LIC-95-0177
Attachment 1

FORT CALHOUN STATION UNIT NO. 1

ENGINEERING ANALYSIS EA-FC-90-062
Revision 3

"Diesel Generator Upper Temperature Limits"

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PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

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EA REVIEW CHECKLIST

EA-FC- 90-062 Rev. No. 3 EA Page No. 1 Total Pages ~~192~~ 190

EA TITLE:
DIESEL GENERATOR UPPER TEMPERATURE LIMITS

QA CATEGORY:
☒ CQE ☐ Fire Protection
☐ Non CQE ☐ Limited CQE

REPORT TYPE:
☐ Revision
☒ Analytical Report
☐ Special

Does this change require a DBD Revision? ☐ YES ☒ NO	Does this analysis identify any potentially reportable conditions? ☐ YES ☒ NO	Does this change require a USAR Revision? ☐ YES ☒ NO

INITIATION:

Responsible PED Department DEN- MECHANICAL - 357

Responsible Department Head Alan W. Richard Date 9/8/95

Preparer KEVIN HYDE Date 8/21/95

* Mgr - Station Eng./Mgr - DEN ______ Date ______

PED Department No. 357 Due Date ______

ENGINEERING ANALYSIS TYPE:

Electrical Equipment Qualification (EEQ) ☐
Seismic Equipment Qualification (SEQ) ☐
Core Reload Analysis (CRA) ☐
Fire Protection Analysis (FPA) ☐
Cable Separation Analysis (CSA) ☐
Associated Circuits Analysis (ACA) ☐
Safe Shutdown Analysis (SSA) ☐
OTHER: ______ ☐

Computer Code Error Analysis (CCE) ☐
Nuclear Mat'l Accountability (NMA) ☐
Operations Support Analysis (OSA) ☒
USAR Justification (USJ) ☐

* Only required when independent review authorization is required.

DISTRIBUTION:

Group	Name & Location	Copy Sent (X)	Group	Name & Location	Copy Sent (X)
352	Supervisor - System Engineering KEVIN HYDE FC-2-4 (3-HOLE)	X			

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PREPARATION/REVIEW:

Preparer(s) Signature 8/21/95 Date

Reviewer(s) R F Mehaffey Signature 9/1/95 Date

Independent Reviewer(s) R F Mehaffey Signature 9/8/95 Date

AFFECTED DOCUMENTS:

Title	Revision	Responsible Division/Dept
USAR SECTION 8.4.1.2		356
TDB FIG III.26.A		356/357

AFFECTED SYSTEM/EQUIPMENT:

System	Tag No.(s)
DG	DG-1, DG-2
	VA-52A, 52B, 759A, 759B
	AI-133A, AI-133B

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EA REVIEW CHECKLIST

	YES	NO	N/A
1. Does the PURPOSE section adequately and correctly state the reason: or the need to prepare the EA?	✓		
2. Does the EA adequately and correctly address the concerns as stated in the PURPOSE section?	✓		
3. Are the RESULTS AND CONCLUSIONS stated and reasonable and supportive of the PURPOSE and SCOPE?	✓		
4. Were the methods used in the performance of the Analysis appropriately applied?	✓		
5. Have adjustment factors, uncertainties and empirical correlations used in the analysis been correctly applied?	✓		
6. Were the INPUTS correctly selected and incorporated into the EA?	✓		
. Are all INPUTS to the ANALYSIS correctly numbered and referenced such that the source document can be readily retrieved?	✓		
8. Were the ASSUMPTIONS used to prepare the EA adequately documented?	✓		
9. Have the appropriate REFERENCE and the latest revisions been identified?	✓		
10. Have the REFERENCES been appropriately applied in the preparation of the EA?	✓		
11. Is the information presented in the ANALYSIS accurate and clearly stated in a logical manner?	✓		
12. If manual calculations are presented in the ANALYSIS are they:			
a. free from mathematical error?	✓		
b. appropriately documented commensurate with the scope of the analysis?	✓		
13. Have the affected documents, identified on the PED-QP-5.1 form been accurately marked up and included with a 10CFR50.59 evaluation (if applicable)?	✓		~~✓~~ RJM [illegible]

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	YES	NO	N/A
14. Is the EA free of unconfirmed references and assumptions?	✓		
15. Have all crossouts or overstrikes been initialed and dated by the Preparer/Reviewer?	✓		
16. Is the EA legible and suitable for reproduction and microfilming?	✓		
17. Has the EA Cover Sheet been appropriately completed?	✓		
18. For <u>Revisions</u> only, is the change identified and the reason for the change provided on the Record of Revision Sheet?	✓		
19. Does the computer run have page number ans alphanumeric program number on every sheet?	✓		
20. Is the listing or file reference of the final computer input and output provided?			✓
21. Is the computer code title and version/level properly documented in the EA?			✓
22. Is the identification number (Ref. PED-MEI-23, Section 5.3.1) on the cover sheet as part of the EAs description?			✓
NOTE: Only applies to DEN Mechanical and Electrical/I&C Departments.			
23. Are final computer runs correctly identified?			✓
24. Is the computer program validated and verified in accordance with NOD-QP-5?			✓
25. If the computer program was developed for limited or onetime use and not validated and verified in accordance with NOD-QP-5, has a functional description of the program, identification of the code (title, revision, manufacturer), identification of the software and brief user's instructions been documented in the EA?			✓
26. Is the modeling correct in terms of geometry input and initial conditions?			✓

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	YES	NO	N/A
27. If the analysis has identified a condition that may be outside the design basis of the plant, has a PED-QP-19 reportability evaluation been completed?			✓

NOTE: Applicable only to analysis of existing conditions.

NOTE: For all "No" responses, a written comment shall be documented on Comment Form PED-QP-5.5 briefly explaining the deficiency and, as appropriate, providing a suggested resolution.

COMMENTS:

Reviewer(s) Signature

9/8/95
Date

356/DEN
Department/Organization

PRODUCTION ENGINEERING DIVISION
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EA INDEPENDENT REVIEW CHECKLIST

	YES	NO	N/A
1. Were the INPUTS correctly selected and incorporated into the EA?	✓		
2. Are the ASSUMPTIONS necessary to perform the EA adequately described and reasonable and appropriately documented?	✓		
3. If applicable, have the appropriate QA requirements been specified?	✓		
4. Are the applicable codes, standards and regulatory requirements including issue and addenda properly identified and the requirements correctly applied in the EA?	✓		
5. Is the approach used in the ANALYSIS section appropriate for the scope of the EA?	✓		
6. Were the methods applied in the performance of the ANALYSIS appropriate?	✓		
7. Has applicable operating experience been considered (e.g. for replacement parts/components, has NPRDS, INPO, NRC, industry experience been used supporting the application)?			✓
8. Have any interface requirements been appropriately considered (e.g. between disciplines, Divisions, etc.)?	✓		
9. Are the results and conclusions reasonable when compared to the purpose and scope?	✓		
10. Has the impact on Design Basis Documents and the USAR been correctly identified and considered?	✓		
11. Have all applicable licensing commitments regarding the subject EA been met?	✓		

NOTE: For all "No" responses, a written comment shall be documented on Comment Form PED-QP-5.5 briefly explaining the deficiency and, as appropriate, providing a suggested resolution.

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COMMENTS:

R F Mehaffey 9/8/95 355/DEN

Independent Reviewer(s) Signature

Date

Department/Organization

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REV. 3

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Review and Approval
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Record of Revision

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Rev. No.	Description/Reason for Change
0	INITIAL ISSUE
1	Revised Analysis as noted with sidebars based on Revision 2 of calculation FC03382 and latest Diesel Generator jacket water outlet gauge calibrations.
2	Revised analysis as noted with side bars based on Rev. 3 of calculation FC03382, MR-FC-90-073 DG Exciter Cabinet Cooling, Jacket Water System Improvements and Coolant Change.
3	REVISE WORDING of SECTION 6.9.1 (PG 23) PER CID 920024/01 ADD STATEMENT TO CONCLUSIONS (SEC 7.2, PG 29) INDICATING CONCLUSIONS ARE SUPERSEDED BY CALCULATION FC05916 REV 3.

REV. 3

1.0 PURPOSE

The purpose of this Engineering Analysis is to establish the maximum outdoor ambient air temperature at which diesel generators DG-1 and DG-2 can be expected to provide power to the Engineered Safety Features (ESF) loads to assure safe reactor shutdown should a Design Basis Event requiring diesel generator response occur. This maximum limit also assures that single failure criteria are met.

2.0 SCOPE

The scope of this Engineering Analysis is to:

2.1 Define the worst case load and load profile.

2.2 Establish the engine/generator outputs based on the outdoor ambient temperature, diesel generator operational effects on room ambient temperature, results of radiator cleaning and results of engine coolant changeout.

△2

2.3 Establish the capability of the generator/exciter to operate in the diesel generator room environment based on the exciter cooling modification, MR-FC-90-073, as well as with the cabinet doors off in the event of cooler failure.

2.4 Establish the margin available to allow operator restart of equipment to enhance shutdown, i.e. an air compressor.

2.5 Determine maximum ambient temperatures for which the DG's are operable. 110°F has been established as a goal for diesel ambient air operating limits, based on review of meteorological data for this area predicts that 110°F will not be exceeded as an outdoor ambient air temperature.

3.0 INPUTS TO THE ANALYSIS

3.1 Calculation number FC03382 Rev. 3, Diesel Generator LOCA Loads

3.2 Power Systems Analysis of FCS Generator Capabilities

3.3 EMD Specification Sheet for the Generator

3.4 Diesel Generator Nameplate data

3.5 Tables from the "Standard Handbook for Electrical Engineers"

3.6 ES-87-12, FCS Weather Tower Uncertainty Calculation #FC01381, Rev. 0.

3.7 MR-FC-90-073 DG Exciter Cooling

3.8 DG-1 Testing - Airflows Before Steam Cleaning, 3/8/91

3.9 DG-1 Testing - Airflows After Steam Cleaning, 3/14/91

3.10 DG-2 Testing - Airflows Before Steam Cleaning, 2/27/91

3.11 DG-2 Testing - Airflows After Steam Cleaning, 3/25/91

3.12 Young Radiator Company Radiator Performance Analysis

4.0 REFERENCES

4.1 Letter dated 7/2/90 from M. J. Fleckenstein of EMD to R. F. Mehaffey OPPD Engine Loads Above the 2000 HR Rating

4.2 Letter dated 7/20/90 from Roland Royal of G.E. to G. P. Schwartz - G. E Static Exciter

4.3 "Data Reduction and Error Analysis for the Physical Sciences", Philip R. Bevington, McGraw-Hill, 1969, p. 71-72 (See EA-FC-90-062, Rev. 1)

4.4 DG-1 Testing Performed, 6/25/90 (See EA-FC-90-062, Rev. 1)

4.5 DG-1 Testing Performed, 6/26/90 (See EA-FC-90-062, Rev. 1)

4.6 DG-2 Testing Performed, 7/16/90 (See EA-FC-90-062, Rev. 1)

4.7 DG-2 Testing Performed, 7/17/90 (See EA-FC-90-062, Rev. 1)

4.8 DG-1 and DG-2 Jacket Water Outlet Gauge Calibrations (9/17/90 and 10/9/90) (See EA-FC-90-062, Rev. 1)

4.9 DG1 Testing Performed 9/25/90 (See EA-FC-90-062, Rev. 1)

4.10 MR-FC-90-073, DG Exciter Cooling Post Modification Testing

4.11 EA-FC-90-091, Rev. 0

4.12 Letter from R. L. Phelps to R. L. Jaworski and T. L. Patterson, dated 5/31/91 (Attachment 8.10)

5.0 ASSUMPTIONS

5.1 The sequential loading of the diesel generator has only a secondary effect on long term engine/generator performance because loading is complete within approximately 60 seconds and will not be considered here.

