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REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8211120458 DOC.DATE: 82/11/08 NOTARIZED: NO DOCKET #
FACIL:50-387 Susquehanna Steam Electric Station, Unit 1, Pennsylva 05000387
AUTH.NAME AUTHOR AFFILIATION
CURTIS,N.W. Pennsylvania Power & Light Co.
RECIP.NAME RECIPIENT AFFILIATION
SCHWENCER,A. Licensing Branch 2

SUBJECT: Submits explanation of failure of emergency svc water sys & discussion of impact on plant performance.During recent design activities associated w/mod,unidentified & unevaluated single failure discovered in sys.

DISTRIBUTION CODE: B001S COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 27
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NOV 08 1982

Mr. A. Schwencer, Chief
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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
ADDITIONAL INFORMATION - ESW SYSTEM
ER 100450 FILE 841-2
PLA-1388

Docket No. 50-387

Dear Mr. Schwencer:

As discussed in our meeting with the Staff on November 5, 1982, PP&L has identified single failure concerns with the Emergency Service Water (ESW) System of the Susquehanna plant. This letter provides an explanation of those concerns, and a discussion of the impact on plant performance.

## Introduction

During recent design activities associated with a modification at Susquehanna Steam Electric Station, it was discovered that an unidentified and unevaluated single failure potential exists in the Emergency Service System (ESW). This system supplies cooling water for on site emergency A.C. power Diesel Generators (DG's), for the Control Structure HVAC chiller, and to ECCS equipment and room coolers. The single failure could result in degradation of these systems' performance.

Upon investigation it was found that this failure, ie. the ESW loop bypass valve failing to open when the system is initiated, was missed in the failure mode and effects analysis (FMEA) because the analysts assumed the valve to be normally open and not subject to failure on system initiation. The system operation as originally planned in the early 1970's included a normally open position for this valve but the line-up was changed in late 1977 to prevent the system from draining while shutdown, thus reducing the potential for water hammer. This change was not properly factored into the FMEA performed later (1981).

The following sections discuss plant performance and what is being done to demonstrate adequate plant performance for the period until the ESW system can be modified to conform to the design basis.

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Plant Performance

In order to demonstrate adequate plant performance in accordance with the FSAR, even when a single failure results in loss of an Emergency Service Water loop (either A or B), the following must be demonstrated:

1. Sufficient onsite emergency power sources (Diesel Generators) are available to meet accident mitigation and safe shutdown load requirements.

2. Adequate cooling is supplied to one of the two control structure chillers to maintain required environmental conditions in the Control Structure and Emergency Switchgear rooms, and

3. Adequate cooling is supplied to ECCS equipment and ECCS room coolers to support operation of ECCS equipment for times assumed in the FSAR ECCS analysis (10 CFR analysis).

Each of these requirements are discussed below:

1. Diesel Generators

   Adequate On Site Emergency Power is obtained if three of the four emergency D.G.'s function when called upon in an emergency condition. The four D.G.'s are normally cooled by ESW loop "A". If inadequate cooling is supplied then all four D.G.'s will switch to ESW loop "B" for cooling. Currently the indication of "inadequate flow" is generated by ESW pump breaker position. This may not be adequate under all circumstances. Therefore, this transfer logic is being modified to initiate transfer on a direct indication of low flow in the "A" ESW loop. The flow measuring device is located in the common discharge of the "A" ESW loop pumps. This modification is described in Attachment A, Plant Modification, and will be installed prior to exceeding 5% power.

2. Control Structure Chillers

   There are two control structure chillers, either one of which can supply sufficient cooling to meet the Control Structure and Emergency Switchgear Room environmental condition requirements during accident conditions. One chiller is supplied by ESW Loop "A" and the other by ESW Loop "B". Therefore, even a single failure that incapacitates one ESW loop does not result in loss of Control Structure Cooling.

3. ECCS Room and Equipment Cooling

If ESW loop "A" is lost then Division I ECCS equipment and rooms will receive no cooling water flow. Likewise, if ESW Loop "B" is lost, Division II ECCS equipment and rooms will receive no cooling water flow. The most limiting LOCA (break size and break location) requires at least one core spray loop be operating plus one RHR pump from each Division.

During the loss of one ESW loop, a core spray system and two RHR pumps are provided from the division which has cooling. Both DG's providing AC power to this completely operable ECCS Division are running and have cooling, and room and equipment cooling is provided by the operating ESW loop. ECCS equipment in the other Division associated with the inoperable ESW loop does start, however it does not have component and room cooling. In the most limiting case one RHR pump starts.* In other cases more ECCS equipment is available.

The FSAR ECCS Analysis (Appendix K Analysis) demonstrates that Appendix K limits can be met even for the worst break scenarios if flow from the RHR pump associated with the inoperable ESW loop can be maintained for 10 minutes. (See discussion in Attachment B, Effects of ESW Single Failure on LOCA Analysis).

During accident conditions, the RHR System pumps suppression pool water which is heating up as a result of the LOCA blowdown and injects it into the reactor. This heated water warms the RHR room as it passes through and also heats up the pump as does internally generated heat in the pump. Based on design information for the pump and motor combined with a test to confirm the effects of internally generated heat in the pump and motor, it has been shown that the pump can operate effectively for at least 10 minutes and probably considerably more without room or component cooling. See Attachment C, RHR Pump Operation Without Cooling, below for details of the RHR pump capability.

Therefore it is concluded that adequate core cooling is assured for all LOCA cases since ECCS equipment is available for sufficient time to meet the requirements of the FSAR ECCS Analysis even if an ESW loop is lost. This demonstrates compliance with Appendix K requirements for all power levels, combinations of break sizes, and break locations required as a design basis.

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* The most limiting case is the loss of either A or B Diesel generator which results in the loss of A or B ESW respectively because these DG's supply power to the Bypass valves and to the ESW pump discharge valves in those loops and also results in loss of one RHR pump and loss of the core spray loop on that side because these DG's power the respective core spray injection valve.

It is not PP&L's intention to rely on this evaluation as a long term basis for operation. Modifications will be made to eliminate this single failure. While a specific plant modification has not been decided upon, several alternatives (see Attachment D, ESW System Modification Alternatives) have been identified which can solve the problem. These are currently being evaluated for equipment availability, complexity of installation, effectiveness in solving this problem and improving the design, etc. A decision on which modification will be installed is expected before December 1, 1982. We will inform you of the chosen modification and its implementation schedule at that time.

Very truly yours,

NW Curtis

N. W. Curtis
Vice President-Engineering & Construction-Nuclear

WEB/mks

Attachments

cc: R. Perch - USNRC
G. Rhoads - USNRC

# ATTACHMENT A

## PLANT MODIFICATION

The listed change is being made to correct the current design which is not single failure proof. In the current design, cooling to the diesel generators will not be provided if the bypass valve fails to open. Note: the diesel generators are normally aligned to the "A" ESW loop. The change is:

- If low flow is sensed in the A loop this actuates the automatic valve transfer at the diesels. (An additional change is being made to address water hammer if the bypass valve fails to close).

This change is intended to provide cooling to the diesel generators in the event the spray pond bypass valve fails to open in the A loop or the valves indicate open but are failed closed. In the event that any of these valves fail, a low flow switch will cause an automatic valve transfer at the diesel generators. This action provides adequate cooling to the diesels and also allows the operator to open a spray network valve providing a flow path thus, cooling to the room coolers if the bypass valve is the failure.

After this change has been incorporated, the single failure of the bypass valve to open will not jeopardize cooling to the diesels.

ATTACHMENT B

## Effect of ESW Single Failure on LOCA Analysis

The SSES ECCS evaluations performed in FSAR Chapter 6 identify the potential single failures as shown on Table 6.3-5 (attached). Also shown on Table 6.3-5 are the ECCS systems remaining for the corresponding single failures. The effect of the ESW single failure is similar to the failure of a single diesel generator. For the case where the ESW bypass valve fails to open as the result of a diesel generator failure, the following ECCS equipment remains available:

(1) For suction breaks - all ADS, HPCI, 1 CS, 2 LPCI injecting into the broken loop, 1 LPCI available for at least 10 minutes in the intact loop.

(2) For discharge breaks - all ADS, HPCI, 1 CS, 1 LPCI available for at least 10 minutes in the intact loop.

GE has performed an analysis documented in SSES FSAR question 211.105 (LPCI diversion study) which addresses a situation similar to that described above, i.e., one RHR pump in LPCI injection mode for 10 minutes only. The GE analysis considers the impact of diverting LPCI to containment spray cooling at 10 minutes, which is equivalent to assuming that the LPCI pump without cooling water can only operate for 10 minutes (actual testing of the pump without cooling has shown that operation of the pump beyond 10 minutes is possible - see Attachment C RHR Pump Operation, without Cooling).

The FSAR analysis shows that for break sizes from large down to less than .08 ft$^2$, core reflooding is achieved prior to 10 minutes. Therefore, for this range of breaks, the loss of a RHR pump at 10 minutes will have no effect on PCT. For smaller breaks, GE has shown in response to FSAR question 211.105 that the most limiting break location and size affected by the loss of one RHR pump at 10 minutes is a .026 ft$^2$ core spray line break. This break results in a calculated PCT of 1644 F. For breaks smaller than .026 ft$^2$, calculated PCTs will be lower since core uncovery will be for a shorter time period and decay heat at the time of uncovery will be lower. Breaks larger than .026 ft$^2$ get some reflooding benefit from the RHR pump before the assumed loss of the pump at 10 minutes resulting in lower PCTs. Based on the results of the RHR pump testing we expect the RHR pump without cooling to be available for longer than 10 minutes, thus resulting in PCTs less than those discussed above.

