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Director of Nuclear Reactor Regulation
ATTN: Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing
U. S. Nuclear Regulatory Comm.
Washington, D.C. 20555

SUBJECT: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Evaluation of HPSI
Operability Without Service
Water Cooling
(File: 2-0510.5)

Gentlemen:

In our November 6, 1980 transmittal of information concerning service water problems, AP&L committed to submit further information on High Pressure Safety Injection (HPSI) pump operation without service water supplied to the bearing and seal coolers. This evaluation has been completed and is attached for your review.

Please contact us if any further information is desired.

Very truly yours,

David C. Trimble

David C. Trimble
Manager, Licensing

DCT:LDY:lp
Attachment

8101200298 P

ANO-2 EVALUATION OF HPSI PUMP OPERABILITY WITHOUT SERVICE WATER COOLING

Introduction

During an outage in September 1980 to investigate low service water flow through the ANO-2 containment cooling units, the high pressure safety injection pump seal and bearing coolers were inspected. This inspection revealed that the HPSI pump small service water supply piping was plugged with silt and corrosion products such that little or no cooling water flow was available. Since that time, a series of tests and analyses have been performed to determine what effect having no cooling water flow through these coolers has upon the operability and reliability of the HPSI pumps. This report describes the testing performed, summarizes test results and explains the analyses performed to extrapolate the measured data to the conditions which would exist in an accident.

Test Description

The inboard and outboard bearing temperatures were monitored by temporary installation of local dial indicating thermometers installed in the bearing lube oil reservoirs. The inboard and outboard seal water temperatures were monitored by local dial indicating thermometers installed in the seal water cooler vent connections. (See Figures 1 and 2.) The ambient room temperature was measured with temporary thermometers located slightly above the outboard bearing housing. In addition, bearing race temperatures were measured using a contact pyrometer for comparison with oil temperature measurements at several times during the tests.

The three HPSI pumps were tested separately with the pump lined up for recirculation to the refueling water tank. The service water supply was isolated and the pump was started. Temperature data was collected at 2-minute intervals for the first 10 minutes, 5-minute intervals for the next 20 minutes, then at 30-minute intervals until stable bearing and seal temperatures were achieved.

The testing procedures specified that the test should be aborted and the pump secured if either bearing oil temperatures or seal water cooler temperatures should exceed 180°F. In all cases testing was not performed until it was confirmed that two HPSI trains were operable not including the pump being tested.