5.2 Station Blackout analysis requires that the loss of offsite power and diesel generator onsite power must be assumed. This Design Basis Event (DBE) is outside the bounds of this EA.

5.3 Limitorque motor operated valves are not considered long term loads. Cycling time is insignificant compared to long term loads.

5.4 For radiator performance analysis, a design jacket water flow of 1100 gpm (minimum) is assumed for all cases. This flow rate is the discharge capacity of the engine water pumps per EMD and has been confirmed by test during full coolant flow operation.

5.5 For radiator performance analysis, Young Radiator Company utilizes uniform air velocities measured immediately downstream of radiator core to determine required SCFM for heat removal at various temperatures. All air velocities (converted to flows) obtained during FCS diesel tests were measured at the closest convenient point downstream of the radiator core. Due to flow restrictions present in system, the actual core face velocities would not be uniform, but the overall radiator capability would not be significantly degraded. 2

5.6 At elevated ambient temperatures (>95°F), it is assumed that inlet air to the radiator fan is the same temperature as outdoor ambient. This assumption based on test data taken 7/17/90, per Reference 4.11, Attachment 8.11, page 9 and 10 of 15.

5.7 Instrument uncertainties from past data collection will be utilized in the turbo charger inlet air and JW analyses and heat-up rate projections and are considered conservative. See Reference 4.3 and 4.8.

6.0 ANALYSIS

This analysis will establish the temperature limits at which the engine/generator can operate the worst case safety-related loads in response to a Design Basis Accident with a loss of offsite power. To accomplish this, accident loading will be compared to elevated ambient air temperature engine performance determined by analysis of the expected DG cooling system performance and test data to project DG room temperature rise above outside ambient air. The analysis also demonstrates that the static exciter and generator can operate at the analyzed higher temperatures.

The analysis is organized to:

1. Determine the Worst Case accident load and peak load on the diesel generator.
2. Define the Test Data Reduction Criteria for use in the analysis.
3. Define the Engine/Generator Power Output criteria.
4. Define the engine, exciter and Generator Derating Methodology.
5. Define Test Data Instrument uncertainty for use in this analysis.
6. Perform an Engine Derating Analysis and establish Operating Temperature Limits based on Jacket Water and Turbocharger inlet air temperature.
7. Establish Operating Temperature limits for Generator and exciter.
8. Determine margin for additional loads.

6.1 Worst Case Load and Load Profile

The Fort Calhoun Station is required to have sufficient onsite electrical generation capacity to safely shutdown the reactor and maintain it in a safe shutdown condition under all Design Basis Events (DBE) which could result in a loss of offsite power or require the assumption of a loss of offsite power (except station blackout). In addition, single failure criteria must be met. The following discussions review the expected electrical/DG system requirements under specific DBEs to define the worst case load and load profile.

6.1.1 Worst Case Load

A process of elimination is used to determine the worst case load by looking at the equipment required to respond to a DBE. This is discussed below.

6.1.1.1 Reactor Trip and Coincident Loss of Offsite Power

A reactor trip and coincident loss of offsite power where the Reactor Coolant System (RCS) and the Steam Generator secondary system remain intact require a minimal amount of equipment for safe shutdown. The basic systems required are raw water, component cooling water, auxiliary feedwater, charging, containment cooling, and low pressure safety injection (shutdown cooling). In addition the operators would be expected to have the instrument air system in operation.

6.1.1.2 Uncontrolled Heat Extraction

The most limiting Uncontrolled Heat Extraction case would be a main steam line break in containment which would require automatic initiation of Engineered Safety Features. In this case the Raw Water (RW), Component Cooling (CCW), Charging (CH), Auxiliary Feedwater (AFW) sequential start of FW-6, Containment Filtering and Cooling (VA) Containment Spray (CS), High Pressure Safety Injection (HPSI), and Low Pressure Safety Injection (LPSI) systems will be automatically aligned and sequentially loaded on the diesel generator. The initial loading is expected to be nearly the same as a large break LOCA, however, once the RCS inventory has been restored, the HPSI and LPSI pumps will operate on minimum recirculation resulting in a reduced load to the diesel generators.

6.1.1.3 LOCA

The ESF response to a LOCA automatically aligns and loads the ESF and auxiliary systems on the diesel generator. In the small break LOCA case, the LPSI pumps are expected to be on minimum recirculation and not running at full load. In the case of a tube rupture, containment spray is not required resulting in a smaller load on the diesel generator. In the large break LOCA scenario, the LPSI and HPSI pumps are expected to run at full flow until the SIRW Tank is emptied. This represents the largest load for the longest time. The large break LOCA loads will be used in all further discussions.

6.2 DG Peak Load and Load Profile

The expected load is based on a large break LOCA for DG-1 2551 KW and for DG-2 is 2421 KW (calculation #FC03382 Rev. 3, Attachment 8.1). The peak loads are expected to occur after the final loads have automatically sequenced on the diesel and accelerated to full speed.

6.3 Worst Case Load Profile

The large break LOCA load profile is based on loads which either reduce over time as a result of accident mitigation or receive automatic trip signals some time into the event.

6.3.1 Load Reduction Due to Containment Depressurization

Load reduction over time occurs on the containment filtering and cooling fans (VA-7C, VA-7D, VA-3A and VA-3B). These fans are initially loaded to 100% power when the containment air/steam mixture is near 60 PSIG. As the steam in containment is condensed by the containment spray system and containment filtering and cooling units, the containment atmospheric density is reduced causing the fans to unload.

6.3.2 Automatic Trip

The LPSI pumps meet the automatic trip criteria (no operator action required). These pumps are tripped on RAS at which minimum safety injection occurs at approximately 3740 seconds (USAR Section 6.2.5).

6.3.3 Load Profile

The load profile is graphed in Attachment 8.8 for each diesel. This load profile is based on the large break LOCA, as defined in Calculation FC03382 Rev. 3, Attachment 8.1 (Figure 1 and 2).

6.4 Test Data Reduction

Due to the room specific configuration for each engine, testing was used to establish the relation between outdoor ambient air and the room air temperature dependant functions of the diesel generators, e.g., turbo charger inlet air temperature.

6.4.1 The test data from Rev. 0 of this analysis (used in this analysis (See References 4.4 - 4.7)) was compiled using a thermocouple datalogger. The test data used in this analysis concerning the exciters was obtained in the test procedures of MR-FC-90-073 discussed in the next section. The critical parameters used in this analysis are outside ambient air temperature, combustion inlet air temperature (turbocharger intake air temperature), generator inlet temperature and jacket water temperature. The analysis is based on the following:

a. Thermocouple average temperature for ambient air temperature.
b. Thermocouple average temperature for turbocharger inlet temperature.
c. Thermocouple for generator inlet air temperature.

Data reduction was accomplished in two steps. First, it was determined that the data required could be compiled at 15 minute intervals versus the datalogger 5 minute interval printout. This was done due to the relatively slow rate of change of the observed temperatures. Second, averages were taken at each time interval where more than one thermocouple was used to measure the same temperature area.

6.4.2 The test data used for the exciter temperature discussion is based on MR-FC-90-073 and was obtained with RTD temperature detectors with ± 1°F accuracy. The following temperatures were measured:

a. Average of 3 center mounted exciter cabinet RTDs.
b. Single hand-held RTD temperature detector for room ambient temperature.
c. Weather tower or the hand-held probe was used for outdoor ambient temperatures.

6.5 Engine/Generator Power Output Criteria

6.5.1 Engine Capability

The deration of engine capability limit based on temperature is to ensure that the ESF loads do not result in unacceptable engine wear and potential decreased reliability of the engine. This is interpreted as the engine 2000 Hr/Yr capability rating. To quantify the engine reliability, Electro-Motive Division, General Motors Corporation (EMD) has established output ratings for its engines based on potential engine degradation over a specified period of time. The time intervals specified are 30 minutes, 4 hours, and 2000 hours. The time ratings provide a measure of stress on the engine. Operation at the 30 minutes and 4 hour ratings should be minimized, however, the engines are expected to provide reliable performance even with brief excursions into the 30 minute and four hour rating range. EMD has developed these ratings based on detailed knowledge of the temperature related engine stress caused by operation at elevated loads, and operating experience with the engines (refer to Attachment 8.7). Following an engine run that exceeds one of the interval ratings it should be inspected for abnormal wear and refurbished if required to achieve the highest possible reliability for future use.

The 2000 hour rating is a guide to schedule maintenance frequency. Operation at the 2000 hour rating for 2000 hours would indicate that an inspection be performed at the end of the run.

The acceptance criterion is based on the 2000 hour rating, the goal being not to exceed this rating which is consistent with Technical Specification 3.7.

The published engine ratings are based on turbo charger intake temperatures of 90°F. For intake temperatures above 90°F, EMD has provided de-rating curves (Attachment 8.2). These are straight line curves showing intake air temperatures versus percent of full load rating. The curve used is based on jacket water outlet temperature (JWOT) of either 190°F or less, or 200°F to 210°F. For the purposes of this analysis where test data shows JWOT above 190°F, the 200°F to 210°F curve will be used.

When jacket water outlet temperature and turbocharger inlet temperatures are known while the engine is heating up during the initial stages of operation, a time versus engine/generator output limit can be plotted for the 2000 hour engine rating. Past test data (used in Rev. 0 of this analysis) gathered during the initial stages of engine operation allow a heat-up rate to be determined. From this, jacket water temperatures vs. time can be predicted for other outdoor ambient temperature.

In the highly unlikely event that a large break LOCA were to occur shortly after the engine has completed its monthly surveillance, the 30 minute rating curve would be applied to the initial LOCA loads in excess of the 2000 hour rating. This would assure operation of the ESF loads based on EMD's expectations for engine performance.

6.6 Derating Methodology

6.6.1 Engine Derating

The limiting parameters for engine/generator power output (in kilowatts) are jacket water temperature and turbo charger air inlet temperature. The jacket water outlet temperature (JWOT) determines what turbocharger air intake temperature de-rating curve is applicable. The percent of standard rating versus elevated inlet temperature curves (based on jacket water temperatures) are shown in Attachment 8.2. The graph shows two deratings, the upper right curve is based on a JWOT of 190°F, the lower curve on a JWOT in the range of 200°F to 210°F. In this analysis, engine/generator power output is based on the 190°F curve when JWOT is 190°F or less, and the curve of 200°F to 210°F when JWOT is above 190°F. For purposes of this analysis, 208°F will be used as the maximum JWOT, based on cylinder head life (refer to Attachment 8.2).