Long-term core and containment cooling requirements are discussed in FSAR Sections 6.2 and 6.3. For the Case of core cooling, the analysis shows that either one core spray loop or one LPCI pump is adequate to assure long-term core cooling. Long-term containment cooling can be achieved in two ways (1) one RHR pump aligned to pass flow through one RHR heat exchanger with flow discharged to the reactor vessel, or (2) one core spray loop injecting into the vessel with one RHR pump and heat exchanger operating in the containment spray

mode. For the special case of a core spray line break, RHR flow would be drawn from the suppression pool, pumped through the heat exchanger and injected into the vessel to maintain core cooling with water returned to the suppression pool via the break or alternatively through opened ADS valves by flooding the vessel. Either of these methods is acceptable in assuring long-term core and containment cooling. Thus, the minimum equipment required for long-term core and containment cooling is one RHR pump and heat exchanger, ADS, and, if available, one core spray loop.

In conclusion, since for all cases adequate core and containment cooling can be maintained, a single failure in the ESW system will not result in LOCA consequences more severe than those previously discussed in FSAR Sections 6.2 and 6.3.

## TABLE 6.3-5

4

## SINGLE FAILURE EVALUATION

| Assumed Failure | Suction Break Systems Remaining | Discharge Break Systems Remaining |
|---|---|---|
| LPCI Injection Valve | All ADS, HPCI, 2 CS, 2 LPCI (1 loop) | All ADS, HPCI, 2 CS |
| HPCI | All ADS, 2 CS, 4 LPCI (2 loops) | All ADS, 2 CS, 2 LPCI (1 loop) |
| Diesel Generator | All ADS, HPCI, 1 CS 3 LPCI (2 loops) | All ADS, HPCI, 1 CS, 1 LPCI (1 loop) |
| One ADS Valve | All ADS minus one, HPCI, 2 CS, 4 LPCI (2 loops) | All ADS minus one, HPCI, 2 CS, 2 LPCI (1 loop) 1 |

Other postulated failures are not specifically considered because they all result in at least as much ECCS capacity as one of the above designated failures.

ATTACHMENT C

# Residual Heat Removal Pump Operation Without Cooling

## Test Objective:

The objective of this test is to demonstrate that the Residual Heat Removal (RHR) pumps are capable of operation without Emergency Service Water (ESW) cooling water for a minimum of 10 minutes without exceeding the design temperature limits for the pump/motor components. In addition, the results of this test will be evaluated to insure that the test will adequately predict the postulated accident conditions including the effects of elevated Suppression Pool temperatures. This report has been prepared to support interim ESW operational conditions.

## Discussion of Test Conditions:

In order to meet the above objective with a safe and reliable test, the "RHR Quarterly Flow Verification" (quarterly full-flow surveillance test) was modified to approximate the conditions needed. The RHR system was lined up for automatic Low Pressure Coolant Injection (LPCI), except that the RHR "C" pump was prevented from starting to simulate the loss of its electric power. The RHR system was filled and vented in accordance with the normal operating procedures. The only other exception to the normal system line ups was that the ESW system was secured, but available for operation. The RHR system flow path was from the suppression pool, thru the RHR pump, discharging back into the suppression pool thru the RHR system full-flow test line.

To approximate the accident condition as nearly as possible, normal and emergency ventilation to the RHR pump room was secured. Emergency ventilation was secured because it is normally cooled by ESW. The cooling fan for the "A" emergency ventilation cooler was allowed to start and run because it is powered by the same diesel as the "A" RHR pump; however, ESW was not available to the cooler. The only other heat sources in the RHR pump room were the RHR "A" pump itself, along with its associated piping, and the High Pressure Coolant Injection (HPCI) turbine steam line cross connection to the RHR heat exchanger. This steam line was hot up thru the steam pot drain to the normally closed isolation valves. The line is the cross tie for the Steam Condensing Mode of the RHR system. All other potential heat sources (i.e. lighting, instrumentation and valve motors) operated in their normal mode.

The only heat source for which the test conditions did not closely approximate the postulated accident conditions was the Suppression Pool During the test the Suppression Pool temperature was at ambient conditions Figures 1 and 2 show that the expected temperature variation could be an increase of 54° from the upper Technical Specification limit of 90°F to 144°F as shown. Justification for this correlation is contained under "Conclusions" of this report.

To evaluate the pump and motor heatup rates the following points were monitored and recorded every 30 seconds:

1. Motor bulk oil temperature (portable temperature monitor).
2. Motor thrust bearing temperature.
3. Motor upper guide bearing temperature
4. Motor lower guide bearing temperature
5. Air intake temperature to pump motor (portable temperature monitor)
6. Pump room ambient air temperature (portable temperature monitor)

Additionally, the following points were monitored every 2 minutes to insure test conditions remained constant during the test period:

1. Pump flow rate
2. Pump suction pressure
3. Pump discharge pressure
4. Suppression pool temperature (2 channels)

Before the test was performed, the NRC Resident Inspector was notified.

Test Results/Performance:

The test was intended to be run for 10 minutes with T=0 being the start of the pump. Actually the pump was running for 10 minutes and 30 seconds, the extra 30 seconds being the time required to close the full-flow test line discharge valve. In order that a trend might be established for the period following pump operation all parameters were monitored for 20 minutes from T=0 and all data recorded.

The highest internal pump temperature recorded was 140.0°F at T=10.5 minutes on the Kingsbury thrust bearings, while the highest bulk oil temperature was 118.4°F at T=12.5 minutes, 2 minutes after the pump was secured. Figure 3 is a graph showing the bulk oil temperature plotted every 30 seconds for a period of 20 minutes with an extrapolation showing the potential temperature increase had the pump not been secured at T=10.5 minutes. The thrust bearing temperature is also shown extrapolated to the high temperature alarm point of 185°F. This extrapolation implies that the pump can be run for approximately 26 minutes before exceeding the manufacturer's recommended alarm point on any bearing surface. The maximum temperatures recorded on the upper and lower guide bearings were 95°F and 110°F, respectively. As expected, the thrust bearing temperature was the limiting condition. During the test the following parameters remained constant:

1. Pump flow rate = 12,200 gpm
2. Pump suction pressure = 6 psig
3. Pump discharge pressure = 240 psig

The pump room temperatures averaged 71.7°F at T=0, reached an average peak temperature of 74.6°F at T=12.5 minutes, and decreased to an average temperature of 73.5°F at T=20.0 minutes.

During the test the average Suppression Pool temperature was 75.7°F, with a slight temperature decrease of approximately 1.2°F experienced our the length of the test. This decrease was attributable to the mixing action in the Suppression Pool due to running the RHR pump.

## Conclusions:

Prior to conducting this test the motor manufacturer, General Electric Company, and the pump manufacturer, Ingersoll-Rand Company, were consulted and briefed on the extent and objectives of the test. Their recommendations were then incorporated into the test. Additionally, they were asked to predict, based upon their own fields of expertise, what might be expected from such a test. Their predictions and our results are compared in the following paragraphs.

For the pump (see Figures 4 and 6) the only component of concern is the pump shaft seal manufactured by the Crane Packing Company (see Figure 7). The shaft seal is normally cooled by diverting process water through a seal cooler; the seal cooler is in turn cooled by ESW. The purpose of seal water is to 1) remove dirt from the seal and 2) cool the seal. Since the seal water is taken from the pump discharge process fluid, the flow is not interrupted by the loss of ESW and the cleaning function is still performed. For this test the process fluid was Suppression Pool water at 75°F, therefore the cooling function was also performed.

Since the postulated accident could raise the Suppression Pool temperature to 144°F, a condition not duplicated during the test, pump seal failure had to be evaluated. Ingersoll-Rand Company representatives stated that this seal design is used in several of their pump lines, including heater drain pumps. In these pumps it is recommended that the seal water be cooled to 160°F for maximum performance (note: this is the same model pump and seal as our RHR pump). Additionally, the actual failure of the seal is dependent primarily upon the melting point of the elastomer "O-ring" in the seal. The "O-rings" in this seal are "CRANELAST" material code 3807 which meets the requirements of ASTM-D-2000-2BA-810C-12F17. The design range of the shaft seal as stated by Crane Packing Company is 40°F to 360°F, well above our expected process fluid temperatures. Ingersoll-Rand stated that their experience showed, however, that seals run at temperatures greater than 200-250°F deteriorate rapidly and that if 200°F were exceeded, the seals should be replaced, even though the manufacturer's recommended maximum operating temperature was not exceeded. Considering the above design information, operation of the seal at 144°F would not cause a credible seal failure.

The upper and lower guide bearings, the thrust bearing and the breakdown of the lubricating oil were examined for the evaluation of the pump motors. General Electric engineers were consulted and they stated that RHR pump motors (see Figure 5) had been previously tested by their motor-plant and run for approximately 45 minutes without exceeding bearing or oil temperature design limits. This testing, however, was performed with the motor unloaded, starting from cold conditions. Based upon their testing their opinion was that neither our test nor operation with the postulated accident conditions would be detrimental to the pump or motor. Additionally they predicted that we should see a bulk oil temperature rise of no more than 5°F per minute which should decrease as the test proceeds. This temperature rise, if accurate, would keep both the bearing and oil temperatures well within the design limits.

