NUCLEAR SAFETY-RELATED

CONTAINMENT COOLING SERVICE WATER PUMP ROOM COOLER HEAT LOAD STUDY

DRESDEN STATION - UNITS 2 AND 3

Report Prepared for

Commonwealth Edison Company

Report SL-7120

Revision 1

July 12, 1988

Sargent & Lundy

26pp.

TABLE OF CONTENTS

G. IE Bulletin 78-05 "Malfunctioning of Circuit Breaker Auxiliary Contact Mechanism - General Electric Model CR105X," dated April 14, 1978.

I. INTRODUCTION

The containment cooling service water (CCSW) pump room for each unit is located in the Turbine Building at elevation 495'-0" (Reference A). Each pump room contains two CCSW pumps and four coolers. Each pump has two coolers associated with it. Each cooler includes a coil and two fans. Depending on the mode of operation, one or two CCSW pumps operate in the room. Therefore, when one pump operates, four cooler fans are normally operating in the room. When two pumps operate, eight cooler fans are normally operating in the room. The pumps and coolers are part of the low pressure coolant injection system. 1

Per Reference B, the Dresden plant has been experiencing frequent trips of the the CCSW pump room cooler fan breakers causing 1 or 2 fans to be inoperable. The CCSW pumps and cooler fans can continue to operate until the room temperature reaches 131°F without exceeding their qualification temperatures (Reference Q). The purpose of this study is twofold:

A. First, determine how long one CCSW pump operation can continue without exceeding a CCSW pump room temperature of 131°F, with varying numbers of fans operating and entering service water temperatures of 95°F, 85°F and 75°F. Also, determine how long two CCSW pump operation can continue without exceeding a CCSW pump room temperature of 131°F with varying numbers of fans operating and entering service water temperatures of 95°F, 85°F and 75°F.

B. Secondly, determine the reason for the frequent fan cooler trips and provide recommendations for eliminating this problem.

II. TRANSIENT ANALYSIS

The transient analysis for the estimation of the room air temperature involved the preparation of a cubicle model which represents the geometry and heat transfer characteristics of the pump room and a fan cooler model which describes its heat removal capability for various

combinations of one or two CCSW pumps operating, inlet service water temperature and number of fans operating. Details of the analysis are found in Reference P. The salient assumptions and information used in this analysis are stated below.

A. Cubicle Modeling Assumptions and Information

1. Thermophysical heat sink properties from Reference C were used to model the concrete and steel boundaries of the CCSW cubicle.

2. The free volume of the CCSW cubicle was taken to be 85% of its gross volume to account for equipment, piping, ductwork, etc., within the cubicle.

3. A LOCA temperature of 120°F (Reference D) exists in all surrounding cubicles.

4. A loss-of-offsite power was assumed to occur, so that no normal ventilation to the CCSW cubicle or its surrounding cubicles was considered in the analysis.

5. Because of the close proximity of the buried circulating water header, the soil on the north side of the cubicle was assumed to be the same temperature as the condenser discharge circulating water temperature (115.3°F maximum per Reference D).

6. The duct/concrete/steel plate combination in the cubicle floor was modeled conservatively as a 15 ft^2 steel plate.

7. The heat load of each pump motor is 100,915 Btu/hr (Reference E), the lighting heat load is 1638 Btu/hr (Reference F) and the heat load due to each cooler fan was conservatively assumed to be 7632 Btu/hr (Reference G).

8. Radiation and convection heat transfer from the 120°F air surrounding the CCSW cubicle to the cubicle was accounted for. A conduction path through the soil/concrete was modeled on the north side of the cubicle.

9. An initial CCSW cubicle temperature of 105°F was assumed (Reference H).

10. The hinged test plates, used when pressure testing water tight doors on CCSW cubicles, are assumed to be open or removed.

B. Fan Cooler Modeling Assumptions and Information

1. The heat removal rate for the fan coolers is assumed to depend on the number of fans operating in the room, the inlet cooling water temperature and the room air temperature.

2. The heat exchanger coil associated with each fan is assumed to be half of the coil of a 2-fan unit and the heat transfer in each half does not depend on whether or not the other fan is operating. Also, see 3, below.

3. The mean cooling water temperature in each fan's associated coil is assumed the same as with both fans of a 2-fan unit operating even if one fan is off. This is conservative since without one fan operating, the mean cooling water temperature would be less and provide a lower temperature heat sink.

4. The reduction in air flow rate through a fan-coil path due to increase in the air temperature is assumed to be negligible.

5. The overall heat transfer coefficient for the coil is assumed to be independent of room air temperature.

6. The effectiveness of each fan-coil unit was assumed to be constant and based on the design point data of Reference I.

7. Based on the above, the methodology of Reference J was used to determine the heat exchanger effectiveness and the heat removal rate at each inlet water and number of operating fans combination.

8. For the case of two CCSW pump operation, the number of operating fans are assumed divided as evenly as possible between each CCSW pump's fan cooler units. This is to ensure adequate mixing of the CCSW pump room air. | 1

III. CCSW FAN FAILURE

A. Brief History of CCSW Fan Failures

On October 1, 1987, at 0915 hours, with Unit 2 at 93% rated thermal power while conducting DOS-1500-2, Monthly Containment Cooling Service Water Pump Test for the In-Service Test (IST) Program, the equipment operator discovered that one of the four (specifically fan 2-5700-30D) CCSW watertight vault room cooler fans (which cools the 2C CCSW pump) was not operating. The Unit 2 Shift Foreman immediately investigated this anomaly and discovered that the 480 Vac contactor was open. Electrical Maintenance (EM) personnel were immediately dispatched to Motor Control Center (MCC) 29-2 compartment D3 to investigate and repair this failure under the direction of Work Request #69311. The contactor coil was burned out and was replaced. The watertight vault cooler fan (2-5700-30D) was then declared operable along with its associated CCSW pump.

