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TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

DPST-84-228

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December 9, 1983

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L-AREA CAVITATION TESTS
FINAL ANALYSIS - LIMITS APPLICATION

INTRODUCTION AND SUMMARY

The L Area cavitation test was designed to better define the onset of cavitation in the reactor system. Preliminary tests began in early 1983 and the L Area tests were completed in October, 1983. The onset of gas evolution in the effluent piping and pump cavitation was measured using state-of-the-art equipment to provide data with a high confidence and low uncertainty level. The limits calculated from the new data will allow an approximate 2% increase in reactor power if the reactor is effluent temperature limited with no compromise in reactor safety.

*Appendix Not Included

OUTLINE

Purpose of L Area Test

The L Area cavitation test was designed to better determine the conditions at onset of pipe and pump cavitation. Cavitation can adversely effect system performance and, over a long period (several months), cause pump impeller erosion. The reactor effluent temperature limit protects the SRP reactors from cavitation. The limits are currently based on a series of tests run in K Area in 1957[1] and tests by the Bingham Pump Company[2] run in 1956. The data from these earlier tests have a large uncertainty applied to them because of nonidealities, measurement techniques, and undefined differences among the reactor systems to which they are applied.

Review of Preliminary Work

Several preliminary tests were run to study the cavitation phenomena and establish detection techniques. This preliminary work is described in detail in DPST-83-2006.[3] The basic conclusions drawn from these tests were:

1. Gas evolution will preceed cavitation.

2. Damage to pipe walls would be less severe than previously thought.

3. Cavitation can be easily detected with acoustic monitoring techniques.

4. Cavitation can also be detected by an increase in pressure drop through the effluent piping.

Test Description - Instrumentation

A special instrumentation package was designed for the L Area cavitation test. The Equipment Engineering Department assisted in the procurement, calibration, and installation of the following instruments in 105-L.

- 1 Displacement probe (system #2 ramshorn)
- 6 Bingham Pump DP transducers
- 6 Pump suction pressure transducers
- 6 Temperature transducers (failed due to improper electrical isolation)
- 1 Low pressure header transducer
- 1 Bottom tank centerline pressure transducer
- 1 Effluent line pressure tap (system 1 by biological shield)
- 2 Ultrasonic flowmeters (failed at temperatures above 80°C)
- 2 Fast response pressure transducers (connected to monitor pins)
- 1 Atmospheric pressure transducer (in process room)

The outputs from these transducers were connected to the vibration and acoustic monitoring (VAM) system. The VAM is a newly installed permanent system which uses accelerometers to monitor for vibration related problems in the radiation zone.

Twelve of the accelerometers were used during the test to monitor for cavitation noise.

The location of all of the transducers and the instrumentation layout are shown schematically in Figures 1 and 2.

The VAM took only 35 seconds to scan all of the sensors. Approximately 10 MBYTES of data were collected and stored on disk.

Procedure

Five separate cavitation tests were run with different and varying number of pumps on line. No blanket gas was applied and the septifoil flow was shut off. During each test, pump heat was used to increase the temperature of the flowing fluid and take the system into cavitation. When one of the following limits was reached cooling water flow to the heat exchangers was cut on to cool the fluid and stop the cavitation.

Limits:	10%	drop in pump DP
	5%	drop in flow
	6.5 g's	pump acceleration
	150 mils	ramshorn displacement
	98°C	moderator temperature

It should be noted that the 10% drop in pump DP limited all of the tests because the pump DP becomes very erratic as soon as the pump begins to cavitate.

AC Start Up

The startup of the AC motors was monitored during all of the testing. The accelerations during startup ranged from 8 to 13 gs if the system was cold and only 2 to 3 gs if the system was at 50°C or higher.

Three Pump Test

The three pump test was run with the tank at overflow. Systems 1, 2, and 5 were operating. During the three pump test, system flows were approximately 30 KGPM.

Five Pump Test

The test was run with the tank at overflow. Only system six was not operating. System flows ranged from 26 to 28 KGPM.

Six Pump Tests

Three tests were run with all six systems operating, one test was run at a tank level of 8.2 feet* and the others at a tank level of 9.2 feet*. The tank level was lowered to induce cavitation below the 98°C limit. System flows ranged from 24 to 26.5 KGPM.

Description of the Phenomena

The cavitation tests had three distinct stages - heat-up, gas evolution, and pump cavitation. These stages can be seen on the preliminary data plots of acceleration, pump DP, and temperature verses time shown in Figure 3. The first stage includes the normal operating region. Pump DP and acceleration decrease slowly as the system temperature increases.

Gas Evolution

The second stage is marked by an increasing pump DP and decreasing acceleration caused by the evolution of dissolved gases in the fluid. This phenomenon was seen in the preliminary tests at Georgia Iron Works. As conditions at the muff begin to approach the saturation temperature and pressure of the flowing fluid, dissolved non-condensible gases come out of solution. These gases cause an increase in the pressure drop from the tank to the pump suction - lowering the suction pressure and increasing the pump DP. The evolved gases also allow slight compressibility of the flowing fluid which decreases the flow noise and pipe/pump acceleration.

Pump Cavitation

Because the pump suction pressure is dropping and temperature is still increasing during stage two, the pump soon begins to cavitate. The third and last stage of the phenomena is marked by extremely erratic pump DP and a marked increase in acceleration. This is the pump cutoff point. The pump itself is cavitating, impeller erosion is beginning, and any increase in temperature or reduction in system pressure will cause a significant flow reduction.

*See Appendix E

Technical Limit

The technical limit is set to prevent steady state operation of a reactor in a region where damage may take place.[4] The technical limit is set at the first indication of gas evolution in the effluent lines. Several measurements were used to determine the onset of gas evolution. Plots of pump DP, pump acceleration, and effluent line (elbow) DP verses temperature were analyzed. The raw data is shown in Table 1; the plots are in Appendix A; and the technical limit as calculated for L reactor with 5 PSIG blanket gas is shown in Figure 4. The raw data was adjusted by the procedure described in Appendix B.

The adjusted L-Area data can be curve fitted using the following equation in a range of 24 to 30 KGPM system flow.

Technical Limit, °C at 5 PSIG blanket gas pressure

$$T = 49.2296 + 5.31218 \times F - 0.12177 \times F^2$$

where F is system flow in KGPM

Pump Cutoff Curves

The pump cutoff curve is used in the transient protection limits analyses to establish temperatures at which pump flow is significantly affected by cavitation.[4,5] Plots of pump DP and pump acceleration (Appendix A) were analyzed to determine the pump cut off point. Also the data from the Bingham Pump Company tests, contained in Appendix C, was analyzed to assure that this was the pump cutoff point. The raw data is shown in Table 2 and Figure 5 show the pump cutoff curves for L reactor at 5 psig blanket gas pressure.

The adjusted L-Area pump cutoff data can be curve fitted using the following equations in a range of 24 to 30 KGPM system flow.

Pump Cutoff limit, °C at 0 PSIG blanket gas pressure

$$T = 2.34795 + 8..56714 \times F - 0.1883 \times F^2$$

Pump Cutoff limit, °C at 5 PSIG blanket gas pressure

$$T = 41.78315 + 5.91187 \times F - 0.131216 \times F^2$$

where F is system flow in KGPM

Uncertainty Analysis*

The uncertainties of the measured parameters during the L

*Appendix C contains instrument calibration data.

area test are described below. Each uncertainty is converted to a temperature uncertainty by the use of the D_2O saturation curve, the current pump cutoff curve, or the moderator heat up data. As shown, the uncertainties (ω) are combined as independent variables (square root of sum of squares) to yield an overall value.

ω_{TL} Tank Level $\pm$3" (0.12 psi x 2.5°C/1 psi @ 90°C)	$\pm$ 0.3°C
ω^{**}_F Flow (pump DP) $\pm$ 1.8 psid ($\pm$0.4 KGPM x 1.2°C/1 KGPM @ 25 KGPM)	$\pm$ 0.48°C
ω_t Time $\pm$ 30 sec. (x 0.3°C/60 sec)	$\pm$ 0.15°C
ω_{RTD} RTD $\pm$ 0.15°C	$\pm$ 0.15°C
ω_{CRE} Curve Reading Error	$\pm$ 0.15°C

$$\omega_{DATA} = (\omega_{TL}^2 + \omega_F^2 + \omega_t^2 + \omega_{RTD}^2 + \omega_{CRE}^2)^{1/2} = 0.62°C$$

An uncertainty must be applied to account for the differences in the six reactor systems. Figure 6 was used to determine this uncertainty.

$$\omega_{RS} = \pm 1.45°C$$

An uncertainty must be applied to account for the fact that the six reactor systems do not have the same flow. Even though the limit is applied to the hottest system in a reactor, this could be the lowest flow system.

$$\omega_{SF} = \pm 1.32°C \quad (\pm 1100 \text{ GPM})$$

Two more uncertainties[6] unrelated to the test, but related to the limits application must be included. The uncertainty in reactor temperature monitoring and the uncertainty in blanket gas pressure.

$$\omega_M = \pm 0.9°C \qquad \omega_{BGP} = \pm 0.8°C$$

$$\omega_{Total} = (\omega_{DATA}^2 + \omega_{RS}^2 + \omega_{SF}^2 + \omega_M^2 + \omega_{BGP}^2)^{1/2} = \pm 2.4°C$$

With this uncertainty applied to the L Area test data the limits can be used in P, K, L reactors with high confidence. Note that by using several different types of analysis techniques, (pump DP, acceleration, and suction line DP) the confidence in the data is greatly increased. Also, the good agreement between the K-Area,

**Flow was calculated from pump DP using equation in DPST-83-282.

Bingham Pump Co., and L-Area data indicates that there is no significant variation in the cavitation temperatures for different reactors.

It should be noted that the effect of temperature on fluid properties[7] was not accounted for in the adjustment of the raw data (see Appendix D). This conservatism amounts to approximately 1.5°C. Further laboratory testing could possibly prove the assumptions made in Reference 3 and allow the reduction of this conservatism.

C-Area Limits[4,8]

The data from L Area cannot be directly applied to C Area. It is the opinion of the author that no extrapolations or similitude analyses would improve the uncertainty of the C Area limits. However, it is comforting to note that the new L Area data lined up so well with the Bingham Pump Company data that is used in calculating the C-Area limits.

Audit

The calculation procedure and limits presented in this document have been audited by W. M. Massey, Jr. of Reactor Technology Department of SRP and L. L. Hamm of the Nuclear Engineering Division of SRL.

Summary

The onset of gas evolution and pump cavitation has been well defined by the L Area tests. The lower uncertainty associated with the new data will allow a safe increase in reactor power.

DCW:cjl

<u>REFERENCES</u>

1. DPSP-57-1405, "Cavitation Characteristics of Bingham Pumps".
2. Bingham Pump Company Tests 1-64160, K to O.
3. DPST-83-2006, "Preliminary and Intermediate Cavitation Tests".
4. DPSTM-110.
5. DPSP-66-1322, "Limits On Reactor Effluent Temperature".
6. TA-1-2134, "Reduction of Reactor Effluent Uncertainty Analysis".
7. Stepanoff, A. J. <u>Centrifugal and Axial Flow Pumps</u>, 2nd. Edition, John Wiley & Sons.
8. DPST-81-845, "Revised Effluent Technical Limit for C-Reactor".
9. DPST-84-227, "L-Area Cavitation Tests - Raw Data".
10. Laboratory Notebook E35146, DPSTN-4197.
11. Laboratory Notebook E35145, DPSTN-4196.

TABLE 1
TECHNICAL LIMIT - RAW DATA

Test	System	Flow	T (Pump DP)	T (Accel)	T (Elbow DP)
6 - 1	1	25360 GPM	83° C	80° C	81° C
	2	26310	83	83.5	83
	3	26125	82.8	82	82
	4	24980	82.6	83	83
	5	24317	85.5	85	82
	6	-	-	-	-
6 - 2	1	25321	84.5	84	82
	2	26274	84.5	85.2	84.5
	3	26085	84.5	83	84
	4	25091	82	86.4	84.5
	5	24256	84	85	84
	6	-	-	-	-
6 - 3	1	25341	83.7	-	82.7
	2	26455	84.8	-	84.8
	3	26251	85.5	-	83.5
	4	25110	85.2	-	85.5
	5	24311	85.7	-	85
	6	-	-	-	-
5	1	27309	92	93.5	91.5
	2	28073	94.5	92	92.7
	3	27981	90.5	92	92
	4	26753	92	95	94.5
	5	26234	94	94	93.2
3	1	30591	82	85.5	82
	2	31640	84.5	86	85.5
	5	30413	82.5	82.5	82

(-) Indicates Bad Data

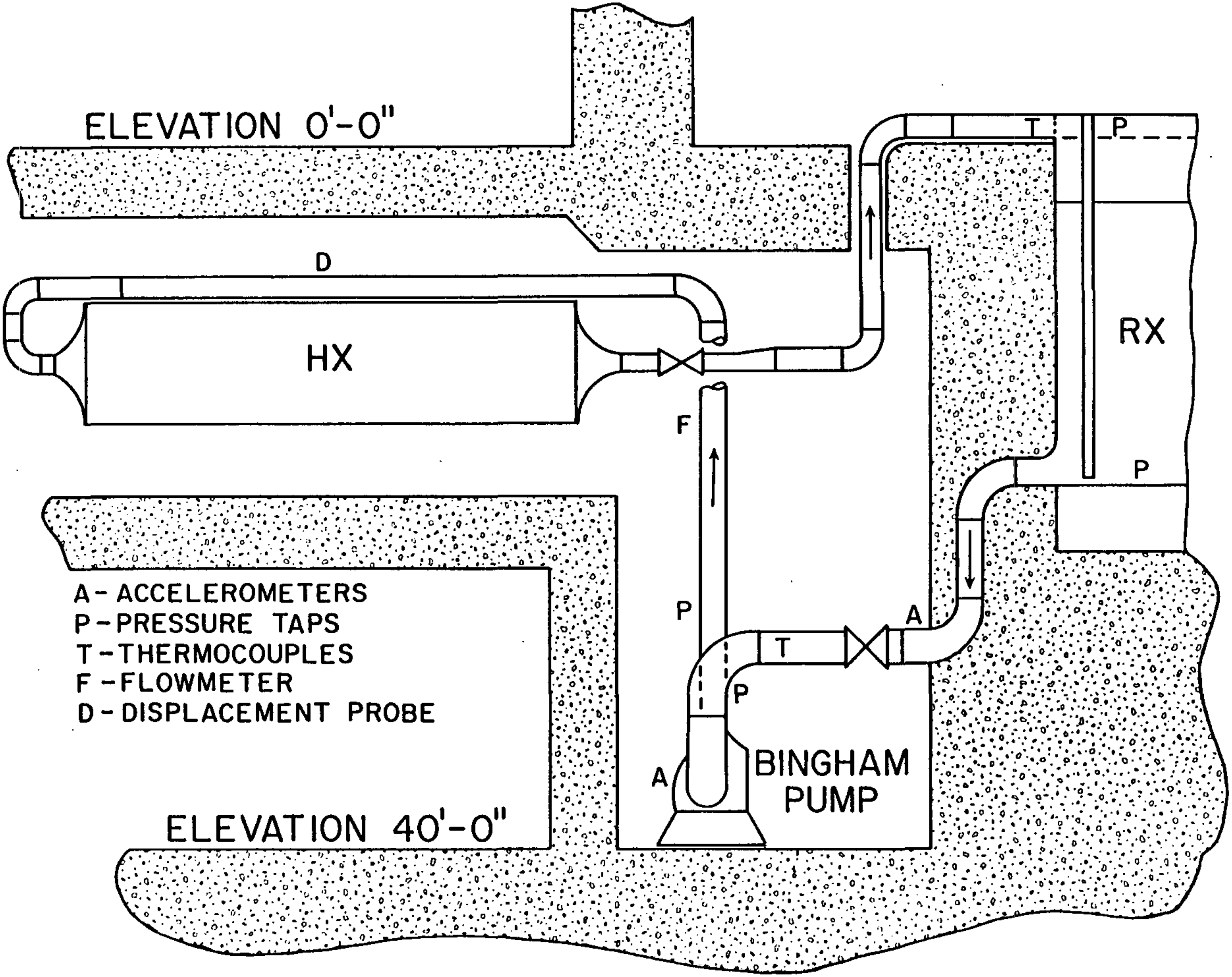
TABLE 2
PUMP CUTOFF LIMIT - RAW DATA

Test	System	Flow	T (Pump DP)	T (Accel)
6 - 1	1	25360 GPM	84.8	87.0
	2	26310	86.0	87.5
	3	26125	85.5	88.0
	4	24980	87.7	88.0
	5	24317	86.8	87.5
	6	-	-	-
6 - 2	1	25321	86.0	86.5
	2	26274	86.5	87.3
	3	26085	87.0	86.9
	4	25091	87.0	89.0
	5	24256	87.0	87.5
	6	-	-	-
6 - 3	1	25341	86.0	-
	2	26455	87.0	-
	3	26251	87.8	-
	4	25110	88.8	-
	5	24311	87.3	-
	6	-	-	-
5	1	27309	93.0	95.5
	2	28073	95.5	95.4
	3	27981	95.0	96.0
	4	26753	95.0	97.0
	5	26234	96.0	95.8
3	1	30591	86.0	87.0
	2	31640	86.5	88.5
	5	30413	86.0	87.0

(-) Indicates Bad Data

FIGURE ONE

INSTRUMENTATION LOCATIONS



INSTRUMENTATION LAYOUT SCHEMATIC

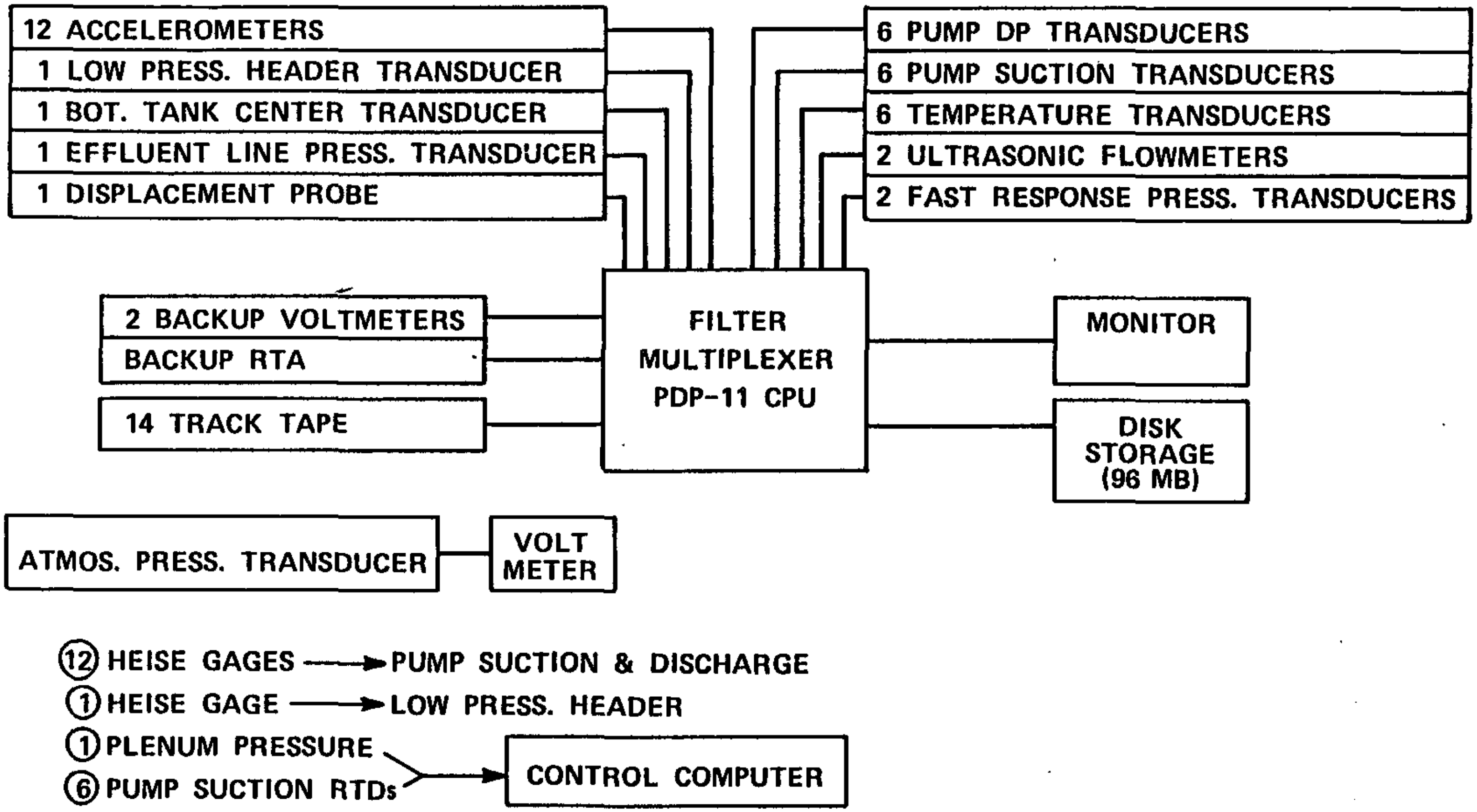


FIGURE TWO

FIGURE THREE

CAVITATION PHENOMENA

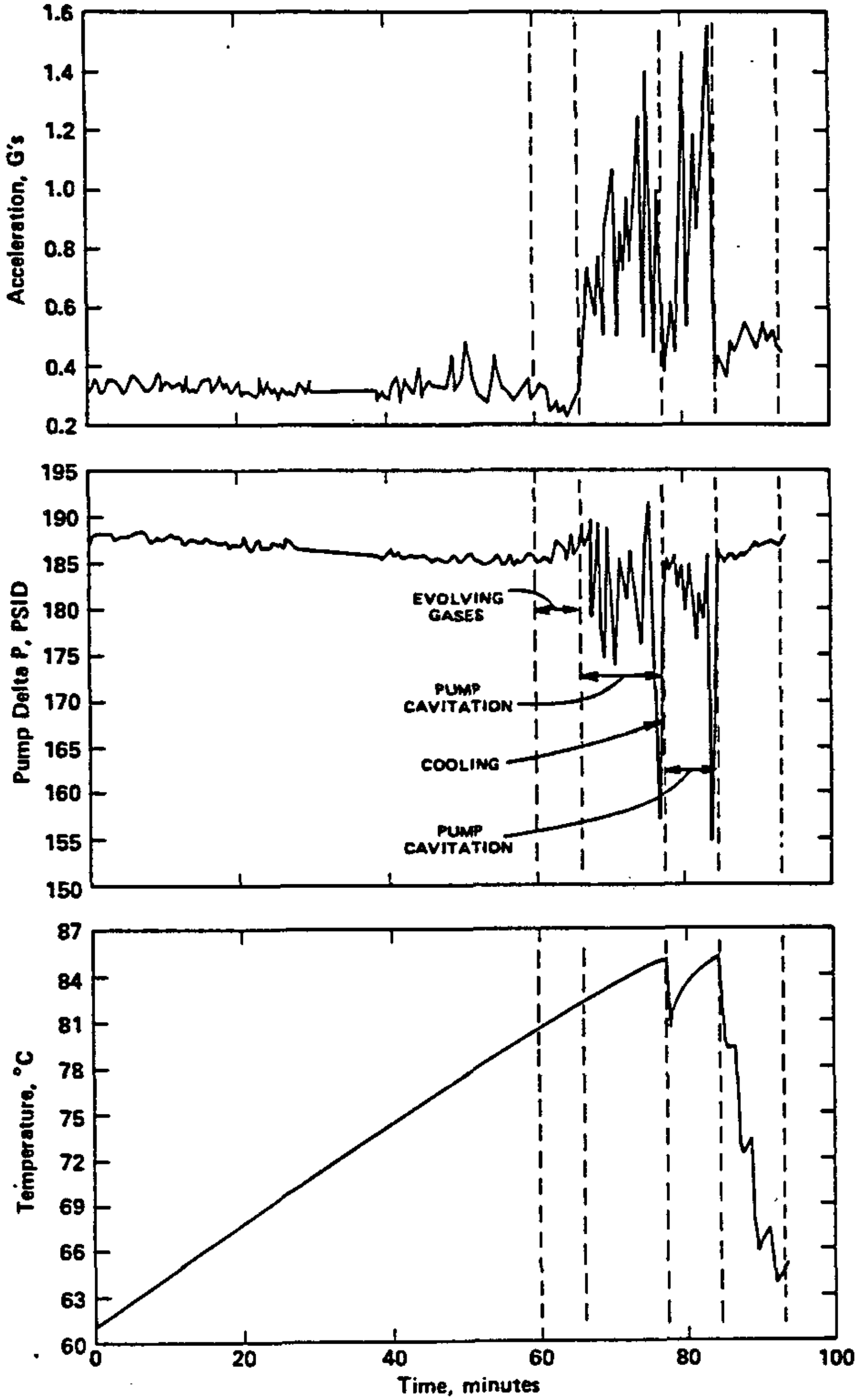
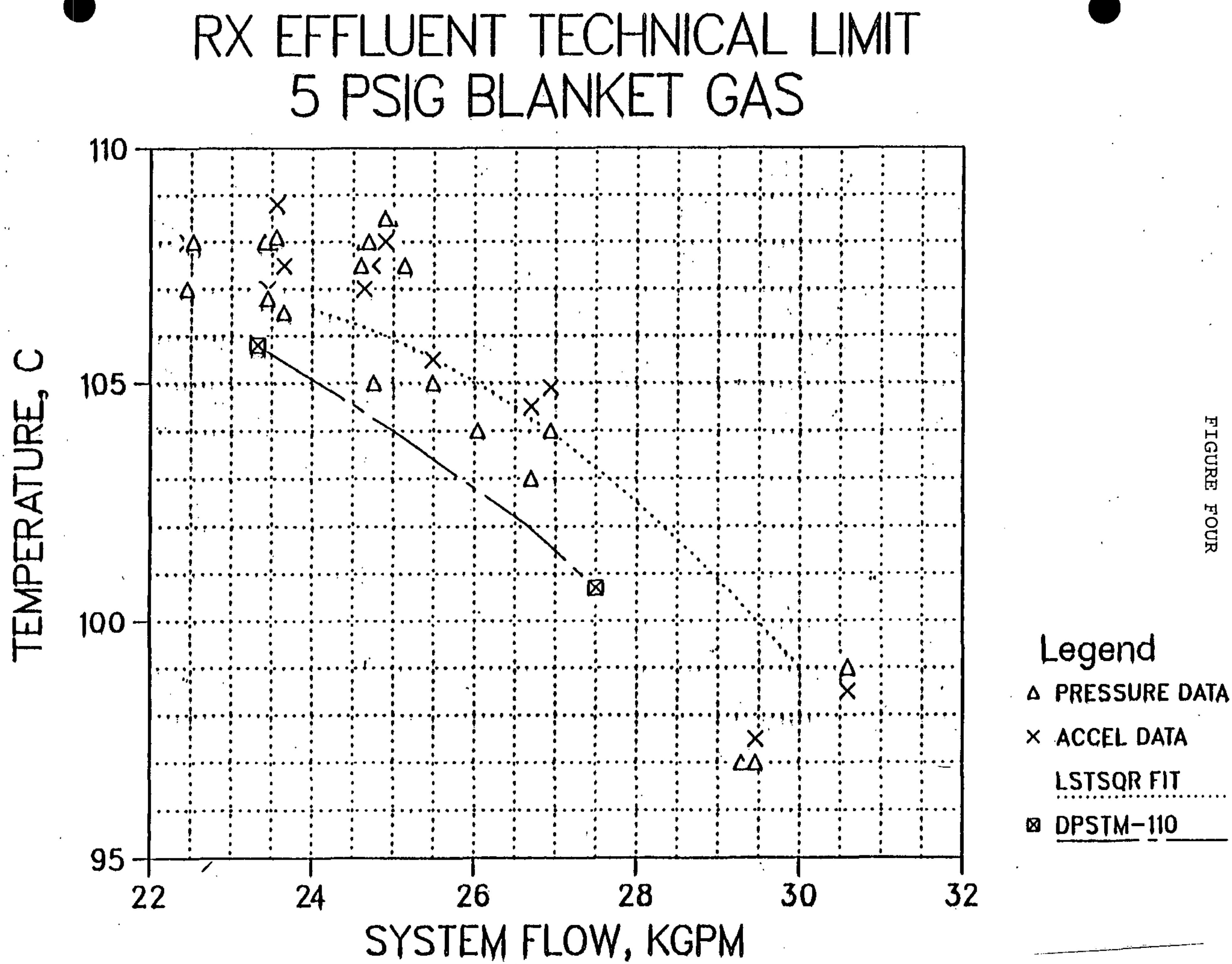


FIGURE FOUR



RX EFFLUENT TECHNICAL LIMIT
5 PSIG BLANKET GAS
TEMPERATURE, C
110
105
100
95
22
24
26
28
30
32
SYSTEM FLOW, KGPM
Legend
PRESSURE DATA
ACCEL DATA
LSTSQR FIT
DPSTM-110

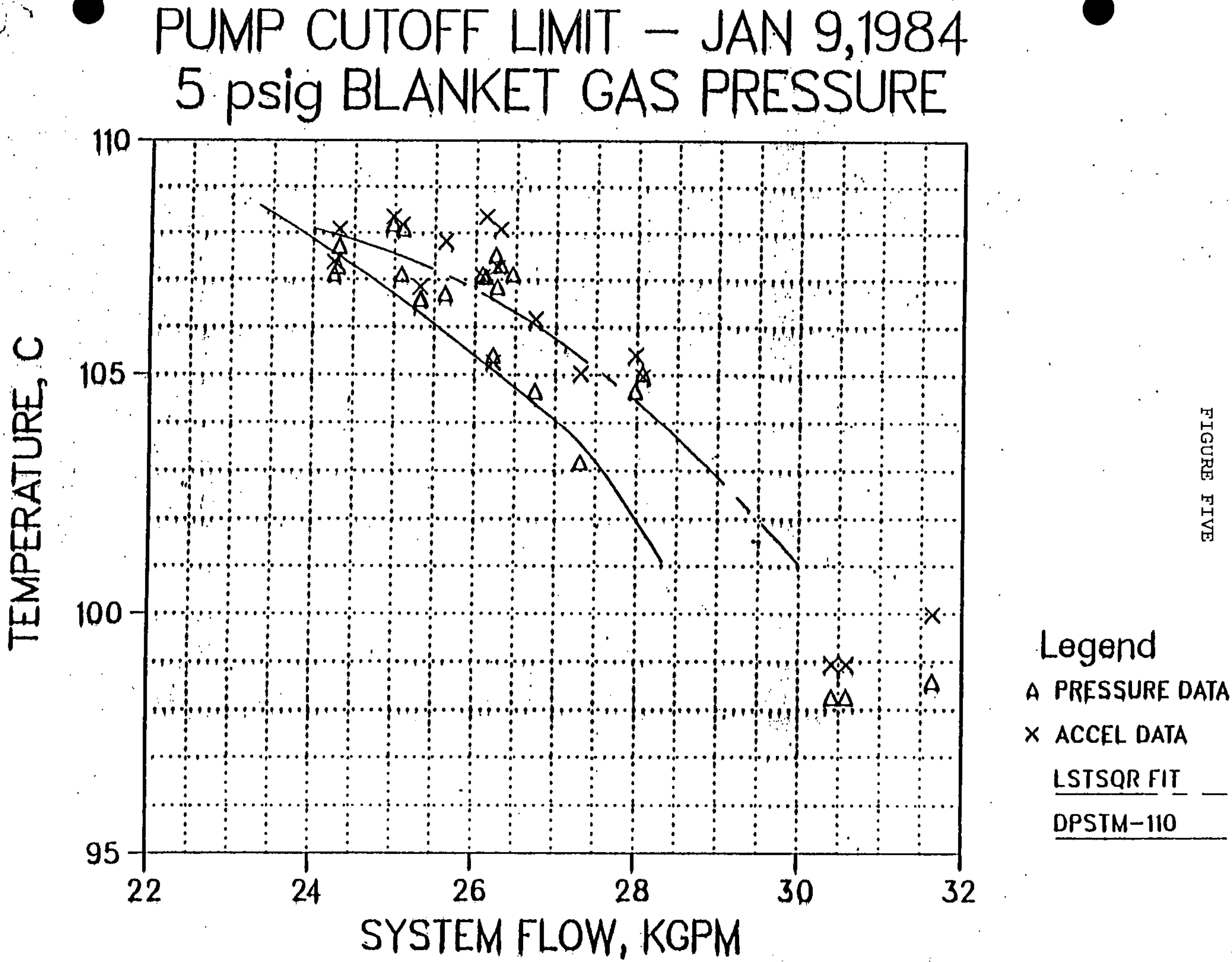

PUMP CUTOFF LIMIT — JAN 9,1984
5 psig BLANKET GAS PRESSURE
110
105
100
95
TEMPERATURE, C
22
24
26
28
30
32
SYSTEM FLOW, KGPM
Legend
PRESSURE DATA
ACCEL DATA
LSTSQR FIT
DPSTM-110

FIGURE FIVE

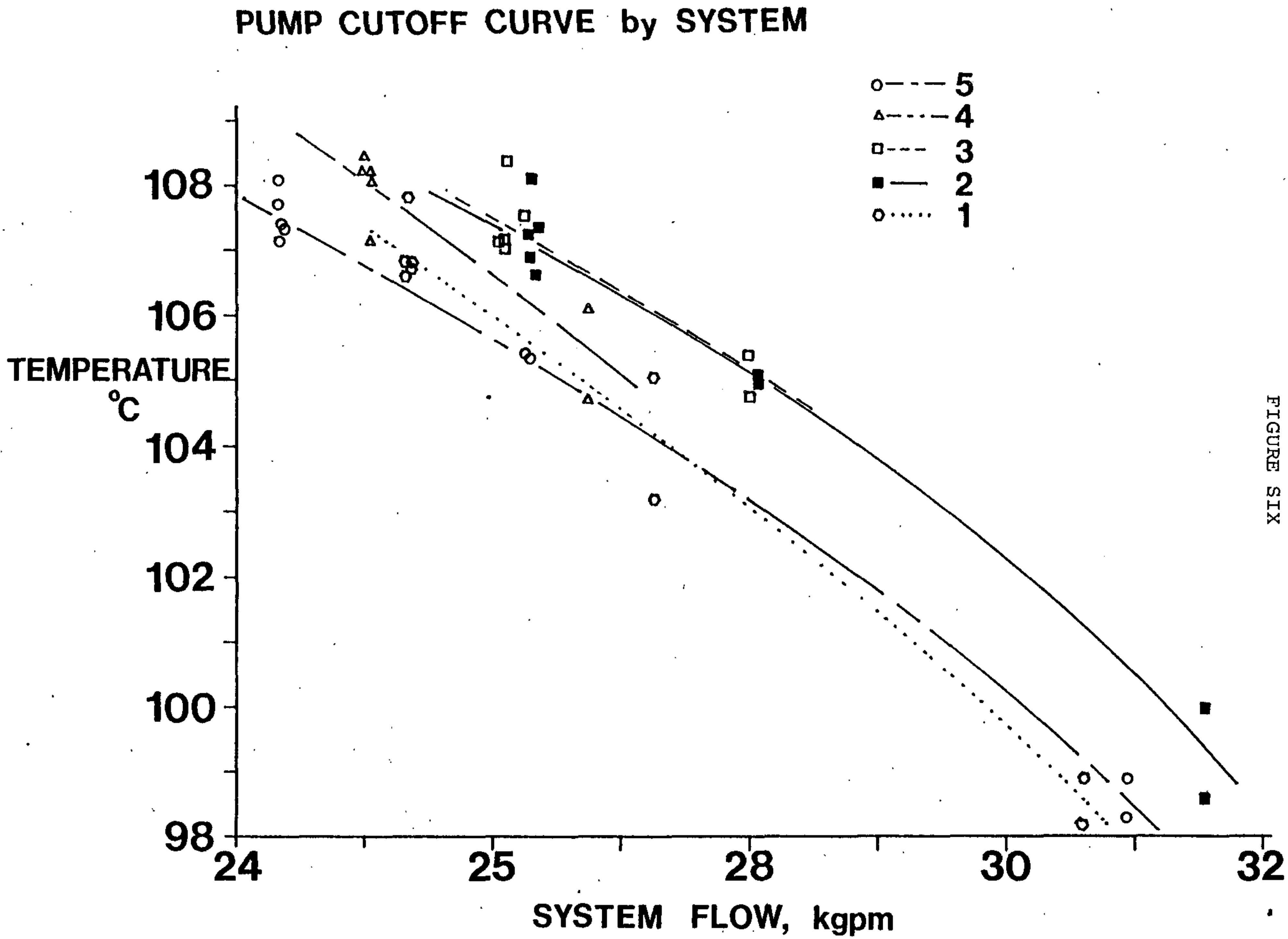

PUMP CUTOFF CURVE by SYSTEM
5
4
3
2
1
108
106
104
102
100
98
TEMPERATURE °C
24
25
28
30
32
SYSTEM FLOW, kgpm

FIGURE SIX

APPENDICES

A) Data Curves
   1) Pump DP vs. Temperature
   2) Acceleration vs. Temperature
   3) Elbow DP vs. Temperature

B) Data Adjustment Procedure

C) Calibration Data

D) Fluid Property Effects

E) Low Pressure Header and Tank Level

F) Dissolved Gases

G) Bingham Pump Company Data

H) Uses of the L-Area Test Data and Miscellaneous Calculations

Appendix A - Data Curves

1) Pump DP vs. Temperature

These curves contain the pump delta P measured during each of the cavitation tests plotted against the associated RTD temperature readings. The pump DP becomes very erratic with cavitation. The system 6 pump DP is in error because of a problem in the pump suction pressure tap.

NOTES: The first plot in each set shows all system curves and the individual system curves flow.

Any lines or markings on the curves are not necessarily representative of the limits.

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,1

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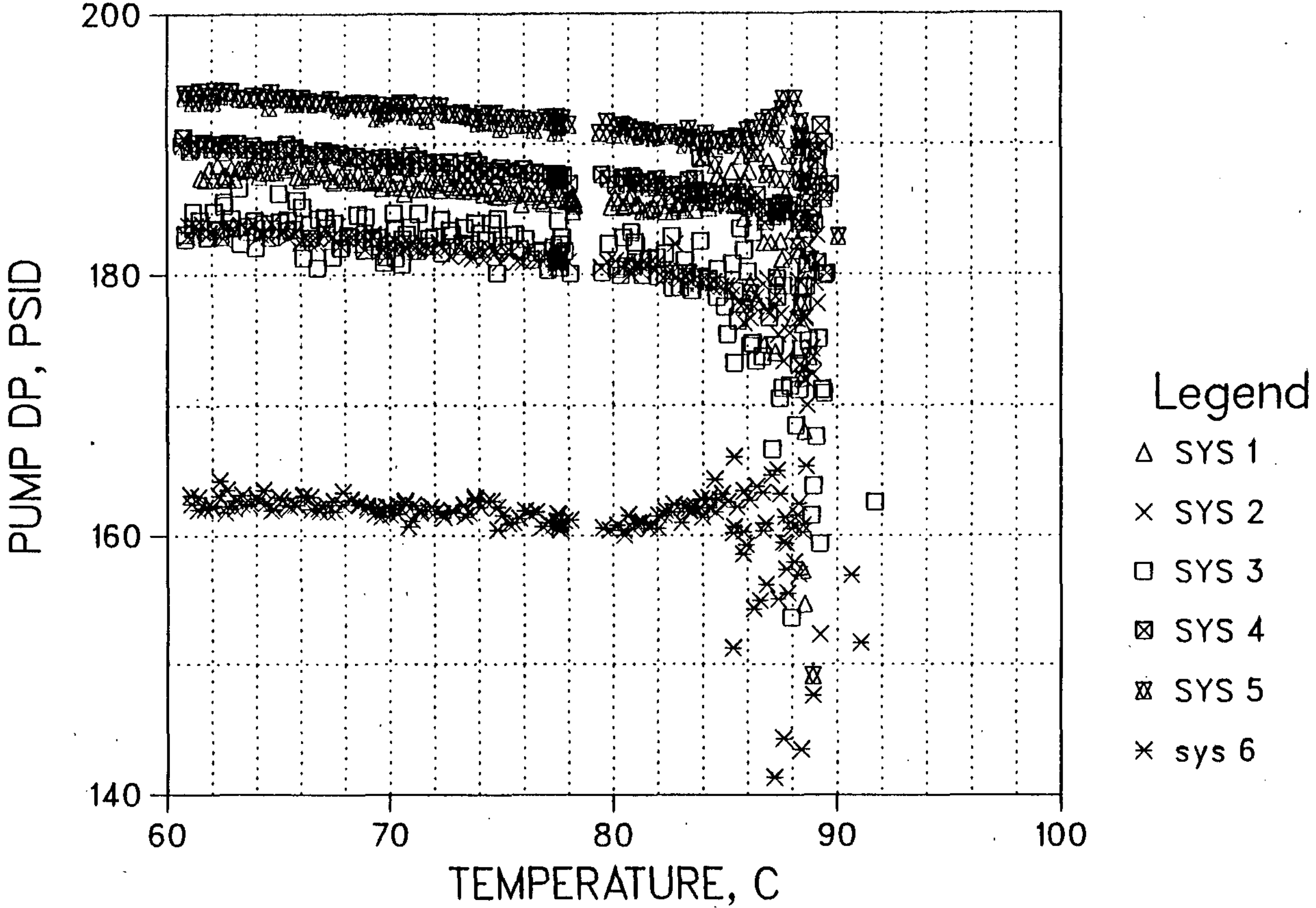

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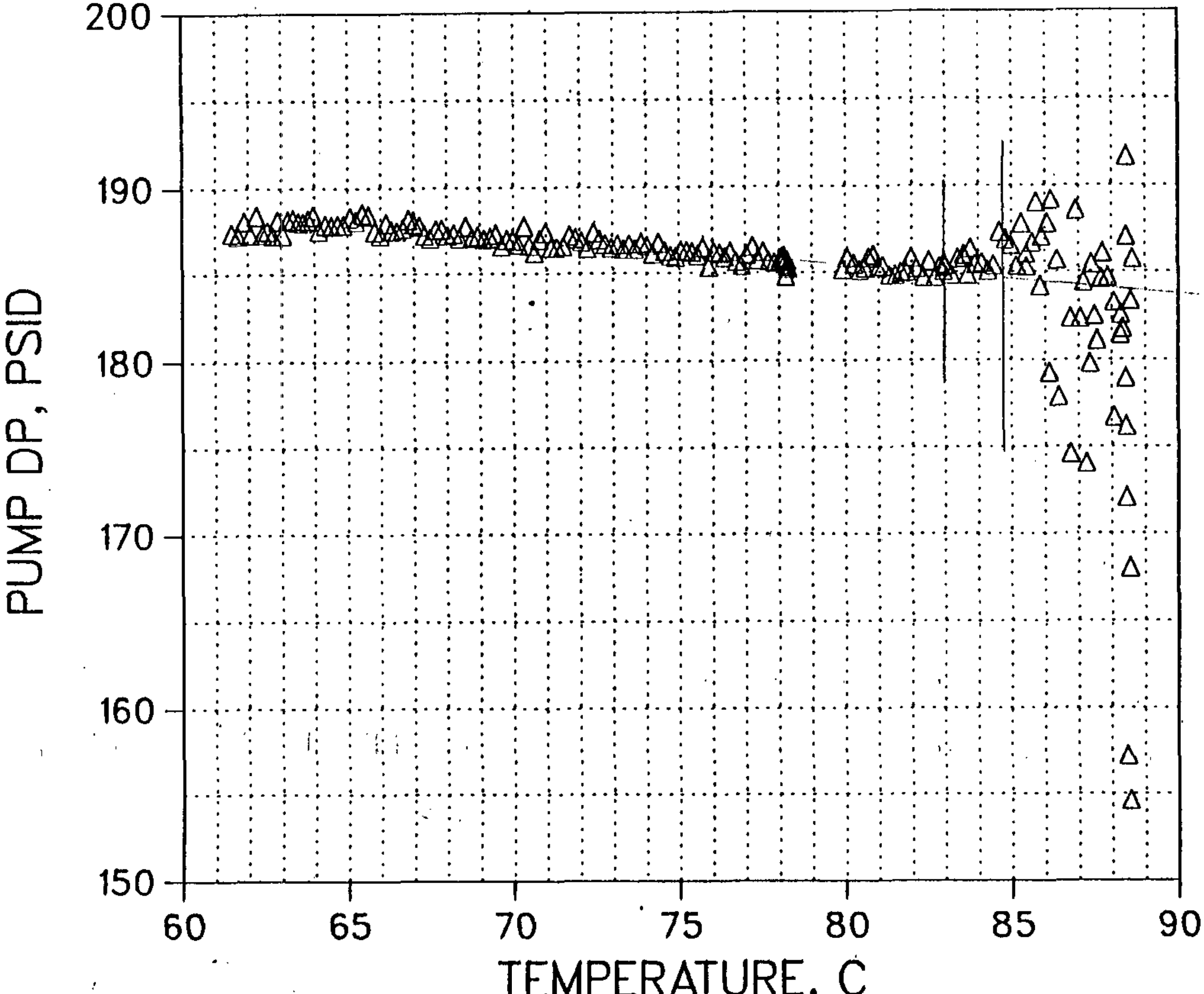

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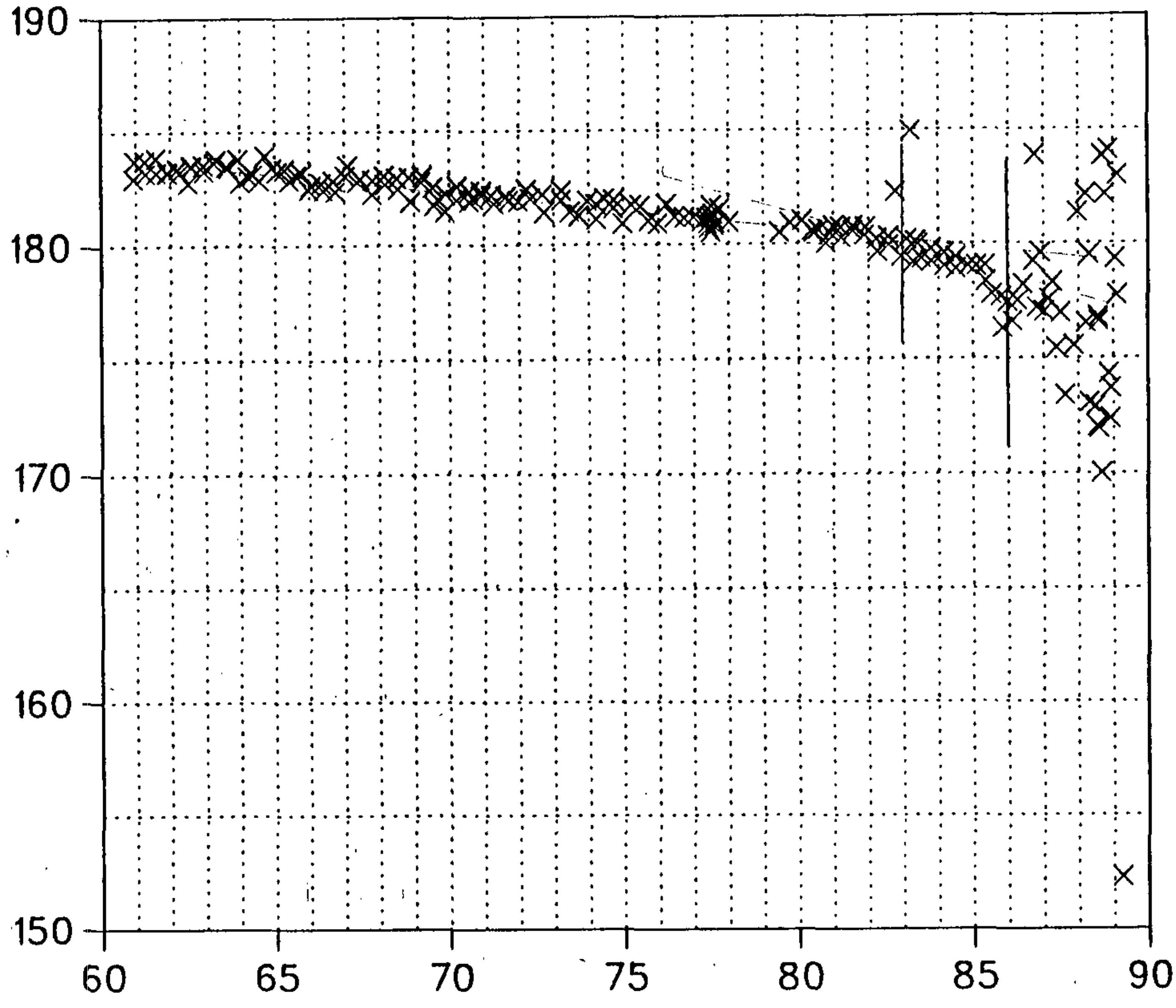

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PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,1

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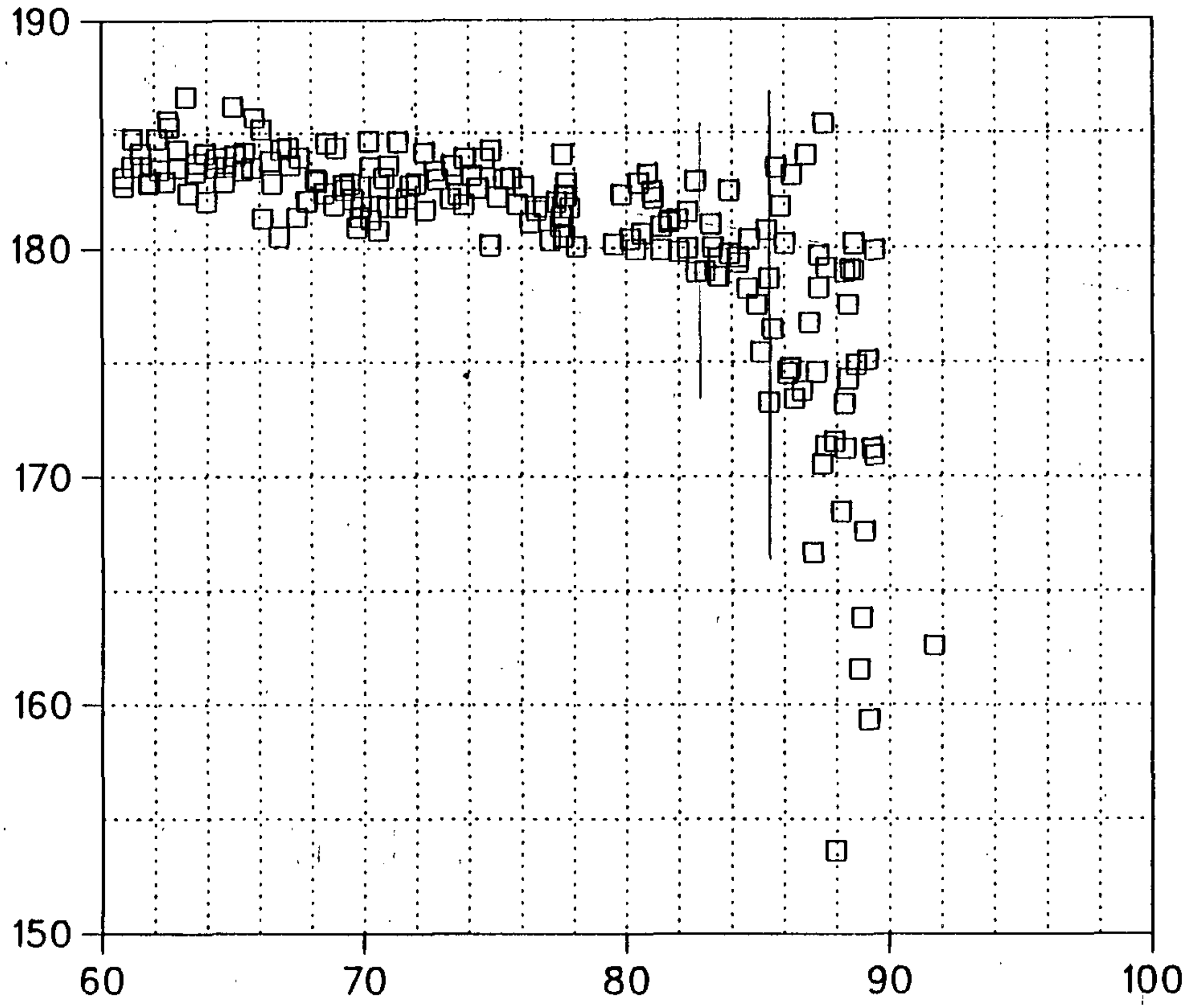

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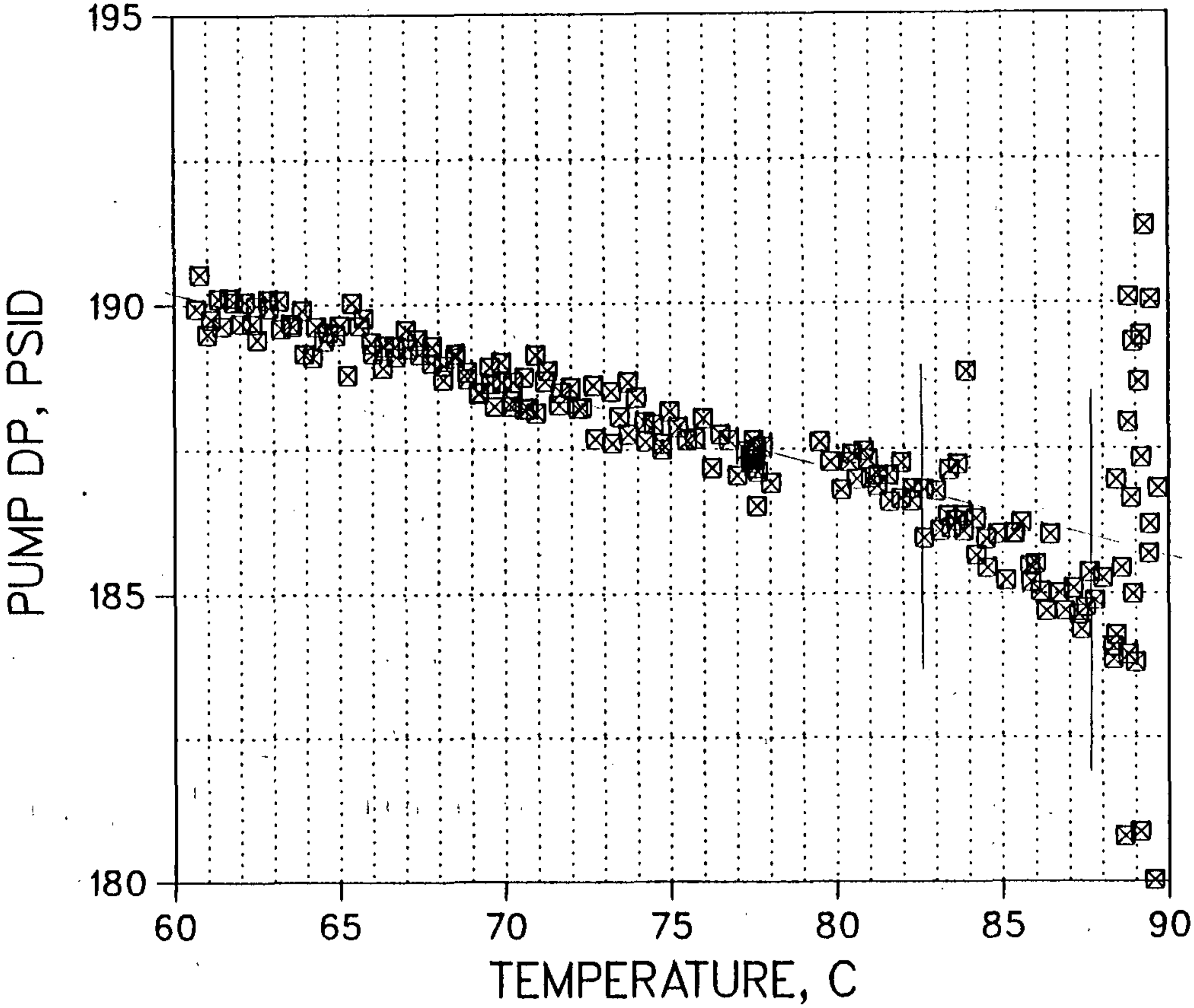

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UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,1

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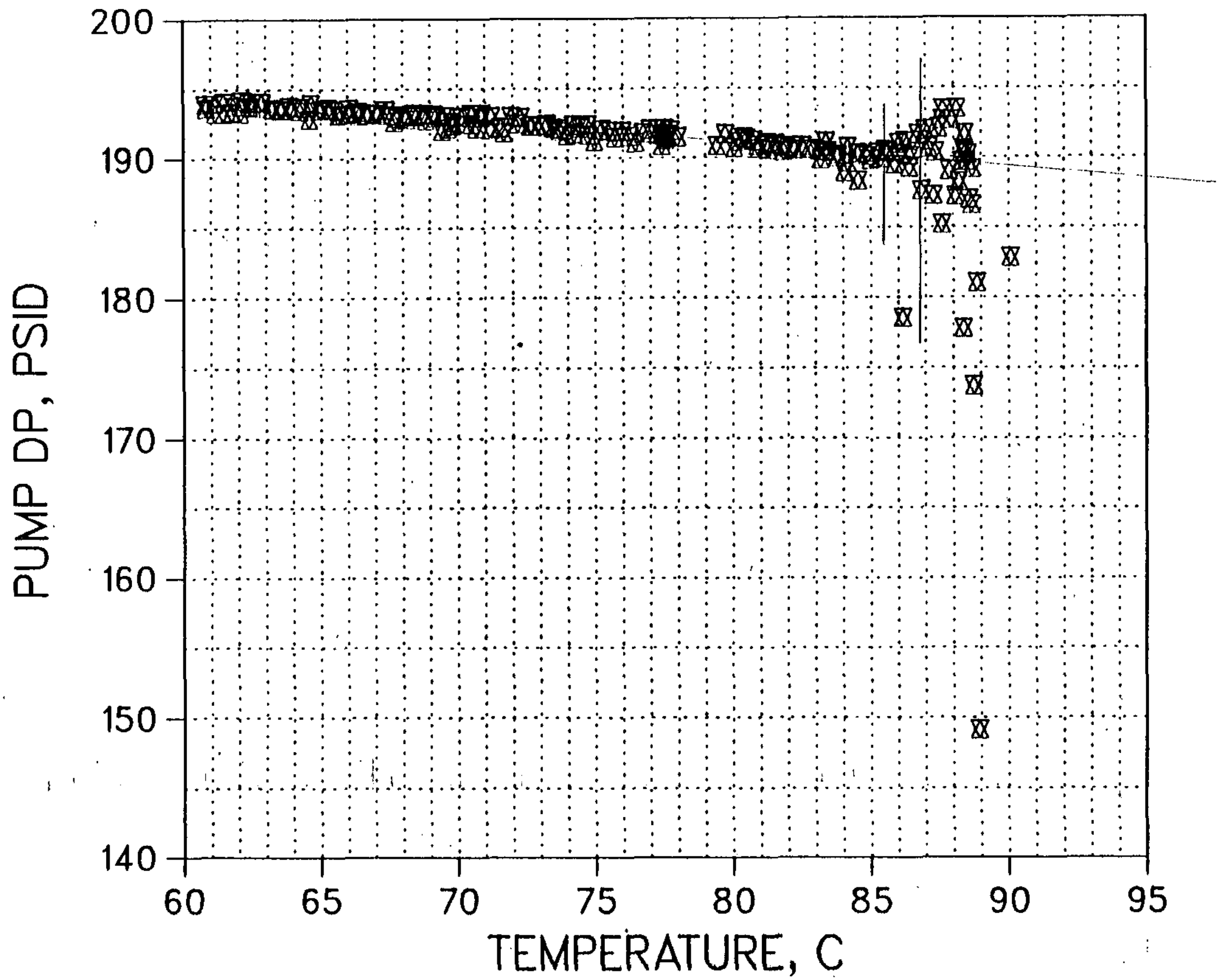

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps, 1

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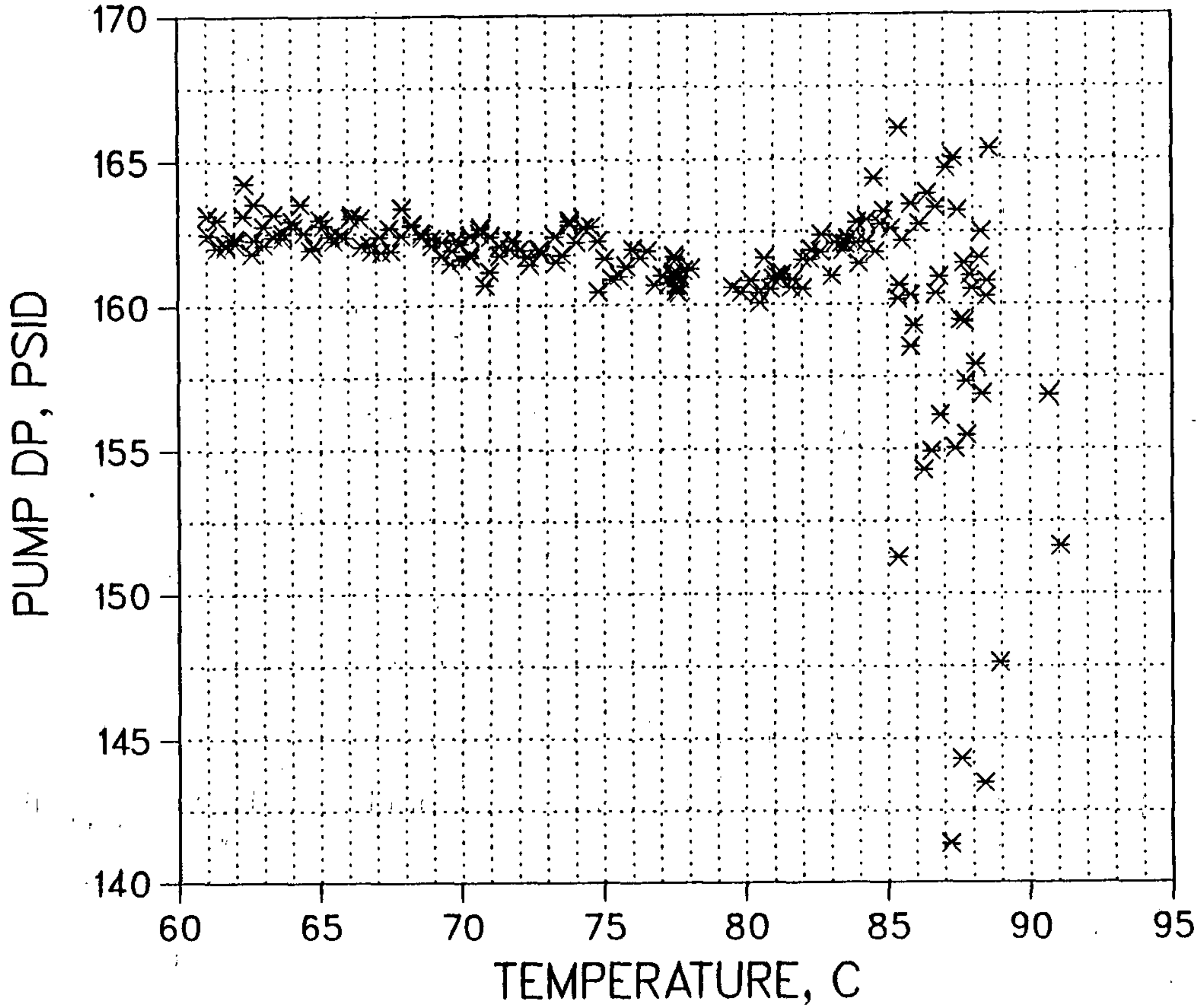

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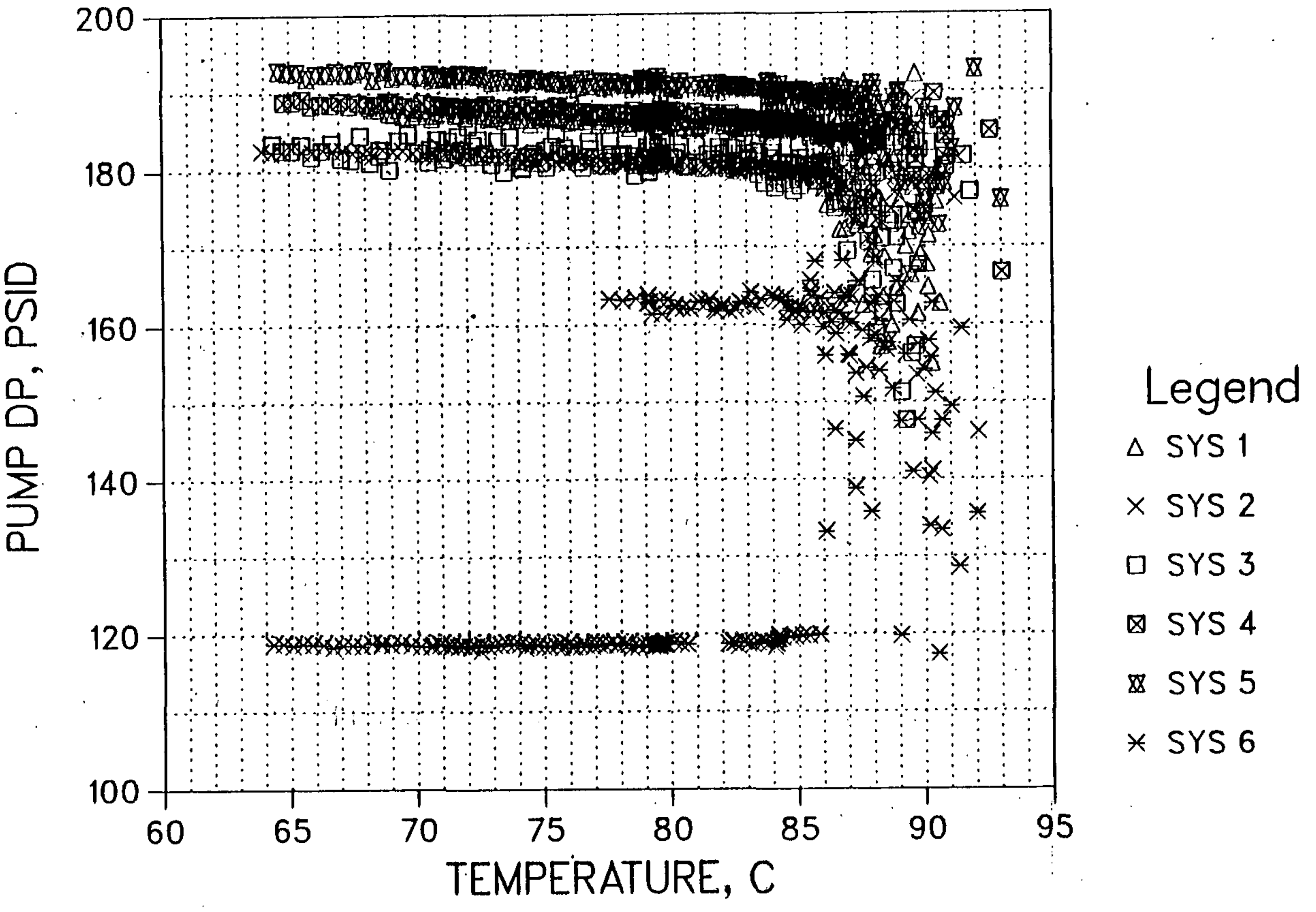