During our test the thrust bearing temperature was significantly higher than either the upper or lower guide bearings. Therefore, we limited our examination to the thrust bearing and the breakdown of the lubricating oil. Our test showed an average bulk oil temperature rise of 3.6°F per minute after an initial fluctuation; this was consistent with the manufacturer's predictions. The oil used in the RHR pump motor is oxidation and corrosion inhibited turbine oil with a viscosity of 450 SUS at 100°F and a viscosity of 60 SUS at 210°F. This demonstrates that the degradation point of the lubricating oil is in excess of 210°F. For the thrust bearing a maximum temperature of 140°F was observed. This is well below the alarm point 185°F, the temperature at which the manufacturer recommended we secure the test.

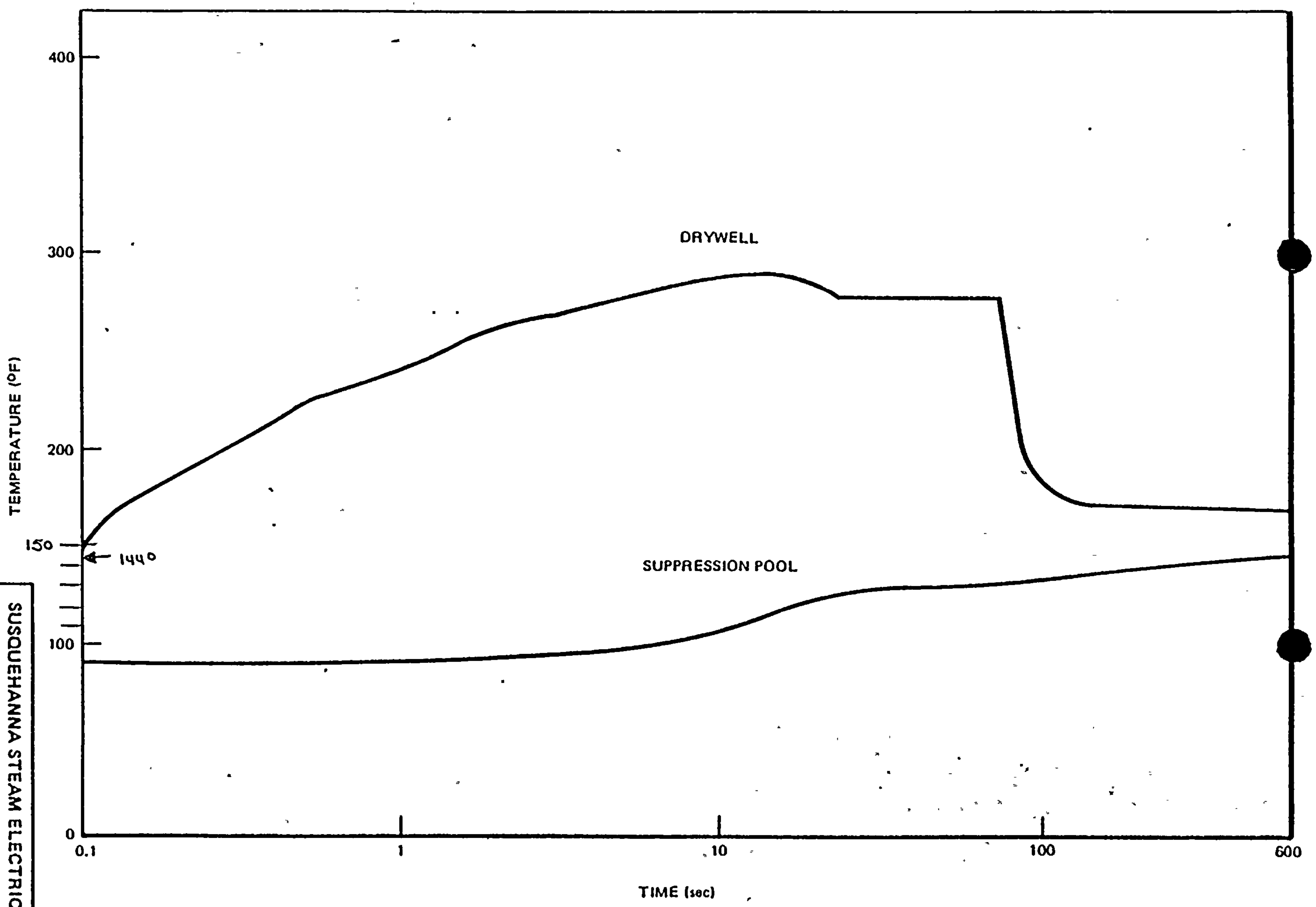
No temperature limits were exceeded during this test; however, because the Suppression Pool temperature could be as high as 144°F, this effect must be considered. We feel the elevated Suppression Pool temperature will not have an effect on oil or bearing temperature for the following reasons 1) the cross sectional area for heat transfer by conduction thru the pump casing and shaft is small compared to the distance separating the pump flow channels and the oil baths (see Figures 4, 5 and 6 for pump/motor details), and 2) the time of operation without cooling water (10 minutes) is insignificant to allow the very large RHR pump room to heatup and thereby increase the oil or bearing temperature; additionally, the inlet and out let piping of the RHR Pumps are insulated further hindering heatup of the area. (This was evidenced by the small increase in ambient temperature of 2.5°F observed during the test.) To further demonstrate that the bearings and oil will not be affected by the expected accident conditions it should be known that these motors are designed to be operated with or without cooling water. When operated without cooling water the bulk oil temperature limit is allowed to rise to approximately 200°F with the only additional precaution of using a high grade oil with an oxidation inhibitor, which, as noted above, is the type of oil in the RHR pumps.

Because of our testing and the manufacturer's assurances of conservatisms in design, we conclude that the RHR pumps and motors are capable of operation without ESW for a minimum period of 10 minutes and perhaps as long as 25 to 30 minutes.

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

TEMPERATURE RESPONSE FOR
RECIRCULATION LINE BREAK

FIGURE 1



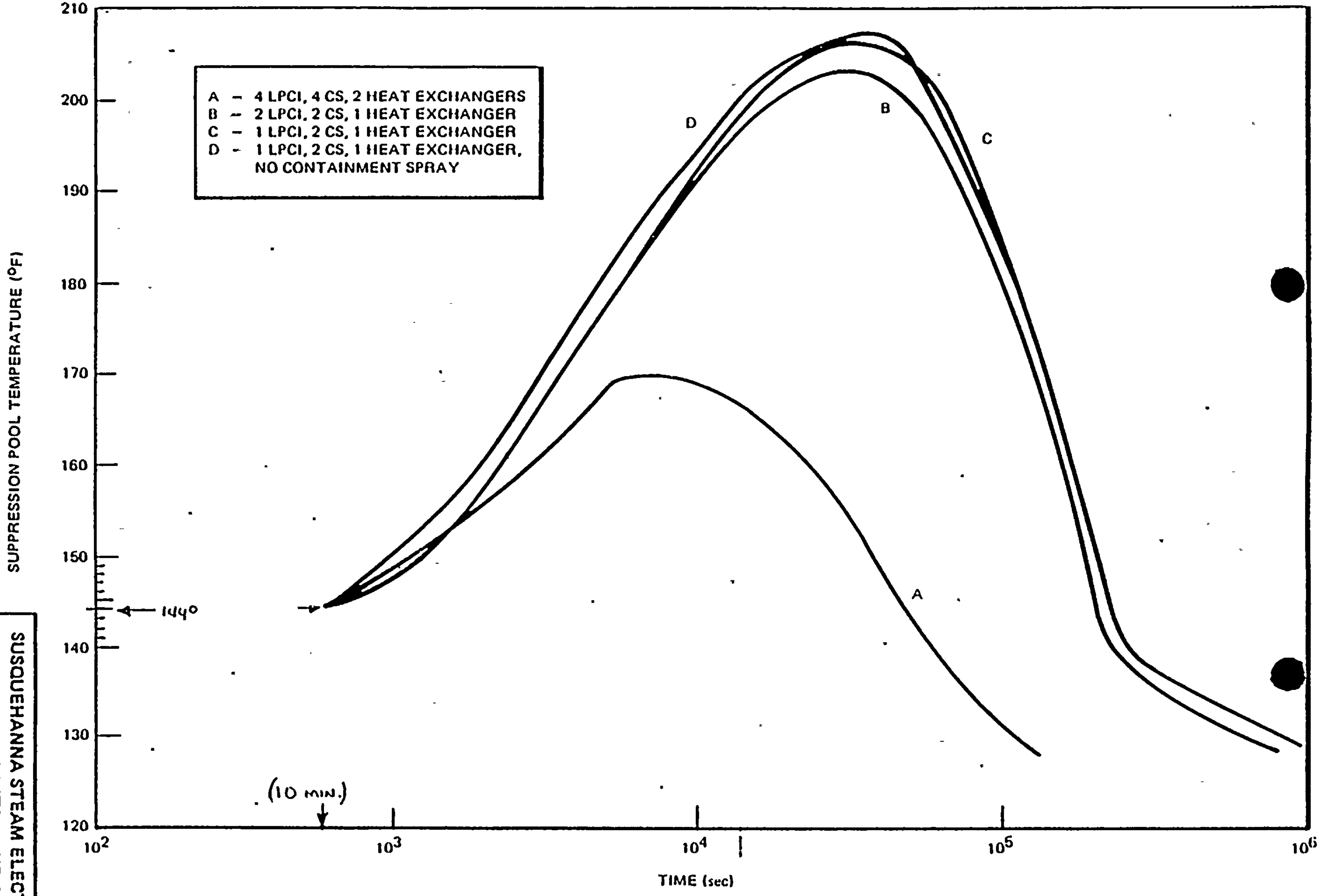


FIGURE 2

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 AND 2
FINAL SAFETY ANALYSIS REPORT