On October 4, 1987, at 2140 hours with Unit 2 at 99% rated thermal power while conducting DOS-1500-3, CCSW Pump Test, which results in the 2B LPCI pump being out of service, the CCSW watertight vault cooler fan (2-5700-30D) which cools the 2C CCSW was again found inoperable due to the 480 Vac contactor being open. Investigation and repairs by EM personnel were then initiated. The watertight vault cooler fan (2-5700-30D) was declared operable at 0625 hours on October 5, 1987.

B. Analysis of Failure

Deviation Investigation Report (DIR) titled "Orderly Unit Shutdown Due to Inoperable 2B LPCI and 2C CCSW Pumps", DIR number 12-02-37-136-00, was written to address this problem. The DIR stated the root cause of the 480 Vac contactor failure has been attributed to binding auxiliary contacts on the 480 Vac contactor. These auxiliary contacts would bind in the partially open/closed position causing high resistance and arcing when the 480 Vac contactor attempted to seal in. The binding of the auxiliary contacts resulted in high temperatures of the contactor coil windings and eventual coil burnout. The binding auxiliary contacts are believed to be the cause for both (October 1 and October 4) CCSW watertight vault cooler fan (2-5700-30D) failures.

IV. SUMMARY-CONCLUSIONS AND RECOMMENDATIONS

A. One CCSW Pump Operating

Figures 1, 2 and 3 are plots of the transient CCSW cubicle temperature for 95°F, 85°F and 75°F entering cooling water temperature, respectively. Figure 1 presents five curves describing the transient temperature as a function of time with 0, 1, 2, 3 or 4 fans operating. From this figure it is seen that the CCSW cubicle will reach a temperature of 131°F in less than 2 minutes when no fans operate. Although not shown in this figure the CCSW cubicle temperature would exceed 160°F in 6 minutes with no fans operating. When 1 fan operates, the temperature at 10

hours as shown in the figure is approximately 128°F. At 100 hours the additional temperature increase in the cubicle is less than 2 degrees above the 10-hour value. Efforts to qualify the CCSW pump motors to temperatures greater than 131°F would have marginal success because our results indicate that only a marginal increase in the operating time could be justified. The cubicle remains below 115°F for a 10-hour period for the conditions of 2, 3 or 4 operating fans. Also, the temperature rate of increase, at 10 hours, is minimal.

The 85°F inlet cooling water results are presented in Figure 2 and they indicate that the cubicle temperature will reach 120°F in approximately 10 hours with 1 fan operating. The heat removal rate in the 2 fan case balances the heat load in the room and the 3 fan case causes the cubicle temperature to decrease.

Figure 3 presents the case of one fan operating with 75°F inlet water temperature. In this case, the CCSW temperature is approximately 112°F after 10 hours and is increasing slowly.

Results for the 4 fans operating case at an entering cooling water temperature of 85°F and the 2, 3 or 4 fans operating cases at 75°F entering water temperatures were not calculated because the results are bounded by the cases presented.

B. Two CCSW Pumps Operating

Figures 4, 5 and 6 present CCSW cubicle temperature transients for 95°F, 85°F and 75°F entering cooling water temperature with two CCSW pumps operating. Figure 4 presents five curves describing transient temperature as a function of time with 1, 2, 3, 4 or 6 fans operating. From this figure it is seen that the CCSW cubicle will reach a temperature of 131°F in less than 2 minutes when only 1 fan operates. When 2 fans operate, the temperature at 10 hours as shown in the figure is approximately 129°F. At 100 hours the additional temperature increase in the cubicle is less than 1 degree above the 10-hour value. For the condition of 3, 4 or 6

fans operating, the cubicle remains below 120°F for a 10-hour period and the temperature rate of increase after 10-hours is minimal.

The 85°F inlet water results are presented in Figure 5 and they indicate with only one fan operating the cubicle temperature will also exceed 131°F in less than 2 minutes. With 2 fans operating the cubicle temperature will reach 120°F in approximately 10 hours. With 3 fans operating, the cubicle temperature remains below 110°F. The heat removal rate slightly exceeds the heat load with 4 fans operating.

Figure 6 indicates that even with 75°F entering water temperature and 1 fan operating the qualification temperature for the CCSW pump motors is exceeded in less than 3 minutes. With 2 fans operating the temperature in the cubicle is less than 111°F after 10 hours.

Results for the cases of more than 6 fans operating at an entering cooling water temperature of 95°F, the cases of more than 4 fans operating at an entering cooling water temperature of 85°F, or the cases of more than 2 fans operating at an entering cooling water temperature of 75°F were not calculated because the results are bounded by the cases presented.

To ensure adequate mixing, the above results assume the number of fans operating are evenly divided between each CCSW pump's fan coolers. When three fans operate, however, one fan would be associated with one CCSW pump's cooler and two fans would be associated with the other CCSW pump's coolers. 1

C. CCSW Fan Failure

Sargent & Lundy (S&L) agrees with DIR 12-02-87-136-00 and concurs that the 480 Vac contactor coil failed as a result of the binding auxiliary contacts mounted on the the 480 Vac contactor.

S&L investigated Nuclear Plant Reliability Data System (NPRDS) and determined there was no similar occurrences noted in the data system.

In addition, S&L investigated to determine if the failed auxiliary contact [General Electric (G.E.) Model No. CR 105X100D] had any IE Bulletins written against it in common failures elsewhere.

IE Bulletin No. 78-05 "Malfunctioning of Circuit Breaker Auxiliary Contact Mechanism General Electric Model CR105X" describes the following generic problem with GE CR105X auxiliary contacts:

> The specific cause for failure was binding of the plunger arm due to burrs and nicks on its surface."

Although IE Bulletin No. 78-05 does not specifically state that the auxiliary contact that failed at Dresden (Model No. CR 105X100D) is one of the model numbers that they suggest be replaced, S&L contacted GE, San Jose, in care of Dennis Tretheway to confirm this.