FIGURE 1

HPSI PUMP TEMPERATURE MONITORING

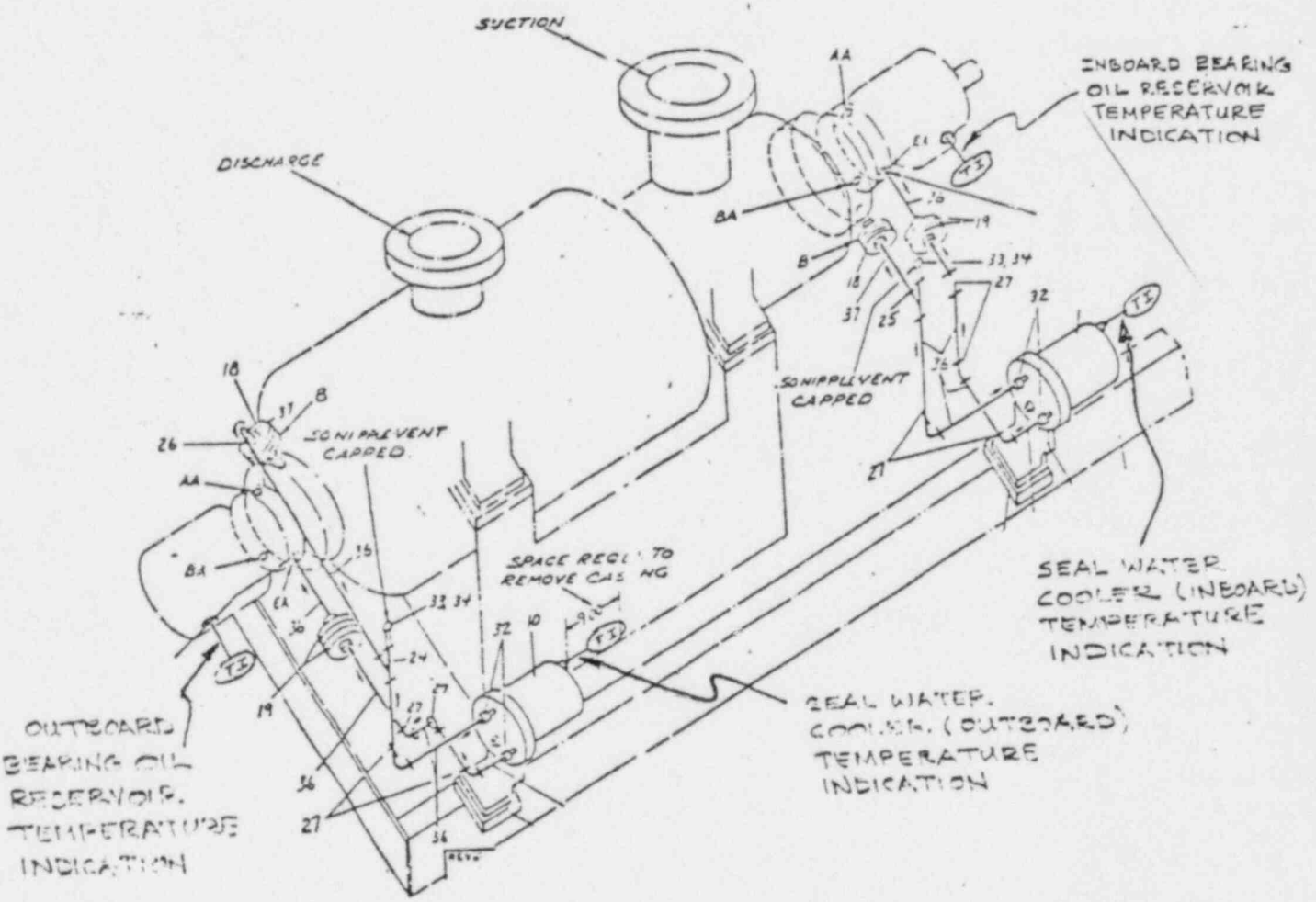
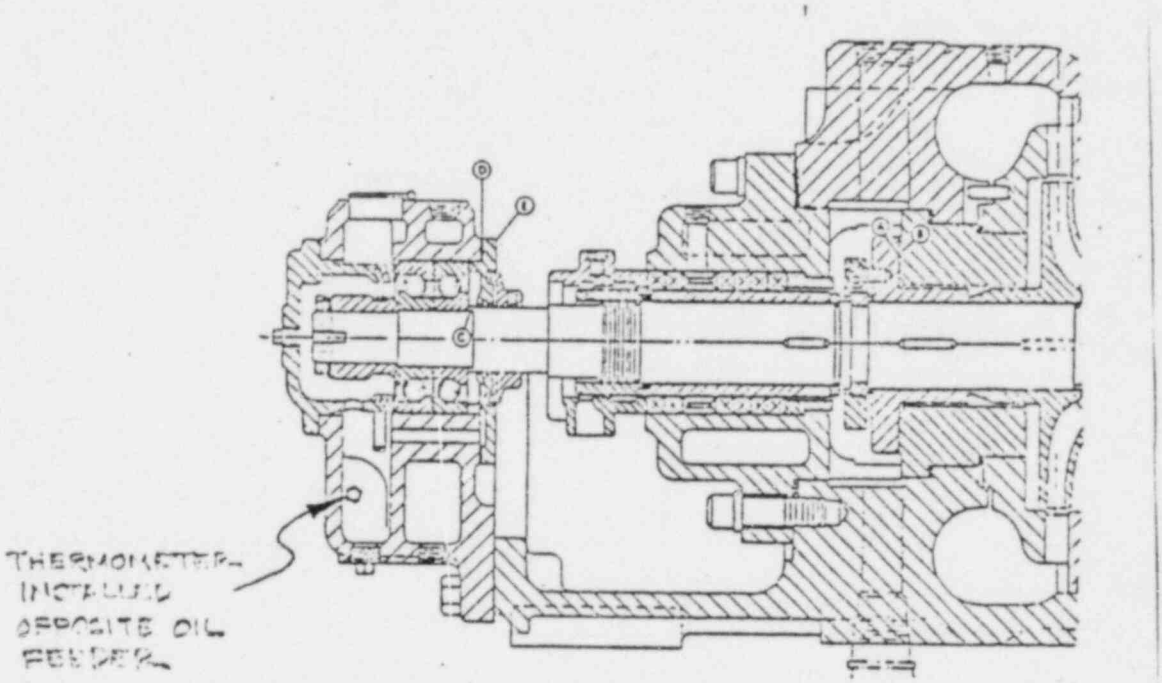


FIGURE 2

HPSI PUMP BEARING DETAIL



Test Results

Presented below are the initial conditions recorded during the test with the pump idle followed by the final conditions after all temperatures had stabilized.

	Outboard Bearing (°F)	Inboard Bearing (°F)	Outboard Seal Water (°F)	Inboard Seal Water (°F)	Room* (°F)	RWT Temp (°F)
2P89A						
Idle	69	69	69	66	68.6	75
Stable	122	101	142	130	68.6	75
2P89B						
Idle	65	66	62	66	75.4	76
Stable	168	90	126	103	74.3	76
2P89C						
Idle	61	62	68	57	73.4	74
Stable	142	112	126	119	87.3**	74

NOTE: 2P89B test performed on 11/9/80.
2P89C test performed on 11/17/80.
2P89A test performed on 11/20/80.