SUPPRESSION POOL TEMPERATURE RESPONSE

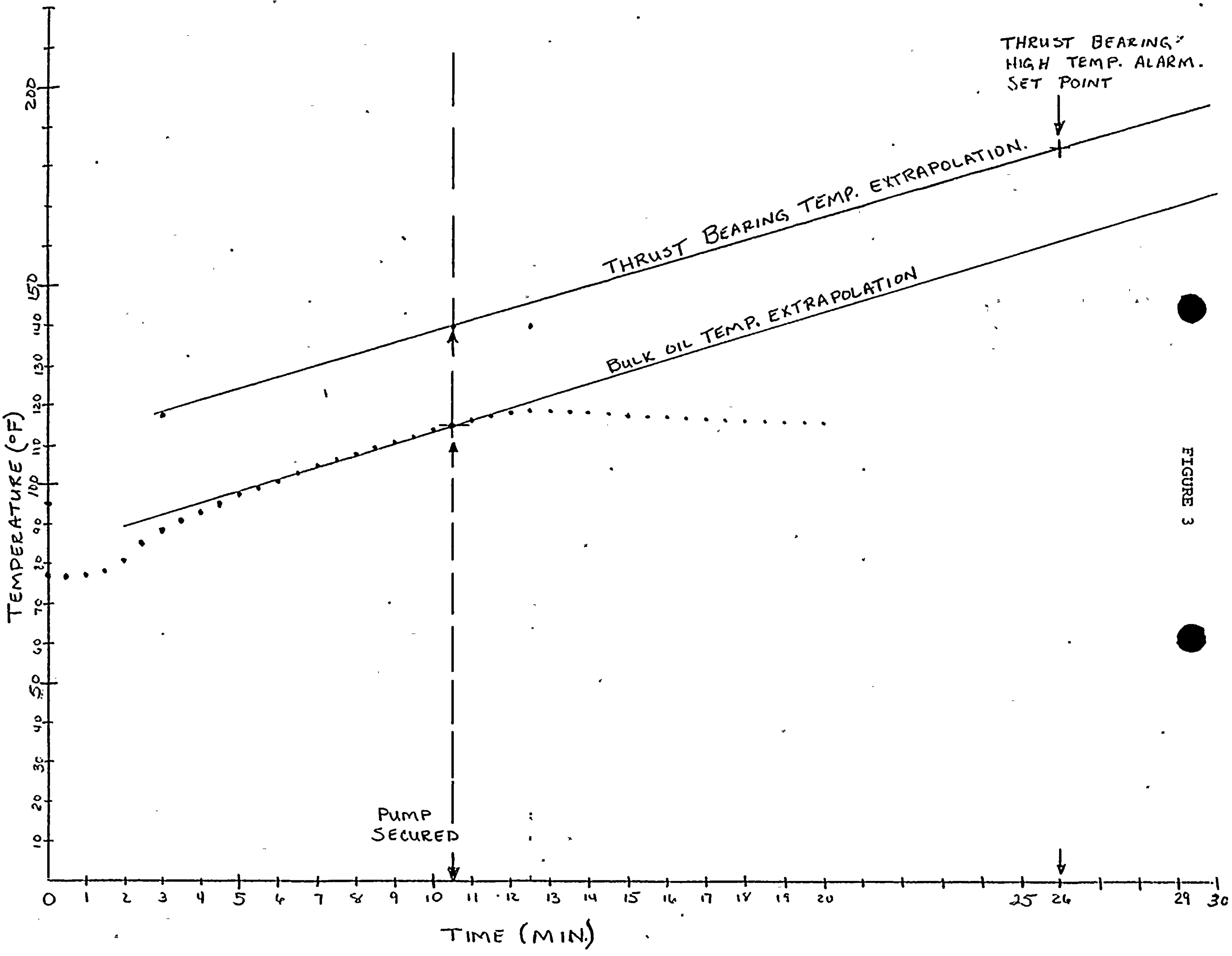

THRUST BEARING HIGH TEMP. ALARM. SET POINT
THRUST BEARING TEMP. EXTRAPOLATION.
BULK OIL TEMP. EXTRAPOLATION
PUMP SECURED
TEMPERATURE (°F)
200
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
TIME (MIN.)
0
1
2
3
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FIGURE 3

## GENERAL NOTES

ALLOW .25" FOR VARIATION OF DRAWING AND FOUNDATION BOLT HOLES. FOUNDATION BOLTS SHOULD NOT BE SET RIGIDLY UNTIL RECEIPT OF EQUIPMENT.

TOLERANCE FOR SETTING AND SHELL LENGTH ± .30

PIPING AND FITTINGS NOT SHOWN ARE TO BE FURNISHED BY CUSTOMER. DO NOT CONNECT TO PIPE TAPS UNLESS SPECIFIED ON DRAWING.

ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE NOTED.

ALL HOLES IN FLANGES STRADDLE CENTERLINE.

DISCHARGE LINE TO CHECK VALVE SHOULD BE FULLY PRIMED TO AVOID WATER HAMMER DAMAGE. IF THIS IS NOT PHYSICALLY POSSIBLE, PROVISIONS SHOULD BE MADE FOR SLOW MOTOR START, FLYWHEEL ADDITION, OR BY-PASS.

THIS DRAWING IS NOT TO SCALE—WORK FROM DIMENSIONS.

READ INSTRUCTION BOOK BEFORE STARTING EQUIPMENT.

### NOZZLES

TOLERANCE FOR NOZZLE LOCATIONS ± .30

| DISCHARGE | SUCTION |
|---|---|
| 20.00 IN. 300 LB RAISED FACE | 30.00 IN. 300 LB RAISED FACE |
| 30.50 IN. O. DIA FLANGE | 43.00 IN. O. DIA FLANGE |
| [illegible] IN. I. DIA FLANGE | 28.75 IN. I. DIA. FLANGE |
| 24 - 1.375 IN. HOLES ON | 28 - 1.875 IN. HOLES ON |
| 27.00 IN. BOLT CIRCLE | 39.25 IN. BOLT CIRCLE |
| 23.00 IN. DIA. RAISED FACE | 33.75 IN. DIA. RAISED FACE |
| 2.50 IN. THICK INCLUDING | 3.62 IN. THICK INCLUDING |
| .06 IN. RAISED FACE) | .06 IN. RAISED FACE) |

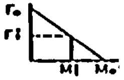
### AUX. CONNECTIONS

EA .500 PIPE TAP = GLAND FLUSHING CONNECTION
BA .500 PIPE TAP = GLAND DRAIN = PLUGGED
P .500 PIPE = CAPPED = SEAL PIPING VENT VENT AT START UP.
N .750 PIPE CAPPED = SUCTION VENT = VENT ON AT START UP.

### ALLOWABLE NOZZLE FORCES AND MOMENTS

THE FOLLOWING EXPRESSION RELATES THE ALLOWABLE COMBINATION OF FORCES AND MOMENTS ON THE EQUIPMENT NOZZLES.

$$\frac{FI}{FO} + \frac{MI}{MO}$$



WHERE,

FI = THE LARGEST OF THE THREE ACTUAL EXTERNAL ORTHOGONAL FORCES (FX, FY, AND FZ) THAT MAY BE IMPOSED BY THE PIPE AND
MI = THE LARGEST OF THE THREE ACTUAL EXTERNAL ORTHOGONAL MOMENTS (MX, MY, AND MZ) PERMITTED FROM THE PIPE WHEN THEY ARE COMBINED SIMULTANEOUSLY FOR A SPECIFIC CONDITION.

FO = THE ALLOWABLE VALUE OF FI WHEN ALL MOMENTS ARE ZERO AND
MO = THE ALLOWABLE VALUE OF MI WHEN ALL FORCES ARE ZERO. THE VALUE OF FO AND MO ARE GIVEN IN THE TABLE BELOW FOR THE CONDITIONS SPECIFIED.

|  | SUCTION NOZZLE FO LB. MO-IN. LB. | DISCHARGE NOZZLE FO-LB. MO-IN. LB. |
|---|---|---|
| A | 9641 - 560856 | 10611 - 504732 |
| B | 9641 - 560856 | 10611 - 504732 |

CONDITION A = (NORMAL PLUS UPSET) = ALL APPLICABLE NOZZLE LOAD COMBINATIONS OF WEIGHT, THERMAL, OPERATING BASIS EARTHQUAKE, ETC.

