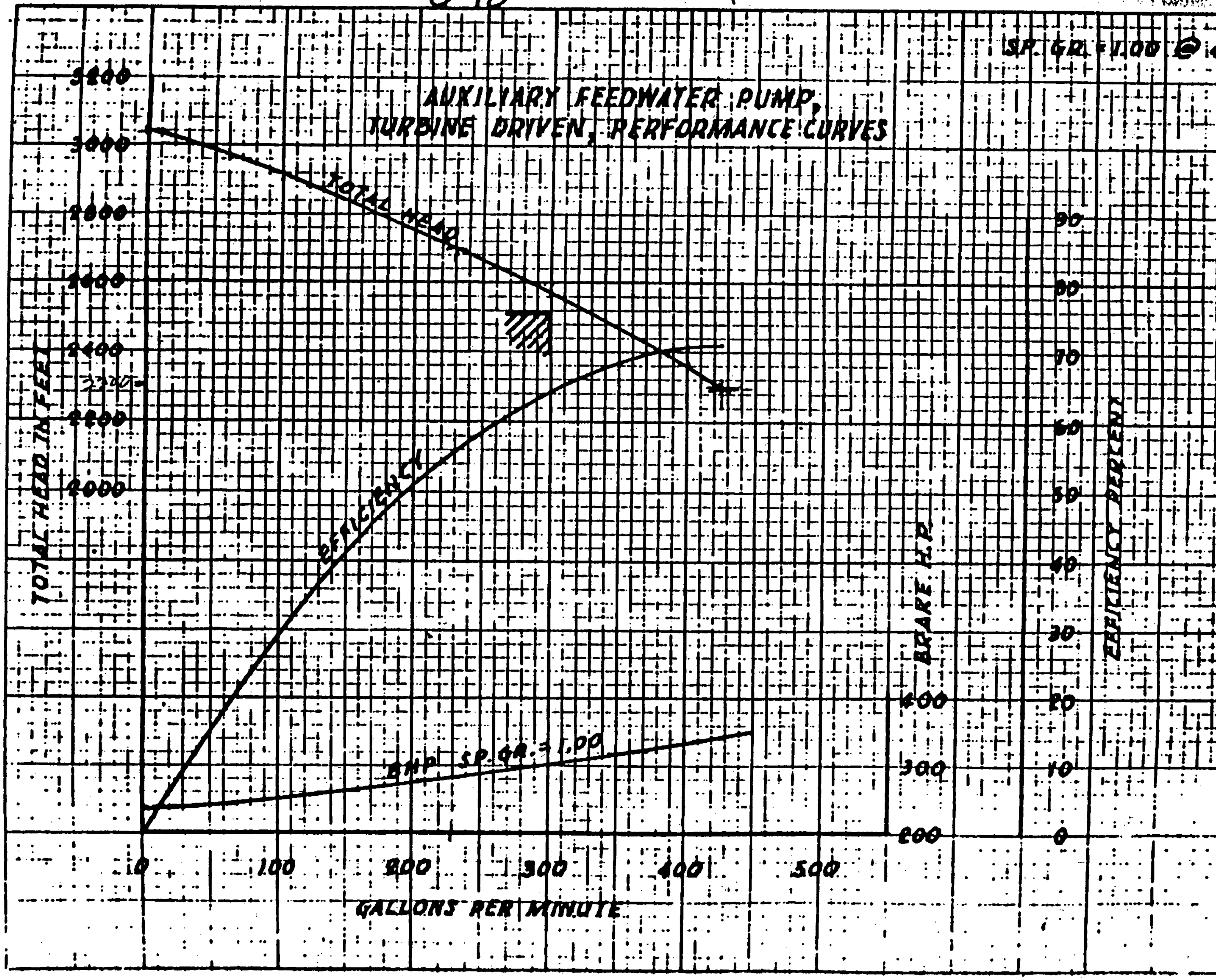
REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	SK	8/20/90	4	29AUG90					

REV. INDICATOR

ATTACHMENT A

SCE 26-426 NEW 4/90

G-10



SUPPLEMENT A DC-2836 REV. 30
BY K. PFAHL DATE 3/15/90
CHK BY DATE 3/22/90
SHT 24-45 OF 60

CONTRACTOR BECHTEL

CUSTOMER SO. CAL. EDISON

ITEM NO. ______ P.O. 6J036807

IMPELLER PATTERN	H-6149	H-6150/51
MAXIMUM DIAMETER	8	8
RATED DIAMETER	8	8
MINIMUM DIAMETER	7	7

SUPPLEMENT A DC-2836 Rev. 30 KLP

By K. PFAHL KLP DATE 3/22/90

CHK BY [illegible] DATE 3/22/96

SHT R4-46 OF 60

G105 PUMP CURVE

ATTACHMENT 2

TEST PERFORMANCE CURVE NO. 42768-SP

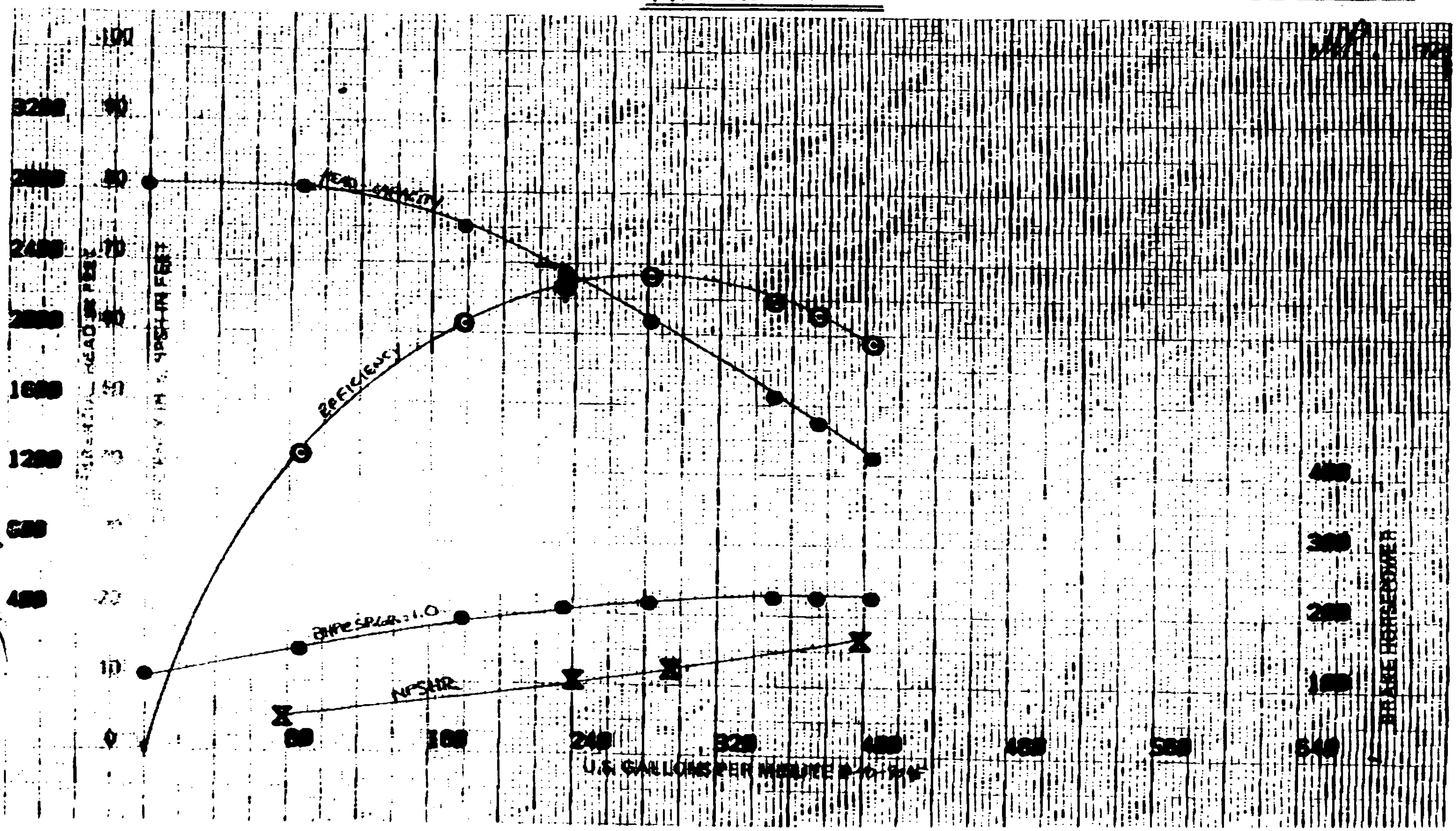
SIZE 2" TYPE BFJTC STAGES 18

R.P.M. 3570 DATE 5/13/86

PUMP NUMBER 42768-SP

PERFORMANCE ALSO APPLIES TO PUMP

NUMBER NH 43212



CK 5/12/92

IDRO PUMPS (DRESSER) HUNTINGTON PARK, 'IA

CONTRACTOR ____

CUSTOMER WESTINGHOUSE NES

ITEM NO. ____ P.O. MN 47417-D

IMPELLER PATTERN H-7844 H-7881

MAXIMUM DIAMETER 8-9/16" 8-9/16"

RATED DIAMETER 8" 8"

MINIMUM DIAMETER 7-9/16" 7-9/16"