6.6.2 Generator and Exciter Derating

6.6.2.1 The temperature limit for the generator is determined by taking the known upper limit of the generator and reducing it by the rise between ambient outside and the generator inlet temperature.

Instrument uncertainty will be included in a conservative manner.

6.6.2.2 Modification MR-FC-90-073 installed cooling in the exciter housing.

The testing done by the modification will be analyzed to determine the adequacy of the newly installed A/C units (VA-759A, VA-759B) at outdoor ambient temperatures of 110°F.

6.7 Instrument Uncertainty

This section discusses the expected uncertainties of the instrumentation used to measure the critical parameters of ambient air into the diesel generator rooms, turbocharger inlet temperatures, generator air cooling temperatures, and exciter cabinet air temperatures.

6.7.1 Outside Ambient Air Temperature Test Data Uncertainty

Ambient Air entering the room was measured using 6 thermocouples mounted at the room air intake and recorded on a data logger (this information was not used for the exciter discussion in this revision). Each of these type J thermocouples has an uncertainty of 2.2°C or 3.96°F. The data logger has a .72°F uncertainty, however, post calibration testing indicated an uncertainty of .22°F. Using the square root of the sum of the squares method, the loop uncertainty for each thermocouple is ± 3.97°F.

The use of six thermocouples to measure the ambient air temperature will result in a more accurate reading. Using the error analysis method for multiple inputs of equal uncertainty as defined in Chapter 5 of "Data Reduction and Error Analysis for the Physical Sciences", reference 4.3, the overall uncertainty of the average temperature is reduced to the individual loop uncertainty divided by the square root of the total number of channels. For the ambient air case, the uncertainty would be $\pm 3.97°F/\sqrt{6} = \pm 1.62°F$. The actual outdoor ambient air temperature will be the average reading minus 1.62°F, which is conservative. The outdoor ambient air temperature calculated in this manner is conservative because this temperature is used to calculate delta Ts between the outdoor ambient and other temperatures greater than ambient (jacket water outlet, turbo intake air, and generator intake air temperatures) which produces larger delta Ts. A larger delta T will give a larger temperature rise above ambient for the system being analyzed yielding a conservatively lower upper temperature limit for that system.

6.7.2 Turbocharger Intake Air Temperature Uncertainty

The turbocharger intake air (combustion air) temperature uncertainty was determined using the same method and equipment as the outside ambient air temperature. In the case of the turbocharger air intake, nine thermocouples were used. The expected uncertainty is ± $3.97°F/\sqrt{9}$ = ± 1.32°F. For the purposes of engine derating due to turbocharger intake temperature, any temperature rise of the turbocharger intake over ambient will be increased by 1.32°F, resulting in a conservative derating.

6.7.3 Exciter Cabinet Internal Air Temperature Uncertainty

MR-FC-90-073 installed air conditioning units on each exciter panel. Testing was performed by the modification to determine the effects of a failed A/C unit on the ambient temperature limits of the exciters. The test used 9 platinum RTDs which were mounted inside the exciter cabinet and connected to a datalogger. The above measuring devices have a ± 1°F uncertainty for each RTD. Only the center 3 RTDs will be used for determining the enclosure temperature with the door open because these are located in the area of the most heat sensitive components. This provides an uncertainty of ± $1°F/\sqrt{3}$ = 0.58°F.

6.7.4 Generator Cooling Air Inlet Temperature Uncertainty

The generator cooling air inlet temperature was measured using one thermocouple and the same datalogger as outside ambient air. The expected uncertainty is ± 3.97°F. The 3.97°F uncertainty will be subtracted from the upper generator operating temperature limit, which is a conservative application.

6.7.5 Weather Tower Outside Ambient Temperature Uncertainty

The weather tower 10 meter air temperature can be used to determine the margin available to manually load additional equipment on the diesel generators. ES-87-12, Weather Tower Instrument Uncertainty Calculation FC01381 (Input 3.6), established a temperature uncertainty for the ERF computer readout of ± .71°F. This uncertainty is not considered significant, the reading alone without correction can be applied. Data taken during the 6/25/90 testing confirms the adequacy of the weather tower as shown below:

Time	Tower	Thermocouples	Delta T
14:38	87°F	86°F	1°F
15:30	90°F	89°F	1°F
17:40	89°F	88°F	1°F

6.8 Basic Engine Limit and Rating Calculation Including Uncertainty with a Jacket Water Outlet Temperature Based Operating Limit

The basis for the following equations is that the limits of concern vary linearly with outside ambient temperature.

A. DG-1 Turbo Derating Temp. = DG-1 Operating Limit + $((T_{TI} + 1.32) - (T_{AA} - 1.62))$

B. DG-2 Turbo Derating Temp. = DG-2 Operating Limit + $((T_{TI} + 1.32) - (T_{AA} - 1.62))$

C. Generator Outdoor Ambient Temperature Limit DG-1 = $T_{GL} - ((T_{GI} + 3.97) - (T_{AA} -1.62))$

D. Generator Outdoor Ambient Temperature Limit DG-2 = $T_{GL} - ((T_{GI} + 3.97) - (T_{AA} -1.62))$

E. Exciter Outdoor Ambient Temperature Limit DG-1 = $T_{EL} - (T_{AVE} + 0.58 - T_{AMB})$ (Door open, A/C off)

F. Exciter Outdoor Ambient Temperature Limit DG-2 = $T_{EL} - (T_{AVE} + 0.58 - T_{AMB})$ (Door open, A/C off)

All variables are in °F.

T_{AA} - outside ambient air measured during the test
T_{TI} - turbocharger inlet temperature measured during the test
T_{EL} - exciter temperature limit (maximum rated temperature)
T_{AVE} - exciter temperature measured in the testing of MR-FC-90-073
T_{AMB} - outside ambient temperature measured in the testing of MR-FC-90-073
T_{GL} - generator temperature limit (maximum rated temperature)
T_{GI} - generator inlet temperature measured in the test

6.9 Engine Derating Analysis

6.9.1 DG-1 Ambient Air Temperature Limit Based on Jacket Water Cooling System Improvements

As a result of temperature limitations on the diesel generators imposed in 1990, steps were taken during the first quarter of 1991 to improve the heat removal capabilities of the diesel generator radiators. Access doors installed in the exhaust duct above the radiator core allowed for steam cleaning and maintenance of the radiator cooling fins. Post maintenance testing confirmed a significant improvement in air flow across/the radiator cores. See

Table 1, Attachment 8.9d and Attachments 8.11 through 8.14 for actual before/after air flow data.

According to literature (documented in EA-90-062 Rev. 1 and EA-90-091 Rev. 0) received from MK Power Systems, OPPD's representative for EMD stationary diesel generating units, a net horsepower savings of 180 bhp can be assumed if the Ethylene Glycol engine coolant is replaced by treated water. This can be converted to an additional 130 KW to be applied to offset the diesel generator deration curve. The addition of 130 KW to the rated capacity of 2654 yields 2784 KW available. The diesels will satisfy the post-LOCA loads if this 2784 KW power available is applied to the 2000 hr. deration curve.

The combined benefits of a "near new" cleaned condition of the radiator in conjunction with efficiency savings associated with changing coolant from Ethylene Glycol to treated water result in higher output capacity such that the temperature limit could be raised. Limiting JW temperature per MFG, is 208°F. Test results shown on Attachment 8.8 show that with ambient temperature of 110°F the JW temperature is expected to be 208°F, AT SOME POINT IN TIME ~~after~~ 20 minutes OR MORE AFTER A COLD START. Therefore:

<u>DG-1 Operating Limit = 110°F</u>
<u>(Based on JW temperature)</u>

See Attachment 8.8 for expected engine/generator performance at 110°F and Attachments 8.9 and 8.10 (Attachment A) for supporting analysis.

6.9.2 Derating Description of DG-1 Based on Test for Turbo Charger Inlet Temperature and Revised DG-1 Capacity Rating

The test data on DG-1 taken on 6/25/90 was used to determine room specific temperatures. The test was conducted using water as the engine coolant. Readings were taken every five minutes from thermocouples and every 10 minutes of the engine jacket water outlet panel temperature indicator. For this analysis, turbocharger inlet air temperatures, at 10 minute intervals, were used to establish a correlation to outside ambient temperatures as well as to derive a heat-up rate profile for use in projecting turbocharger inlet temperatures at an outdoor ambient temperature of 110°F. From these projected inlet temperatures, deration factors (from Attachment 8.2) were applied to gross available output power and compared to ESF power requirements as shown in Attachment 8.8. Operation at 110°F was considered an acceptable limit.

6.9.3 DG-1 Derating Based on a Hot Engine

There is expected to be a period of some three hours per month when DG-1 would be at elevated temperatures after a monthly surveillance test. In the event of a LOCA under these conditions, the engine would still be expected to perform its safety function, based on the 30 minute capability rating.

6.10 DG-2 Engine Derating Analysis

6.10.1 DG-2 Ambient Air Temperature Limit Based on Jacket Water Cooling System Improvements

See discussion in Section 6.9.1.

DG-2 Operating Limit = 110°F
(Based on JW temperature)

See attachment 8.8 for expected engine/generator performance at 110°F and Attachments 8.9 and 8.10 (Attachment A) for supporting analysis.

6.10.2 Derating Description of DG-2 Based on Test for Turbo Charger Inlet Temperature and Revised DG-2 Capacity Rating

DG-2 was tested on 7/16/90 and 7/17/90 to determine room specific temperatures. The test on 7/16/90 was conducted using ethylene-glycol as the engine coolant and the test on 7/17/90 used water as the engine coolant. Readings were taken every five minutes of the thermocouples and every 15 minutes of the engine JWO panel temperature indicator for the test on 7/16/90 and every 10 minutes of the engine JWO panel temperature indicator for the test on 7/17/90. For this analysis, turbo-charger inlet air temperatures from the 7/17/90 test, taken every 10 minutes, were used to establish a correlation to outside ambient temperatures as well as to derive a heat-up rate profile for use in projecting turbocharger inlet temperatures at an outdoor ambient temperature of 110°F. From these projected inlet temperatures, deration factors (from Attachment 8.2) were applied to gross available output power and compared to ESF power requirements as shown in Attachment 8.8. Operation at 110°F was considered an acceptable limit.

6.10.3 DG-2 Derating Based on a Hot Engine

There is expected to be a period of some three hours per month when DG-2 would be at elevated temperatures after a monthly surveillance test. In the event of a LOCA under these conditions, the engine would still be expected to perform its safety function, based on the 30 minute rating.

6.11 DG-1 and DG-2 Generator Temperature Limits

6.11.1 Generator Peaking Duty Temperature Rating

The generators' upper temperature limits can be derived from the nameplate data of the generators which specify the rotor and stator insulation temperature rise limits. See Attachment 8.3 and the EMD Generator Characteristic Data, Attachment 8.4. The peaking stator rise limit rating is 105°C and the rotor rise limit is 70°C above 40°C (a common design number). From the generator data sheet, the load based rise at 2500 KW (which represents the peak DG loading by OPPD) is 56°C for the stator and 50°C for the rotor above 40°C. The rotor is limiting which equates to a limit of 60°C maximum temperature (40°C ambient, plus a 20°C margin in the rotor between the 70°C limit and the 50°C load induced temperature rise).