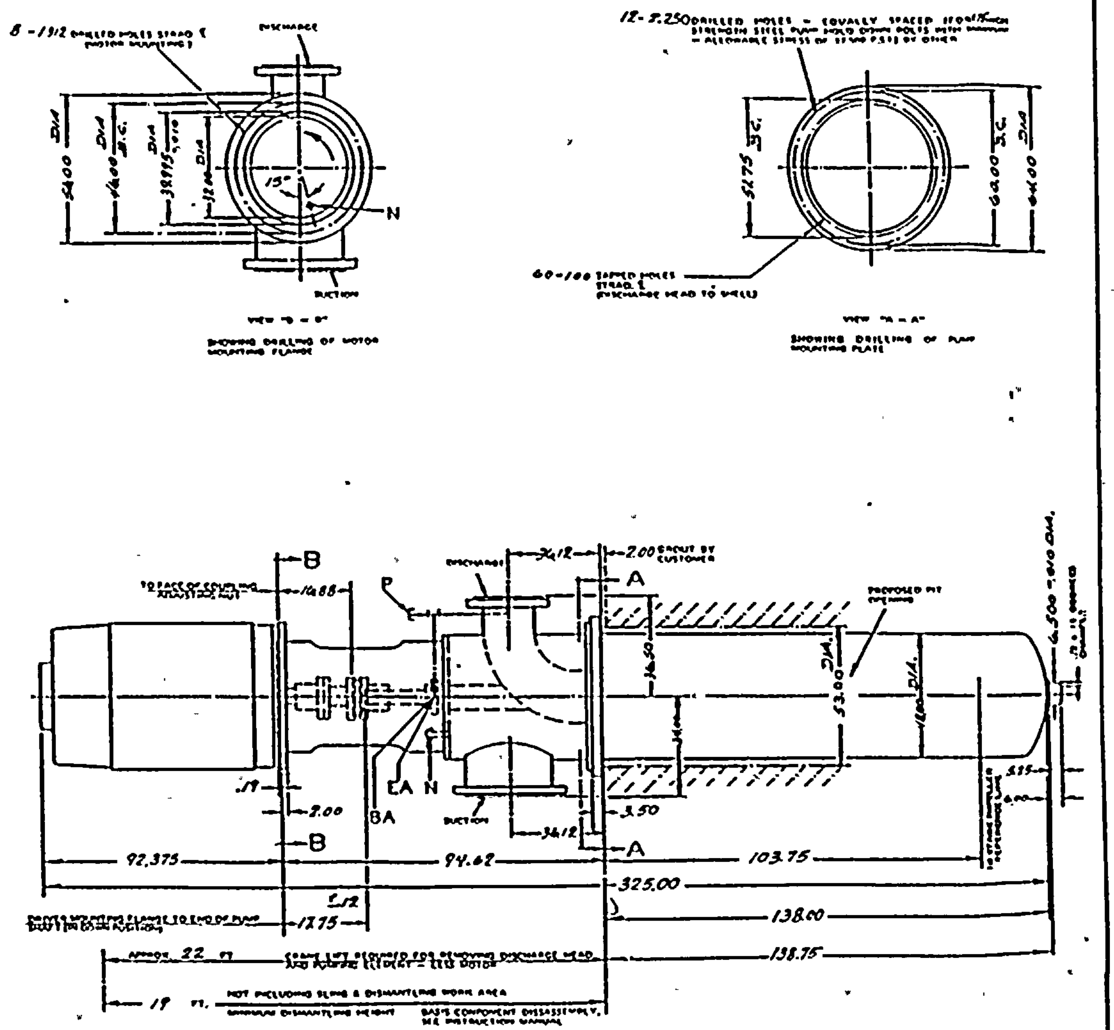
CONDITION B = (EMERGENCY) = ALL APPLICABLE NOZZLE LOAD COMBINATIONS OF WEIGHT, THERMAL, DESIGN BASIS EARTHQUAKE, ETC.

### APPROX. WEIGHT

| | |
|---|---|
| WT. OF PUMP ELEMENT & DISCH. HD. | 16,100 |
| WT. OF SHELL | 4,550 |
| TOTAL WT. OF PUMP DRY | 20,650 |
| WT. OF WATER IN PUMP | 10,160 |
| WT. OF MOTOR | 18,000 |
| WT. OF TOTAL FLOOR LOAD | 48,810 |

PIN TO SUPPORT REACTIONS

ONE 5110# ONE 11240#



| REV | DWN | CKD | APP | REV | DWN | CKD | APP | REV | DWN | CKD | APP | REV | DWN | CKD | APP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | | | JT | 3 | | | | 2 | | | | 1 | | | |
| DATE 23 JL 74 | | | | DATE 13 DEC 73 | | | | DATE 3-13-73 | | | | DATE 22 JAN 73 | | | |

| | | | |
|---|---|---|---|
| ORDER NO. G.E. | SERVICE RHR. | CUSTOMER GENERAL ELECTRIC | I-R ORD. NO. 006-36049 |
| TYPE K | | CUST. ORD. NO. AE-234 | ITEM NO. 1&2 |
| FRAME 6334P2553 | ROTATION CCW-HS | ITEM NO. 1A,B,C,D & 2A,B,C,D | DATE 11-14-72 |
| H.P. 2000 | SLEEVE PUMP | REQ. NO. | DRAWN CHANDO |
| R.P.M. 1800 | | SUSQUEHANNA 1&2 | CHECKED CHANDO |
| SER. NO. 712CG89 | | | APPROVED |

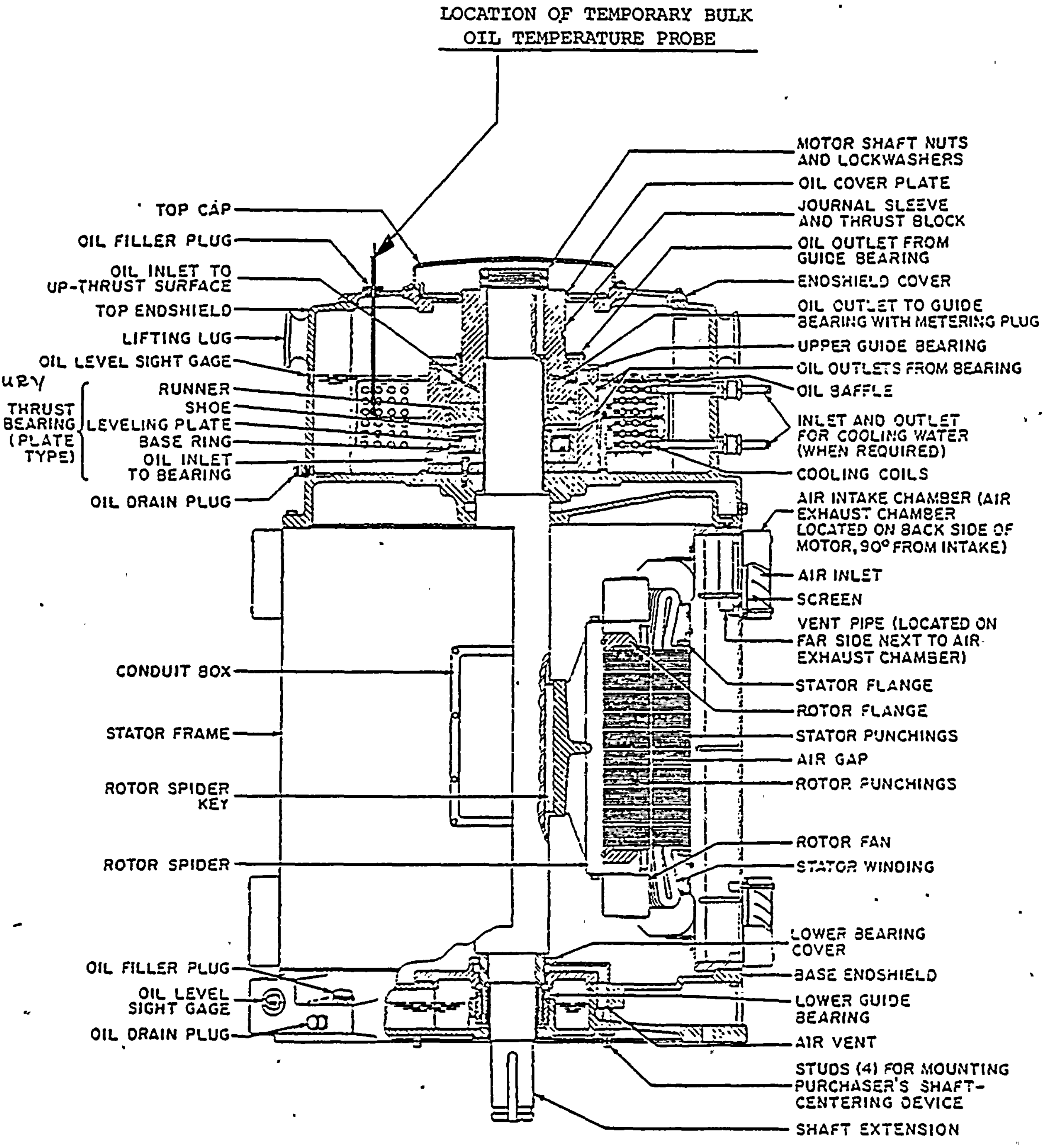
Ingersoll-Rand
CAMERON PUMP DIVISION
PHILLIPSBURG N.J. 08865