Bearing race temperature measurements indicated 4°F to 6°F higher than bearing oil temperatures. See also plots of temperatures versus time (Figures 3-8).

A large deviation in temperature between the outboard and inboard bearings for 2P89B was observed during these tests. (The difference was 78°F versus 21°F for 2P89A and 30°F for 2P89C.) The testing on 2P89B was performed immediately following maintenance on its motor and the data indicated that the pump and motor may not have been adjusted optimally causing a greater than necessary thrust loading. For this reason further maintenance on 2P89B is planned in the future, and these test results were not used for assessing operability.

*Thermometer was located just above the outboard bearing.
**Reason for temperature rise due to small room for 2P89C.

FIGURE 3

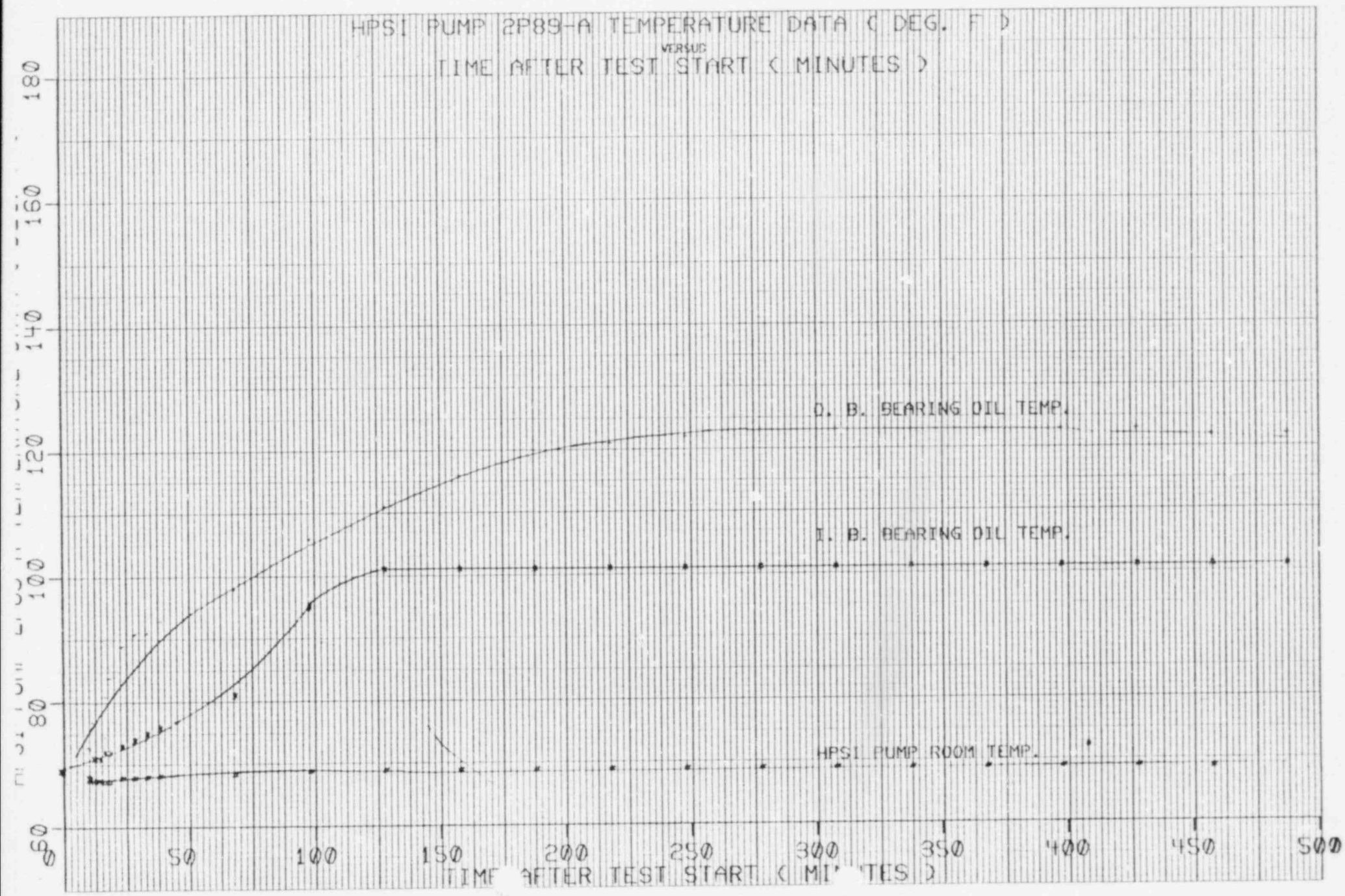

HPSI PUMP 2P89-A TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES)
O. B. BEARING OIL TEMP.
I. B. BEARING OIL TEMP.
HPSI PUMP ROOM TEMP.
60
80
100
120
140
160
180
0
50
100
150
200
250
300
350
400
450
500
TIME AFTER TEST START (MINUTES)