Mr. Tretheway confirmed that G.E. Model No. CR 105X100D is one of the auxiliary contacts identified in IE Bulletin 78-05. The suggested recommended action to be taken by Licensees is shown on page two of IE Bulletin 78-05 (Appendix G).

Dresden procedure DMP 7300-5, Unit 2(3) Inspection and Maintenance of 480V MCC Breakers/Contactors and 208V Contactors, is the procedure used to clean Motor Control Centers (MCCs) internals, including 480 VAC contactors and auxiliary contacts. CECo should confirm that procedure DMP 7300-5 is suitable to meet requirements of IE Bulletin 78-05. If this is so, S&L believes the failed 480 Vac contactor for the watertight vault room cooler fan 2-5700-30D can be treated as an isolated case with no additional failures expected in the future. If not, CECo should investigate this matter further.

V. REFERENCES

A. Sargent & Lundy Drawing M-5, Revision D

B. "CCSW Pump Room Cooler Heat Load Study," Inter-Office Memorandum from J. M. Nosko (PMED) to E. Schumacher (EPED) and M. D. Stout (HVAC), dated February 2, 1988.

C. Standard Review Plan 6.2.1.5, NUREG-0800, Branch Technical Position CSB 6-1, Table 2, "Heat Sink Thermophysical Properties", p 6.2.1.5-8, Rev. 2, 1981.

D. DIT-DR-HVAC-0014, "Containment Cooling Service Water (CCSW) Pump Room Heat Load Study"

E. "Primary Containment Service Water Coolers", HVACD Calc. No. HV86-1, Rev. 0, July 11, 1986.

F. DIT-DR-EPED-0192-00, "Additional Electrical Equipment in CCSW Pump Rooms for HVAC Considerations."

G. Buffalo Forge Drawing No. 7C-64356, Rev. A, March 15, 1973.

H. Containment Cooling Service Water Pump Room Heat Load Study-Kickoff Meeting," Interoffice Memorandum from B. Pesha (HVACD) to J. M. Nosko (PMED), dated April 8, 1988.

I. "Dresden Station, Units 2 & 3 Cubicle Coolers," Letter from S. O. Johnson (Buffalo Forge Co.) to P. M. Mehrotra (Sargent & Lundy), dated January 8, 1973.

J. Kays, W. M. and London, #Water Pump Cooler Fan Motors 2(3)-5700-30A-D."

K. IE Bulletin No. 78-05 "Malfunctioning of Circuit Breaker Auxiliary Contact Mechanism - General Electric Model CR 105X, dated April 14, 1978.

L. G.E. response to IE Bulletin No. 78-05, dated April 14, 1978.

M. Telephone Conversation Memorandum between D. Tretheway (G.E.) and S. P. Cevigney (S&L) dated April 28, 1988.

N. DMP 7300-5, Unit 2(3) Inspection and Maintenance of 480V MCC Breakers/Contactors and 208V Contactors, Revision 8.

O. DIR 12-02-87-136-00, Orderly Unit Shutdown Initiated Due to Inoperable 2B LPCI and 22C CCSW Pumps, dated 11-4-87.

P. "Containment Cooling Service Water Cubicle Heat Load Study" NSLD Calc. No. 3C2-0488-001, Rev. 0, dated June 14, 1988.

Q. DIT-DR-CQD-510109-00, "Operability of Containment Cooling Service Water Pump Motor 2(3)B-1501-44 and 2(3)C-1501-44" and DIT-DR-CQD-510108-00, "Operability of Containment Service Water Pump Cooler Fan Motors 2(3)-5700-30A-D."

SARGENT & LUNDY

Prepared by : T J Kane Date: July 12, 1988

T. J. Kane
Senior Safeguards Engineer
Nuclear Safeguards & Licensing Division

S P Cevigney Date: July 12, 1988

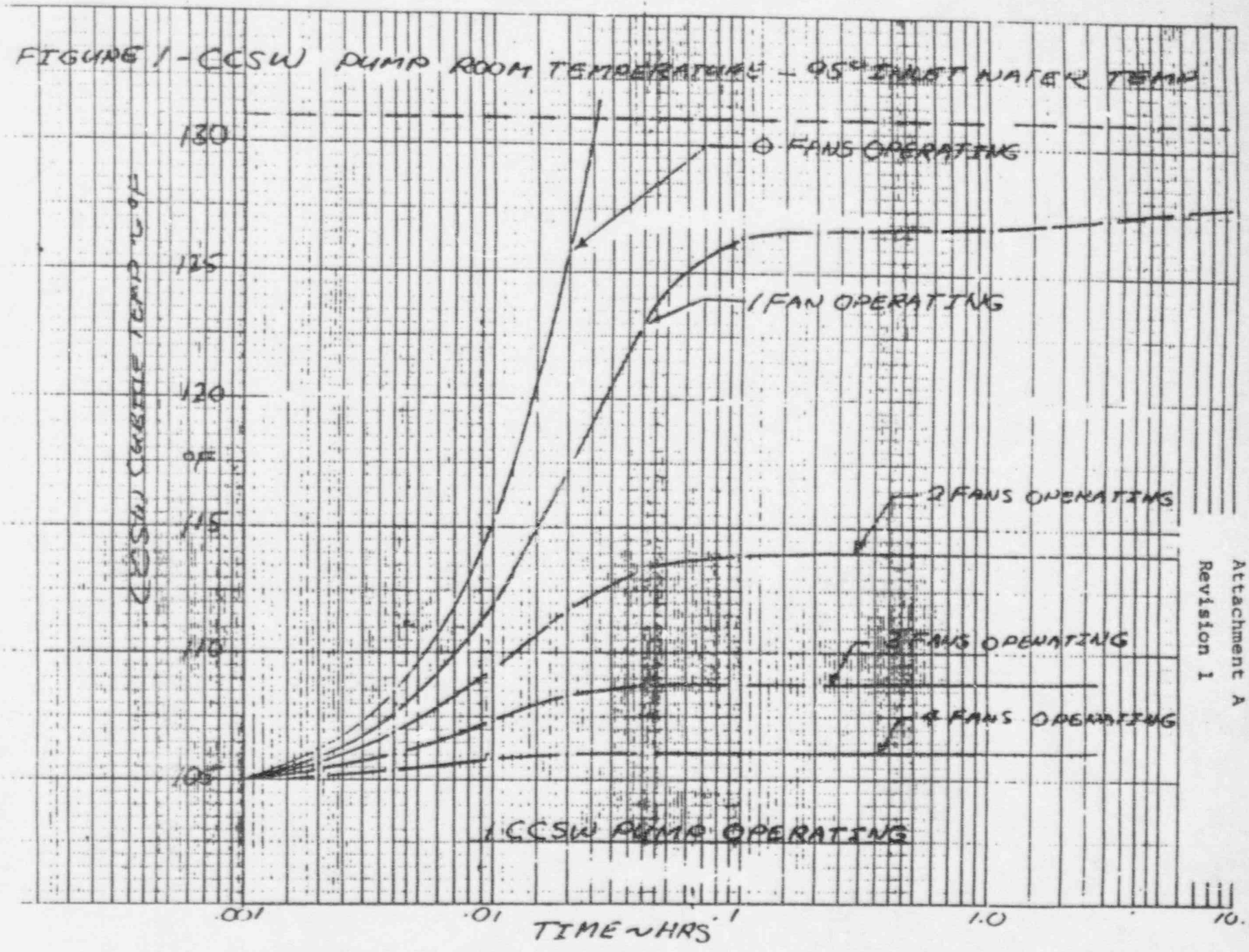
S. P. Cevigney
Electrical Engineer
Electrical Project Engineering Division