The operating temperature limits would be 60°C (140°F) minus the room inlet to the generator inlet temperature rise and correcting for uncertainty as shown in Equation 6.8 C and D. Attachments 8.19 through 8.22 provide plots of the generator inlet temperature rise. Using the data in Attachment 8.22-1 to determine generator air inlet temperature rise, a limit of 120°F can be calculated for DG-1 (140 - ((102.6 + 3.97) - (88.8 - 1.62))). Using the data from Attachment 8.21-1 to determine generator inlet air temperature rise, a limit of 114°F can be calculated for DG-2 (140 - ((110 + 3.97) - (90 - 1.62))).

Please note that when using the data, or graphs in Attachments 8.19 through 8.21 the data taken when the room fan is off should be used, since fans VA-52A and VA-52B are not to be in operation.

6.11.2 This judgement is supported by the ratings of the Class H insulated stator and Class F insulated rotor. Looking at motor insulation ratings (which can provide information on the insulation systems), Class F insulation is capable of 105°C rise above a 40°C ambient and Class H insulation is capable of 125°C rise above a 40°C ambient. Refer to the tables in Attachment 8.5 taken from the "Standard Handbook for Electrical Engineers".

6.12 Exciter Temperature Limits

Each Emergency Diesel Generator (EDG) receives field excitation via a General Electric Model 3S7930SA212A11 Static Exciter. These exciters were part of the original EDG installation and are approximately 20 years old. G.E. (Letter dated July 20, 1990, Attachment 8.6) has stated that the open exciter panel will have no problem operating at 50°C (122°F).

6.12.1 Exciter Limit with Left Door Open, Air Conditioner Off

Modification MR-FC-90-073 installed an air conditioning unit on each diesel generator exciter cabinet to provide cooling for the components inside the cabinet. The temperature ratings for this configuration will be analyzed and discussed later. This section will develop temperature limits for each exciter with the A/C unit off and the left door open.

6.12.2 Exciter Test Data

EDG test data obtained in MR-FC-90-073 will be used to develop exciter ambient temperature limits with the A/C unit off and the left door open. This will establish a set of limits for the exciter if the A/C units were to fail.

6.12.2.1 Testing Procedure T-1 for DG-1 from MR-FC-90-073 (5/30/91)

This test ran the diesel at approximately 2500 KW throughout the test. RTDs (9) were mounted inside the exciter cabinet to measure the internal cabinet temperature. The average of the center 3 temperatures will be used as the ambient air temperature which will be used to calculate the delta T between outside ambient and cabinet temperature. Attachment 8.15 shows that at 15:46:05 the cabinet temperature stabilized with the left door open and the A/C unit (VA-759A) off. The average of the 3 center cabinet readings is:

$$T_{AVE} = \frac{99.9 + 100.1 + 100.2}{3} = 100.1°F$$

The outside ambient temperature at this time was 80°F (T3 from page 9 of T-1 from MR-FC-90-073 is the weather tower thermistor). Therefore, the delta T between the outside ambient and the cabinet temperature is calculated with instrument uncertainty as follows (refer to equation E from Section 6.8):

$$\Delta T = T_{AVG} + \frac{1°F}{\sqrt{3}} - T_{AMB} = 100.1 + .58 - 80 = 20.68°F$$

The outdoor ambient could reach 101°F (122°F - 20.68°F) and the exciter would still be expected to function with no A/C and the left door open.

6.12.2.2 Testing Procedure T-2 for DG-2 from MR-FC-90-073 (5/15/91)

This test was performed identical to the test for DG-1. Attachment 8.16 shows that at 14:57:27 the exciter cabinet temperature stabilized with the left door open and the A/C unit (VA-759B) off. The average of the 3 center cabinet readings is:

$$T_{AVE} = \frac{91.3 + 92.0 + 93.6}{3} = 92.3°F$$

The outside ambient temperature at this time was 76.9°F which was measured using MT-00014 which was post-mod tested at better than ± 1°F uncertainty (per Attachment 8.17) and therefore will be used with no uncertainty. The delta T between the outside ambient and the cabinet temperature is calculated with instrument uncertainty for the cabinet temperature as follows (refer to equation F from Section 6.8):

$$\Delta T = T_{AVG} + \frac{1°F}{\sqrt{3}} - T_{AMB} = 92.3°F + .58 - 76.9°F = 16°F$$

The outdoor ambient could reach 106°F (122°F - 16°F) and the exciter would still be expected to function with no A/C and the left door open.

6.12.3 Exciter Test Data (A/C On, Door Closed)

This section will demonstrate that the VA-759A and VA-759B exciter air conditioners will maintain the internal exciter cabinet air temperature below the 122°F limit.

The exciter A/C unit on each diesel generator was tested by MR-FC-90-073. The testing obtained A/C duty cycles at known temperature differentials (between cabinet interior and exterior).

6.12.3.1 DG-1 Exciter A/C Test

The diesel generator was run at approximately 2520 KW for 1 hour with the A/C unit (VA-759A) cooling the exciter cabinet. At the beginning of the test, the A/C unit duty cycle was approximately 56% while removing primarily the heat generated internal to the exciter cabinet. The average internal cabinet temperature averaged around 80°F. The room ambient temperature rose from 81°F to 100°F within 1 hour. At the end of this part of the test, the A/C unit duty cycle increased to approximately 64% to maintain a 20°F delta T between the room ambient and the internal cabinet temperature.

Predicting the A/C unit duty cycle at 110°F outside ambient is accomplished as follows:

For a 20°F increase in delta T between internal cabinet and room ambient, the A/C unit duty cycle increased 8% based on a 100% duty cycle. Therefore, there is a 8%/20°F = 0.40 percent increase in duty cycle per °F increase in delta T between room ambient and internal cabinet air temperature. At the time of the test, the outdoor ambient temperature will be assumed to be 74°F which is conservative (actual temperature went from 74°F to 78°F during the test). An outside ambient of 110°F is an increase of 36°F over 74°F. At 0.40% per °F this gives a 14.4% increase in duty cycle which when added to 64% duty cycle gives a duty cycle of approximately 78%. The above does not account for the increased A/C unit efficiency from approximately 70% to 92% at higher operating temperatures as discussed in Attachment 8.18. Since the above discussion is based on maintaining the cabinet internal temperature at 80°F with a 110°F outdoor ambient at a 78% duty cycle at reduced efficiency, it is judged that there is enough margin to assure an internal cabinet temperature of less than the required 122°F upper limit with an outdoor ambient of 110°F.

6.12.3.2 DG-2 Exciter A/C Test

The analysis for the A/C unit (VA-759B) for DG-2 will be discussed different from that of DG-1 since the room ambient at the start of the A/C unit test was approximately 7°F higher than the internal cabinet temperature. The A/C unit test ran for about 1 hour with the A/C unit cooling the exciter cabinet at a diesel generator load of 2540 KW. At the end of the test the A/C unit duty cycle was approximately 50%. The average internal cabinet temperature was 80°F and the room ambient was 89°F. Therefore, the A/C unit maintained a 9°F differential between the room ambient and the internal cabinet temperature with a 50% duty cycle. From Attachment 8.18, the A/C unit efficiency was approximately 60%. Therefore, it is judged that the A/C unit would be able to maintain a 9°F differential or better between room ambient and the cabinet internal temperature due to the available margin in the A/C unit by the increase in duty cycle and efficiency as temperatures rise. From Revision 1 of this analysis, it was found that there was a 17°F delta T between the outdoor ambient and the room temperature. Therefore, the room ambient could reach 127°F with a 110°F outdoor ambient temperature.

It is judged that the A/C unit would be able to maintain an enclosure temperature of less than 122°F at an outdoor ambient of 110°F.

7.0 RESULTS AND CONCLUSIONS

7.1 Results

	Engine/Radiator Max. Out. Amb. Limit	Cooling Liquid	Exciter Max. Out. Amb. Limit	Generator Max. Out. Ambient Limit	Room Temperature Based On Fan Status
DG-1	110°F	Water	101°F No A/C Door Open 110°F A/C On Door Closed	120°F	VA-52A off
DG-2	110°F	Water	106°F No A/C Door Open 110°F A/C On Door Closed	114°F	VA-52B off

2

7.2 Conclusions

Based on the results of this analysis, the maximum outdoor ambient air temperature for each diesel generator to carry the loads as stated in the purpose are as follows:

Maximum Outdoor Ambient Temperature

DG-1	110°F
DG-2	110°F

These limits are based on the diesel generator's anticipated jacket water outlet and turbocharger air intake temperatures based on test data, and therefore are the limiting parameters. These temperatures allow each diesel generator to operate within its 2000 hour rating for the LOCA analyzed here. Additionally, the generator and exciter cabinet (with A/C running) are not expected to see temperatures which would exceed their limits at an outdoor ambient temperature of 110°F. The VA-52A and B fans shall be "OFF" when the respective diesel is run. 2

Through the course of the accident (LOCA) the diesel generator will unload such that the load will always be below the 2000 hour rating of the engine. The KW margin between the actual load and the 2000 hour rating is available for addition equipment starts, for the large break LOCA analyzed here. Actual margin is dependant on the pump loads and ambient air temperature.

The conclusions of this EA have been superseded by calculation FC5916 Rev 3. Some of the information provided in this EA were used as input for the new calculation. 3

REV. 3

8.0 LIST OF ATTACHMENTS

Attachment	Description
8.1	Calc. No. FC03382 Rev. 3, Diesel Generator LOCA Loads
8.2	a. Derating Curves For EMD Diesels b. Letter From Ted Fryar of M-K to Randy Mueller, Dated 2/21/80
8.3	Diesel Generator Nameplate Data
8.4	EMD Specification Sheet for the Generator
8.5	Tables From The "Standard Handbook For Electrical Engineers"
8.6	G. E. Letter, Dated 7/20/90
8.7	Letter From GM-EMD and R. F. Mehaffey, Dated 8/16/90
8.8	a. Data Sheets, Projected Performance and Deratings at 110°F Ambient, DG-1 and DG-2 b. Revised Diesel Generator Available KW/Required KW vs. Time Plots Utilizing Calc. FC03382, Rev. 3, DG-1 and DG-2
8.9	a. Young Radiator Company Radiator Performance Analysis b. Telecon Between M-K Power Systems and D. G. Borcyk, Dated 4/19/91 c. Calculated Heat Inputs to Engine Coolant d. Delivered Air vs. Required Air Analysis
8.10	Letter from R. L. Phelps to R. L. Jaworski and T. L. Patterson, Dated 5/31/91
8.11	DG-1 Testing - Airflows Before Steam Cleaning, 3/8/91
8.12	DG-1 Testing - Airflows After Steam Cleaning, 3/14/91
8.13	DG-2 Testing - Airflows Before Steam Cleaning, 2/27/91
8.14	DG-2 Testing - Airflows After Steam Cleaning, 3/25/91
8.15	DG-1 Datalogger Points at 15:46:05
8.16	DG-2 Datalogger Points at 14:57:27
8.17	Telecon with Ken Beach
8.18	A/C Efficiency Data
8.19	Graph or Air Temperatures for DG-1 on 6/26/90 (2 pages)
8.20	Graph of Air Temperatures for DG-2 on 7/16/90 (2 pages)
8.21	Graph of Air Temperatures for DG-2 on 7/17/90 (2 pages)
8.22	Graph of Air Temperatures for DG-1 on 6/25/90 (2 pages)