FIGURE 4

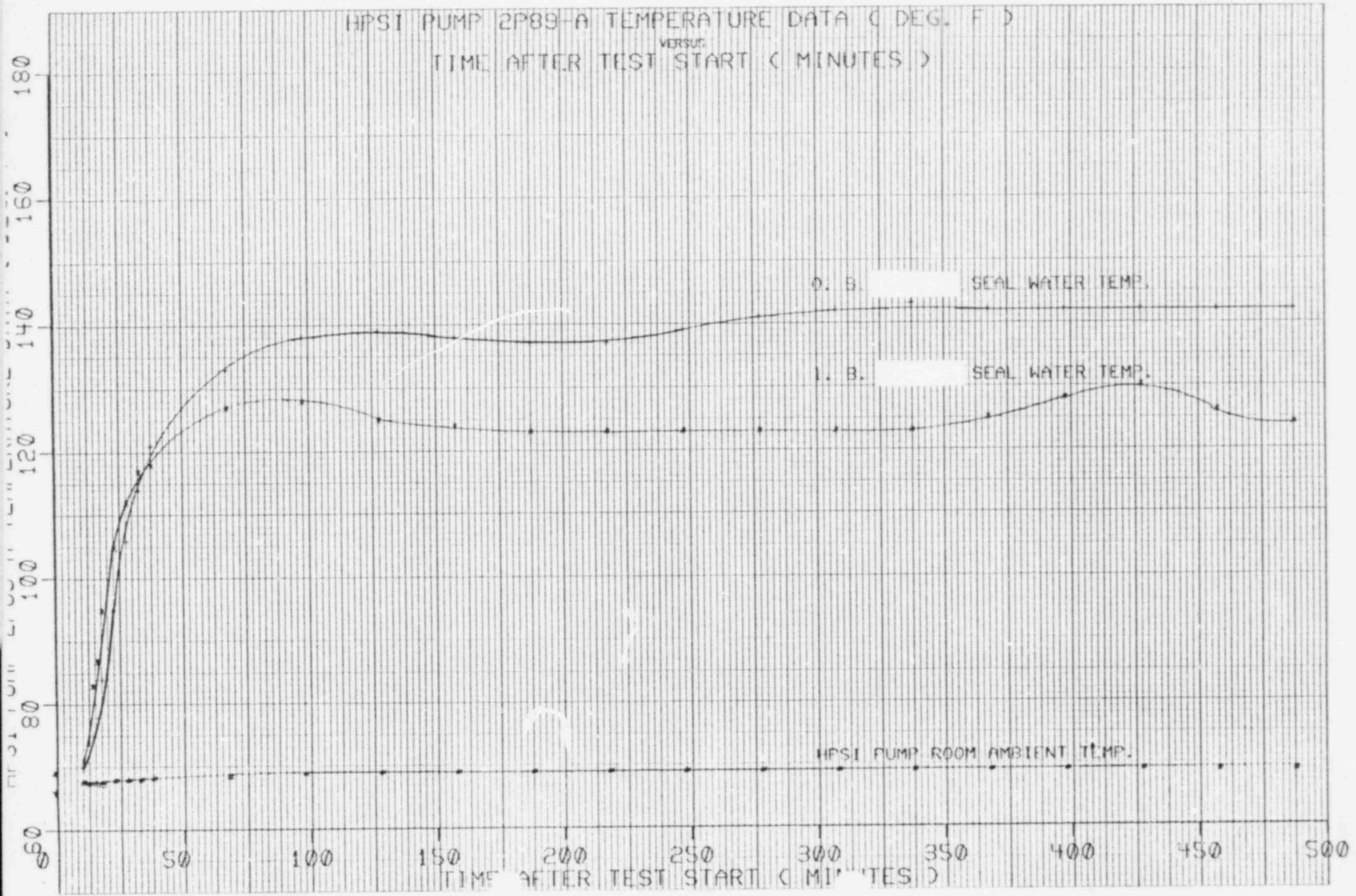

HPSI PUMP 2P89-A TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES)
O. B. SEAL WATER TEMP.
I. B. SEAL WATER TEMP.
HPSI PUMP ROOM AMBIENT TEMP.
180
160
140
120
100
80
60
0
50
100
150
200
250
300
350
400
450
500
TIME AFTER TEST START (MINUTES)