GENERAL ARRANGEMENT

PUMP SIZE 34APKD - 4STAGE 74

DWG. NO. C-34-4APKD86X5-D

FIGURE 4

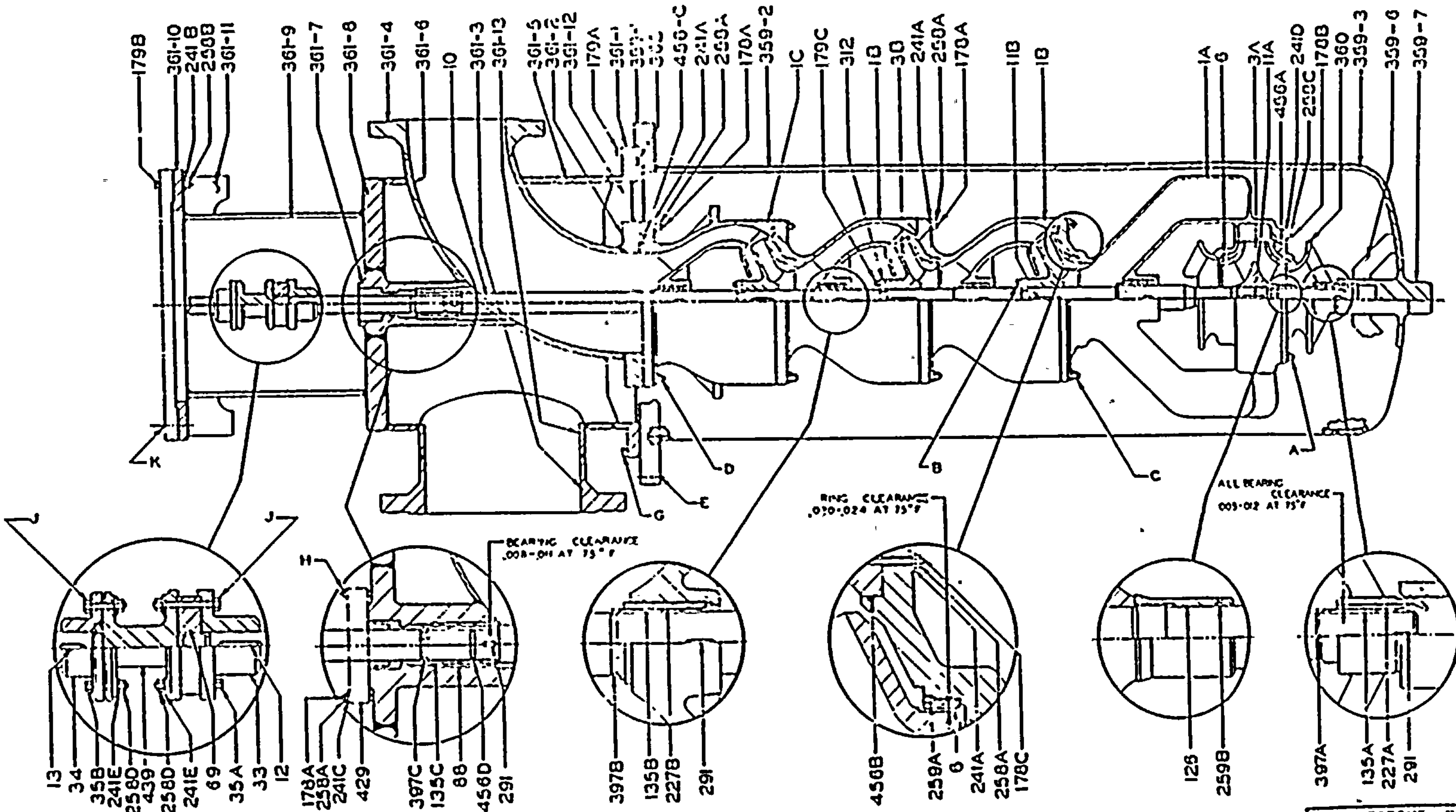


LOCATION OF TEMPORARY BULK OIL TEMPERATURE PROBE

KINGSBURY
JV15

*Fig. 5. Typical solid-shaft motor with plate-type thrust bearing and sleeve guide bearings*

FIGURE 5



| TORQUE BOLTING PER COCP-1035 | | |
|---|---|---|
| BOLTING LOCATION | BOLTING SIZE | TORQUE FT.LBS. |
| A | 5/8 | 100-115 |
| B | 1/2 | 14-16 |
| C | 7/8 | 265-300 |
| D | 7/8 | 265-300 |
| E | 1 3/4 | 2000-3000 |
| G | 1 | 450-475 |
| H | 7/8 | 90-110 |
| J | 1 | 450-475 |
| K | 1 1/8 | 700-750 |