Reviewed by: B. Pesha Date: July 12, 1988

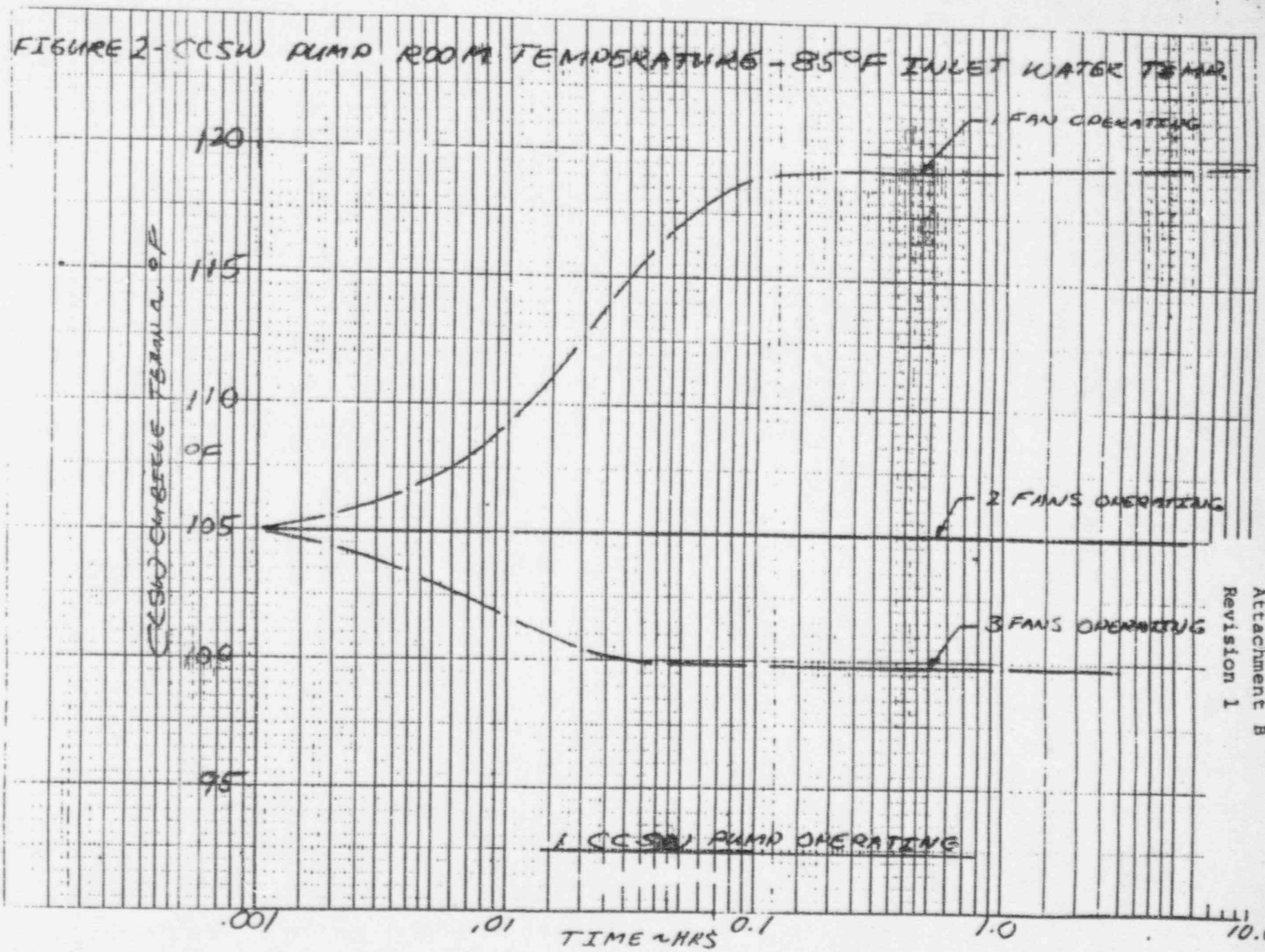
B. Pesha
HVAC Project Engineer
Heating, Ventilating and Air Condition Division