FIGURE 5

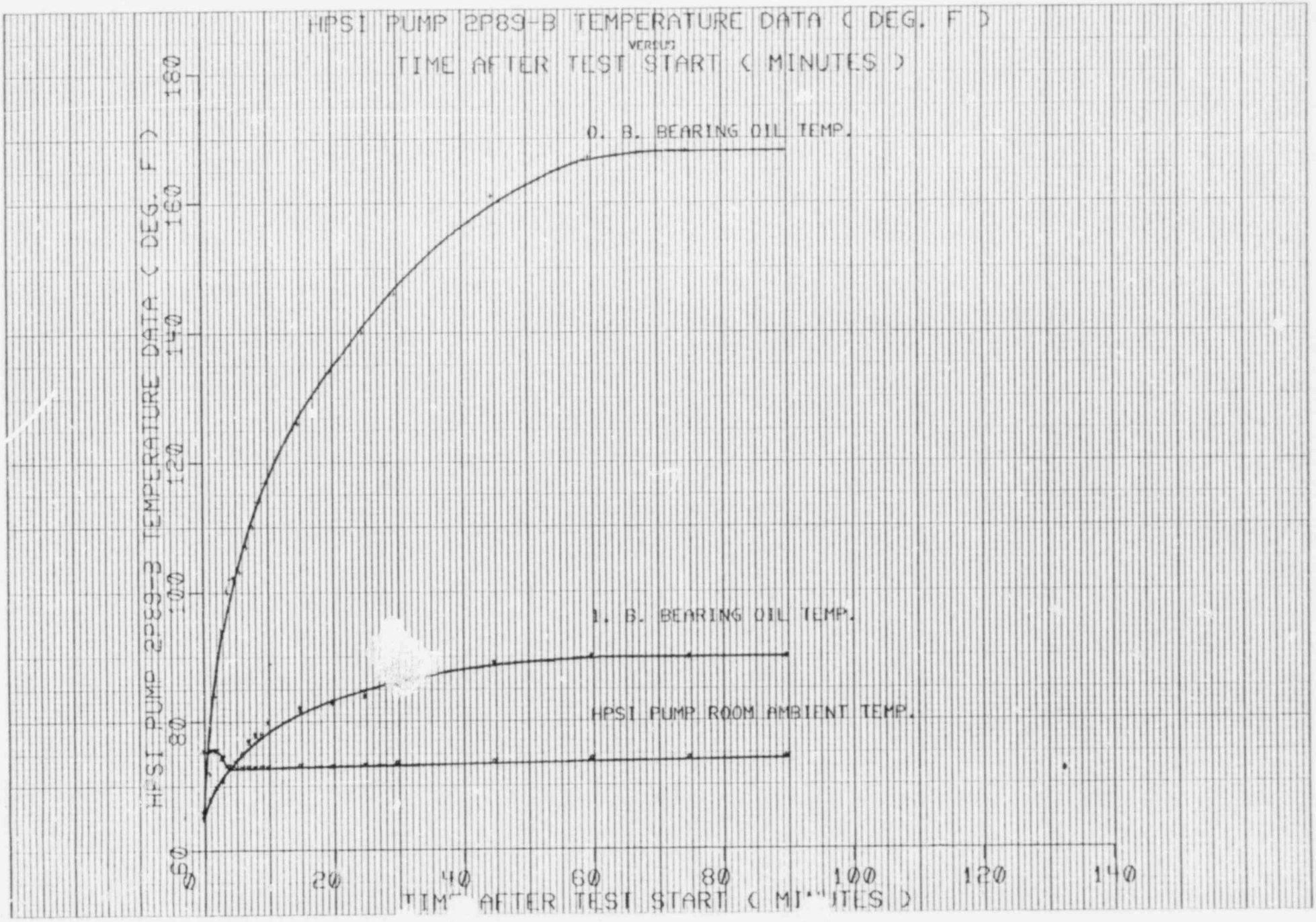

HPSI PUMP 2P89-B TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES)
O. B. BEARING OIL TEMP.
I. B. BEARING OIL TEMP.
HPSI PUMP ROOM AMBIENT TEMP.
HPSI PUMP 2P89-B TEMPERATURE DATA (DEG. F)
180
160
140
120
100
80
60
20
40
60
80
100
120
140
TIME AFTER TEST START (MINUTES)