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Rev. 2
Attachment 8.1
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Calculation Number FC03382 Rev. 3 Diesel Generator LOCA Loads

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CALCULATION COVER SHEET ~~REV 2~~ ZP 9-11-95 REV. 3

EA-90-062

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 1 of 2 Calculation Cover Sheet •SHORT TERM CALC: YES ☐ NO ☑	CALCULATION NUMBER — Calc. Page No. 1a •FC 03282 •TOTAL PAGES 36 ~~25~~ ~~29~~ ~~47~~ QA Category: ☑ CQE ☐ LIMITED CQE ☐ FIRE PROT. ☐ NON CQE •FILE NO. 53.65 PED DEPARTMENT 356
CALCULATION TITLE Diesel Generator LOCA Loads	VENDOR CALC. NO. N/A ☐ MR NO. ☐ ENGR. ANALYSIS ☐ DBD NO. ☑ OTHER EAD

•APPROVALS - SIGNATURE & DATE

PREPARER(S)/DATE(S)	REVIEWER(S)/DATE(S)	INDEPENDENT REVIEWER(S)/DATE(S)	•REV. NO.	SUPERSEDES •CALC NO.	CONFIRMATION •REQUIRED (✓) YES	NO
RF Mehaffey 8/25/89	P. T. Vonk 8/25/89	J.J. Foley by RFM 8/25/89 per telecon	0	NA		✓
Paul T. Vonk 7/19/90	RF Mehaffey 7/19/90	Rich Ronning 8/6/90	1	~~N/A~~ RFM FC03186 FC05087		✓
Paul T. Vonk 10/25/90	Gary Peterson 10-26-90	10/24/90	2	N/A		✓
*Check intermittent loads on DG-2. * Evaluate NSR loads, Load Shed and manually reset, then EPLS						
Bruce Bulger per telecon 5/2/91 RFM	Gary Bell per telecon 5/2/91 RFM	RF Mehaffey 5/2/91	3	MR-FC-79-181 Calc. FC03186 MR-FC-87-61		

•EXTERNAL ORGANIZATION DISTRIBUTION

NAME & LOCATION	COPY SENT (✓)	NAME & LOCATION	COPY SENT (✓)
- RR Ronning FCS RF Mehaffey ~~EP~~ EP7 DG Borcyk EP7		-	

CALCULATION COVER SHEET EA-90-062

REV. 3

Calculation Preparation, Review and Approval Form PED-QP-3.1 Form Page No. 2 of 2 Calculation Cover Sheet	CALCULATION NUMBER FC 03382 FACILITY/SYSTEM FCS / DG KEYWORD* Calculation
	Calc. Page No. 2

CALCULATIONS USED AS INPUT IN THE ANALYSIS		EQUIPMENT TAGS		
CALC./REV.NO.	DEPT.NO.*	SYSTEM	ADDED	DELETED
S&L 7752-14-E02, Rev 1	356	DG	D1	
		DG	D2	
		DG	DG1	
		DG	DG2	

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~~REV 2~~ pje 9-19-95 Page 3

Calc Preparation, Review and Approval PED-QP-3.5 Page 1 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC03382 Rev. 3

		YES	NO	N/A
1.	Is Calculation Cover Sheet attached and completed, as required, to the calculation?	✓		
2.	Is the calculation objective stated? Was this achieved?	✓		
3.	Are inputs correctly selected and incorporated into the analysis?	✓		
4.	Have inputs and/or assumptions which require confirmation at a later data, been identified on the Calculation Cover Sheet and in the calculation body?			✓
5.	Are the applicable codes, standards, regulatory requirements, and other references including issue and addenda identified such that they are traceable to source document?	✓		
6.	Was an appropriate calculation method used? Was the basic theory appropriate?	✓		
7.	Have assumptions been noted and justified?	✓		
8.	Are the calculations free of arithmetic errors?	✓		
9.	Is the calculation consistent with the design basis requirements?	✓		
10.	Is the conclusion stated?	✓		
11.	Is the calculation legible and suitable for microfilming?	✓		

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Calc Preparation, Review and Approval PED-QP-3.5 Page 2 of 2 Reviewer's Checklist-Calculations	CALCULATION NUMBER FC03382 Rev. 3

		YES	NO	N/A
12.	Are all blocks on the Calculation Cover Sheet addressed correctly?	✓		
13.	Have Forms PED-QP-3.2, 3, 4 and 5 been used and correctly completed?	✓		
14.	If the calculation has been prepared to supersede another calculation, has all the valid information been transferred in the new calculation?			✓

REVIEWER COMMENTS:

G A Bell
Reviewer

3/11/91
Date

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Calc Preparation, Review and Approval PED-QP-3.7 Page 1 of 1 Independent Reviewer's Checklist - Calculations	CALCULATION NUMBER FC03382 Rev. 3

		YES	NO	N/A
1.	Are the calculation methods accurate and appropriate?	✓		
2.	Are input data sufficiently detailed?	✓		
3.	Are the calculation assumptions reasonable?	✓		
4.	Has the basis for engineering judgement been included in the calculation, when used?	✓		
5.	Is the calculation documented sufficiently such that the analysis is understandable to someone competent in the discipline without recourse to the Preparer?	✓		
6.	Have the design interface requirements been satisfied?	✓		
7.	Are the results reasonable and do they resolve the calculation objective?	✓		
8.	If an alternate calculation was used to verify the adequacy of the analysis, is it attached to the calculation?			✓
9.	If qualification testing was used to verify the adequacy of the analysis, has it been documented using a retrievable source, or attached to the calculation?			✓
10.	Are calculations involving Technical Specification values and associated margins of safety identified?	✓		

INDEPENDENT REVIEWER COMMENTS:

RF Mehaffey 5/2/91

Independent Reviewer Date

Rje
9-19-95

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PRODUCTION ENGINEERING DIVISION
CALCULATION REVISION SHEET

CALCULATION NO.
FC03382

REV. NO.	DESCRIPTION /REASON FOR CHANGE
0	INITIAL ISSUE
1	Added VA-63A, VA-63B, VA-64A, VA-64B, and deleted VA-63 per MR-FC-87-20.
	CH-1A, CH-1B, CH-1C: Changed load from 62.2KW to 50.0KW due to section 6.4.1 of EA-FC-90-76.
	EE-4S: Changed load from 10KW to 0KW due to Inverter #1 is assumed to be powered from the battery charger which is already assumed at full load in this calculation.
	VA-80A: Changed load from 4.36KW to 0KW. Fan is manually started cont. hydrogen removal - not required for initial stage of accident.
	Added assumption 10
	Added References 12,13, &14
	CONCLUSIONS: Changed KW loading values to reflect latest loading info. due to MR-FC-90-53.
	Changed KW load of SI-3A from 235.6 KW to 258.7 KW to reflect the 319 bhp requirement of the pump and using 92% as the efficiency instead of the previous 95%.
	Changed KW load of SI-3C from 240.6 KW to 243.3 KW and SI-3B from 235.6 KW to 243.3 KW to reflect an efficiency of ~~95%~~. 92% RFM 5/2/91
	Added section 3.0 to discuss SI-3A.
	Added Attachments A & B.
	Deleted Rev. 0 pages which were attached to Rev. 1.
3	Deleted Assumption #7 which assumed CH-1A, B & C to run full load.
	Added formula to determined KVAR.
	Added tables for DG-1 & 2 Power Factor Calculation.
	Added Load Calculations for pumps; SI-1A & B, SI-2A,B & C, SI-3A, B & C, CH1A, B & C, AC-3A, B & C, AC-10A, B, C & D, VA-3A & B, VA-&C & D and FW-6.
	Revised load information to reflect calculation results.
	Added pump curves.

ALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED—QP—3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC03382
Rev. No. 3

REF. NO.

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FOR

CALCULATION FC03382, REV. 3

DIESEL GENERATOR LOCA LOADS

CQE

ATTACHMENTS

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CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.3 FORM Page No. 1 of 5

CALCULATION NO.

PRODUCTION ENGINEERING CALCULATION
SUMMARY SHEET

FC03382

Rev. No. 3

OBJECTIVE

ELECTRICAL LOADING MODEL FOR DIESEL GENERATORS

The objective of this calculation is to provide a model of the expected loading of each of the emergency diesel generators DG-1 and DG-2 which load in response to a Loss of Coolant Accident (LOCA) coincident with a loss of offsite power. This model will begin with the point in time in which the final sequenced load group has accelerated to full speed and running at its expected accident load and will end at the point RAS occurs.

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ALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.3 FORM Page No. 2 of 5	CALCULATION NO.
PRODUCTION ENGINEERING CALCULATION SUMMARY SHEET	EC003882 Rev. No. 3

METHODS

The load information for equipment dead loaded on the diesel generators will be calculated and summarized using the ELMS printout and the ELDL data base (See Inputs). The Load Shed Information Summary will include the load shed status and electrical load in KW for each item listed.

The load (in KW) for each motor can be determined by:

$$P \text{ (in KW)} = \frac{[\text{Rated HP}] \times 0.746 \text{ KW/HP}}{\%\ \text{efficiency}}$$

The load (in KW) for each load given in KVA can be determined by:

$$P \text{ (in KW)} = [\text{load (in KVA)}] \times [\text{power factor}]$$

The Load Shed Information Summary for DG-1 includes 4.16KV Bus 1A3 and all 480V Buses fed from 1A3. These 480V Buses are 1B3A, 1B3A-4A, 1B3B, 1B3C and 1B3C-4C. Also included in the summary is any 480V MCC that is fed from one of the aforementioned 480V Buses and is not load shed. These MCC's are MCC-3A1, MCC-3A2, MCC-3B1, MCC-3C1 and MCC-3C2.

The Load Shed Information Summary for DG-2 includes 4.16KV Bus 1A4 and all 480V Buses fed from 1A4. These 480V Buses are 1B4A, 1B4B, 1B3B-4B and 1B4C. Also included in the summary is any 480V MCC that is fed from one of the aforementioned 480V Buses and is not load shed. These MCC's are MCC-4A1, MCC-4A2, MCC-4B1, MCC-4B2, MCC-4C1, MCC-4C3 and MCC-4C4.

Please note that load shed means 4.16KV load shed, 480V under voltage breaker trip, ESF 480V load shed, OPLS load shed and those control circuits which drop out as a result of loss of offsite power and require manual starting.

The value (in KW) of the load for each device which is load shed or is sequentially loaded will be placed in the "LOAD(KW)" column of the Load Shed Information Summary. Each device which is not load shed needs to be examined to determine whether it is a continuous or intermittent load (such as valve cycling).

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EC03382
Rev. No. 3

METHODS

The value (in KW) of a continuous load will be placed in the "LOAD(KW)" column while the value of a intermittent load will be placed in the "INT LOAD" column of the Load Shed Information Summary.