SUPPLEMENT A DC-2836 Rev. 0 KLP

BY K. PFAHL KLP DATE 3/15/90

CHK BY [signature] DATE 3/22/90

SHT R4 47 OF 60

GIOW PUMP CURVE

ATTACHMENT 3

TEST PERFORMANCE CURVE NO. 516

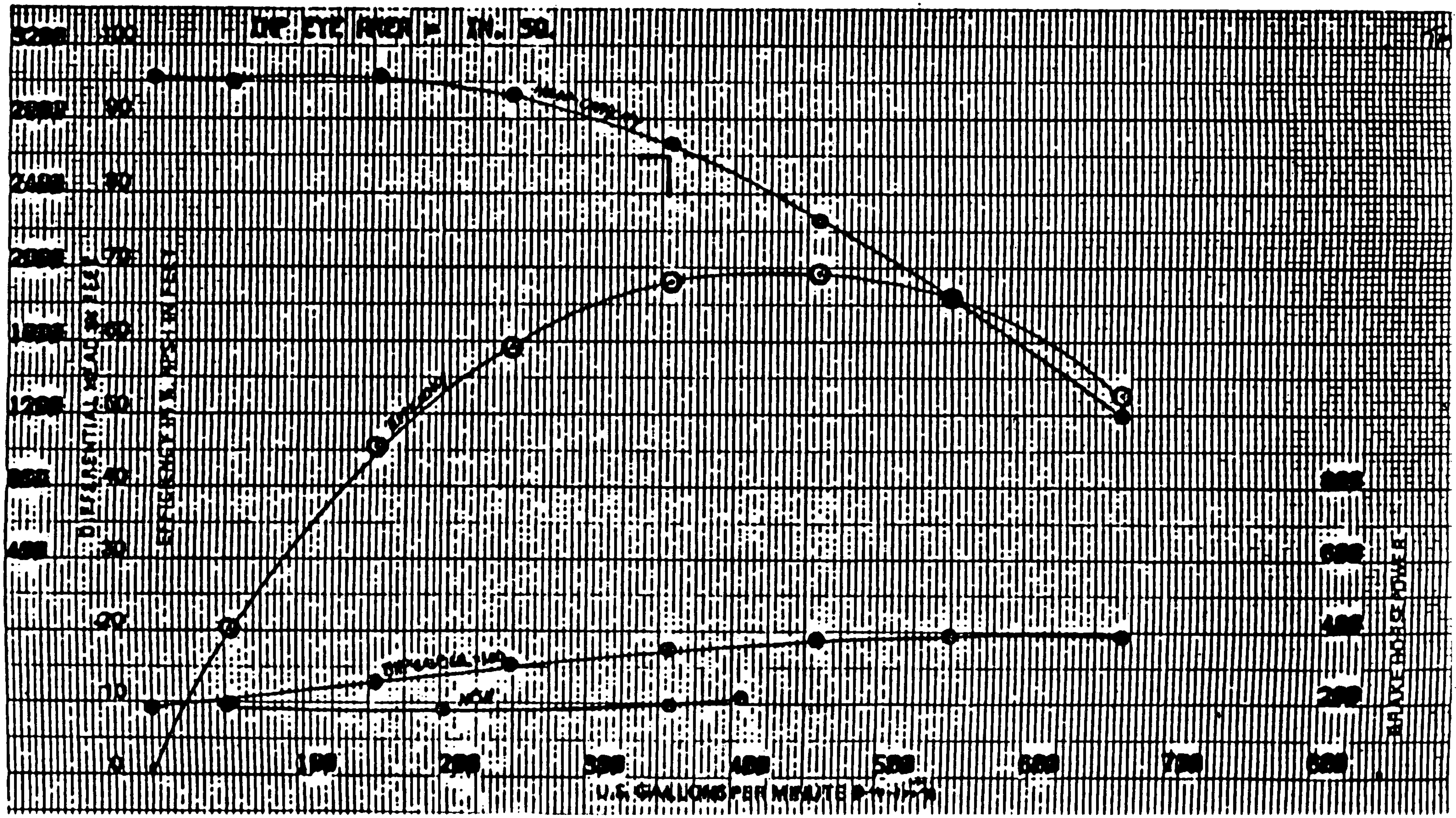
SIZE 3" TYPE JHF STAGES 11

R.P.M. 3565 DATE 1/31/86

PUMP NUMBER 51658-01

PERFORMANCE ALSO APPLIES TO PUMP

NUMBER NH 43206



CI-416 SK 813.316 27 MAR 90

INSERVICE PUMP TEST RECORD

SUPPLEMENT A DC-2836 REV. 30 KLP
BY K. PFAHL DATE 3/15/90
CHK BY [illegible] DATE 3/22/90
SHT R4-48 OF 60

Test Procedure Used [illegible] 14.1 Attch. 3

Unit 1

CDM Encode No

Test Date [illegible]

Record No. [illegible]

1 Plant Tag No. (EXAMPLE: 3-CCW-O-3C-52-203MPC23, ETC.) [illegible]	2 Pump Name (System) (EXAMPLE: COMPONENT COOLING WATER PUMP, ETC.) Aux. Feedwater		
3 Tested By [illegible]	4 Reason for Test (QUARTERLY, POST MAINTENANCE, ETC.) COLD SHUTDOWN TEST (18 Month)		
5 Plant Power M-1 (< 25%)	6 Reference IST Record No./Date 6-10-5-87 RECORD NO. 5-5-87 DATE		
7 Test Frequency COLD SHUTDOWN	8 Date Last Tested 2-14-89	9 Run Time Before Test > 5 Min. (MUST BE AT LEAST 5 MIN.)	

HYDRAULIC DATA	INSTRUMENT ID (ENTER "C" FOR CALC'D VALUE)	CALIBRATION DUE DATE	UNITS	SET REF.	REFERENCE VALUE	TEST VALUE	ACCEPTABLE RANGE
10 Prestart Suction Pressure (Pa)	M2-5353	8/16/89	PSI		15.2	15.2	> 0
11 Speed (N)	M2-5619	9/27/89	RPM		4274	4402 ✓	4400 ± [illegible]
12 Discharge Pressure (Po)	M2-4349	9/18/89	PSI		~~1120~~ 1120	1080	NA
13 Running Suction Pressure (Pi)	M2-5353	8/16/89	PSI		~~13~~ 13.5	12.1	> 0
14 Differential Pressure (Po - Pi)	C	NA	PSI		1106.5	1067.9	1127 [illegible]
15 Motor Current (A)	NA	NA	NA		NA	NA	NA
16 Flow Rate (Q)	C	C	GPM		300	296.4	300 ± 10

Calculations

FTL 3453 (M1 1552 / 9-10-89) Y = 30.5" wc Q = 95.7 gpm

FTL 3455 (M1 1551 / 11-3-89) 35.1" w 102.6 gpm

FTL 3454 (M1 1550 / 11-3-89) 32.1" w 98.1 gpm

(ΔP = 1080 − 12.1 = 1067.9)

Throttled Flow ?

Q total = 296.4 gpm where $Q = 300\sqrt{\frac{Y}{300'' wc}}$ + See Test procedure SOI-XXVI-[illegible]

MECHANICAL DATA

Vibration Instrument ID I28620/8620A Calibration Due Date 11-11-89 [illegible]

	Vibration Axis	Displacement (Mils) REFERENCE VALUE	TEST VALUE	ACCEPTABLE RANGE	Velocity (IPS) REFERENCE VALUE	TEST VALUE	ACCEPTABLE RANGE
17	Point No. 1 Horiz. (0 Deg.)	0.38	.4	0-1	0.16	.1	NA
18	Point No. 1 Vert. (90 Deg.)	0.22	.2	0-1	0.10	.1	
19	Point No. 1 Axial	0.32	.38	0-1	0.23	.2	
20	Point No. 2 Horiz. (0 Deg.)	0.22	.2	0-1	0.09	.1	
21	Point No. 2 Vert. (90 Deg.)	0.12	.19	0-1	0.13	.15	
22	Point No. 2 Axial	0.32	.28	0-1	0.10	.14	

23 Lubrication Level/Pressure — Bulls Eye ✓ Chicken Feeder ✓ Other Sightglass / Wick Sat ✓ UnSat ____

24 BEARING TEMPERATURES

Instrument ID. I2-7537 / M1 2281

Cal. Due Date 8-28-89 9-24-89

Date Last Taken This test

Reference Data Record No. This test

Reference Temperature #1 91.7°F #2 125.1°F

Max. Allowable Temperature < 160°F

	Point No. 1 TIME	TEMP	% CHANGE	Point No. 2 TIME	TEMP	% CHANGE
1	0	91.5		0	124.2	
2	10	91.7	.2	10	124.7	.4
3	20	91.9	.4	20	125.5	1.0
4	30	92.0	.5	30	126.1	1.5