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UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,2

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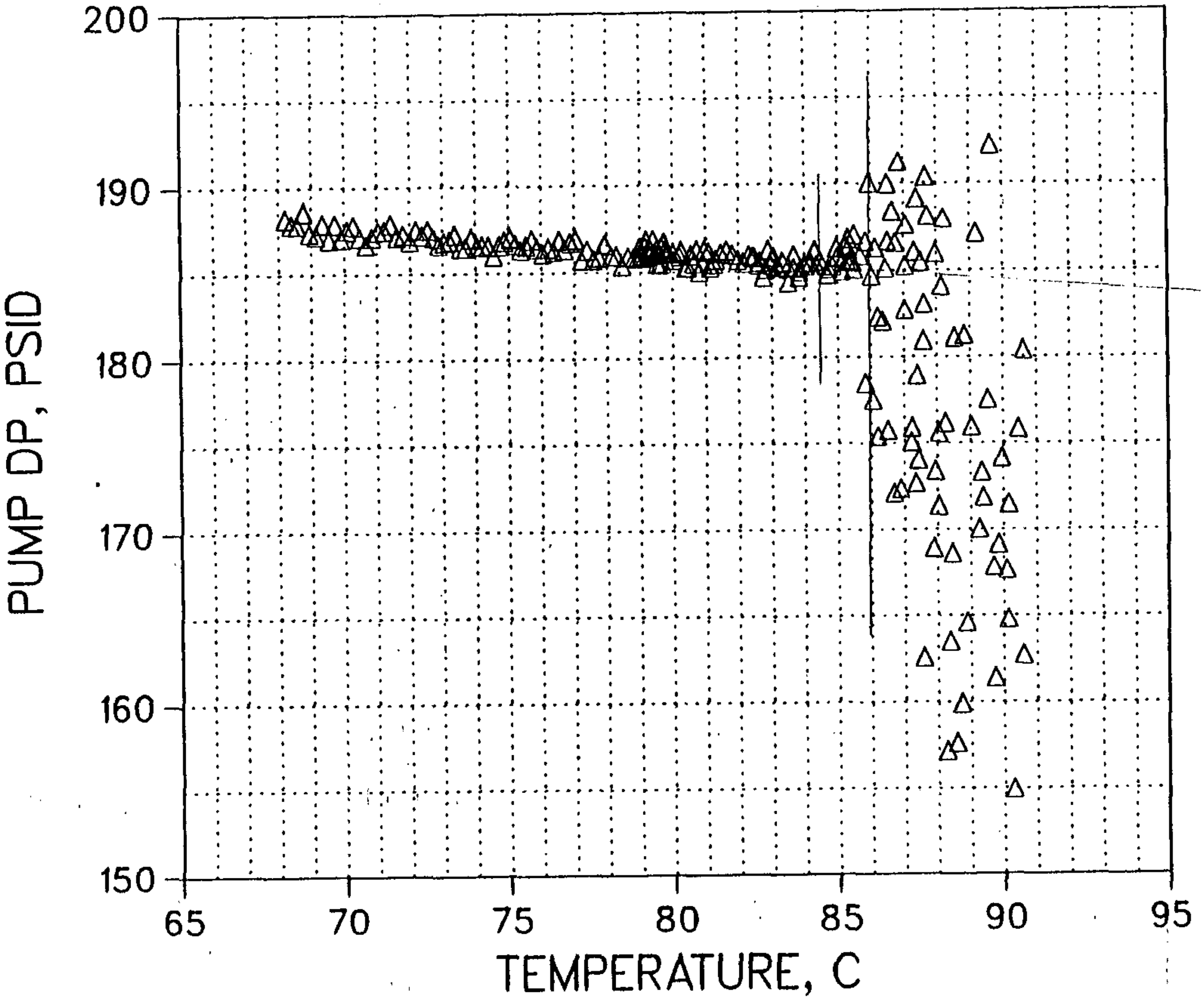

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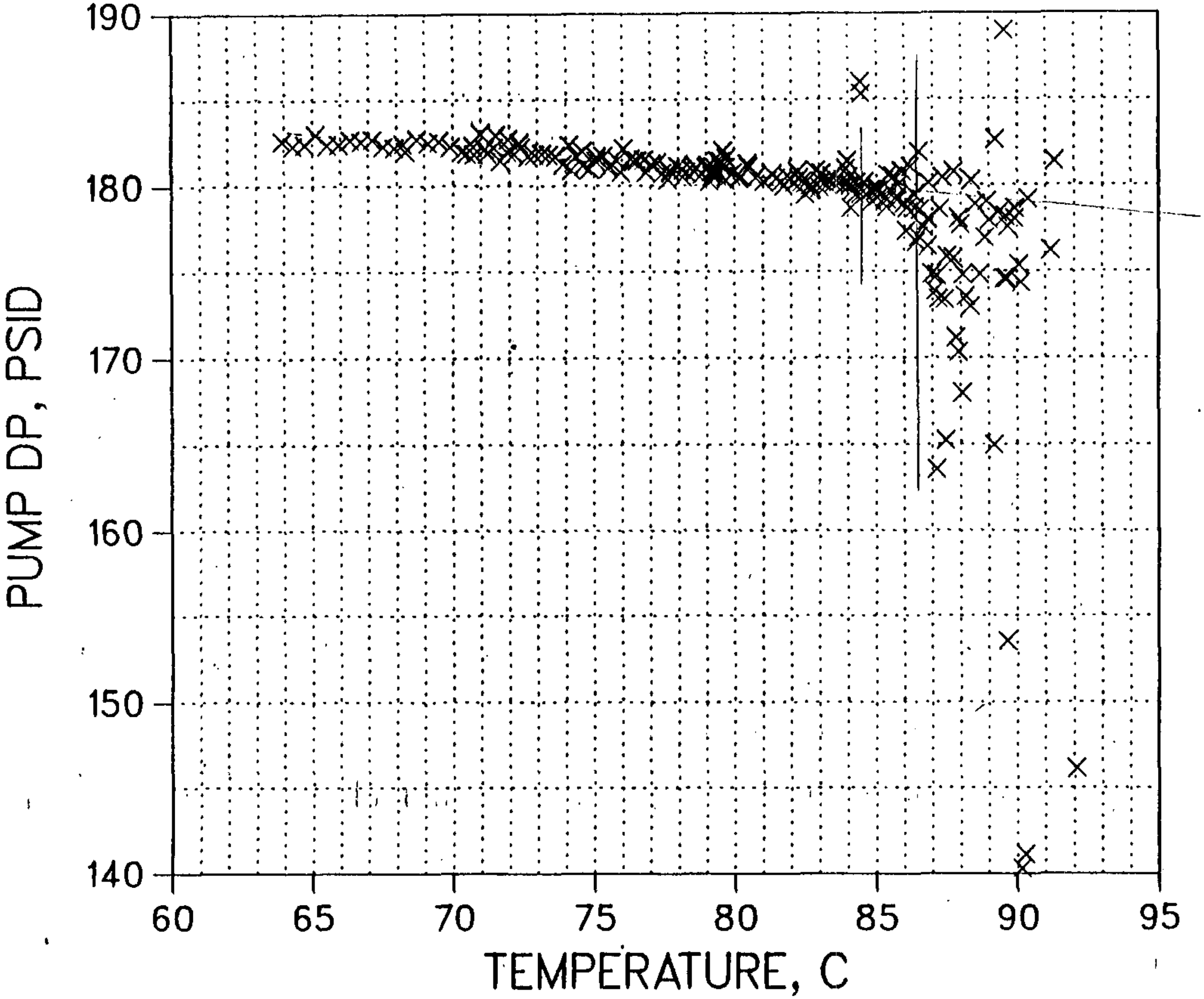

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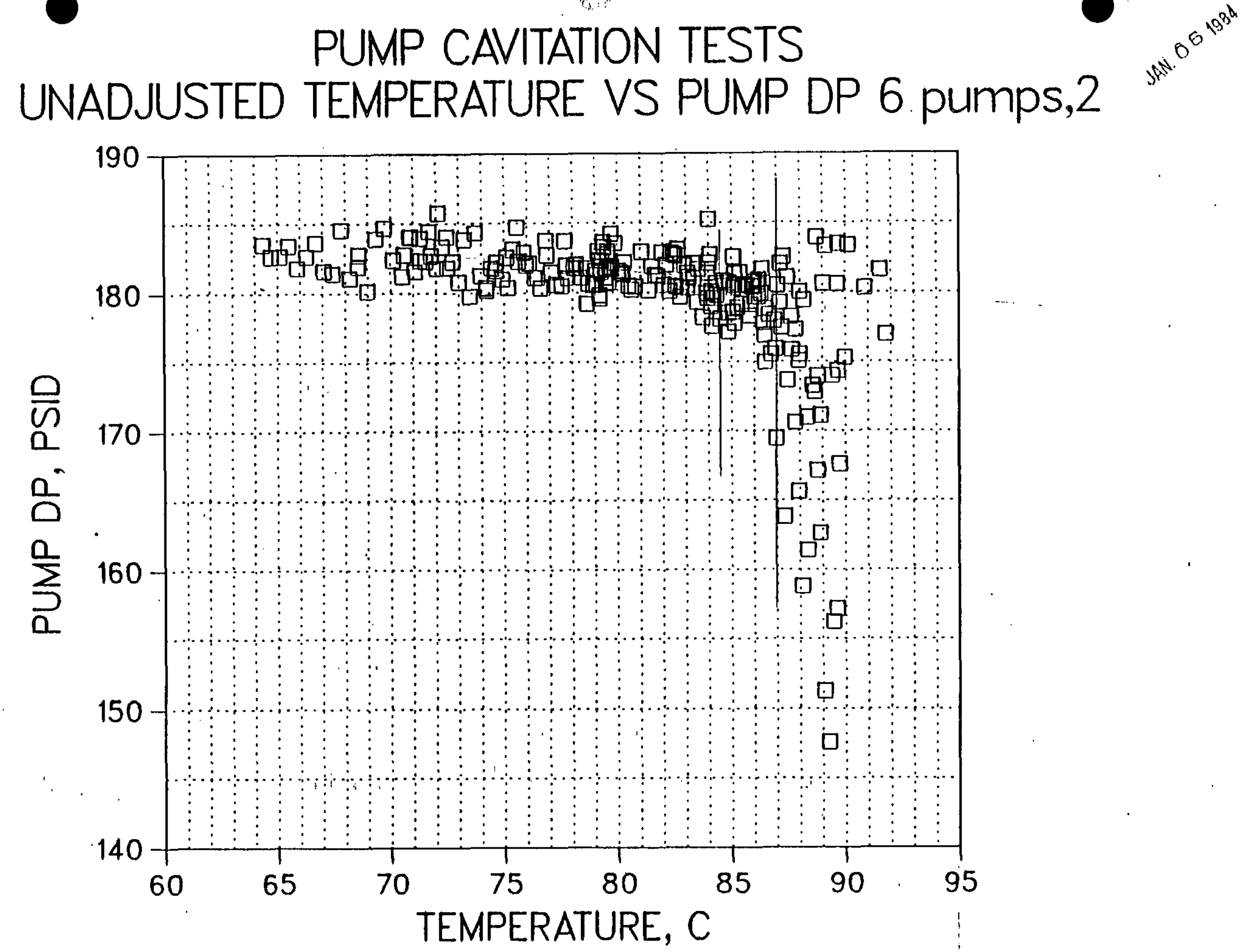
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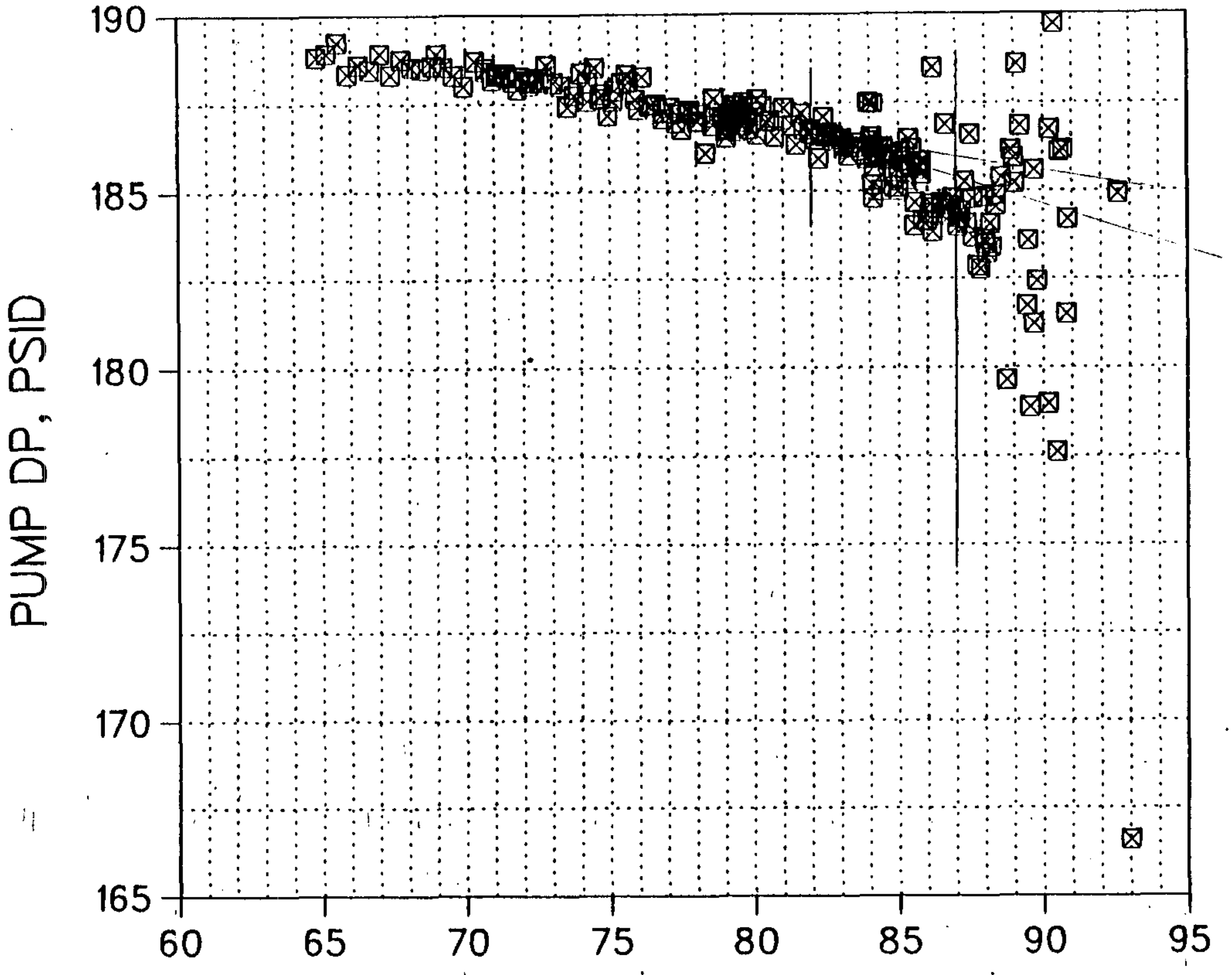
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,2
PUMP DP, PSID
190
180
170
160
150
140
60
65
70
75
80
85
90
95
TEMPERATURE, C

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,2



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PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,2

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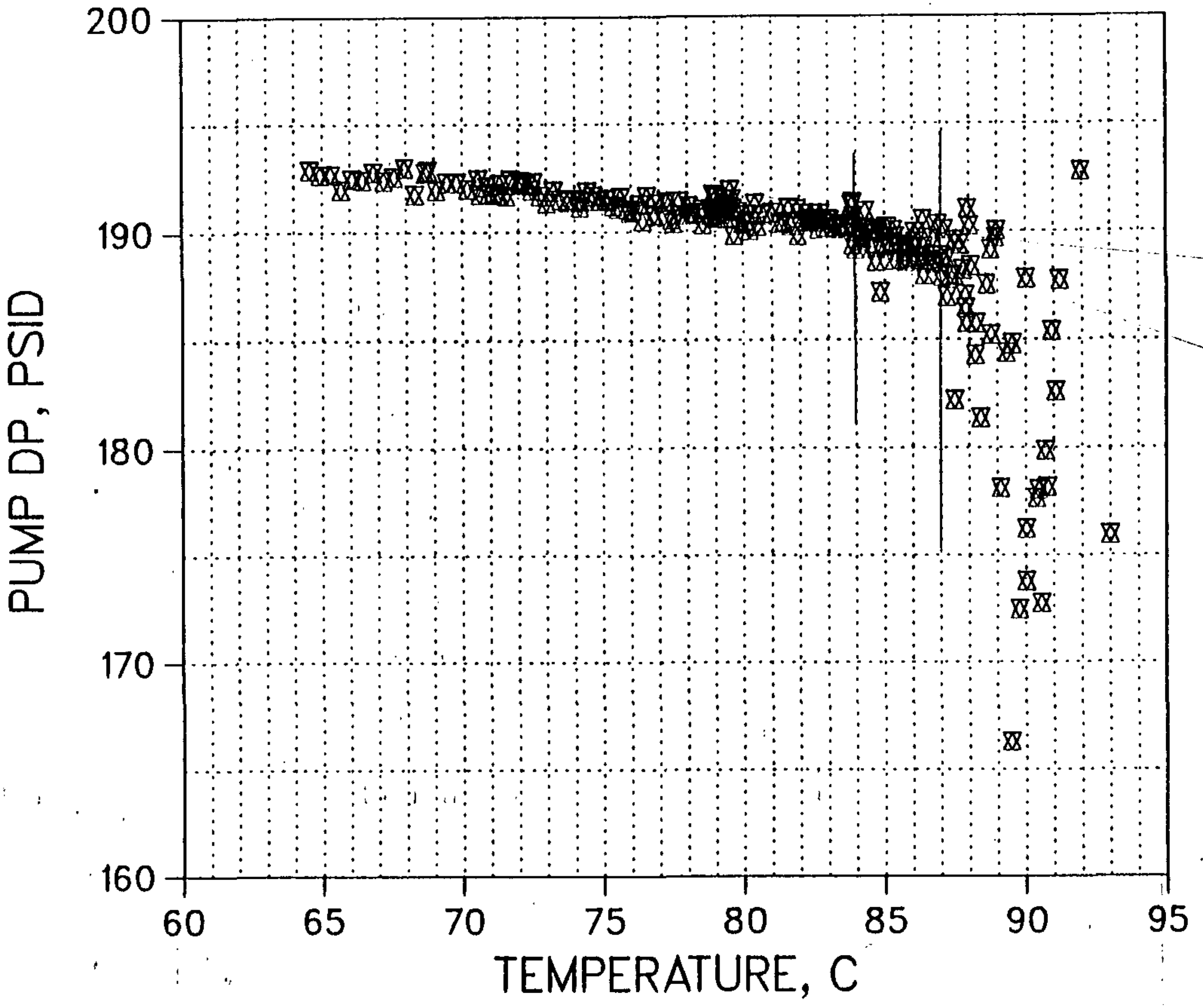

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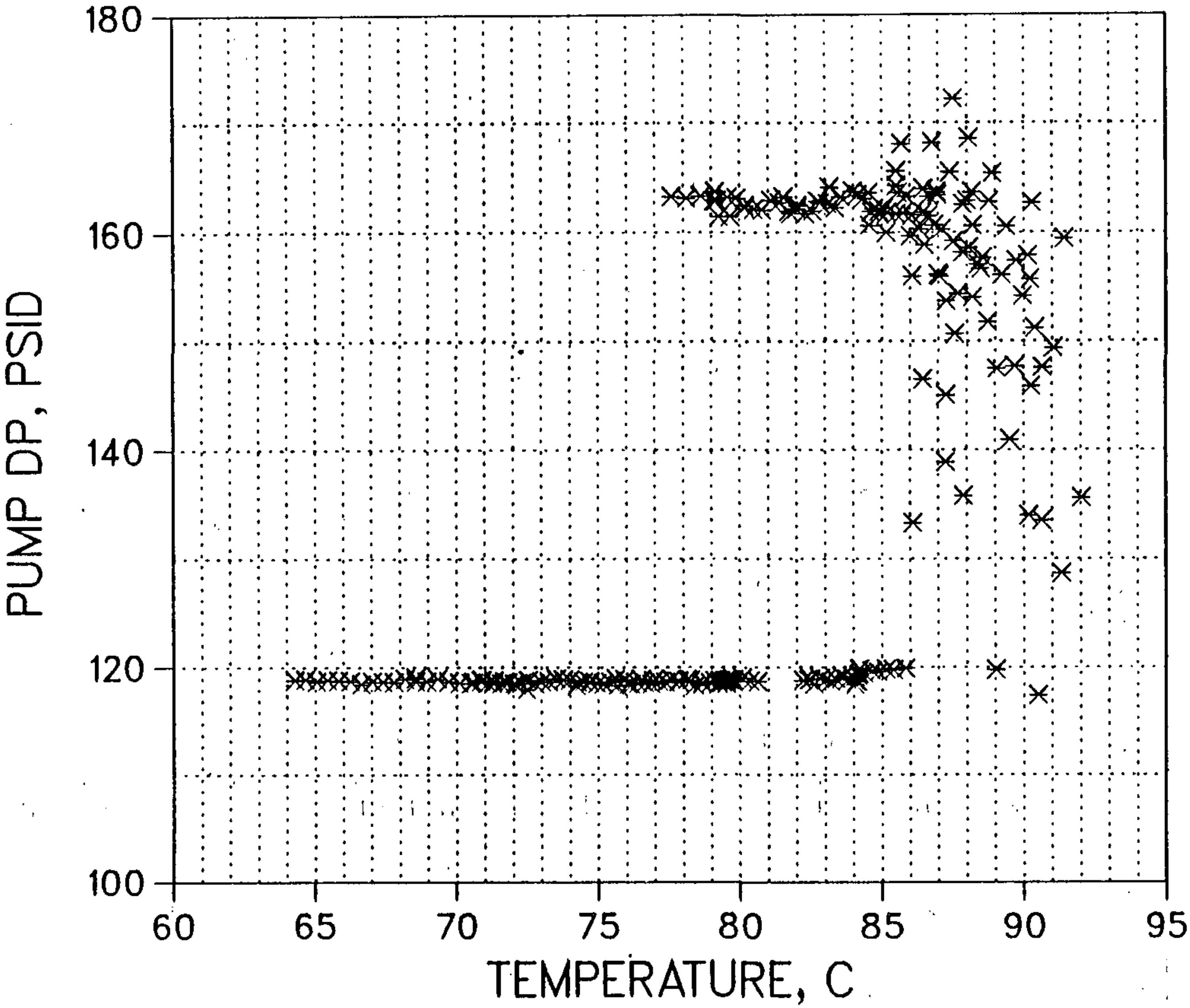
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,2



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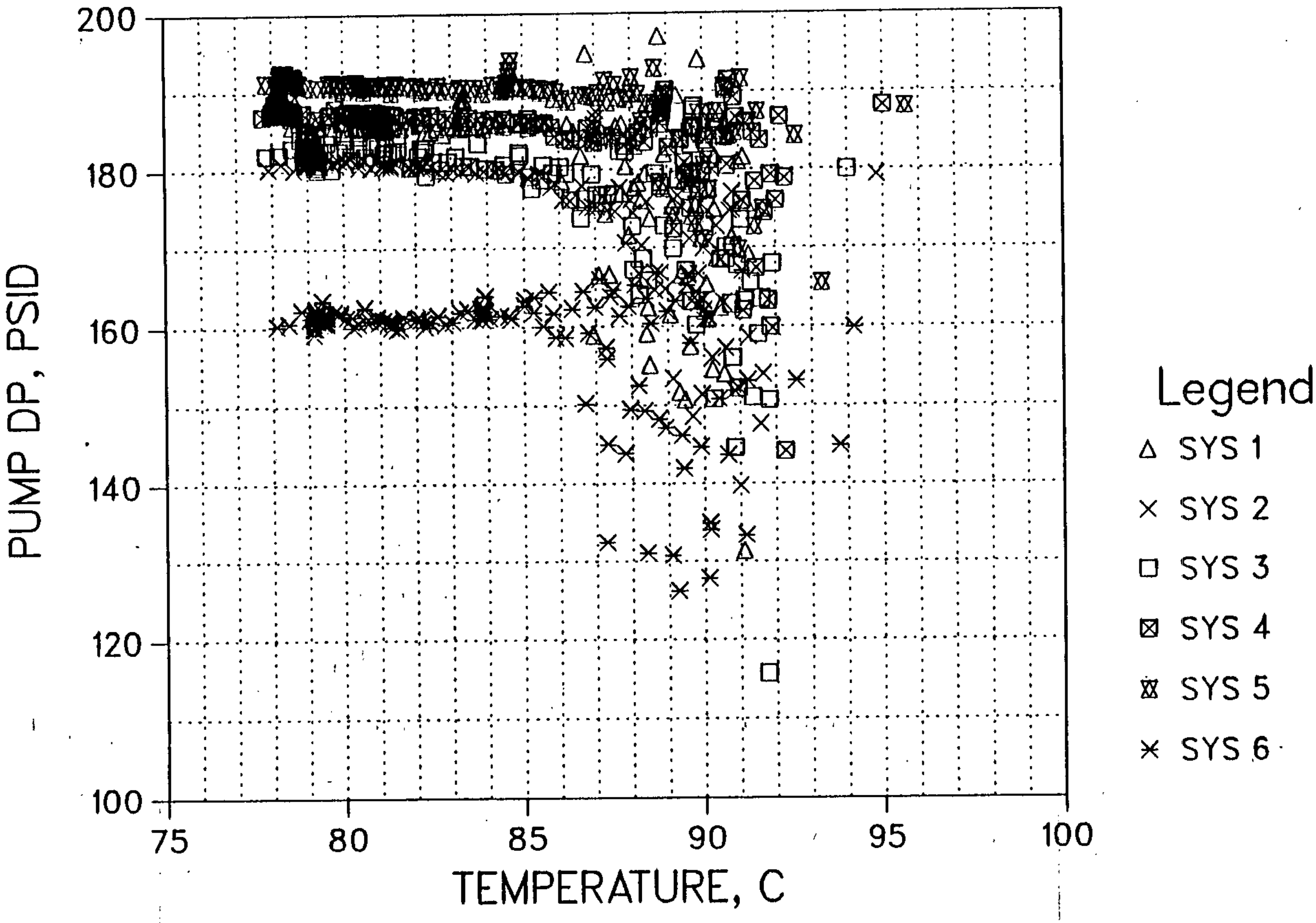

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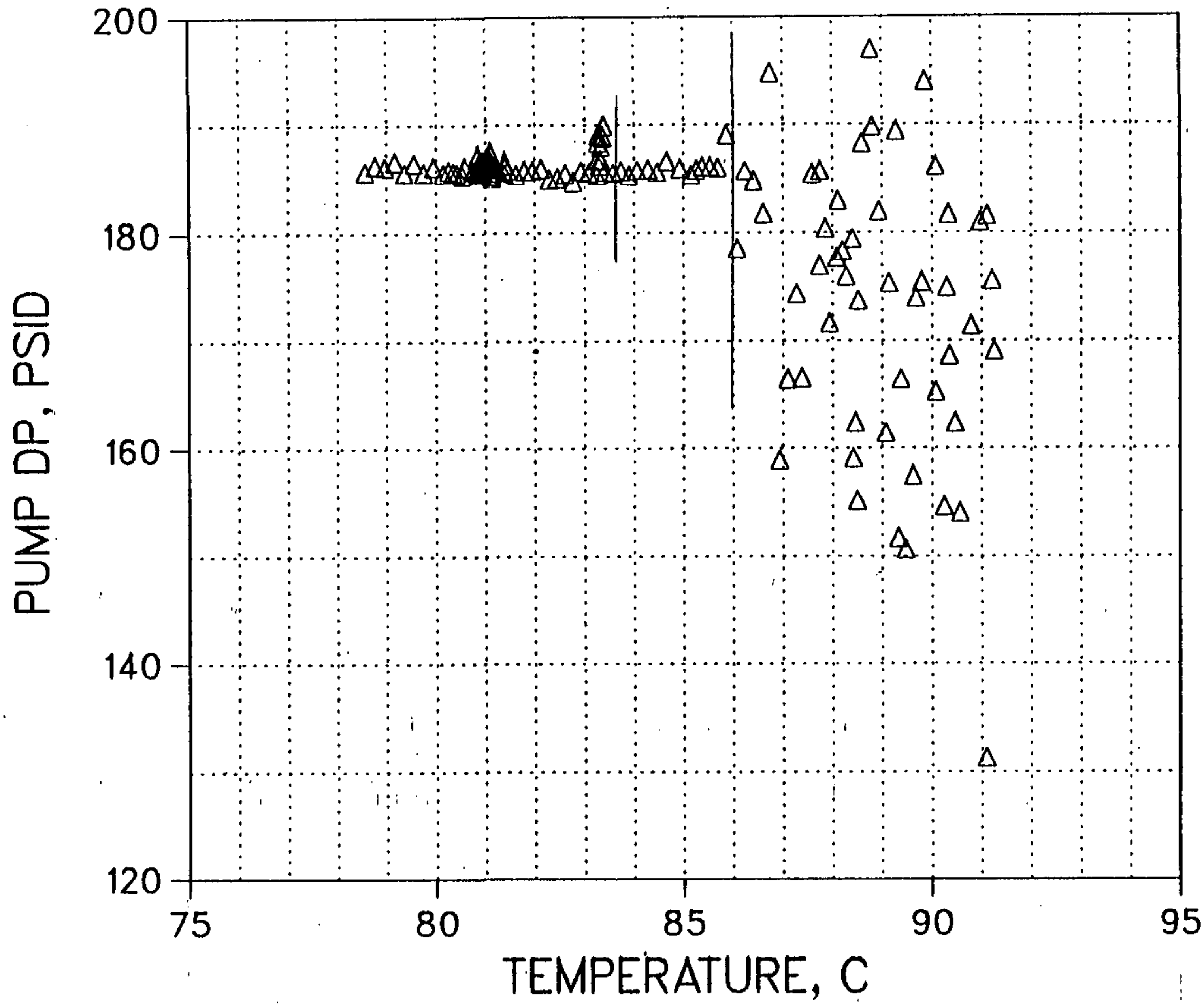

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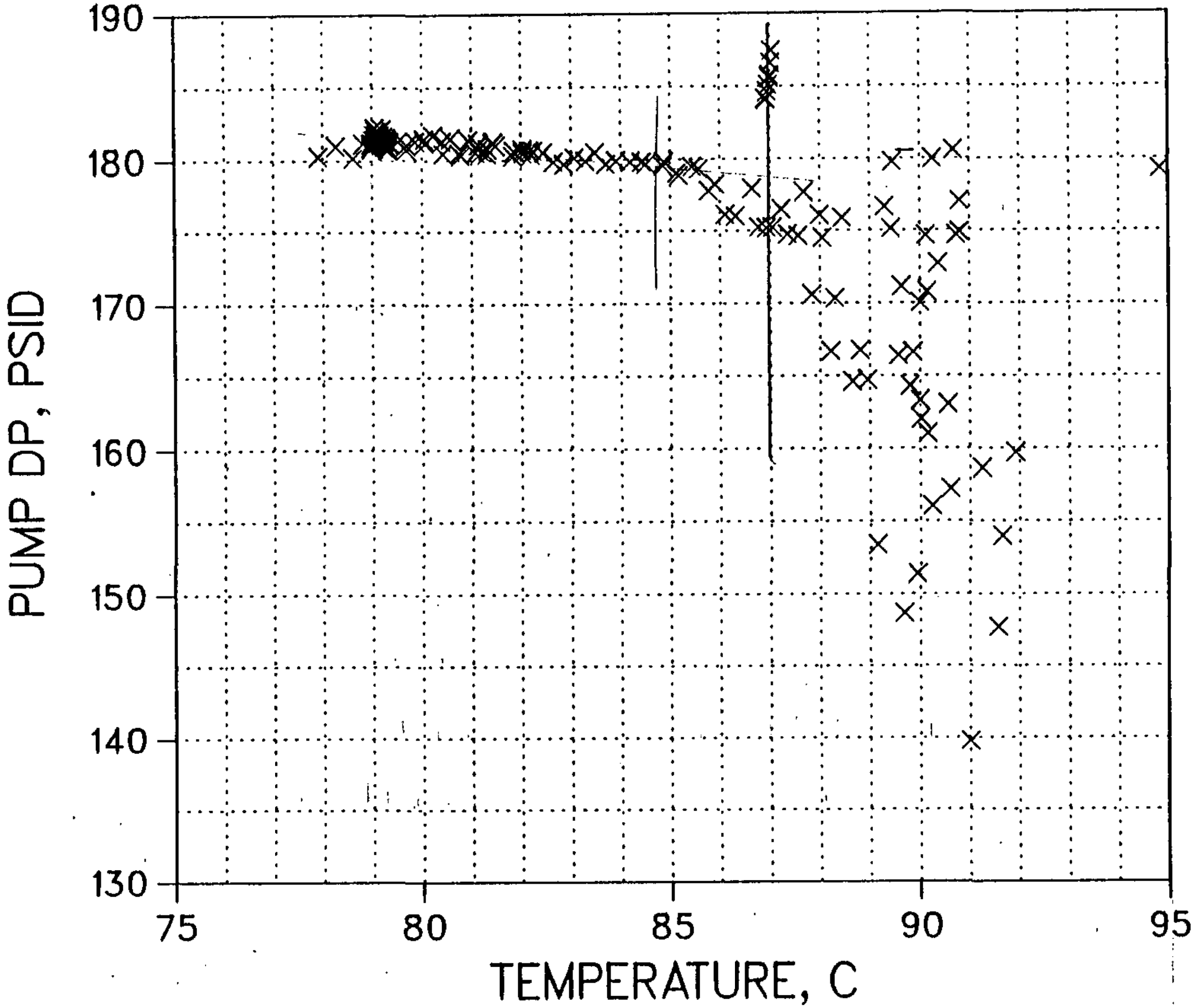
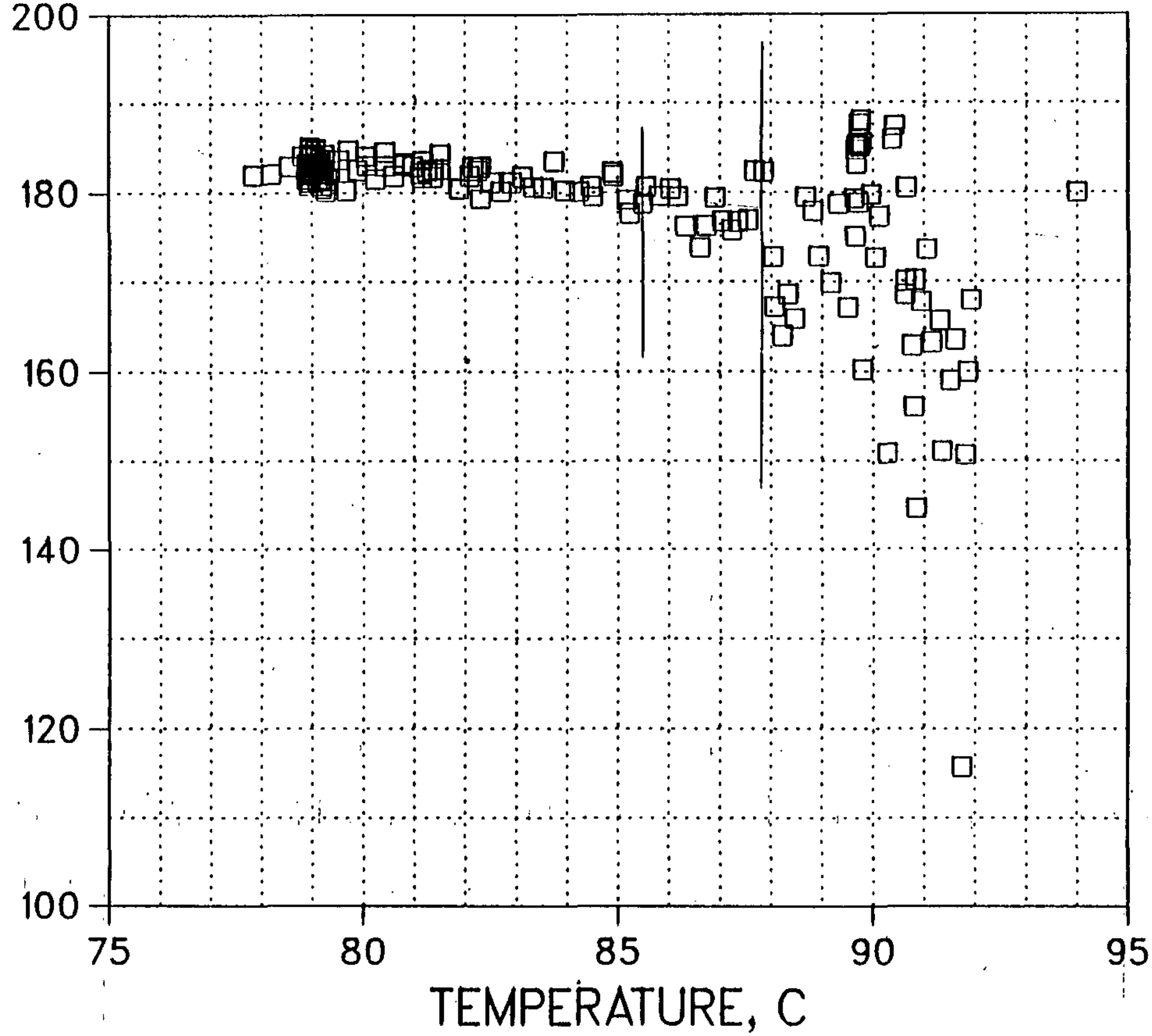
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,3



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,3

3

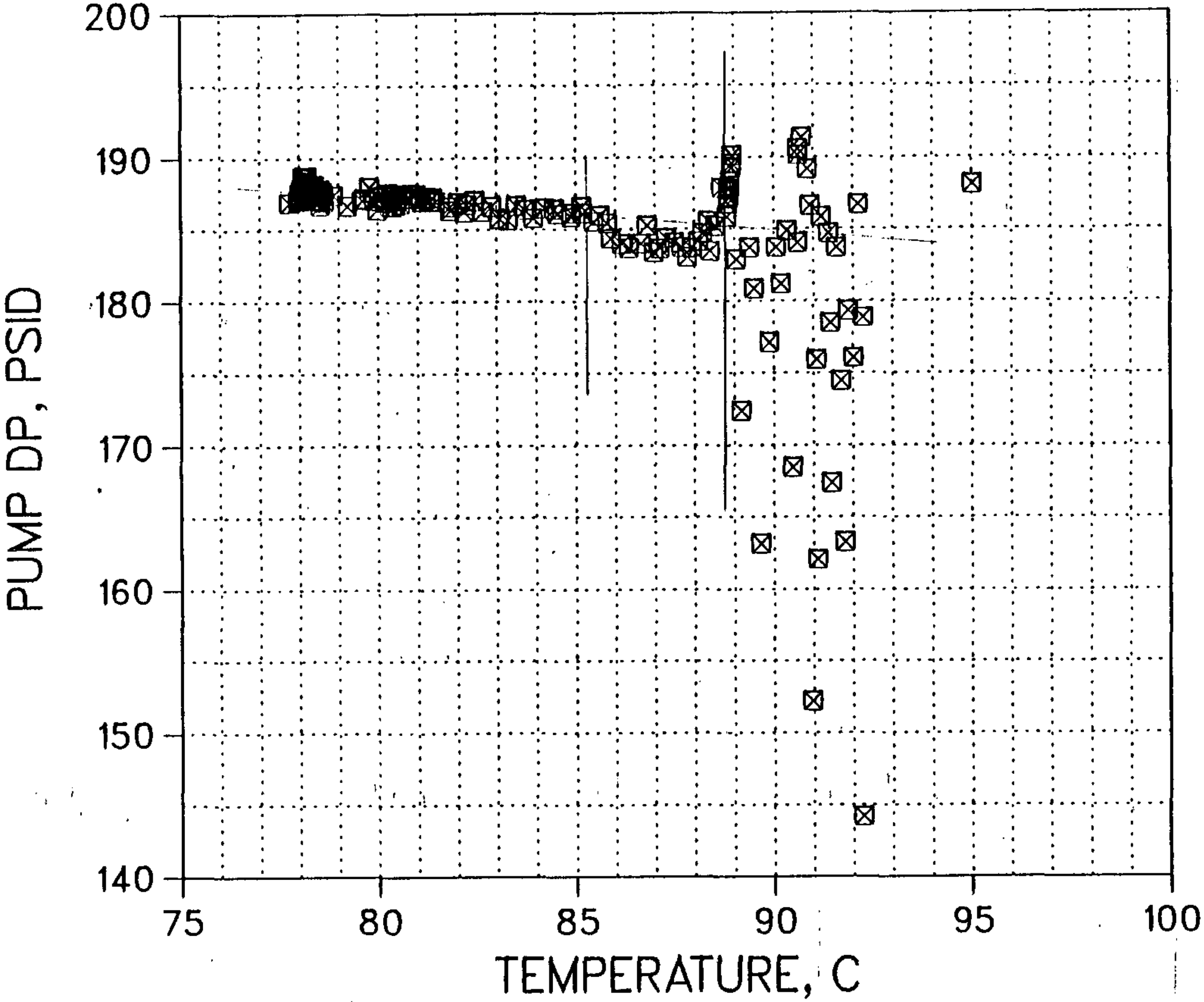


JAN. 06 199

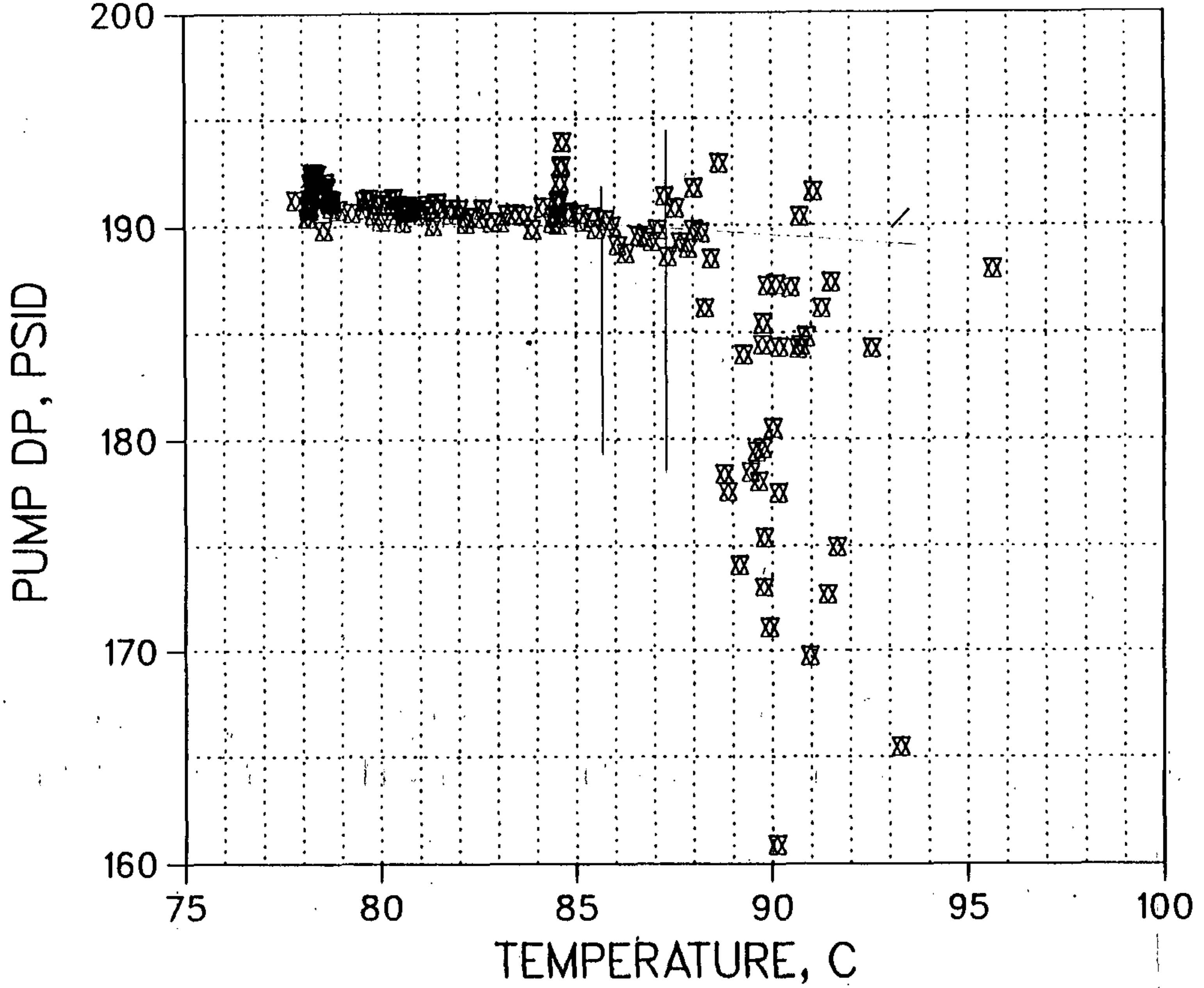
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,3

JAN. 06 1984

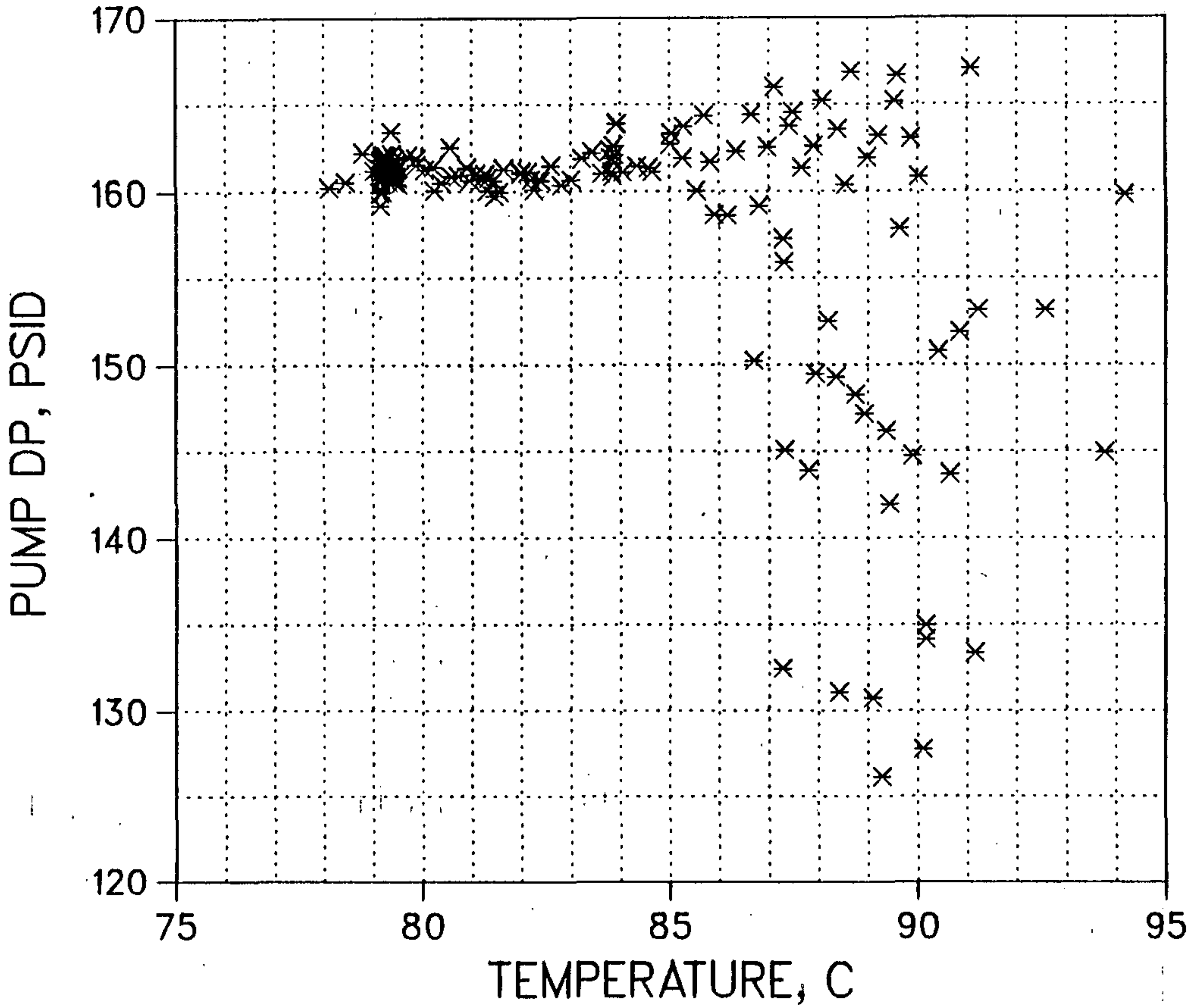
4



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,3

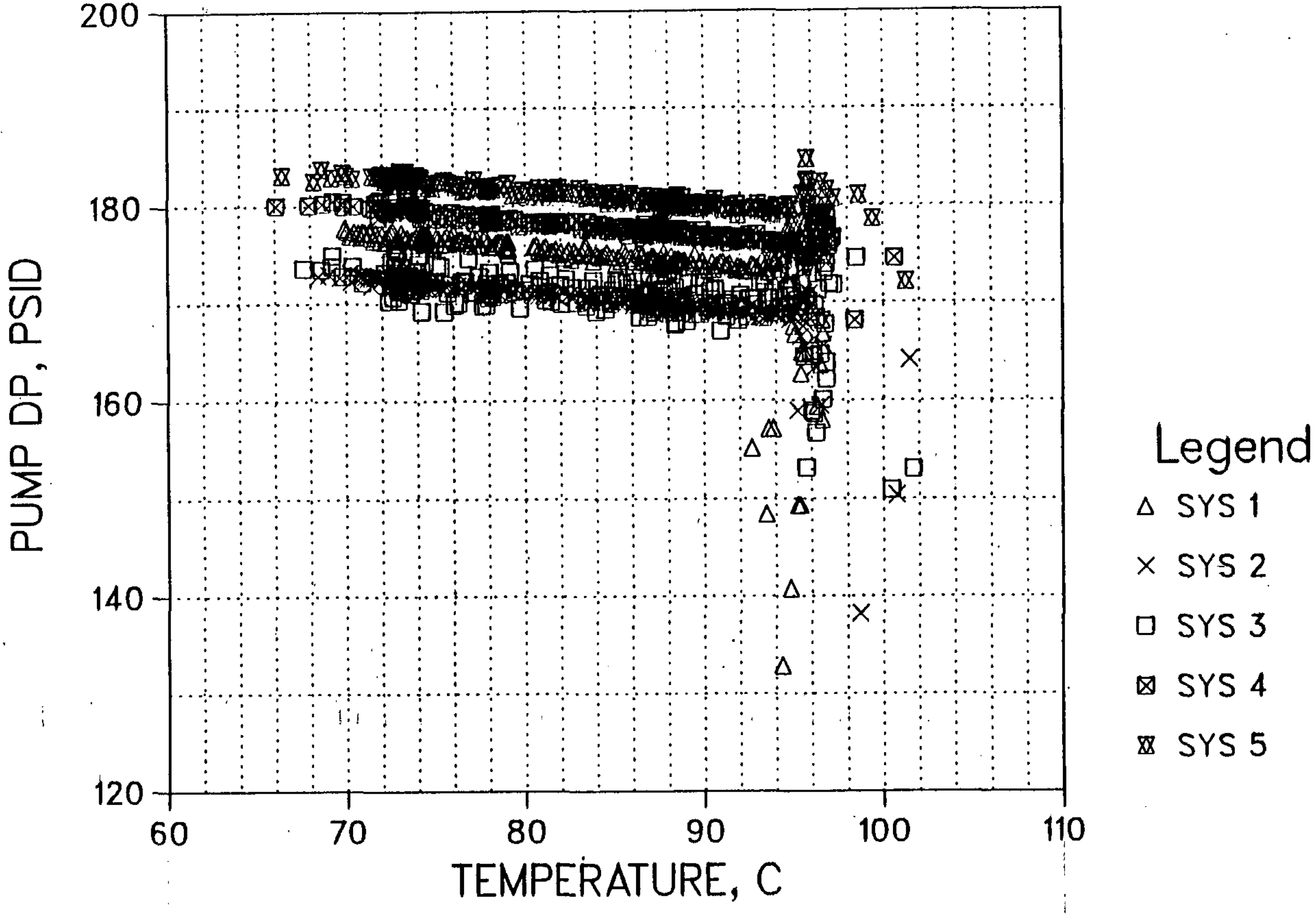


PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 6 pumps,3



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps

JAN. 06 1984



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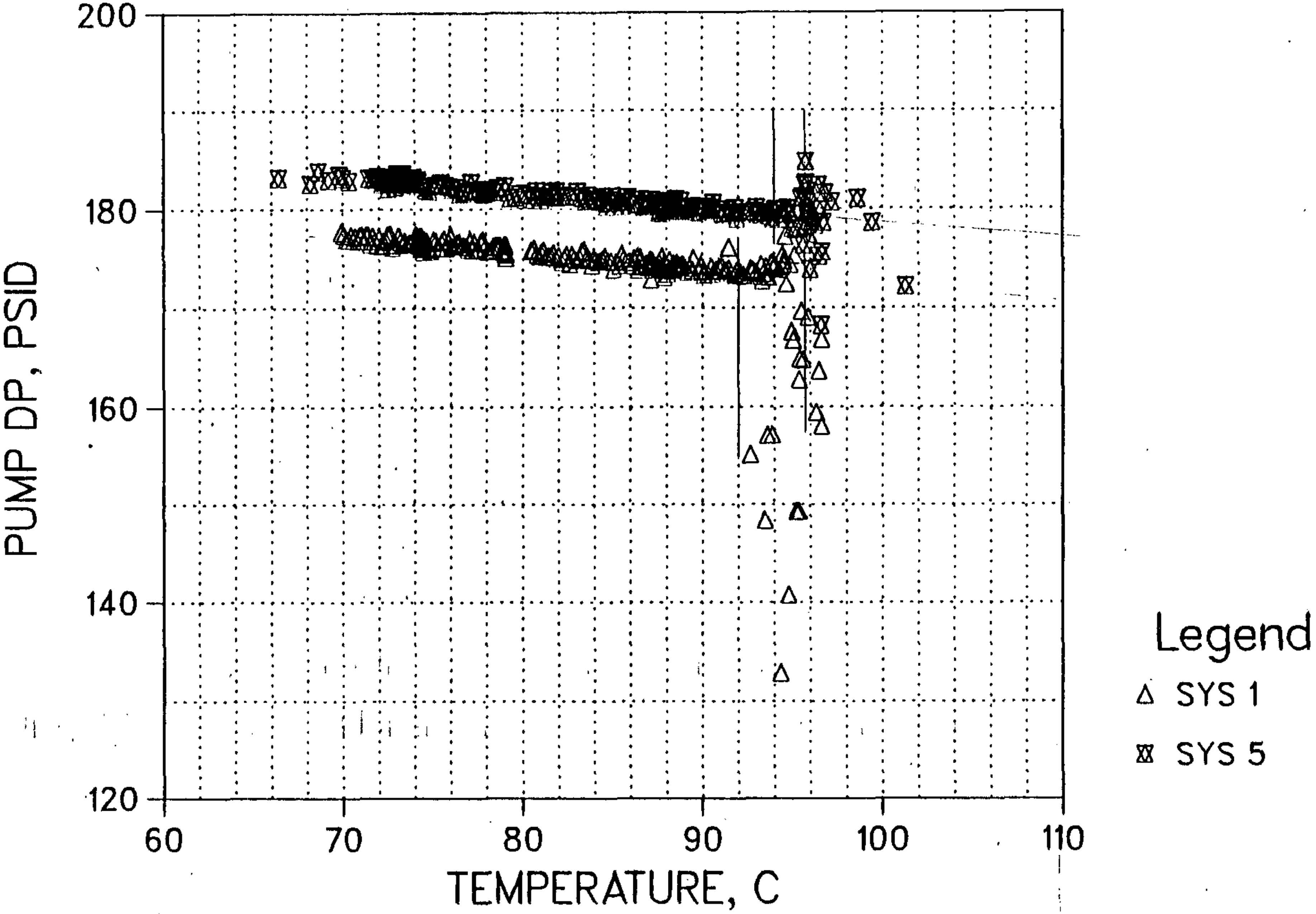
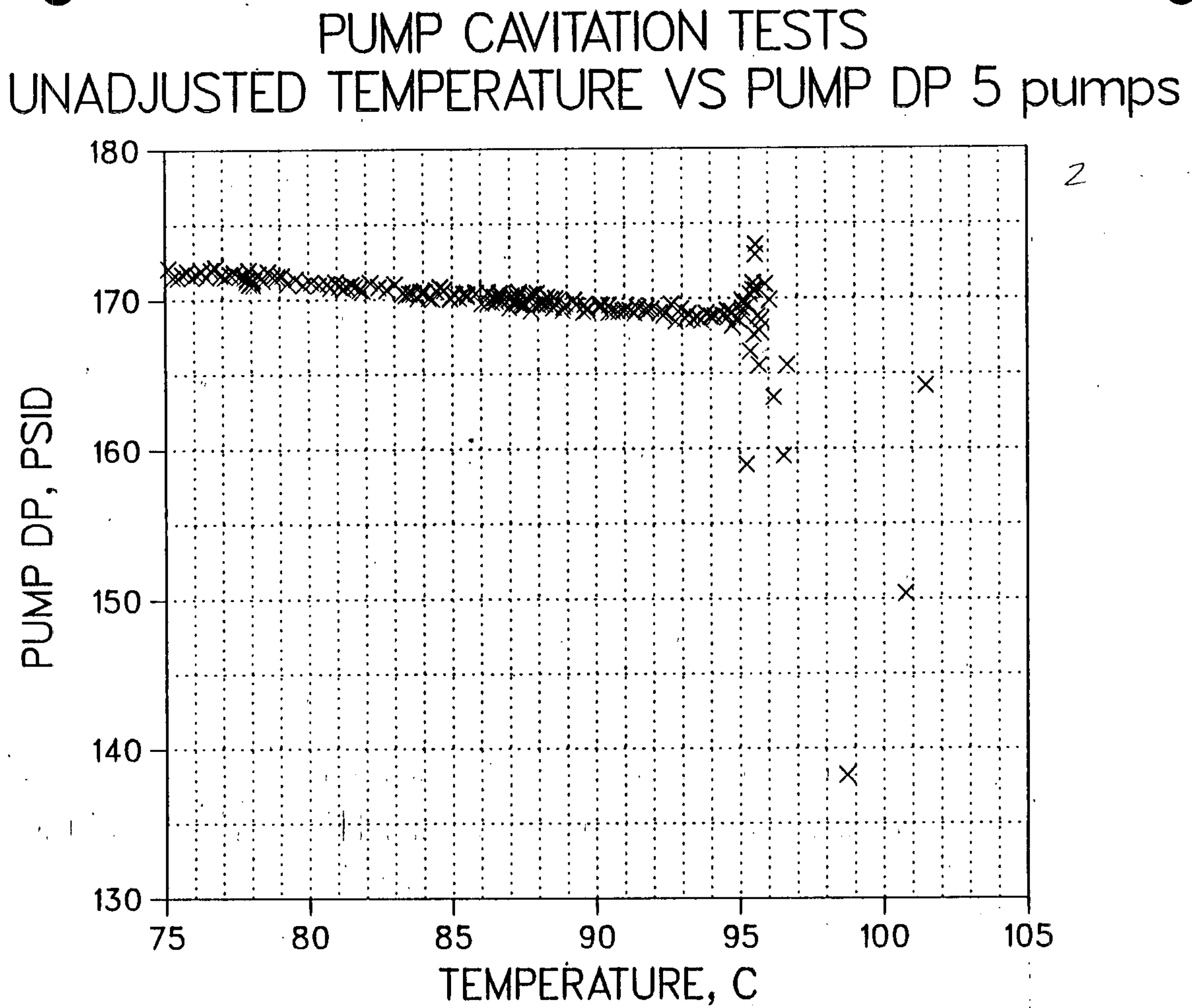
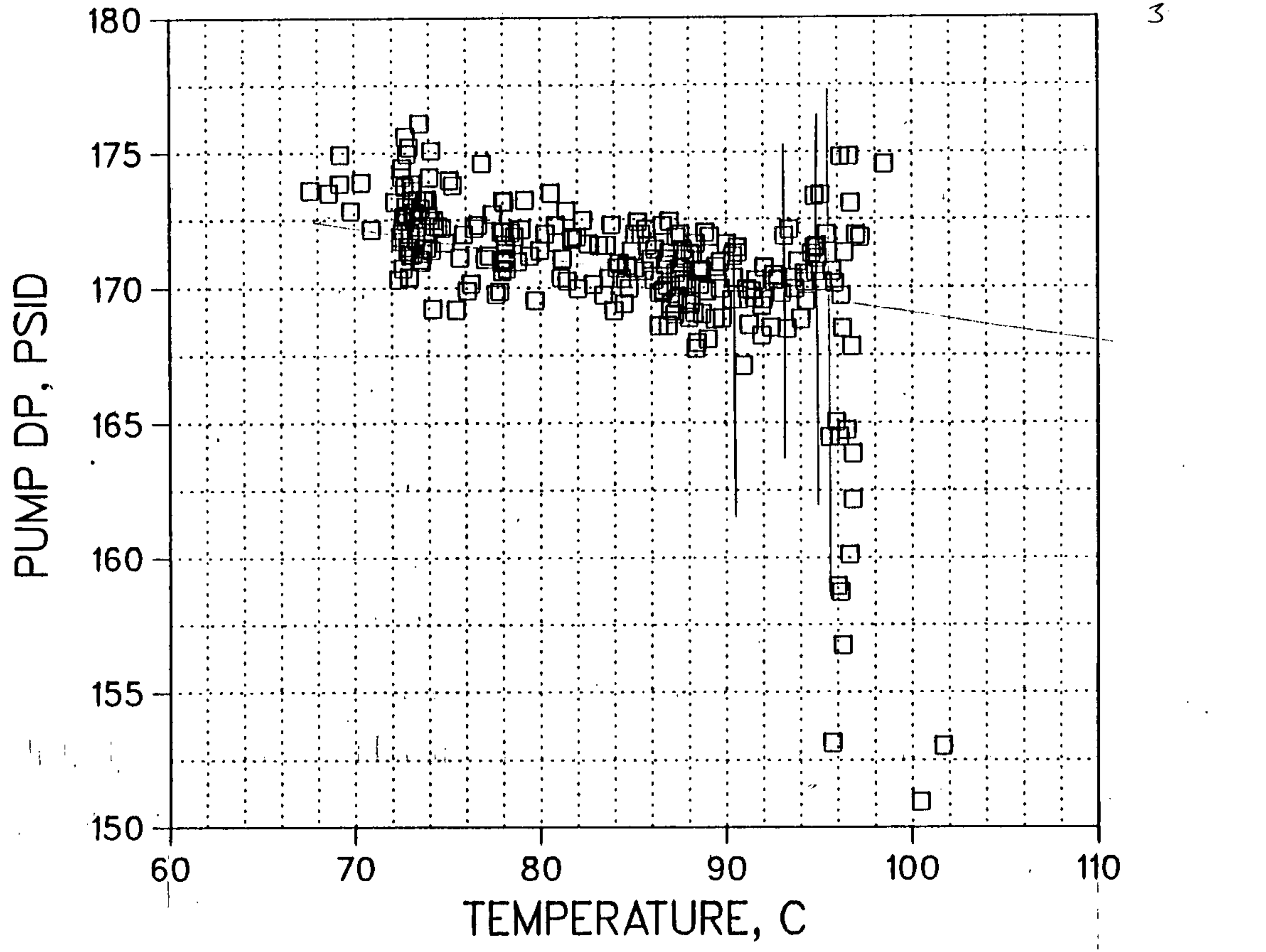
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps



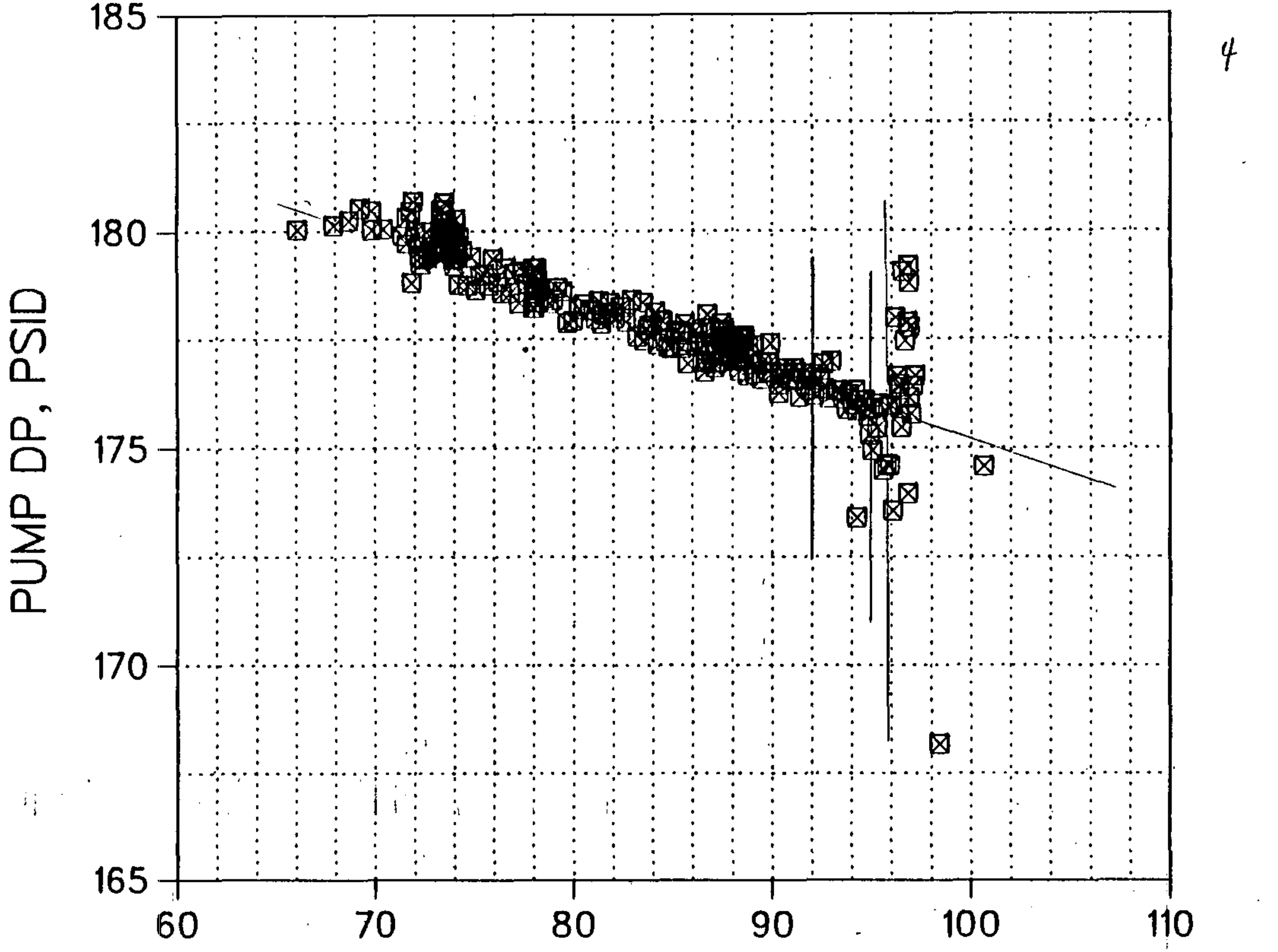
JAN. 06 1984


PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps
180
170
160
150
140
130
PUMP DP, PSID
75
80
85
90
95
100
105
TEMPERATURE, C
2

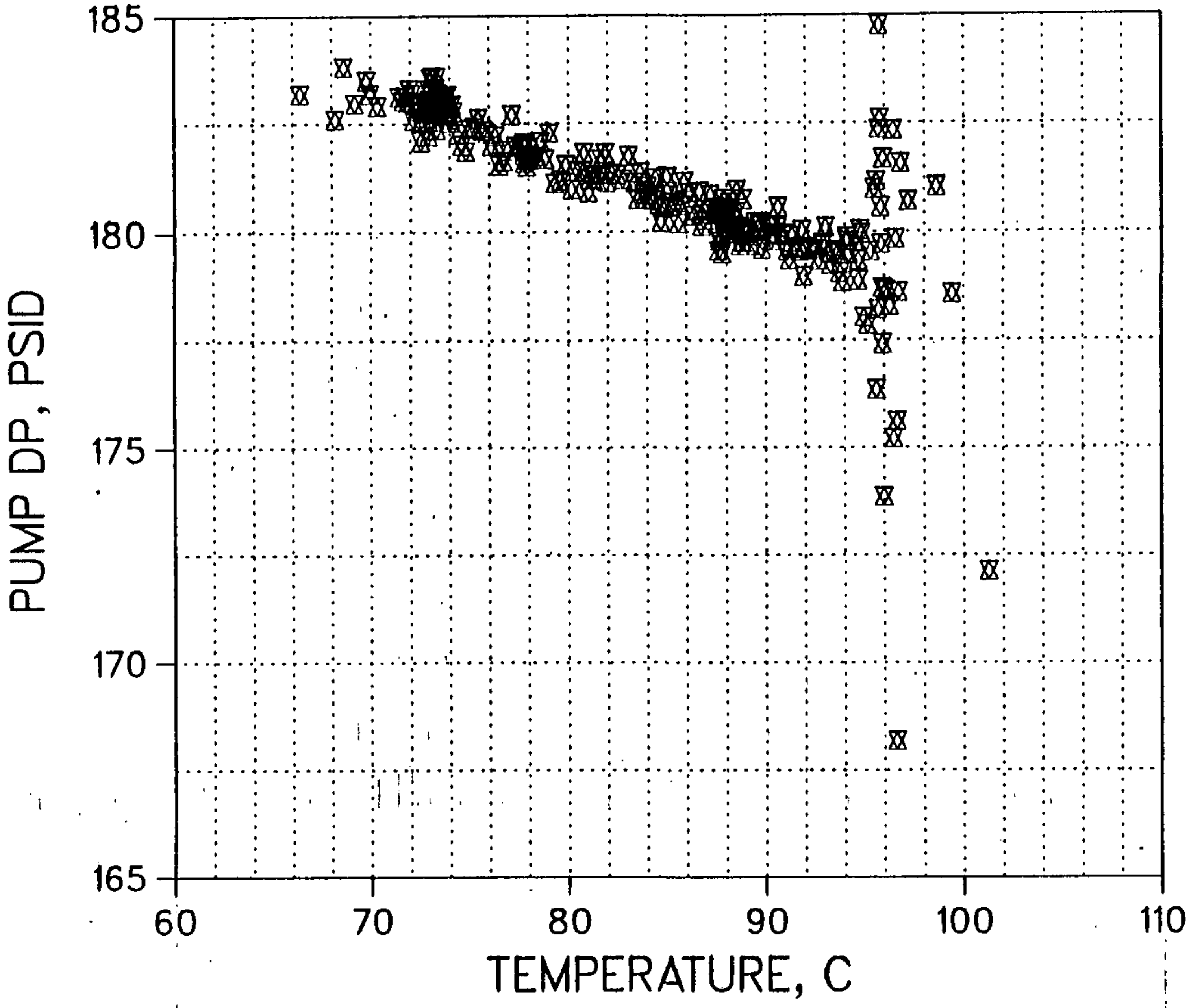
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps



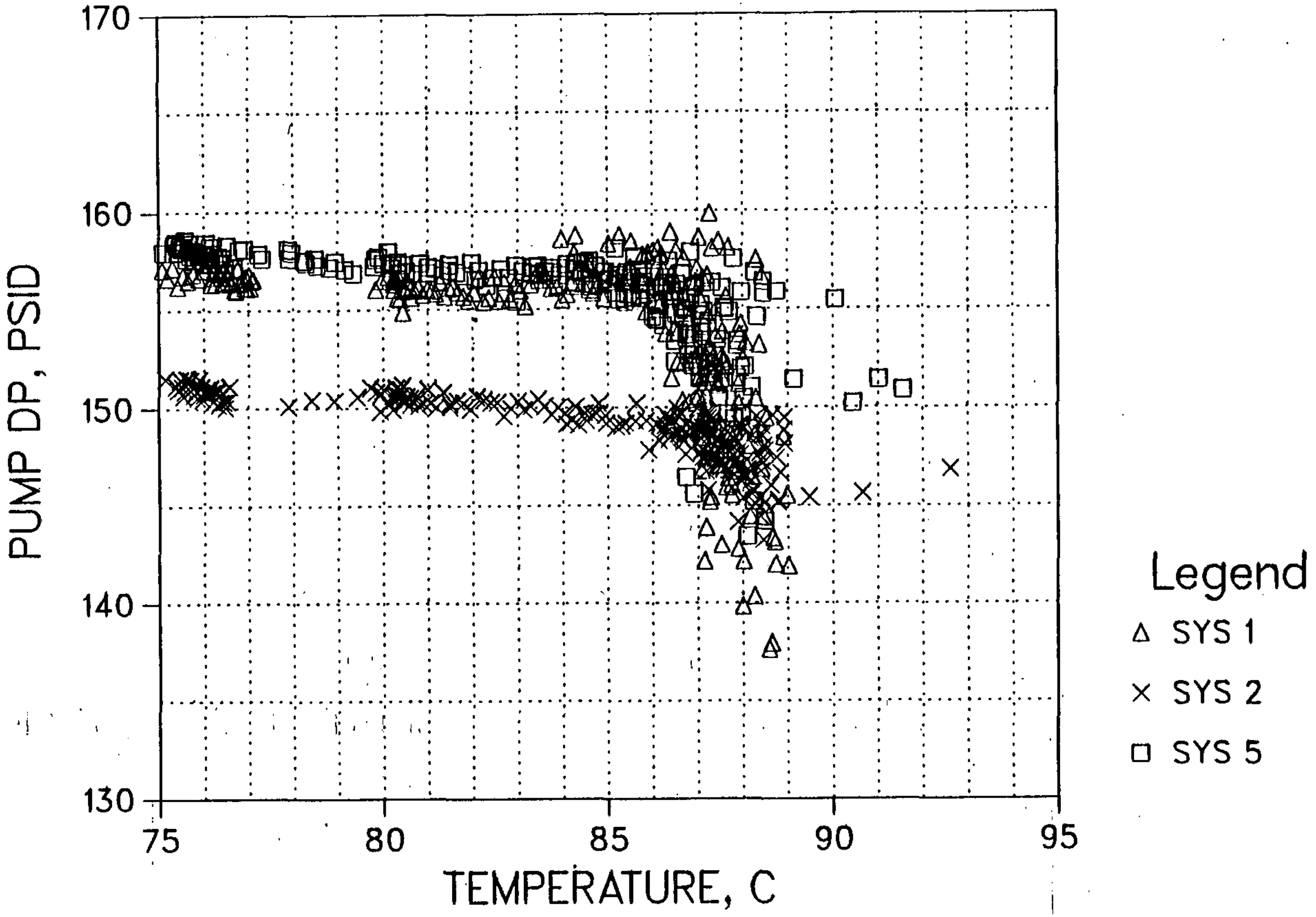
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps



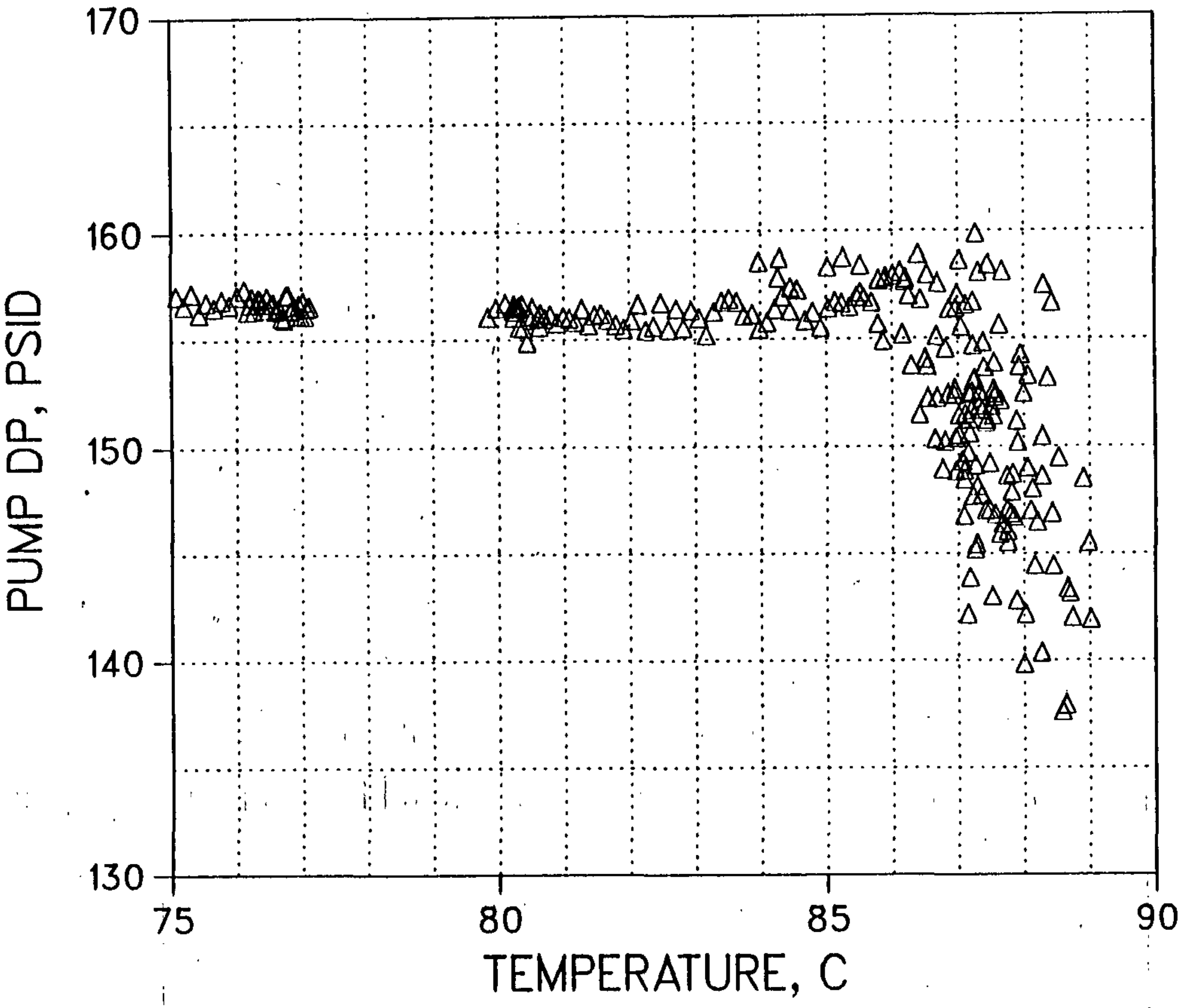
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 5 pumps



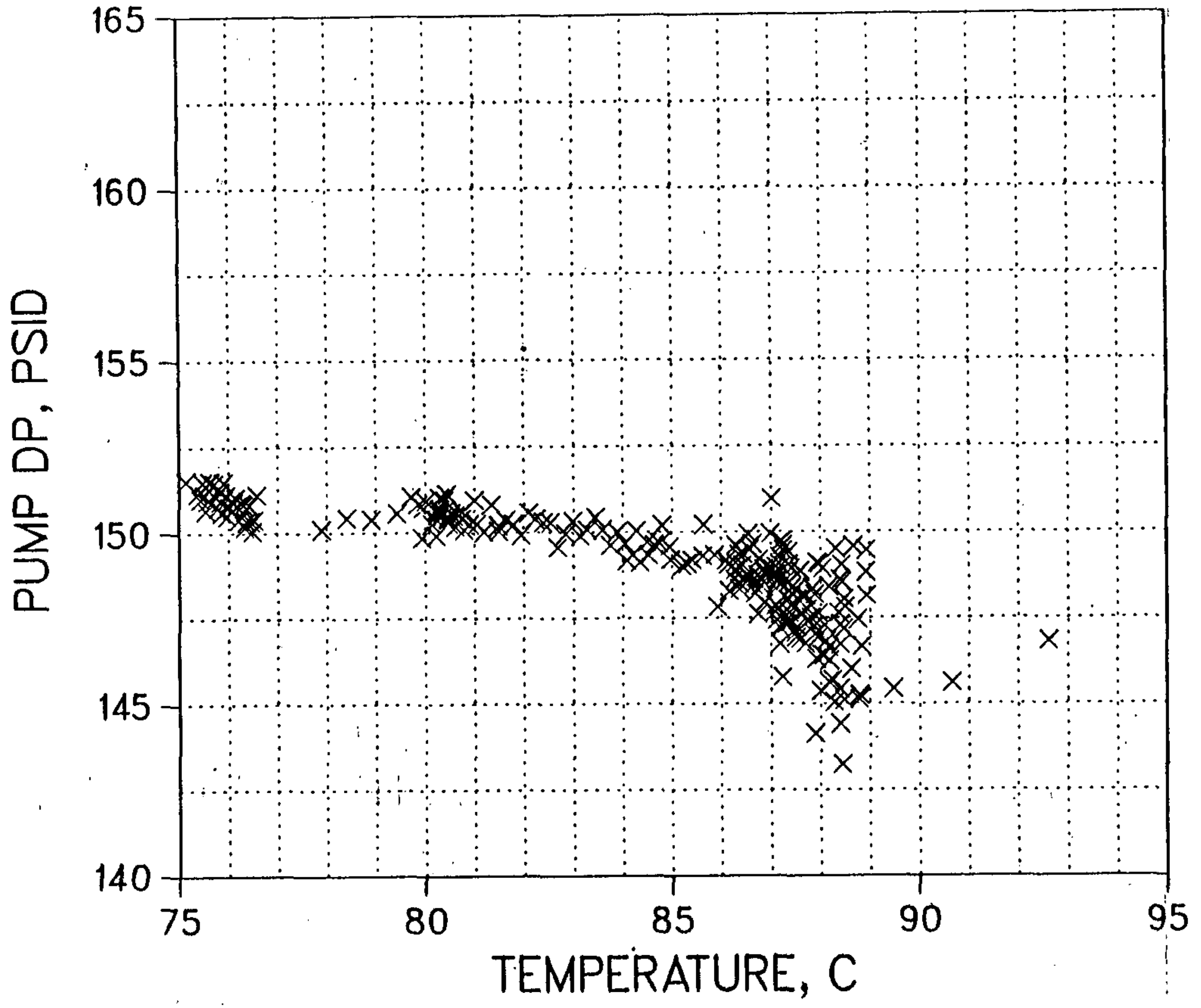
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 3 pumps



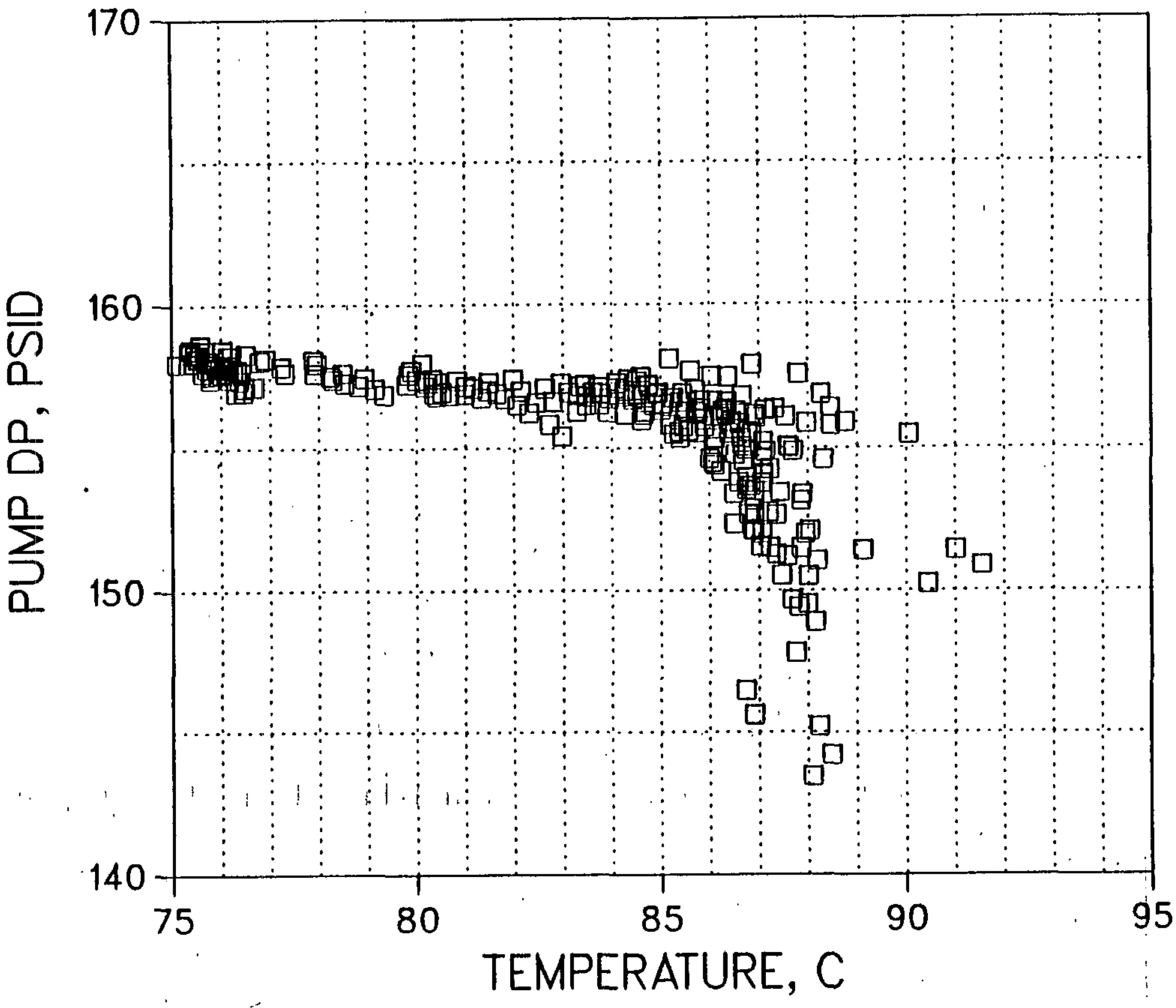
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 3 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 3 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS PUMP DP 3 pumps



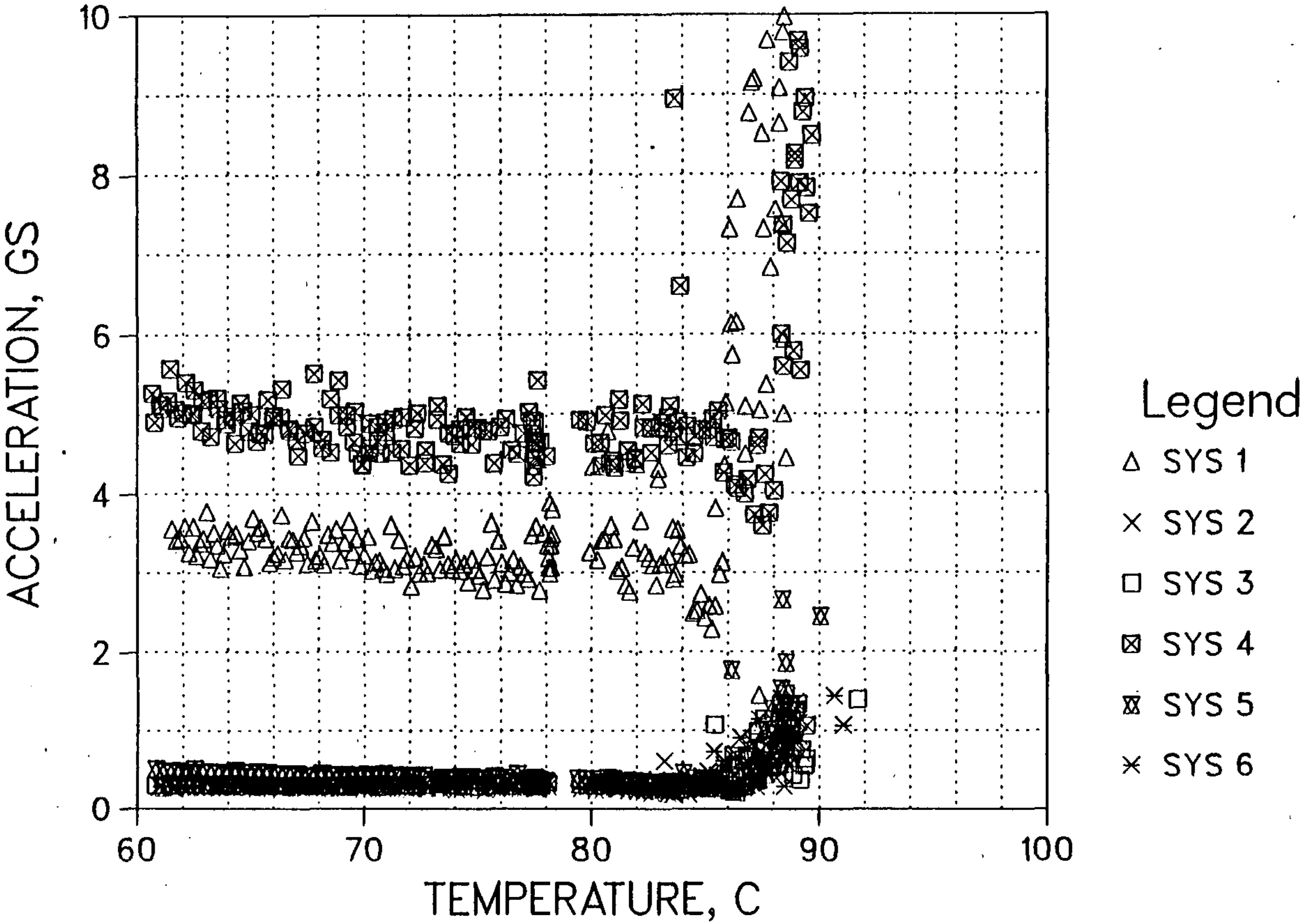
A) Data Curves

2) Acceleration vs. Temperature

The pump casing acceleration is plotted against the associated RTD temperature. Note that in the middle of the (number 3) 6 pump test these signals were lost due to a filter failure.

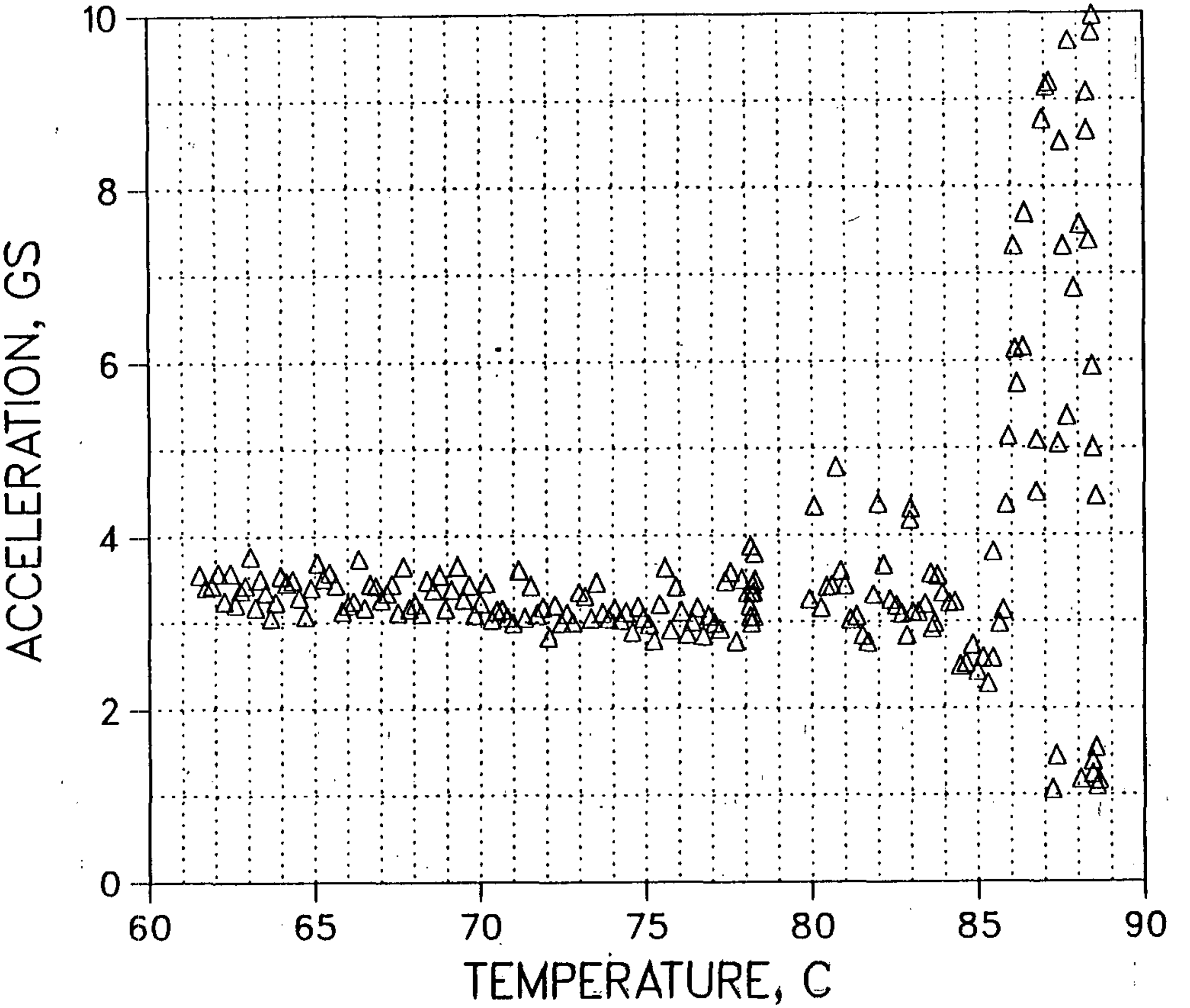
See notes at Appendix A-1.

PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1

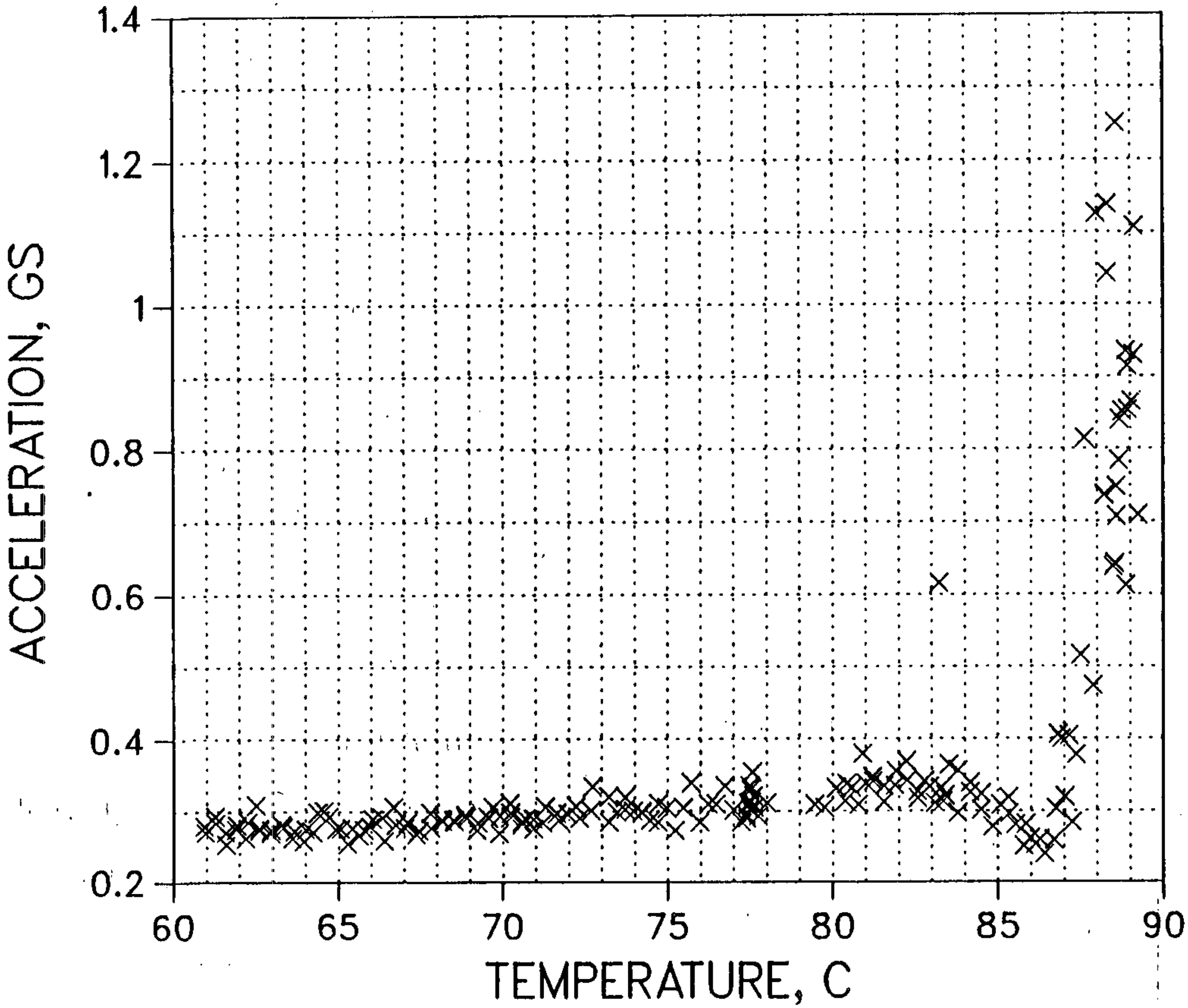


PUMP CAVITATION TESTS

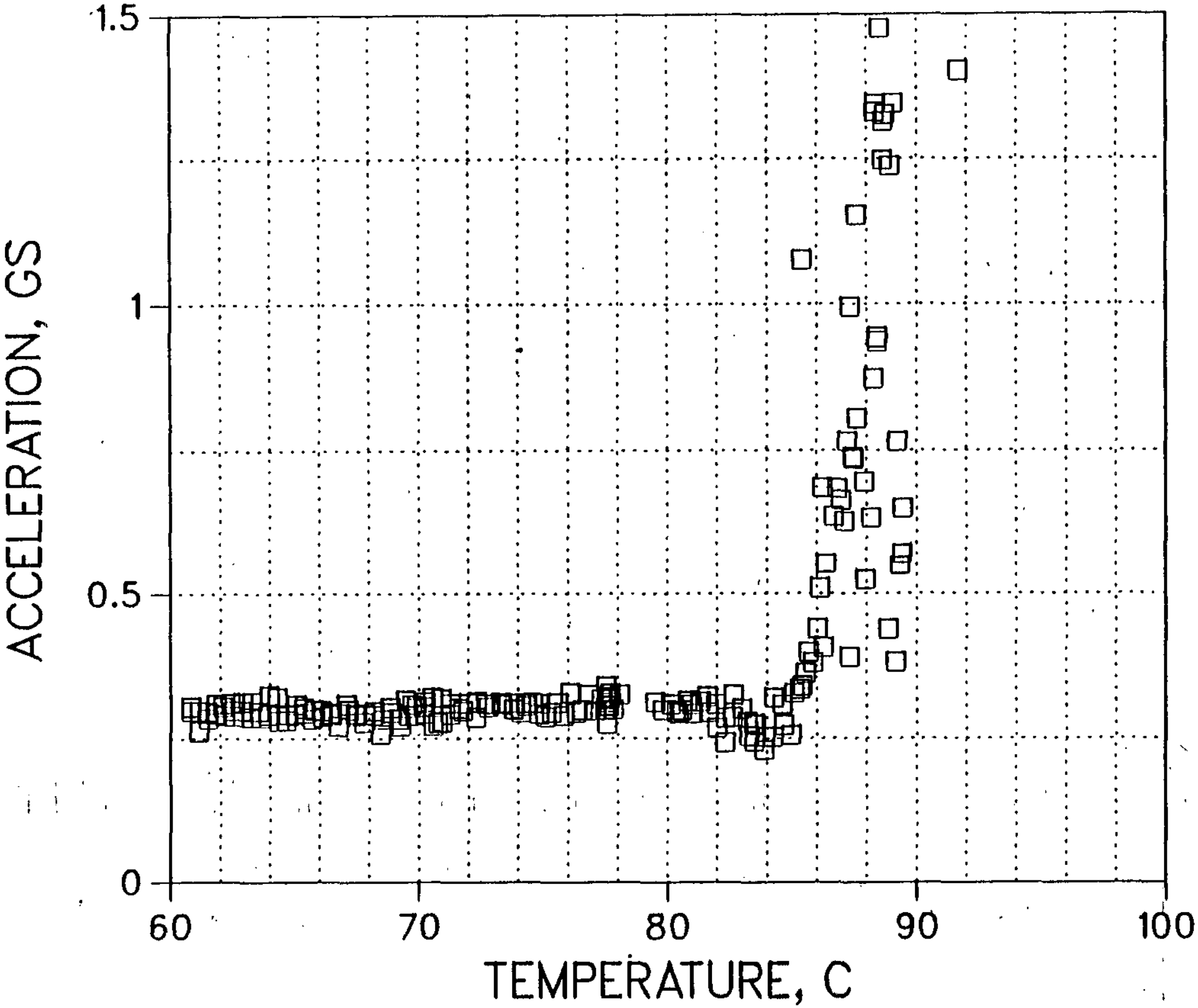
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



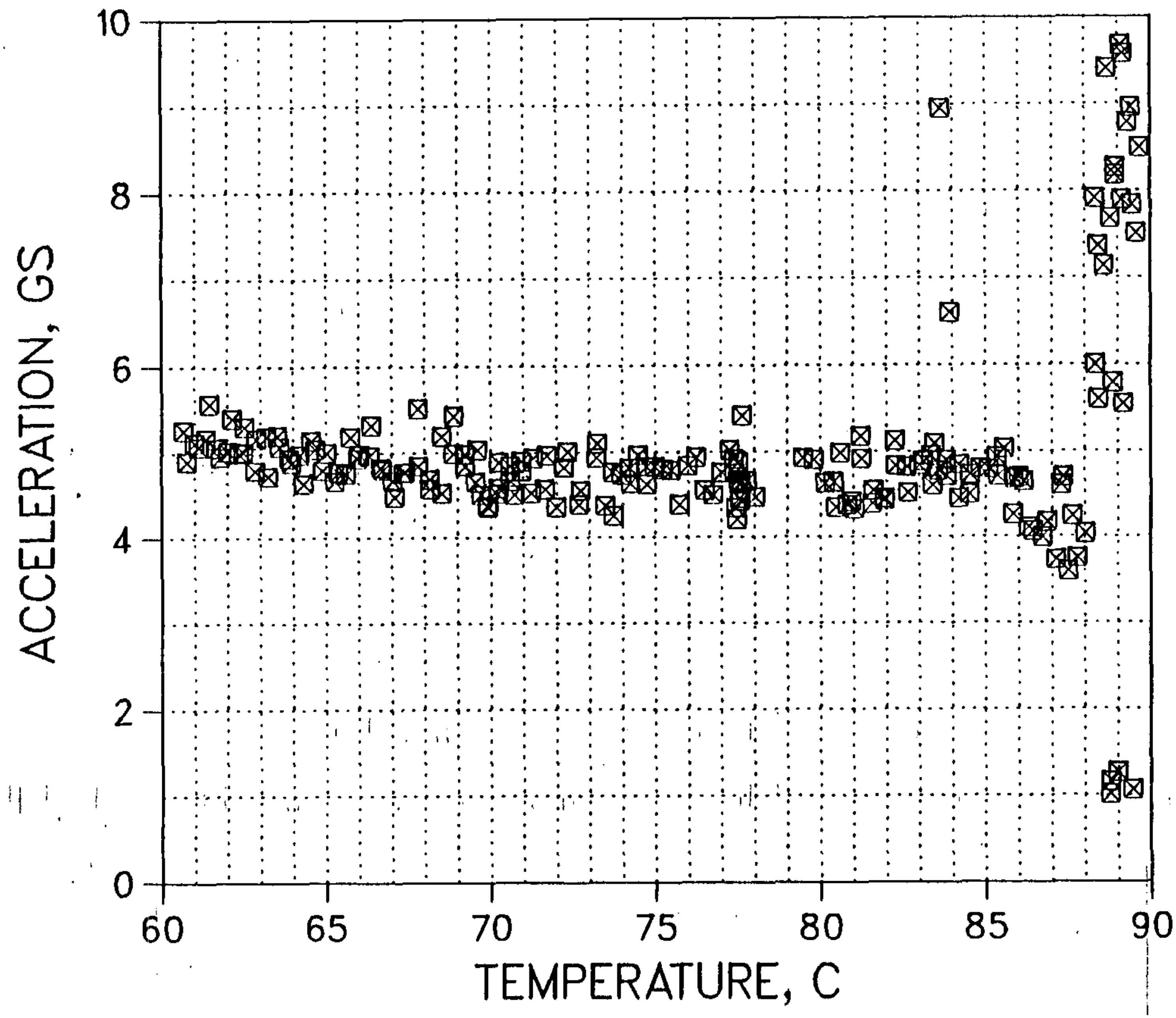
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



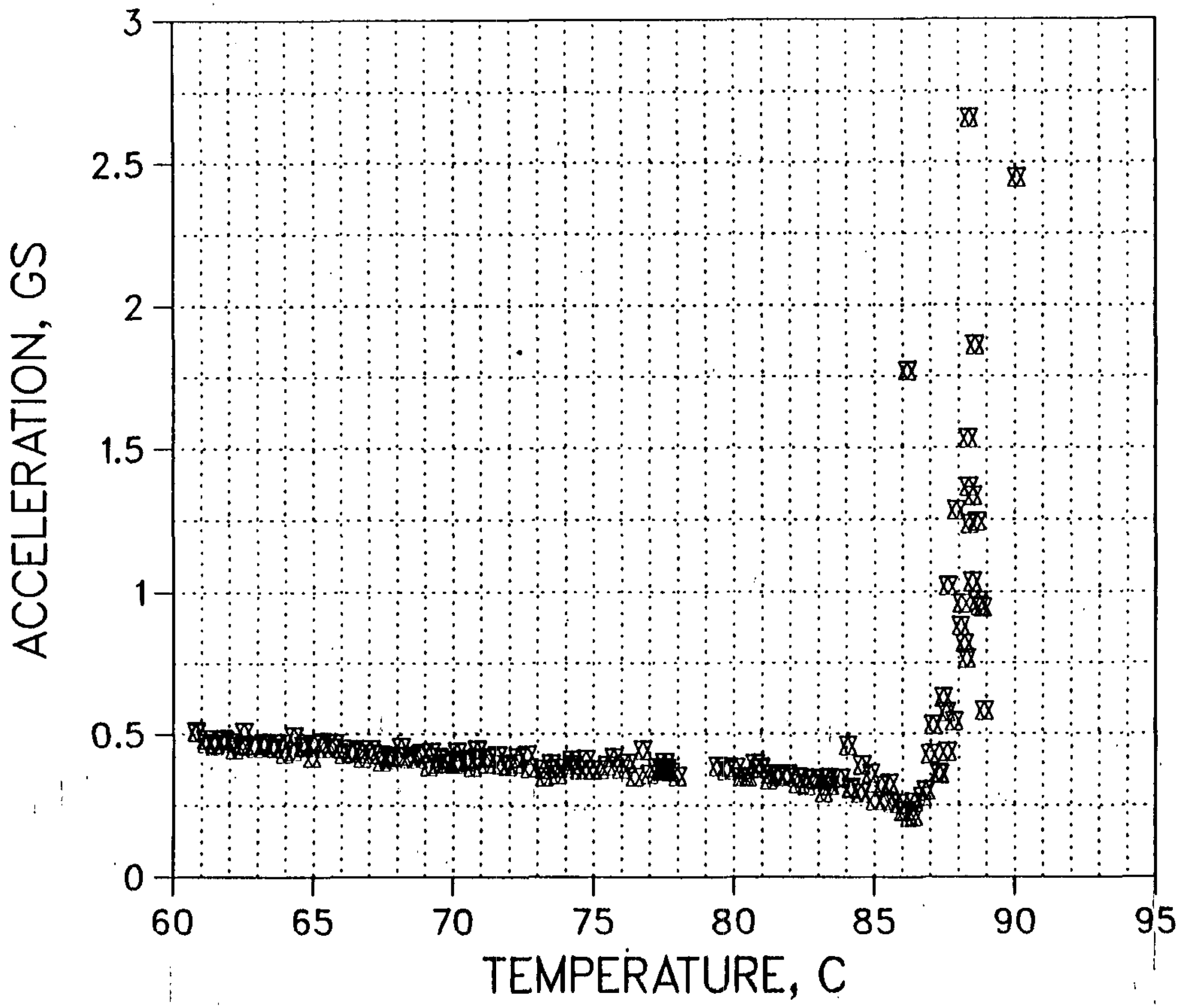
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



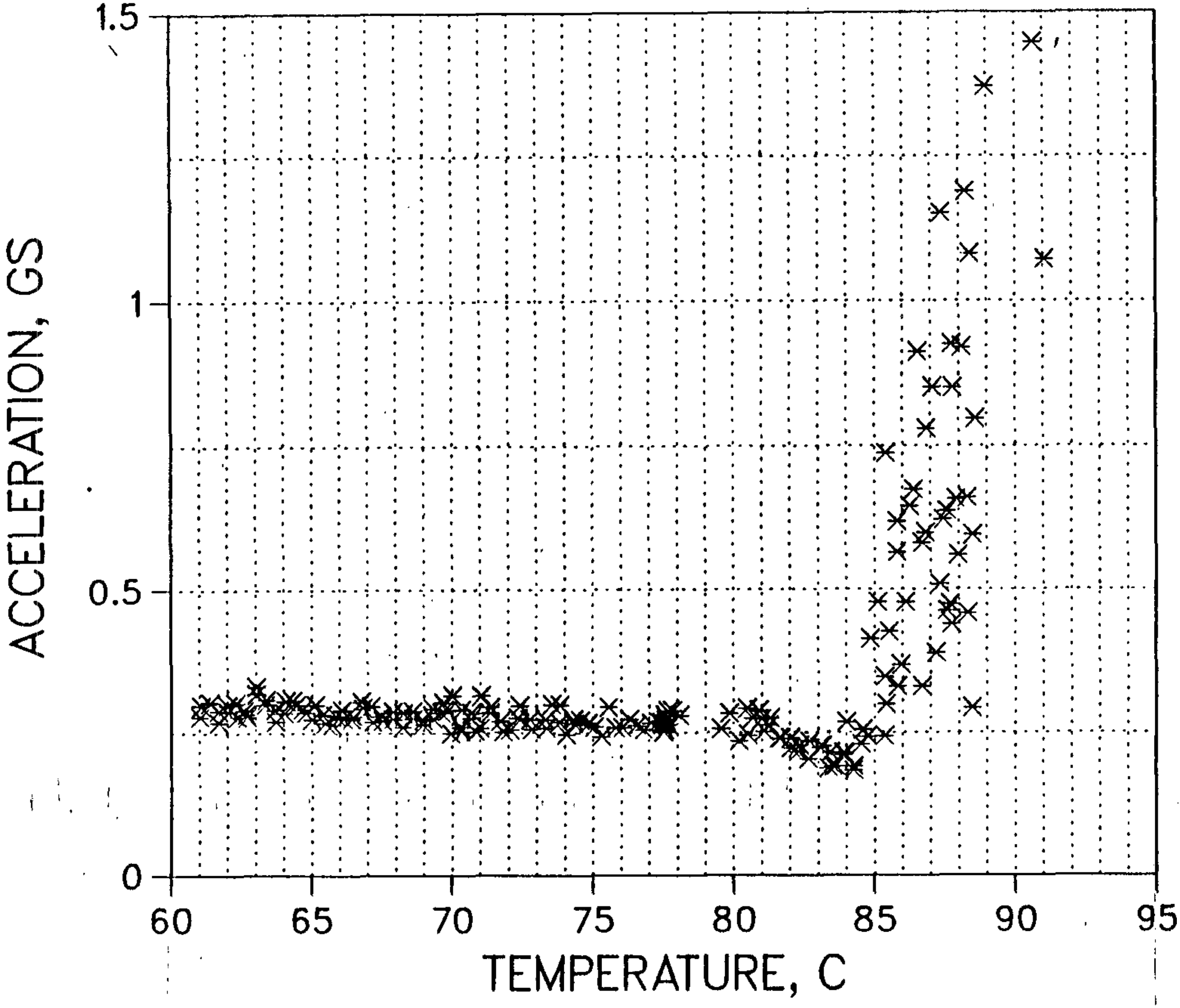
4

PUMP CAVITATION TESTS

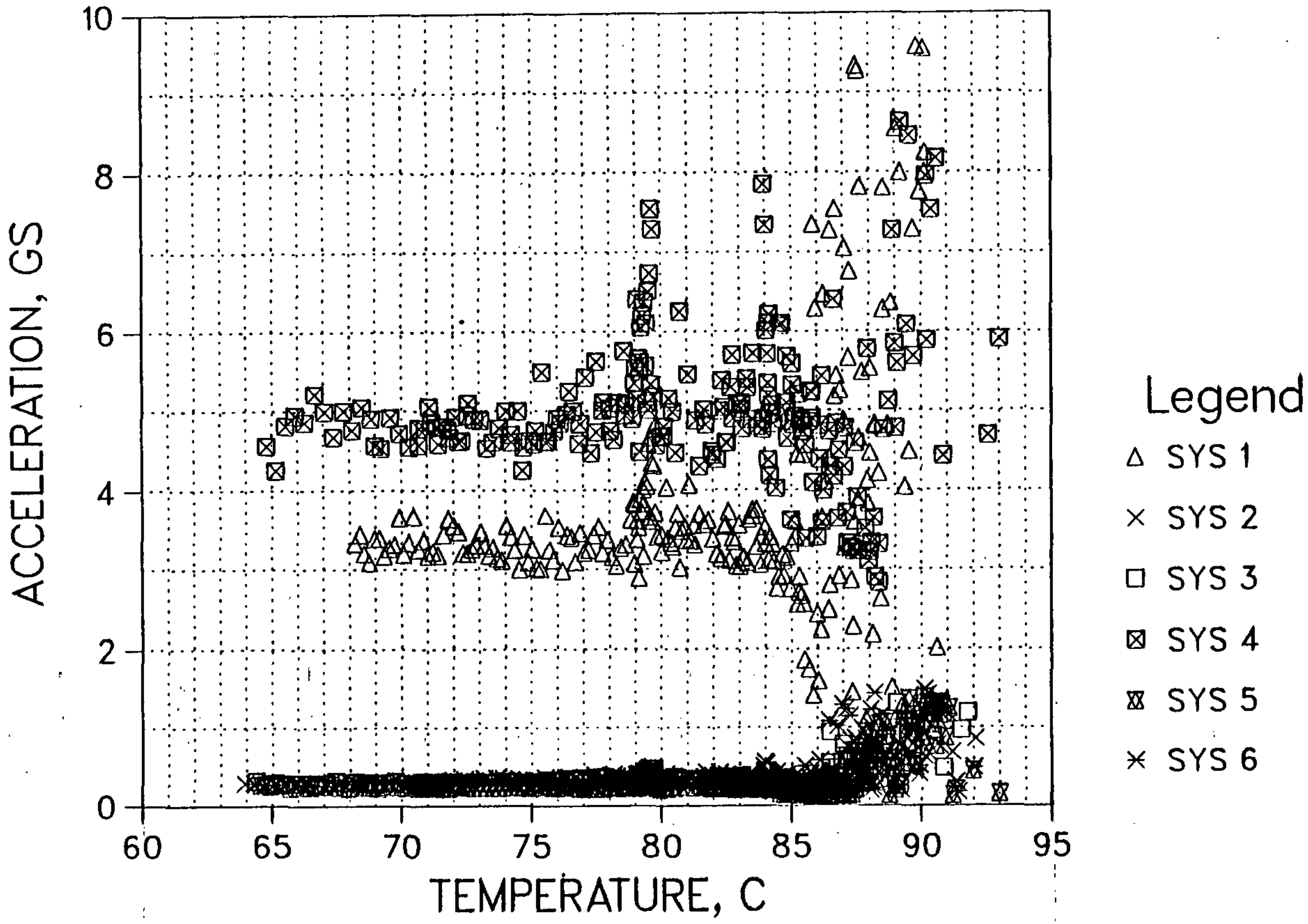
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



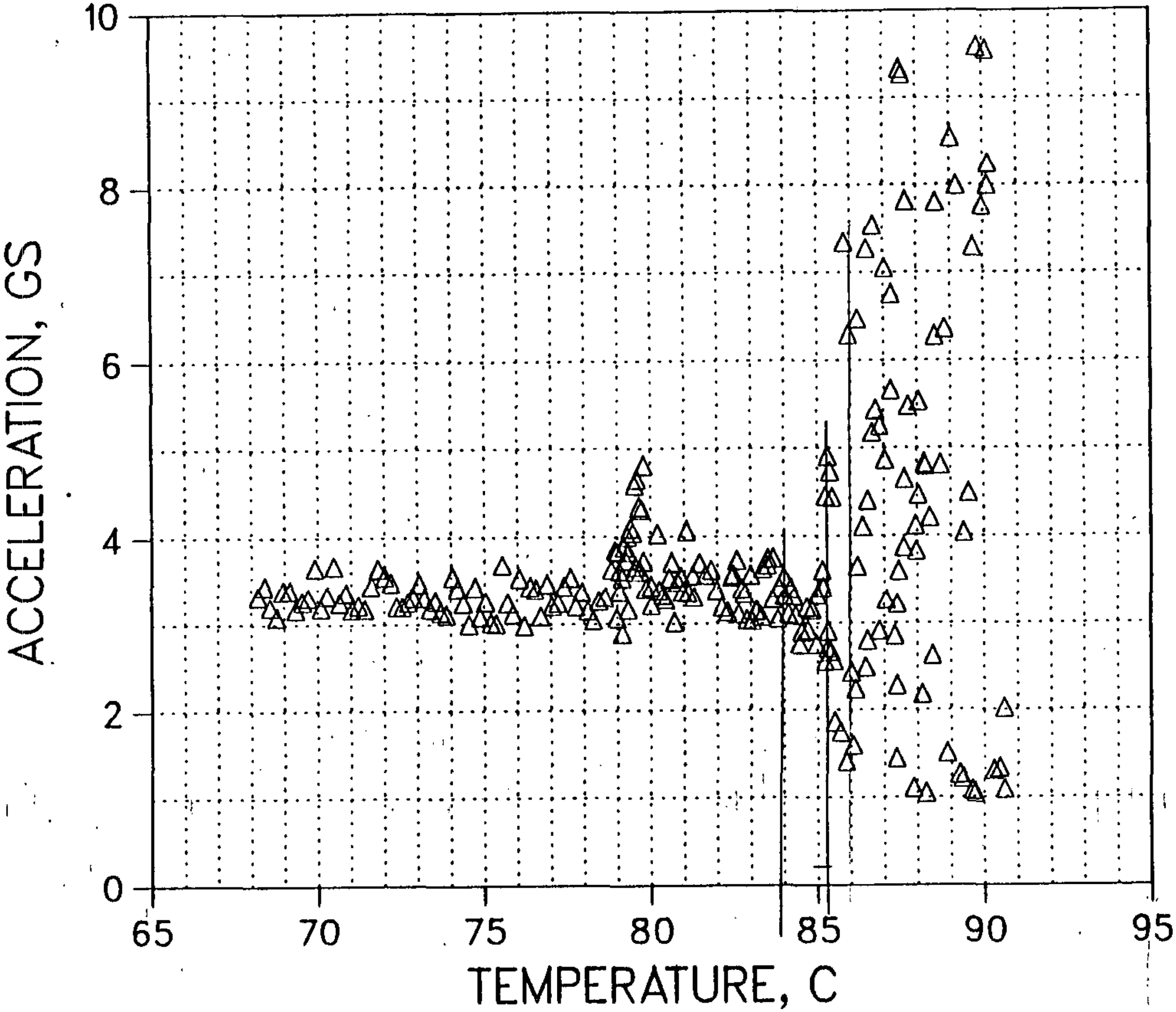
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,1



PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2

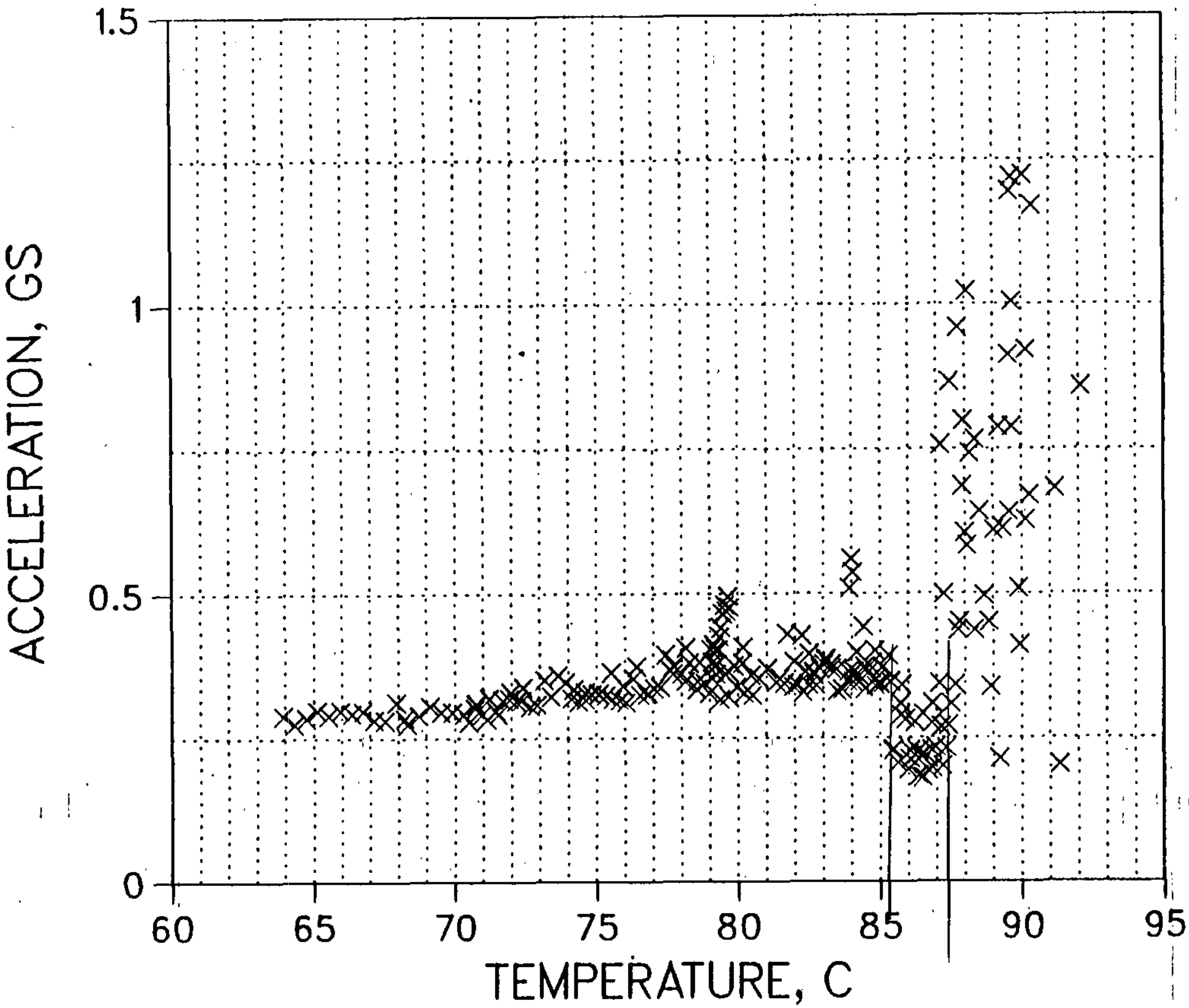


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2

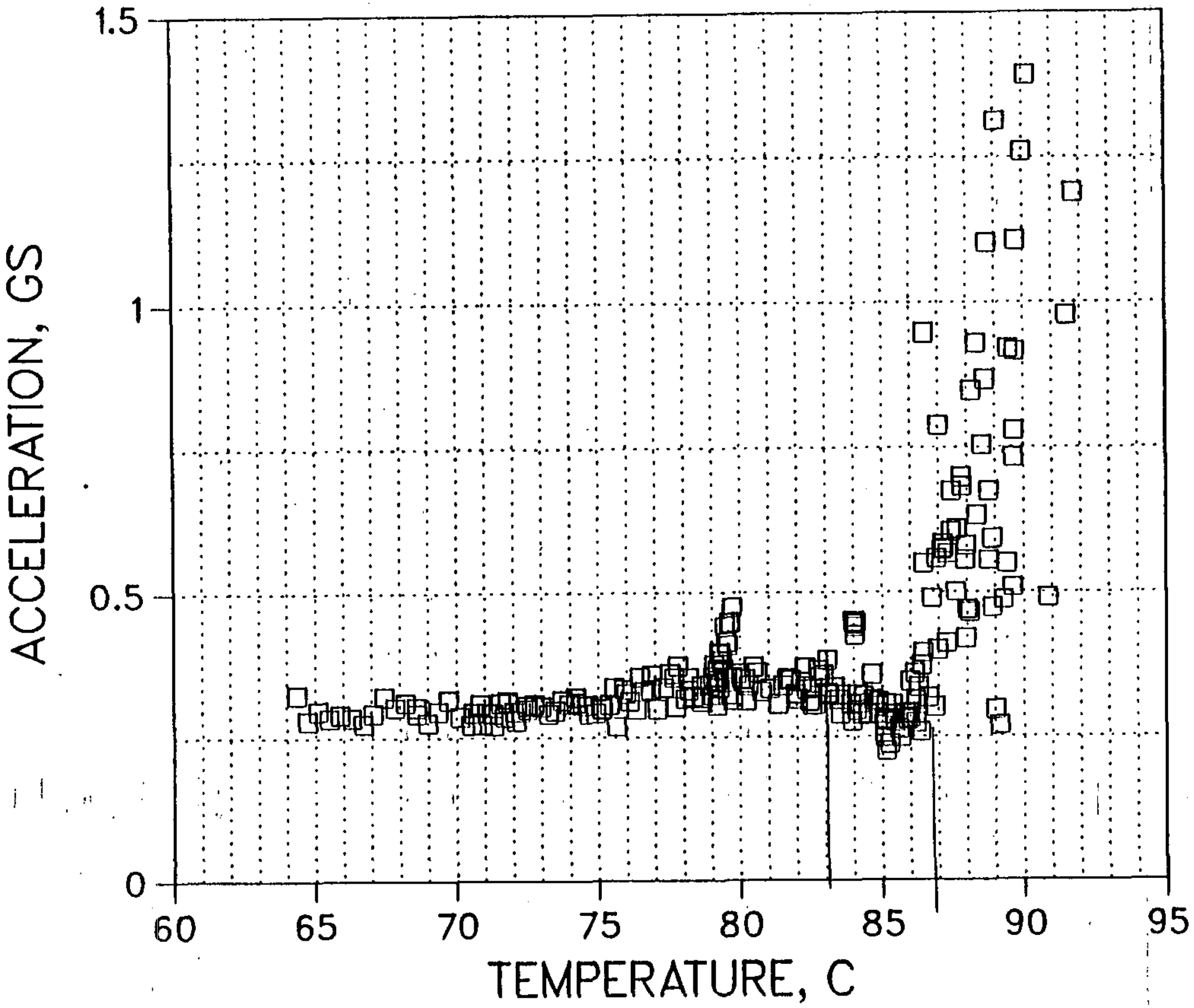


PUMP CAVITATION TESTS

UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2

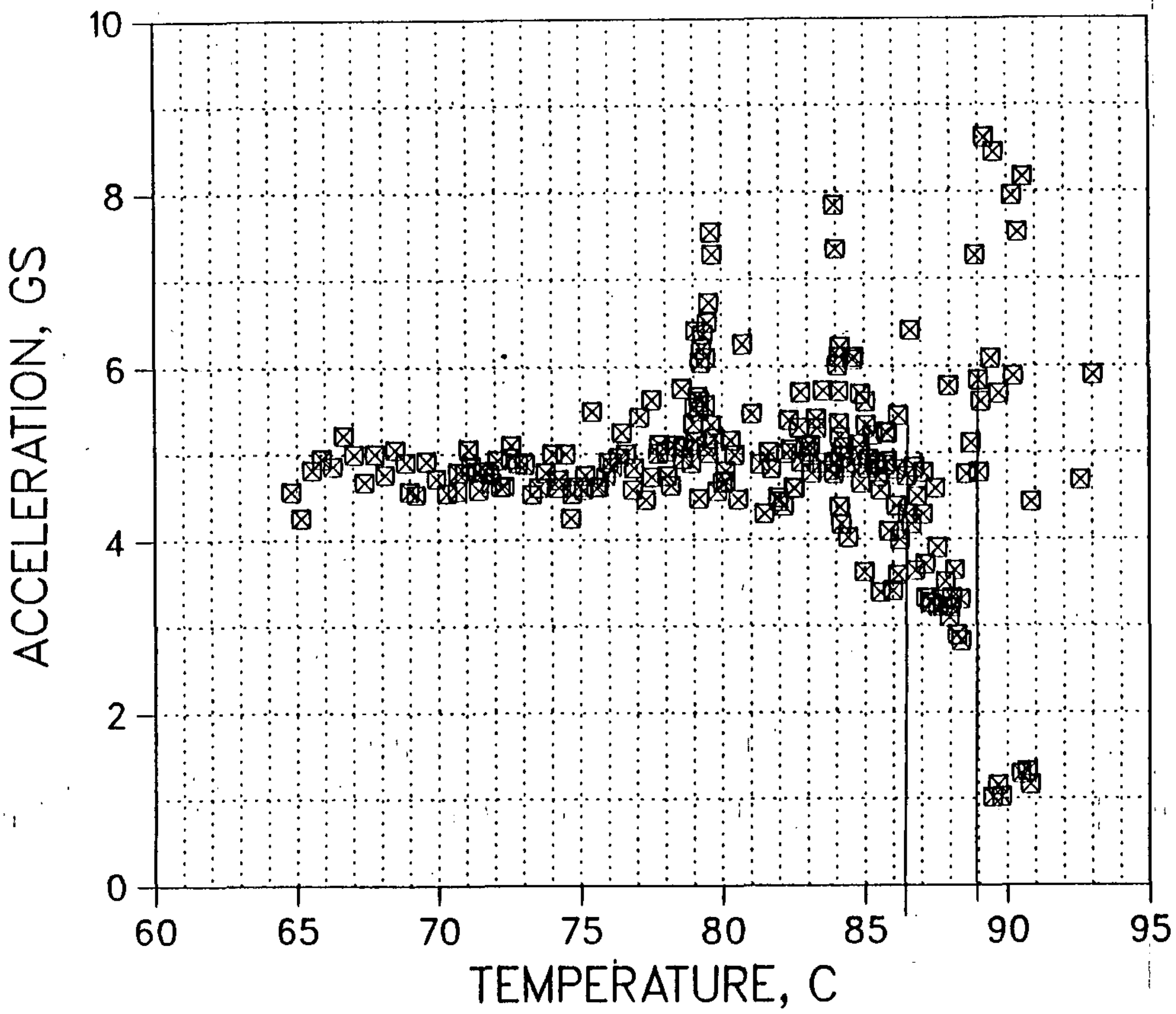


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2

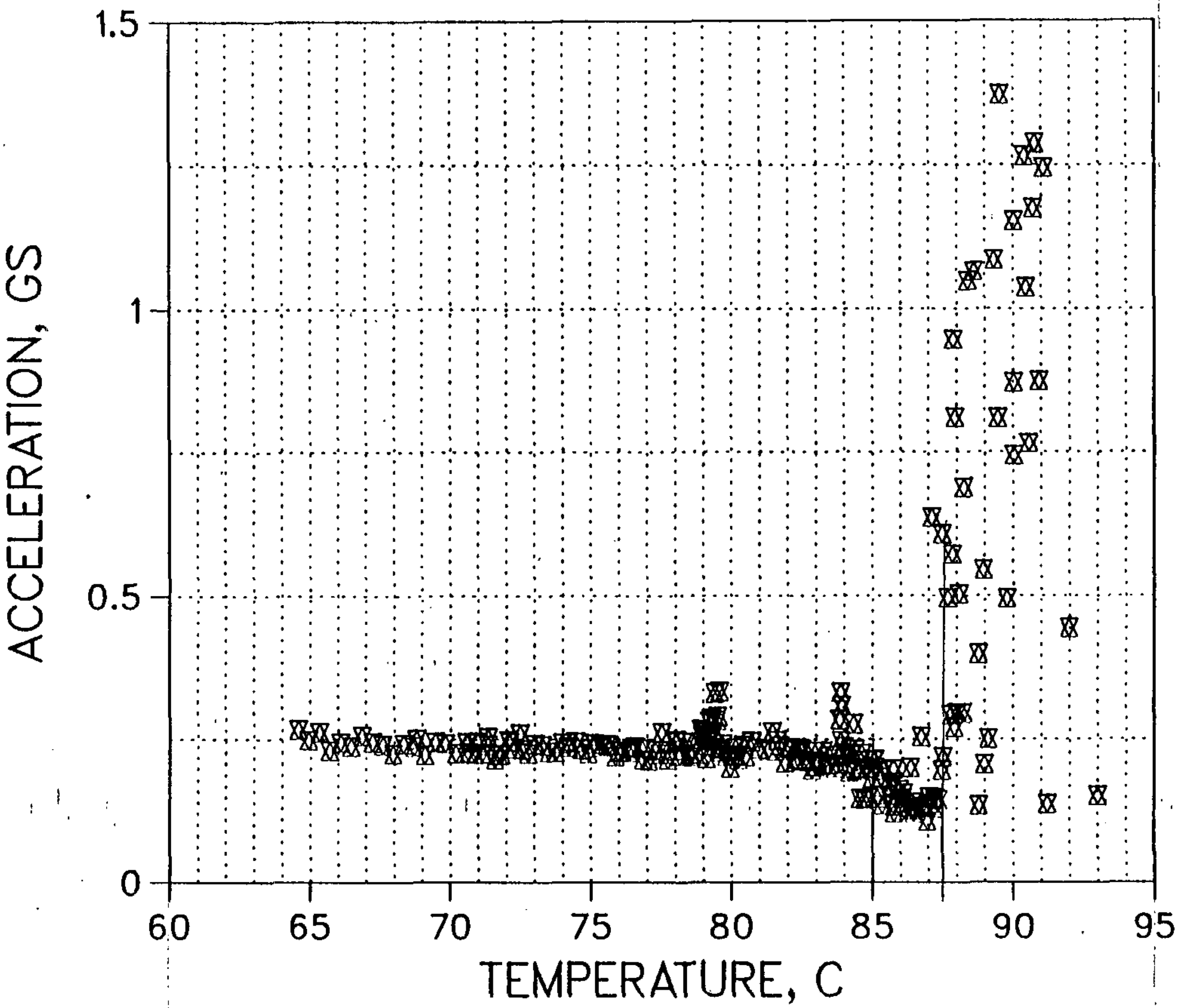


PUMP CAVITATION TESTS

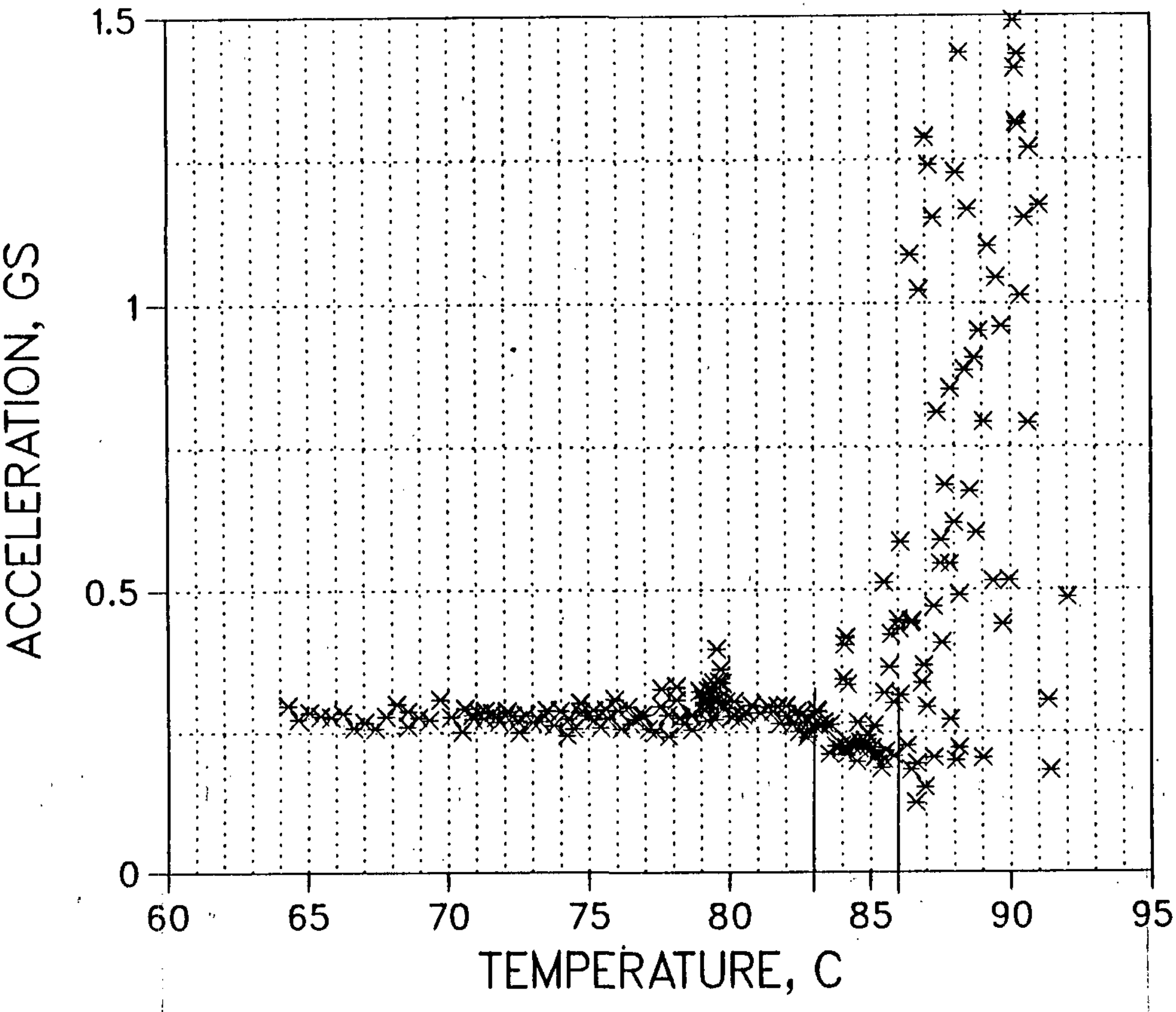
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2



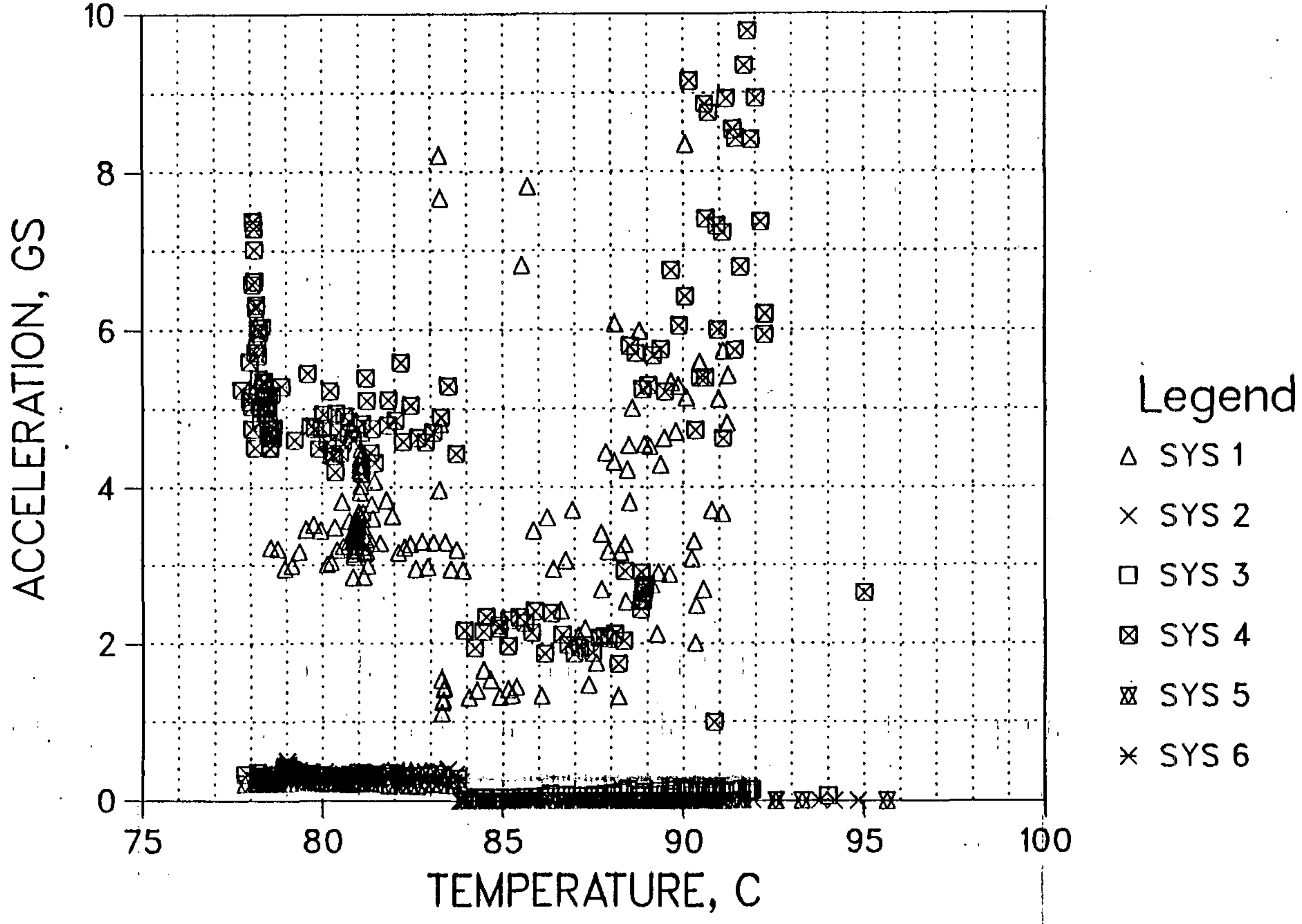
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2

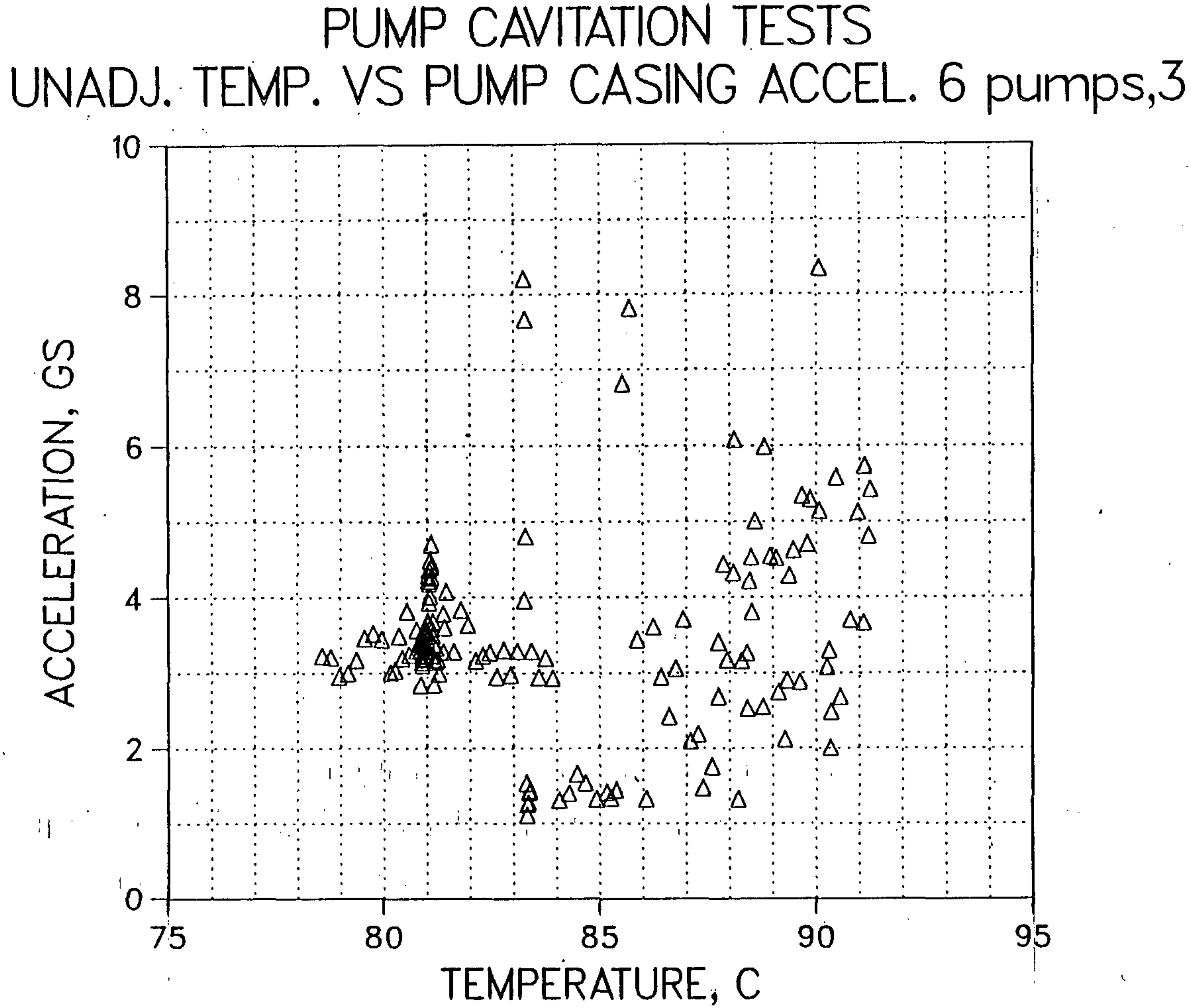


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,2



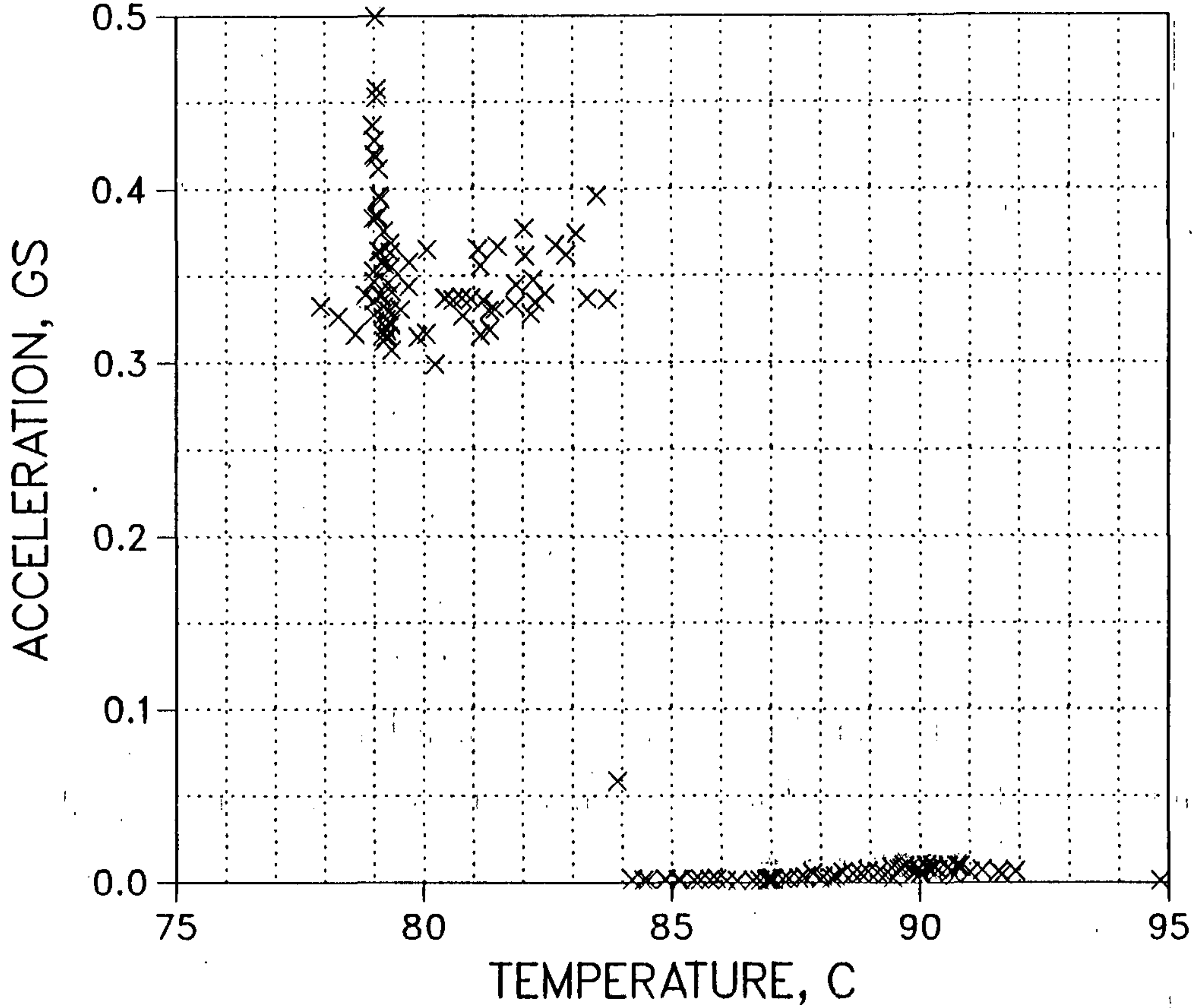
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3



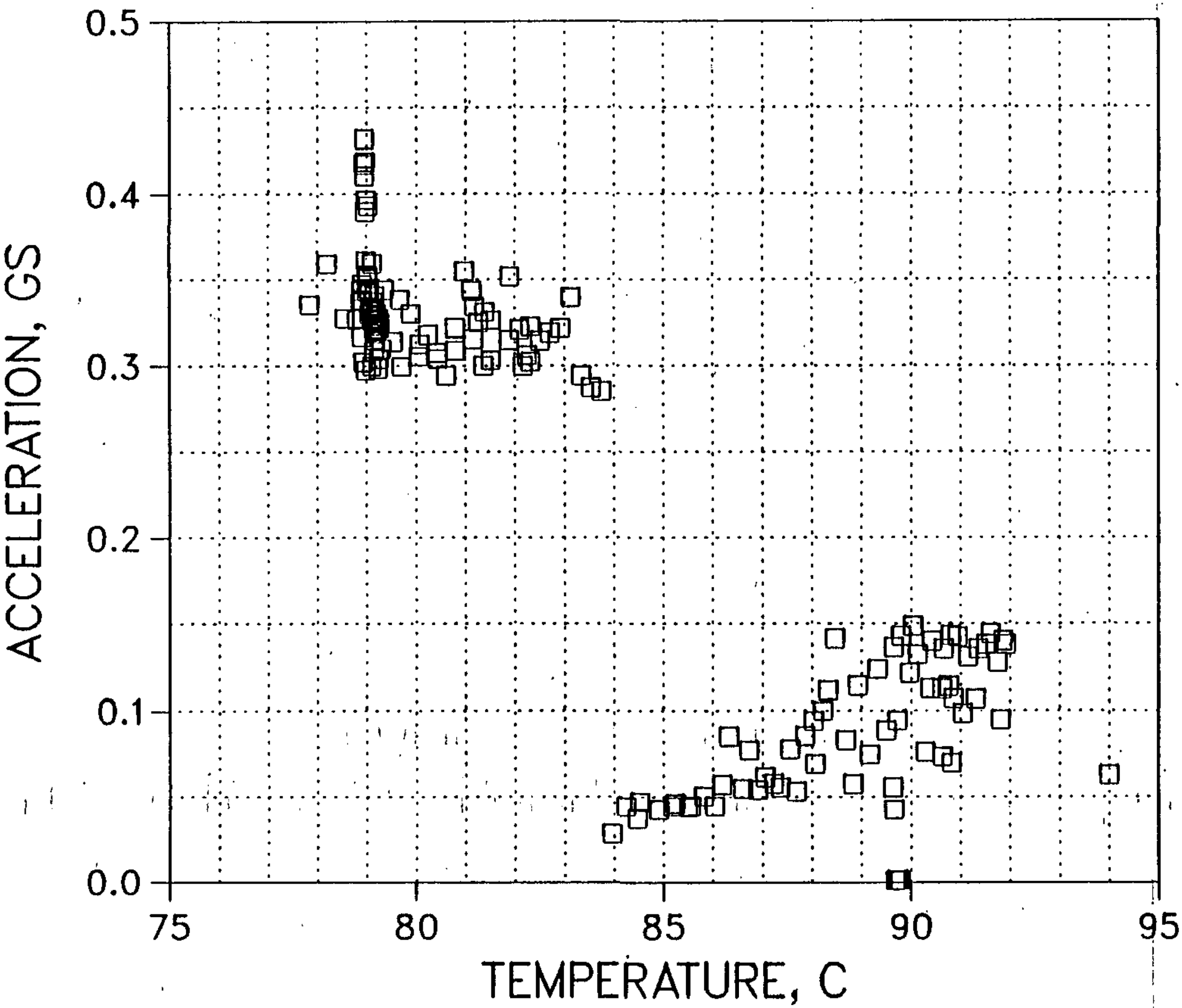

PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3
ACCELERATION, GS
0
2
4
6
8
10
75
80
85
90
95
TEMPERATURE, C

PUMP CAVITATION TESTS

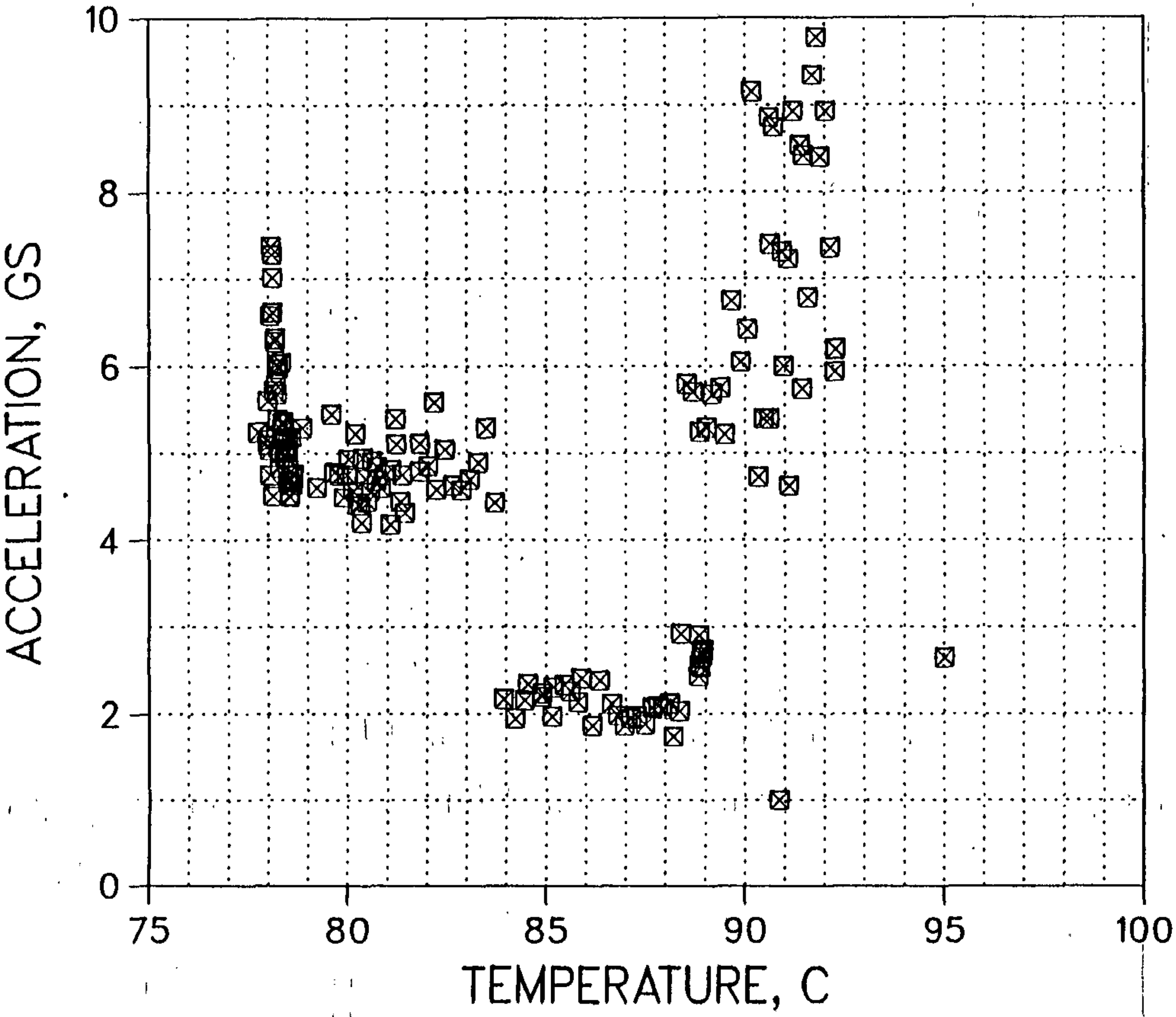
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3



PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3

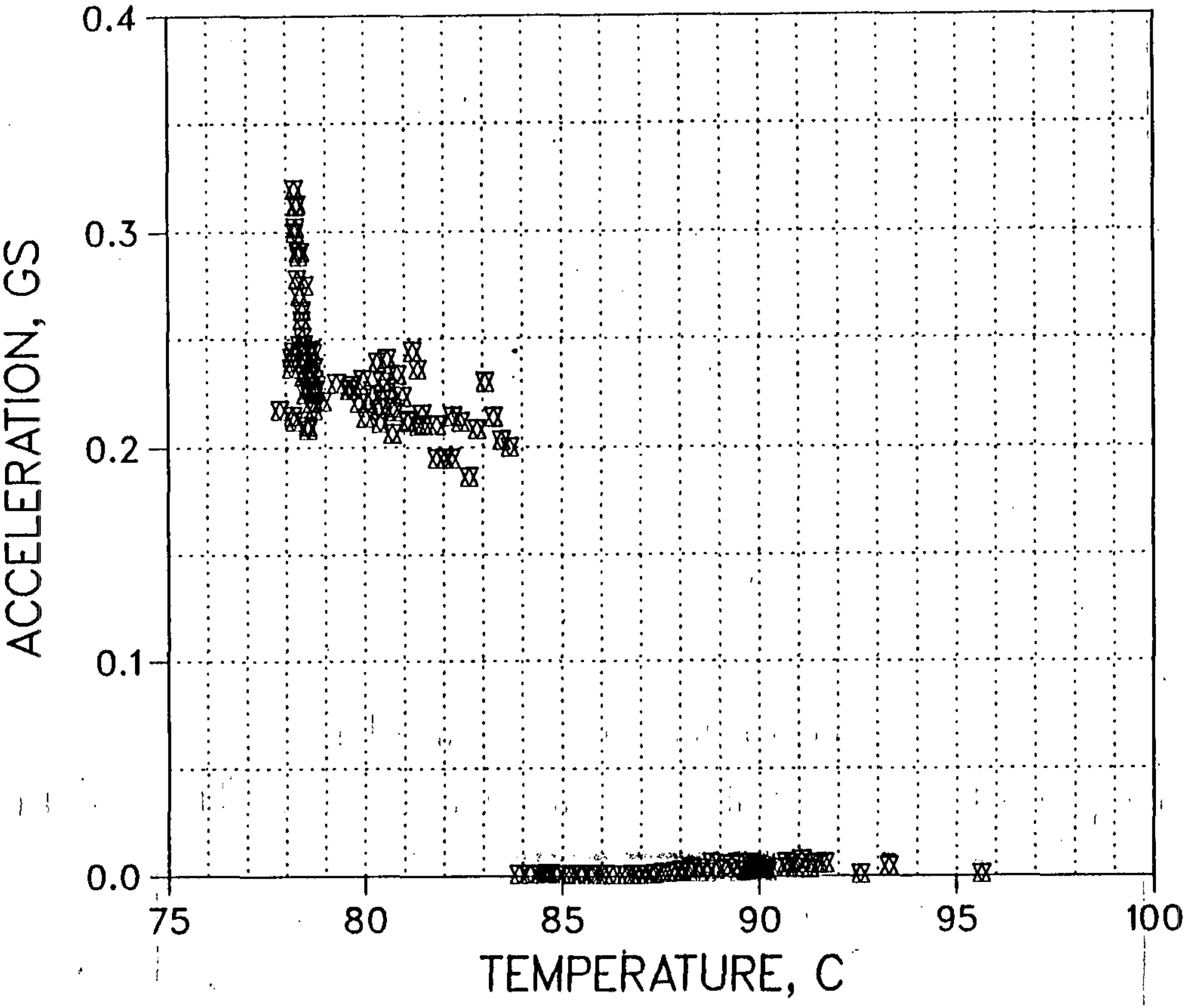


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3



PUMP CAVITATION TESTS

UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3



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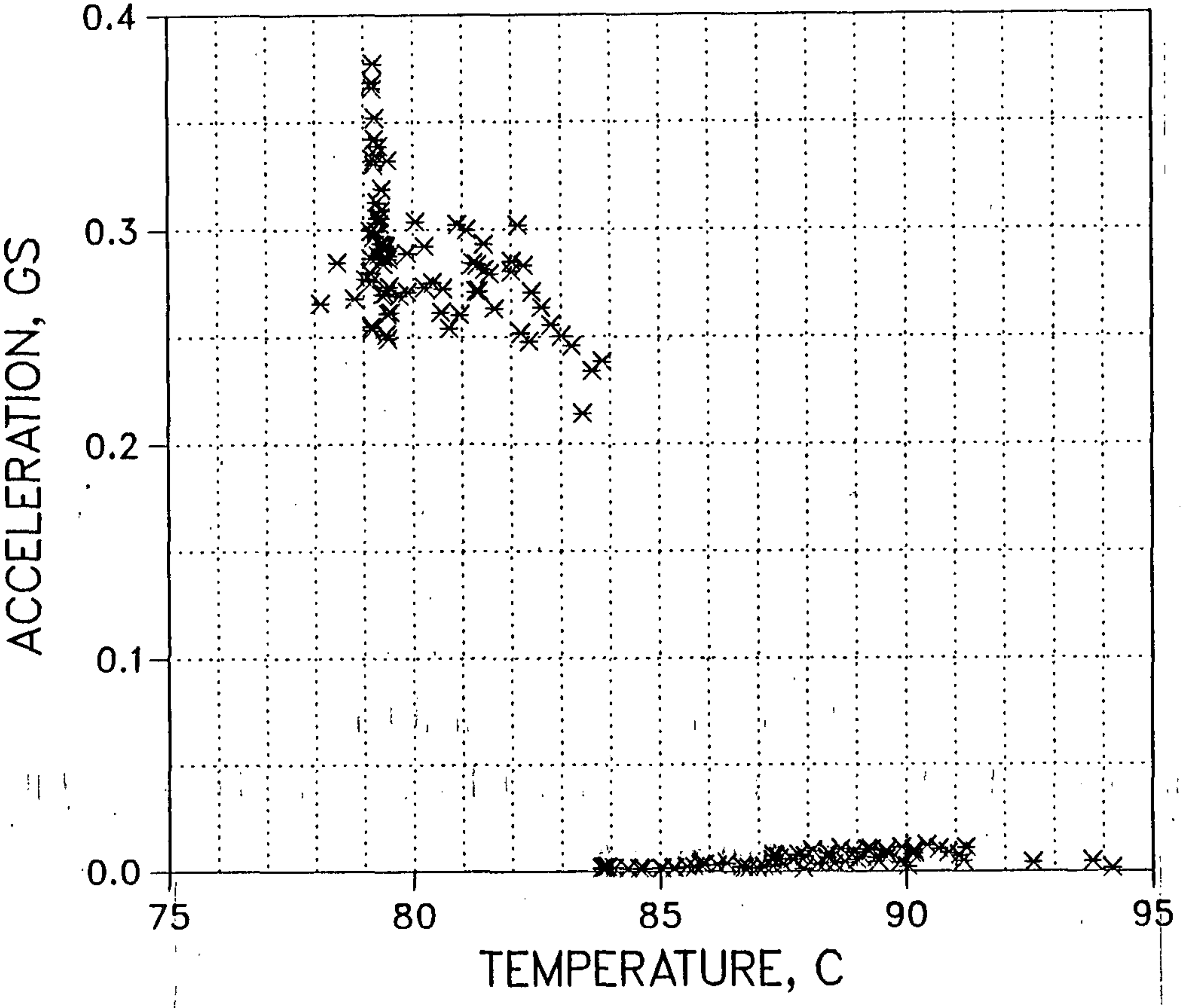
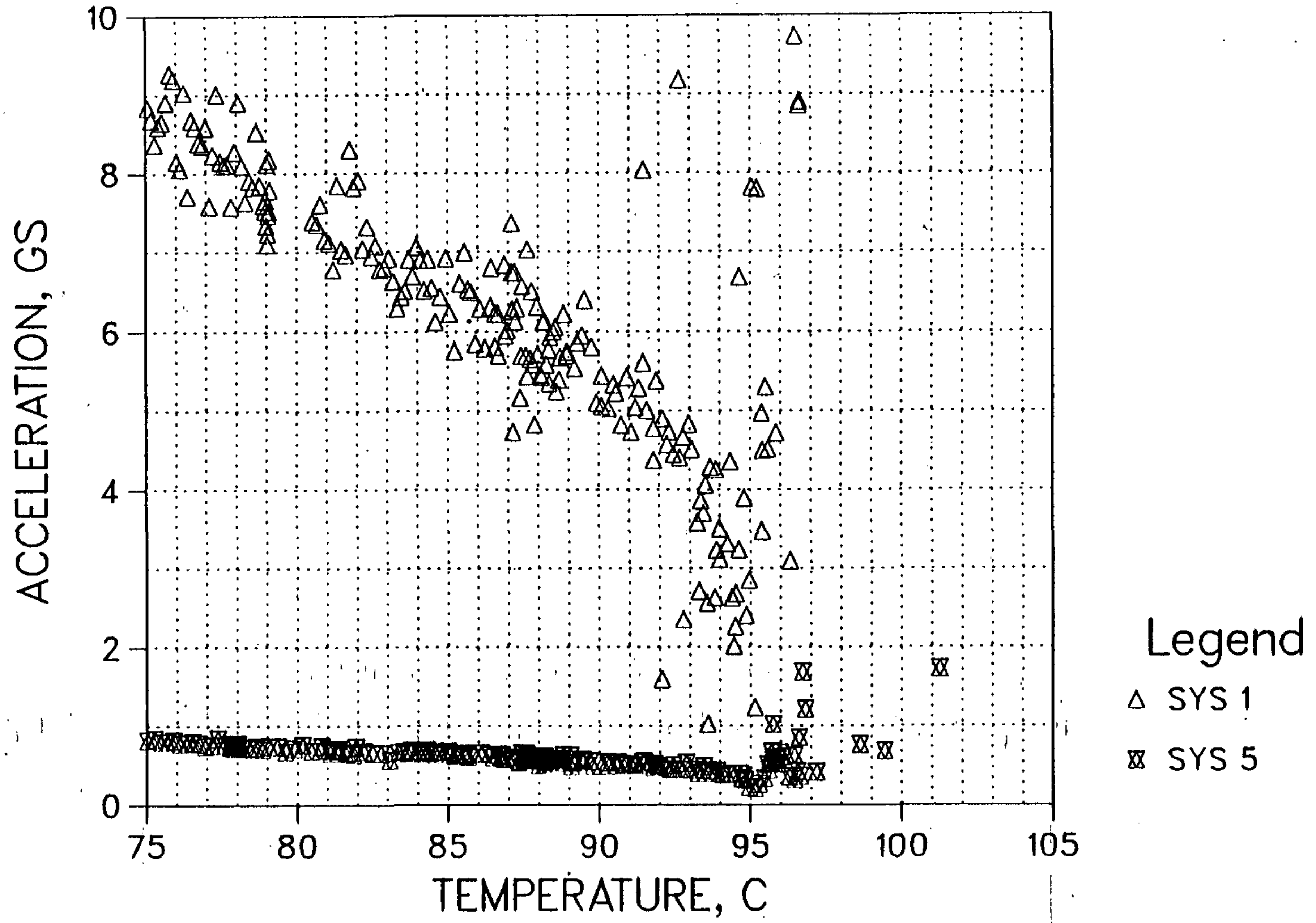
PUMP CAVITATION TESTS

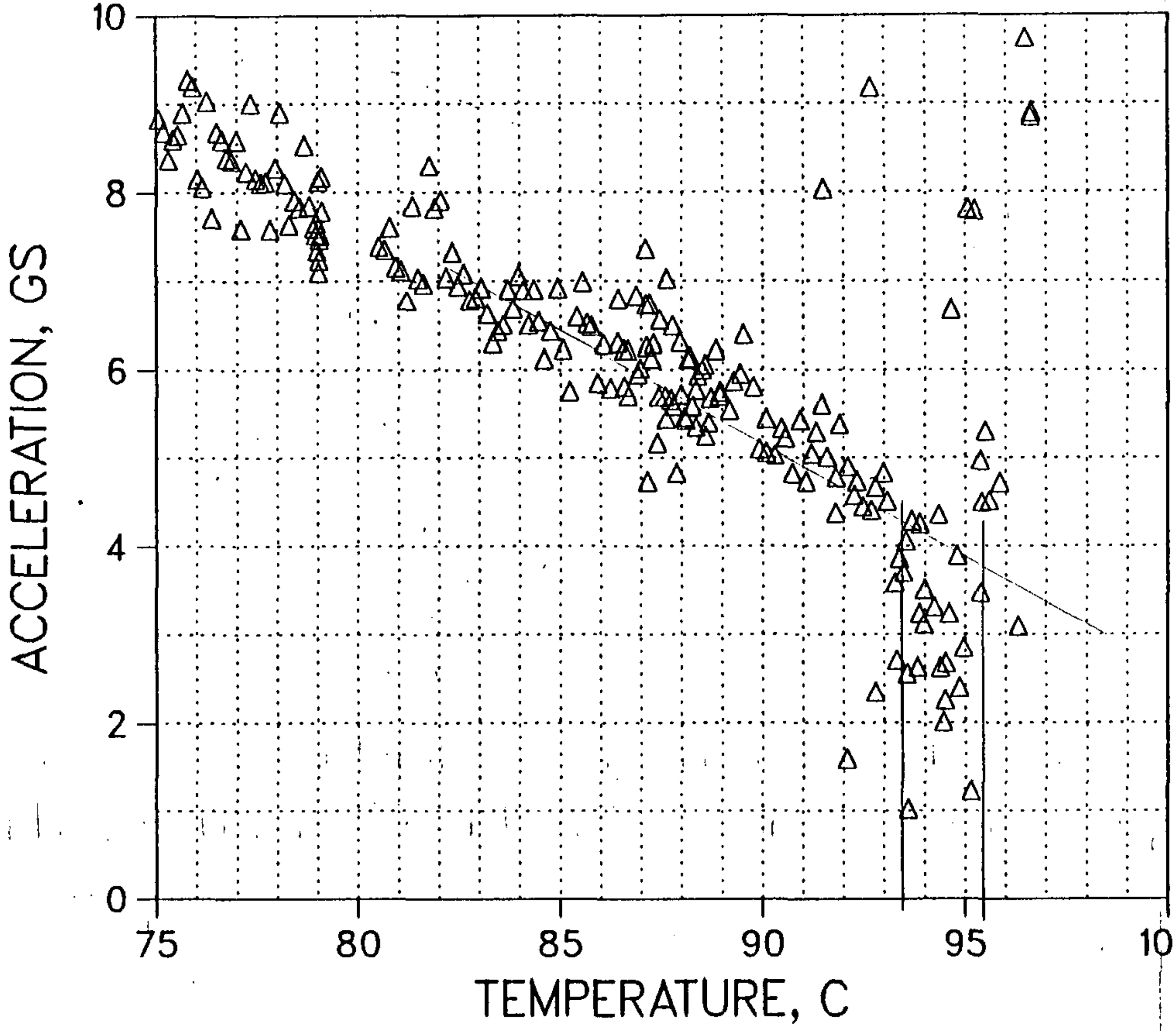
UNADJ. TEMP. VS PUMP CASING ACCEL. 6 pumps,3

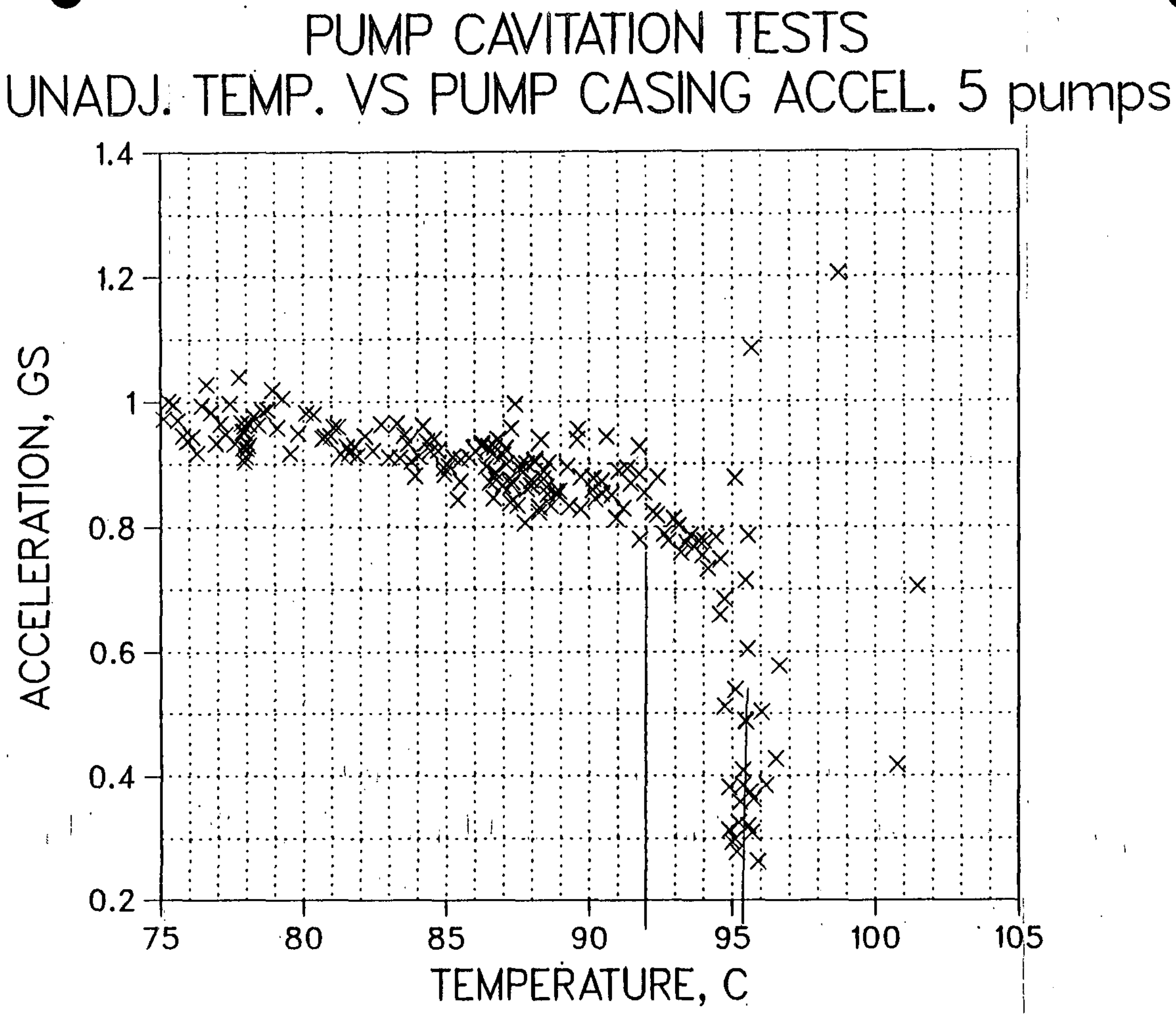


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps



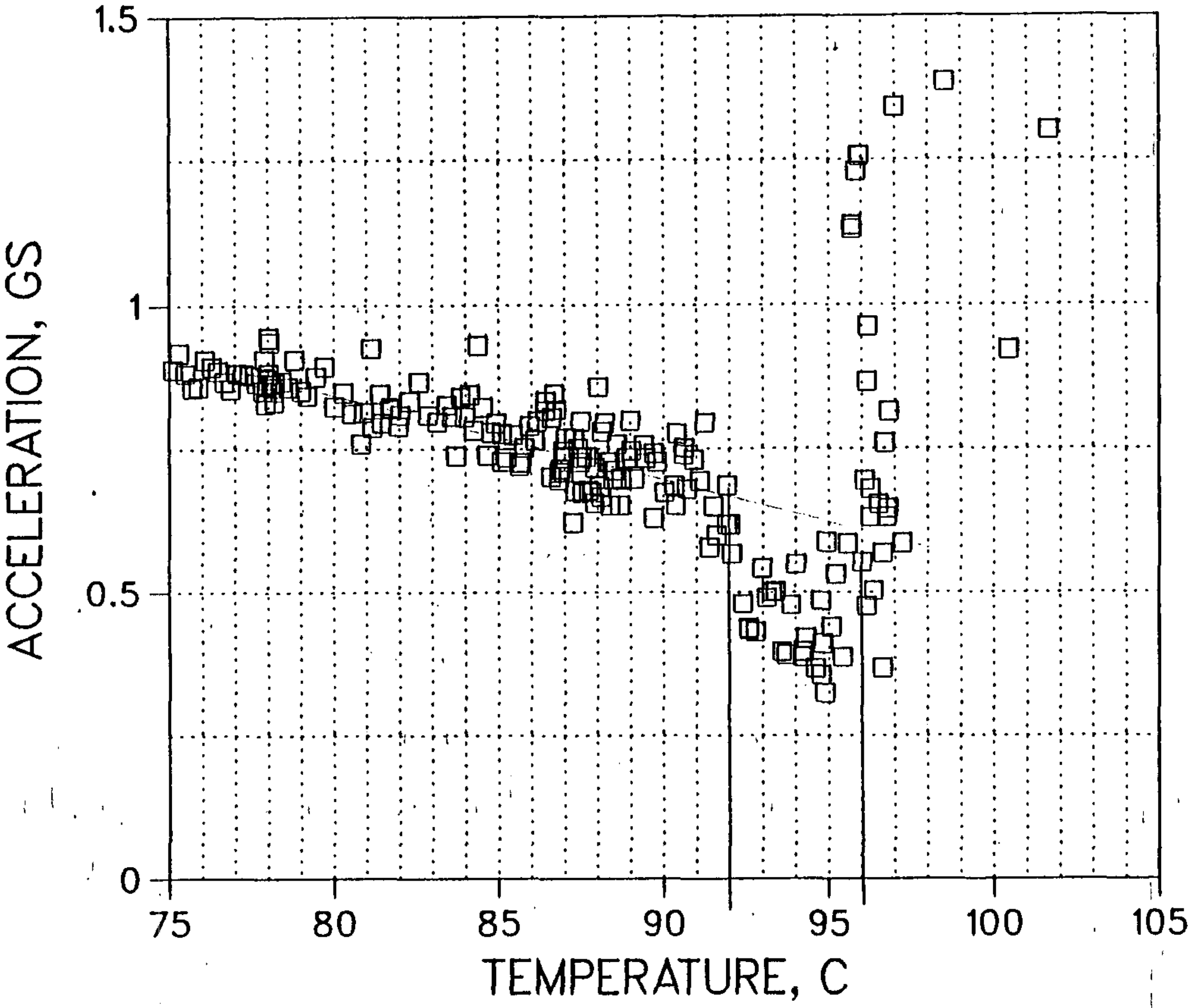
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps



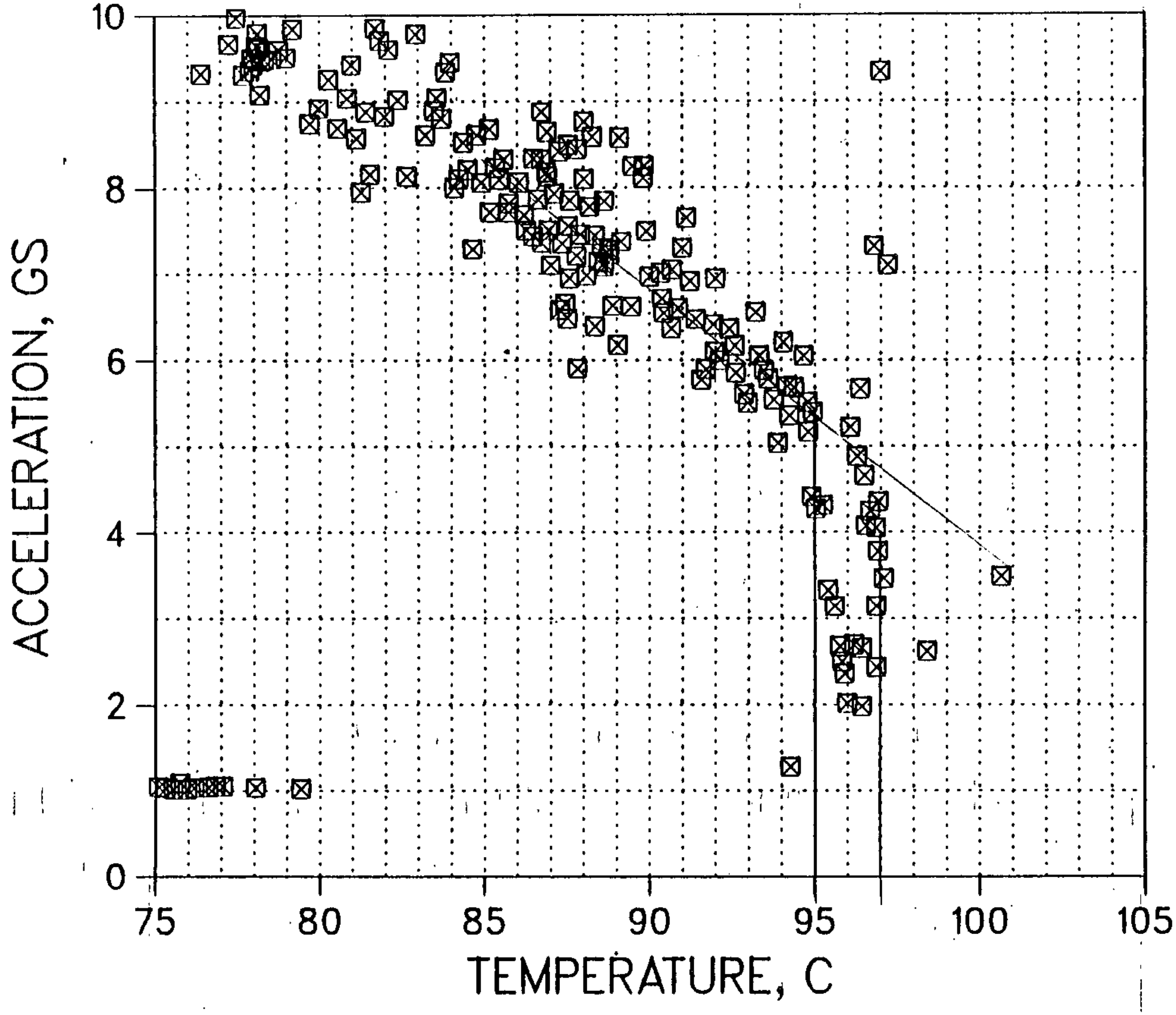


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps
ACCELERATION, GS
1.4
1.2
1
0.8
0.6
0.4
0.2
75
80
85
90
95
100
105
TEMPERATURE, C

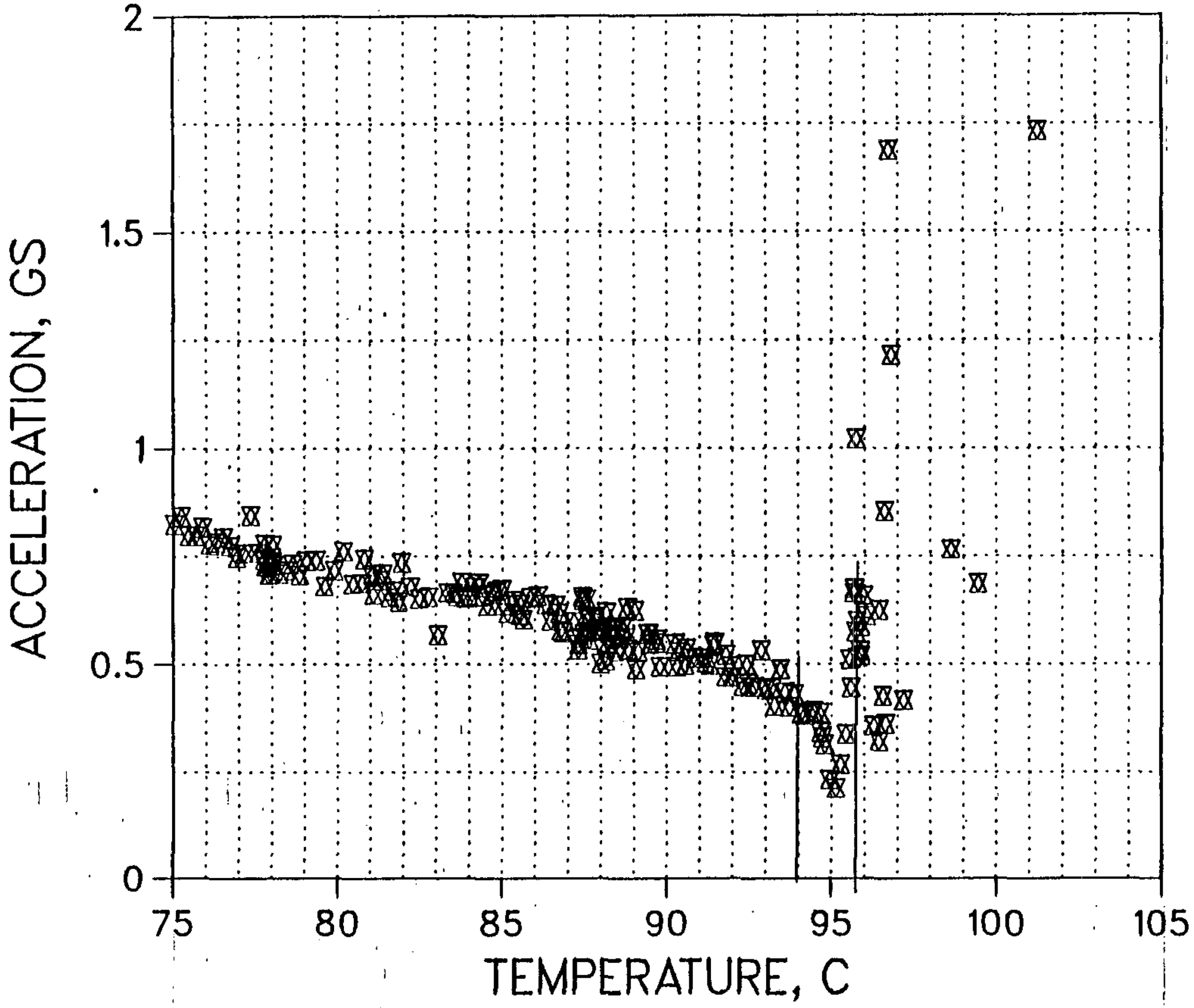
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps

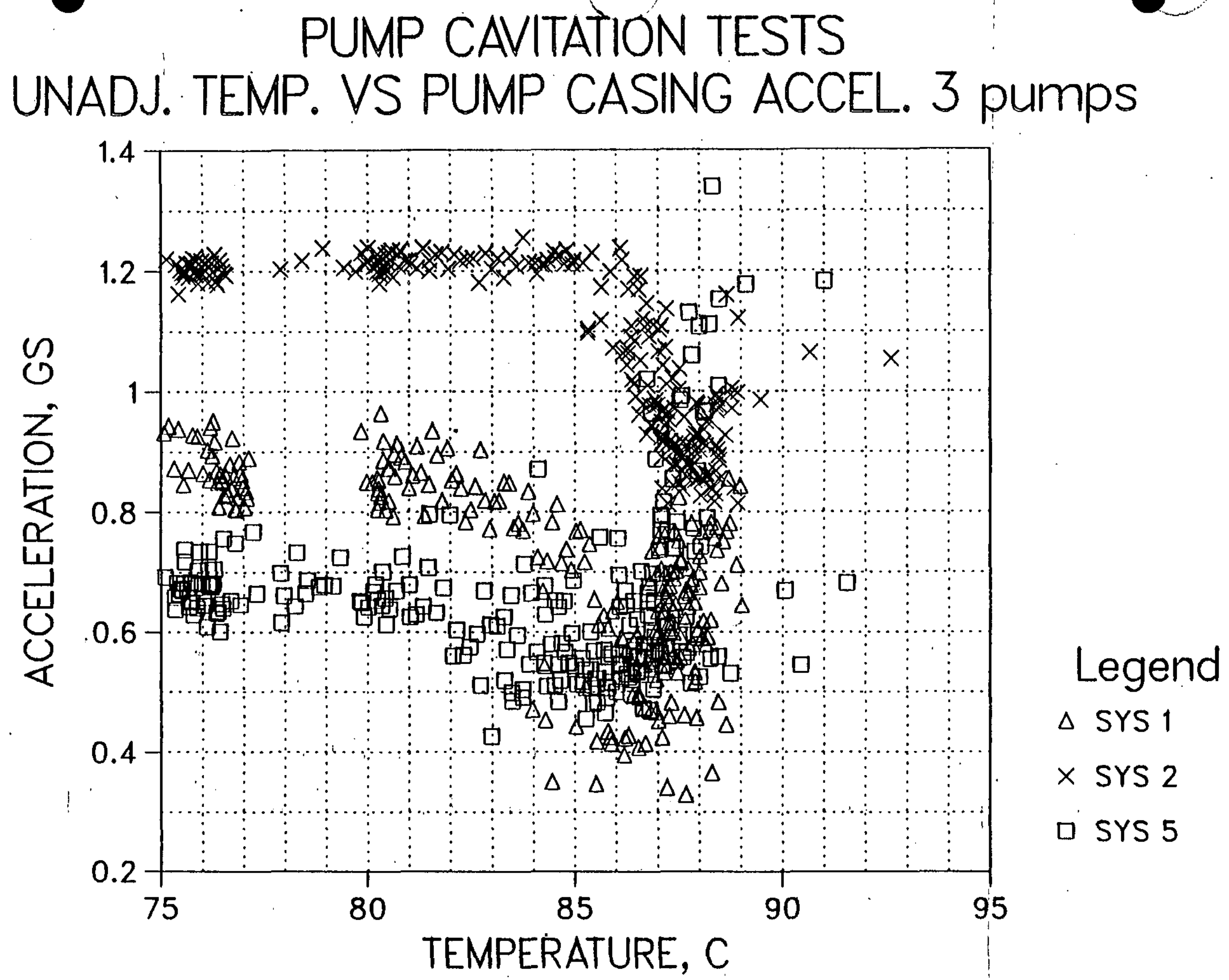


PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps

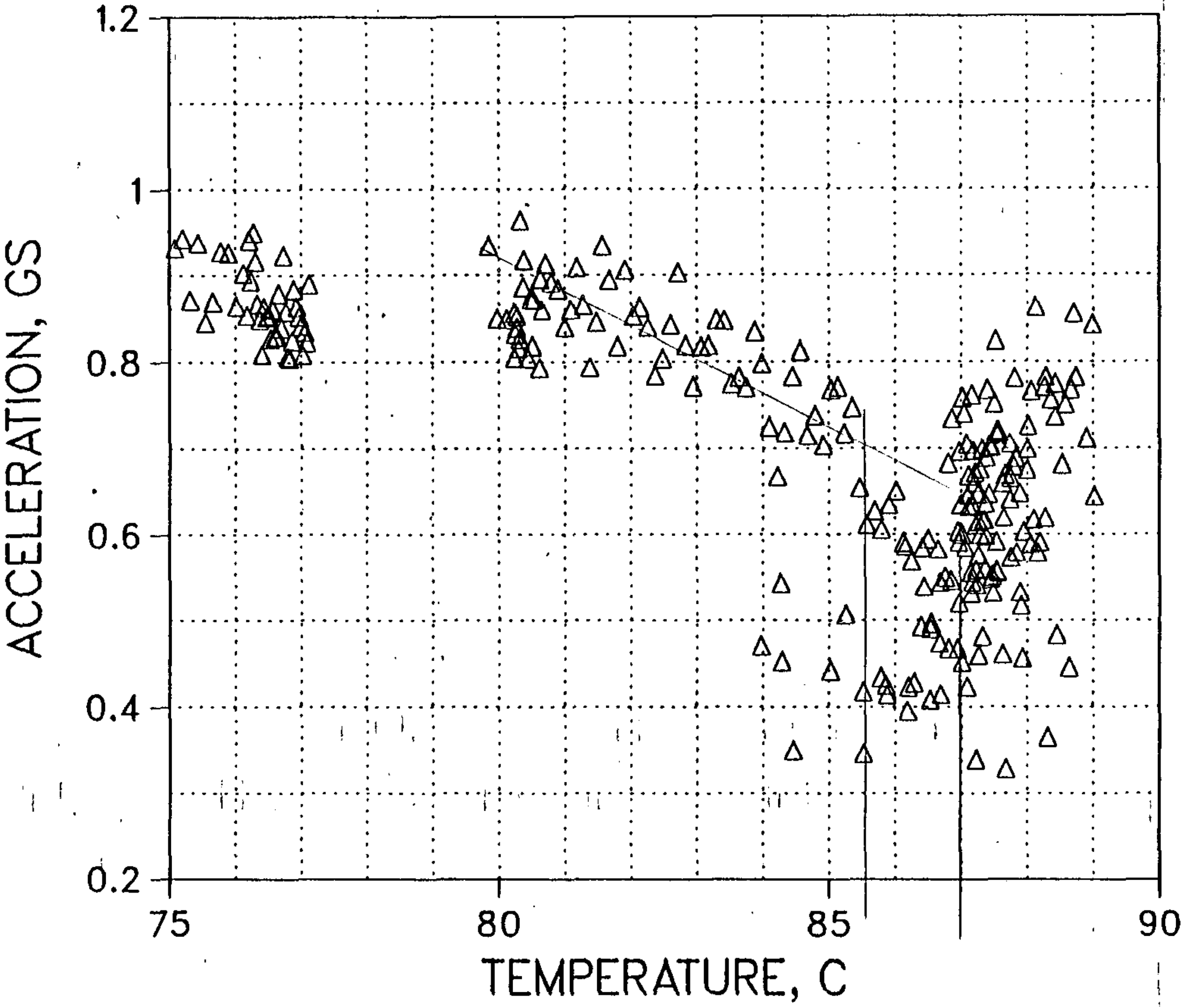


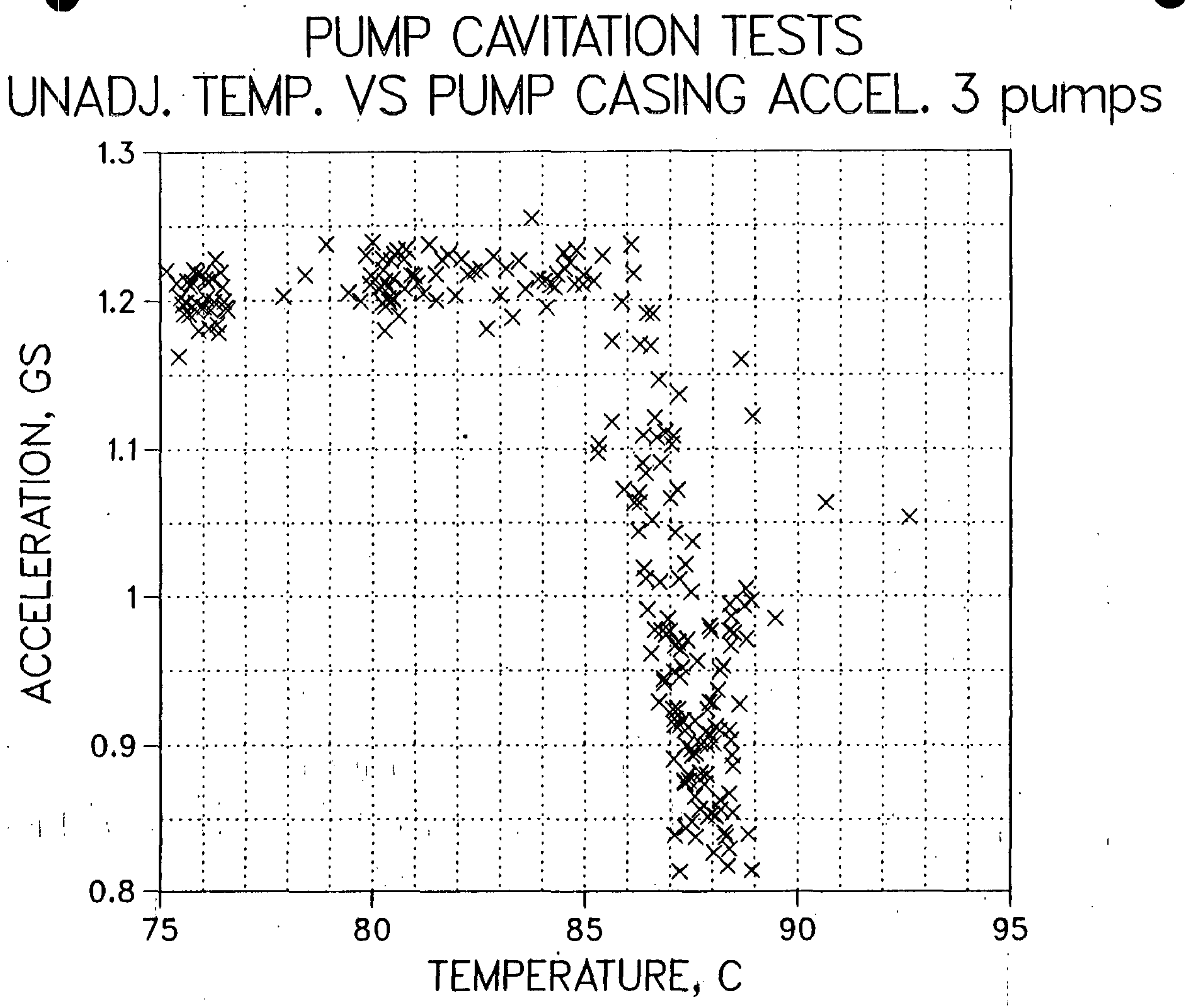
PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 5 pumps




PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 3 pumps
ACCELERATION, GS
1.4
1.2
1
0.8
0.6
0.4
0.2
75
80
85
90
95
TEMPERATURE, C
Legend
SYS 1
SYS 2
SYS 5

PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 3 pumps




PUMP CAVITATION TESTS
UNADJ. TEMP. VS PUMP CASING ACCEL. 3 pumps
ACCELERATION, GS
1.3
1.2
1.1
1
0.9
0.8
75
80
85
90
95
TEMPERATURE, C

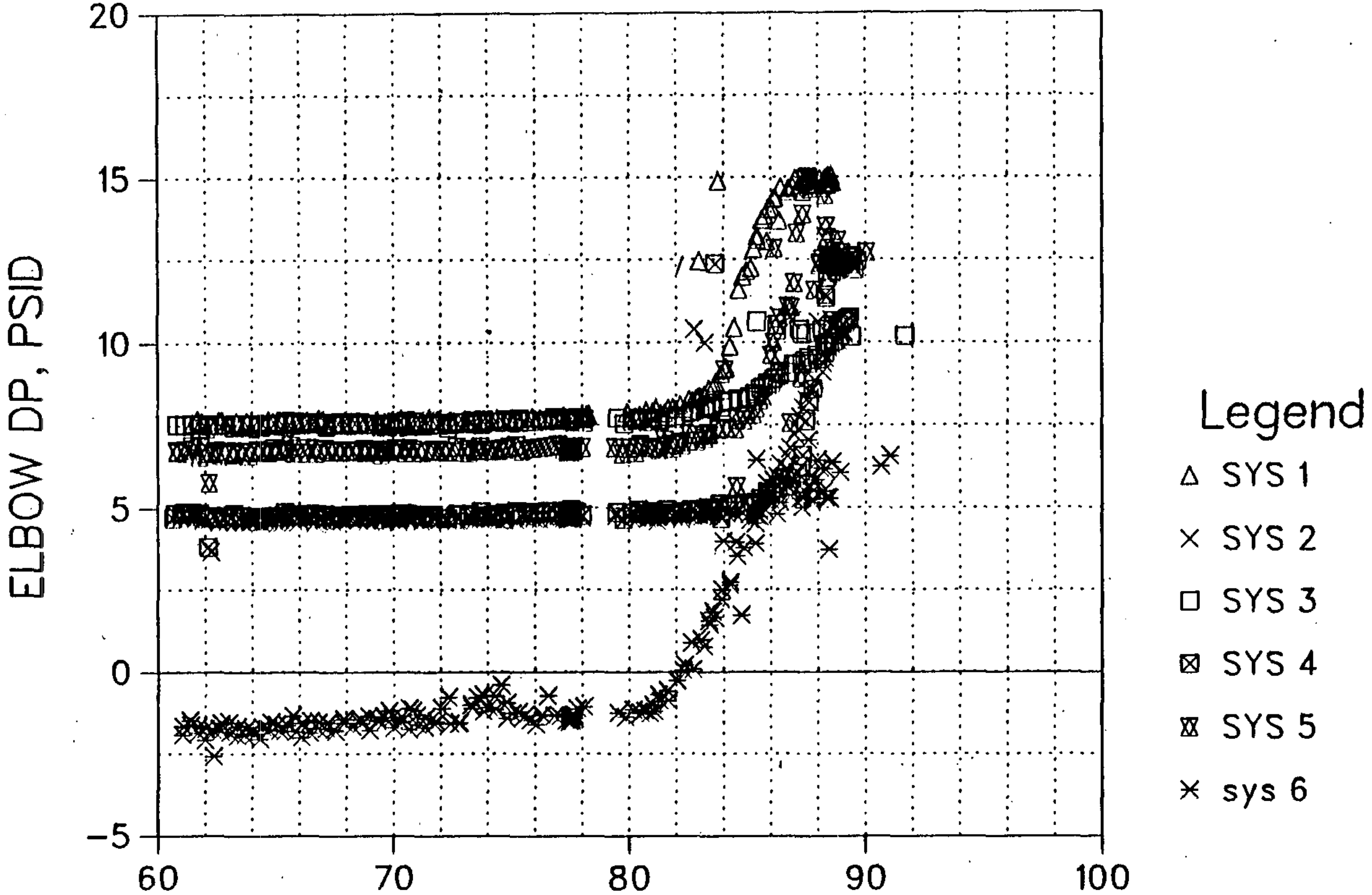
A) Data Curves

3) Elbow (Suction Line) DP vs. Temperature

The low pressure header reading minus the pump suction pressure is plotted against the associated RTD temperature. Appendix E on the low pressure header should be reviewed before these numbers are used for any absolute analysis. System 6 pump suction reading is bad.