Also included in the summary will be the cycle time (in seconds) for any applicable valve listed.

Once the Load Shed Information Summary is completed, a total will be determined for non-load shed continuous loads, non-load shed intermittent loads and sequential loads. As noted in the assumptions, the intermittent loads are not considered part of the total long time running load on the diesel generators. The total load on each diesel generator is equal to the sum of the total not load shed continuous load (dead load) and the total sequential load.

The expected containment cooling fan load will be estimated based on 100% load at maximum containment pressure and 50% load during "normal" condition - no steam/air atmosphere. It will be limited for the purpose of this calculation to a minimum long term load of 75% of motor name plate rating.

Horsepower used for the sequential loads are based on the brake horsepower requirements of the driven pumps. Operating points are shown on the pump curves included in this calculation. △3

A separate table has been added to calculate the expected power factor of the diesel generator load. KVAR is based on nameplate horsepower rating. KVAR based on nameplate rating will be used for both lightly loaded and overloaded cases. KVAR will be determined by:

$$KVAR = KW[\ (\ 1/pf^2\ ) - 1\ ]^{1/2}$$

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1. Non-load shed loads which are used intermittently are not considered to be part of the total longer term load on the diesel generators.

2. Equipment which is used infrequently, such as welding receptacles and stress gallery disconnect switch, are assumed to have no load.

3. When %efficiency or power factor information is not available, a power factor = 0.80 and a %efficiency = 0.95 will be used as typcial values for electrical equipment.

4. The diesel generator model assumes that the sequenced load group has accelerated to full speed and is running at expected load.

5. RAS is assumed to occur with minimum safeguard actuation maintaining the highest diesel loading for the maximum expected time on each diesel generator.

6. This model assumes that no manual restart of equipment such as air compressors, turbine plant cooling pump, and Auxiliary Building ventilation fans occurs.

7. The calculation represents the worst case in that equipment which could be running (not intermittent) is running on each safeguard train at the time of the loss of offsite power and DBA.

8. For conservatism, the battery chargers are assumed at full load.

9. SI-3A, 3B, and 3C motors are assumed at 92% efficiency since the motor nameplate states full load amps at 340 amps. When 92% eff and .90% pf are used to calculate the above SI motor amps, 339.2 amps is obtained as follows:

$$\frac{300\text{ hp} \times .746\text{KW/hp}}{.92\text{eff.} \times .90 \times 1.73 \times .46\text{KV}} = 339.2\text{ amps.}$$

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ASSUMPTIONS

10. KVAR for an induction motor will not change significantly from the nameplate value with either a lightly loaded motor or motor loaded into its service factor, see reference 16 section 6.4.

11. For the purposes of determining the load losses of the unit substation transformers it is assumed that the dead load is equally distributed between the transformers connected to each diesel generator. Since the dead load is small when compared to the sequenced load this assumption little effect on the results.

12. Certified test reports could not be retrieved for unit substation transformers T1B-4A and T1B-4C. For the purposes of determining the transformer losses the no load and load loss values for these transformers will be assumed to be equal to the highest values of the other transformers. This assumption is reasonable because the variance in measured losses of the six transformers in the test report is 1% and the losses of T1B-4A & T1B-4C will be comparable.

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INPUTS / REFERENCES

REF. NO.

1. Sargent & Lundy Electrical Load Monitoring System (ELMS) Printout.
2. Electrical Load Distribution Listing (ELDL), Vol. 3, 4.16KV and 480V Buses and MCCs.
3. GHD&R Drawings 11405-E-3, 4.16KV One Line Diagram
   11405-E-4, 480V One Line Diagram, Sh. 1
   11405-E-5, 480V One Line Diagram, Sh. 2
   11405-E-6, 480V MCC One Line Diag., Sh. 1
   11405-E-7, 480V MCC One Line Diag., Sh. 2
4. GE Drawings 177B2371, 480V MCCs Elementary Drawings.
5. EEQ Manual, Section 2, Containment LOCA Response Curves.
6. USAR, Figure 14-6-6, Containment Response
7. USAR, Section 6.2.5, Time to RAS
8. USAR, Section 8.4, Emergency Power Sources
9. Stone & Webster Calculation (16472.19), Confirmation of D1 and D2 Loading.
10. EA-FC-90-76: Cable Tray Loading Calc / Justification
11. MR-FC-87-20: Control Room Outside Air Filter Unit Replacement.
12. USAR, Figure 14.16-2 Long Term Pressure Response Loss of Coolant Accident Rev. 1 (7/89) (Attachment A to this calc.).
13. C.E. letter O-MPS-90-079 from R.W. Bradshaw to R.L. Phelps dated 10/2/90 (Attachment B to this calc.).
14. Modification Request MR-FC-90-53, Containment Spray Header Valve (HCV-344) Interlock.
15. Modification Request MR-FC-84-105, Replacement of Transformers T1B-3A,3B,3C
16. EPRI Power Plant Electrical Reference Series Volume 6, Motors, Copyright 1987

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CONCLUSIONS

Attached are the Load Shed Information Summaries for DG-1 and DG-2. These summaries note the load shed status for each device, the load in KW, the intermittent load (if applicable), and the cycle time (in seconds) for appropriate valves.

To determine the loading on each diesel generator, the total sequential load and the total non-load shed continuous load are needed. The total non-load shed intermittent load will also be found.

Reference the attached Load Shed Information Summary for DG-1 for load information on individual equipment loaded on DG-1. The load totals for DG-1 are as follows:

Total Non-Load Shed Intermittent Load:	61.3 KW
Total Non-Load Shed Continuous Load:	302.1 KW
Total Sequential Load:	2248.9 KW

Therefore, the total load which would be loaded on DG-1 as a result of LOCA coincident with a loss of offsite power is

302.1 KW + 2248.9 KW = <u>2551.0 KW</u>

After approximately <u>2000 seconds</u> into the event, the ventilation fans VA-3A and VA-7C would be expected to unload by approximately 25% of rated KW or 73.6 KW and SI-3A will be at 336.8 hp which is a 17.8 hp increase over the 319 hp (17.8 hp = 14.4 KW for SI-3A). This would reduce the load to approximately 2549.1 - 73.6 + 14.4 = <u>2491.8 KW</u>.

At RAS <u>3740 seconds</u> into the event (minimum safety injection), SI-1A trips reducing the load by 256.1 KW. SI-3A's bhp increases to 338.8 hp which is a further 2.0 hp increase over the 336.8 hp (2.0 hp = 1.6 KW for SI-3A). These two events reduce the load a further (256.1 - 1.6)KW to 2491.8 - 254.5 = <u>2237.3 KW</u>.

For the <u>long term loading</u> (based on automatic load reduction only and no operator action to reduce the load - refer to OPPD calc. FC05522 for long term loading based on operator action), SI-3A will be assumed to be at 343 hp (0 psig containment pressure) for conservatism (refer to Attachments A & B). Therefore, the load will increase another (343 hp - 338.8 hp) = 4.2 hp which for SI-3A is equal to 3.4 KW. Long term KW load = 2237.3 + 3.4 = <u>2240.7 KW</u>. This final long term loading is assumed to occur at 5000 seconds for conservatism (Ref. USAR Figure 14.16-2, Attachment A).

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CONCLUSIONS

Reference the attached Load Shed Information Summary for DG-2 for load information on individual equipment loaded on DG-2. The load totals for DG-2 are as follows:

Total Non-Load Shed Intermittent Load:	208.6 KW
Total Non-Load Shed Continuous Load:	594.4 KW
Total Sequential Load:	1826.2 KW

Therefore, the total load which would be loaded on DG-2 as a result of LOCA coincident with a loss of offsite power is

594.4 KW + 1826.2 KW = 2420.6 KW

After approximately 2000 seconds into the event, the ventilation fans VA-3B and VA-7D would be expected to unload by approximately 25% of rated KW or 73.6 KW and SI-3AC & 3B bhp would increase to 325 hp each (total increase of 40.5 KW). These two events reduce the load further (73.6 KW - 40.5 KW) to 2420.6 KW - 33.1 KW = 2387.5 KW.

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At RAS 3740 seconds into the event (minimum safety injection), SI-1B trips, reducing the load a further 256.1 KW to 2131.4 KW.

The calculated power factor for the diesel generators are:

DG-1	0.87 pf
DG-2	0.85 pf

These power factors are larger than the nameplate rating of .80 at 2500 KW and demonstrate that the LOCA loads are expected to operate within the generator and exciter ratings.

Diesel Generator loading has a direct effect on diesel generator fuel oil consumption, reference FCS Tech Spec. 2.7, and the following calculations should be reviewed for affects of load changes any time this calculation is revised.

FC 05393	DG Sequential loading
FC 05522	DG Fuel Consumption
EA-FC-90-062	DG Operating Temperature Limits

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1.0 LOAD SHED INFORMATION FOR DIESEL GENERATORS DG-1 & DG-2

Attached are the Load Shed Information Summaries for Diesel Generators DG-1 and DG-2. Each summary was developed from a Knowledgeman™ database which contained load information for each electrical device included in the calculation.

The heading of the printout contains the page number, title, revision number and revision date. The first three columns contain the source bus number, breaker number and device tag number, respectively. The next column shows the load shed status for each tag. The column will have a "YES" for load shed loads, a "NO" for not load shed loads and a "SEQ" for sequentially loads.

The fifth column (LOAD) and the sixth column (INTERMITTENT LOAD) contain the actual value of the load in Kilowatts (KW). If the load is continuous, the value will be located in the "LOAD" column. If the load is intermittent, the value will be in "INTERMITTENT LOAD" column. For equipment which would constitute no load in an emergency situation, such as welding receptacles, cranes and fuel handling equipment, both columns will be zero.