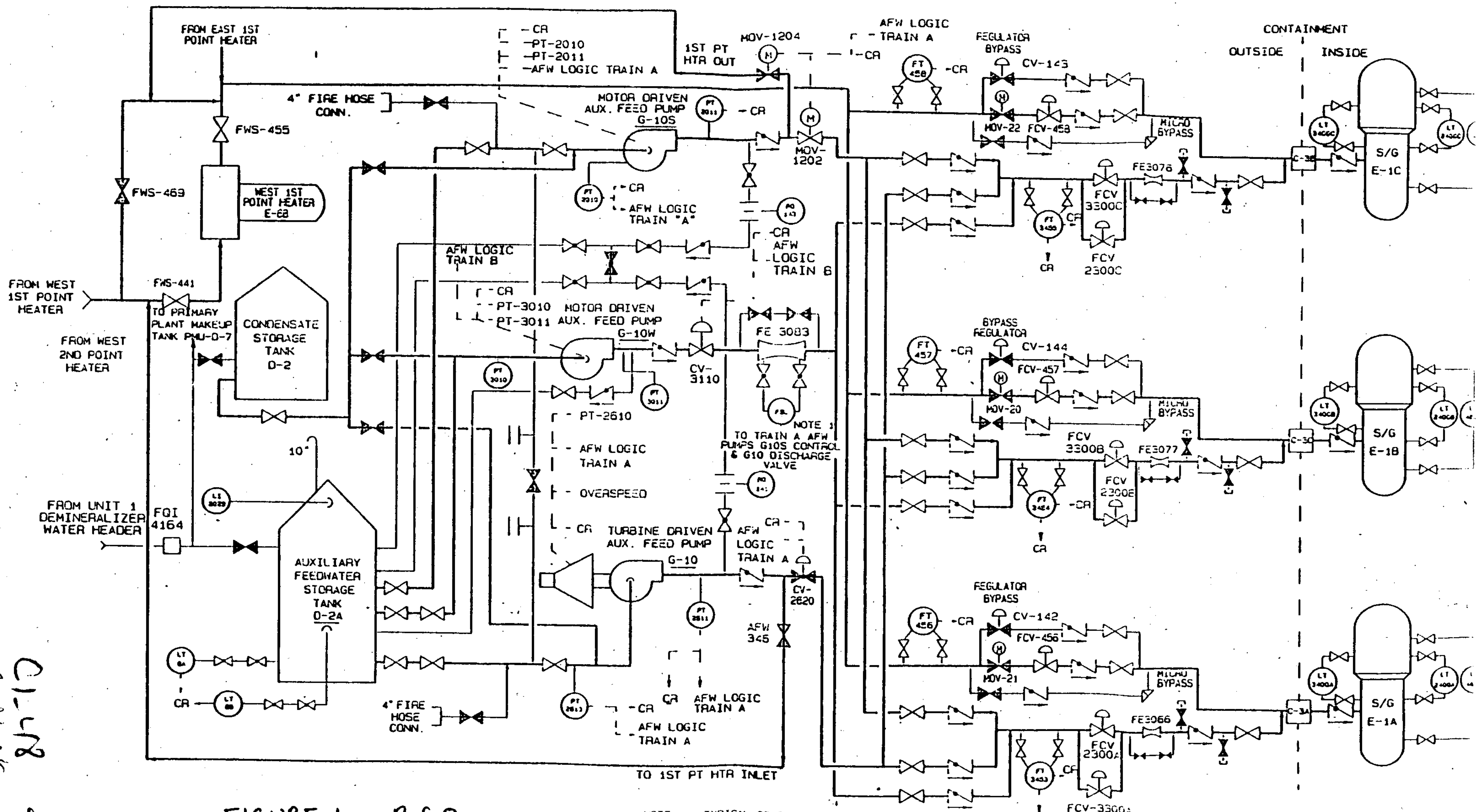
CORRECTIVE ACTION/REVIEW RESULTS

25 REQUIRED ACTION None	26 NCR NO. AND/OR M.O. NO. N/A
27 ENGINEER PERFORMING OPERABILITY ANALYSIS [illegible]	28 SUPERVISING ENGINEER OR DESIGNEE [illegible] DATE

SCE EG-123:53 REV 2 06/23/88

C1-47 SK 3/28/90 CK [illegible]

AUXILIARY FEEDWATER SYSTEM



NOTE 1: TYPICAL OF FOUR LOW FLOW SWITCHES (FSL-2306, 2307, 2308, 2309)