FIGURE 6

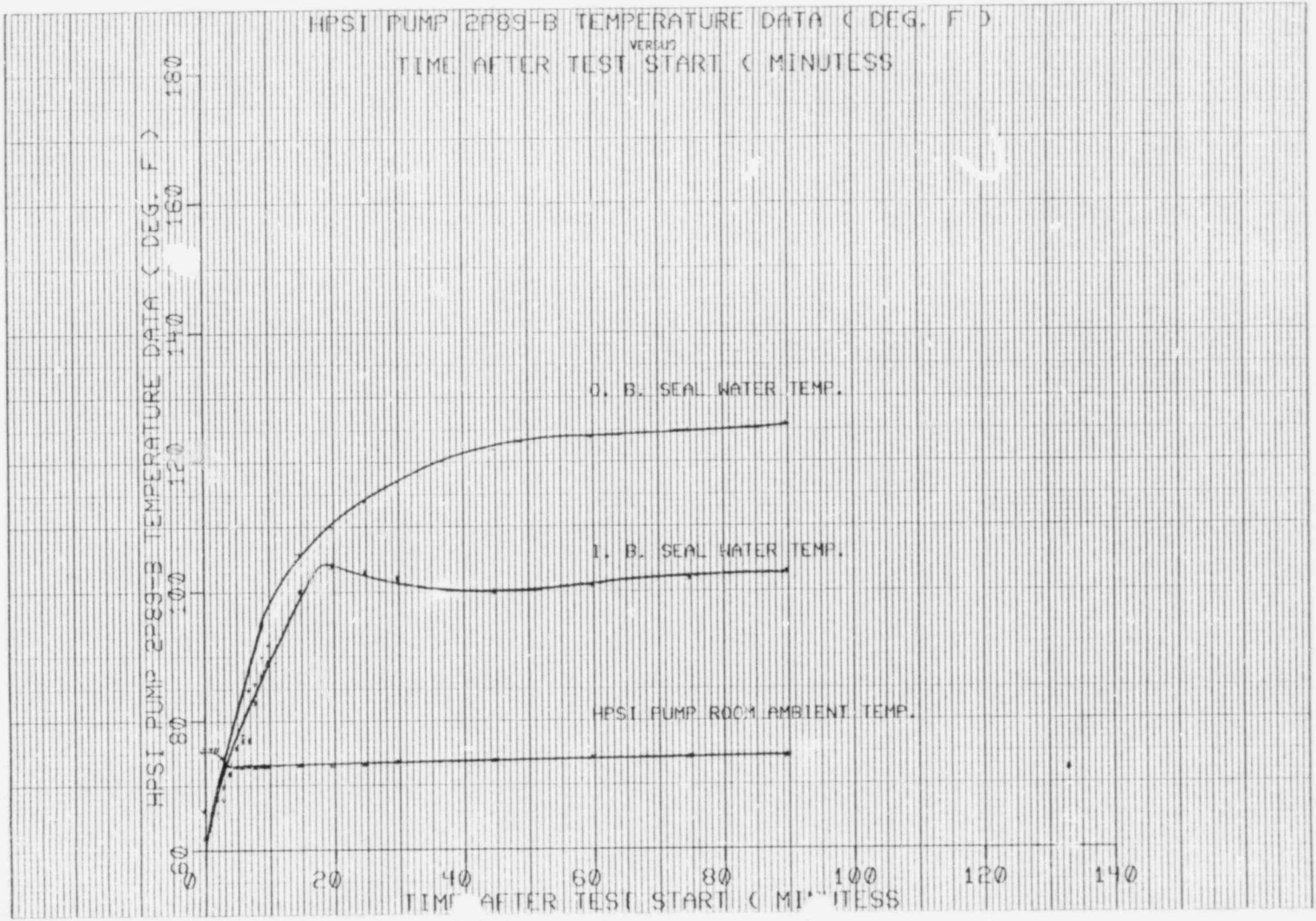

HPSI PUMP 2P89-B TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES
HPSI PUMP 2P89-B TEMPERATURE DATA (DEG. F)
180
160
140
120
100
80
60
0
20
40
60
80
100
120
140
TIME AFTER TEST START (MINUTES
O. B. SEAL WATER TEMP.
I. B. SEAL WATER TEMP.
HPSI PUMP ROOM AMBIENT TEMP.