PROJECT NAME - SUSQEHANNA 1&2
RESIDUAL HEAT REMOVAL

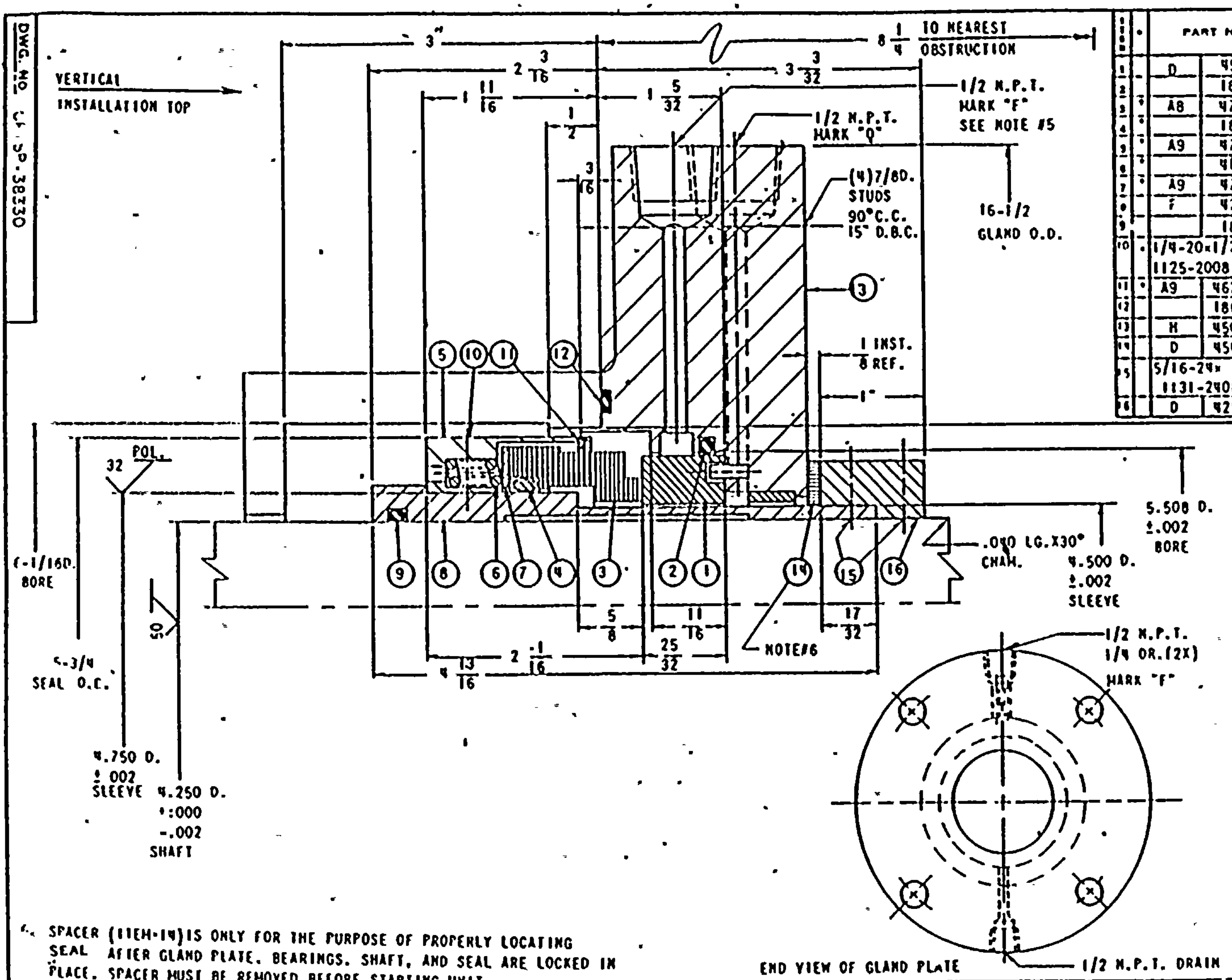
34APKD500X17 RLNPG1&2

APKD PUMP

F-34APKD500X17A

FIGURE 6

DWG. NO. CF-SP-38330



END VIEW OF GLAND PLATE

| ITEM | * | PART NUMBER | | | MAT'L CODE | PART NAME | * | QUAN. REQ'D | MATERIAL | REC. SPARE PARTS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | D | 4500 | 105 | 9200 | STATIONARY RING | | 1 | T.C. AIQ-9200 | x |
| 2 | | | 1866 | 32 | 3807 | GASKET | | 1 | CRANELAST ** | x |
| 3 | * | A8 | 4750 | 43 | 9003 | MATING RING | | 1 | AIQ-9003 CARBON | x |
| 4 | * | | 1866 | 26 | 3807 | "O" RING | | 1 | CRANELAST ** | x |
| 5 | * | A9 | 4750 | 15 | M547 | RETAINER | | 1 | ASTM-A-276*** T 316 | |
| 6 | * | | 4176 | | | SPRING | | 20 | QQ-W-423 | x |
| 7 | * | A9 | 4750 | 12 | M547 | DISC | | 1 | ASTM-A-276.*** T 316 | |
| 8 | | F | 4250 | 62 | M620 | SLEEVE | | 1 | ASTM-A-276*** T-410 | |
| 9 | | | 1866 | 22 | 3807 | "O" RING | | 1 | CRANELAST ** | x |
| 10 | * | 1/4-20×1/2 LG.<br>1125-2008 | | | M546 | SET SCREW | | 4 | QQ S-763 D. | |
| 11 | * | A9 | 4625 | 15 | M545 | SNAP RING | | 1 | QQ-W-423 | |
| 12 | | | 1866 | 37 | 3807 | GASKET | | 1 | CRANELAST ** | x |
| 13 | | H | 4500 | 12 | M783 | GLD.FLT.ASS'Y | | 1 | ASTM A182-F6 CARBON | |
| 14 | | D | 4500 | 95 | 7341 | SPACER | | 1 | 555 | x |
| 15 | | 5/16-24× 1/2LG.<br>1131-2408 | | | M545 | SET SCREW | | 12 | QQ-S-763 D | |
| 16 | | D | 4250 | 156 | M547 | COLLAR | | 1 | ASTM-A-276*** T-316 | |

** MAT'L CODE 3807-CRANELAST MEETS REQUIREMENTS OF ASTM-D-2000-2BA-810C-12F17 .

6.000 D. +.002 -.000 BORE

KEEP OIL FROM CONTACTING ELASTOMERIC PARTS. FOR INSTALLATION USE PROPYLENE GLYCOL, GLYCERINE OR DISTILLED WATER.

*** ALT. MATL. CAN BE ASTM A 276, T-304 (A1) OR A 182 F 304

| | | | | | | |
|---|---|---|---|---|---|---|
| CODE: | $O_{40}$ | $F_3$ | I | D | I | ASTM-A-276 T-316 |

* PART OF ASSEMBLY
+ SPECIAL PART

SEAL ASS'Y. No A8-4750-42

SEAT ASS'Y. No

SPEC. No

RADIATION

MAX. DOSE RATE 1.4 x$10^4$ RAD/HR.

INTEGRATED DOSE RATE $10^6$RAD(1800A)

OPERATING CONDITIONS: RESIDUAL HEAT REMOVAL

LIQUID DEMINERALIZED WATER PH 9.0 TO 9.7 WITH 5 PPM. MAX. CHLORIDES. ALTERNATE : DEMINERALIZED WATER PH 6 TO 8 WITH NO ADDITIVES

1180 R.P.M. 100 TO 160 °F PRESS 200 P.S.I. SUCT. P.S.I. DISCH.

UNIT REF. 3" APKD PUMP BY INGERSOLL RAND CO.

ULT. CUST. G.E.A.P.E.D.

B/P REF. DWG. C-34APKD64-3 DT'D 1-25-73 BY I-RAND CO.

I-RAND REF: 006-36019 (ITEMS 1 & 2)
I-RAND P.O. C-511562

6. SPACER (ITEM-14) IS ONLY FOR THE PURPOSE OF PROPERLY LOCATING SEAL AFTER GLAND PLATE, BEARINGS, SHAFT, AND SEAL ARE LOCKED IN PLACE. SPACER MUST BE REMOVED BEFORE STARTING UNIT.
5. USE A "JOHN CRANE" ABRASIVE SEPARATOR IF PUMPAGE CONTAINS SOLIDS IN SUSPENSION.
4 VENT GAS ENTRAPMENT BEFORE STARTUP.
3 MAINTAIN PRESSURE IN SEAL CAVITY ABOVE VAPOR POINT DURING OPERATION.
2. CLEAN SEAL FACES BEFORE FINAL ASSEMBLY.
1. LUBRICATE ITEMS# 2,4, & 9 BEFORE INSTALLING SEAL.

REV (A1) WAS ASTM-A-276 T-410 CARBON F3. 2-22-74 TY
(A2) INCLD ALT MATL ASTM A 276 T 304 (4-9-76)
(A3) *** INCLD ALT. MATL ASTM A 182 F 304 (7-27-76)

John Crane
CRANE PACKING COMPANY
6400 W. OAKTON ST.
MORTON GROVE, ILL.

DR R.J.J.
CH'D
APP
DATE 7-13-73
SCALE NONE

TYPE-8B1
4.750 PACKAGE SHAFT SEAL
FOR
4.250 D. SHAFT
INGERSOLL RAND CO.