FIGURE 1
SD-S01-620-01-5

AS1006500
0293W.AUT

FIGURE 1 - Ref. 8
SUPPL. A DC-2836 Rev. 10 KLP

MADE BY K. PFAHL KLP DATE 3/15/90

CL-48
SE 8/2/95

20 Squares to the Inch

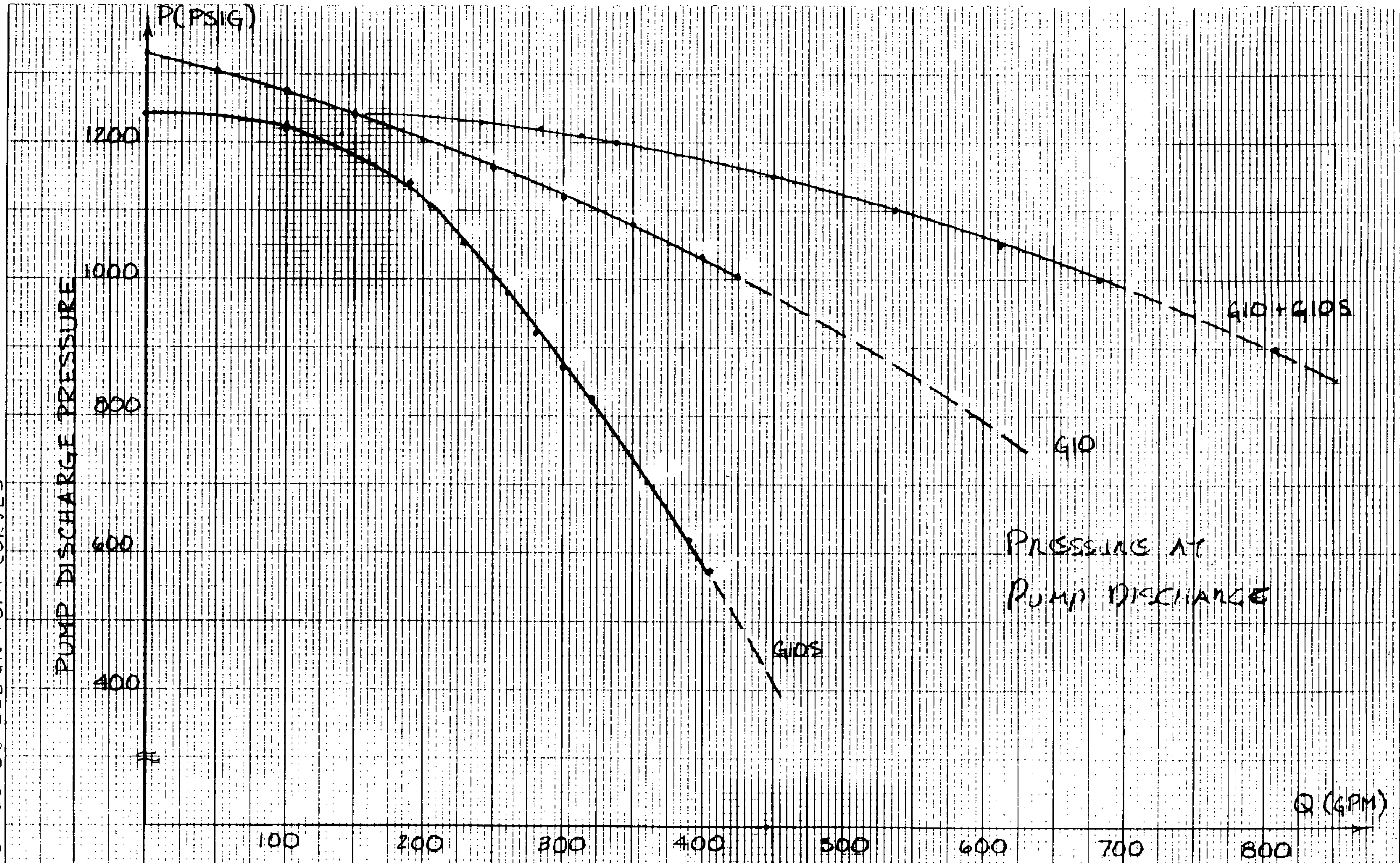


FIGURE 2

DTE BASED ON DESIGN PUMP CURVES

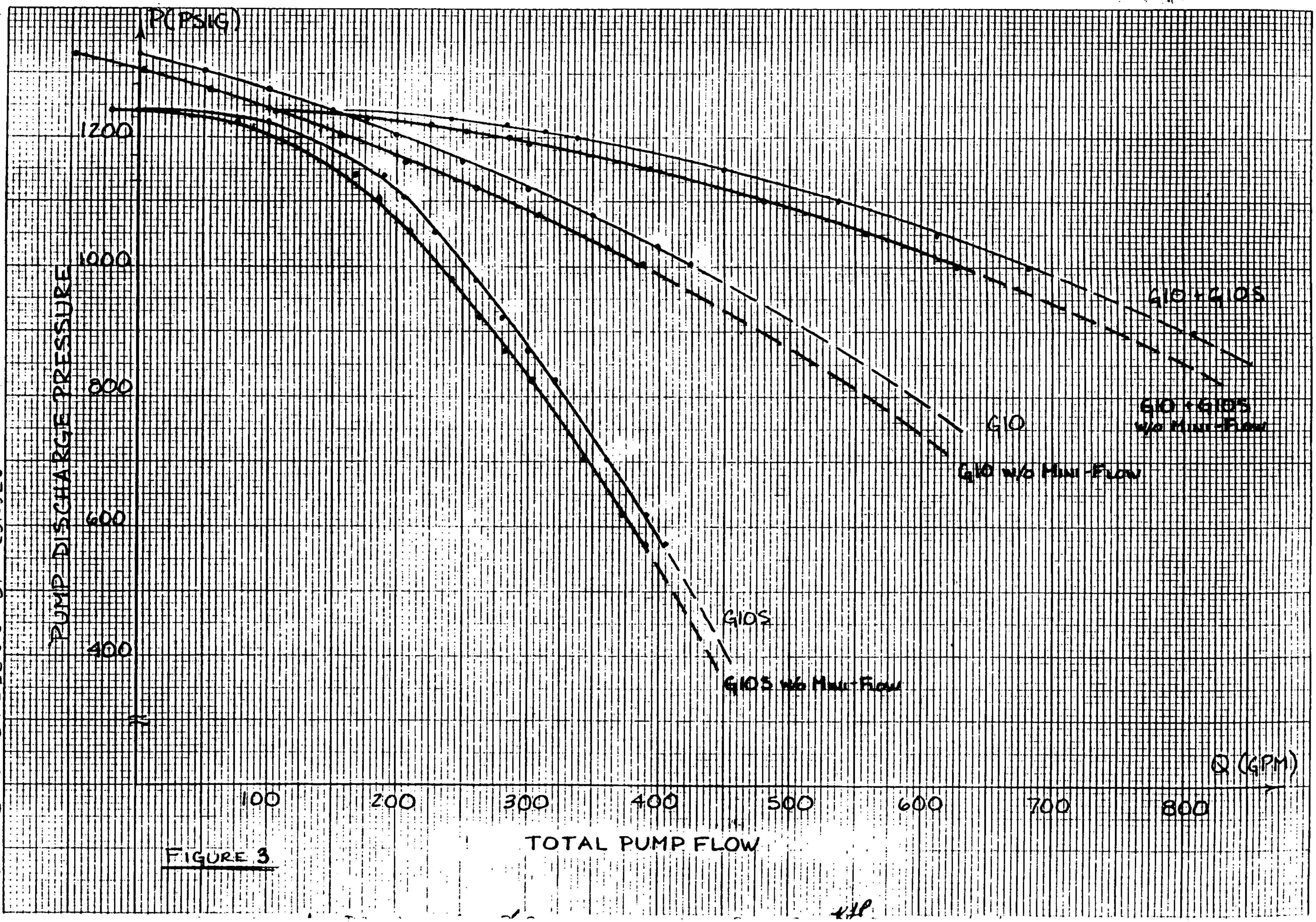


FIGURE 3

NOTE BASED ON DESIGN PUMP CURVES

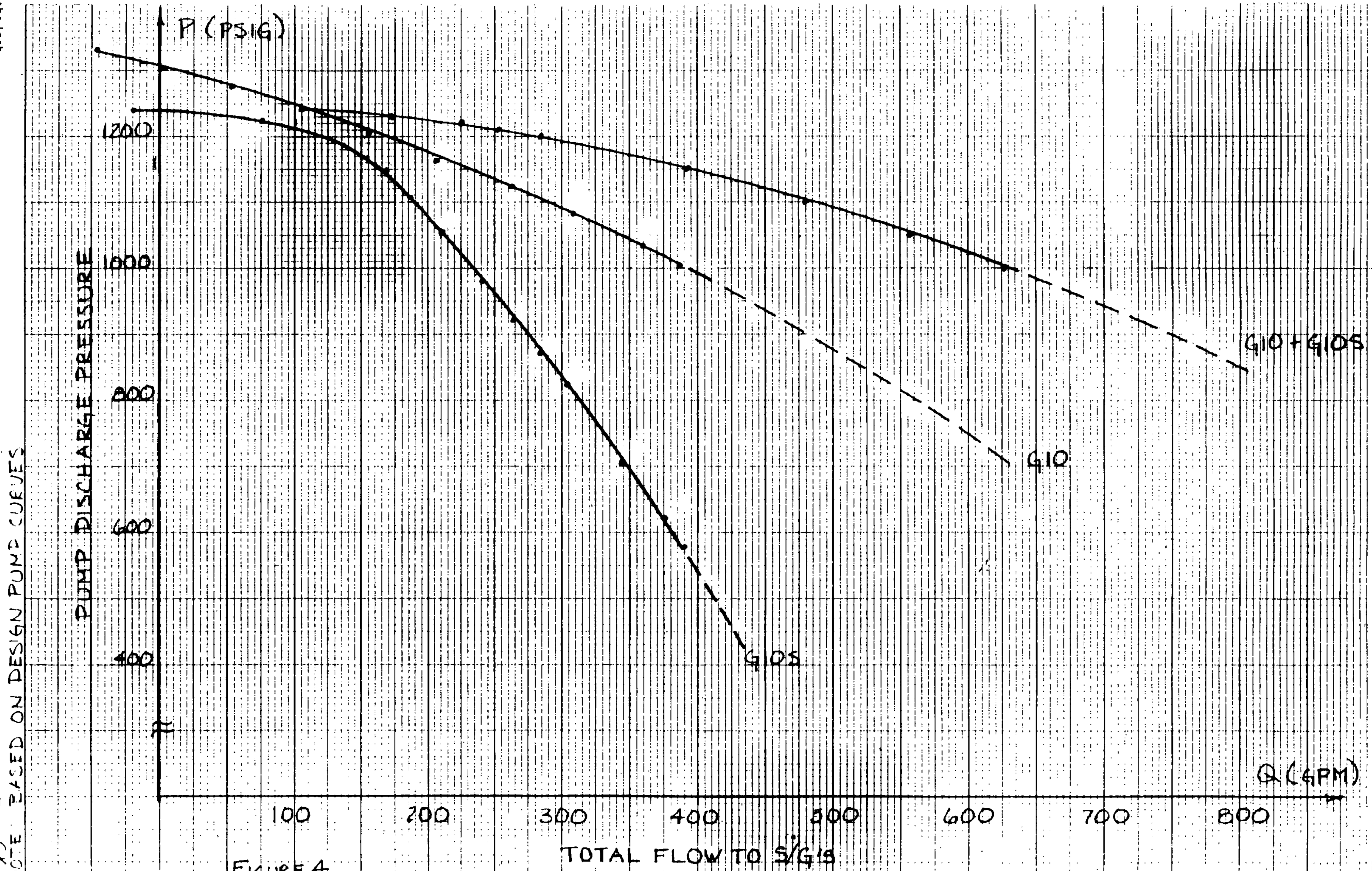


FIGURE 4