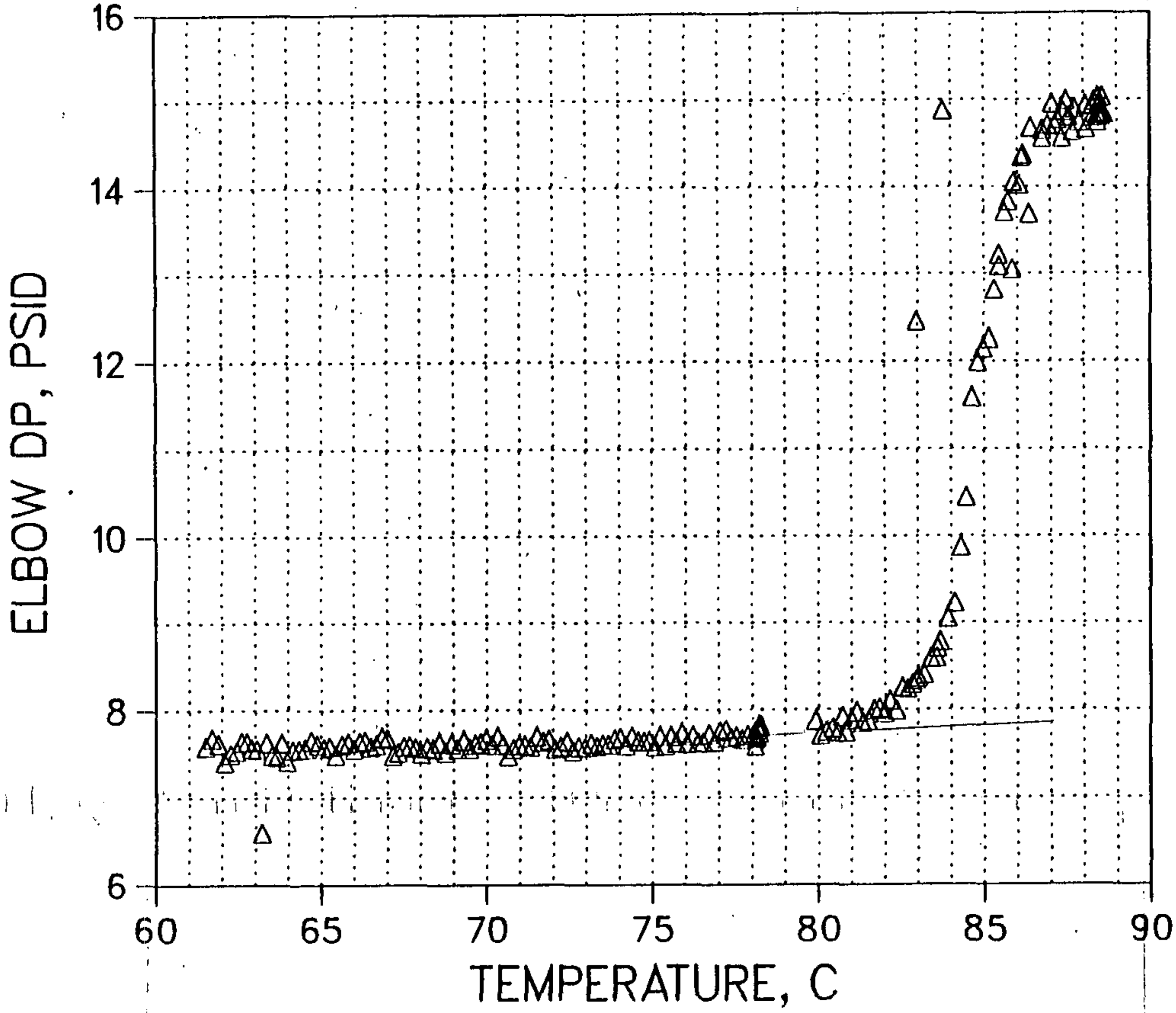
See notes at Appendix A-1.

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1

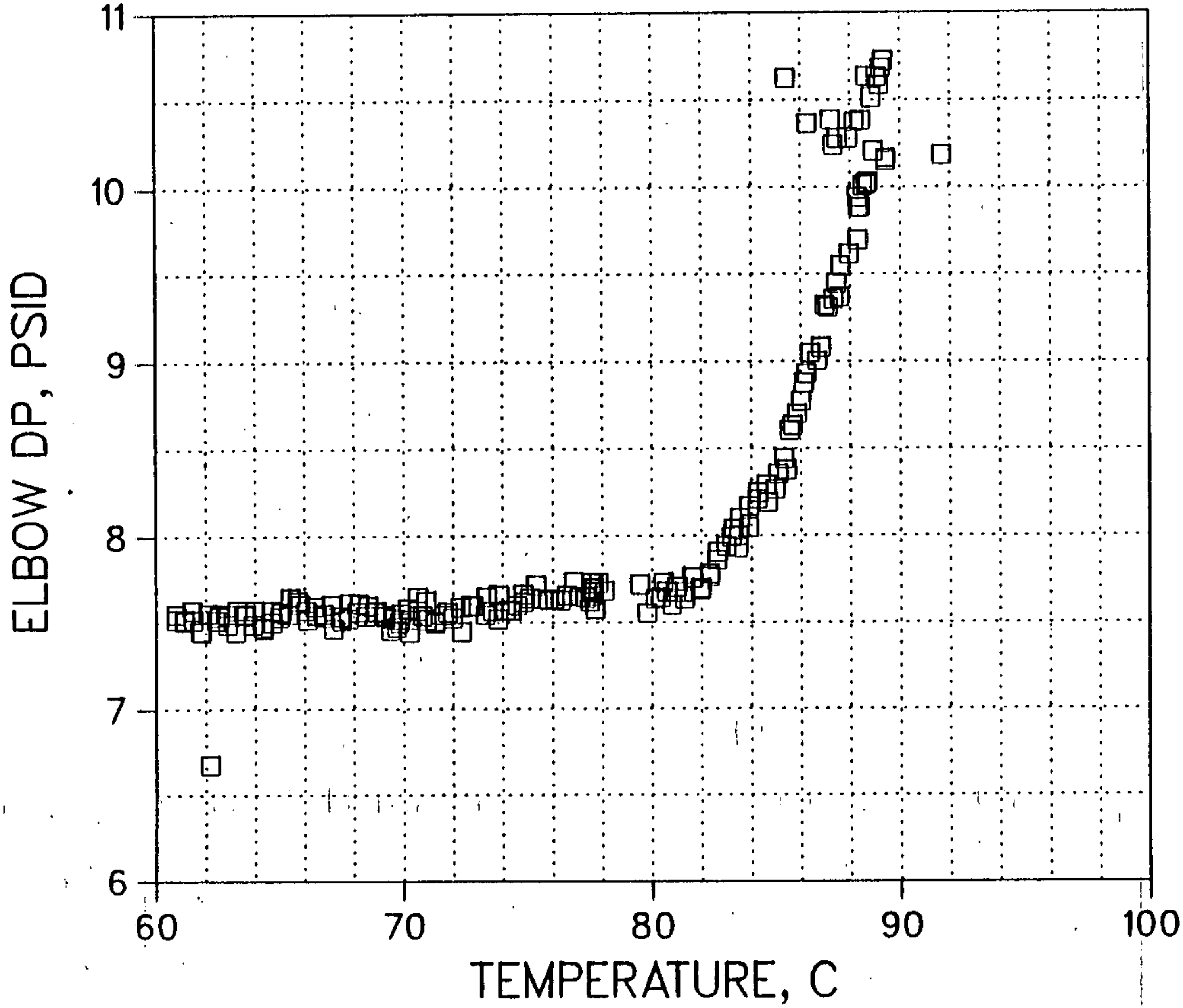


PUMP CAVITATION TESTS

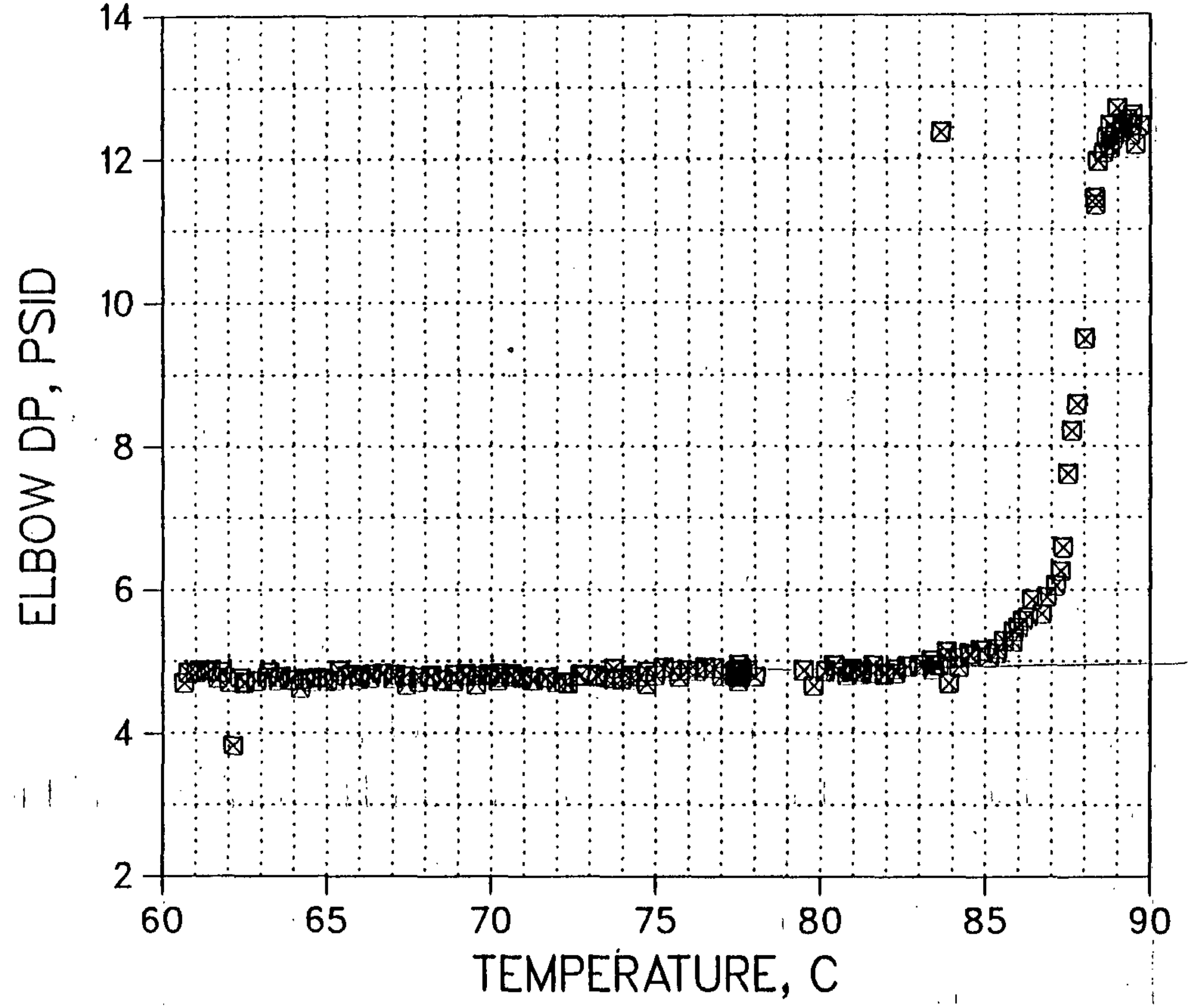
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



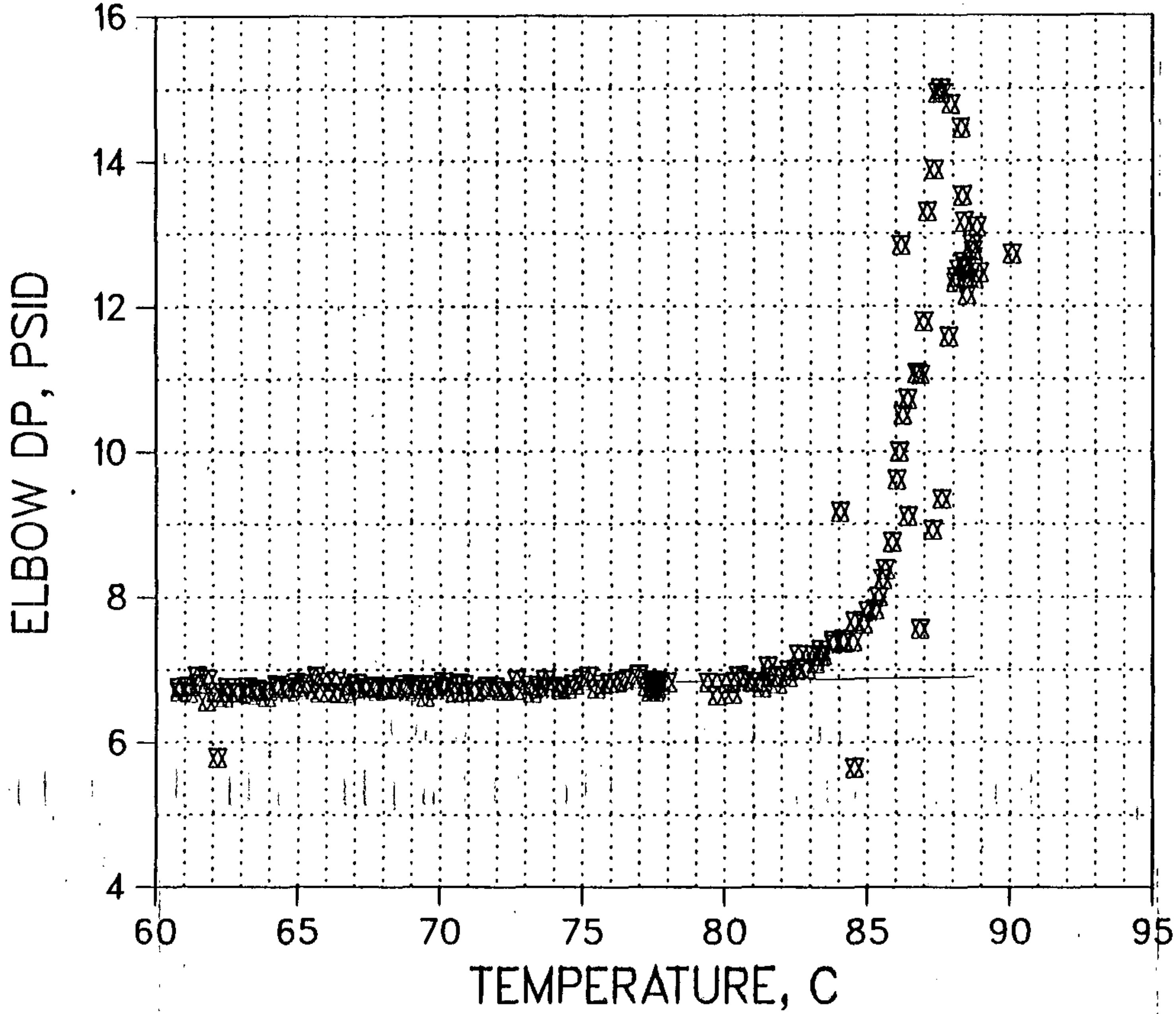
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



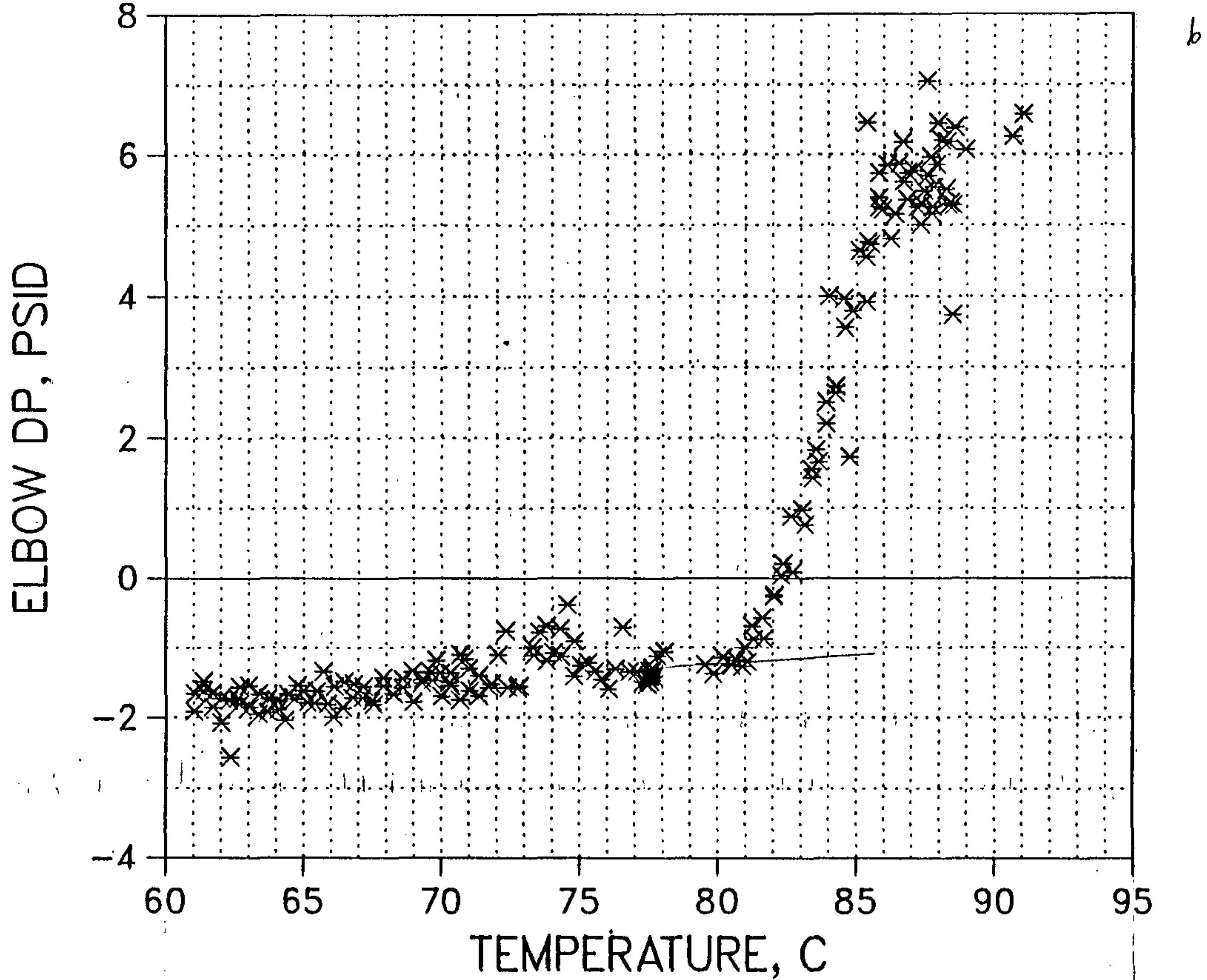
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



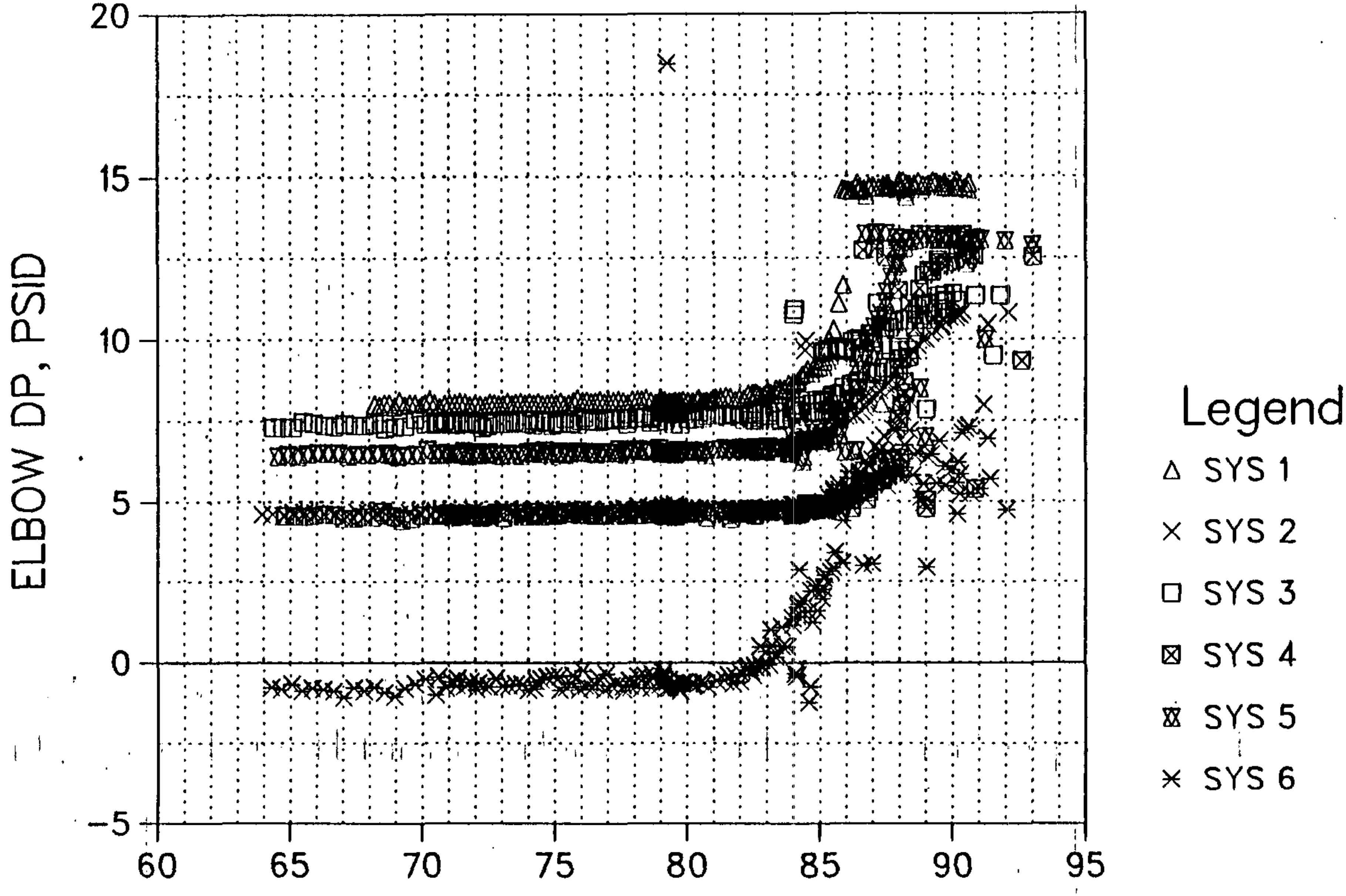
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



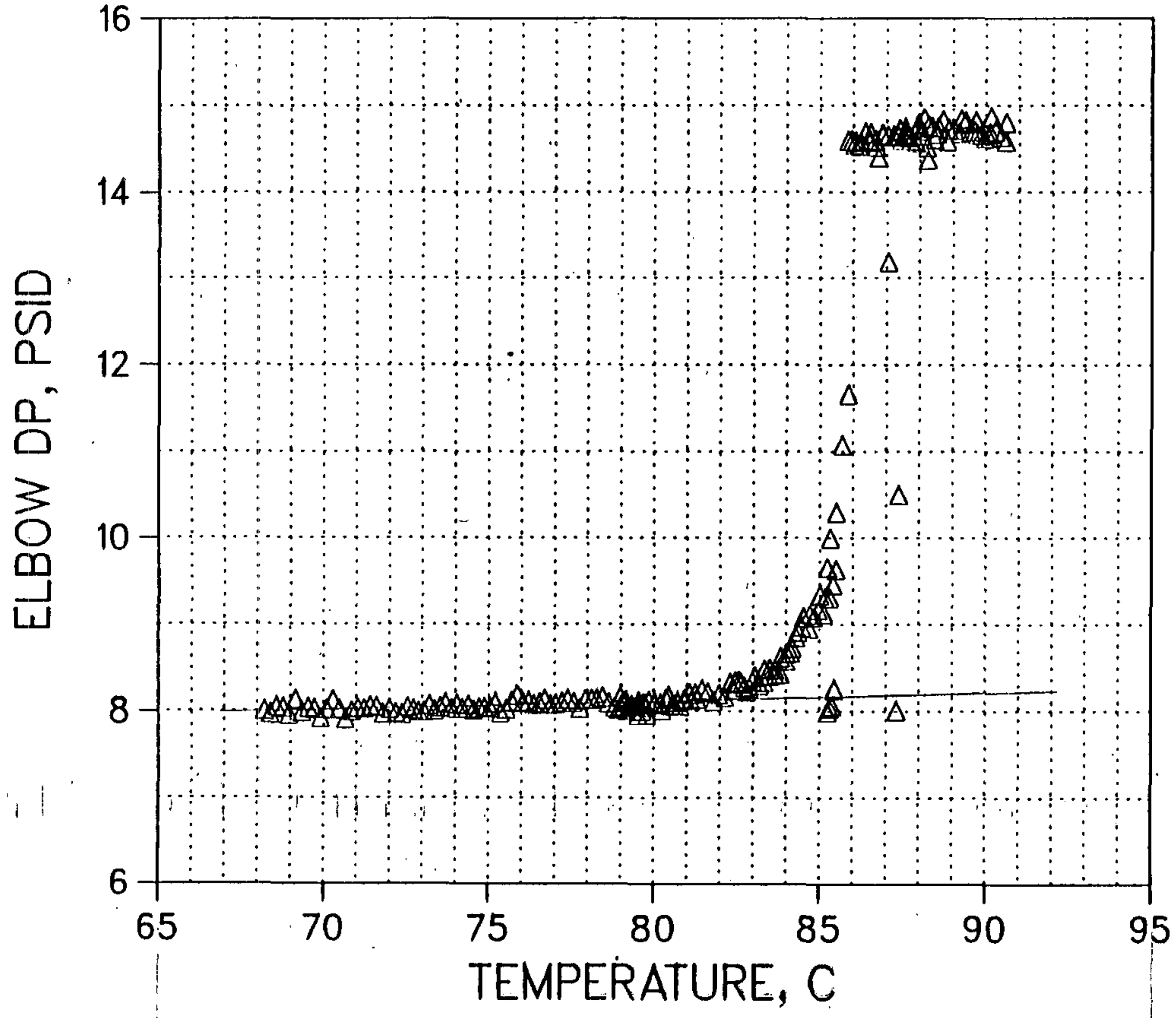
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



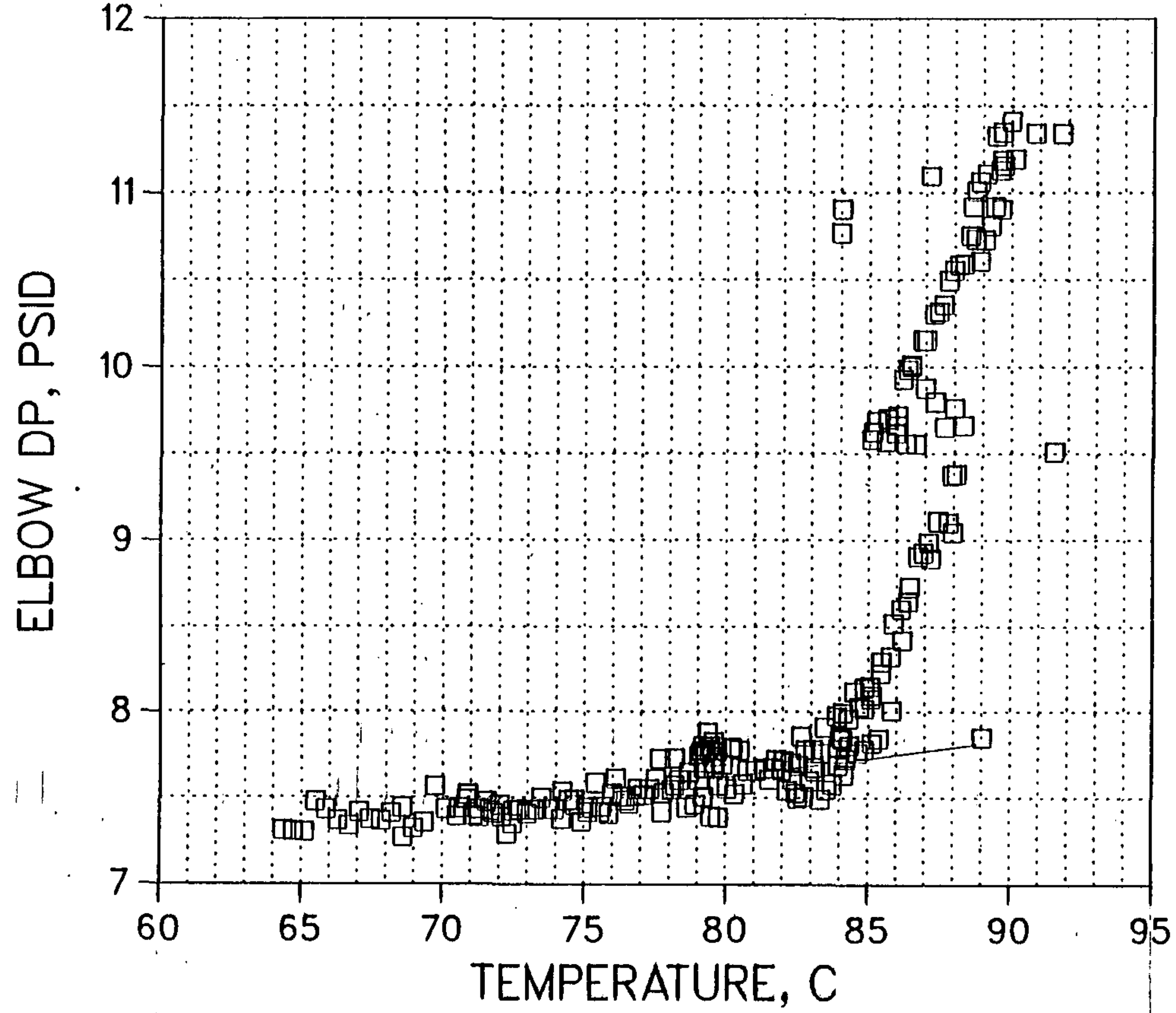
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2



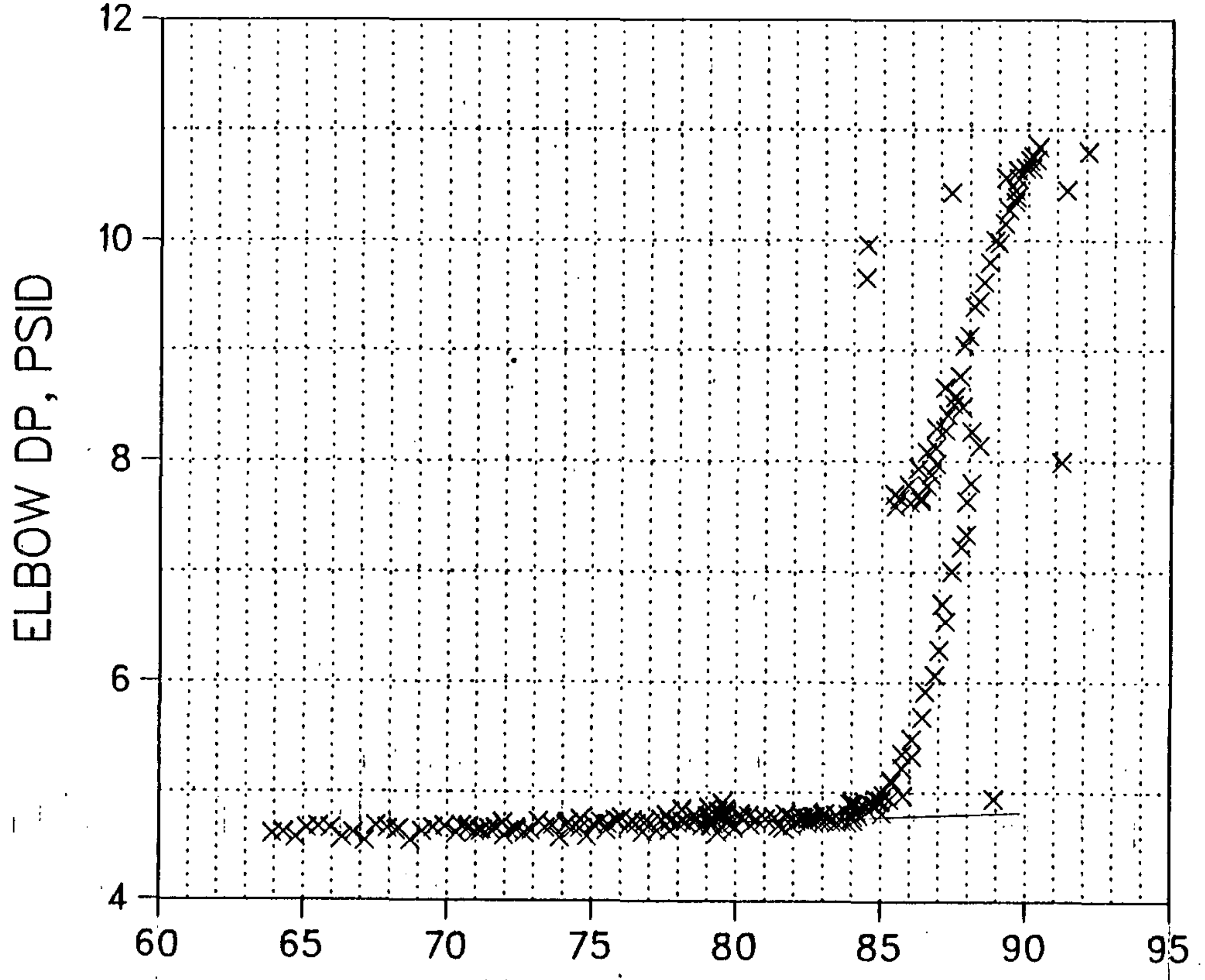
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2



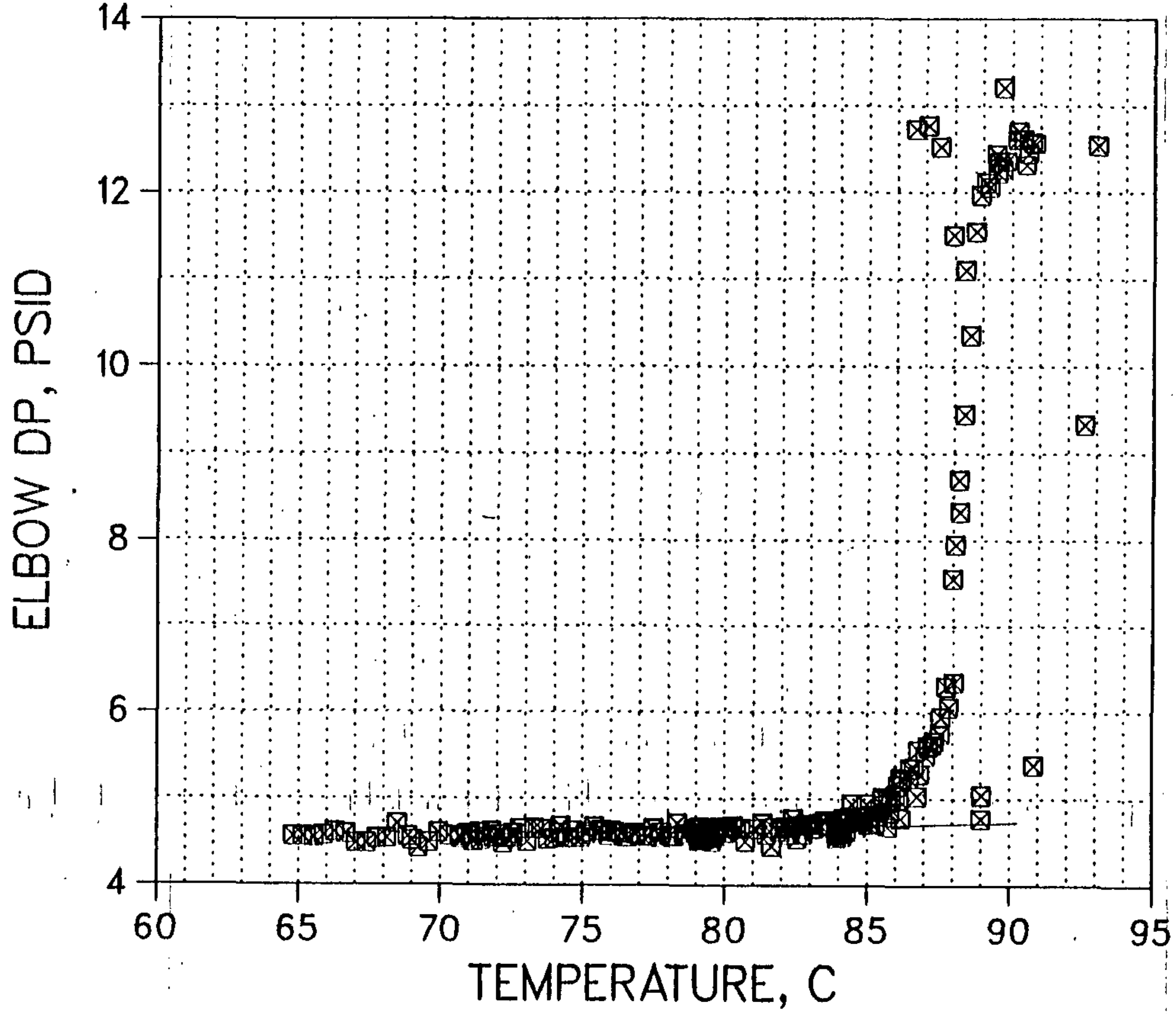
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2

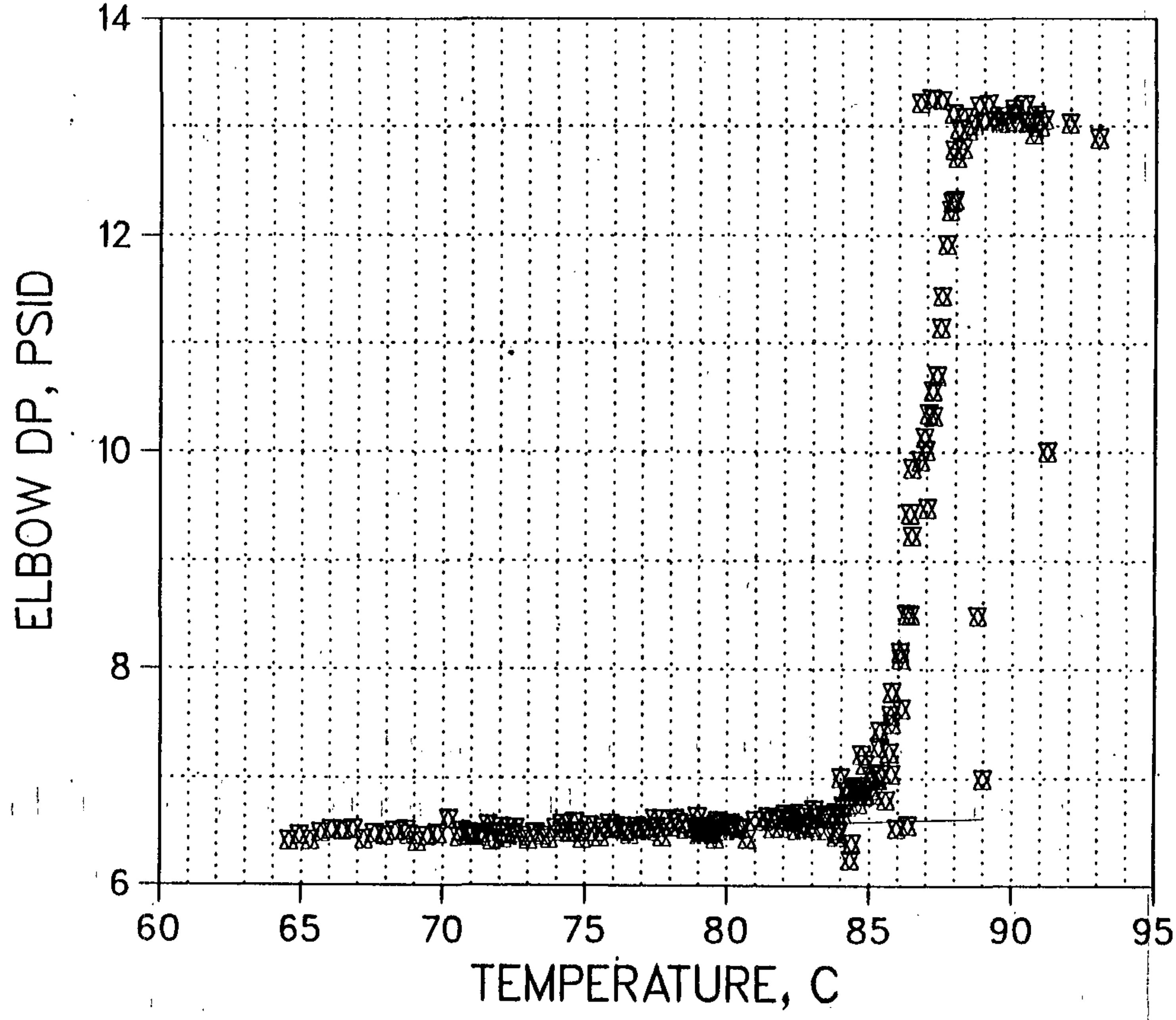


PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2

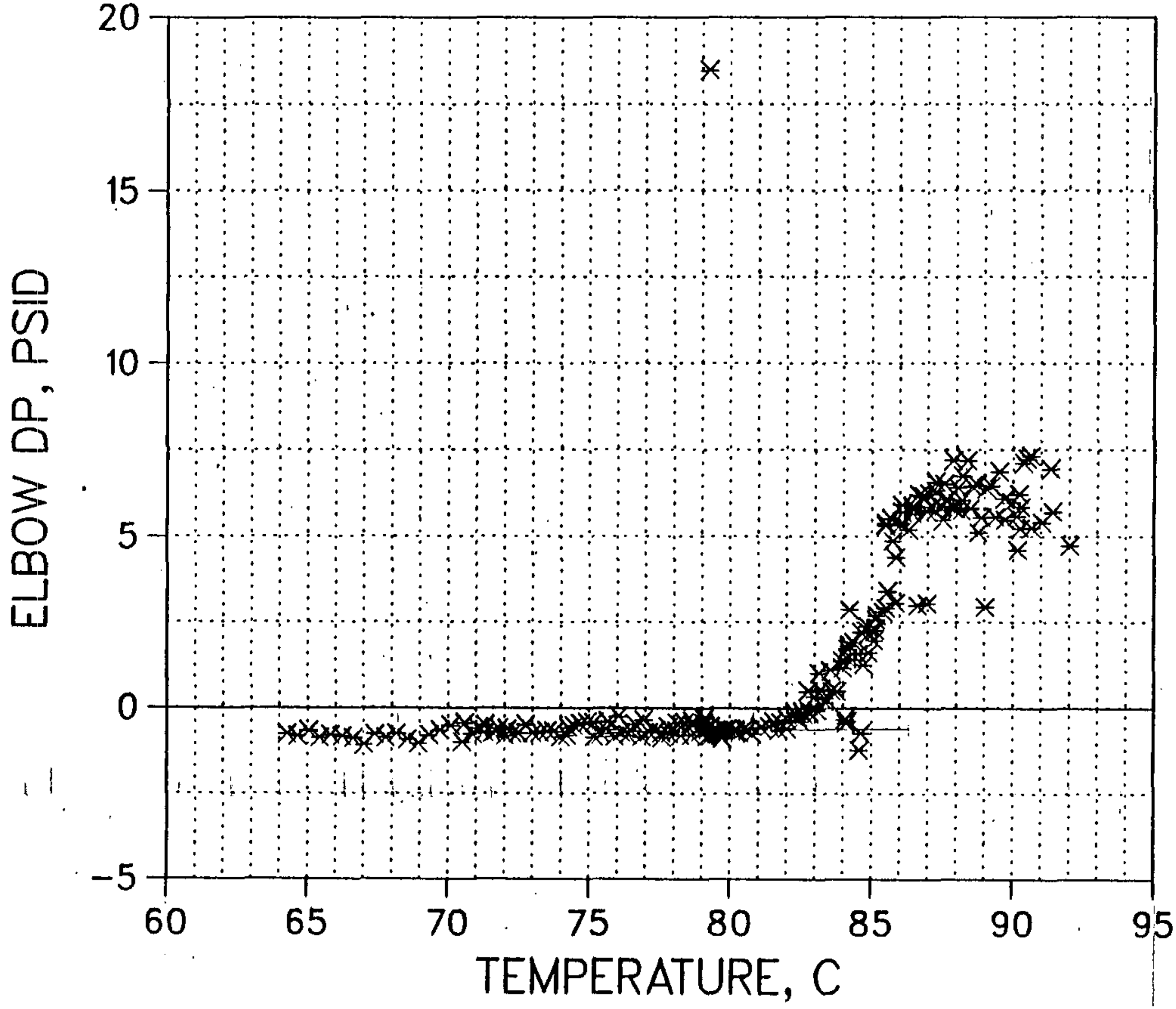


OMS LASERGRAFIX 1200--DATE=84.006 TIME= 8.45.30 BADGE=T6237 BOX 1888

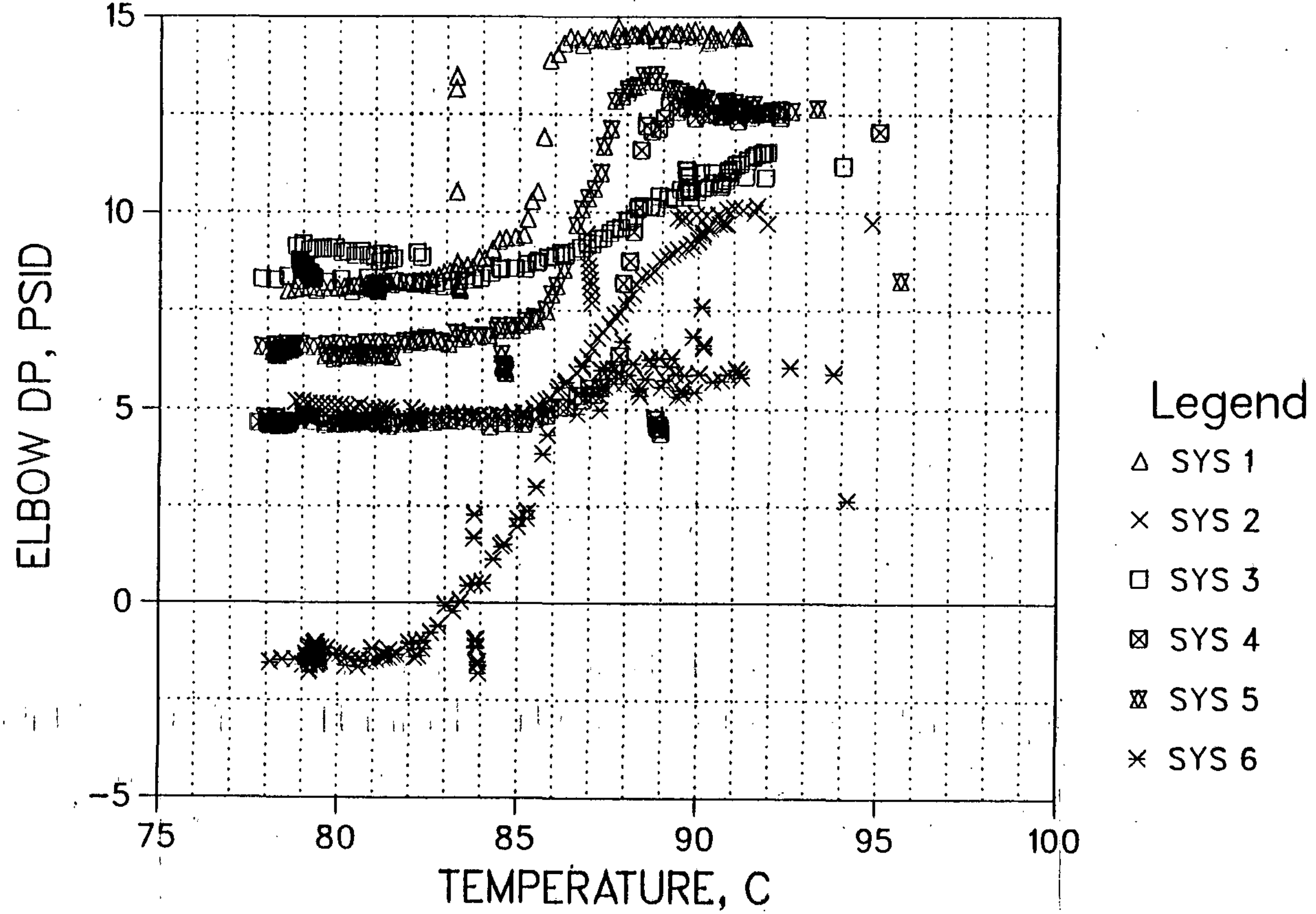
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2



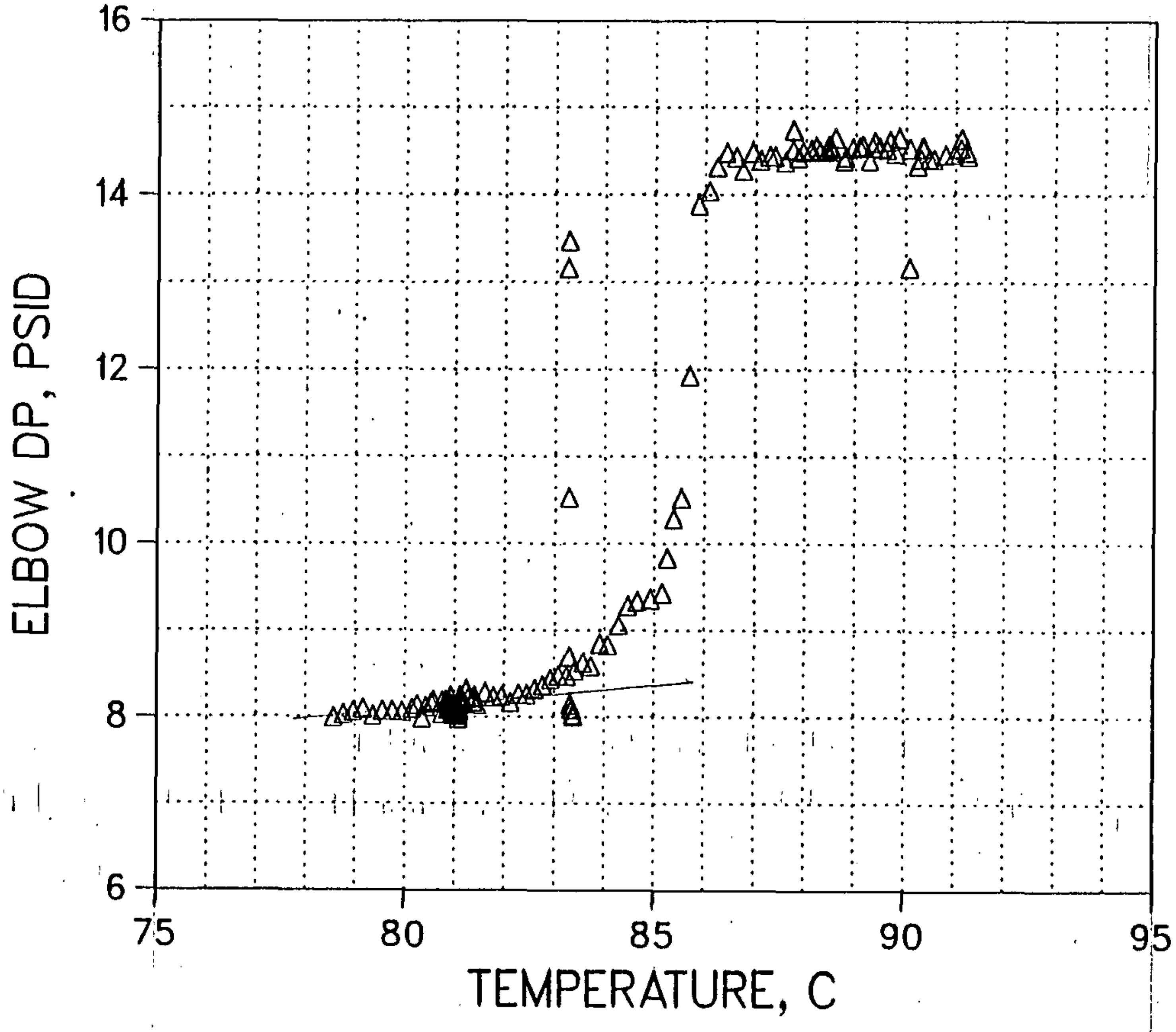
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,2



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3

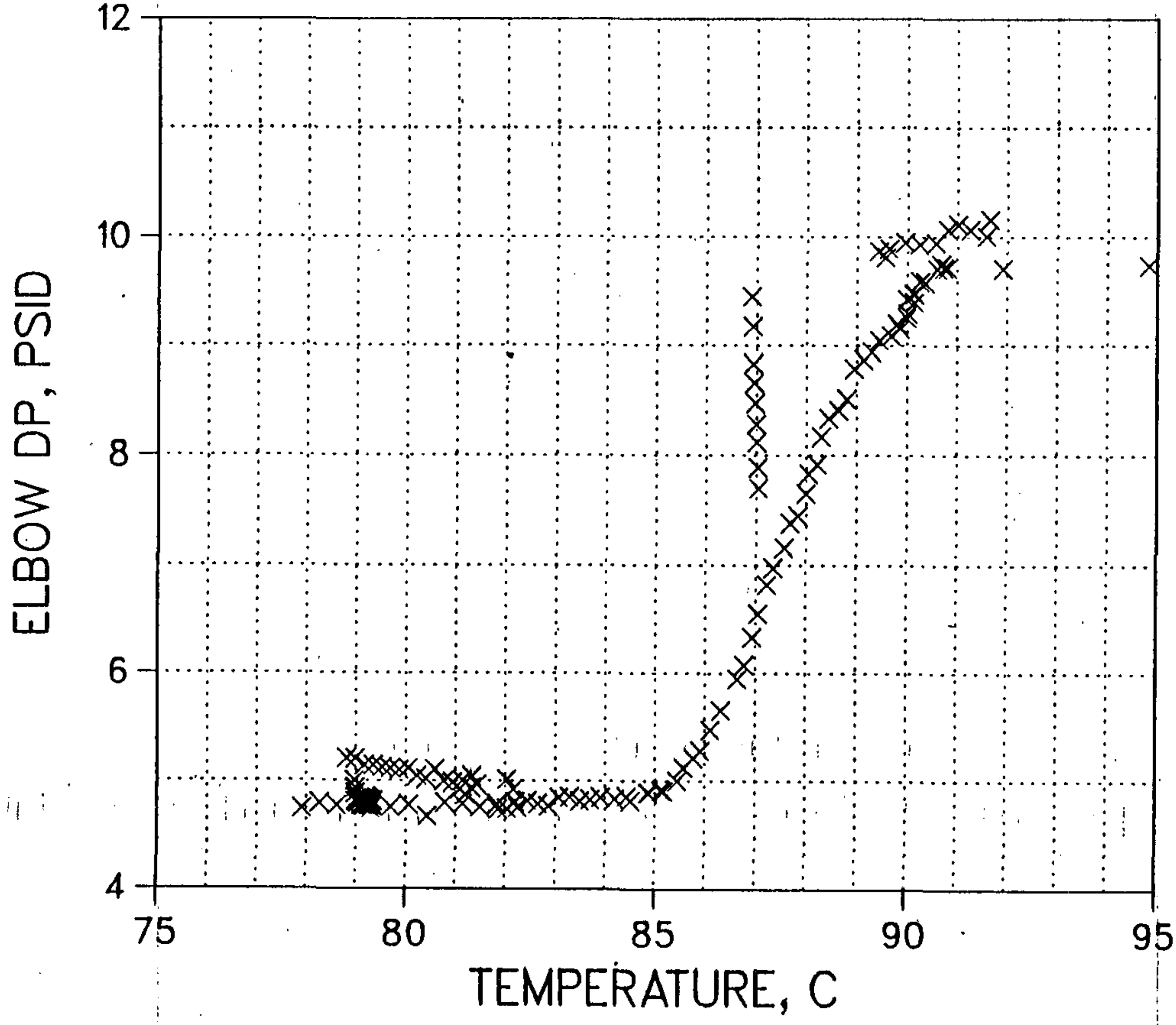


PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3



QMS LASERGRAFIX 1200 DATE=84.006 TIME= 9.51.33 BADGE=T6237 BOX=1023

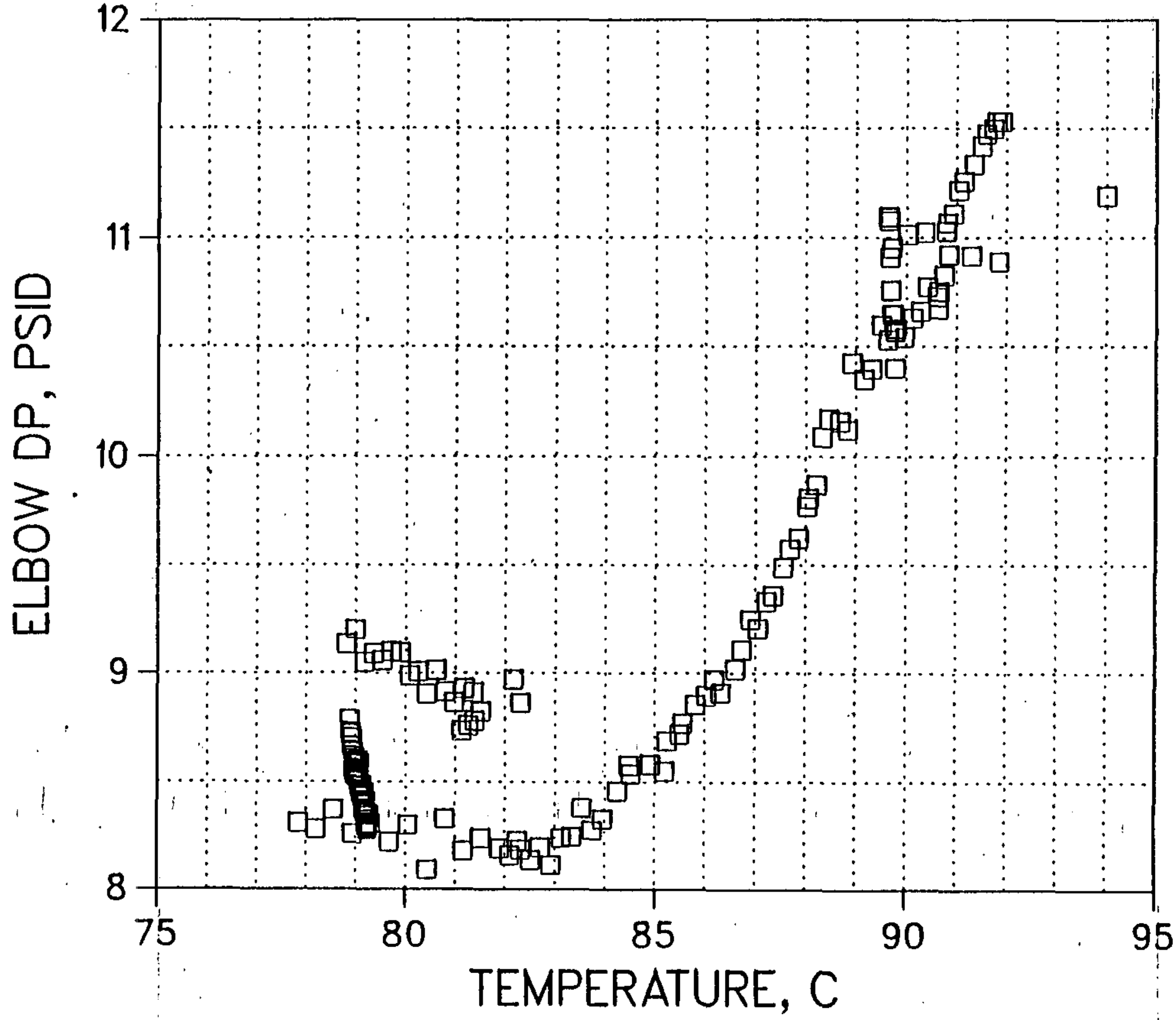
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3