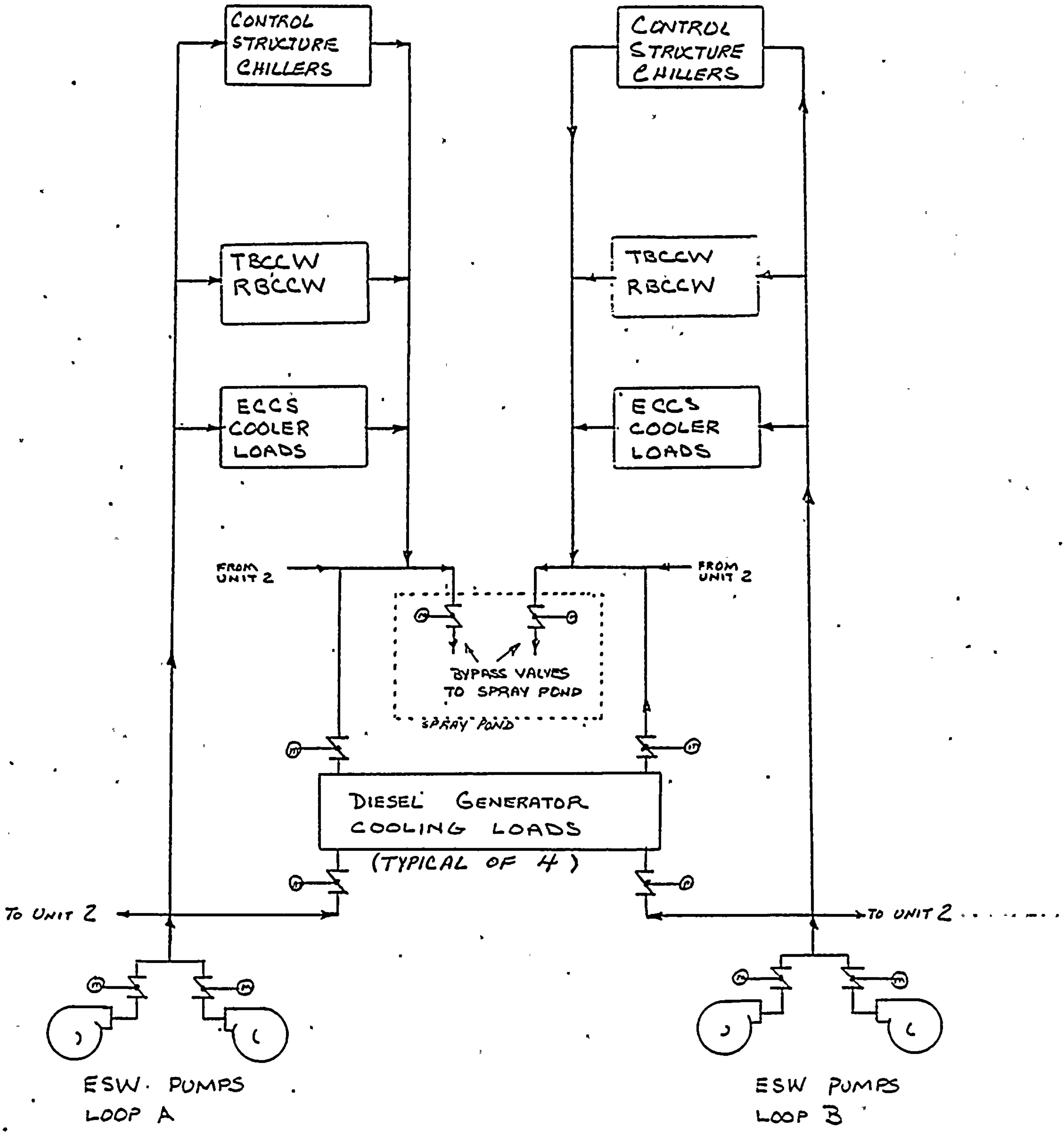
DWG. No. CF-SP-38330

FIGURE 7

# ATTACHMENT D

# ESW SYSTEM MODIFICATION ALTERNATIVES

# ESW AS IT PRESENTLY EXISTS



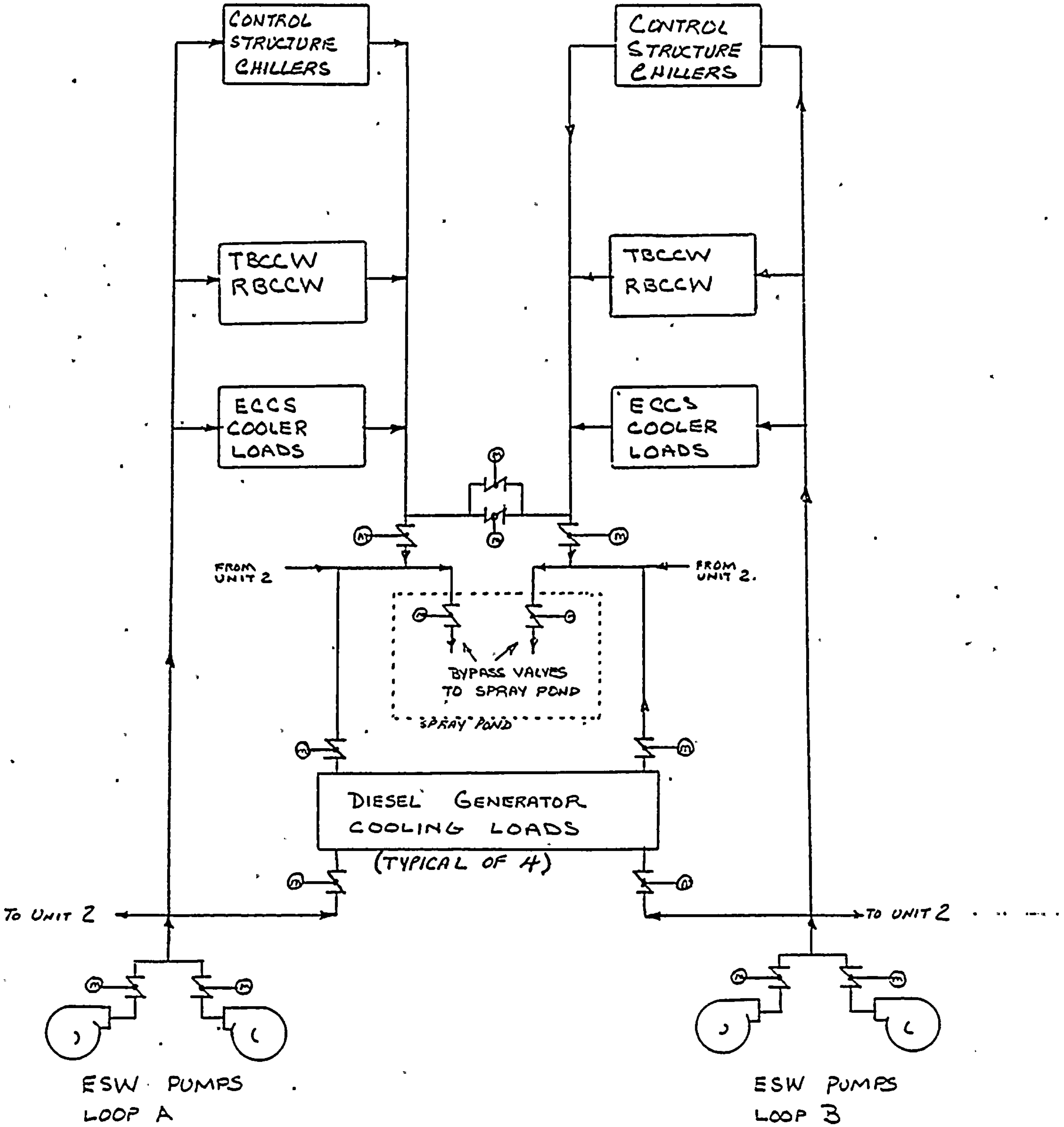
# ESW SYSTEM MODIFICATION

Option 1: This option would interconnect ESW Loop A & B return loops to provide a flow path through the alternate bypass valve if either one fails. Drain down protection is also provided through installation of additional valves.

The ESW discharge valves (powered off separate power supplies) are jogged open 7° upon pump start and fully opened once the system is filled. The bypass valves remain closed until 120 sec's after ESW pump start. The interconnection between ESW Loop A and Loop B is provided to address failure of a bypass valve to open. This interconnection has parallel isolation valves powered off of separate power supplies. Additional ESW Loop A and Loop B valves are provided to prevent waterhammer given failure of a bypass valve to close. The additional valves are provided separate power supplies. Valve transfer is accomplished on flow signals. Automatic transfer from ESW Loop B to Loop A would be incorporated in the design.

A schematic of the system is attached for reference.

# ESW FIX - OPTION 1



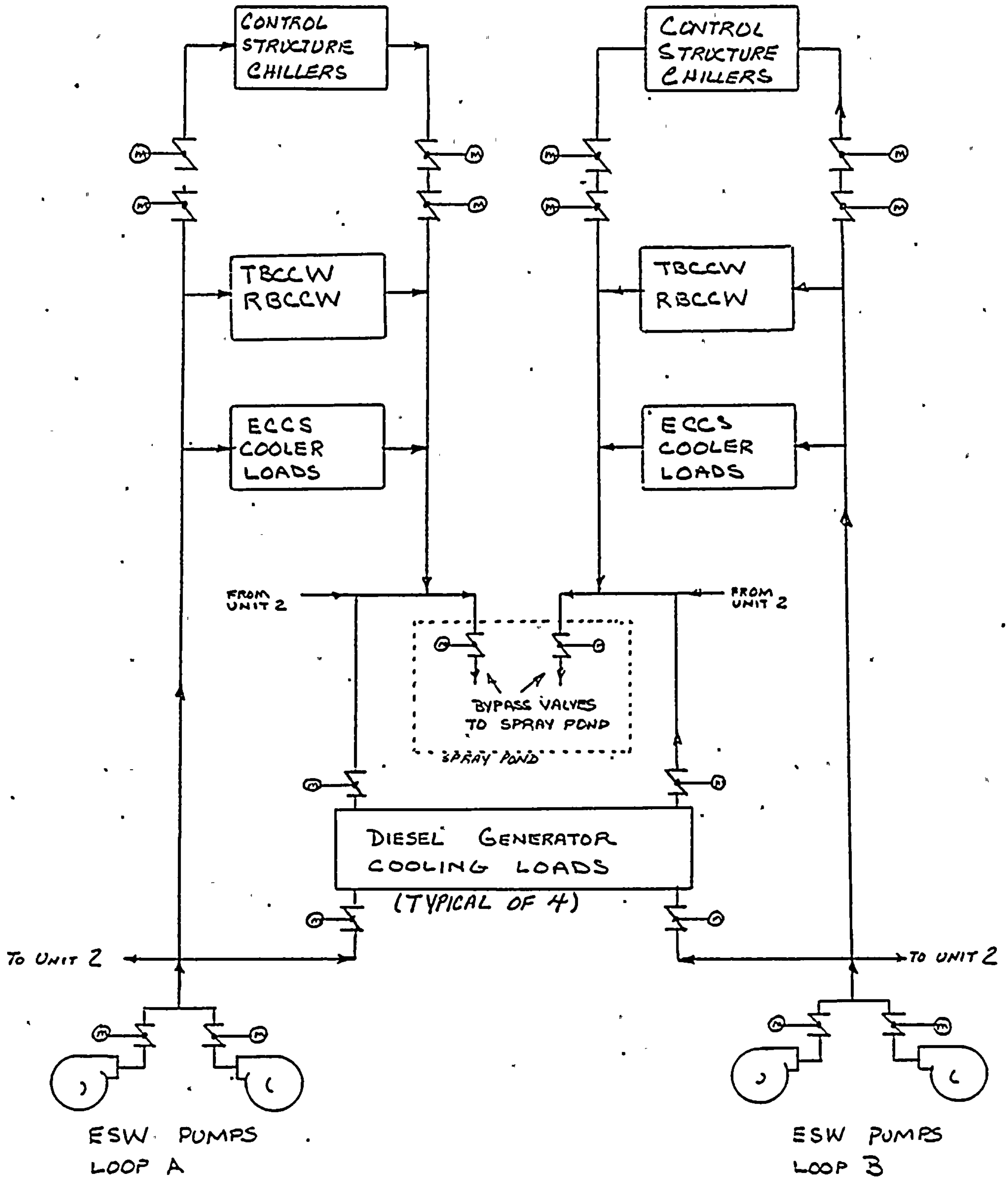
## ESW SYSTEM MODIFICATION

Option 2: This option would keep the ESW discharge valves and bypass valves open at all times.

Isolation of the vertical secitons of supply and return piping is provided to avoid drain down with normally closed series valves powered off different power supplies. The isolation valves on ESW supply are jogged open until a pressure switch at the ESW Loop highpoint picks up allowing the valves to fully open. Failure of one of the supply valves to open will result in loss of flow to the control structure chillers on the failed loop. This is acceptable as the control structure chillers require only 1 of 2 ESW loops for cooling. Automatic transfer from ESW Loop B to Loop A would be incorporated in the design.

A schematic of the system is attached for reference.

# ESW FIX - OPTION 2



# ESW SYSTEM MODIFICATION

Option 3: This option provides a flow path and drain down protection through either of two redundant trains of bypass valves should a single failure occur.

The ESW discharge valves (powered off separate power supplies) are jogged open 7° upon pump start and fully open once the system is filled. The bypass valves remain closed until 120 sec's after ESW pump start. Two trains of series bypass valves powered off separate power supplies provide protection against single failure.

Automatic transfer from ESW Loop B to Loop A would be incorporated in the design.

A schematic is attached for reference.

# ESW FIX - OPTION 3