NOTE: BASED ON DESIGN PUMP CURVES

S-10

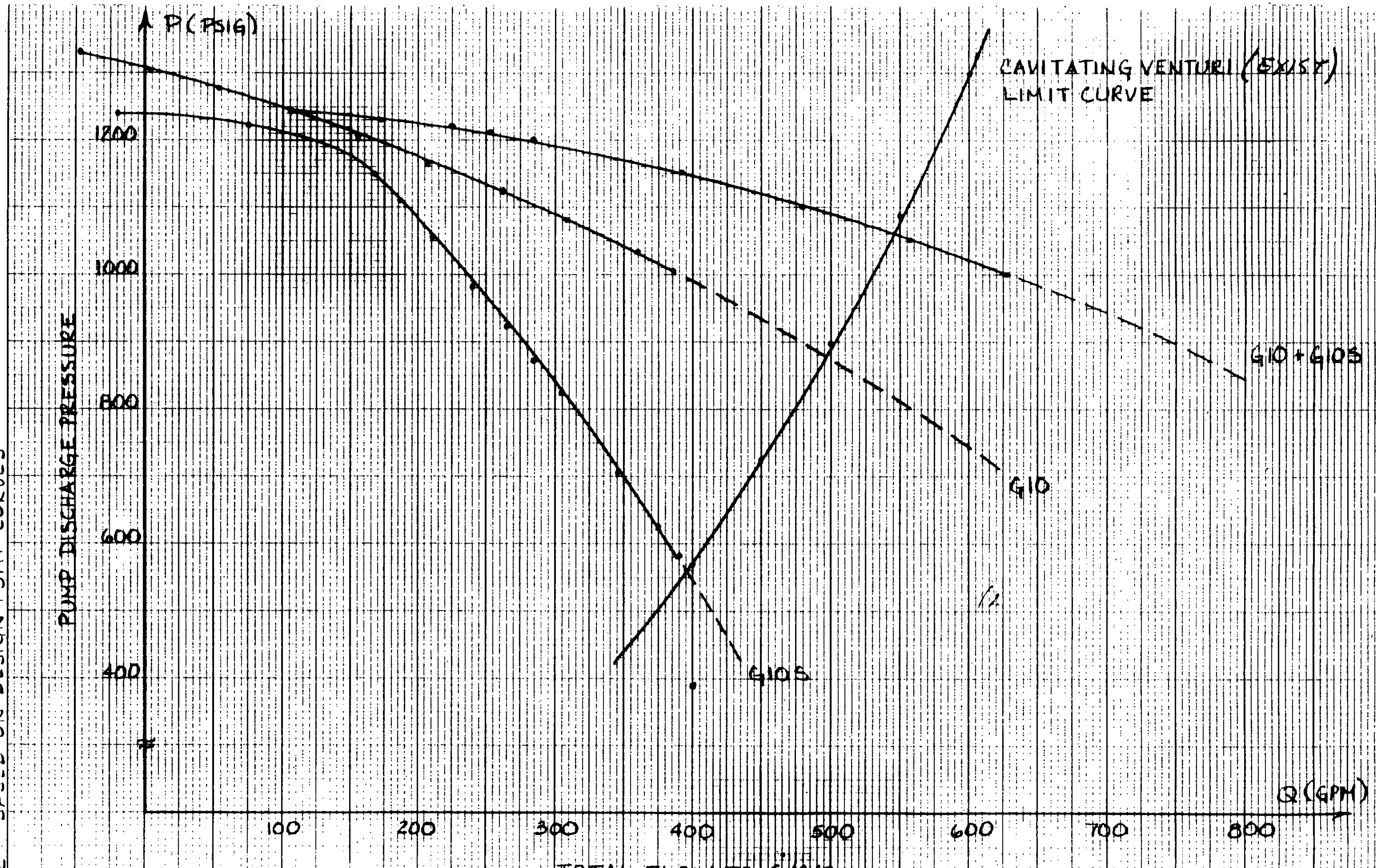


FIGURE 5

NOTE BASED ON DESIGN PUMP CURVES

C1-52

20 Squares to the Inch

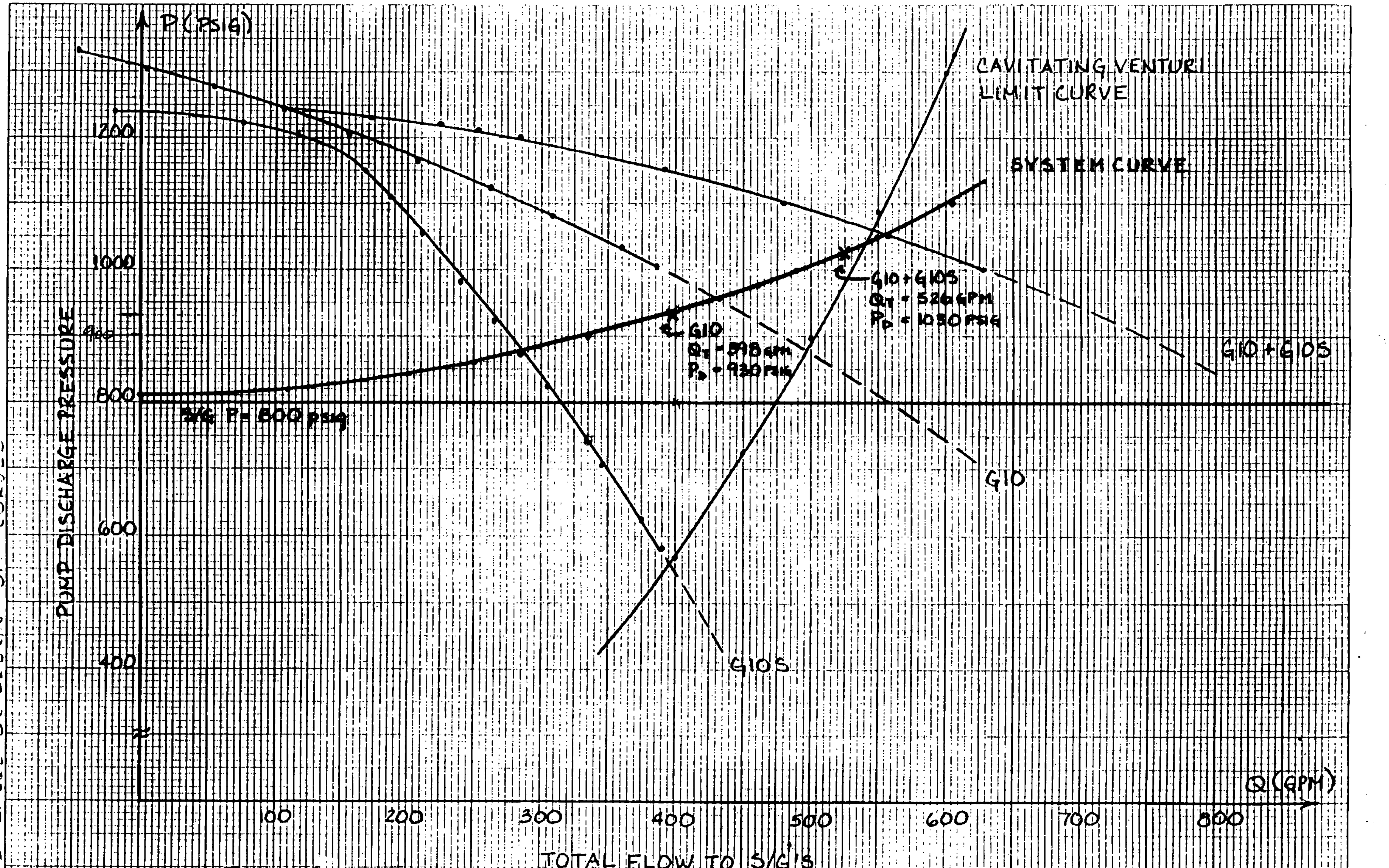


FIGURE 6

NOTE: BASED ON DESIGN PUMP CURVES

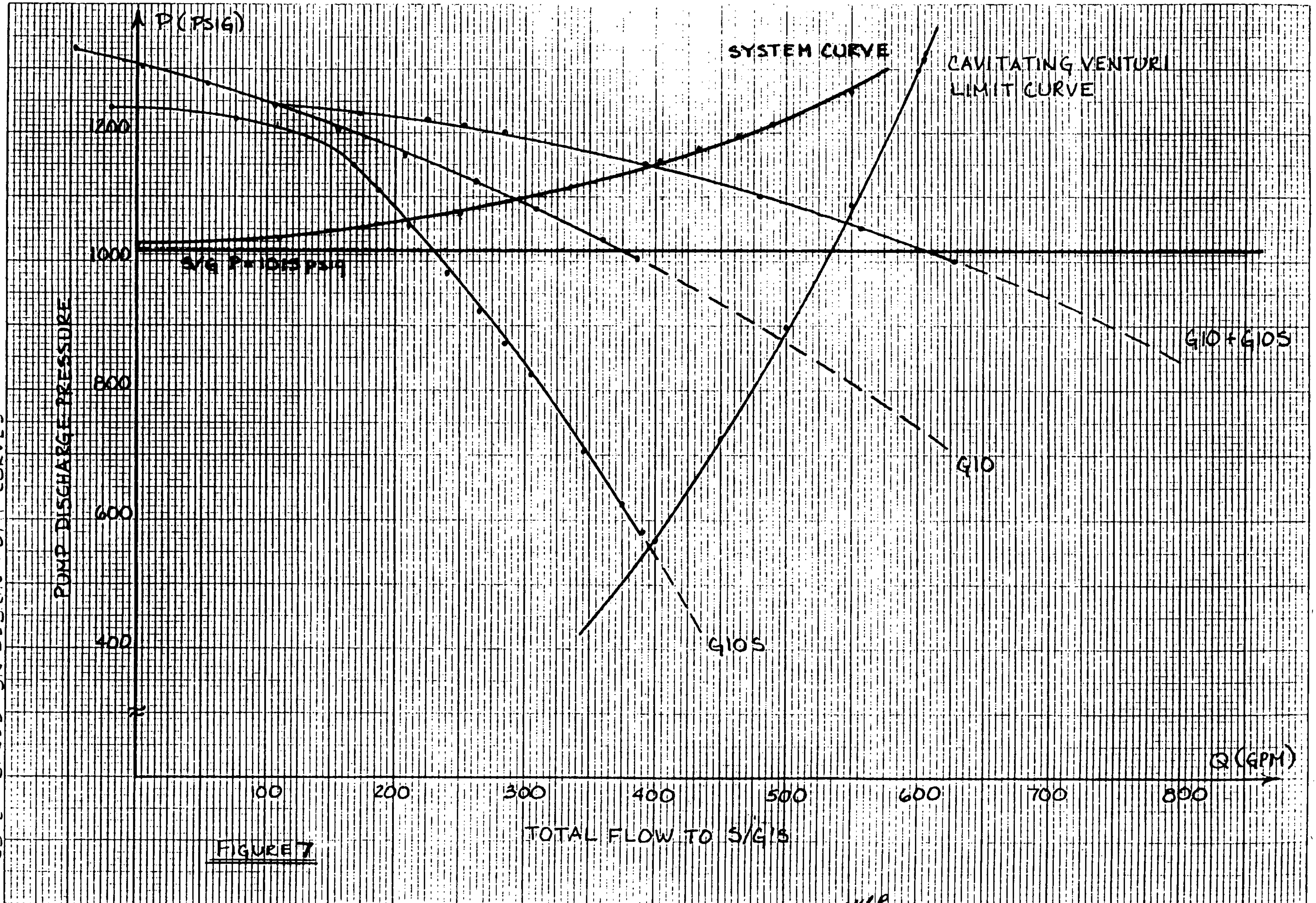


FIGURE 7

NOTE: CURVES BASED ON DESIGN PUMP CURVES

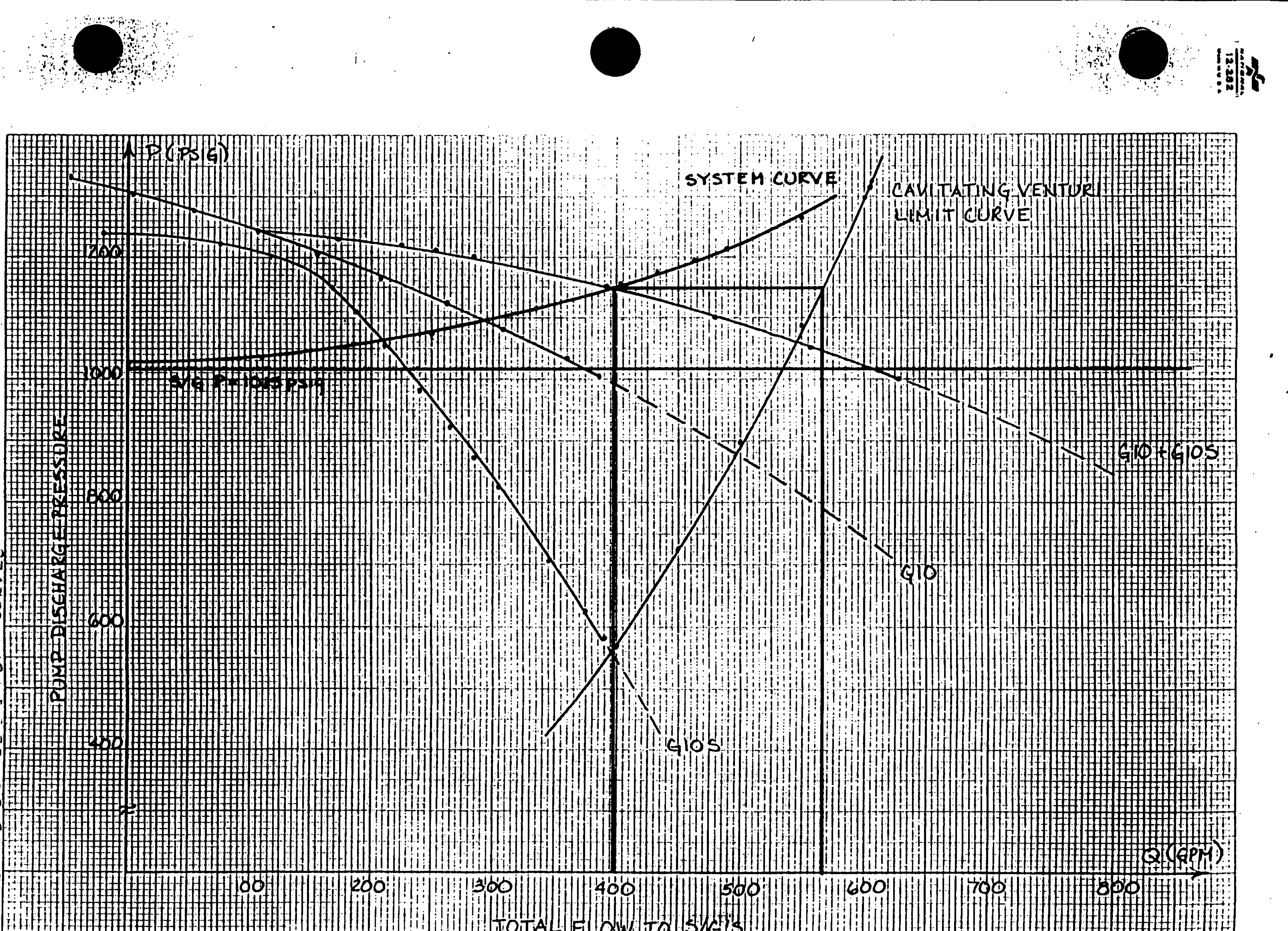
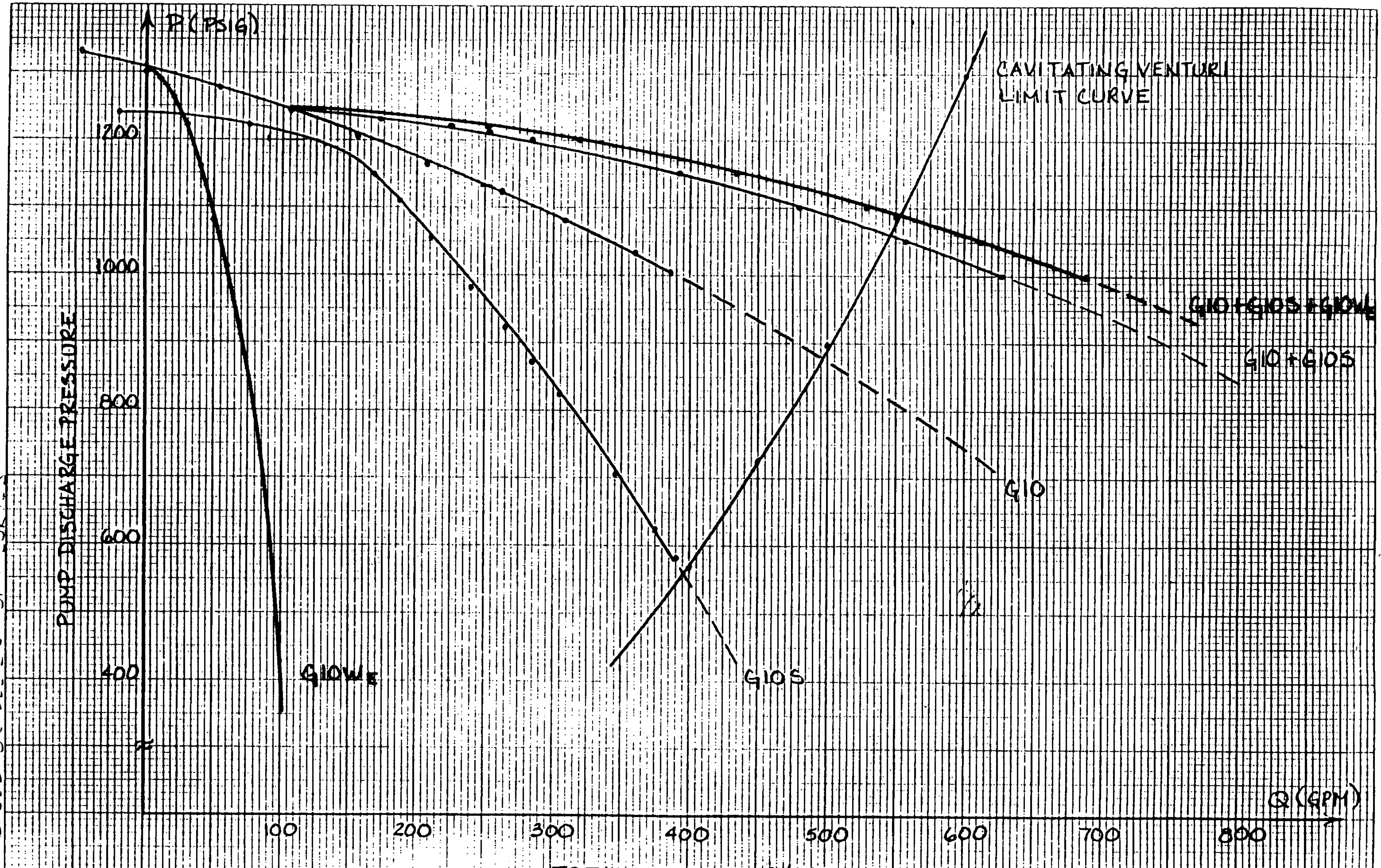