FIGURE 7

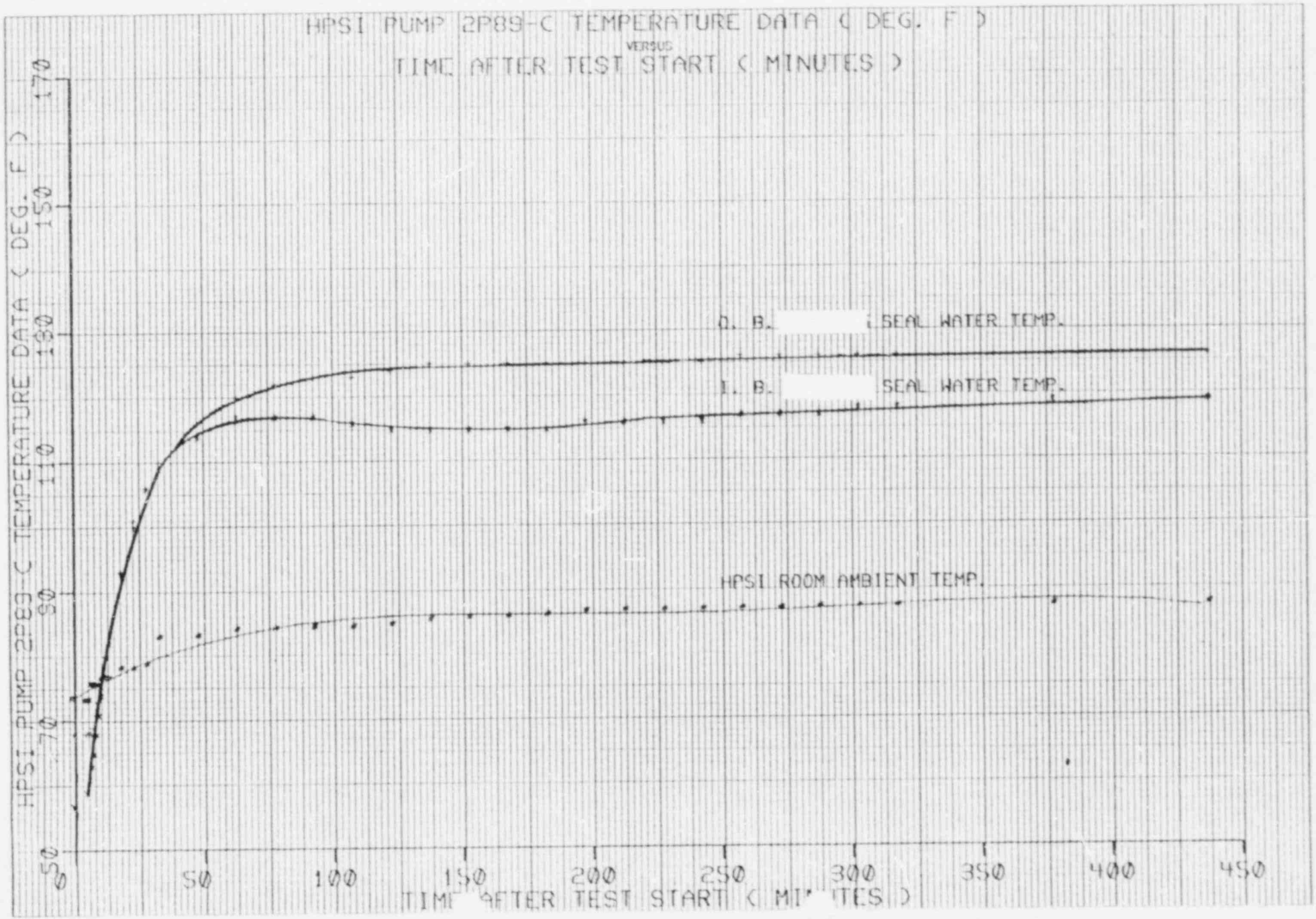
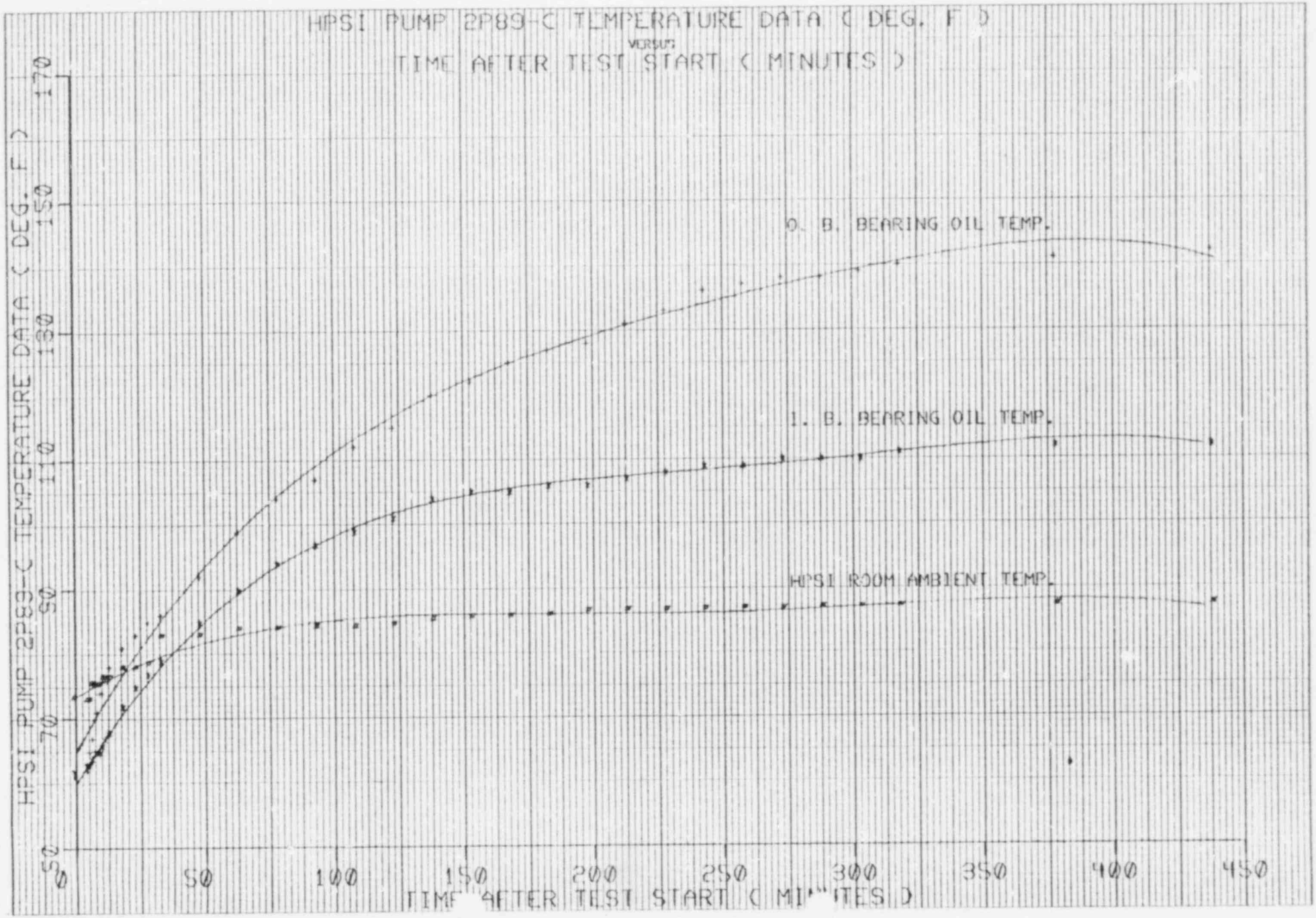