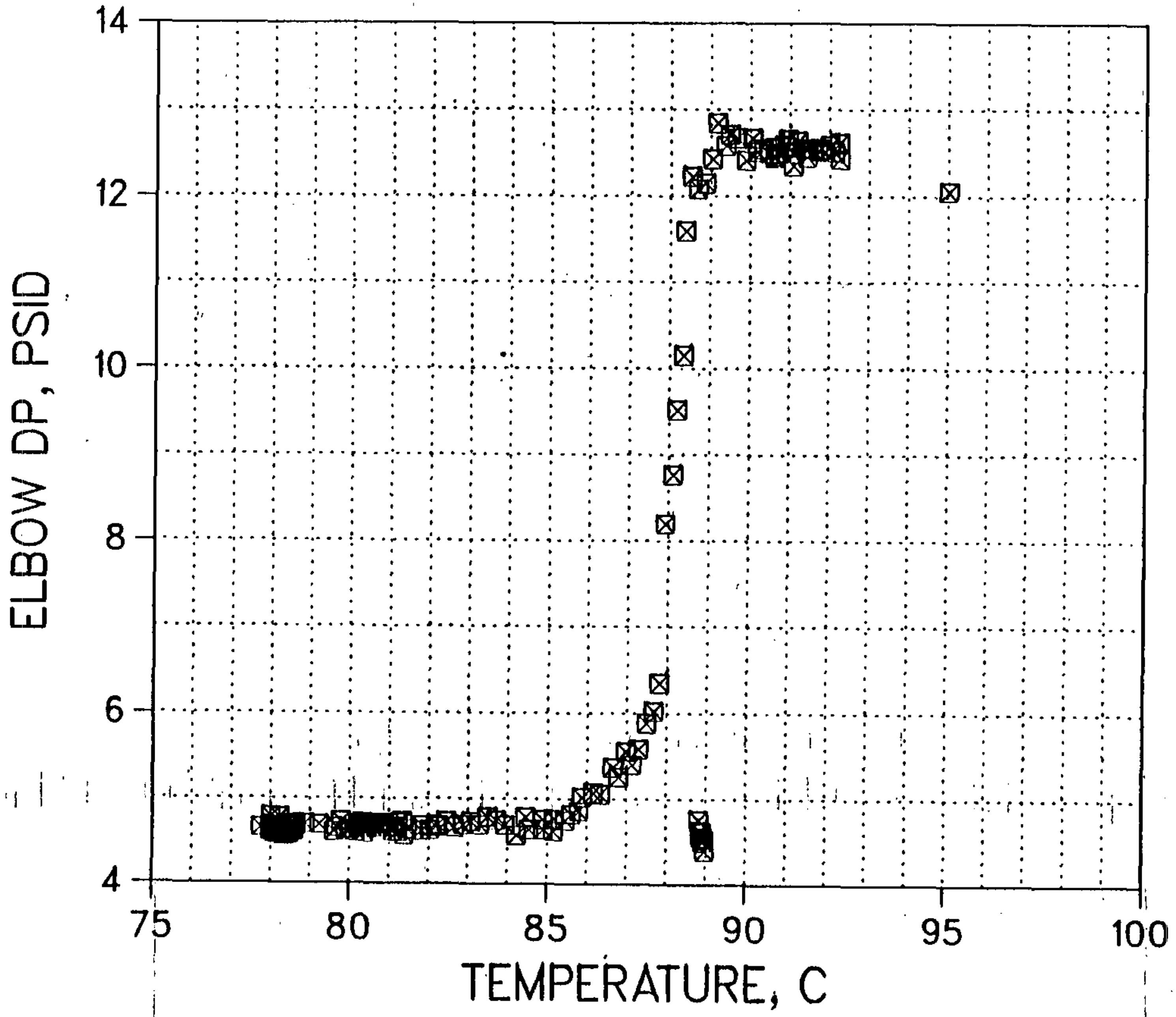
QMS LASERGRAFIX 1200, DATE=84.006, TIME= 9.52.40, BADGE=T6237, BOX=L023

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3

3



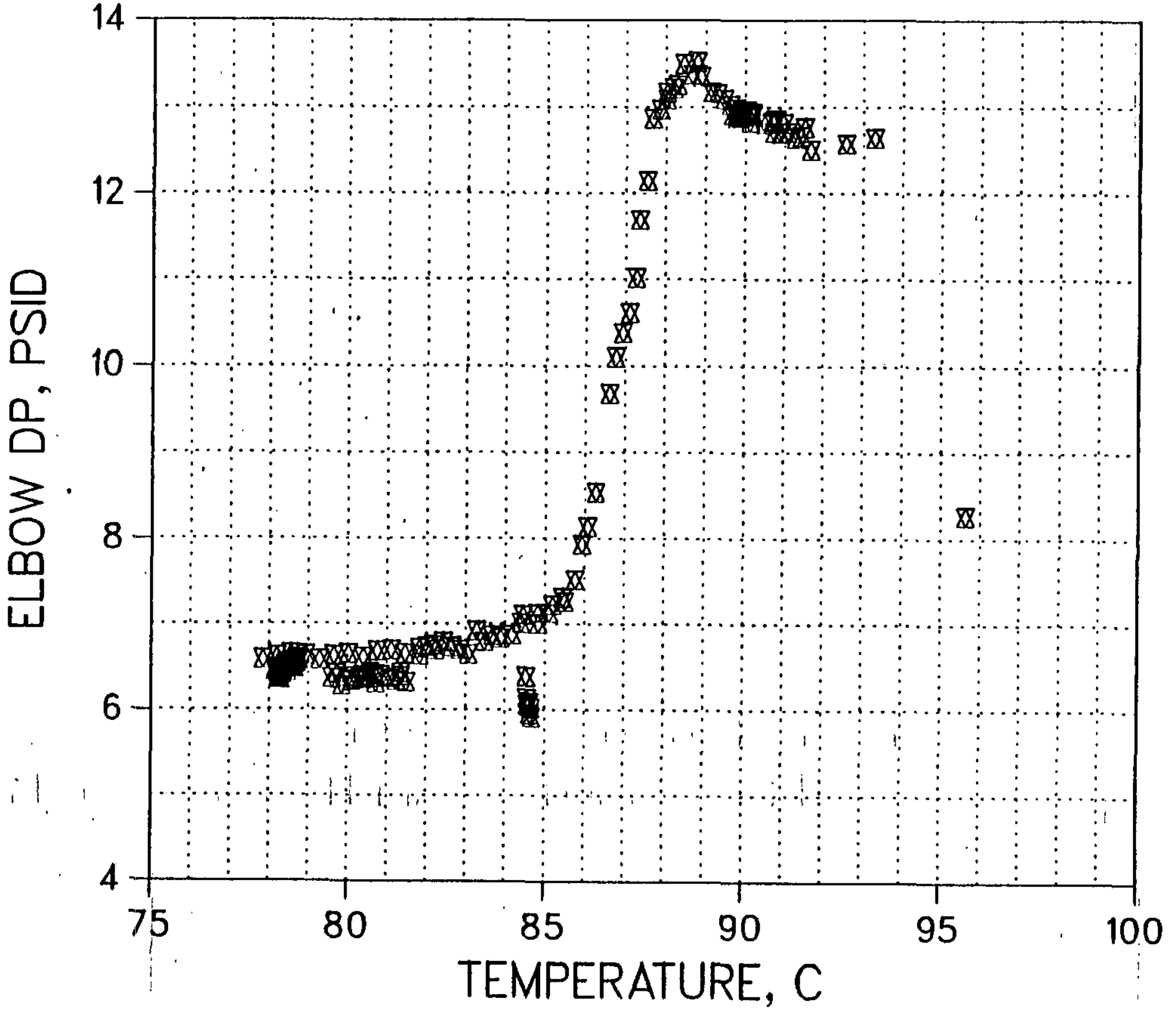
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3

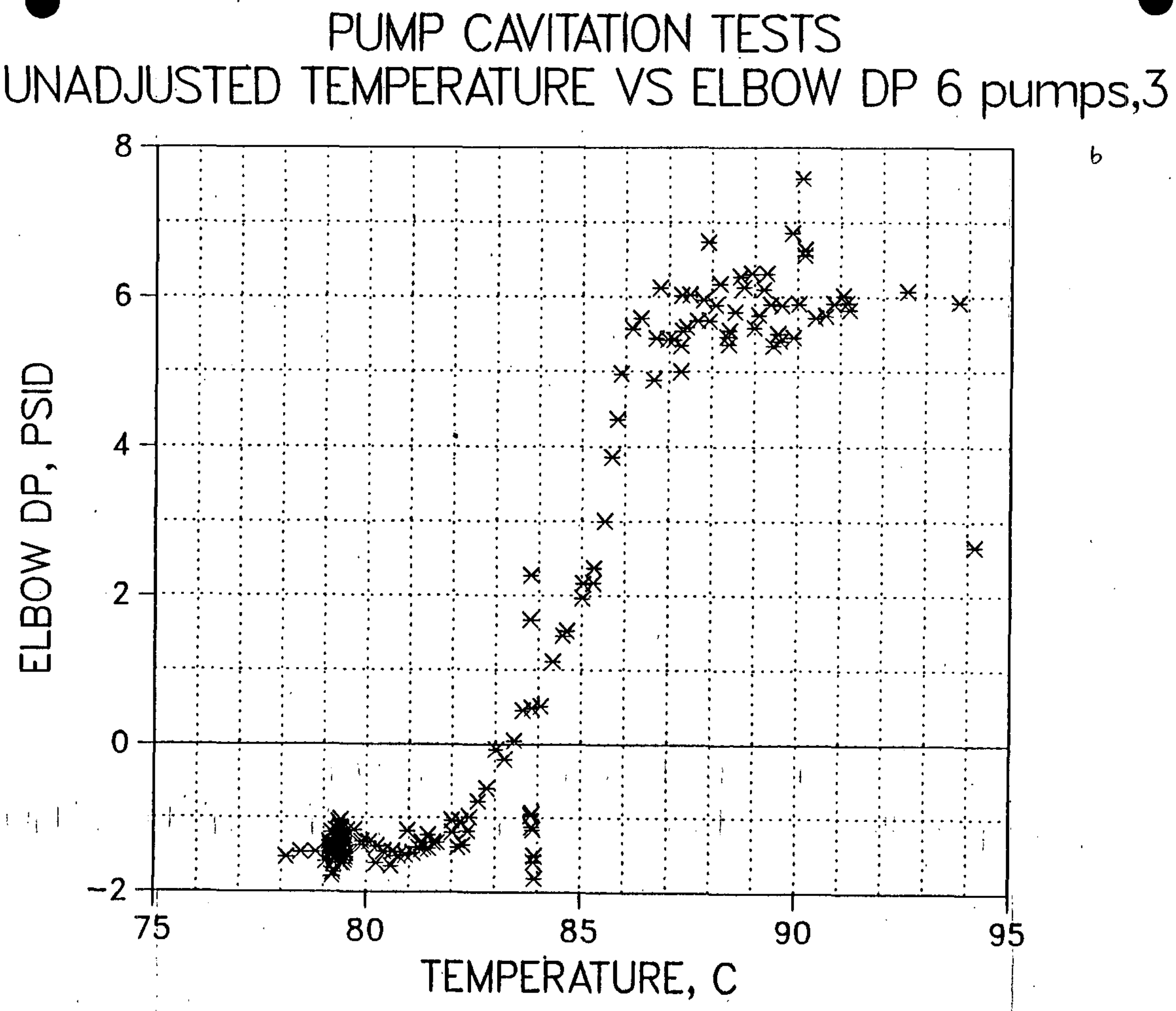


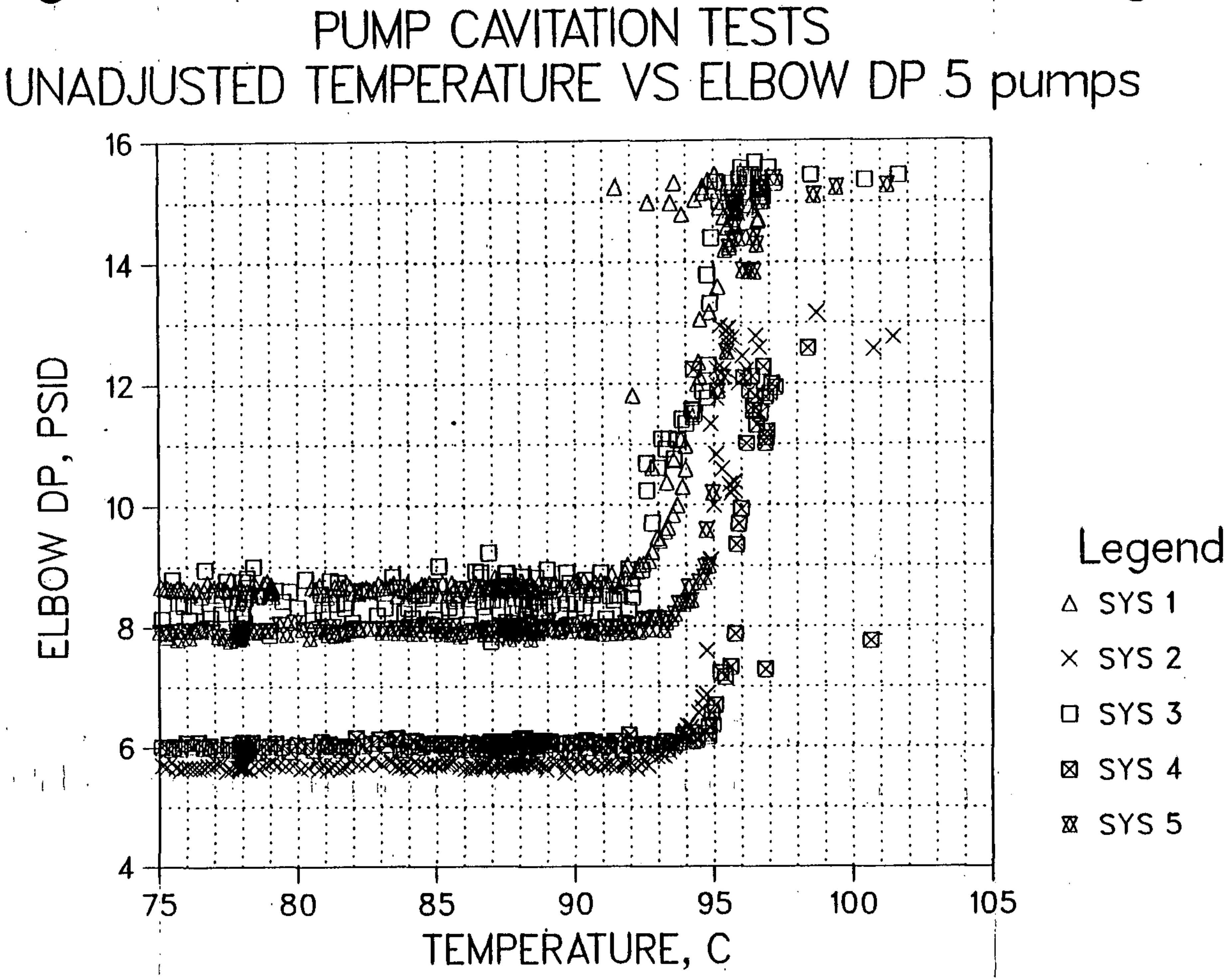
4

QMS LASERGRAFIX 1200, DATE=84.006, TIME= 9.55.33, BADGE=T6237, BOX=1023

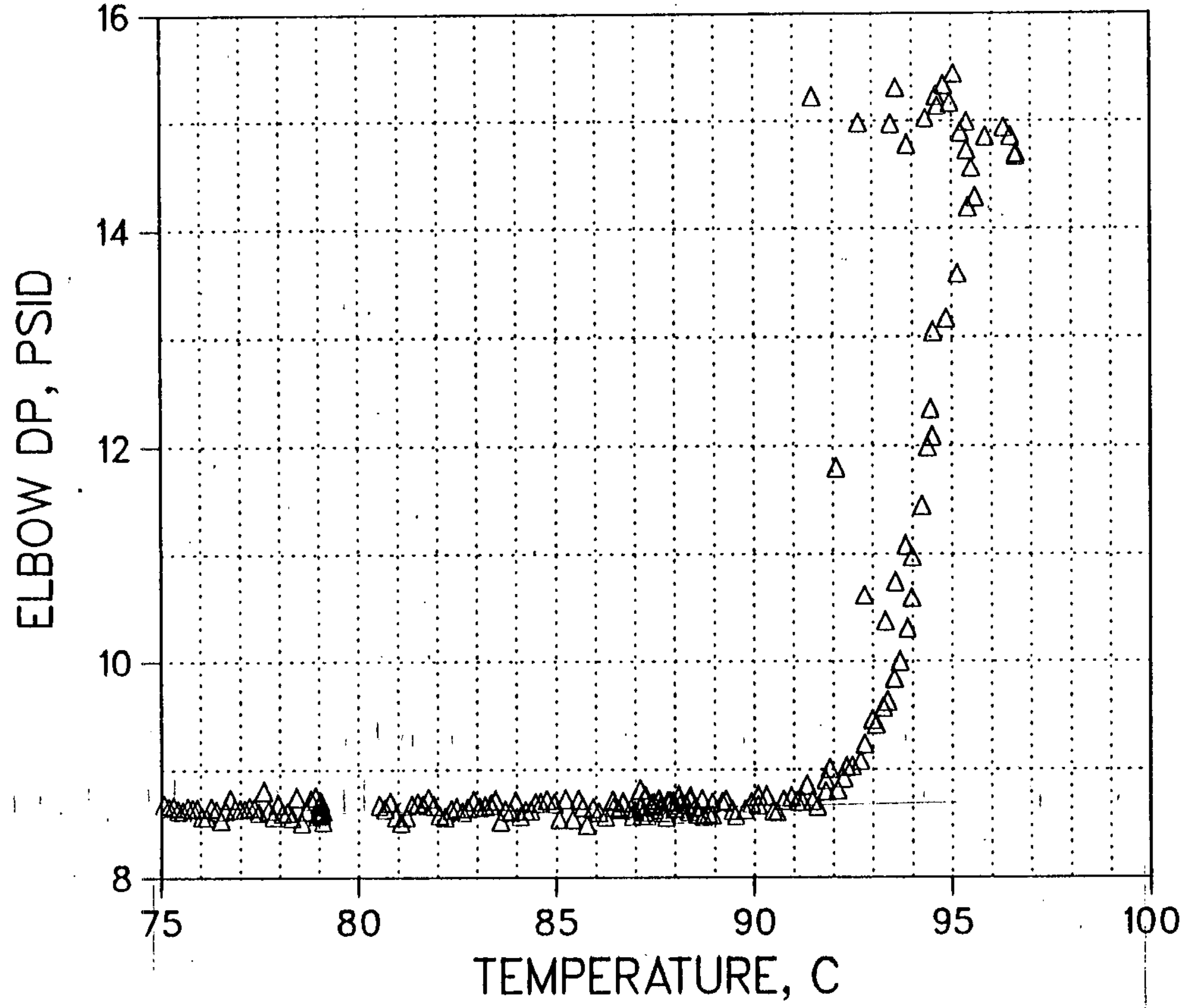
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3



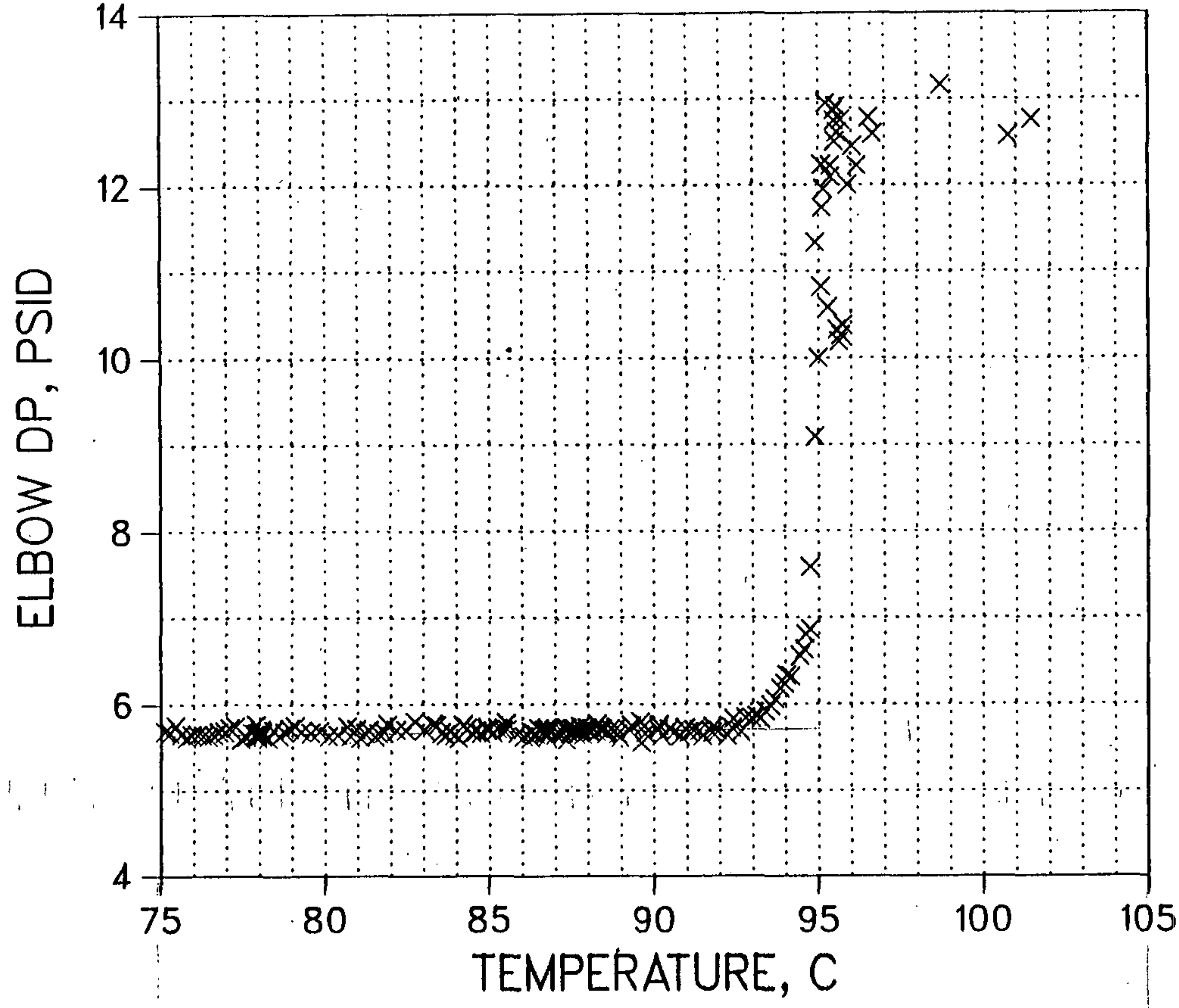

PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,3
b
ELBOW DP, PSID
8
6
4
2
0
−2
75
80
85
90
95
TEMPERATURE, C


PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps
ELBOW DP, PSID
16
14
12
10
8
6
4
75
80
85
90
95
100
105
TEMPERATURE, C
Legend
SYS 1
SYS 2
SYS 3
SYS 4
SYS 5

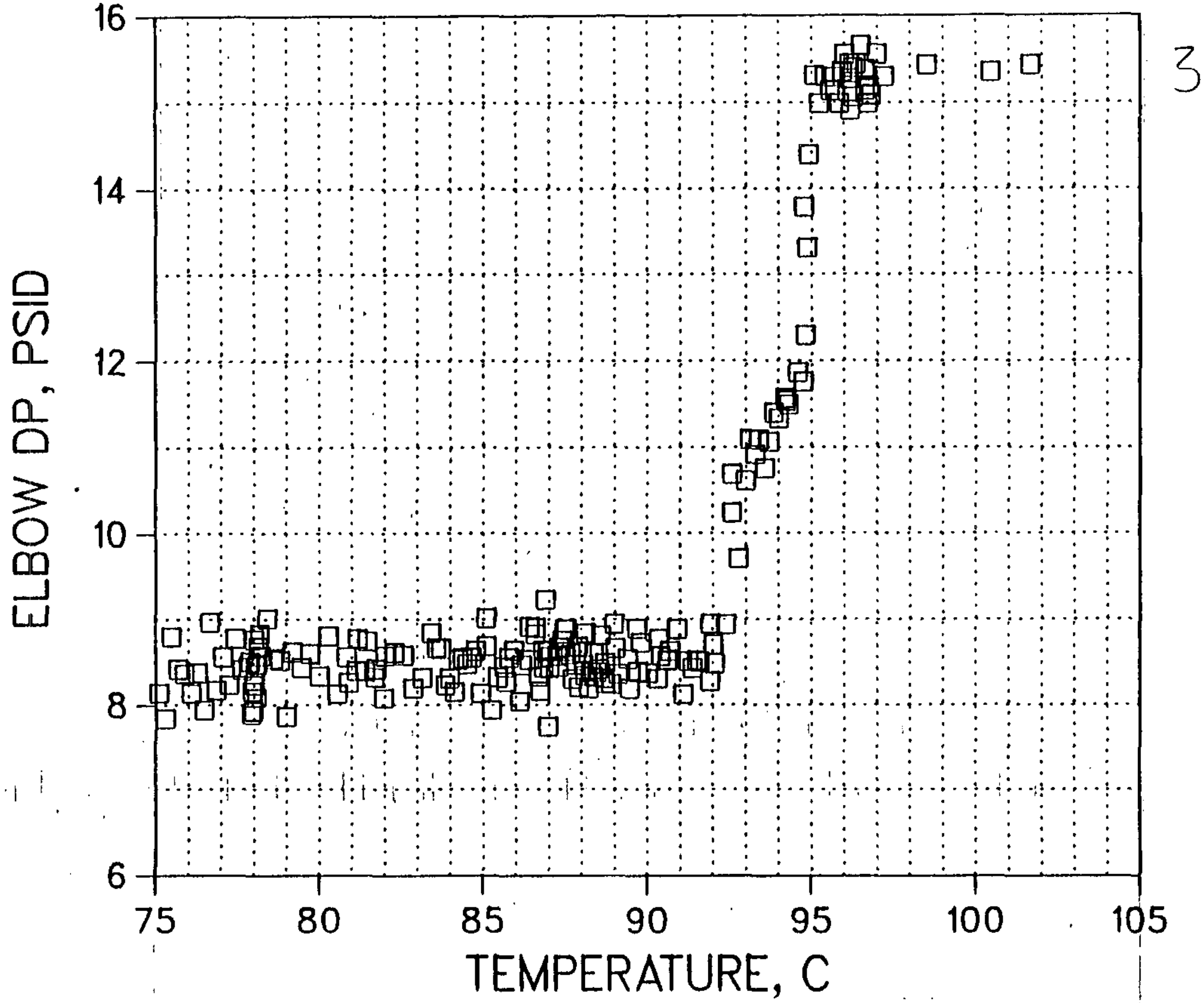
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps



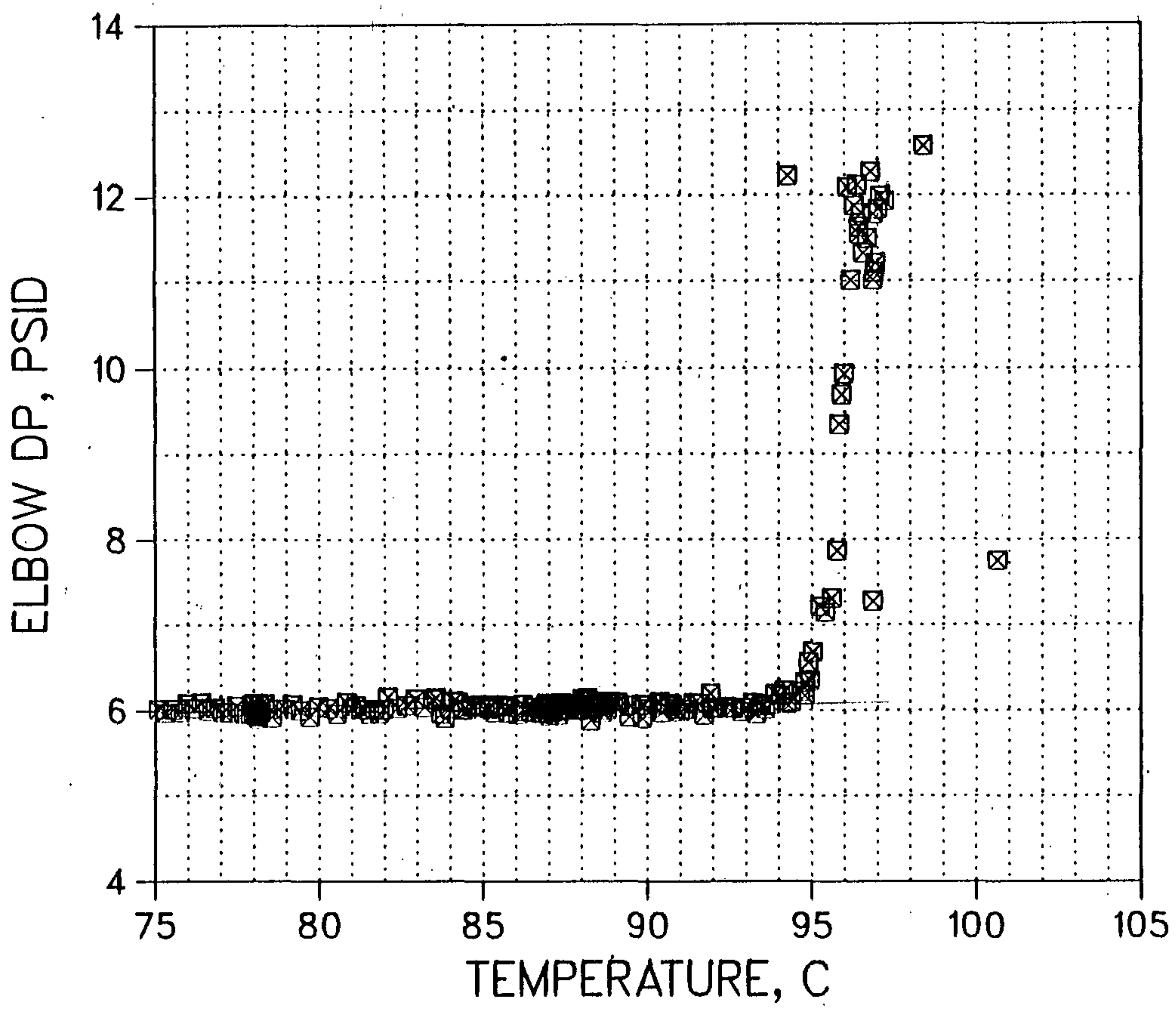
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps



OMS_LASERGRAFIX 1200 DATE=84.006 TIME=13.15.11 BADGE=T6237, BOX=L023

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-~~5~~/353~~4~~-01

SERIAL NO. 94504

CAPACITY 0-250 PSID

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C − 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9963	Volts
	100	10.0021	Volts
Descending	50	4.9991	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8-27 NPT female

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0163 VOLTS DC

ACCEPTED AND CERTIFIED [signature]

DATE 7/8/83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97617

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

H + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9946	Volts
	100	10.0012	Volts
Descending	50	4.9983	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0116 VOLTS DC

ACCEPTED AND CERTIFIED Michael [illegible]

DATE 7/8/83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97606

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM Rm °F TO 203 °F

A + 15 VDC

B COMMON

C - 15 VDC

D output

E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	5.0000	Volts
	100	10.0054	Volts
Descending	50	5.0016	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0034 VOLTS DC

ACCEPTED AND CERTIFIED Michael [illegible]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97605

CAPACITY 0 - 50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9936	Volts
	100	10.0001	Volts
Descending	50	4.9970	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0193 VOLTS DC.

ACCEPTED AND CERTIFIED [illegible]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97607

CAPACITY 0 - 50 PSIA

COMPENSATED TEMPERATURE RANGE FROM Rm °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9958	Volts
	100	10.0002	Volts
Descending	50	4.9968	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4 - 18 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E & F PROVIDES AN OUTPUT OF 7.9936 VOLTS DC

ACCEPTED AND CERTIFIED [signature]

DATE 7/8/83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97616

CAPACITY 0 - 50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9979	Volts
	100	10.0047	Volts
Descending	50	4.9973	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9980 VOLTS DC

ACCEPTED AND CERTIFIED Michael [illegible]

DATE 7/8/83

Cavitation Test for 105-L

J.K.Cathey
Rec'd 15 July 83
AX 612078

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10V Date 8-1-83

Equipment Under Test Sensotec A5 No. 70477

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity % Temperature 80°F

Equipment From: Foreman J. Cathey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.003		21	199.940	8.002	
2	25.000	.999		22	175.020	7.004	
3	50.030	2.001		23	150.000	6.001	
4	75.000	3.000		24	124.940	4.997	
5	100.075	4.006		25	100.015	3.998	
6	125.050	5.005		26	74.985	2.995	
7	149.975	6.003		27	50.040	1.996	
8	174.955	7.003		28	25.050	.997	
9	200.030	8.006		29	00.000	.005	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure: 0-250 PSI, 0-10V   Date: 8-1-83

Equipment Under Test: SENSOTEC A5   No. 94511

Standard Used: S/N 10568   No. S/N 1169

Range: 0-250 PSI   Calibration Expires: 8-5-83   By: E. KIRK

Barometric Pressure: 30" Hg   Humidity: ____ %   Temperature: 80°F

Equipment From: Foreman: J. CAThey   Bldg. 723   Area: A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.012		21	199.945	7.965	
2	25.030	.986		22	175.040	6.974	
3	50.040	1.983		23	150.050	5.978	
4	75.065	2.982		24	125.000	4.978	
5	100.025	3.978		25	99.970	3.979	
6	125.080	4.978		26	75.020	2.983	
7	150.030	5.974		27	50.010	1.983	
8	175.070	6.973		28	25.040	.985	
9	200.050	7.968		29	00.000	.015	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ____________________

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10V Date 8-1-83

Equipment Under Test SENSOTEC A5 No. 94509

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J. CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	.009		21	199.915	8.001	
2	25.020	1.009		22	174.960	7.006	
3	50.050	2.008		23	150.025	6.010	
4	75.005	3.006		24	124.995	5.009	
5	100.015	4.007		25	99.960	4.008	
6	125.050	5.008		26	75.015	3.011	
7	150.070	6.009		27	49.910	2.007	
8	174.980	7.005		28	24.990	1.010	
9	199.980	8.003		29	00.000	.014	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP

CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10 V Date 8-1-83

Equipment Under Test SENSOTEC A5 No. 94508

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J Cathey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.008		21	199.930	7.977	
2	25.020	.990		22	175.010	6.983	
3	50.065	1.989		23	149.990	5.982	
4	74.990	2.985		24	124.955	4.982	
5	99.980	3.983		25	99.990	3.984	
6	125.040	4.985		26	75.090	2.989	
7	150.090	5.986		27	49.985	1.986	
8	175.050	6.984		28	25.050	.992	
9	200.060	7.982		29	00.000	-.006	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP

CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10V Date 8-1-83

Equipment Under Test Sensotec AS No. 94510

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ______ % Temperature 80°F

Equipment From: Foreman S. Eathey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	.038		21	200.075	8.026	
2	24.925	1.033		22	175.005	7.027	
3	50.060	2.037		23	149.920	6.025	
4	75.020	3.036		24	125.030	5.030	
5	99.930	4.032		25	100.075	4.032	
6	124.970	5.034		26	74.965	3.027	
7	150.030	6.035		27	50.025	2.030	
8	175.030	7.032		28	24.970	1.027	
9	199.983	8.028		29	00.000	.031	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10V Date 8-1-83

Equipment Under Test Sensotec A5 No. 73827

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J. eAthey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	.009		21	199.990	8.001	
2	25.000	1.008		22	175.020	7.003	
3	50.050	2.009		23	150.015	6.003	
4	74.990	3.005		24	125.015	5.002	
5	100.055	4.008		25	100.035	4.003	
6	124.960	5.003		26	75.070	3.004	
7	150.055	6.007		27	50.075	2.004	
8	174.980	8.002		28	20.085	1.004	
9	200.040	7.001		29	00.000	.007	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

CALIBRATION DATA SHEET

Unit of Measure 0-250 PSI, 0-10 V Date 8-1-83

Equipment Under Test SENSOTEC A5 No. 94504

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J. CAThey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	.009		21	200.040	8.007	
2	25.080	1.009		22	174.960	7.004	
3	50.030	2.005		23	150.080	6.009	
4	75.070	3.007		24	124.890	5.000	
5	100.070	4.007		25	100.060	4.007	
6	125.000	5.003		26	75.060	3.007	
7	150.010	6.004		27	50.040	2.007	
8	174.990	7.004		28	25.040	1.008	
9	200.055	8.007		29	00.000	.011	
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10V   Date 8-2-83

Equipment Under Test SENSOTEC Z   No. 92607

Standard Used S/N 10568   No. S/N 1169

Range 0-200 PSI   Calibration Expires 8-5-83   By E. KIRK

Barometric Pressure 29.96" Hg   Humidity ______ %   Temperature 75°F

Equipment From: Foreman CATHey   Bldg. 723   Area A

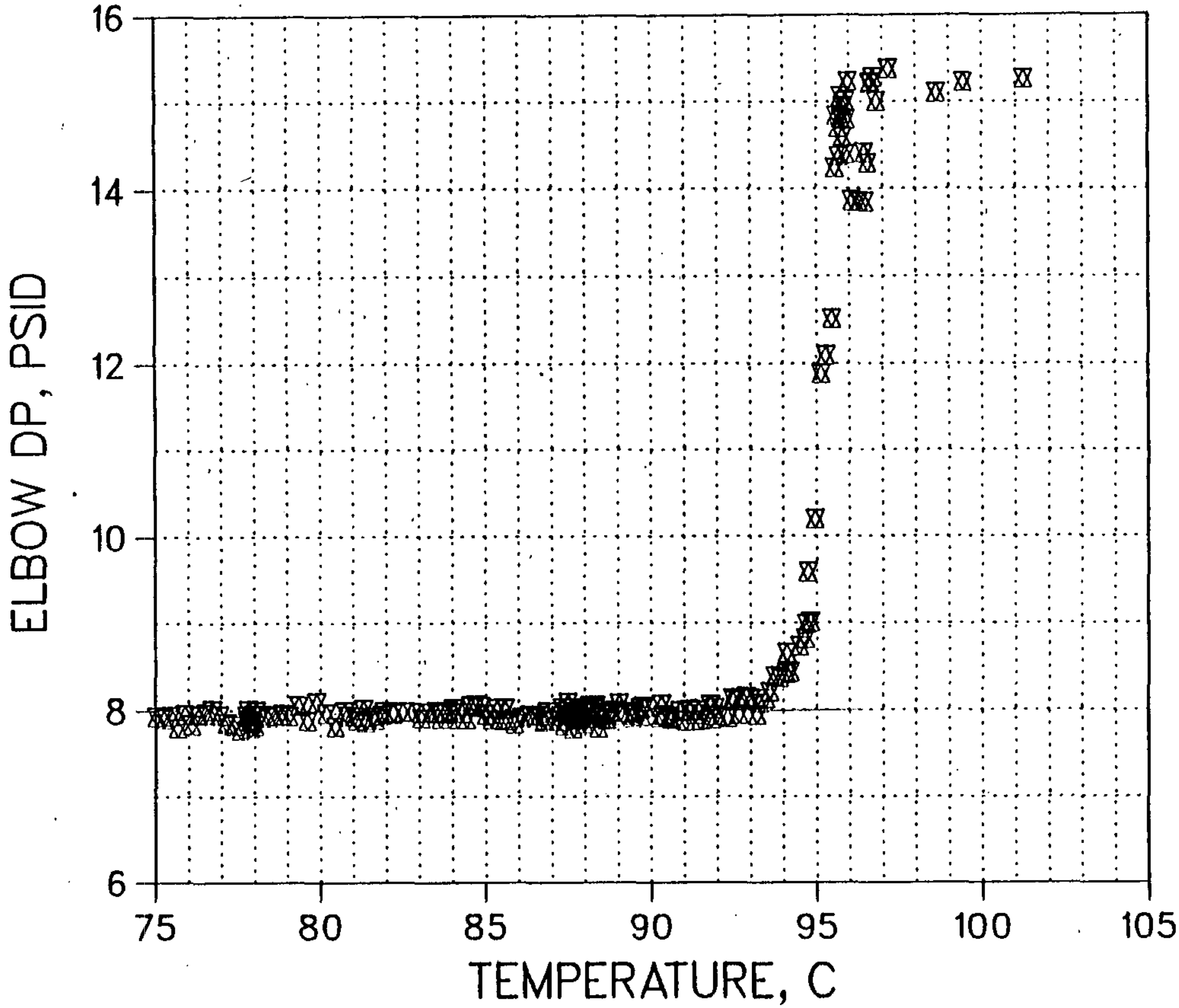
Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.006	-.014		21	49.930	10.012	
2	14.710	2.877		22	39.940	8.011	
3	19.975	3.996		23	30.040	6.023	
4	30.030	6.013		24	19.940	3.998	
5	40.030	8.022		25	14.710	2.910	
6	50.040	10.031		26	00.000	-.005	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

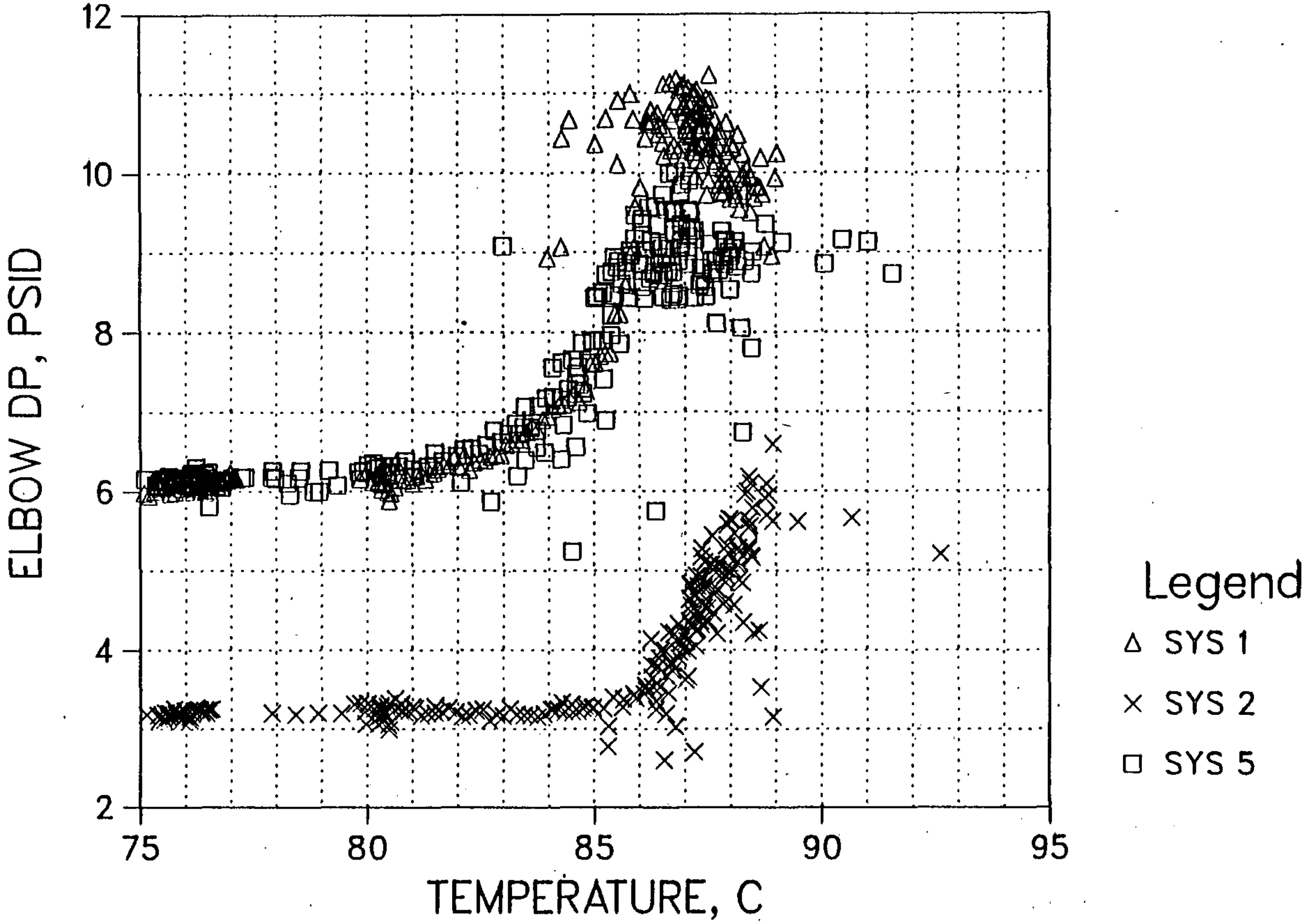
This not sent w/ other data sheets
Emory Kirk sent one a day later

Figure 1

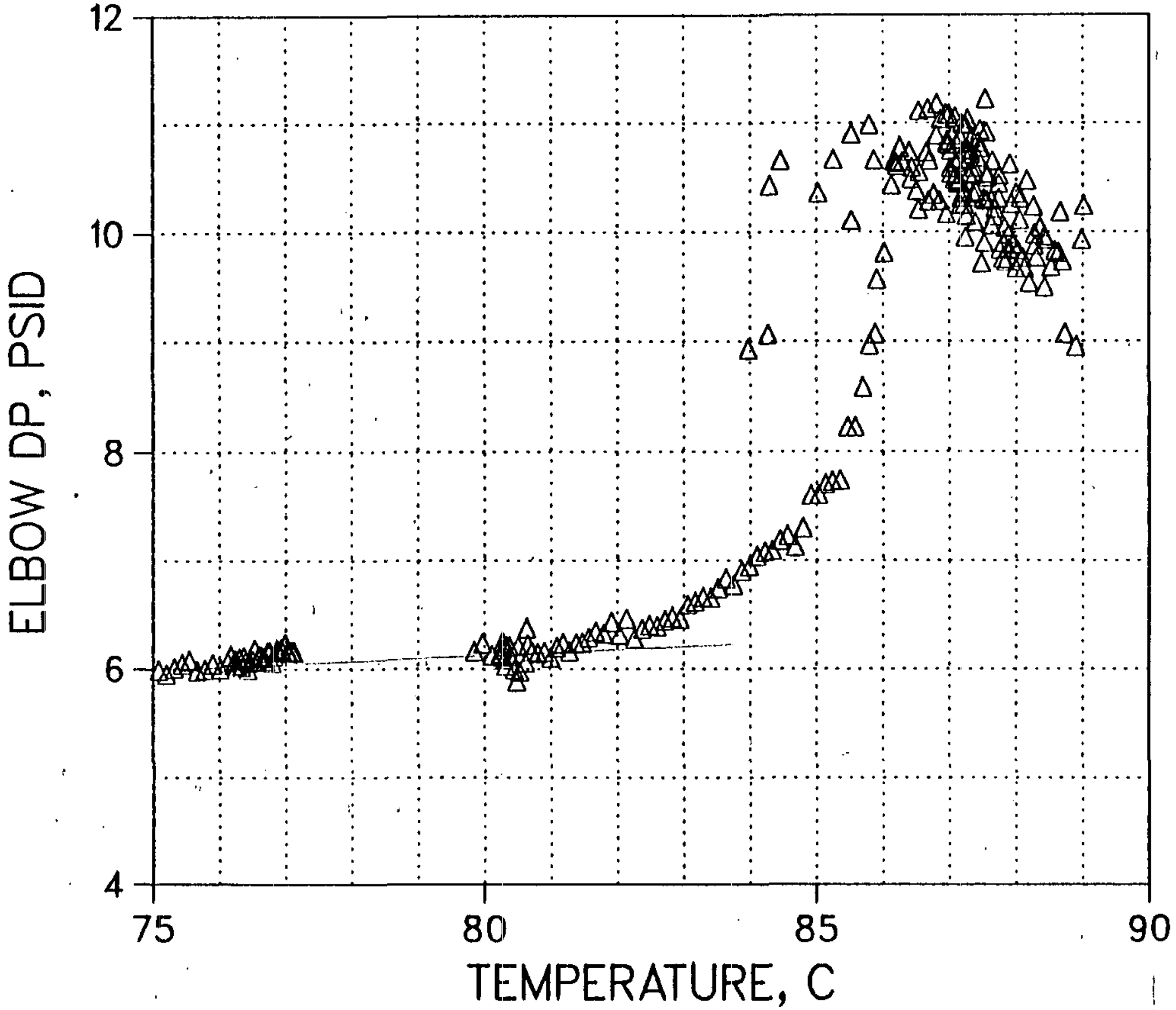
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 5 pumps



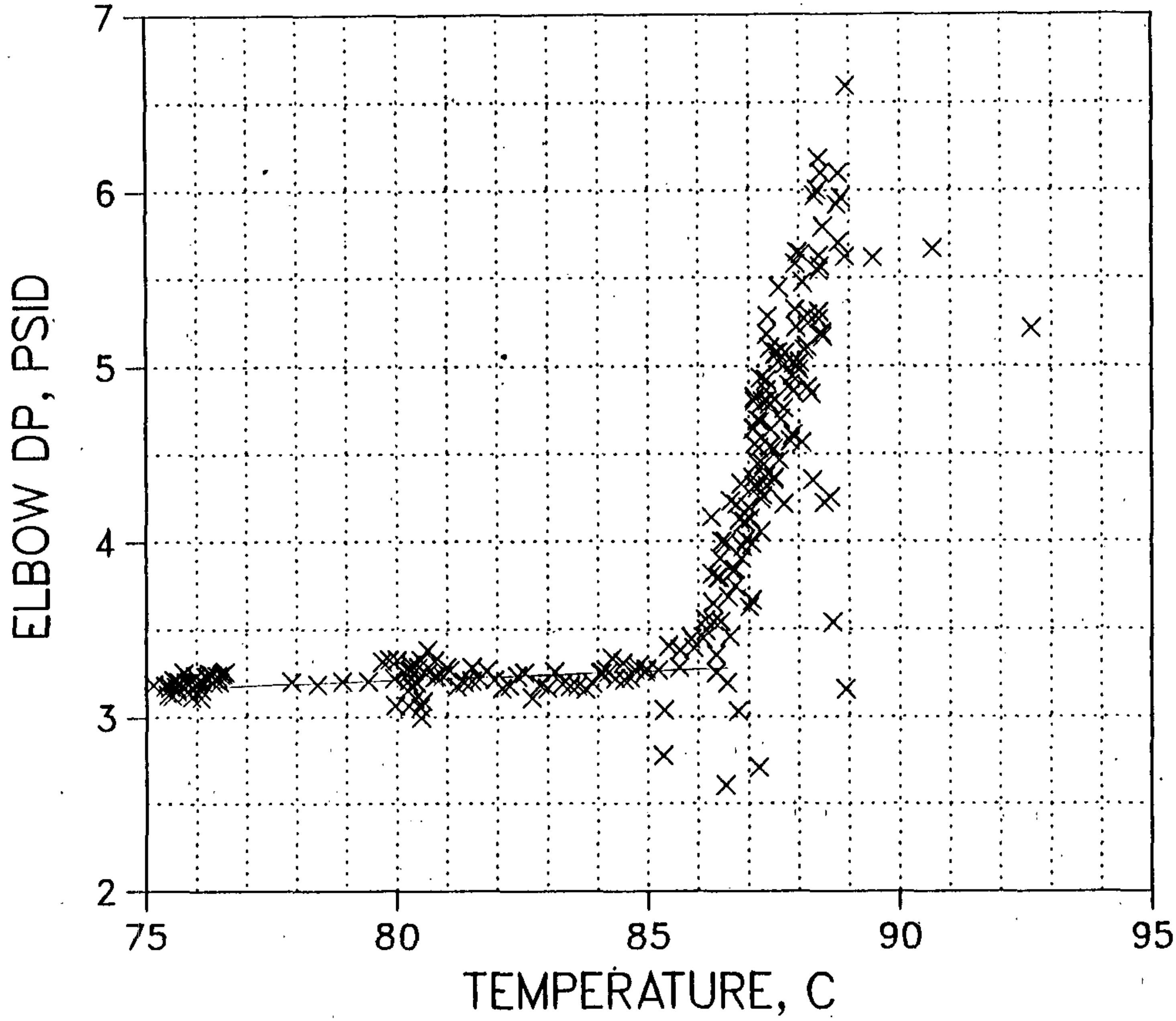
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 3 pumps



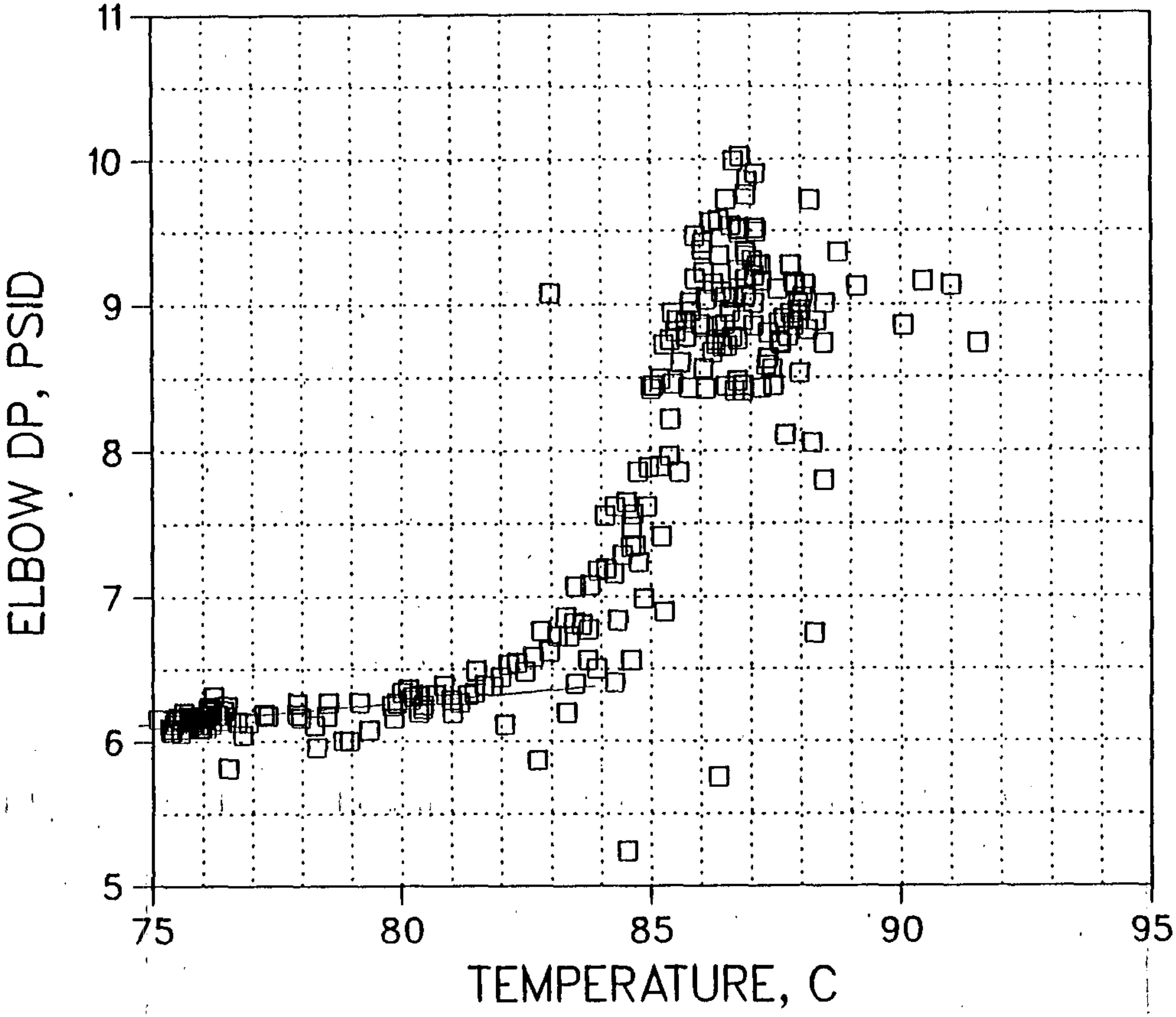
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 3 pumps



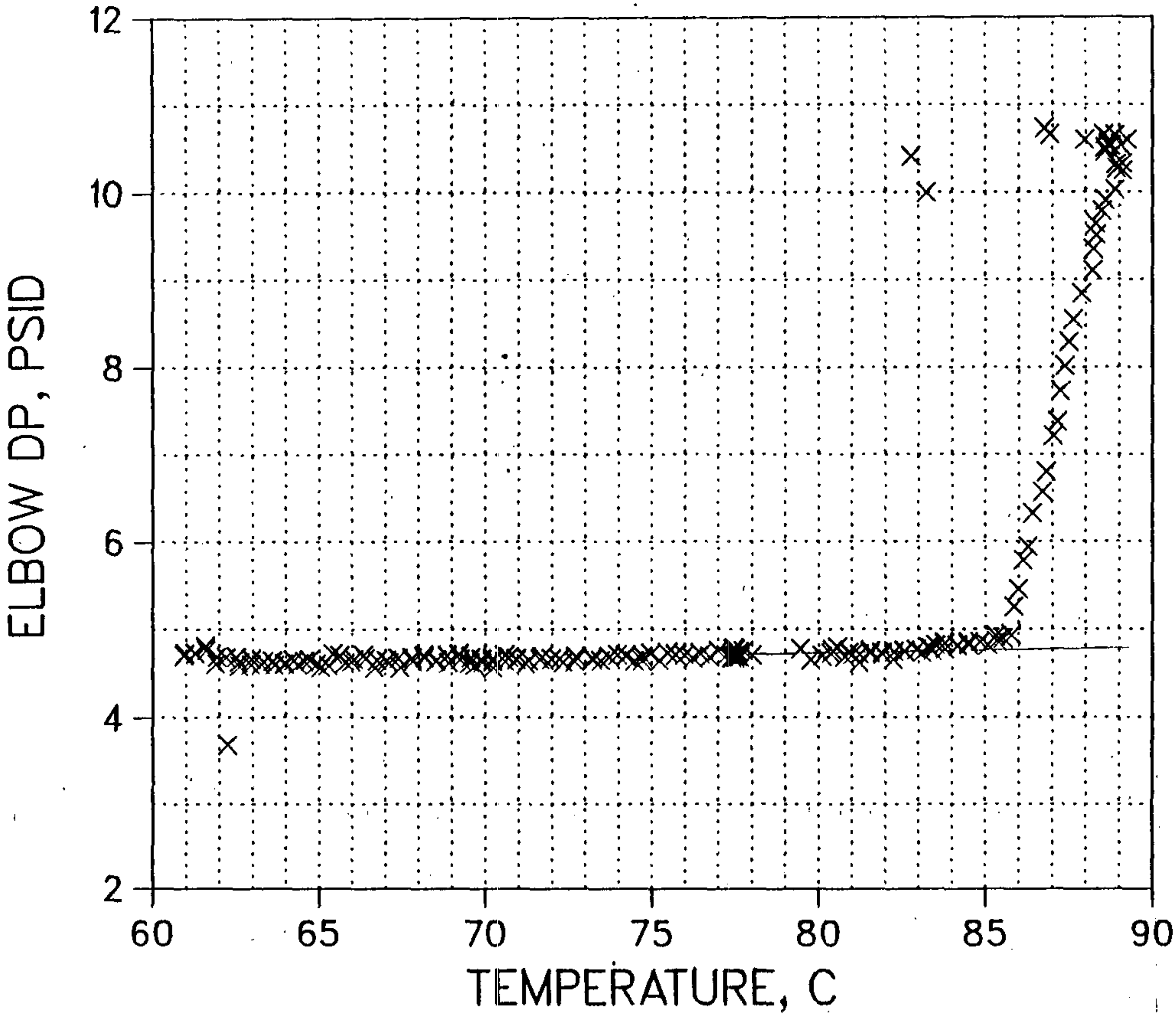
PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 3 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 3 pumps



PUMP CAVITATION TESTS
UNADJUSTED TEMPERATURE VS ELBOW DP 6 pumps,1



Appendix B - Data Adjustment Procedure

To calculate the operating limits the L-Area test data had to be corrected to normal condition of a full tank and 5.0 psig of blanket gas pressure. The following procedure was automated in the program listed in this appendix.

1) $P_{saturation\ in\ test} = [(6.4537 - 0.3977(228.3315-T_{Test})^{1/2}]^4$

2) $P_{adjustment}$ = blanket gas pressure + (19.2-Tank Level)

3) $P_{operating} = P_{saturation\ in\ test} + P_{adjustment}$

4) $T_{operating} = -34.9645 + 81.9577\ (P_{operating})^{1/4}$
$- 6.3218\ (P_{operating})^{1/2}$

All pressures are in psi, temperatures in °C, and the tank level is in feet. Equations (1) and (4) are univalued fits of the D_2O saturation curve obtained from J. P. Morin, SRL.

C) Calibration Data

This appendix contains the following calibration data for QA purposes.

1. Calibration for effluent line RTDs.

2. Calibration of atmospheric pressure transducer.

3. Calibration and identification of 0-25 psig, 0-250 psid, 0-50 psia transducers.

cc: J. W. Joseph, 703-A
R. R. Butterworth, 723-A
M. M. Widener, 105-L
M. T. Cox, 704-L
T. C. Sealy, 704-L
[redacted]
J. L. Jones, 706-C
J. L. Cathey, 723-A
C. M. Schaumann, 706-C
V. D. Vandervelde, 706-C

October 12, 1983

TO: D. R. MUHLBAIER, 704-L

FROM: A. W. GARTNER, 723-A

PUMP SUCTION RTD CALIBRATION

Refernces:
1) "L-Area RTD Calibration", DSIWI to J. L. Cathey from D. R. Muhlbaier, 9/30/83.
2) L-Area Pump Suction RTD Calibration Test Results (attached).

Introduction

Accurate pump suction temperature is important to efficent reactor operation. It was desirable to verify the calibration of the pump suction RTDs.

Summary

Cailbration was accomplished during the week of October 3rd using an NBS traceable RTD and a temperature bath. Data points were taken at approximately 30, 70, and 90°C. It was desired to obtain differences of less than 0.3°C. With the exception of pump #4 and the low temperature readings, results were within a few hundredths of a degree.

Discussion

The low measurement error was higher than the error for the mid and the high measurements. This did not cause any concern because, they were still within the desired accuracy, all pumps were similiar, and the reactor would not normally be operating in this range.