FIGURE 8

SUPPLEMENT A DC-2836 REV. 3/0 MADE BY K. PFAHL DATE 3/15/90



P (PSIG)
PUMP DISCHARGE PRESSURE
1200
1000
800
600
400
CAVITATING VENTURI LIMIT CURVE
G10+G10S+G10WE
G10+G10S
G10
G10S
G10WE
Q (GPM)
100
200
300
400
500
600
700
800
TOTAL FLOW TO S/G'S

FIGURE 10

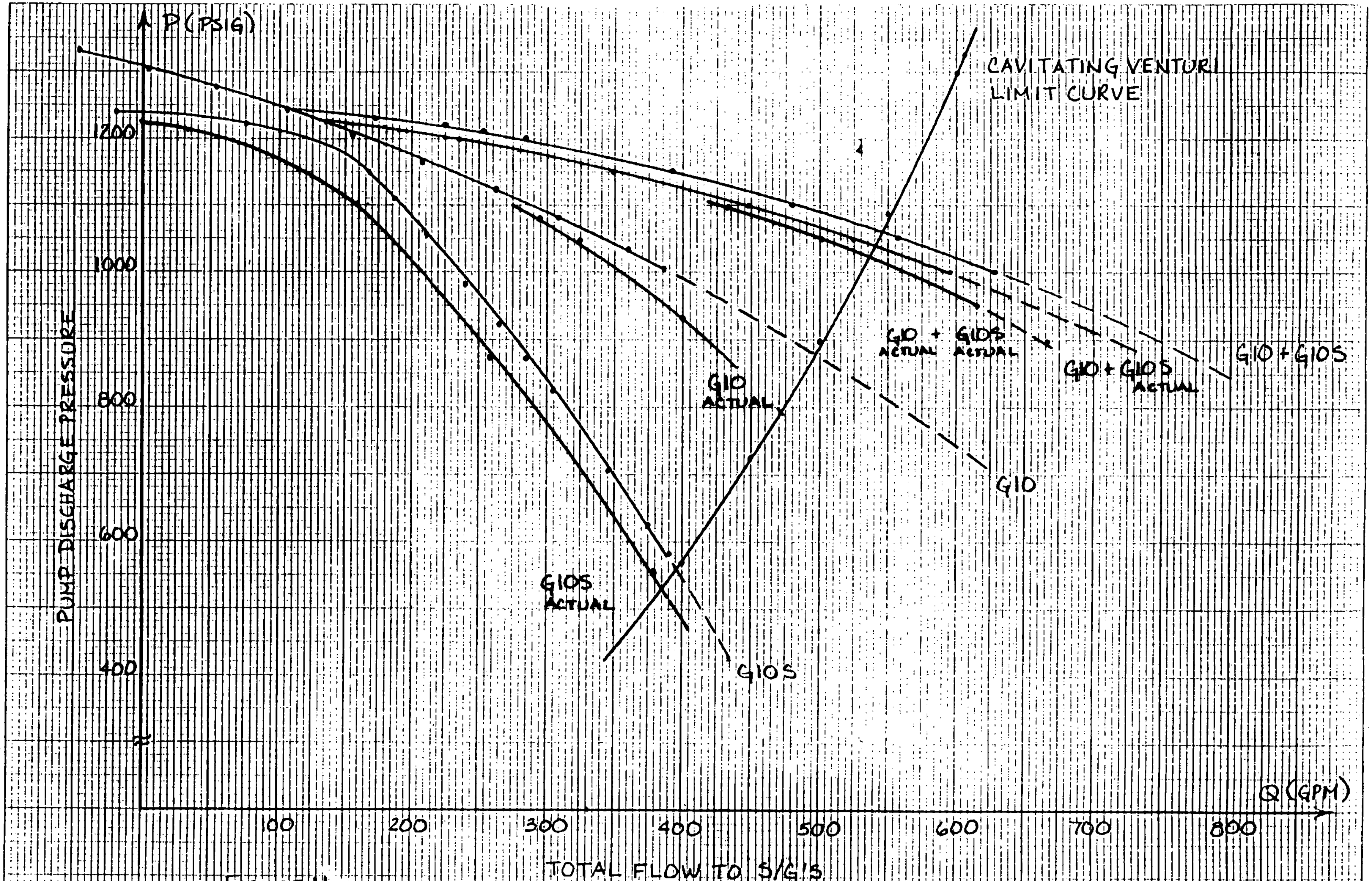


FIGURE 11

SUPPLEMENT A DC-2836 REV. 0 MADE BY K. PFAHL DATE [illegible]