Approved by: J M Nosko Date: 7/12/88

J. M. Nosko
Project Manager
Project Management & Engineering Division



Attachment A
Revision 1



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Revision 1

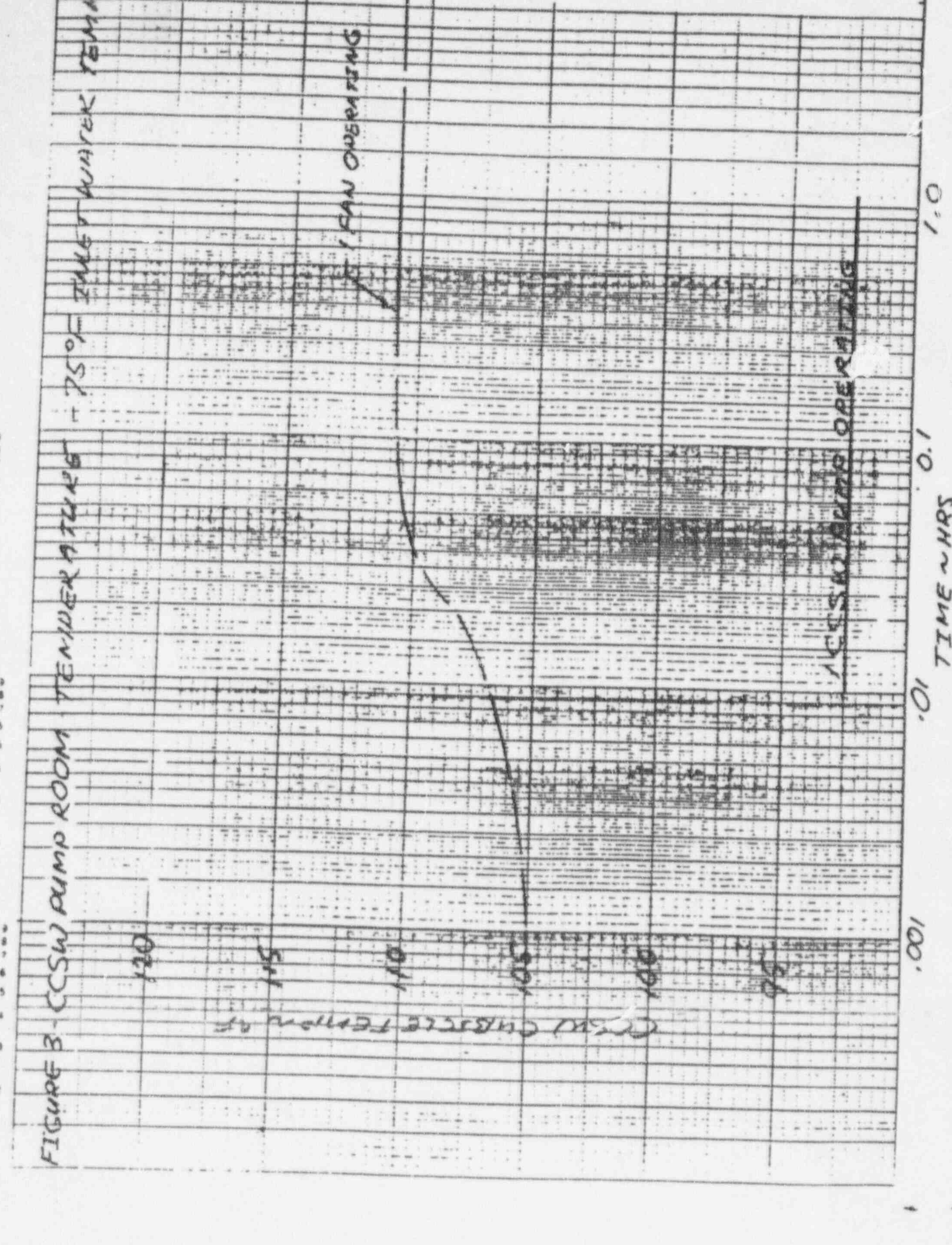
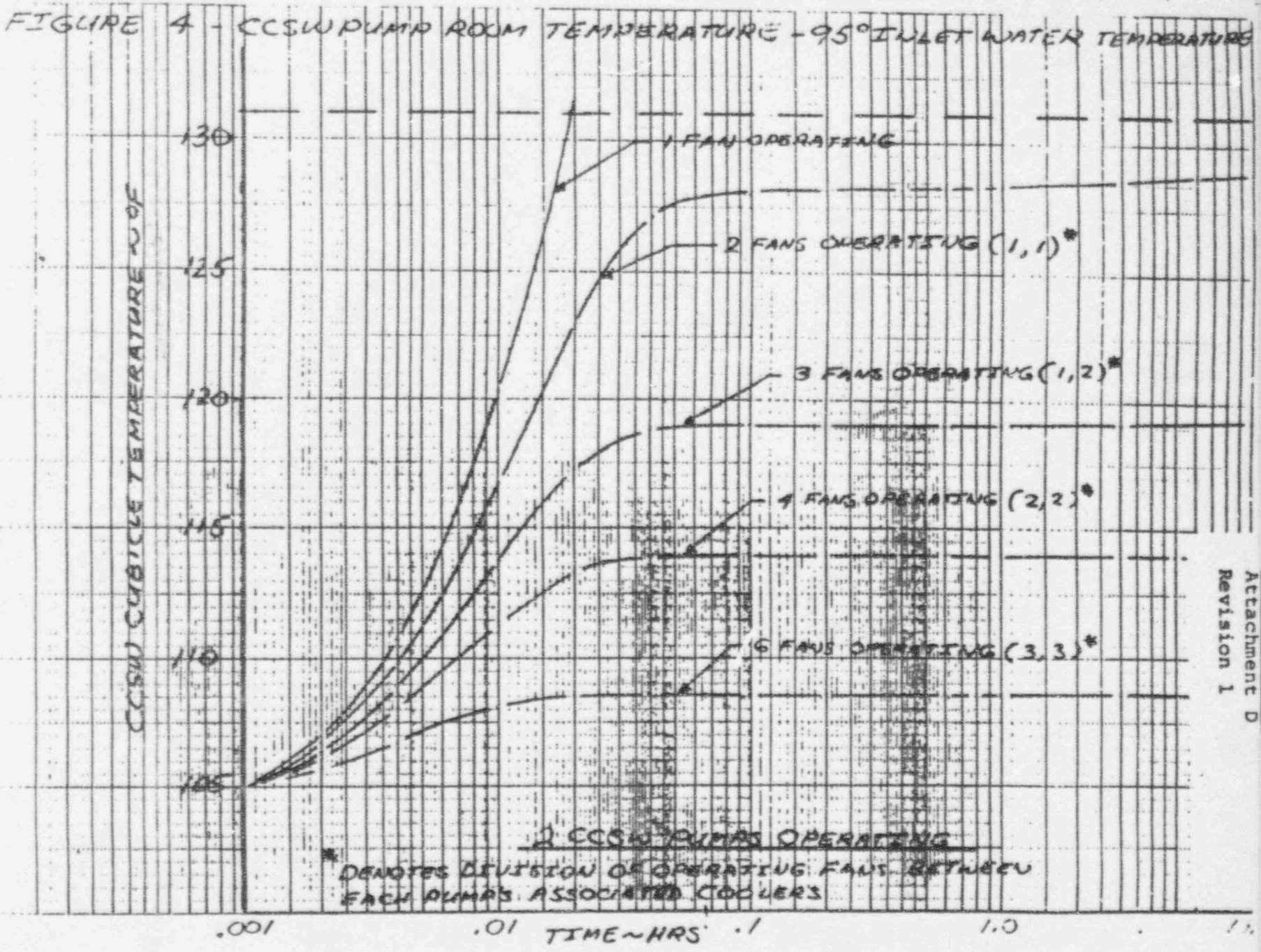
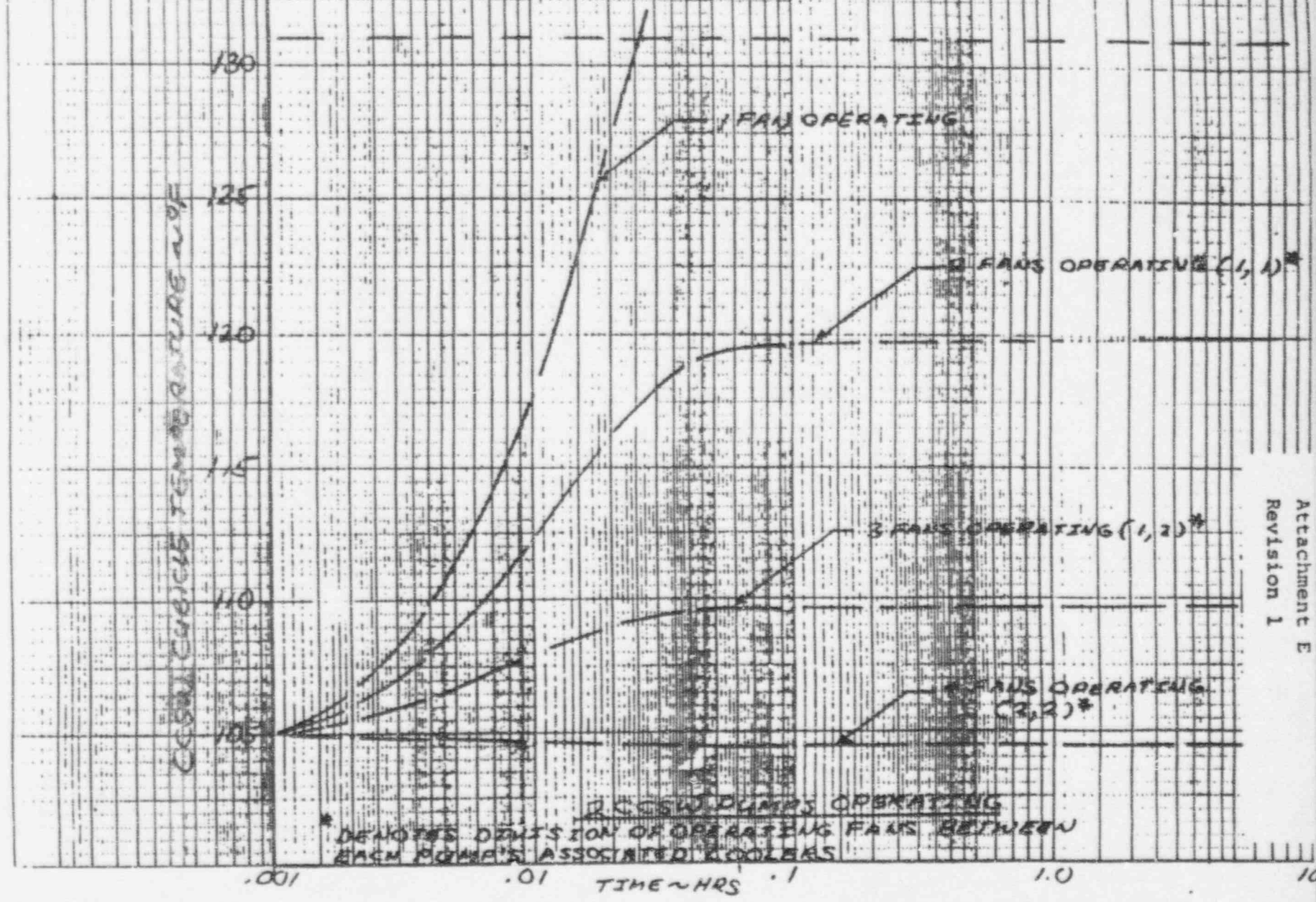