HPSI PUMP 2P89-C TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES)
O. B. SEAL WATER TEMP.
I. B. SEAL WATER TEMP.
HPSI ROOM AMBIENT TEMP.
HPSI PUMP 2P89-C TEMPERATURE DATA (DEG. F)
TIME AFTER TEST START (MINUTES)
50
70
90
110
130
150
170
0
50
100
150
200
250
300
350
400
450

FIGURE 8


HPSI PUMP 2P89-C TEMPERATURE DATA (DEG. F)
VERSUS
TIME AFTER TEST START (MINUTES)
O. B. BEARING OIL TEMP.
I. B. BEARING OIL TEMP.
HPSI ROOM AMBIENT TEMP.
HPSI PUMP 2P89-C TEMPERATURE DATA (DEG. F)
TIME AFTER TEST START (MINUTES)
250
70
90
110
130
150
170
0
50
100
150
200
250
300
350
400
450

Analyses

In order to assess the impact of having no service water flow through the HPSI pump bearing coolers and seal water coolers during accident conditions, a simplistic analysis using conservative assumptions was performed. This analysis involved adjusting the fluid temperature of the pumped fluid upwards from the test value of ~75°F to a conservative value of 250°F for containment sump temperature on recirculation and applying this difference to the seal water cooler temperature. Additionally, the difference in the measured room ambient and the expected room temperature during LOCA (115°F) was applied to both the bearing oil cooler and seal water cooler temperatures. Using this technique, the following worst case temperatures during post-LOCA conditions could be experienced, assuming no service water cooling flow:

	Outboard Bearing Temperature	Inboard Bearing Temp.	Outboard Seal Water Temp.	Inboard Seal Water Temp.
2P89A	168°F	157°F	317°F	305°F
2P89C	170°F	140°F	302°F	295°F
2P89B	Not analyzed (see Test Results)			

The pump manufacturer (Ingersol-Rand) has conservatively set the recommended bearing oil temperature limit at 160°F. This limit is based on the assumption that cooling water is being supplied to the bearing housings. Since the expected operating temperature during normal operation with cooling water flow is nominally under 100°F, a temperature increase to 160°F would indicate a developing problem, thus the limit of 160°F. For bearings without cooling water, higher temperatures would be expected during operation and a higher limit than 160°F is more reasonable in this case. Data from bearing manufacturers and

industrial experience has shown that bearing temperatures in the range of 180°F - 200°F are not detrimental to pump operation. We have chosen to use 180°F as an upper bearing temperature limit.

The highest bearing temperature experienced during these tests was 142°F on 2P89C which could be expected to approach 170°F during post-LOCA conditions. This value is considered to be acceptable for long term operation, thus we have concluded that bearing failure due to overheating during post-LOCA conditions without service water cooling flow is unlikely.

The pump seal manufacturer (Durametallic) prepared a test report for qualifying Dura seals in 1978. This report documents testing performed to prove operability of their seals during various nuclear plant design conditions. When using 2.5 weight % boric acid, Durametallic projects a wear life of 4770 hours with nil leakage when seal temperatures are at 350°F. This case envelopes the ANO-2 HPSI pump test conditions when extrapolated to post-LOCA conditions. Therefore, no seal failure or increase in seal leakage would be expected if a loss of service water flow through the HPSI pump coolers were experienced coincident with a LOCA.

Conclusion

Based upon the testing performed at ANO-2 (running the HPSI pumps without service water flow through the pump bearing and seal water coolers) and the subsequent analyses, we have concluded that the HPSI pumps were not rendered inoperable by the loss of service water flow through their coolers which was discovered during a September 1980 outage.* This analysis was confirmed independently by our NSSS vendor (Combustion Engineering).

*HPSI pump 2P89B was not considered during this analysis since maintenance was performed following the September 1980 outage and prior to testing. Testing indicated that the maintenance had altered the pump's performance and should not be included.