10 Squares to the Inch

NOTE: BASED ON DESIGN PUMP CURVES

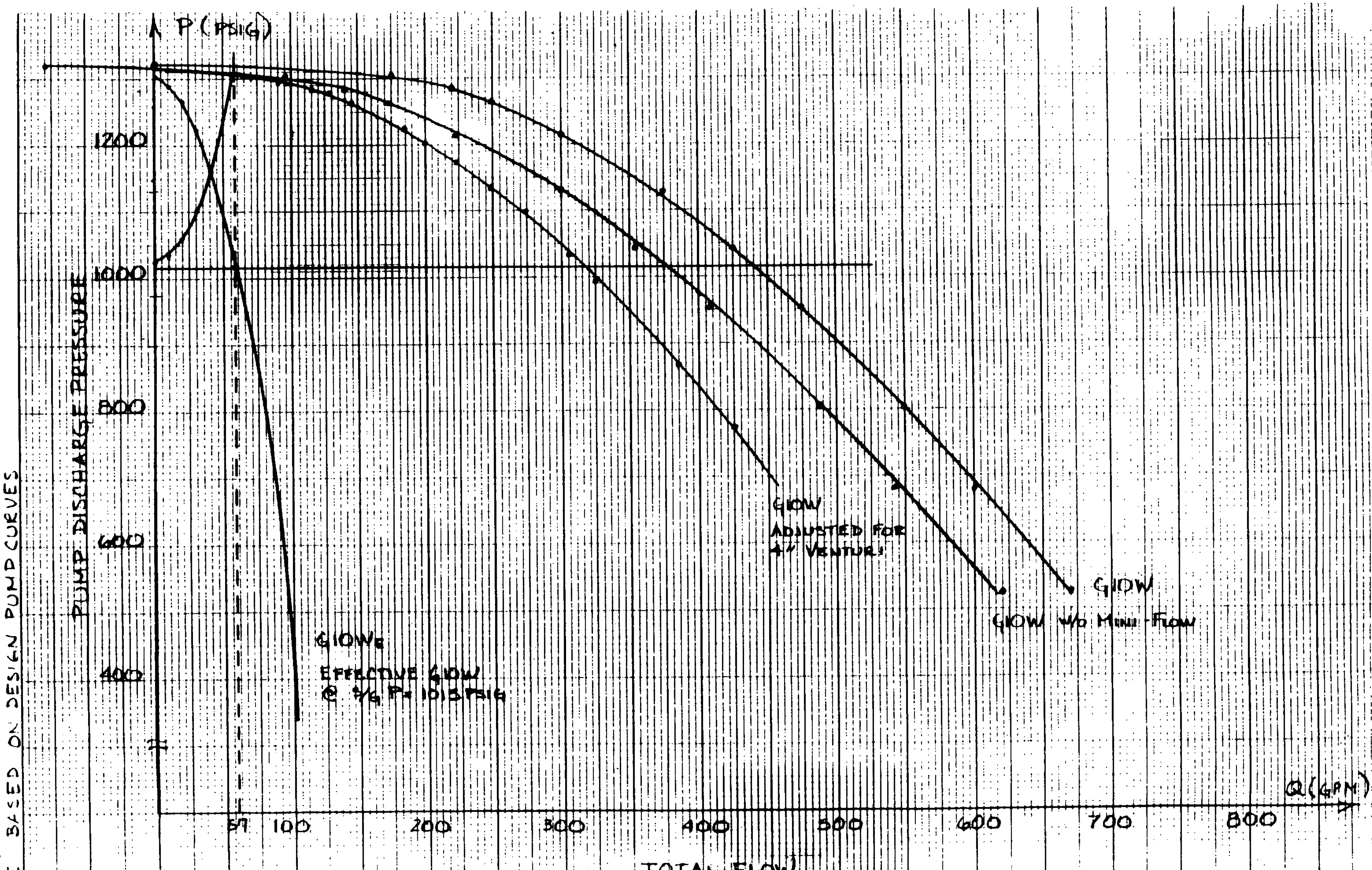


FIGURE 9

NES&L DEPARTMENT

CALCULATION SHEET

ICCN NO./ PRELIM. CCN NO.	PAGE C1-59 OF
	CCN CONVERSION: CCN NO. CCN-- C-1

Project or DCP/MMP 1-3587.01SM Calc No. DC-2836 Suppl. 'C'

Subject AFW FLOW REQUIREMENT VERIFICATION Sheet No.

REV	ORIGINATOR	DATE	IRE	DATE	REV	ORIGINATOR	DATE	IRE	DATE
0	SK	8/28/90	[illegible]	29 Aug 90					

REV. INDICATOR

ATTACHMENT B

SCE 26-426 NEW 4/90

C1-59 SK 8/28/90

WYLE

Procedure No. 4703

Page No. 13

DATA SHEET

Customer: PERMUTIT

Test Title:

Specimen: VENTURI

Part No.

Job No.

S/N: 5530

Date: 8/10/90

RUN NO.	Q (GPM)	T1 (DEG. F)	P1 (PSI)	P2 (PSIA)	P3 (PSI.)	P1-P2 (PSID)	P1-P3 (PSID)			
	136.3	84	1155.4	1.23	923.5	1168.5	231.9	Q - FLOWRATE		
	136.3	84	1158.8	1.68	772.6	1171.4	386.2	T1 - INLET TEMP		
	136.8	84	1162.5	.74	688.2	1176.1	474.3	P1 - INLET PRESSURE		
	136.8	83	1162.7	.67	573.8	1176.3	588.9	P2 - THROAT PRESSURE		
	127.7	84	1163.4	372.7	1038.8	805.0	[redacted]	P3 - OUTLET PRESSURE		
	84.2	89	1152.7	827.0	1097.1	340.0	[redacted]			
	61.4	88	1153.7	986.7	1121.5	181.3	[redacted]			
	55.0	88	1160.8	1030.1	1133.5	145.0	[redacted]			
	36.4	88	1158.3	1111.4	1142.8	61.2	[redacted]			
	106.8	88	1150.8	604.3	1063.9	520.8	[redacted]			
	126.8	83	995.7	.81	718.0	1009.2	277.7			
	120.8	83	901.9	.83	571.5	915.4	390.4			
	112.0	83	775.8	.84	450.6	789.3	325.2			

C1-60

SK 8/18/90

SK [illegible]

WYLE

Procedure No. 4703

Page No. 13

DATA SHEET

CUSTOMER PERMUTIT

Test Title:

Specimen VENTURI

Part No.

Job No.

S/N N-5531

Date [illegible]

RUN NO.	Q (GPM)	T1 (DEG. F)	P1 (PSI)	P2 (PSIA)	P3 (PSI)	P1-P2 (PSID)	P1-P3 (PSID)			
	139.7	86	1162.7	1.28	888.1	1175.7	274.6	Q - FLOWRATE		
	139.9	80	1166.1	.76	764.1	1179.6	402.0	T1 - INLET TEMP		
	139.9	83	1166.1	.73	625.2	1179.7	540.9	P1 - INLET PRESSURE		
	140.3	85	1169.8	.76	533.9	1183.3	635.9	P2 - THROAT PRESSURE		
	121.1	86	1166.1	627.0	1014.6	553.4	[redacted]	P3 - OUTLET PRESSURE		
	101.5	83	1152.7	784.3	1050.6	382.7	[redacted]			
	82.3	83	1155.2	921.0	1087.9	248.5	[redacted]			
	62.4	83	1158.8	1029.6	1119.4	143.5	[redacted]			
	54.4	83	1159.0	1065.5	1129.1	107.8	[redacted]			
	36.1	83	1161.3	1129.5	1146.9	46.1	[redacted]			
	129.6	83	999.1	1.15	752.7	1012.3	246.4			
	123.6	83	904.9	1.10	662.6	918.1	242.3			
	114.7	83	775.5	1.16	502.2	788.6	273.3			

C1-61

SK 8/18/90

[illegible]

Page No. 13

DATA SHEET

CUSTOMER: PERMUTIT

Test Title:

Specimen: VENTURI

Part No.:

Job No.:

S/N: 5532

Date: 8/10/90

RUN NO.	Q (GPM)	TI (DEG. F)	P1 (PSIG)	P2 (PSIA)	P3 (PSIG)	P1-P2 (PSID)	P1-P3 (PSID)			
	136.5	83	1166.1	2.2	926.5	1178.2	239.6			
	136.1	86	1164.9	1.10	749.0	1178.1	415.9	Q - FLOWRATE		
	136.1	86	1164.9	1.10	654.5	1178.1	510.4	TI - INLET TEMP		
	136.1	86	1164.9	1.0	538.5	1178.2	626.4	P1 - INLET PRESSURE		
	136.1	87	1164.9	.87	403.2	1178.3	761.6	P2 - THROAT PRESSURE		
	136.1	87	1164.9	.83	246.1	1178.4	918.8	P3 - OUTLET PRESSURE		
	127.3	88	1168.3	426.3	1036.9	756.3	[redacted]			
	105.1	84	1165.4	673.9	1091.8	505.8	[redacted]			
	84.7	84	1166.6	860.9	1119.6	320.0	[redacted]			
	62.9	83	1162.5	998.4	1133.5	178.4	[redacted]			
	54.5	87	1166.1	[illegible]	1144.6	131.5	[redacted]			
	31.6	87	1168.6	[illegible]	1161.1	39.7	[redacted]			
	126.6	83	999.7	2.12	662.4	1011.9	337.3			
	120.4	83	903.7	1.81	561.0	916.2	342.7			
	112.2	83	777.9	1.23	427.5	791.0	350.4			

C1-62
SK 8/14/90

WYLE LABORATORIES

Procedure No. 4703

Page No. 15

DATA SHEET

CUSTOMER PERMUTIT

Test Title:

Specimen

Part No.

Job No.

S/N S/N: N-5530

Date 8/15/90

PT. NO.	Q (GPM)	T1 (DEG. F)	P1 (PSIG)	P2 (PSIA)	P3 (PSIG)	P1-P2 (PSID)	P1-P3 (PSID)			
1.	135.6	77	1140.5	.89	822.2	1153.9	318.3	Q - FLOWRATE		
2.	106.7	81	696.7	.78	517.8	710.2	178.9	T1 - INLET TEMP		
								P1 - INLET PRESSURE		
								P2 - THROAT PRESSURE		
								P3 - OUTLET PRESSURE		

C1-63

WYLE LABORATORIES

Procedure No. 4703

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DATA SHEET

CUSTOMER PERMUTIT

Test Title:

Specimen

Part No.

Job No.

S/N N-5532

Date 8/15/90

PT. NO.	Q (GPM)	T1 (DEG. F)	P1 (PSIG)	P2 (PSIA)	P3 (PSIG)	P1-P2 (PSID)	P1-P3 (PSID)			
1.	129.9	80	1055.1	.78	247.5	1068.6	807.6	Q - FLOWRATE		
2.	106.7	80	699.8	.69	304.7	713.4	395.1	T1 - INLET TEMP		
								P1 - INLET PRESSURE		
								P2 - THROAT PRESSURE		
								P3 - OUTLET PRESSURE		

C1-65

SK 8/28/90

Procedure No. 4703

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WYLE LABORATORIES

DATA SHEET

CUSTOMER PERMUTIT

Test Title:

Specimen

Part No.

Job No.