The measurements for pump #4, though within the desired accuracy range, deviated greatly from the other pumps. Reactor Tech adjusted the offset by Ø.18°C in the control computer and the test was run again. The results are now accurate and comparable with the other pumps.

L-AREA PUMP SUCTION RTD CALIBRATION TEST RESULTS

Pump #	Control Computer (°C)	Known RTD (°C+/-0.01°C)	Difference (°C)
5	30.68	30.60	0.08
	70.40	70.39	0.01
	93.97	93.97	0.00
6	30.65	30.58	0.07
	72.16	72.17	-0.01
	92.85	92.85	0.00
1	25.24	25.18	0.06
	71.11	71.14	-0.03
	93.59	93.61	-0.02
2	26.17	26.05	0.12
	51.90	51.86	0.04
	72.29	72.26	0.03
	95.76	95.78	-0.02
4*	26.14	26.25	-0.11*
(1st)	70.80	70.97	-0.17*
(run)	90.58	90.76	-0.18*
3	23.32	23.23	0.09
	71.14	71.13	0.01
	90.77	90.78	-0.01
4	24.55	24.47	0.08
(2nd)	71.62	71.60	0.02
(run)	90.14	90.13	0.01

*Original measurements yielding results inconsistent with the other pumps.

AWG
RWB

STD. NO TR-420 . CALIBRATION DATE 10/83 - CALIBRATOR G...

EXPIRATION DATE 10/84 CALIBRATION FREQUENCY 12 MO.

SL EQUIPMENT USED SL-138A

NBS TEST NO. N/A

CALIBRATION UNCERTAINTY IS .1% UNCERTAINTY OF CALIB. GAGE IS .25%

PROCEDURE USED IS DPSTOM - 72 - 311 TYPE GAGE CALIBRATED TRANSDUCER

SL-138A READING PSI	IN/HG	WESTON READING
0	29.76	3854
.2	30.17	4082
.4	30.58	4300
.6	30.99	4483
.8	31.40	4638
1.0	31.80	4920
1.2	32.21	5110

BAROMETER PRESSURE 29.76

POWER SUPPLY READING 28.08V

CERTIFIED BY

EED/Cavitation — 20 May

PRICE QUOTATION

DMS 10647 — JK Cathey

SESCO INC. TECHNICAL SALES REPRESENTATIVES

TO: Mr. Tommy Sessions
E. I. Dupont
Savannah River Plant
Building 723A
Aiken, SC 29808

DATE	5/10/83
YOUR INQUIRY NO.	Verbal
PROPOSED SHIPPING DATE	4-6 weeks ARO
TERMS	Net 30 days
F.O.B.	Columbus, OH
TO BE SHIPPED VIA	Best Way
THIS QUOTATION VALID FOR 30 DAYS.	

GENTLEMEN:

WE APPRECIATE THE OPPORTUNITY OF MAKING THE FOLLOWING PROPOSAL AND QUOTATION.

ITEM	QUAN.	DESCRIPTION	UNIT PRICE	TOTAL
A.	9	Sensotec Type Z Pressure Transducer with Amplifier Output and Mating Connector Range: 0-50 psia Output: 0-10 VDC Accuracy: ±0.25% of full scale	$550.00	$ 4,950.00
B.	6	Sensotec A-5 Differential Pressure Transducer with Amplifier Output and Mating Connector Range: 0-250 psid Output: 0-10 VDC Accuracy: ±0.5% of full scale	$740.00	$ 4,440.00
C.	2	Sensotec Z Type Pressure Transducer with Amplifier Output and Mating Connector Range: 0-25 psig Output: 0-10 VDC Accuracy: ±0.25% of full scale All other specifications on these transducers as per Pages 4, 5, 6, & 7 of the enclosed catalog. A photograph showing the 0-50 and the 0-25 transducers is on the lower left corner of Page 4. On the lower left corner of Page 7, there is a photograph of the differential transducer and its amplifier. The amplifiers that are shown are actually a part of transducer in that it slips inside of that extended "can". These transducers will be temperature compensated to operate at 95°C. The mating connector that I am talking about would mate directly to the Bendix connection which is clearly shown in the drawings on the bottom half of Page 5. That is the transducer connection and we are offering the mate that goes with that. In your	$565.00	$ 1,130.00

Connector number PT06A-10-6S

SESCO, INC.

Daryl Swiss
Daryl Swiss

* Daryl tel 95° temp comp → no significant error until that temp is reached
20 May 83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97604

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

WIRING CODE

A.) +15 VOLTS IN

B.) COMMON
C.) -15 VOLTS IN
D.) OUTPUT
E.) SHUNT
F.) SHUNT

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9939	Volts
	100	10.0000	Volts
Descending	50	4.9943	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9923 VOLTS DC

ACCEPTED AND CERTIFIED Michael J. [illegible]

DATE 7/6/83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97604

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM Rm °F TO 203 °F

WIRING CODE

A.) +15 VOLTS IN

B.) COMMON
C.) -15 VOLTS IN
D.) OUTPUT
E.) SHUNT
F.) SHUNT

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9953	Volts
	100	10.0006	Volts
Descending	50	4.9954	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9675 VOLTS DC

ACCEPTED AND CERTIFIED Michael [signature]

DATE 7/6/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 • TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97612

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

WIRING CODE

A.) +15 VOLTS IN

B.) COMMON
C.) -15 VOLTS IN
D.) OUTPUT
E.) SHUNT
F.) SHUNT

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9904	Volts
	100	10.0004	Volts
Descending	50	4.9901	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9980 VOLTS DC

ACCEPTED AND CERTIFIED

DATE 7/6/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 • TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97603

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

WIRING CODE

A.) +15 VOLTS IN

B.) COMMON
C.) -15 VOLTS IN
D.) OUTPUT
E.) SHUNT
F.) SHUNT

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9906	Volts
	100	10.0006	Volts
Descending	50	4.9918	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9990 VOLTS DC

ACCEPTED AND CERTIFIED

DATE 7/6/83

Cavitation Test for 105-L

JK Cathey
Rcvd 15 July 83
AX612078

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL Z/3533-01

SERIAL NO. 97611

CAPACITY 0-50 PSIA

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

WIRING CODE

A.) +15 VOLTS IN

B.) COMMON
C.) -15 VOLTS IN
D.) OUTPUT
E.) SHUNT
F,) SHUNT

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9919	Volts
	100	9.9993	Volts
Descending	50	4.9937	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/4-18 NPT MALE

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0751 VOLTS DC

ACCEPTED AND CERTIFIED Michael [illegible]

DATE 7/6/83

Cavitation Test for Bldg 105-L

J.K. Cothey Recd 19 July 83 AX612078

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 73827

CAPACITY 0-250 PSID

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

H + 15 VDC
B common
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
Ascending	0	0	Volts
	50	4.9960	Volts
	100	10.0013	Volts
Descending	50	4.9944	Volts
	0		Volts

PRESSURE PORT FITTING 1/8-27 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9184 VOLTS DC

ACCEPTED AND CERTIFIED [signature]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 94511

CAPACITY 0-250 PSID

COMPENSATED TEMPERATURE RANGE FROM Rm °F TO 203 °F

H + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9981	Volts
	100	10.0003	Volts
Descending	50	4.9984	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8-27 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9739 VOLTS DC.

ACCEPTED AND CERTIFIED [illegible]

DATE 7/8/83

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 94508

CAPACITY 0-250 PSID

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

	% CAPACITY	OUTPUT	
	0	0	Volts
Ascending	50	4.9986	Volts
	100	9.9995	Volts
Descending	50	4.9958	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8-27 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0046 VOLTS DC

ACCEPTED AND CERTIFIED Michael [illegible]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 94510

CAPACITY 0-250 PSID

COMPENSATED TEMPERATURE RANGE FROM Rm °F TO 203 °F

A + 15 VDC
B COMMON
C − 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	5.0002	Volts
	100	10.0009	Volts
Descending	50	4.9991	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8-27 NPT

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 8.0296 VOLTS DC

ACCEPTED AND CERTIFIED [illegible signature]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 94509

CAPACITY 0-250PSID

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	5.0009	Volts
	100	9.9996	Volts
Descending	50	5.0007	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8-27

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTANCE INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9756 VOLTS DC

TESTED AND CERTIFIED

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

SENSOTEC

CALIBRATION RECORD FOR TRANSDUCERS
WITH INTERNAL ELECTRONICS

MODEL A-5/3534-01

SERIAL NO. 70477

CAPACITY 0 - 250 PSID

COMPENSATED TEMPERATURE RANGE FROM RM °F TO 203 °F

A + 15 VDC
B COMMON
C - 15 VDC
D output
E & F shunt cal

% CAPACITY		OUTPUT	
	0	0	Volts
Ascending	50	4.9978	Volts
	100	10.0021	Volts
Descending	50	4.9960	Volts
	0	0	Volts

PRESSURE PORT FITTING 1/8 - 27

MATING ELECTRICAL CONNECTOR PT06A-10-6S

INTERNAL SHUNT CAL RESISTOR INSTALLED. SHORTING TOGETHER PINS E AND F PROVIDES AN OUTPUT OF 7.9978 VOLTS DC

ACCEPTED AND CERTIFIED [signature]

DATE 7/8/83

SENSOTEC, INC. 1200 CHESAPEAKE AVENUE • COLUMBUS, OHIO 43212 • (614) 486-7723 TWX 810 482 1188

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0 - 50 PSIA 0 - 10V Date 8-1-83

Equipment Under Test SENSOTEC Z No. 97609

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 30" Hg Humidity ______ % Temperature 80°F

Equipment From: Foreman J CAThey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.024		21	50.040	10.030	
2	14.730	2.909		22	39.930	8.006	
3	20.030	4.006		23	30.020	6.019	
4	30.070	6.023		24	20.050	4.022	
5	40.030	8.022		25	14.730	2.924	
6	49.980	10.017		26	00.000	.010	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10V Date 8-2-83

Equipment Under Test SENSOTEC Z No. 97616

Standard Used S/N 10568 r No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 29.96" Hg Humidity ______ % Temperature 75°F

Equipment From: Foreman CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.016		21	50.020	10.035	
2	14.710	2.884		22	39.970	8.017	
3	20.030	4.001		23	30.040	6.024	
4	30.060	6.020		24	19.940	3.997	
5	40.060	8.031		25	14.710	2.909	
6	50.065	10.042		26	00.000	-.007	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10V Date 8-2-83

Equipment Under Test SENSOTEC Z No. 97611

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 29.96" Hg Humidity ____ % Temperature 75°F

Equipment From: Foreman CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.006	-.015		21	49.930	9.947	
2	14.710	2.902		22	40.045	8.018	
3	20.065	4.004		23	30.050	6.013	
4	30.036	5.999		24	19.966	3.990	
5	40.025	8.007		25	14.710	2.908	
6	50.040	10.016		26	00.000	-.012	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10V Date 8-2-83

Equipment Under Test SENSOTEC Z No. 97617

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 29.96" Hg Humidity ___ % Temperature 75°F

Equipment From: Foreman CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.034		21	50.050	10.020	
2	14.710	2.884		22	39.980	8.001	
3	20.080	3.999		23	30.035	6.004	
4	30.030	5.998		24	20.030	3.998	
5	40.050	8.011		25	14.710	2.902	
6	50.050	10.019		26	00.000	-.005	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10V Date 8-2-83

Equipment Under Test SENSOTEC Z No. 92606

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 29.96" Hg Humidity ____ % Temperature 75°F

Equipment From: Foreman CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.427		21	50.000	10.027	
2	00.000	-.010	REZERO	22	40.070	8.035	
3	14.710	2.907		23	29.970	6.006	
4	20.040	4.012		24	20.008	4.005	
5	29.980	6.006		25	14.710	2.904	
6	40.080	8.037		26	00.000	-.014	
7	50.040	10.036		27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-50 PSIA, 0-10 V   Date 8-1-83

Equipment Under Test SENSOTEC Z   No. 97612

Standard Used S/N 10568   r No. S/N 1169

Range 200 PSI   Calibration Expires ______   By E. KIRK

Barometric Pressure 30" Hg   Humidity ______ % Temperature 80°F

Equipment From: Foreman J. Cathey   Bldg. 723   Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.039		21	49.990	9.985	
2	14.730	2.881		22	40.040	7.989	
3	20.040	3.979		23	29.990	5.971	
4	30.025	5.977		24	20.030	3.975	
5	39.990	7.978		25	14.730	2.886	
6	50.070	10.001		26	00.000	-.037	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks ______

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Date 8-2-83

Unit of Measure 0-50 PSIA, 0-10V

No. 97605

Equipment Under Test SENSOTEC Z

No. S/N 1169

Standard Used S/N 10568

Range 0-200 PSI Calibration Expires 8-5-83 By E. KIRK

Barometric Pressure 29.96" Hg Humidity ____ % Temperature 75°F

Equipment From: Foreman CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.007		21	50.000	10.028	
2	14.710	2.899		22	40.070	8.040	
3	20.000	4.008		23	30.040	6.026	
4	30.055	6.025		24	20.020	4.015	
5	40.010	8.023		25	14.710	2.917	
6	50.060	10.040		26	00.000	00.000	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0 - 50 PSIA, 0 - 10V Date 8-1-83

Equipment Under Test SENSOTEC Z No. 97604

Standard Used S/N 10568 No. S/N 1169

Range 0-200 PSI Calibration Expires 8-5-83 By E KIRK

Barometric Pressure 30"Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J. Cathey Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.011		21	49.920	9.998	
2	14.730	2.907		22	40.080	8.027	
3	19.960	3.986		23	30.000	6.005	
4	29.955	5.989		24	20.025	4.006	
5	40.050	8.016		25	14.730	2.915	
6	50.090	10.030		26	00.000	-.011	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

722-A E & I SHOP
CALIBRATION DATA SHEET

Unit of Measure 0-50PSIA 0-10V
Date 8-1-83

Equipment Under Test SENSOTEC Z
No. 97603

Standard Used S/N 10568
No. S/N 1169

Range 200-PSI Calibration Expires 8-5-83 By E KIRK

Barometric Pressure 30"Hg Humidity ____ % Temperature 80°F

Equipment From: Foreman J. CATHEY Bldg. 723 Area A

Reading Number	Standard Reading ↑	Test Reading	Deviation	Reading Number	Standard Reading ↓	Test Reading	Deviation
1	00.000	-.036		21	49.960	10.001	
2	14.730	2.888		22	40.090	8.020	
3	20.060	3.988		23	29.900	5.974	
4	30.010	5.986		24	20.090	4.007	
5	39.980	7.993		25	14.736	2.902	
6	49.960	9.998		26	00.000	-.017	
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			

Remarks

Figure 1

D) Fluid Property Effects

In the adjustment of the L Area test data to operating conditions, the fluid property change s were not taken into account. It is common for a centrifugal pump to require less NPSH at a higher operating temperature due to viscousity, specific heat, and other fluid property changes. This conservative measure was taken because in the SRP reactors gas evolution takes place before cavitation. Without further extensive testing, the effects of evolved gases and two phase flows on the pump characteristics is unknown. In Reference 1 a procedure for accounting for these changes is outlined. The procedure is based around the discussion in Reference 7 and uses the Bingham Pump Company data that was experimentally collected with degassed H_2O (See Appendix G).

Appendix E - Low Pressure Header and Tank Level

The determination of the actual tank level proved to be difficult. This appendix contains the calculations and data used to resolve the discrepancies in the test data. Special attention should be given to the effects of the number of pumps running on the low pressure header readings. Also note that the bottom tank centerline transducer was plugged during most of the testing.

The data listed was collated from references 9, 10, and 11.

Methodology

1. Determine all gauge elevations

2. Determine reading at overflow

3. Adjust for number of pumps running and obtained overflow reference point

4. Calculate tank level from absolute and gage readings (unsucessful)

5. Calculate levels by subtracting (i.e. using delta) from reference value

6. Compare different gage readings

Full analysis of all tank level data indicates that at the cavitation test levels approximately 10' and approximately 8' and at the S.L.O.C. test levels 3' to 0' the DMA calculated level is corrected.

Estimated Error ± 3" (these ranges only)

OSR 25-10 (Rev 6-78) ENGINEERING DUPONT COMPUTATION SHEET SHEET NO.

TITLE OF PROJ. PROJ. NO.

SUBJECT WORKS

COMPUTER DATE 19

CHECK CORRELATIONS

DMA TO LPH (VAM)

ERROR AVG. = 0.73'

DMA = 0.983 (LPH VAM FT) + 0.777

CORR = 0.9932

DMA TO LPH (HIESE)

ERROR AVG. = ⁻0.01'

DMA = 1.172 (LPH HIESE FT) + ⁻0.323

CORR = 0.9929

DRM DATA & ANALYSIS

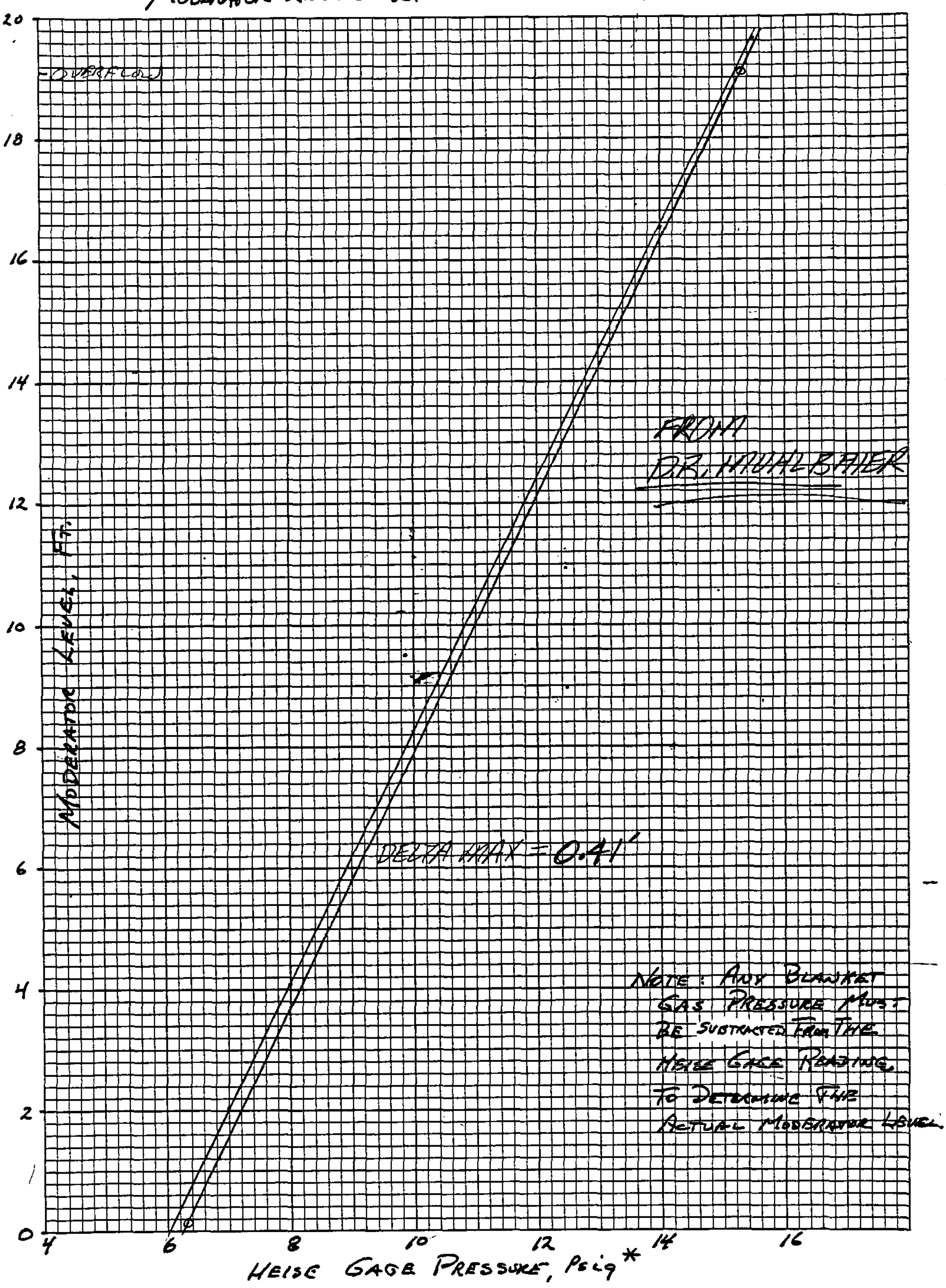
SEE CURVE

ABSOLUTE TANK LEVEL, FT = 2.10 (LPH HEISE) + ⁻13.16

MY DATA 16 POINTS

CORR. = 0.9976

ABSOLUTE TANK LEVEL = 2.071 (LPH HEISE) − 12.457

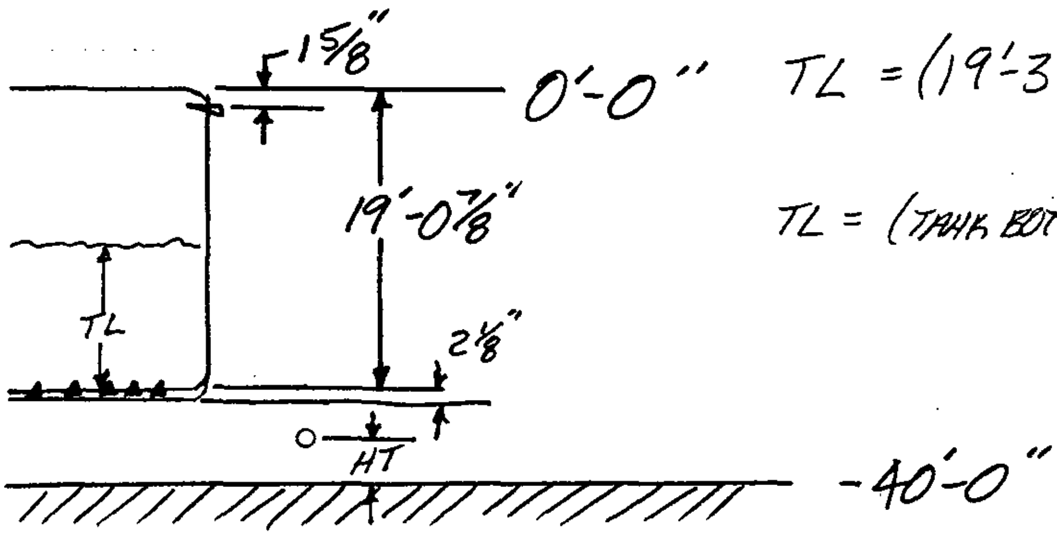


OVERFLOW
MODERATOR LEVEL, FT.
0
2
4
6
8
10
12
14
16
18
20
4
6
8
10
12
14
16
HEISE GAGE PRESSURE, Psig*
FROM DR. MUHLBAIER
DELTA MAX = 0.41'
NOTE: ANY BLANKET GAS PRESSURE MUST BE SUBTRACTED FROM THE HEISE GAGE READING TO DETERMINE THE ACTUAL MODERATOR LEVEL.

CAVITATION
TANK LEVEL DATA

11-22-83

- RX FINE LEVEL MEASURES FROM 0'-0" ELEVATION
- BOTTOM OF TANK IS AT -19'-3"
- MONITOR PIN TAP IS AT -19'-0 7/8"
- BOTTOM OF OVERFLOW WEIR IS AT -0'-1 5/8"
  SEE W231138
- ELEVATION OF VAM LPH XDUCER IS 5'6½" ABOVE -40' FLOOR
- ELEVATION OF HIESE LPH GAGE IS 6' ABOVE -40' FLOOR



TL = (19'-3") - (RX FINE)

TL = (TANK BOT PRESSURE)(FT/PSIG)

CAVITATION TANK LEVEL DATA

11-22-83

REFERENCE DATA WITH TANK FULL

6AC	-1.2" RX FINE	TL = 19'-1.8"
	8.8 BOT TK P	TL = 18.33'
	~29.9 LPH (VAM)	TL = 16.87'

ASSUME RX FINE CORRECT - IF TANK IS AT OVERFLOW LEVEL WOULD BE 19' 1 3/8" $^{+2"}_{-1/8"}$

OBTAIN AVERAGE LPH(VAM) READING WITH TANK AT OVERFLOW 6 ACs

T	RXFINE	LPH (VAM)		
23°	-1.2"	29.88	10-13	
	-1.1"	29.96		
	-1.2"	29.92		
	-1.1"	29.96		
	—	29.97		
	—	29.92		
28°	-0.1"	32.23	10-22	~2PSI BGP
65°	-0.1"	32.19		
85°	-0.15"	32.12		
94°	-0.3"	31.85		
39°	-1.4"	30.19	10-29	3AC
50°	-1.5"	30.14		
66°	-1.7"	30.14		
80°	-1.9"	30.05		
67°	-1.8"	30.12	10-30	5AC
71°	-1.8"	30.14		
73°	-1.9"	30.03		
76°	-1.9"	30.11		

CAVITATION
TANK LEVEL DATA

DAW

- USE DATA FROM 10-13, 10-29, 10-30 TO SET BASELINE FOR LPH(NAM)
- EFFECT OF TEMPERATURE COMPENSATE FOR IN DENSITY
- TO GO FROM 3AC TO 6AC SUBTRACT 0.3
- TO GO FROM 5AC TO 6AC SUBTRACT 0.1

10-13 CORRECTED TO ELEVATION 0'-0"

29.93, 29.97, 30.01, 30.01

10-29 CORRECTED TO ELEV. 0'-0" AND 6AC

29.95, 29.90, 29.91, 29.82*

10-30 CORRECTED TO ELEV. 0'-0" AND 6AC

30.09, 30.11, 30.00, 30.08

MEAN = 29.98 σ = 0.0861

*USE OF CHAUVENET'S CRITERION ELIMINATES BAD DATA POINT(S)

MEAN = 30.00 σ = 0.0728

σ_{MEAN} = 0.02 ~ ±0.5"

CAVITATION
TANK LEVEL DATA

DCW

- ANALYSIS SHOWS THAT A TANK LEVEL OF 19'3" CORRESPONDS TO A LPH (VAM) READING OF 30.00 PSIA

CALCULATE ABSOLUTE LEVEL

⇒ ASSUME ATM PRESS = 14.5 PSIA

$$\text{TANK LEVEL} = (30-14.5)\left(\frac{6894.757}{\rho g}\right)\left(\frac{FT}{M}\right)+(5.54')-(19.25')$$

$$= 18.87'$$

WITHIN 5 INCHES OF ESTIMATE ~.2 PSI

CHECK ATM PRESS ASSUMPTION

ON 10-30 ATM PRESS ≈ 14.8 PSIA
" 10-29 " " ≈ 14.7 PSIA
" 10-13 ?

(FROM PROCESS ROOM XDUCER)

SRL BAROGRAPH DATA

10-13	1007 mBARS	⇒	14.60
10-22	1016 mB	⇒	14.73
10-29	1008 mB	⇒	14.62
10-30	1021 mB	⇒	14.81
		AVG.	14.69

(TO GO FROM SRL TO L-AREA ELEVATION ADD 0.03 NEGLIGIBLE)

TANK LEVEL w/ TRUE ATM PRESS. ≈ 18.2' ?

CAVITATION TANK LEVEL DATA

DW

USE "DELTA's"

FOR REFERENCE 19'3" = 30.00 ON LPH (VAM)
"FULL" = 9.0 PSIG ON DMA

DMA PRESSURE	DMA LEVEL	VAM LPH	HIESE LPH	TEMP
① "FULL"	19.0'	30.09	16.1	~25°C
② 3.3	6.8'	24.40		57°C
③ 3.9	8.2'	25.12	10.9	78°C
④ 4.3	9.2'	25.47		84°C
⑤ 4.8	10.2'	26.03		89°C
⑥ –	11.0'	26.35	12.2	~25°C
⑦ "EMPTY"	0'	21.7		~25°C

CAVITATION
TANK LEVEL DATA

DEW

- "FULL" REFERENCE CONDITIONS

DMA PRESS. = 9.0 , LPH (VAM) = 30.00 GAC

LPH (HIESE) = 16.1 , TANK LEVEL ~19'3"

POINT	TL DMA PRESS	TL DMA	TL LPH (VAM)	TL LPH (HIESE)	AVERAGE
2	7.3'	6.8'	7.3'	—	7.13'
3	8.5'	8.2'	9.0'	8.3'	8.50'
4	9.4'	9.2'	9.7'	—	9.43
5	10.4'	10.2'	10.9'	—	10.50'
6	—	11.0'	11.6'	11.1'	11.23'

LPH (HIESE) DELTA WOULD INDICATE THAT THE DMA LEVEL IS CORRECT

PROCEED TO S.L.O.C. TEST DATA FOR FURTHER ANALYSIS

				VAM		HIESE		
DATE	T	TIME	DMA	LPH	₵	LPH	₵	# OF PUMPS
10-22	28°	13:08	RX FINE -0.1"	32.23	23.02			6AC
	65°	15:06	-0.1"	32.19	24.42			6AC
	85°	16:14	-0.15"	32.12	25.88			6AC
	94°	16:48	-0.30"	31.85	26.92			6AC
	90°	16:51	—	32.52	27.05			6DC
10-30	67°	11:11	RX FINE -1.8" RX COARSE 18.6' RX TANK BP 8.8PSIG	30.12	26.09			5AC
	71°	11:30	-1.8" 18.6' 8.8PSIG	30.14	26.32			5AC
	73.5°	11:45	-1.9" 18.5' 8.8PSIG	30.03	26.53			5AC
	76°	12:00	-1.9" 18.5' 8.8PSIG	(26.73)	(30.11)			5AC

(4075)

				VAM		HIESE		
DATE	T	TIME	DMA	LPH	¢	LPH	¢	# AC's
10-16	~23°	MIDNIGHT		30.83	24.78			3 DC
10-17		10:30		30.18	24.77			6 AC
10-21			<10.7>	31.91	23.03			6 AC
10-21				32.57	22.97			6 DC
10-21		22:28	RX COARSE 19.0" RX FINE -1.3" RX TK BP 10.7 PSIG	31.90	23.10			6 AC
10-13	~23°	10:06	RX FINE -1.2" RX TK BP 8.8 PSIG	29.88	25.69			6 AC
		10:34	-1.1" 8.8 PSIG	29.96	25.71			6 AC
		11:30	-1.2" 8.8 PSIG	29.92	25.73			6 AC
		12:30	-1.1" 8.8	29.96	25.64			6 AC
10-13	~23°	16:04		30.57	25.73			NO AC/NO DC
		16:50		30.60	25.64			6 DC
		16:52		30.63	25.65			1 AC
		16:54		30.30	25.60			2 AC
		16:54½		30.30	25.61			3
		16:55		30.06	25.66			4
		16:56		29.98	25.68			5
		16:58		29.97	25.62			6
		17:15		29.92	25.62			6
		18:30		30.71	25.67			NO AC/NO DC

				VAM		HIESE		
DATE	T	TIME	DMA	LPH	¢	LPH	¢	# OF PUMPS
10-31	56.5°	01:00	~~RX FINE 25.9'~~ RX COARSE 6.8' RX TANK BP 3.3 PSIG	24.41	27.19			6AC
	58°	01:45	6.8' 3.3 PSIG	24.39	26.82			6AC
	62°	05:10	8.0' 3.8 PSIG	24.93	26.64			6AC
	75°	05:45	8.2' 3.9 PSIG	25.08	27.02			6AC
	80°	6:00	8.2' 3.9 PSIG	25.19	27.25			6AC
10-31	84.5°	20:54	9.2' 4.4 PSIG	25.53	28.21	11.38		6AC
	84°	21:20	9.2' 4.3 PSIG	25.49	28.47	11.38		6AC
	85.5°	21:40	9.7' 4.6	25.75	28.80	11.55		6AC
	81°	22:40	9.1' 4.3 PSIG	25.46	29.05	11.30		6AC
	80°	23:00	9.0' 4.3 PSIG	25.44	29.25	11.30		6AC
	84°	23:15	9.2' 4.3 PSIG	25.55	29.42	11.40		6AC
	89°	23:30	10.2' 4.8 PSIG	26.03	29.59	11.90		6AC

(4065)

(4065)

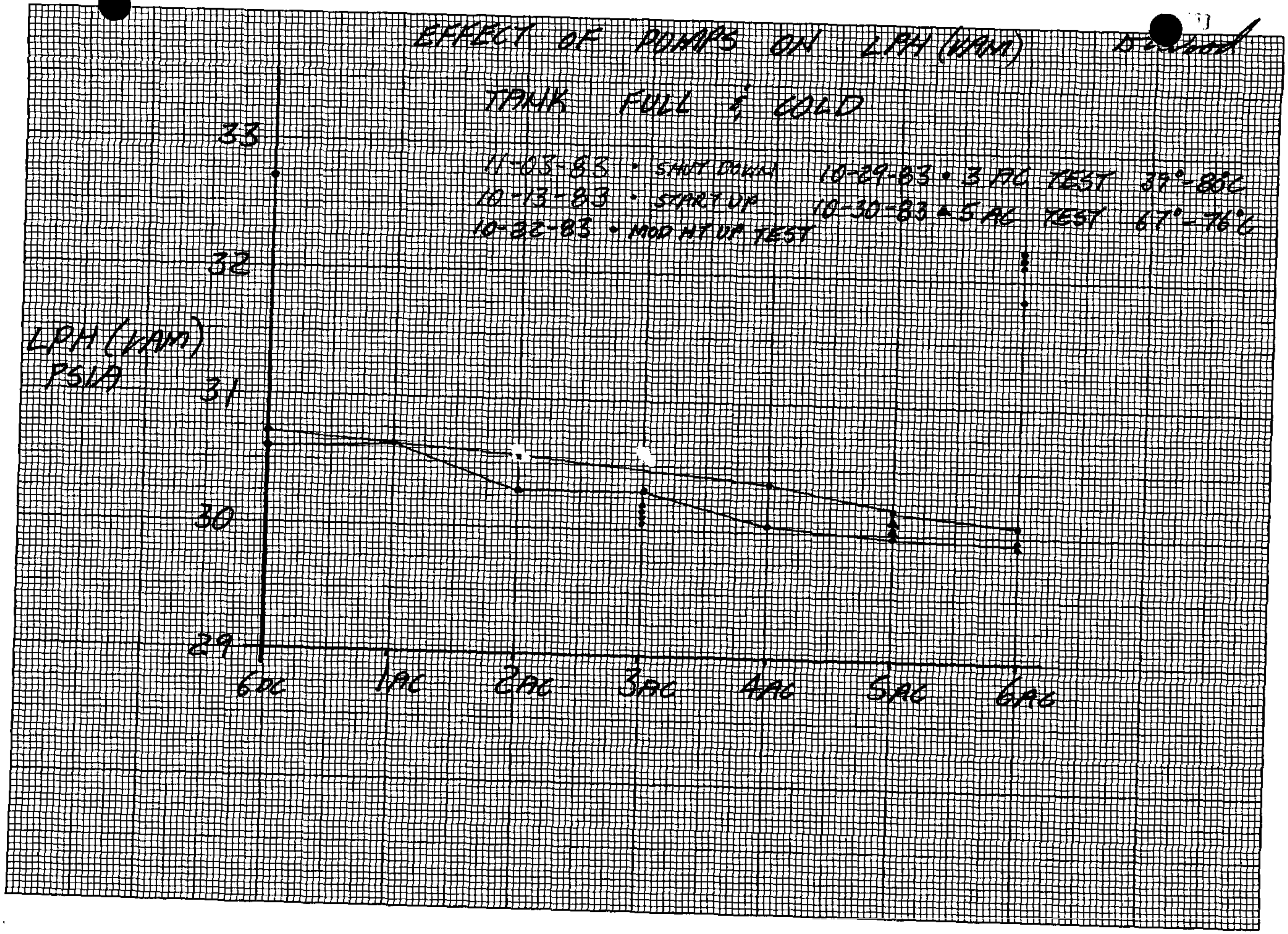
				VAM		HIESE		
DATA	T	TIME	DMA	LPH	¢	LPH	¢	# OF PUMPS
11-02	~25°C	01:35	8.2	25.08	⟨23.88⟩	10.9		6AC
11-03	~25°	09:10	11.0	26.35	22.45	12.2		6AC
11-03	~25°	13:45	19.0	30.09	22.78	16.1		6AC
				30.19	22.93	16.2		5 AC
				30.38	22.95	16.2		4 AC
						16.3		3 AC
				30.54	22.98	16.4		2 AC
						16.5		1 AC
				30.71	22.94	16.6		6 DC

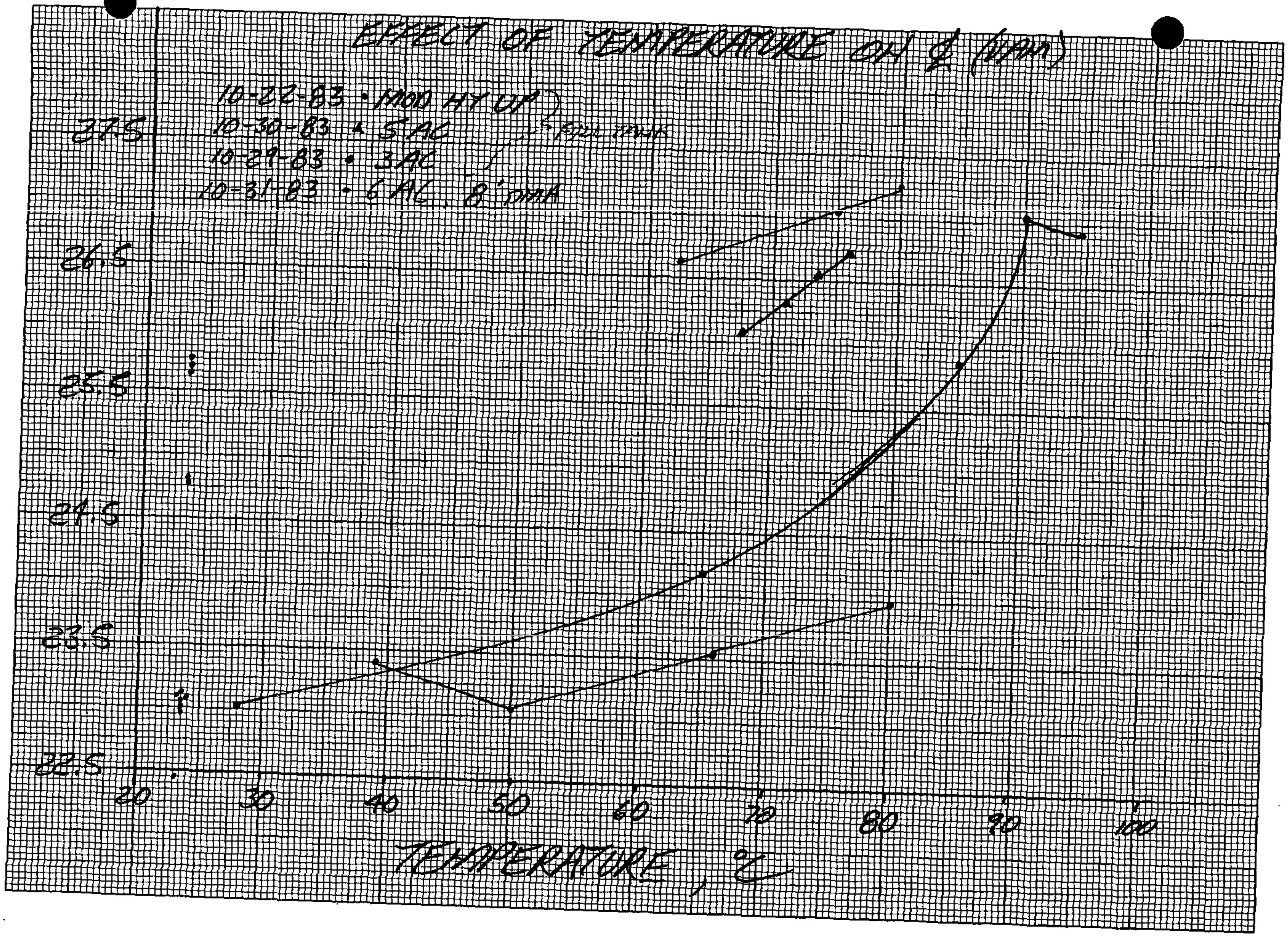
VAN | NIESE

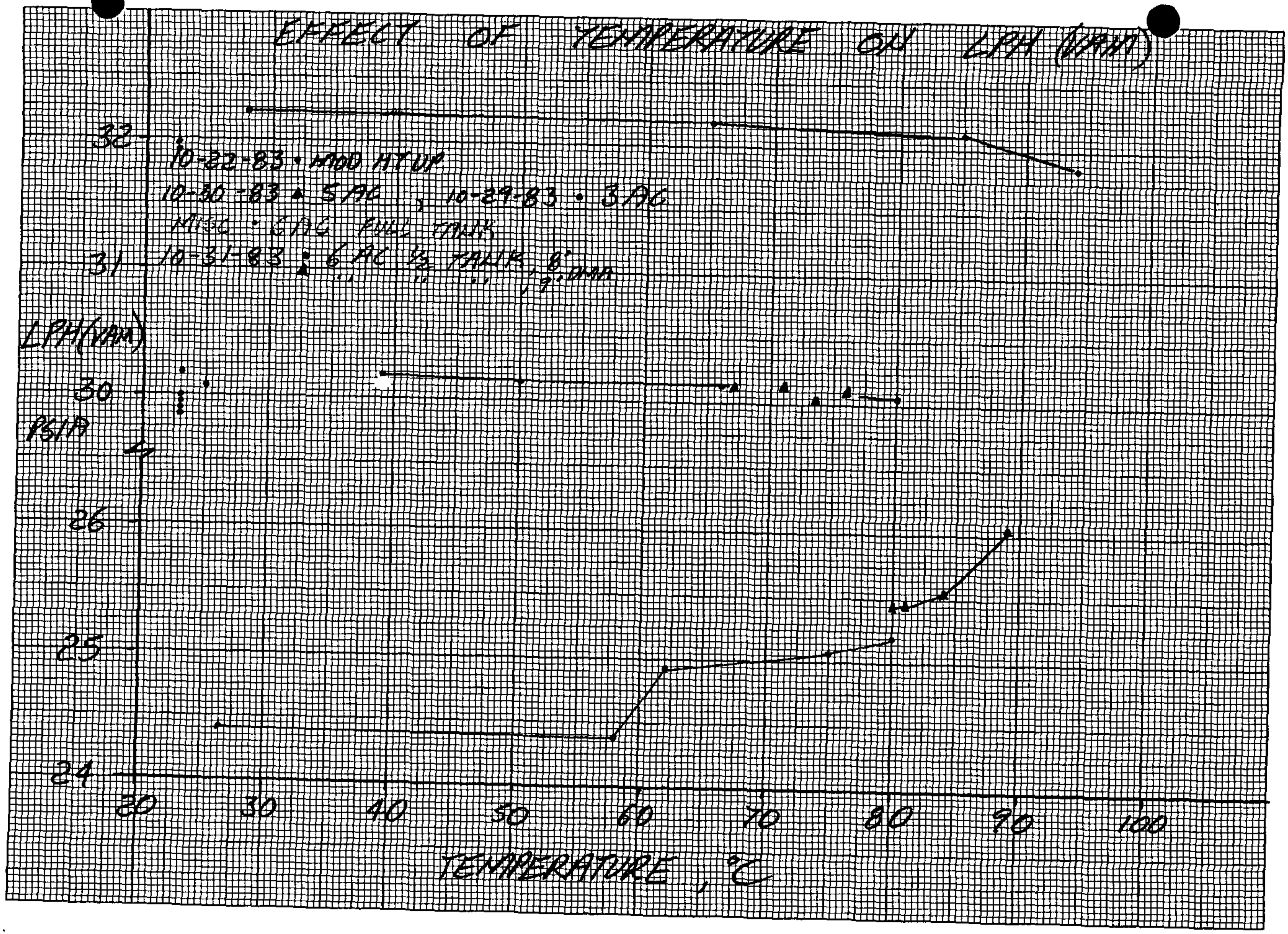
DATE	T	TIME		DHA	LPH	¢	LPH	¢	# OF PUMPS
10-29	39°	16:15	RX FINE / RX TANK P	-1.4" / 9.0 PSIG	30.19	23.40			3:AC
	50°	17:00		-1.5" / 9.0 PSIG	30.14	23.07			
	66°	18:00		-1.7" / 7.0 PSIG	30.14	23.54			
	80°	19:00		-1.9" / 8.9 PSIG	30.05	23.97			

WITH TANK LEVEL ~ 0 i.e. TANK DRAINED

11-11	25°C				21.74	—	6.3	—	

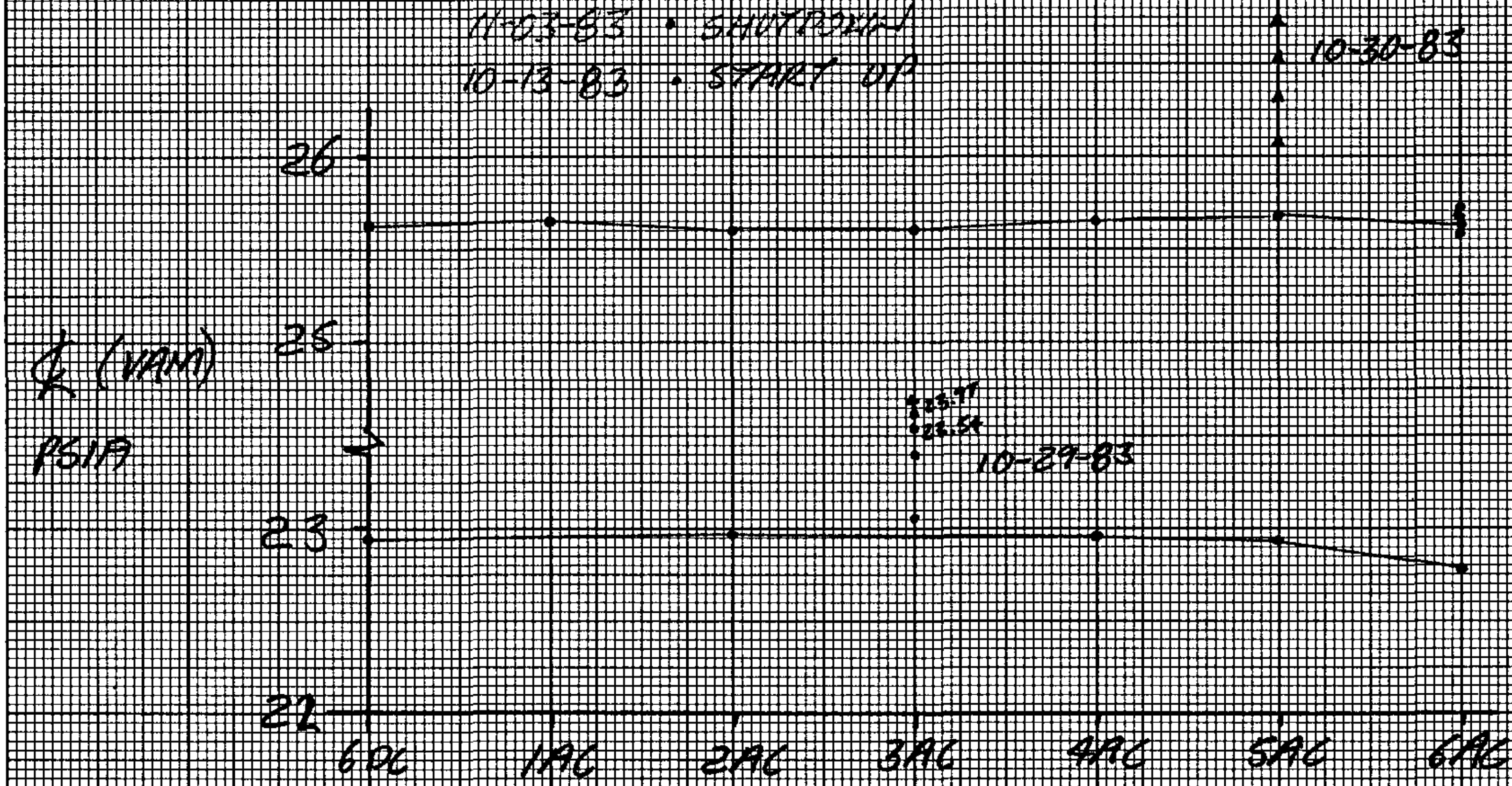

EFFECT OF PUMPS ON LPH (VAM)
TANK FULL & COLD
11-03-83 • SHUT DOWN
10-13-83 • START UP
10-22-83 • MOD HT UP TEST
10-29-83 • 3 AC TEST 39°-86°C
10-30-83 ▲ 5 AC TEST 67°-76°C
LPH (VAM) PSIA
33
32
31
30
29
6DC
1AC
2AC
3AC
4AC
5AC
6AC


EFFECT OF TEMPERATURE ON
10-22-83 • MOD HT UP
10-30-83 ▲ 5 AC
FULL TANK
10-29-83 • 3 AC
10-31-83 • 6 AC
27.5
26.5
25.5
24.5
23.5
22.5
20
30
40
50
60
70
80
90
100
TEMPERATURE, °C


EFFECT OF TEMPERATURE ON LPH (VAM)
10-22-83 • MOD HT UP
10-30-83 ▲ 5 AC , 10-29-83 • 3 AC
MISC • 3 AC FULL TANK
10-31-83 ▲ 6 AC ½ TANK
LPH (VAM)
PSIA
32
31
30
26
25
24
20
30
40
50
60
70
80
90
100
TEMPERATURE, °C

EFFECT OF PUMPS ON ℄ VAM

TANK FULL & COLD



S.L.O.C.
TANK LEVEL

DAW

ASSUME
30.89 PSIA = 19'2"
LPH (VAM)
15.29 PSIG = 19'2"
LPH (HIESE)
15.35 PSIG = 19'2"
℄ (HIESE)

CALCULATE LEVELS $\rho \approx 1107\ kg/m^3$ @ ~20°C

DMA	LPH VAM	LPH HIESE	℄
6.1'	5.4'	5.4'	
6.8'	6.2'	6.1'	
3.0'	2.4'	2.8'	
2.2'	1.5'	1.9'	
1.5'	0.92'	1.4'	
1.1'	0.63'	1.2'	
1.7'	0.77'	1.7'	
3.7'	2.9'	3.5'	
2.1'	1.4'	2.2'	
1.9'	1.1'	2.0'	
1.5'	0.86'	1.8'	
4.6'	3.75'		6.19'
2.1'	1.2'		2.96'
1.6'	0.75'		1.82'
1.4'	0.4'		1.46'

CHECK CORRELATIONS

DMA TO LPH (VAM)

ERROR AVG. = 0.73'

$DMA = 0.983 (LPH_{VAM}) + 0.777$
FT

CORR = 0.9932

DMA TO LPH (HIESE)

ERROR AVG. = -0.01'

$DMA = 1.172 (LPH_{HIESE}) + {}^{-}0.323$
FT

CORR = 0.9929

DRM DATA & ANALYSIS

SEE CURVE

$ABSOLUTE\ TANK\ LEVEL, FT = 2.10 (LPH_{HEISE}) + {}^{-}13.16$

MY DATA 16 POINTS

CORR. = 0.9976

$ABSOLUTE\ TANK\ LEVEL = 2.071 (LPH_{HEISE}) - 12.457$

S.L.O.C. TEST TANK LEVEL DATA

DATE	TIME	DMA LEVEL	DMA PRESSURE	VAN LPH	VAN ℄	HEISE LPH	HEISE ℄
TEMP ≈ 20°C							
11-5-83	23:36	20.1'	9.4 PSIG	30.92	21.37	15.30	15.36
11-6-83	1:20	20.1'	9.4	30.87	21.46	15.30	15.37
	2:36	19.9'	9.4	30.88	21.30	15.27	15.32
	4:30	6.1'	3.0	24.19	<21.29>	8.66	<8.75>
	5:30	6.1'	3.0	24.33	<21.30>	8.68	<8.78>
	7:00	6.8'	3.3	24.64	<21.15>	9.01	<9.10>
	10:26	3.0'	1.6	22.86		7.43	
	15:00	2.2'	1.2	22.40		6.98	
	23:00	1.5'	1.0	22.13		6.78	
11-7-83	7:45	1.1'	0.8	21.97		6.66	
	11:45	1.1'	0.7	22.01		6.70	
11-8-83	2:00	1.7'	1.0	22.06		6.88	
	7:00	3.7'	1.9	23.09		7.79	
	13:30	2.1'	1.3	22.38		7.14	
11-9-83	2:00	1.9'	1.2	22.20		7.07	
	7:00	1.5'	1.0	22.10		6.94	
11-10-83	5:00	4.6'	–	23.49			9.12
	8:26	2.1'	1.2	22.26			7.57

S.L.O.C. TEST TANK LEVEL DATA

DATE	TIME	DANA LEVEL PRESSURE	VAHN LPH ¢	HIESE LPH ¢
11-10-83	14:02	1.6'	22.05	7.02
	16:00	1.4'	21.88	6.85

Appendix F - Dissolved Gases

The concept of gas evolution and its effects on cavitation were not discussed in the results of previous cavitation studies at SRP. During the year long study of cavitation the following conclusions concerning dissolved gases and gas evolution were drawn.

1) The evolution of non-condensable dissolved gases; oxygen, nitrogen, helium, etc., takes place at a temperature below and pressure above the saturation point of the flowing fluid.

2) In the Georgia Iron Works Tests, it was determined that in the range of 0.7 - 2.0% dissolved gases, varying the dissolved gas content did not affect the increase in pressure drop that occurs when the gas evolves.

3) This increasing pressure drop occurs in the reactor effluent line and reduces the pump suction pressure forcing the pump into cavitation.

4) A sample of D_2O from P Area (while in operation) had a dissolved gas content of 1.4%. The L Area D_2O had a dissolved gas content of 0.8%.

5. The presence of evolved gases increase the compressibility of the flowing fluid and reduces flow noise and the cavitation damage potential.

G) Bingham Pump Company Data

The first curves are L Area data shown as NPSH vs. temperature. This can be used for comparison to the Bingham Pump Company data.

The data in this appendix is here for reference. It could not be found in the SRP records and was obtained from:

Bingham-Williamette Co.
2800 N.W. Front Avenue
P. O. Box 10247
Portland, Oregon 97210

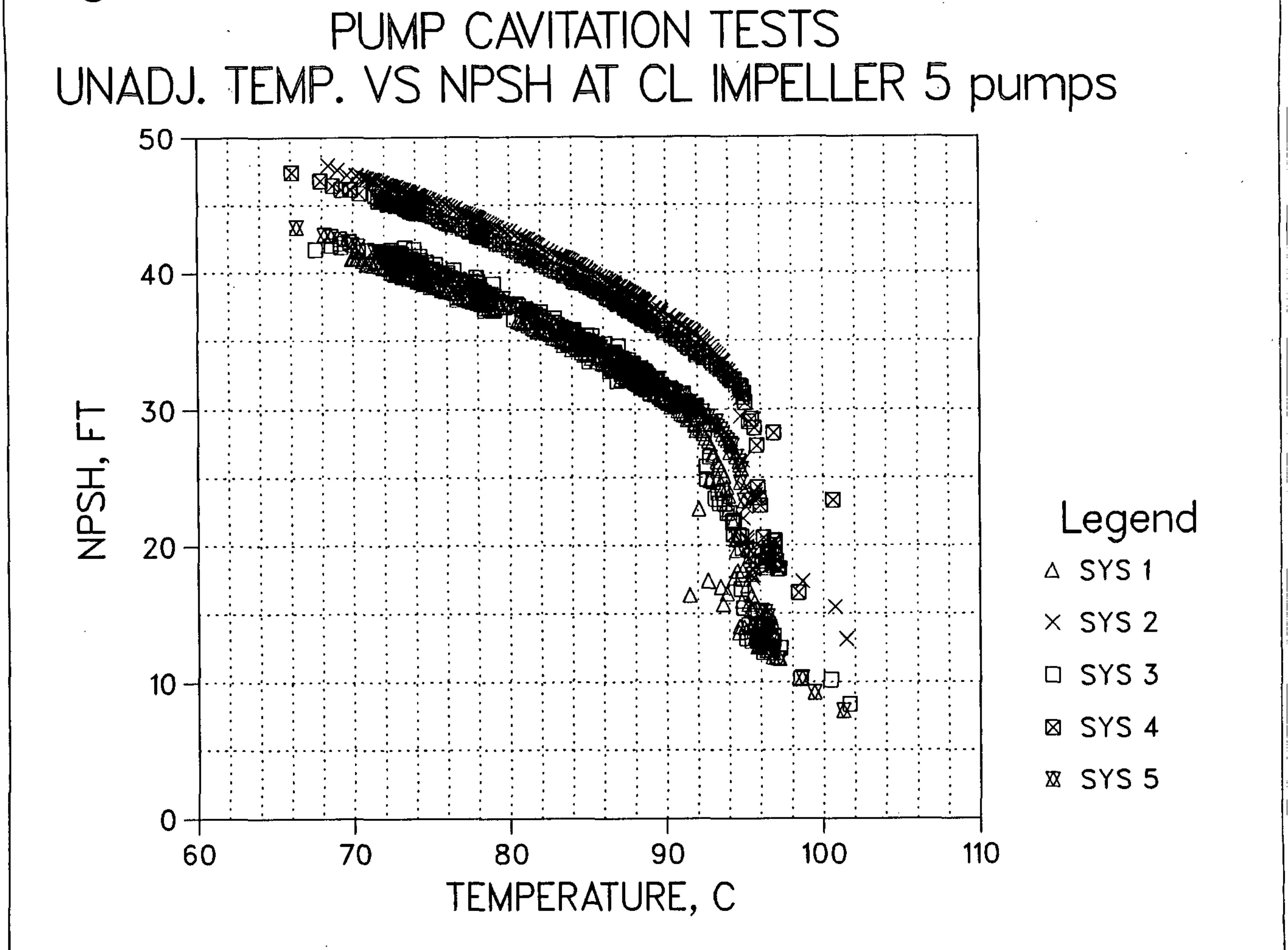
(503) 226-5200

CAVITATION
NPSH CURVES

SYSTEM	FLOW	PUMP CUTOFF T PMP DP & ACCEL	NPSH	(G.E.) NPSH BREAK	BINGHAM NPSH BREAK AT 95°C
1	27.3 KGPM	95.5°C	16'		
2	28.1	95.5	18.5'		
3	28.0	95.5	14'		17' @ 28.0
4	26.8	96	22.5' @ 96.5° => 18.5'		14' @ 25.0
5	26.2	96	14'		

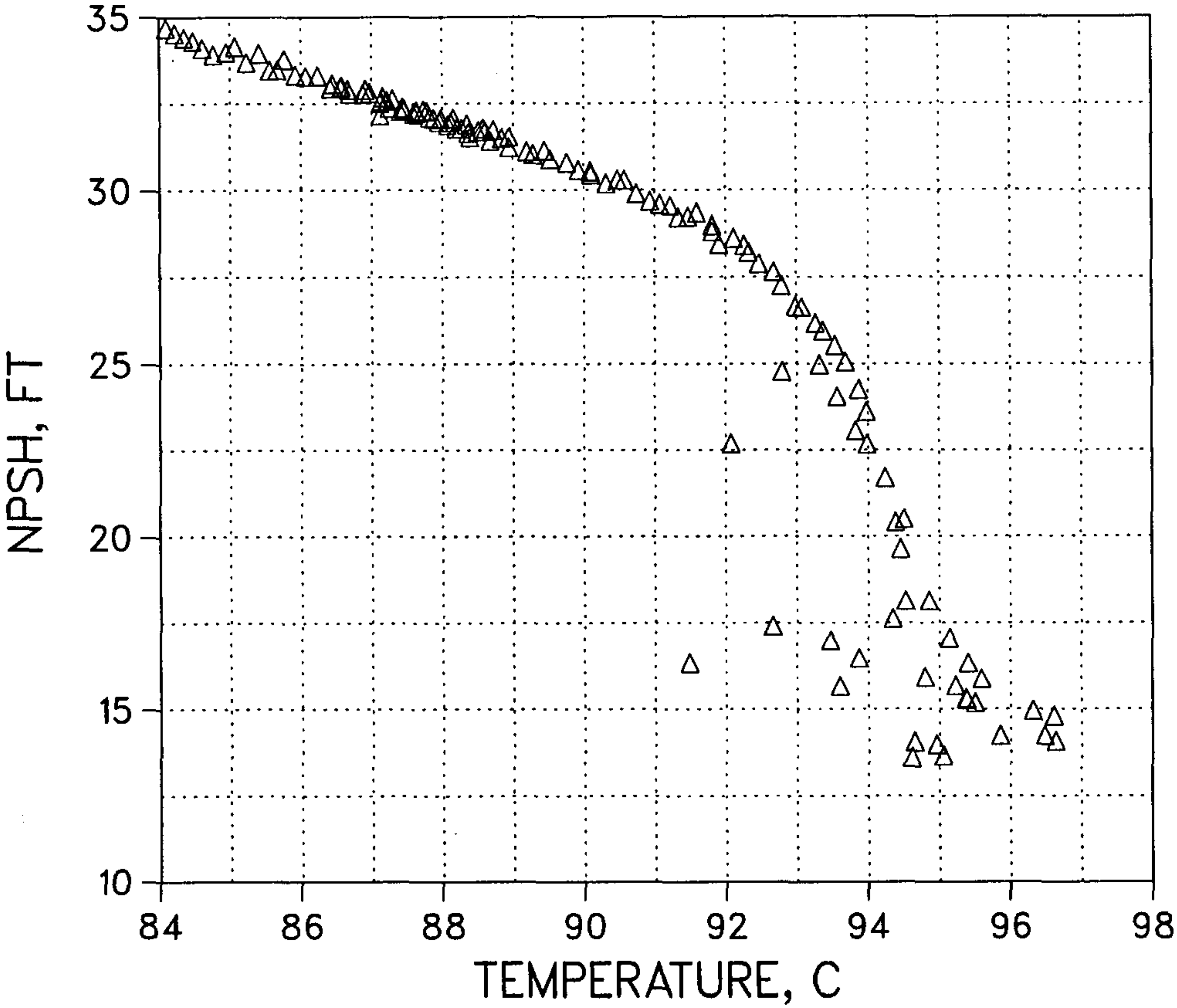
THE ABOVE DATA IS ± 1.5' NPSH AND FOR COMPARISON ONLY

PLEASED THAT NPSH NUMBERS ARE SO CLOSE!