FIGURE 3 CCSW PUMP ROOM TEMPERATURE - 75°F INLET WATER TEMP



Attachment D
Revision 1

FIGURE 5 - CCSW PUMP ROOM TEMPERATURE - 85° INLET WATER TEMPERATURE



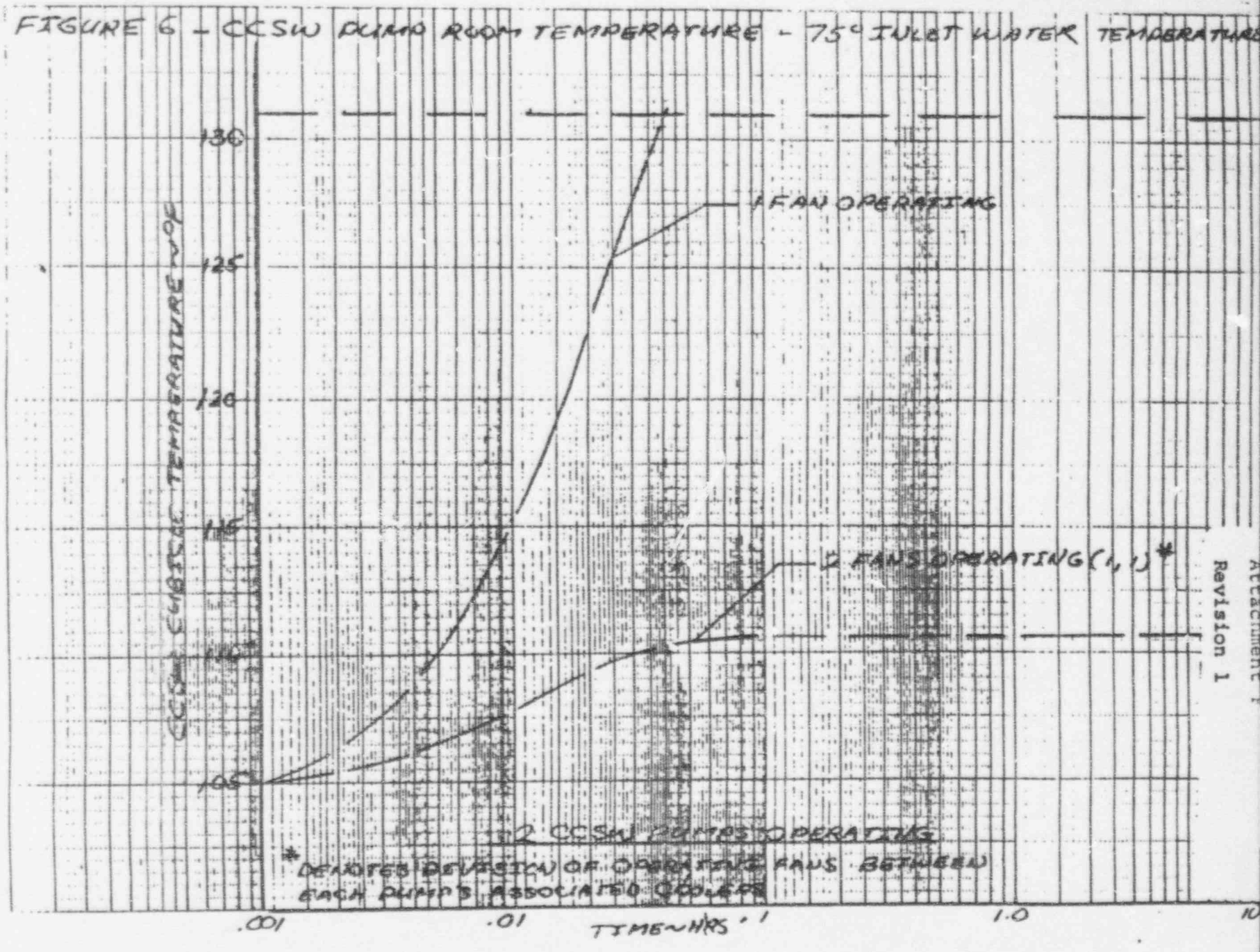


FIGURE 6 - CCSW PUMP ROOM TEMPERATURE - 75° INLET WATER TEMPERATURE
CCSW SUBSYS. TEMPERATURE - °F
130
125
120
115
105
1 FAN OPERATING
2 FANS OPERATING (1,1)*
2 CCSW PUMPS OPERATING
* DENOTES DIVISION OF OPERATING FANS BETWEEN EACH PUMP'S ASSOCIATED COOLER
.001
.01
TIME-HRS
1.0
10
Revision 1
Attachment

UNITED STATES

WASHINGTON, D. C. 20555

April 14, 1978

IE Bulletin No. 78-05

MALFUNCTIONING OF CIRCUIT BREAKER AUXILIARY CONTACT MECHANISM - GENERAL ELECTRIC MODEL CR105X

Description of Circumstances:

The Sacramento Municipal Utility District recently reported a problem encountered with the operation of the GE Model CR105X auxiliary contact mechanism installed in a 480 volt circuit breaker. Investigation into the cause for the inability to shutdown a booster supply fan (SF-A-7) in the control room emergency air conditioning system revealed that an auxiliary contact (GE Model CR105X) had failed in the closed position, preventing the fan's power supply circuit breaker from opening. The specific cause for failure was binding of the plunger arm due to burrs and nicks on its surface.

An investigation was conducted by the licensee to determine the extent of usage of this type auxiliary contact in other circuits throughout the reactor power plant. Approximately fifty (50) positions in the nuclear service motor control centers were identified as having a similar type auxiliary contact mechanism. It was also determined that many of the affected systems which require contact operation similar to that described above, either permit or provide a safety feature function during emergency conditions. An example of this type application is auxiliary contacts that must open to permit closing of certain safety related valves from 480 volt motor control centers.

The attached GE Service Advice Letter and associated instruction/drawing sheet were sent to all nuclear power reactor facilities by GE Field Service Offices. The letter, together with the instruction/drawing sheet identifies the problem and provides the recommended corrective action.