S/N N-5531

Date 8/15/90

PT. NO.	Q (GPM)	T1 (DEG. F)	P1 (PSIG)	P2 (PSIA)	P3 (PSIG)	P1-P2 (PSID)	P1-P3 (PSID)			
1.	109.1	79	~~1003.8~~ 698.6	.64	488.5	712.3	210.1	Q - FLOWRATE		
2.	130.0	79	1003.8	.74	516.1	1017.4	487.7	T1 - INLET TEMP		
								P1 - INLET PRESSURE		
								P2 - THROAT PRESSURE		
								P3 - OUTLET PRESSURE		

C1-64

SK 8/28/90

ENCLOSURE 2

PERMUTIT

CAVITATING VENTURI

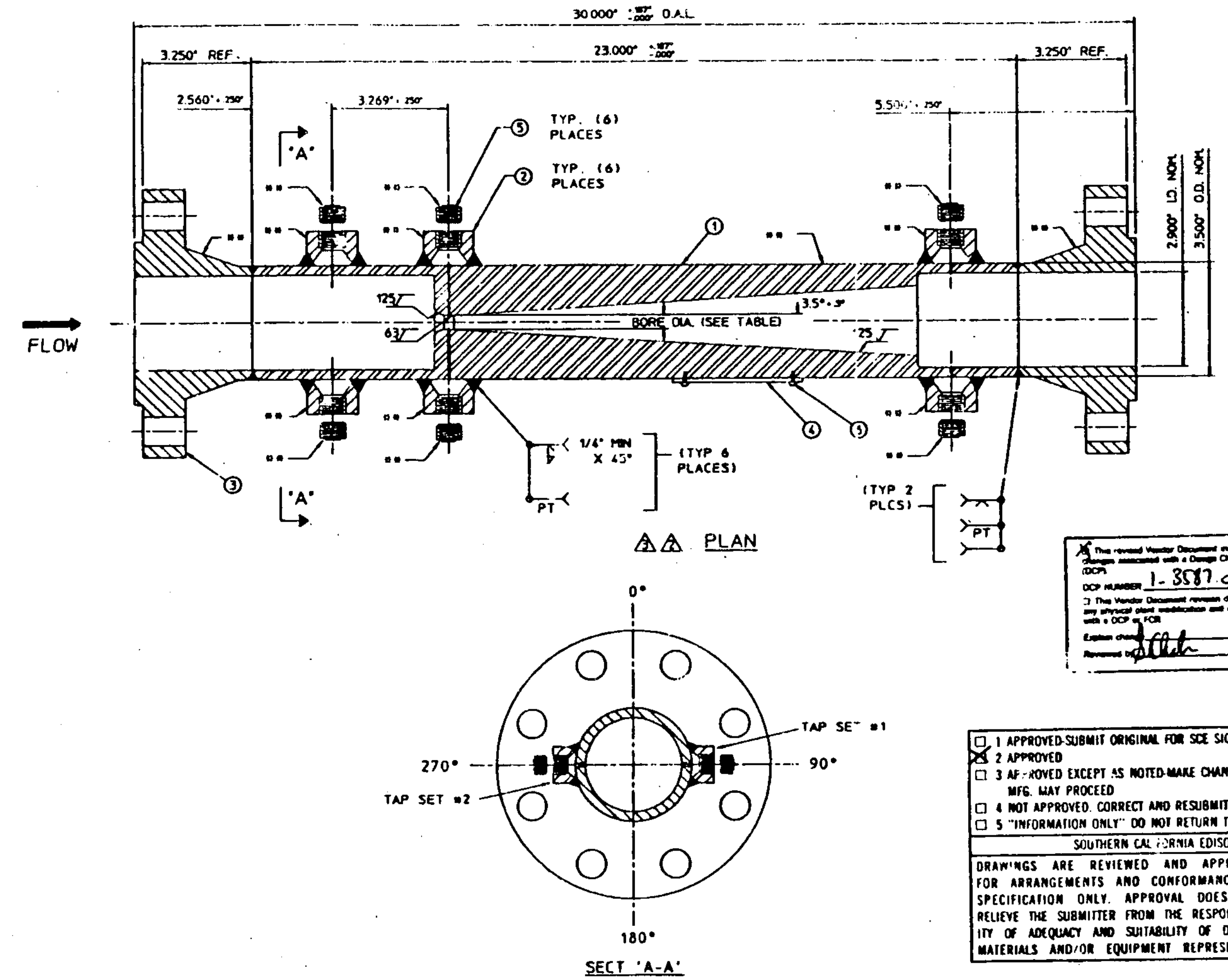
OUTLINE DRAWING

CUSTOMER TAG NUMBER	PERM[illegible] SERIAL NO	PIPE SIZE	BETA RATIO	DESIGN PRESSURE	DESIGN TEMP	OPERATING PRESSURE	OPERATING TEMP	DESIGN FLOW RATE (CAVITATING MODE)	[illegible]D	THROAT DIAMETER (*)
FE-3066	N-5530	3" - SCH 80	.1262	1330 PSIG	200 °F	1160 PSIG	60°F	140 +0/-5 GPM @ 60 °F	WATER	0.366"
FE-3076	N-5531	3" - SCH 80	.1262	1330 PSIG	200 °F	1160 PSIG	60°F	140 +0/-5 GPM @ 60 °F	WATER	0.366"
FE-3077	N-5532	3" - SCH 80	.1262	1330 PSIG	200 °F	1160 PSIG	60°F	140 +0/-5 GPM @ 60 °F	WATER	0.366"

556-34380

BILL OF M[illegible]IAL

ITEM	QTY	DESCRIPTION	MATERIAL
1	1	ELEMENT - BODY	ASTM A-182, F304 S.S.
2	6	1/2" - 6000# THREADOLETS	ASTM A-182, F304 S.S.
3	2	3" - 600# RFWN FLANGE	ASTM A-105, C.S.
4	1	NAMEPLATE	ASTM A-240, 300 SERIES S.S.
5	6	1/2" PIPE PLUGS	ASTM A-182, F304 S.S.
6	4	DRIVE PINS	300 SERIES S.S.



NOTES:

1. GOVERNING CODE: ANSI/ASA B31.1 1989 EDITION.
2. ESTIMATED WEIGHT - 130 LBS.
3. HYDROTEST PRESSURE - 1995 PSIG. (1.5 X DESIGN PRESSURE).
4. ** - INDICATES MATERIAL IDENTIFICATION MARK (APPROXIMATE LOCATION).
5. STAMP TAP SET NUMBERS ON BODY ADJACENT TO EACH TAP SET. USE LOW STRESS INTERRUPTED DOT DIE STAMP. TAP SET ORIENTATION IS IN HORIZONTAL PLANE WITH TAP SET #1 @ 90°, #2 @ 270°. EACH 'TAP SET' CONSISTS OF THREE (3) TAPS, THE UPSTREAM, THE THROAT AND THE RECOVERY TAP.
6. PIPE PLUGS (ITEM 5) WILL BE SCREWED HAND TIGHT IN THE THREADED TAP SOCKET FOR SHIPMENT. THESE SOCKETS WILL THEN BE COVERED WITH TAPE PRIOR TO FINAL PACKAGING.
7. THE TERM 'REFERENCE' IMPLIES 'FOR INFORMATION ONLY'.
8. * - THE THROAT DIAMETER AS NOTED IS FOR REFERENCE ONLY. THE AS BUILT/CALIBRATED DIMENSION WILL BE RECORDED LATER.
9. (Δ1) THE FOLLOWING DESIGN CONDITIONS ARE ALSO APPLICABLE IN ADDITION TO THE DESIGN FLOW RATE (CAVITATING MODE) NOTED IN THE TABLE ON THIS DRAWING.

CASE	INLET PRESSURE (PSIG)	Δ P (PSID)	FLOWRATE (GPM)	TEMP (°F)	CAVITATING
1	1160	N/A	140, +0, -5	60	YES
2	775	N/A	100, +0, -0	60	YES
3	N/A	< 35	55	60	NO
4	N/A	< 45	62.5	60	NO

☒ This revised Vendor Document incorporates changes associated with a Design Change Package (DCP)
DCP NUMBER 1-3587.01SM REV A
☐ This Vendor Document revision does not reflect any physical plant modification and is not associated with a DCP or FCR
Explain change:
Reviewed by [signature] Date 8/15/[illegible]

☐ 1 APPROVED-SUBMIT ORIGINAL FOR SCE SIGNATURE
☒ 2 APPROVED
☐ 3 APPROVED EXCEPT AS NOTED-MAKE CHANGES AND RESUBMIT MFG. MAY PROCEED
☐ 4 NOT APPROVED. CORRECT AND RESUBMIT FOR REVIEW
☐ 5 "INFORMATION ONLY" DO NOT RETURN TO SUPPLIER

SOUTHERN CALIFORNIA EDISON CO.

DRAWINGS ARE REVIEWED AND APPROVED FOR ARRANGEMENTS AND CONFORMANCE TO SPECIFICATION ONLY. APPROVAL DOES NOT RELIEVE THE SUBMITTER FROM THE RESPONSIBILITY OF ADEQUACY AND SUITABILITY OF DESIGN, MATERIALS AND/OR EQUIPMENT REPRESENTED.

SIGNED: RE [signature] PGL [signature]
DATE 8-20-90
C.D.M.

1810-AA319-D0018-[illegible]1

DO NOT SCALE THIS DRAWING - USE DIMENSIONS ONLY

V2-1
34196

REV	BY	DATE	REVISIONS
1	JVP	5-22-90	ADDED NOTE 9. RKS 5-23-90, LCP 5-23-90.
2	JVP	5-29-90	REVISED PLAN VIEW. RKS 5-30-90, LCP 6-1-90.
3	JVP	6-6-90	RESTORED VENTURI BODY (ITEM 1) TO ONE-PIECE DESIGN. REVISED PLAN VIEW. [handwritten initials]

SOUTHERN CALIFORNIA EDISON
SAN ONOFRE
NUCLEAR GENERATING STATION
UNIT #1
S.C.E. PO. # 8P030009

DRAWN PIETRUCHA
CHECKED RKS 5/07/90
APPROVED LCP 5/08/90
DATE 5-03-90
SCALE NONE

OUTLINE DRAWING
3" CAVITATING VENTURI
AUX. FEEDWATER SYSTEM
PERMUTIT JOB NO. A177057457

PERMUTIT

DRAWING NO.	REV
556-34380	3

SHEET 1 OF 1