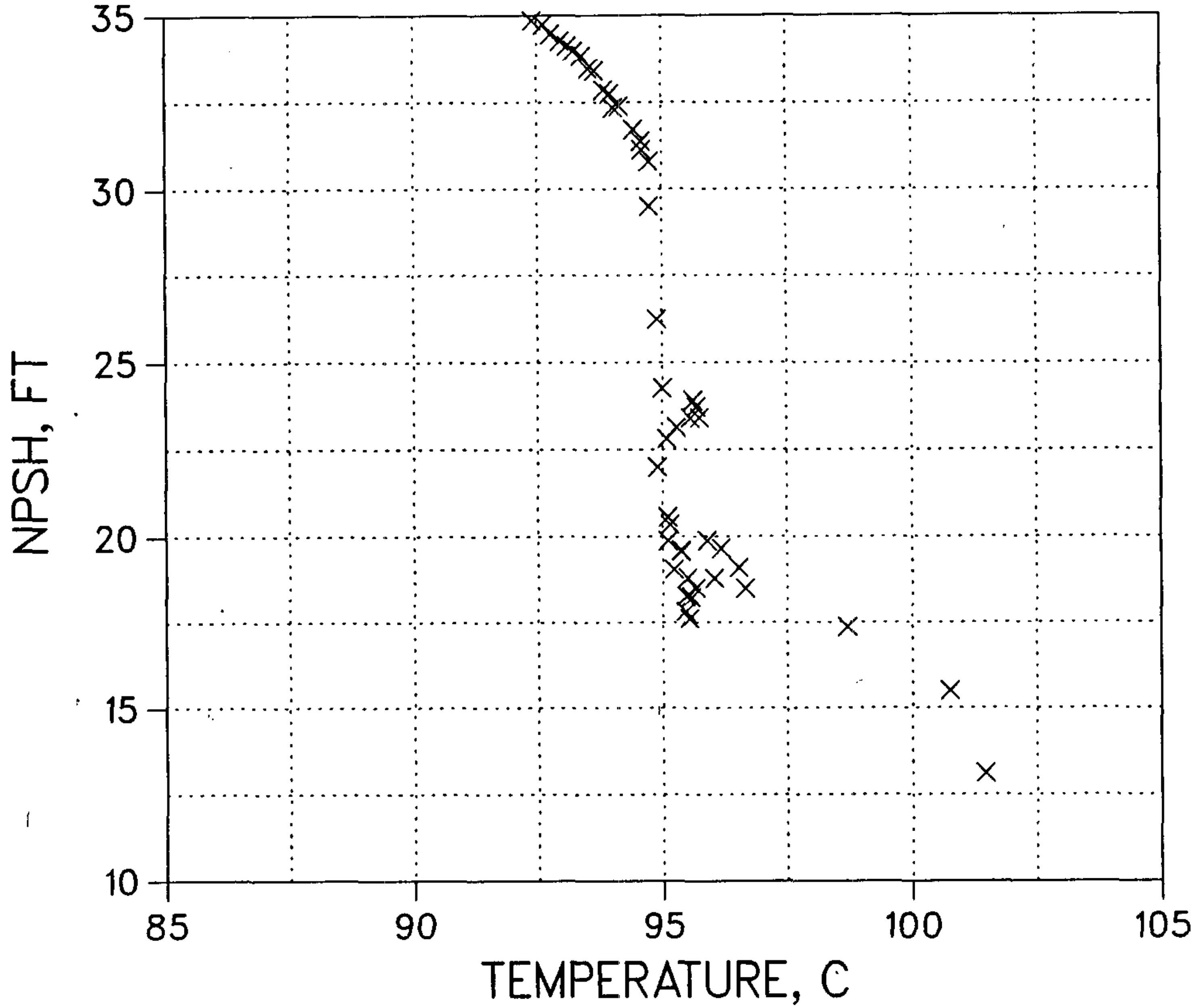


OMS LASERGRAFIX 1200, DATE=84.012, TIME= 8.13.26, BADGE=T6237, BOX=L023

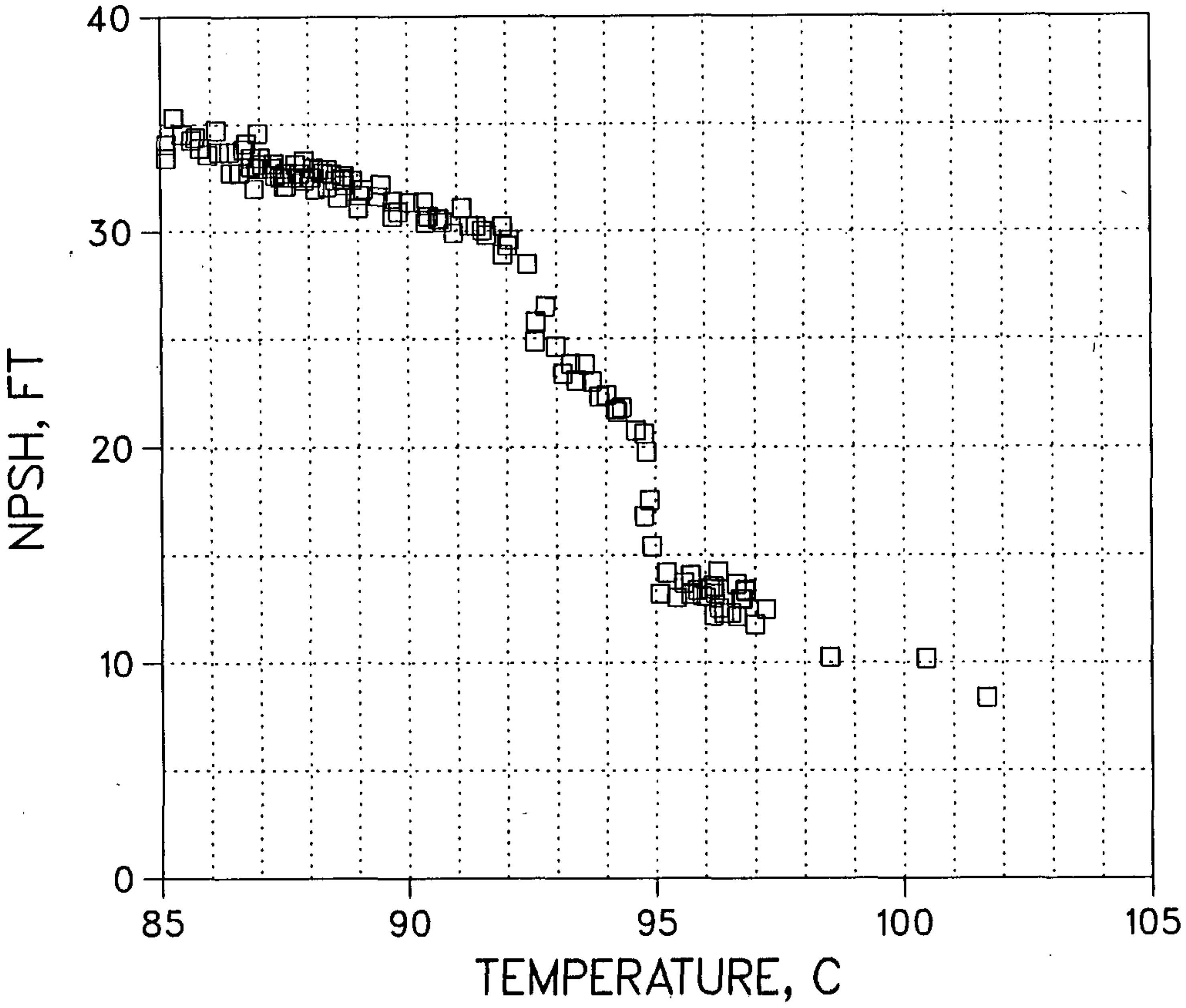
PUMP CAVITATION TESTS
UNADJ. TEMP. VS NPSH AT CL IMPELLER 5 pumps



PUMP CAVITATION TESTS
UNADJ. TEMP. VS NPSH AT CL IMPELLER 5 pumps



PUMP CAVITATION TESTS
UNADJ. TEMP. VS NPSH AT CL IMPELLER 5 pumps



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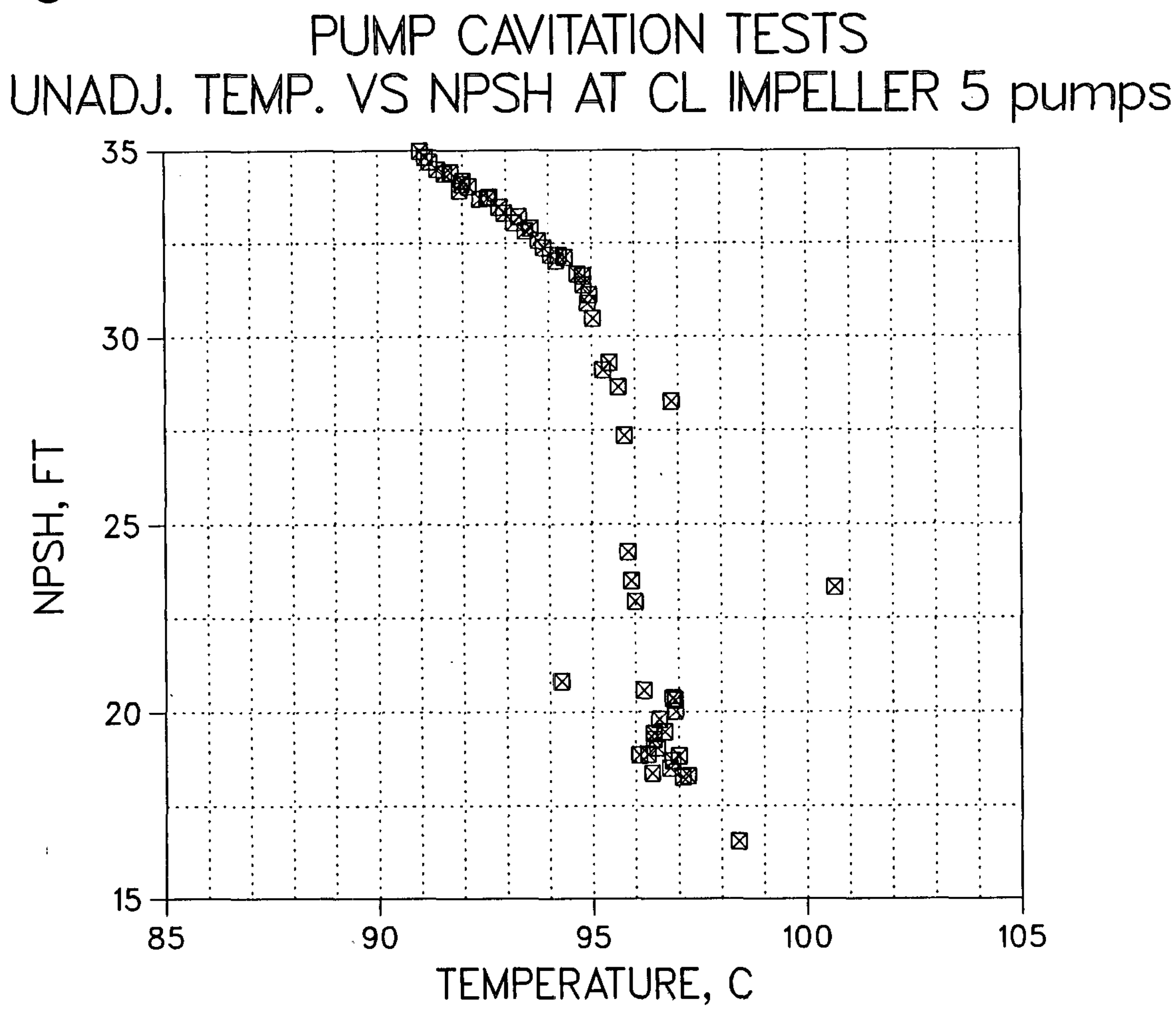
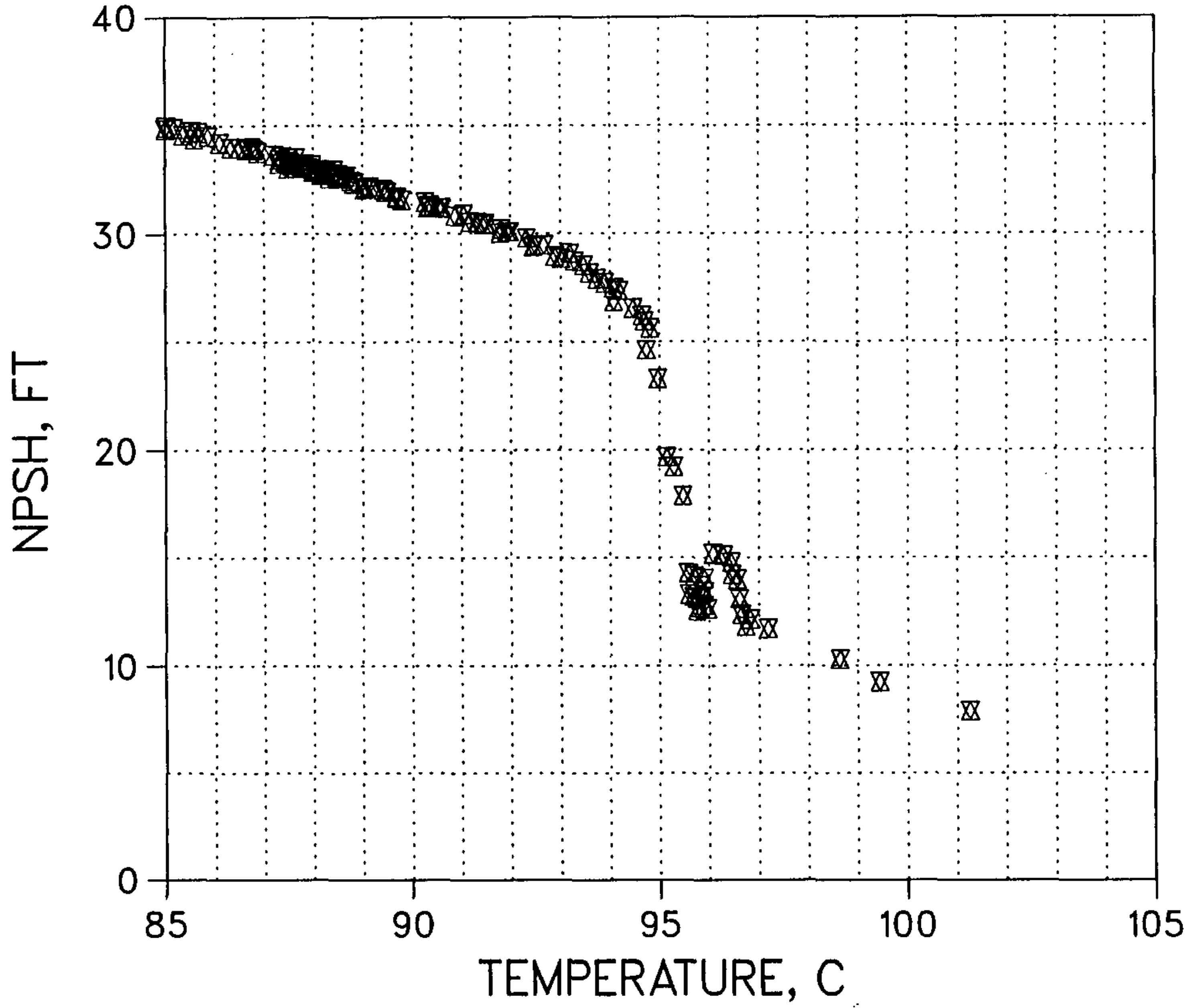
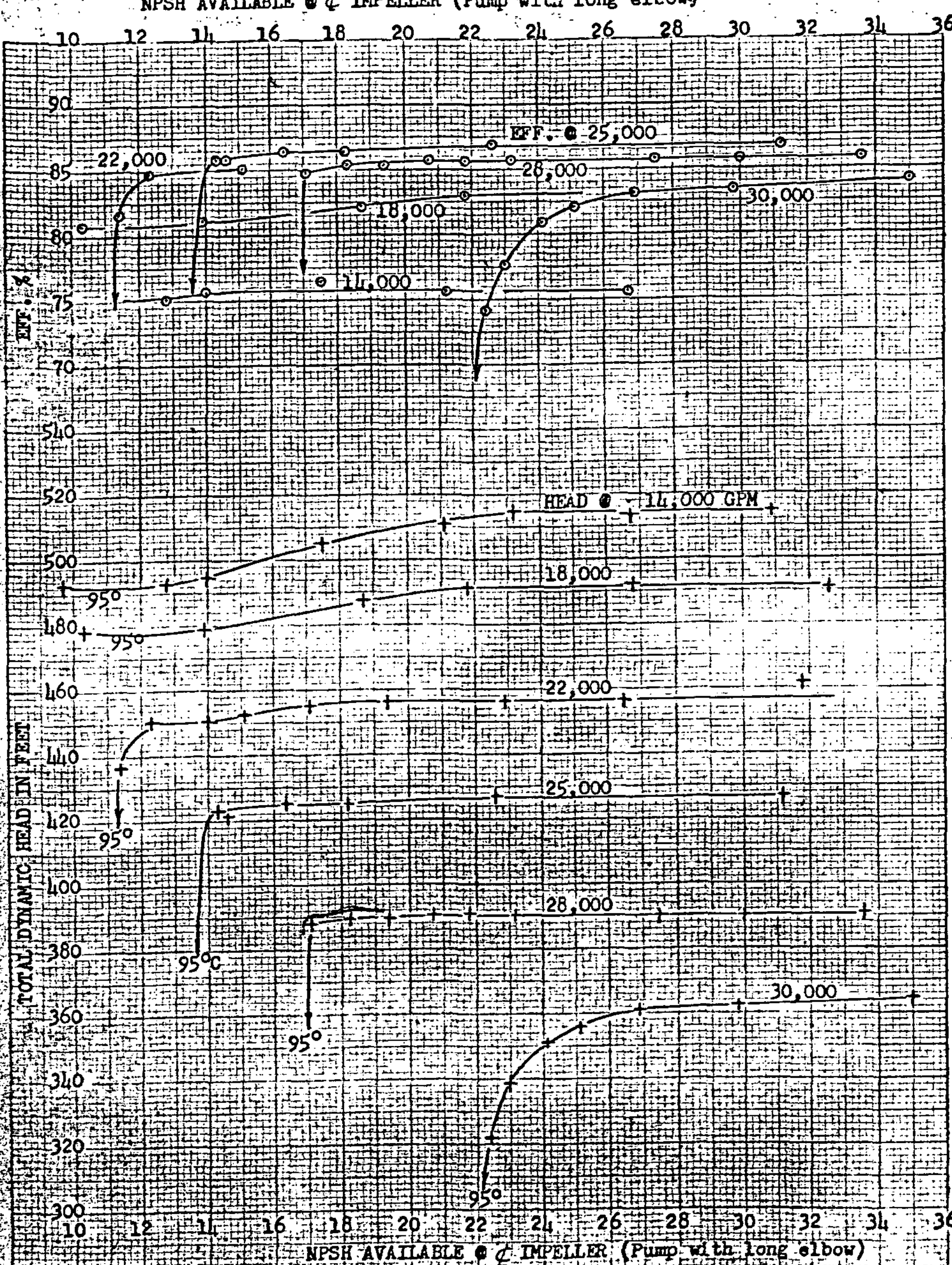

PUMP CAVITATION TESTS
UNADJ. TEMP. VS NPSH AT CL IMPELLER 5 pumps
NPSH, FT
35
30
25
20
15
85
90
95
100
105
TEMPERATURE, C

PUMP CAVITATION TESTS
UNADJ. TEMP. VS NPSH AT CL IMPELLER 5 pumps



T-64160-K



Temp. 95°C
Long Radius Suction elbow
Approach No. 2
ENR 11-17-56
Bingham Pump Company

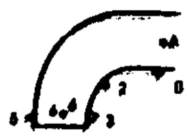
16 x 24 x 43 CD
31799-1
39-3/8 Diameter
1000 RPM
T-64160-K

T-64160-K

FORM 297

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE: 16 x 24 x 43 CD	CUSTOMER: E. I. DuPONT de NEMOURS & CO.	CUST. ORDER NO.: AXC 22156½ AX 2307	PAGE 1 OF 6
IMP. PATT.: 1613 CD; VANE: 4; IMP. MAX DIA.: 42"	EYE DIAMETER: 19½"; EYE AREA: 496 SQ.IN.; ASSEMBLY: Z-2680	TEST MOTOR: CUSTOMER'S ALLIS-CHALMERS MOTOR 2000 HP. 1800 RPM SERIAL No. 164644; % EFF. @ LOAD: 92.8 @ ¼, 94.3 @ ½, 94.8 @ 1, 94.8 @ 1¼	BINGHAM TEST No.: T-64160-K; PUMP SERIAL No.: 31799-1
IMP. TEST DIA.: 39-3/8" U.F. & O.F. to 1¾ x 6 Class B Cleanup	DISCHARGE PIPE I.D.: 15"; SUCTION PIPE I.D.: 23¼"	TEST GEAR: CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	TESTED BY: ENR-MKL; DATE: 9-3/4
NPSH CALC.: NPSH = $H_S + \frac{V^2}{2g} + H_A - H_{VP}$ = H_S + 5.5 + 35.3 − 29.5 = H_S + 11.3 @ 25000 GPM	WATER TEMP. 95 °C; VAPOR PRESS. H_{VP} 29.5 FT. WATER; BAR. H_A 30.08 IN HG 35.3 FT. WATER	SUCTION APPROACH CASE No. 2 Center; SUCTION ELBOW Long Radius; SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION	START 11:10; STOP [illegible]



Run No.	Speed: Time for 10 rev. motor slip (sec.)	Speed: Pump speed (RPM)	NPSH @ ℄ Imp.: Pump only (feet of water)	NPSH @ ℄ Imp.: Pump with L.R. elbow (feet of water)	Suction: Hg. column before elbow, F = 1.174−0.3 (in. Hg. @ A)	Suction (feet of water)	Discharge: DWT. "C", F = 2.398 (PSI)	Discharge (feet of water)	Hv 6.32 ft. per 10,000 GPM	Total dynamic head in feet of water	Capacity: 24" Venturi meter, F 5989 (in. Hg.)	Capacity (G.P.M.)	Power: Curve 14531, C.T. 60:1, P.T. 120:1, F = 4800 (watts read)	Power: BHP output	Water HP, F = 4110	Pump eff. %	Head drop across elbow from B, in. Hg.: 2	3	4	5	6	Avg. 3, 4, 5, 6 (feet of water)	Temp. thermocouple @ °C
1			17.3	18.2	6.1	6.9	168¼	404.7	27.0	424.8	17.45	25000	499	2985	2580	86.4	5.1	2.4	0.5	0	0.6	0.9	
2			15.5	16.4	4.6	5.1	168	402.9	27.0	424.8	17.45	25000	499	2985	2580	86.4	5.0	2.5	0.6	0	0.6	0.9	
3			13.1	14.6	3.1	3.3	166	398.1	27.0	421.8	17.45	25000	500	2990	2565	85.8	5.5	3.5	1.0	0.4	1.2	1.5	
4			10.3	13.6	2.2	2.3	110	263.8	27.0	288.5	17.45	25000	465	2775	1755	63.8	5.0	4.5	2.7	2.2	3.0	3.3	
5			12.6	14.3	2.8	3.0	166½	399.3	27.0	423.3	17.45	25000	501	2995	2570	85.8	5.3	4.4	0.7	0.3	0.6	1.5	
6			21.6	22.6	9.9	11.3	171½	411.3	27.0	427.0	17.45	25000	499	2990	2600	87.0	4.6	2.8	0.5	0	0.7	1.0	
7				31.2	17.2	19.9	175	419.7	27.0	426.8	17.45	25000	499	2990	2595	86.8							
8				30.4	16.5	19.1	174	417.3	27.0	425.2	17.45	25000	499	2985	2585	86.4							
9																							
10																							
11																							
12																							
13																							
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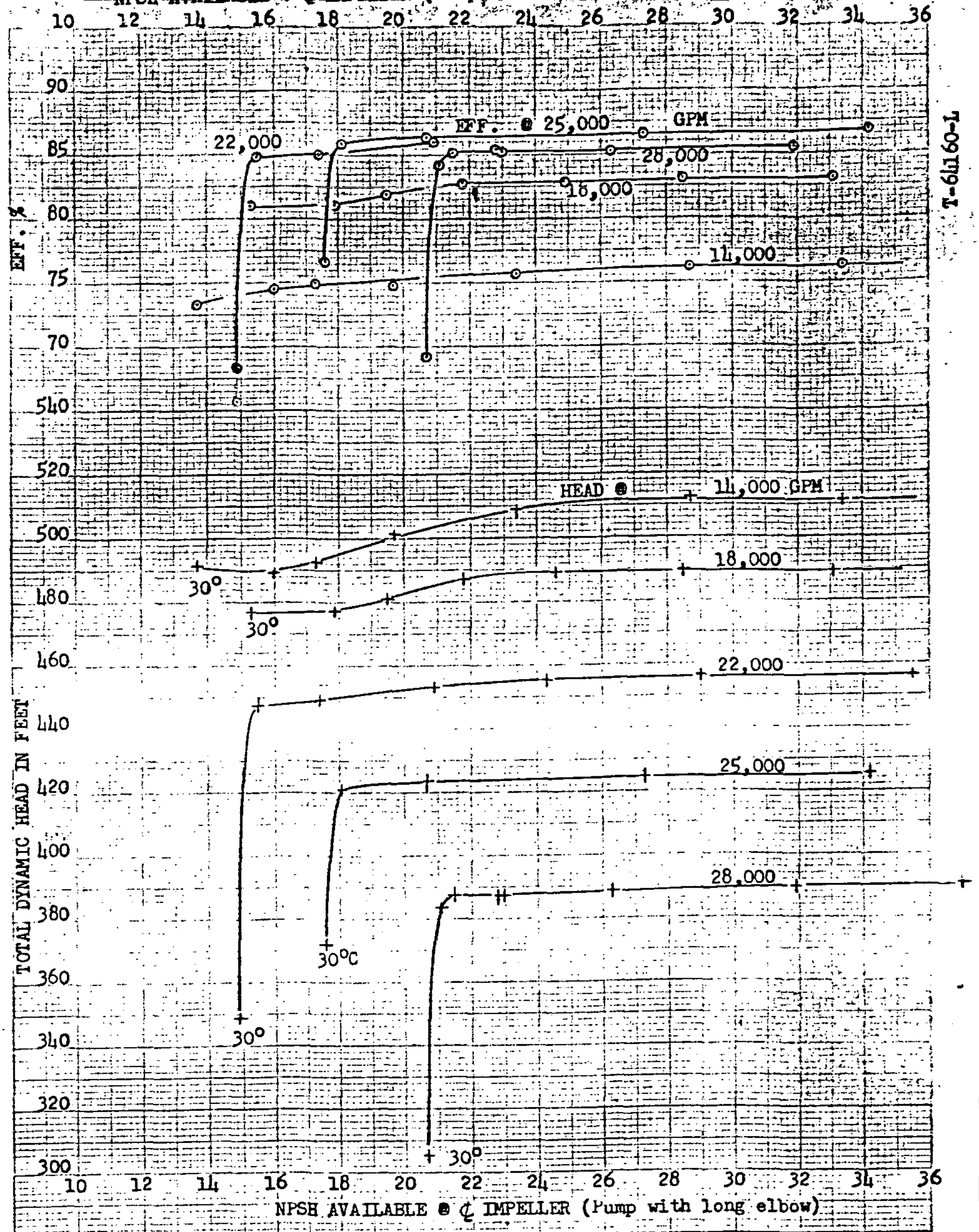
DATA CHECKED AND CERTIFIED CORRECT BY: [signature]

TEST WITNESSED BY: E. I. DuPONT de NEMOURS & CO. S/S J.S. Neill



Temp. 30°C
Long Radius Suction elbow
Approach No. 2
ENR 11-19-56
Bingham Pump Company

16 x 24 x 43 CD
31799-1
39-3/8 Diameter
1000 RPM
T-64160-L

FORM 237

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE: 16 x 24 x 43 CD	CUSTOMER: E. I. DuPONT de NEMOURS & CO.	CUST. ORDER NO.: AXC 22156½ & AX 2307	PAGE 1 OF 5
BINGHAM TEST No.: T-64160-L			

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ IN.	Z-2680	CUSTOMER'S ALLIS-CHALMERS MOTOR. 3000 HP. 1900 RPM SERIAL No. 154544 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799-1

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D	TEST GEAR	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	15"	23¼"	CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	ENR-MKL	9-[illegible]-56

NPSH CALC.

$NPSH = H_S + \frac{V^2}{2g} + H_A - H_{vp}$

$= H_S + 5.5 + 34.1 - 1.4$

$= H_S + 38.2$ @ 25000 GPM

WATER TEMP. 30 °C

VAPOR PRESS. H_{vp} 1.4 FT. WATER

BAR. H_A 30.08 IN HG 34.1 FT. WATER

SUCTION APPROACH CASE No. 2 Center

SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

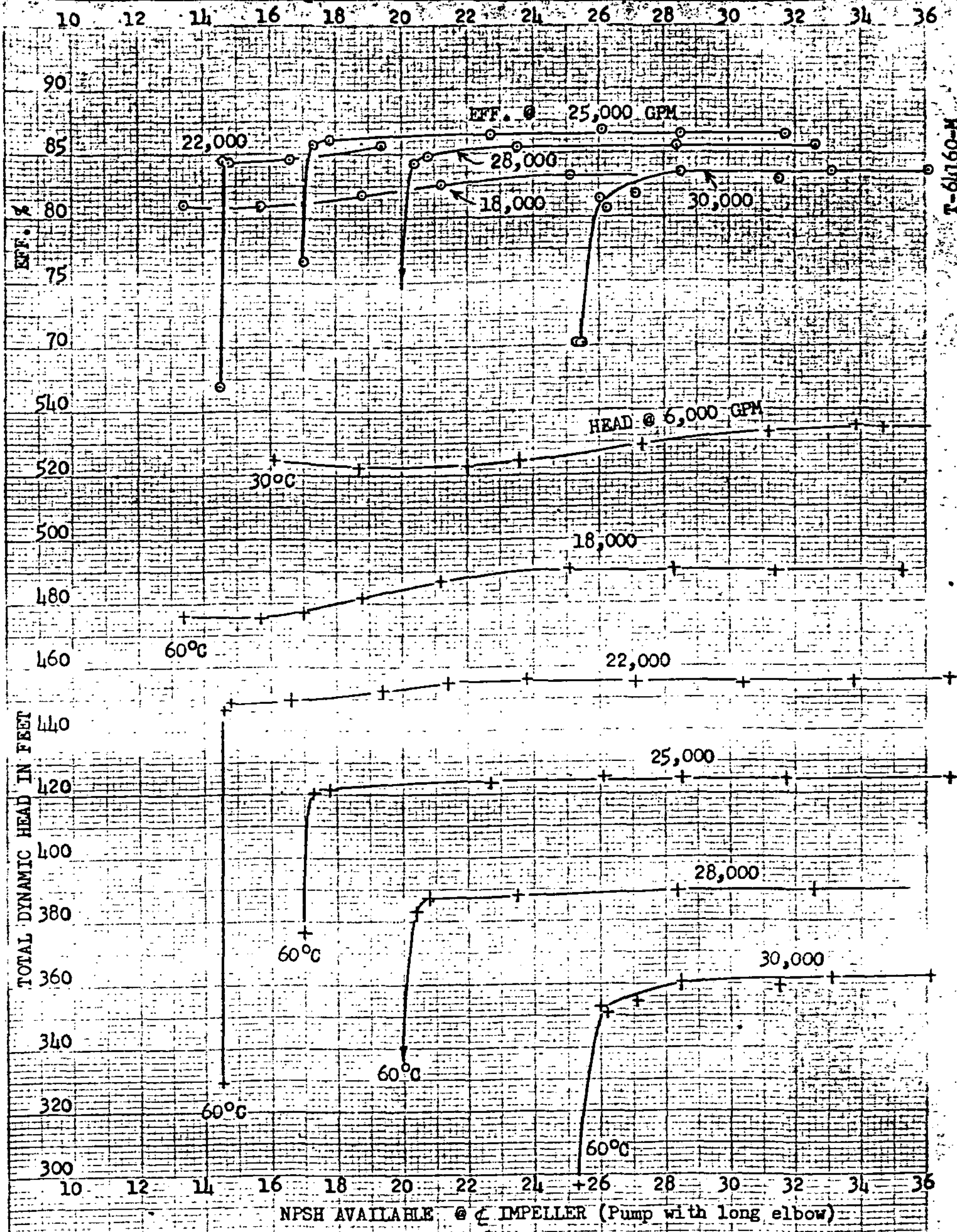
START 4:00 AM

STOP Page 2

RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ℄ IMP: PUMP ONLY FEET OF WATER	NPSH @ ℄ IMP: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F 1.134 IN. HG @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F 2.317 PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F 5885 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F 3972	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM B, IN. HG.: 2	3	4	5	6	AVG. 3, 4, 5, & 6 1.05 FEET OF WATER	TEMPERATURE: THERMO COUPLE @ °C.	TEMPERATURE: TANK RECORDER & CONTROL °C
1				46.8	7.6	8.6	175¾	407.2	27.0	425.6	18.1	25000	514	3075	2680	87.2								30
2			41.1	42.1	3.4	3.9	173¾	402.6	27.0	425.7	18.1	25000	515	3082	2680	86.9	5.1	2.4	0.5	0.3	0.6	1.0		
3			33.4	34.2	-3.5	-4.0	170¼	394.5	27.0	425.5	18.1	25000	515	3082	2680	86.9	5.0	1.9	0.5	0	0.6	0.8		
4			26.4	27.3	-9.6	-10.9	166¾	386.4	27.0	424.3	18.1	25000	515	3082	2670	86.6	5.0	2.2	0.5	0.1	0.7	0.9		
5			19.9	20.7	-15.4	-17.5	163¾	379.2	27.0	423.7	18.1	25000	515	3082	2665	86.4	5.1	2.2	0.6	0.2	0.6	0.8		
6			17.2	18.1	-17.7	[illegible]	161¼	373.6	27.0	420.7	18.1	25000	515	3082	2650	85.9	5.1	2.4	0.6	0	0.6	0.9		
7			14.6	17.6	-18.2	-20.6	140	324.4	27.0	372.0	18.1	25000	510	3050	2340	76.7	4.6	4.2	3.0	1.4	2.6	3.0		
8																								
9																								
10																								
11																								
12																								
13																								
14																								

DATA CHECKED AND CERTIFIED CORRECT BY: [signature] CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. S/S J.S. Neill



Temp. 30° ; 60°C
Long Radius Suction elbow
Approach No. 2
ENR 11-19-56
Bingham Pump Company

16 x 24 x 43 CD
31799-1
39-3/8 Diameter
1000 RPM
T-64160-M

FORM 207

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE	CUSTOMER	CUST. ORDER NO.	PAGE	BINGHAM TEST No.
16 x 24 x 43 CD	E. I. DuPONT de NEMOURS & CO.	AXC 22156½ AX-2307	1 OF 6	T-64160- M

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ.IN.	Z-2680	CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799- 1

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D.	TEST GEAR	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1-1/4 x 6 Class B Cleanup	15"	23¼"	CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	ENR:MKL	9-6/7-56

NPSH CALC.

$NPSH = H_S + \frac{V^2}{2g} + H_A - H_{VP}$

$= H_S + 5.5 + 34.4 - 6.8$

$= H_S + 33.1$ @ 25,000 GPM

WATER TEMP. 60 °C

VAPOR PRESS. H_{VP} 6.8 FT. WATER

BAR. H_A 29.99 IN HG 34.4 FT. WATER

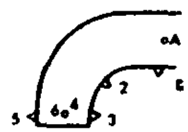
SUCTION APPROACH CASE No. 2 Center

SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

START 11:00 P.

STOP Page 5



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP (SEC.)	SPEED: PUMP SPEED (RPM)	NPSH @ ℄ IMP.: PUMP ONLY (FEET OF WATER)	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW (FEET OF WATER)	SUCTION: HG. COLUMN Before ELBOW F 1.148 - 0.1 IN. HG @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" 2.346 PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F 5922 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F 4021	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM B (IN. HG.): 2	3	4	5	6	AVG. 3, 4, 5, & 6 1.06 FEET OF WATER	TEMPERATURE: THERMOCOUPLE @ °C.	TEMPERATURE: TANK RECORD & CONTROL °C.
1			41.1	42.1	7.9	9.0	173½	407.0	27.0	425.0	17.85	25000	509	3045	2640	86.7	5.0	2.3	0.5	0.	0.8	1.0		60
2			35.7	36.7	3.2	3.6	171	401.2	27.0	424.6	17.85	25000	509	3045	2638	86.5	5.6	2.1	0.5	0	0.9	1.0		
3			30.7	31.7	-1.1	-1.4	168-3/4	395.9	27.0	424.3	17.85	25000	509	3045	2638	86.5	5.2	2.4	0.6	-.1	0.8	1.0		
4			25.1	26.1	-6.0	-7.0	167	391.8	27.0	425.8	17.85	25000	509	3045	2645	86.8	5.2	2.2	0.6	0	0.8	1.0		
5			21.6	22.7	-9.8	-10.4	164-3/4	386.5	27.0	423.9	17.85	25000	509	3045	2635	86.5	5.3	2.3	0.6	0	0.9	1.1		
6			16.8	17.8	-13.2	-15.3	161-3/4	379.5	27.0	421.8	17.85	25000	510	3050	2625	86.1	5.4	2.3	0.5	0	0.8	1.0		
7			16.3	17.3	-13.7	-15.8	161	377.7	27.0	420.5	17.85	25000	510	3050	2615	85.7	5.2	2.2	0.4	0	0.9	1.0		
8			13.5	17.0	-13.9	-16.1	142	333.1	27.0	376.2	17.85	25000	510	3050	2340	76.7	5.0	5.2	3.0	1.8	3.1	3.5		
9				28.5	-3.9	-4.6	167-1/2	393.0	27.-	424.6	17.85	25000	509	3045	2638	86.5								
10																								
11																								
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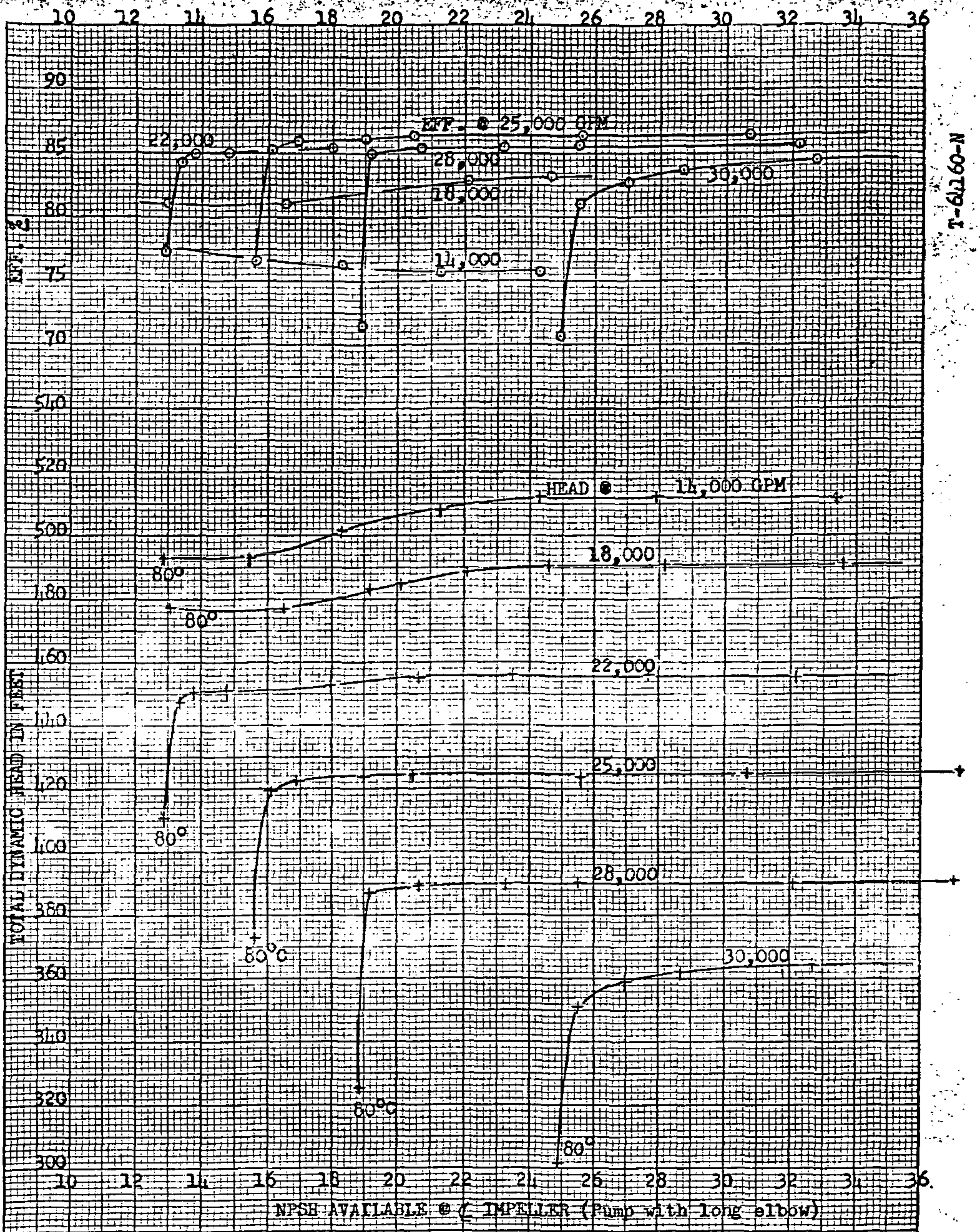
DATA CHECKED AND CERTIFIED CORRECT BY: [signature]

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. Not witnessed



Temp. 80°C
Long Radius Suction elbow
Approach No. 2
ENR 11-19-56
Bingham Pump Company

16 x 24 x 43 CD
31799-1
39 3/8 Diameter
1000 RPM
T-64160-N

FORM 237

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE: 16 x 24 x 43 CD	CUSTOMER: E. I. DuPONT de NEMOURS & CO.	CUST. ORDER NO.: AXC 22156½ / AX2307	PAGE 1 OF 6
BINGHAM TEST No.: T-64160-M	IMP. PATT.: 1613 CD	VANE: 4	IMP. MAX DIA.: 42"
EYE DIAMETER: 19½"	EYE AREA: 496 SQ. IN.	ASSEMBLY: Z-2680	PUMP SERIAL No.: 31799-1
IMP. TEST DIA.: 39-3/8 U.F. & O.F. to 1¼x6 Class B Cleanup	DISCHARGE PIPE I. D.: 15"	SUCTION PIPE I.D.: 23¼"	TESTED BY: ENR-MKL
DATE: 9-12/13	START: 11:00	STOP: Page 6	

TEST MOTOR: CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544
% EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼

TEST GEAR: CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101

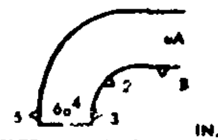
NPSH CALC.

$$NPSH = H_s + \frac{V^2}{2g} + H_A - H_{vp}$$
$$= H_s + 5.5 + 34.9 - 16.1$$
$$= H_s + 24.3 \text{ @ } 25000 \text{ GPM}$$

WATER TEMP. 80 °C
VAPOR PRESS. H_{VP} 16.1 FT. WATER
BAR. H 29.95 IN HG 34.9 FT. WATER

SUCTION APPROACH CASE No. 2 Center
SUCTION ELBOW Long Radius
SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

HEAD DROP ACROSS ELBOW FROM B



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ℄ IMP.: PUMP ONLY FEET OF WATER	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F = 1.162-0.2 IN. HG @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F = 2.374 PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5958 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F = 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F = 4070	PUMP EFF. %	IN. HG. 2	3	4	5	6	AVG. 3, 4, 5, 1.07 FEET OF WATER	TEMPERAT… THERMO COUPLE @ #6 °C.	T…
1			29.6	30.7	+5.7	6.4	170¼	404.2	27.0	424.8	17.6	25000	504	3015	2605	86.5	5.1	2.4	0.5	0	-	1.1	79½	80
2		—	24.5	25.6	+1.3	+1.3	167⅞	398.2	27.0	423.9	17.6	25000	504	3015	2600	86.3	5.2	2.5	0.7	0	-	1.1	80	80
3			19.4	20.5	-3.1	-3.8	165⅞	393.5	27.0	424.3	17.6	25000	504	3015	2604	86.4	5.1	2.5	0.6	0	-	1.1	79	7
4			15.7	16.9	-6.2	-7.4	163½	388.1	27.0	422.5	17.6	25000	505	3020	2595	86.0	5.5	2.6	0.7	0	-	1.2	79	80
5			13.8	16.1	-6.9	-8.2	162	384.6	27.0	419.8	17.6	25000	505	3020	2575	85.2	5.1	3.4	1.9	1.2	-	2.3	79	7
6			12.1	15.6	-7.3	-8.7	142	337.1	27.0	372.8	17.6	25000	500	2990	2290	76.6	4.8	5.7	2.5	1.6	-	3.5	78	7
7				19.0	-4.4	-5.3	165	391.7	27.0	424.0	17.6	25000	504	3015	2600	86.2							79½	7
8				37.2	+11.3	+12.9	173½	411.9	27.0	426.0	17.6	25000	503	3010	2620	87.0							80	80
9				42.3	+15.7	+18.0	175½	416.6	27.0	425.6	17.6	25000	503	3010	2618	86.9							80	80
10																								
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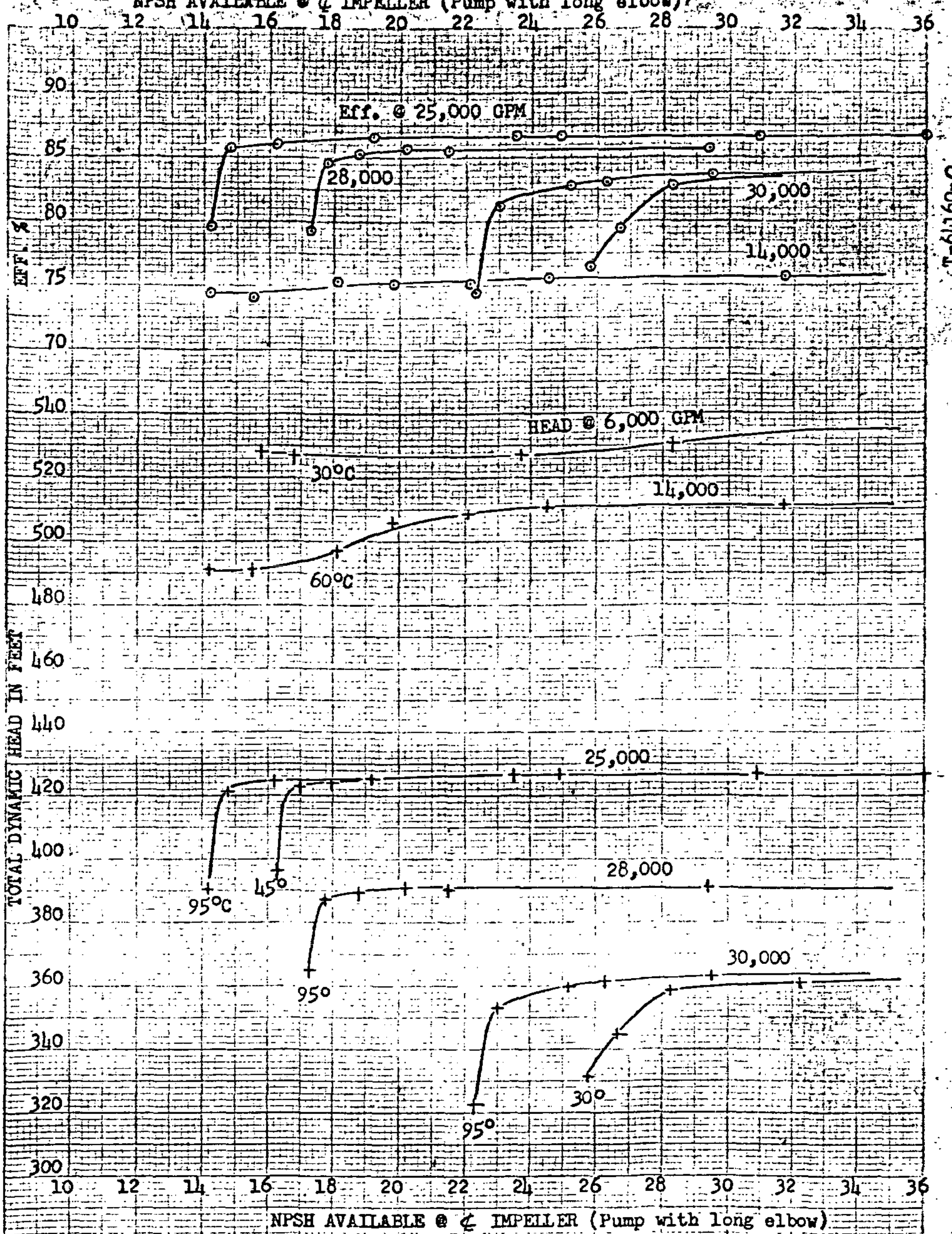
DATA CHECKED AND CERTIFIED CORRECT BY [illegible signature] CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. NOT WITNESSED



Temp. 30°, 45°, & 60°C
Long Radius Suction elbow
Approach No. 2
ENR 11-29-56
Bingham Pump Company

16 x 24 x 43 CD
31799-1
39-3/8 Diameter
1000 RPM
T-64160-0

BINGHAM PUMP CO. PORTLAND, OREGON

FORM 287

PUMP SIZE & TYPE: 15 x 24 x 43 CD	CUSTOMER: E. I. DuPONT de NEMOURS & CO.	CUST. ORDER NO.: AXC 22156½ AX-2307	PAGE 1 OF 7
BINGHAM TEST No.: T-64160- 0	PUMP SERIAL No.: 31799- 1	TESTED BY: ENR:MKL	DATE: 9-13-56
IMP. PATT.: 1613 CD	VANE: 4	IMP. MAX DIA.: 42"	
EYE DIAMETER: 19½"	EYE AREA: 496 SQ. IN.	ASSEMBLY: Z-2680	
DISCHARGE PIPE I. D.: 15"	SUCTION PIPE I.D.: 23¼"	START: 4:50 A.M.	STOP: Page 2

IMP. TEST DIA.: 39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup

TEST MOTOR: CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544
% EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼

TEST GEAR: CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101

NPSH CALC.
$NPSH = H_s + \frac{V^2}{2g} + H_A - H_{VP}$
$= H_s + 5.5 + 35.2 - 29.5$
$= H_s + 11.2$ @ 25,000 GPM

WATER TEMP. 95 °C
VAPOR PRESS. H_{VP} 29.5 FT. WATER
BAR. H_A 29.95 IN HG 35.2 FT. WATER

SUCTION APPROACH CASE No. 2 Center
SUCTION ELBOW Long Radius
SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP (SEC.)	SPEED: PUMP SPEED (RPM)	NPSH @ ℄ IMP.: PUMP ONLY (FEET OF WATER)	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW (FEET OF WATER)	SUCTION: HG. COLUMN Before ELBOW F 1.174-0.3, IN. HG @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F 2.398, PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5989, IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F = 4800, WATTS READ	POWER: BHP OUTPUT	WATER HP F = 4110	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM 6 (IN. HG.): 2	3	4	5	6	AVG. 3, 4, 5 1.09-.1 FEET OF WATER	TEMPERATURE: THERMO COUPLE @ #6 °C.	TEMPERATURE: TANK RECORD & CONTROL °C.
1			18.1	19.2	7.1	8.0	169½	406.5	27.0	425.5	17.45	25000	499	2985	2585	86.6	5.5	2.5	0.7	0	-	1.1	95	95
2			14.8	16.2	4.5	5.0	167-3/4	402.3	27.0	424.3	17.45	25000	500	2990	2575	86.0	6.0	2.7	1.0	0.3	-	1.4	94½	95
3			10.6	14.2	2.8	3.0	152-3/4	366.3	27.0	390.3	17.45	25000	498	2980	2375	79.6	5.3	4.9	3.1	2.2	-	3.6	95	95
4			11.2	14.8	3.3	3.6	166	398.1	27.0	421.5	17.45	25000	500	2990	2562	85.7	4.9	5.2	2.7	1.9	-	3.6	95	95½
5			22.4	23.5	10.7	12.3	171-3/4	411.9	27.0	426.6	17.45	25000	499	2985	2588	86.7	5.6	2.7	0.7	0	-	1.1	94½	95
6				44.7	28.8	33.5	180½	432.8	27.0	426.3	17.45	25000	498	2980	2588	86.8							94½	95
7				36.0	21.4	24.8	177	424.4	27.0	426.6	17.45	25000	499	2985	2568	86.7							94½	94-[illegible]
8				30.9	17.0	19.7	175	419.7	27.0	427.0	17.45	25000	500	2990	2592	86.7							94½	94-[illegible]
9				24.9	11.9	13.7	172¼	413.1	27.0	426.4	17.45	25000	500	2990	2588	86.7							95	95
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DATA CHECKED AND CERTIFIED CORRECT BY: CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. Not witnessed

FORM 217

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE: 16 x 24 x 43 CD	CUSTOMER: E. I. DuPONT de NEMOURS & CO.	CUST. ORDER NO.: AXC 22156½ AX-2307	PAGE 3 OF 7
IMP. PATT.: 1613 CD; VANE: 4; IMP. MAX DIA.: 42"	EYE DIAMETER: 19½"; EYE AREA: 496 SQ IN; ASSEMBLY: Z-2680	TEST MOTOR: CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	BINGHAM TEST No. T-64160-0; PUMP SERIAL No. 31799-1
IMP. TEST DIA.: 39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	DISCHARGE PIPE I. D.: 15"; SUCTION PIPE I.D.: 23¼"	TEST GEAR: CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	TESTED BY: GNR :KL; DATE: 9-14-56

NPSH CALC.

$NPSH = H_s + \frac{V^2}{2g} + H_A - H_{VP}$

$= H_s + 6.9 + 35.2 - 29.5$

$= H_s + 12.6$ @ 28,000 GPM

WATER TEMP. 95 °C

VAPOR PRESS. H_{VP} 29.5 FT. WATER

BAR. H_A 29.97 IN HG 35.2 FT. WATER

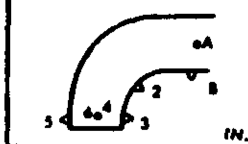
SUCTION APPROACH CASE No. 2 Center

SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

START 12:30 A.M.

STOP Page 7



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP (SEC.)	SPEED: PUMP SPEED (RPM)	NPSH @ ℄ IMP.: PUMP ONLY (FEET OF WATER)	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW (FEET OF WATER)	SUCTION: HG. COLUMN Before ELBOW F = 1.174-0.3, IN. HG. @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F = 2.398, PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5989, IN. HG.	CAPACITY: G.P.M.	POWER (CURVE 14531, C.T. 40:1, P.T. 120:1, F = 4800): WATTS READ	POWER: BHP OUTPUT	WATER HP F = 4110	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM B (IN. HG.): 2	3	4	5	6	AVG. 3, 4, 5, ~~6~~ 1.09-.1 FEET OF WATER	TEMPERATURE: THERMO COUPLE #6 °C.	TEMPERATURE: TANK RECORDER & CONTROL °C.
1				43.1	26.2	30.5	161½	387.3	33.9	390.7	21.9	28000	518	3100	2660	85.8							95	95½
2				29.4	14.6	16.8	156	374.1	33.9	391.2	21.9	28000	519	3105	2660	85.7							95	95
3				21.5	7.8	8.9	152¼	365.1	33.9	390.1	21.9	28000	519	3105	2655	85.5							94½	95
4				20.2	6.7	7.6	152	364.5	33.9	390.8	21.9	28000	519	3105	2660	85.7							95	95
5			17.6	18.8	5.5	6.2	151	362.1	33.9	389.8	21.9	28000	519	3105	2650	85.3	7.0	2.8	0.9	0	-	1.2	95	95
6			14.4	17.3	4.3	4.7	140	335.7	33.9	364.9	21.9	28000	523	3130	2480	79.3	6.0	4.5	2.6	1.1	-	2.9	95	95
7			16.3	17.8	4.7	5.2	149¼	358.5	33.9	387.2	21.9	28000	520	3110	2635	84.6	6.8	2.9	1.2	0.3	-	1.5	95	95
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DATA CHECKED AND CERTIFIED CORRECT BY: [signature] CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. Not witnessed

FORM 207

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE	CUSTOMER	CUST. ORDER NO.	PAGE	BINGHAM TEST No.
16 x 24 x 43 CD	E. I. DuPONT de NEMOURS & CO.	AXC 22156½ AX-2307	4 OF 7	T-64169- 0

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ IN	Z-2680	CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1000 RPM SERIAL No. 154544 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799- 1

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D.	TEST GEAR	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	15"	23¼"	CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	ENR:MKL	9-14-55

NPSH CALC.

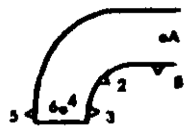
$$NPSH = H_s + \frac{V^2}{2g} + H_A - H_{vp}$$
$$= H_s + 1.7 + 34.4 - 6.8$$
$$= H_s + 29.3 \text{ @ } 14{,}000 \text{ GPM}$$

WATER TEMP. 60 °C
VAPOR PRESS. H_{vp} 6.8 FT. WATER
BAR. H_A 29.97 IN HG 34.4 FT. WATER

SUCTION APPROACH CASE No. 2 Center
SUCTION ELBOW Long Radius
SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

START Page 3
STOP Page 7

HEAD DROP ACROSS ELBOW FROM B:



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ℄ IMP.: PUMP ONLY FEET OF WATER	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F = 1.148-0.1 IN. HG. @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F = 2.346 PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5922 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F = 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F = 4021	PUMP EFF. %	HEAD DROP IN. HG. 2	3	4	5	6	AVG. 3, 4, 5 1.06 FEET OF WATER	TEMPERATURE: THERMO COUPLE #6 °C.	TEMPERATURE: TANK CONTROL °C.
1			39.8	40.2	+9.6	+10.9	219	513.8	8.5	511.4	5.6	14000	396	2350	1782	75.8	1.6	0.9	0.2	0	-	0.4	60	60½
2			31.3	31.7	+2.2	+2.4	215½	505.6	8.5	511.7	5.6	14000	397	2355	1782	75.7	1.7	0.9	0.2	0	-	0.4	60	60
3			24.1	24.5	-4.1	-4.8	212	497.4	8.5	510.7	5.6	14000	397	2355	1780	75.6	1.6	0.9	0.3	0	-	0.4	60	60
4			19.4	19.8	-8.2	-9.5	208	488.0	8.5	506.0	5.6	14000	396	2350	1765	75.1	1.7	0.8	0.2	0	-	0.4	60	60
5			15.1	15.5	-11.9	-13.8	200	469.2	8.5	491.5	5.6	14000	390	2315	1712	74.1	1.7	0.9	0.2	0	-	0.4	60	60
6			13.8	14.2	-13.2	-15.1	199½	468.0	8.5	491.6	5.6	14000	388	2300	1712	74.5	1.7	0.8	0.2	0	-	0.4	60	60
7			17.6	18.1	-9.7	-11.2	203½	477.4	8.5	497.1	5.6	14000	387	2295	1730	75.4	1.6	1.1	0.4	0	-	0.5	60	60½
8				22.1	-6.2	-7.2	210	492.7	8.5	508.4	5.6	14000	396	2350	1768	75.2							60	60
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DATA CHECKED AND

TEST WITNESSED BY

FORM 297

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE	CUSTOMER	CUST. ORDER NO.	PAGE	BINGHAM TEST No.
16 x 24 x 43 CD	E. I. DuPONT de NEMOURS & CO.	AXC 22156½ AX-2307	5 OF 7	T-64160- 0

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ.IN.	Z-2680	CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799- 1

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D.	TEST GEAR	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	15"	23¼"	CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	ENR & HKL	9-14-56

NPSH CALC.

$NPSH = H_S + \frac{V^2}{2g} + H_A - H_{VP}$

$= H_S + 7.9 + 34.0 - 1.4$

$= H_S + 40.5$ @ 30,000 GPM

WATER TEMP. 30 °C

VAPOR PRESS. H_{VP} 1.4 FT. WATER

BAR. H_A 29.97 IN HG 34.0 FT. WATER

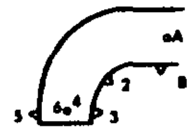
SUCTION APPROACH CASE No. 2 Center

SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

START Page 3

STOP Page 7



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ℄ IMP.: PUMP ONLY FEET OF WATER	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F = 1.134 IN. HG. @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F 2.317 PSI	DISCHARGE: FEET OF WATER	H_V 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F 5885 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F .. 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F = 3972	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM B, IN. HG.: 2	3	4	5	6	AVG. 3, 4, 5, 6 1.05 FEET OF WATER	TEMPERATURE: THERMO COUPLE #6 °C.	TEMPERATURE: TANK ECC. & CON. TEST °C.
1			44.2	45.7	+4.6	+5.2	143	331.3	38.8	364.9	26.0	30000	544	3260	2755	84.5	7.3	3.5	0.9	0	-	1.5	31	31
2			30.7	32.3	-7.2	-8.2	135½	314.0	38.8	361.0	26.0	30000	543	3250	2725	83.8	7.4	3.5	1.0	0	-	1.6	30	30½
3			26.7	28.3	-10.8	-12.2	132-3/4	307.6	38.8	358.6	26.0	30000	546	3270	2710	82.8	7.5	3.5	1.0	0	-	1.6	30	30
4			24.2	25.8	-13.0	-14.7	120	278.0	38.8	331.5	26.0	30000	546	3270	2500	76.5	7.5	3.6	1.0	0	-	1.6	30	30
5			25.1	26.7	-12.2	-13.8	126	291.9	38.8	344.5	26.0	30000	547	3275	2600	79.5	7.5	3.5	1.0	0	-	1.6	30	30
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DATA CHECKED AND CERTIFIED CORRECT BY: E. J. Rein
CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. Not witnessed

FORM 207

DINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TYPE	CUSTOMER	CUST. ORDER NO.	PAGE	[illegible] TEST No.
16 x 24 x 43 CD	E. I. DuPONT de NEMOURS & CO.	AXC 22156½ AX-2307	6 OF 7	T-64160- 2

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR: CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154544	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ IN	Z-2680	% EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799- 01

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D.	TEST GEAR: CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	15"	23¼"		ENR :MKL	9-14-56

NPSH CALC.

$NPSH = H_S + \frac{V^2}{2g} + H_A - H_{VP}$

$= H_S + 0.3 + 34.0 - 1.4$

$= H_S + 32.9$ @ 6000 GPM

WATER TEMP. 30 °C

VAPOR PRESS. H_{VP} 1.4 FT. WATER

BAR. H_A 29.97 IN HG 34.0 FT. WATER

SUCTION APPROACH CASE No. 2 Center

SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ₵ & IMP. ₵ AT SAME ELEVATION

START Page 3

STOP Page 7

RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ₵ IMP.: PUMP ONLY FEET OF WATER	NPSH @ ₵ IMP.: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F = 1.134, IN.HG. @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F = 2.317, PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5885, IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F = 4800, WATTS READ	POWER: BHP OUTPUT	WATER HP F = 3972	PUMP EFF. %	HEAD DROP ACROSS ELBOW FROM B  IN.: 2	3	4	5	6	AVG. 3, 4, 5, [illegible] 1.05 FEET OF WATER	TEMPERATURE: THERMO COUPLE @ #6 °C.	TEMPERATURE: TA[illegible] RECO[illegible] & CONTROL °C.
1			39.6	39.7	+6.0	+6.8	233½	541.0	1.6	535.8	1.04	6000	302	1770	810	45.7	0.3	0.2	0.2	0	-	0.1	29	29
2			28.2	28.3	-4.1	-4.6	226¼	524.2	1.6	530.4	1.04	6000	305	1790	801	44.7	0.3	0.2	0.2	0	-	0.1	29	29
3			23.6	23.7	-8.1	-9.2	223	516.7	1.6	527.5	1.04	6000	310	1820	797	43.8	0.3	0.2	0.2	0	-	0.1	29	29
4			16.7	16.8	-14.2	-16.1	220	509.7	1.6	527.4	1.04	6000	305	1790	797	44.5	0.3	0.2	0.2	0	-	0.1	30	30
5			15.7	15.8	-15.1	-17.1	220	509.7	1.6	528.4	1.04	6000	305	1790	799	44.6								
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DATA CHECKED AND CERTIFIED CORRECT BY: E. J. Rein — CHIEF TEST ENGINEER

TEST WITNESSED BY E. I. DuPONT de NEMOURS & CO. Not witnessed

FORM 297

BINGHAM PUMP CO. PORTLAND, OREGON

PUMP SIZE & TY.	CUSTOMER	CUST. ORDER NO.	PAGE	TEST No.
16 x 24 x 43 CD	E. I. DuPONT de NEMOURS & CO.	AXC 22156½ AX-2307	7 OF 7	-64160-

IMP. PATT.	VANE	IMP. MAX DIA.	EYE DIAMETER	EYE AREA	ASSEMBLY	TEST MOTOR	PUMP SERIAL No.
1613 CD	4	42"	19½"	496 SQ IN	Z-2680	CUSTOMER'S ALLIS-CHALMERS MOTOR 3000 HP. 1800 RPM SERIAL No. 154564 % EFF. @ LOAD: 92.8 @ ½, 94.3 @ ¾, 94.5 @ 1, 94.5 @ 1¼	31799-

IMP. TEST DIA.	DISCHARGE PIPE I. D.	SUCTION PIPE I.D.	TEST GEAR	TESTED BY	DATE
39-3/8" U.F. & O.F. to 1¼ x 6 Class B Cleanup	15"	23¼"	CUSTOMER'S WESTERN GEAR, RATIO 1.783:1, 45 HP LOSS, SERIAL No. 101	ENR : MKL	9-14-5

NPSH CALC.

$NPSH = H_S + \frac{V^2}{2g} + H_A - H_{VP}$

$= H_S + 5.5 + 34.2 - 3.3$

$= H_S + 36.4$ @ 25,000 GPM

WATER TEMP. 45 °C

VAPOR PRESS. H_{VP} 3.3 FT. WATER

BAR. H_A 29.97 IN HG 34.2 FT. WATER

SUCTION APPROACH CASE No. 2 Center

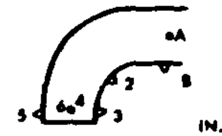
SUCTION ELBOW Long Radius

SUCTION GAGE ZERO, DWT ℄ & IMP. ℄ AT SAME ELEVATION

START Page 3

STOP 6:40 A

HEAD DROP ACROSS ELBOW FROM B:



RUN NO.	SPEED: TIME FOR 10 REV. MOTOR SLIP SEC.	SPEED: PUMP SPEED RPM	NPSH @ ℄ IMP.: PUMP ONLY FEET OF WATER	NPSH @ ℄ IMP.: PUMP WITH L.R. ELBOW FEET OF WATER	SUCTION: HG. COLUMN Before ELBOW F = 1.140 IN. HG. @ A	SUCTION: FEET OF WATER	DISCHARGE: DWT. "C" F = 2.330 PSI	DISCHARGE: FEET OF WATER	Hv 4.32 FT. PER 10,000 GPM	TOTAL DYNAMIC HEAD IN FEET OF WATER	CAPACITY: 24" VENTURI METER F = 5902 IN. HG.	CAPACITY: G.P.M.	POWER: CURVE 14531 C.T. 40:1 P.T. 120:1 F = 4800 WATTS READ	POWER: BHP OUTPUT	WATER HP F = 3992	PUMP EFF. %	HEAD DROP IN. HG. 2	3	4	5	6	AVG. 3, 4, 5, REB. 1.05 FEET OF WATER	TEMPER. THERMO COUPLE #6 °C.
1			44.6	45.8	+8.3	+9.4	175	407.8	27.0	425.4	17.95	25000	512	3060	2665	87.2	5.1	2.6	0.8	0	-	1.2	45
2			34.1	35.3	-0.8	-0.9	171	398.4	27.0	426.3	17.95	25000	512	3060	2670	87.2	5.2	2.4	0.9	0	-	1.2	45
3			23.5	24.6	-10.3	-11.8	165-3/4	386.2	27.0	425.0	17.95	25000	511	3055	2665	87.2	5.5	2.4	0.8	0	-	1.1	45
4			18.0	19.2	-15.1	-17.2	163-3/4	381.9	27.0	425.7	17.95	25000	513	3070	2668	87.0	5.6	2.6	0.9	0	-	1.2	45
5			16.7	18.0	-16.1	-18.4	162½	378.6	27.0	424.0	17.95	25000	512	3060	2658	86.8	5.8	2.7	1.0	0	-	1.3	45
6			15.7	17.0	-17.0	-19.4	161½	376.3	27.0	422.7	17.95	25000	512	3060	2645	86.4	5.4	2.8	1.0	0	-	1.3	45
7			12.5	16.3	-17.6	-20.1	150	349.5	27.0	396.6	17.95	25000	516	[illegible]	2480	80.4	4.9	5.0	3.8	2.0	-	3.8	45
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9																							
10																							
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DATA CHECKED AND CERTIFIED CORRECT BY: E R Rein
CHIEF TEST ENGINEER

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