Action To Be Taken By Licensees:

For all power reactor facilities with an operating license or construction permit:

1. If you have received the enclosed General Electric letter and instruction/drawing sheet addressing the auxiliary contact mechanism problem, and if you have these devices in use at your facility, it is requested that you describe what corrective action you have taken.

2. If you have not received the enclosed GE documents before, it is requested that you describe what action you plan to take if the GE CR105X auxiliary contact mechanism is in use or planned for use in safety systems at your facility(ies).

3. Facilities having an operating license should report in writing, within 45 days, and facilities with construction permits within 60 days, the results of action taken or planned with regard to Items 1 and 2 above. Your written reply should also include the date when such actions were or will be completed. Reports should be submitted to the Director of the appropriate NRC Regional office and a copy should be forwarded to the U. S. Nuclear Regulatory Commission, Office of Inspection and Enforcement, Division of Reactor Operations Inspection, Office of Inspection and Enforcement, Washington, D, C, 20555.

Approved by GAO, B180225 (R0072); clearance expires 7/31/80. Approval was given under a blanket clearance specifically for identified generic problems.

Attachments:
1. GE Letter
2. ~~GE Control and Instruction~~ Sheet

File
Room
Coolers

August 3, 1988

Subject: Dresden Station Units 2 and 3
CCSW Pump Room Cooler
Heat Load Study
AIR 12-87-37

Reference: Letter dated 7/21/88 from W.B. Fancher to E.D. Eenigenburg; Subject: Final Report-Revision 1

To: E.D. Eenigenburg
Station Manager

The above referenced letter stated that one CCSW pump can continue to operate if one out of four fans are inoperable with an entering cooling water temperature of 95 degrees F. This is not a true statement. The statement should have read that for one CCSW pump operation, only one out of four fans is required to be operable with an entering cooling water temperature of 95 degrees F.

If there are any further questions, please contact me on extension 2874.

Prepared by: Sam Powers 8/3/88
S. Powers Date
BWRED Engineer

Approved by: Z. J. Boxer 8/10/88
for W.B. Fancher Date
Project Engineer
Dresden/Quad Cities

8/3/88

cc: E. Zebus
J. Achterberg
M. Korchynsky
M. Reed
J. Lizelek
J. McDonald
Z. Boxer
W. Fancher
M. Schriem
T. Brunner

July 21, 1988

Subject: Dresden Station Units 2 and 3
CCSW Pump Room Cooler
Heat Load Study
AIR No. 12-87-37
Final Report-Revision 1

Reference: Letter dated July 12, 1988 from J.M. Nosko (S&L) to S.P. Powers

To: E.D. Eenigenburg
Station Manager

The attached above referenced letter provides revision 1 to the final report that addresses the subject AIR. The purpose of this transmittal is to provide clarification as to the number of fans that are required to be operable during two CCSW pump operation. The results indicate that two CCSW pumps can operate if one cooler fan associated with each CCSW pump is operable (two cooler fans out of eight) with an entering cooling water temperature of 95 degrees F. Also, similiarly one CCSW pump can continue to operate if one out of four fans are inoperable with an entering cooling water temperature of 95 degrees F.

Also in regards to the fan breaker failure problems, the Station should confirm that procedure DMP 7300-5 is suitable to meet requirements of I.E. Bulletin 78-05, " Malfunction of Circuit Breaker Auxilary Contact Mechanism General Electric Model CR 105X " and to preclude any future fan breaker failures.

With the issue of this revision to the final report, the Station should close the AIR indicating no further action is needed by the BWR Engineering Department.

If there are any further questions, please contact me on extension 2834.

Prepared by: Sam Powers 7/21/88
S. Powers Date
BWRED Engineer

Approved by: for Z. J. Boxer 7/26/88
W.B. Fancher Date
Project Engineer
Dresden/Quad Cities

Attachment
Copies: E. Zebus
J. Achterberg
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July 12, 1988
Project No. 7927-36

Commonwealth Edison Company
Dresden Station - Units 2 & 3

Report SL-7120, Revision 1
Containment Cooling Service Water (CCSW)
Pump Room Cooler Heat Load Study

Mr. S. P. Powers
BWR Engineering Department
Commonwealth Edison Company
P. O. Box 767, 35FNW
Chicago, Illinois 60690

Dear Mr. Powers:

Enclosed is a copy of the following report:

Report SL-7120
Containment Cooling Service Water
Pump Room Cooler Heat Load Study
Revision 1, July 12, 1988

This report was revised to include Commonwealth Edison's comments and it is being re-issued in its entirety.

The objectives of this study were:

- To determine how long the CCSW pumps can continue to operate without exceeding their qualification temperature with various combinations of cooler fans out of service.
- To determine the reasons for the frequent fan cooler trips and to provide recommendations to eliminate this problem.

We have performed the necessary temperature transient analyses for the CCSW pump room with one and two CCSW pumps operating. We have also investigated the reasons for the frequent fan cooler trips. The results of our evaluation indicate:

- One CCSW pump can operate if only one of four cooler fans operate, with an entering cooling water temperature of 95°F.

Mr. S. P. Powers
Commonwealth Edison Company

July 12, 1988
Project No. 7927-36

- Two CCSW pumps can operate if one cooler fan associated with each CCSW pump operates (i.e. two cooler fans out of eight), with an entering cooling water temperature of 95°F.
- The cooler fan 2-5700-30D failures can be treated as an isolated case with no additional failures expected as long as Dresden Procedure DMP-7300-5 is in place and is being followed.

It is our understanding that BWR Engineering will distribute this report per Commonwealth Edison Company distribution list. If you have any questions, please contact Mr. B. Pesha at (312) 269-6794.

Yours very truly,

J. M. Nosko
Project Manager

JMN:BP:mjb
In duplicate
Enclosure
Copies:
W. B. Fancher (1/0)
R. J. Mazza (1/1)
R. H. Jason (1/0)
E. Schumacher (1/1)
T. J. Kane (1/1)
B. Pesha (1/1)
M. D. Stout (1/1)