The next two columns contain the cycle time (in seconds) for applicable valves. If the valve fails open, the time will be in the "OPEN" column. Similarly, if the valve fails closed, the time will be shown in the "CLOSE" column. The final two columns contain the related schematic drawing number and any comments

After all of the equipment records have been printed, the load totals are printed on the last page. Given are the total not load shed intermittent load , the total not load

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LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-1

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	CLOSE	SCHEMATIC DRAWING	COMMENTS
1A3	1A3-10	AC-10C	SEQ	155.800	0.000			11405-E-24	
1A3	1A3-11	T1B-3A	NO	9.000	0.000			11405-E-16	
1A3	1A3-12	T1B-3B	NO	3.700	0.000			11405-E-16	
1A3	1A3-13	T1B-3C	NO	7.300	0.000			11405-E-16	
1A3	1A3-15	T1B-3D	YES	225.000	0.000			11405-E-16	
1A3	1A3-16	FW-6	SEQ	196.700	0.000			11405-E-16	
1A3	1A3-5	RC-3C	YES	2866.000	0.000			11405-E-17	
1A3	1A3-6	T1C-3A	YES	225.000	0.000			11405-E-16	
1A3	1A3-7	SI-1A	SEQ	256.100	0.000			1[illegible]5-E-17	
1A3	1A3-9	AC-10A	SEQ	155.800	0.000			11405-E-24	
1B3A	1B3A-1	SI-2A	SEQ	240.600	0.000			11405-E-142	
1B3A	1B3A-2	MCC-3A1	NO	0.000	0.000			0204A8668 SH. D2N	
1B3A	1B3A-3	MCC-3A2	NO	0.000	0.000			0204A8668 SH. D2P	
1B3A	1B3A-4	CH-1A	SEQ	12.600	0.000			11405-E-143	
1B3A	1B3A-5	MCC-3A3	YES	0.000	0.000			11405-E-45	
1B3A	1B3A-6	MCC-3A4	YES	0.000	0.000			11405-E-45	
1B3A	1B3A-7	VA-3A	SEQ	196.300	0.000			11405-E-145	
1B3A-4A	1B3A-4A-2	CA-1C	YES	124.300	0.000			11405-E-143	
1B3A-4A	1B3A-4A-3	HE-1	NO	0.000	0.000			0204A8668 SH. D2S	NOT NORMALLY RUNNING
1B3A-4A	1B3A-4A-4	SI-2C	SEQ	240.600	0.000			11405-E-142	
1B3B	1B3B-1	CW-3A	YES	98.200	0.000			11405-E-270	
1B3B	1B3B-2	MCC-3B1	NO	0.000	0.000			0124B4392 SH. 57	
1B3B	1B3B-4	AC-3A	SEQ	217.800	0.000			11405-E-144	
1B3B	1B3B-5	MCC-3B2	YES	0.000	0.000			11405-E-45	
1B3B	1B3B-6	MCC-3B3	YES	0.000	0.000			11405-E-45	
1B3B	1B3B-7	VA-121	YES	80.200	0.000			SK-FC-83-04-01	
1B3B	1B3B-8	DW-46A	YES	123.000	0.000			11405-E-58	
1B3C	1B3C-1	MCC-3C1	NO	0.000	0.000			0124B4392 SH. 101	
1B3C	1B3C-2	MCC-3C2	NO	0.000	0.000			0209A1555 SH. 172	
1B3C	1B3C-3	T1C-3B	YES	0.000	0.000			11405-E-45	
1B3C	1B3C-4	T1B-3C-1	NO	0.000	0.000			0124B4392 SH. 110	
1B3C	1B3C-5	MCC-3C3	YES	0.000	0.000			11405-E-45	
1B3C	1B3C-6	SI-3A	SEQ	258.700	0.000			11405-E-143	used eff. of 92%;319hp per fc-90-53
1B3C	1B3C-7	HE-3	NO	0.000	0.000			0124B4392 SH. 101	NOT NORMALLY RUNNING

LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-1

Rev. 3, 03/25/91

BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
1B3C	1B3C-8	CA-1A	YES	124.300	0.000			11405-E-142	
1B3C	1B3C-9	FW-8A	YES	103.600	0.000			11405-E-45	
1B3C-4C	1B3C-4C-1	MCC-3C4C-1	YES	0.000	0.000			11405-E-45	
1B3C-4C	1B3C-4C-2	MCC-3C4C-2	YES	0.000	0.000			11405-E-45	
1B3C-4C	1B3C-4C-3	VA-7C	SEQ	100.100	0.000			11405-E-145	
1B3C-4C	1B3C-4C-4	AC-3C	SEQ	217.800	0.000			11405-E-143	
MCC-3A1	MCC-3A1-A01	HCV-1103	NO	0.000	17.100			11405-E-26 SH. 3	
MCC-3A1	MCC-3A1-A03	RC-3C-SPACE-HTR	NO	4.500	0.000			11405-E-32 SH. 5	
MCC-3A1	MCC-3A1-A04	RC-3C-1	NO	1.490	0.000			11405-E-32 SH. 3	
MCC-3A1	MCC-3A1-A2R	EE-4S	NO	0.000	0.000			11405-E-75	
MCC-3A1	MCC-3A1-B01	HTRS-BNK1-GRP1	YES	75.000	0.000			11405-E-45	
MCC-3A1	MCC-3A1-C01	HTRS-BNK1-GRP2	YES	75.000	0.000			11405-E-45	
MCC-3A1	MCC-3A1-D01	HTRS-BNK1-GRP3	YES	75.000	0.000			11405-E-45	
MCC-3A1	MCC-3A1-E01	HCV-317	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-3A1	MCC-3A1-E02	HCV-331	NO	0.000	2.420	12		11405-E-29 SH. 3	
MCC-3A1	MCC-3A1-E03	T1B-3A-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-3A1	MCC-3A1-E04	HCV-1385	NO	0.000	17.100		15	11405-E-26	
MCC-3A1	MCC-3A1-F01	HCV-314	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-3A1	MCC-3A1-F02	HCV-2954	NO	0.000	0.696			11405-E-29	
MCC-3A2	MCC-3A2-A02	WD-14A	YES	13.000	0.000			11405-E-42	
MCC-3A2	MCC-3A2-A03	DW-43A	YES	34.300	0.000			11405-E-45	
MCC-3A2	MCC-3A2-B01	WD-34	YES	6.700	0.000			11405-E-37 SH. 7	
MCC-3A2	MCC-3A2-B02	WD-12A	YES	0.888	0.000			11405-E-37 SH. 7	
MCC-3A2	MCC-3A2-B03	WD-26A	YES	6.700	0.000			11405-E-47	
MCC-3A2	MCC-3A2-C01	WD-40A	YES	0.950	0.000			11405-E-37 SH. 3	
MCC-3A2	MCC-3A2-C02	WD-41A	YES	0.950	0.000			11405-E-37 SH. 5	
MCC-3A2	MCC-3A2-C03	WD-27A	YES	0.853	0.000			11405-E-36 SH. 5	
MCC-3A2	MCC-3A2-D01	WD-5A	YES	11.000	0.000			11405-E-47 SH. 4	
MCC-3A2	MCC-3A2-D02	WD-6	YES	12.600	0.000			11405-E-37 SH. 7	
MCC-3A2	MCC-3A2-D03	VD-18A	NO	0.000	0.953			11405-E-30 SH. 8	
MCC-3A2	MCC-3A2-D04	HCV-308	NO	0.000	0.298	20	20	11405-E-51 SH. 3	
MCC-3A2	MCC-3A2-E02	HCV-383-3	NO	0.000	1.590	25		11405-E-29 SH. 6	
MCC-3A2	MCC-3A2-E03	LCV-218-3	NO	0.000	0.497	20		B-23866-414-353	
MCC-3A2	MCC-3A2-E04	LCV-218-2	NO	0.000	0.696		28	11405-E-51 SH. 4	

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LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-1

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-3A2	MCC-3A2-F04	VA-81A	NO	0.000	0.995			02030	
MCC-3A2	MCC-3A2-F05	AC-5A	YES	33.200	0.000			11405-E-45	
MCC-3B1	MCC-3B1-A01	WELDING RECEPTS	NO	0.000	0.000			11405-E-93	USED INTERMITTENTLY
MCC-3B1	MCC-3B1-A2L	WELDING RECEPTS	NO	0.000	0.000			11405-E-93	USED INTERMITTENTLY
MCC-3B1	MCC-3B1-B01	HTRS-BNKP1-GRP6	NO	75.000	0.000			11405-E-45	
MCC-3B1	MCC-3B1-C01	VA-63A	NO	9.330	0.000			11405-E-34 SH. 9	
MCC-3B1	MCC-3B1-C03	WD-2A	YES	8.670	0.000			11405-E-34	
MCC-3B1	MCC-3B1-C04	VA-12A	YES	34.200	0.000			11405-E-45	
MCC-3B1	MCC-3B1-C2L	EE-8C	NO	56.200	0.000			D-55-16105	
MCC-3B1	MCC-3B1-D01	VA-45A	YES	8.780	0.000			11405-E-34 SH. 6	
MCC-3B1	MCC-3B1-D02	VA-41	YES	13.000	0.000			11405-E-55	
MCC-3B1	MCC-3B1-D03	RC-3A-SPACE-HTR	NO	4.500	0.000			11405-E-59	
MCC-3B1	MCC-3B1-D04	RC-3A-1	NO	1.490	0.000			11405-E-59	
MCC-3B1	MCC-3B1-E01	VA-46A	NO	58.900	0.000			B-4415-2207	INSTALLED UNDER MR-FC-81-51
MCC-3B1	MCC-3B1-E04	T1B-3B-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-3B1	MCC-3B1-E05	WD-3A	YES	0.950	0.000			11405-E-35	
MCC-3B1	MCC-3B1-E2L	FH-2A	NO	0.000	0.796			C-10233-E	
MCC-3B1	MCC-3B1-E2R	VA-71A	NO	1.400	0.000			11405-E-48 SH. 1	
MCC-3B1	MCC-3B1-E3R	EE-4N	NO	0.000	0.000			IDF-1104W	
MCC-3B1	MCC-3B1-F01	VA-2A	YES	12.600	0.000			11405-E-35	
MCC-3B1	MCC-3B1-F03	HCV-327	NO	0.000	2.420	12		11405-E-29 SH. 3	
MCC-3B1	MCC-3B1-F04	HCV-348	NO	0.000	7.020		82	11405-E-51 SH. 2	
MCC-3B1	MCC-3B1-G05	HCV-311	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-3B1	MCC-3B1-G2L	EE-15	YES	24.000	0.000			11405-E-319	
MCC-3B1	MCC-3B1-G2R	ATA-D2	NO	0.000	0.000			11405-E-360 SH. 3	
MCC-3B1	MCC-3B1-G3L	VA-52A	YES	13.200	0.000			11405-E-45	
MCC-3B1	MCC-3B1-G3R	FH-1	NO	0.000	0.000			C-10179-E	NORMALLY OFF
MCC-3B1	MCC-3B1-G3R	VA-64A	NO	9.000	0.000			D-4599	
MCC-3B1	MCC-3B1-G4L	EE-22	YES	11.300	0.000			E-23866-414-450	NORMALLY OFF
MCC-3B1	MCC-3B1-G4R	ATA-D1	NO	6.500	0.000			11405-E-360 SH. 3	
MCC-3B1	MCC-3B1-H01	RM-050/051	NO	1.180	0.000			11405-E-3? SH. 2	
MCC-3B1	MCC-3B1-H02	HCV-150	NO	0.000	0.497			11405-E-32	
MCC-3B1	MCC-3B1-H03	HCV-2914	NO	0.000	0.696			11405-E-51 SH. 1	
MCC-3B1	MCC-3B1-H04	HCV-320	NO	0.000	1.690	12		11405-E-29 SH. 3	

LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-1

Rev. 3, 03/25/91

BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-3C1	MCC-3C1-A01	PCV-102-1	NO	0.000	0.000			B-23866-414-370	
MCC-3C1	MCC-3C1-A05	T1B-3C-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-3C1	MCC-3C1-A2L	EE-8E	NO	0.000	0.000			D-55-16105	NORMALLY OFF LINE
MCC-3C1	MCC-3C1-A2R	AUX-ROOF-DISC-SW	NO	0.000	0.000			11405-E-74	NO LOAD
MCC-3C1	MCC-3C1-A3L	CA-4	YES	36.000	0.000			11405-E-45	
MCC-3C1	MCC-3C1-A3R	STRESSING-DIS-SW	NO	0.000	0.000			11405-E-73	NO LOAD
MCC-3C1	MCC-3C1-A4R	EE-4Q	NO	0.000	0.000			IDF-1104W	
MCC-3C1	MCC-3C1-B01	HTRS-BNK2-GRP4	YES	75.000	0.000			11405-E-45	
MCC-3C1	MCC-3C1-C01	HTRS-BNK2-GRP5	YES	75.000	0.000			11405-E-45	
MCC-3C2	MCC-3C2-A01	DW-41A	YES	13.000	0.000			11405-E-45	
MCC-3C2	MCC-3C2-A02	VA-32A	YES	33.200	0.000			11405-E-33 SH. 7	
MCC-3C2	MCC-3C2-A03	VA-40A	YES	49.900	0.000			11405-E-34 SH. 3	
MCC-3C2	MCC-3C2-B01	FW-34A	YES	8.780	0.000			11405-E-45	
MCC-3C2	MCC-3C2-B02	VA-24A	YES	33.200	0.000			11405-E-33 SH. 5	
MCC-3C2	MCC-3C2-B03	VA-40C	YES	49.900	0.000			11405-E-34 SH. 3	
MCC-3C2	MCC-3C2-C01	HCV-265	NO	0.000	0.298	46		11405-E-42 SH. 6	
MCC-3C2	MCC-3C2-C02	HCV-268	NO	0.000	0.497	24		11405-E-42 SH. 6	
MCC-3C2	MCC-3C2-C03	WD-10	YES	1.870	0.000			11405-E-47 SH. 4	
MCC-3C2	MCC-3C2-C04	VA-80A	NO	0.000	0.000			11405-E-49 SH. 4	
MCC-3C2	MCC-3C2-D02	CH-4A	NO	25.600	0.000			11405-E-51 SH. 5	
MCC-3C2	MCC-3C2-D03	CH-12	YES	36.000	0.000			11405-E-42 SH. 1	
MCC-3C2	MCC-3C2-D04	AC-13A	YES	12.600	0.000			11405-E-45	
MCC-3C2	MCC-3C2-E01	EE-23	NO	24.800	0.000			D50734 SH. 2	
MCC-3C2	MCC-3C2-E02	VA-35A	YES	49.900	0.000			11405-E-34 SH. 1	
MCC-3C2	MCC-3C2-E04	WD-8A	YES	11.000	0.000			11405-E-45	
MCC-3C2	MCC-3C2-E3L	EE-28A	YES	7.200	0.000			C-4068	
MCC-3C2	MCC-3C2-E3R	EE-29A	YES	9.600	0.000			WD-891-60	
MCC-3C2	MCC-3C2-F02	WELDING RECEPTS	YES	0.000	0.000			11405-E-64	USED INTERMITTENTLY

Total Not Load Shed Intermittent Load : 61.3

Total Not Load Shed Continuous Load : 302.1

Total Sequential Load : 2248.9

Total Load on DG-1 : 2551.0 KW

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LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-2

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	CLOSE	SCHEMATIC DRAWING	COMMENTS
1A4	1A4-10	T1B-4A	NO	4.600	0.000			11405-E-16	
1A4	1A4-11	AC-10B	SEQ	155.800	0.000			11405-E-24	
1A4	1A4-12	AC-10D	SEQ	155.800	0.000			11405-E-24	
1A4	1A4-14	SI-1B	SEQ	256.100	0.000			11405-E-23	
1A4	1A4-15	T1C-4A	YES	225.000	0.000			11405-E-16	
1A4	1A4-16	RC-3D	YES	2866.000	0.000			11405-E-17	
1A4	1A4-3	CW-1C	YES	981.600	0.000			11405-E-24	
1A4	1A4-4	FW-5C	YES	471.200	0.000			11405-E-11	
1A4	1A4-5	FW-4C	YES	2748.000	0.000			11405-E-11	
1A4	1A4-6	FW-2C	YES	1571.000	0.000			11405-E-11	
1A4	1A4-8	T1B-4C	NO	7.100	0.000			11405-E-16	
1A4	1A4-9	T1B-4B	NO	9.100	0.000			11405-E-16	
1B3B-4B	1B3B-4B-2	FW-8C	YES	103.600	0.000			11405-E-330	
1B3B-4B	1B3B-4B-3	SI-3C	SEQ	243.300	0.000			11405-E-143	used eff. of 92%
1B3B-4B	1B3B-4B-4	VA-7D	SEQ	98.200	0.000			11405-E-145	
1B3B-4B	1B3B-4B-5	CH-1C	SEQ	12.600	0.000			11405-E-143	
1B3B-4B	1B3B-4B-6	HE-2	NO	0.000	0.000			0204A8668 SH. D2V	NOT NORMALLY RUNNING
1B4A	1B4A-1	AC-3B	SEQ	209.700	0.000			11405-E-144	
1B4A	1B4A-2	MCC-4A1	NO	0.000	0.000			0209A1045 SH. D2M	
1B4A	1B4A-3	MCC-4A2	NO	0.000	0.000			0209A1045 SH. D2N	
1B4A	1B4A-4	FW-8B	NO	103.000	0.000			11405-E-330	
1B4A	1B4A-5	CW-3B	YES	98.200	0.000			11405-E-45	
1B4A	1B4A-6	SEC.	YES	0.000	0.000			11405-E-270	
1B4A	1B4A-7	MCC-4A3	YES	0.000	0.000			11405-E-45	
1B4B	1B4B-1	SI-3B	SEQ	243.300	0.000			11405-E-143	use eff. of 92%
1B4B	1B4B-2	MCC-4B1	NO	0.000	0.000			0124B4392 SH. 73C	
1B4B	1B4B-4	CA-1B	YES	124.300	0.000			11405-E-142	
1B4B	1B4B-5	MCC-4B2	NO	0.000	0.000			0124B4392 SH. 73B	
1B4B	1B4B-6	MCC-4B3	YES	0.000	0.000			11405-E-45	
1B4B	1B4B-8	DW-46B	YES	123.000	0.000			11405-E-58 SH. 6	
1B4C	1B4C-2	MCC-4C1	NO	0.000	0.000			0209A1045 SH. D2R	
1B4C	1B4C-3	MCC-4C2	NO	0.000	0.000			0124B4392 SH. 124C	
1B4C	1B4C-4	MCC-4C3	NO	0.000	0.000			0124B4392 SH. 124B	

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1B4C	1B4C-5	SI-2B	SEQ	240.600	0.000			11405-E-142	
1B4C	1B4C-6	CH-1B	SEQ	12.600	0.000			11405-E-143	
1B4C	1B4C-7	MCC-4C4	NO	0.000	0.000			012484392 SH. 124A	
1B4C	1B4C-8	VA-3B	SEQ	196.300	0.000			11405-E-145	
MCC-4A1	MCC-4A1-A01	RC-3B-SPACE-HTR	NO	4.500	0.000			11405-E-32 SH. 5	
MCC-4A1	MCC-4A1-A02	EE-22	YES	11.300	0.000			E-23866-414-450	
MCC-4A1	MCC-4A1-A03	ATA-D1	NO	0.000	0.000			11405-E-360 SH. 3	
MCC-4A1	MCC-4A1-A05	EE-4T	NO	0.000	0.000			11405-E-75	
MCC-4A1	MCC-4A1-A06	RC-3B-1	NO	1.490	0.000			11405-E-32 SH. 3	
MCC-4A1	MCC-4A1-A07	EE-36	NO	0.000	3.990			157673	
MCC-4A1	MCC-4A1-B01	HTRS-BMKP2-GRP7	NO	75.000	0.000			11405-E-52 SH. 9	
MCC-4A1	MCC-4A1-C01	VA-12B	YES	34.200	0.000			11405-E-45	
MCC-4A1	MCC-4A1-C02	EE-8D	NO	56.200	0.000			D-55-16105	
MCC-4A1	MCC-4A1-C03	VA-64B	NO	9.000	0.000			D-4600	
MCC-4A1	MCC-4A1-C04	HCV-1041C	NO	0.000	0.099		110	11405-E-44 SH. 4	
MCC-4A1	MCC-4A1-C05	HCV-151	NO	0.000	0.497			11405-E-51 SH. 3	
MCC-4A1	MCC-4A1-D01	VA-46B	NO	58.900	0.000			B-4415-2560	INSTALLED UNDER MR-FC-81-51
MCC-4A1	MCC-4A1-D02	WD-2B	YES	2.700	0.000			11405-E-47	
MCC-4A1	MCC-4A1-D03	HCV-315	NO	0.000	1.650	12		11405-E-29 SH. 3	
MCC-4A1	MCC-4A1-D04	HCV-318	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-4A1	MCC-4A1-E01	VA-45B	YES	8.510	0.000			11405-E-34 SH. 6	
MCC-4A1	MCC-4A1-E02	VA-52B	NO	13.200	0.000			11405-E-54 SH. 9	
MCC-4A1	MCC-4A1-E03	VA-71B	NO	0.796	0.000			11405-E-48 SH. 1	
MCC-4A1	MCC-4A1-E04	HE-7B	NO	0.000	0.000			11405-E-74	
MCC-4A1	MCC-4A1-E05	ATA-D2	NO	6.500	0.000			11405-E-360 SH. 3	
MCC-4A1	MCC-4A1-E06	WELDING RECEPTS	NO	0.000	0.000			11405-E-73	USED INTERMITTENTLY
MCC-4A1	MCC-4A1-E07	WD-3B	YES	0.950	0.000			11405-E-35 SH. 3	
MCC-4A1	MCC-4A1-F01	VA-2B	YES	12.600	0.000			11405-E-33 SH. 1	
MCC-4A1	MCC-4A1-F02	T1B-4A-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-4A1	MCC-4A1-F03	HCV-2934	NO	0.000	0.696			11405-E-51 SH. 1	
MCC-4A1	MCC-4A1-F04	HCV-329	NO	0.000	2.420	12		11405-E-29 SH. 3	
MCC-4A2	MCC-4A2-A01	DW-41B	YES	13.000	0.000			11405-E-58 SH. 1	
MCC-4A2	MCC-4A2-A03	RM-060	NO	1.490	0.000			11405-E-39 SH. 3	

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LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-2

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-4A2	MCC-4A2-A04	VA-32B	YES	33.200	0.000			11405-E-33 SH. 7	
MCC-4A2	MCC-4A2-A2R	AUX-ROLL-UP-DOOR	NO	0.000	0.000			11405-E-63	NORMALLY OFF
MCC-4A2	MCC-4A2-B01	FW-34B	YES	8.780	0.000			11405-E-45	
MCC-4A2	MCC-4A2-B03A	MPP-6	NO	0.000	75.000			11405-E-10	
MCC-4A2	MCC-4A2-B03B	VA-123	YES	0.000	0.000			11405-E-64	
MCC-4A2	MCC-4A2-B04	EE-29B	YES	0.393	0.000			WD-891-60	
MCC-4A2	MCC-4A2-B05	VA-24B	YES	33.200	0.000			11405-E-33 SH. 5	
MCC-4A2	MCC-4A2-B2L	FH-2B	NO	0.000	0.000			C-10233-E	NORMALLY OFF
MCC-4A2	MCC-4A2-B2R	FH-12	NO	0.000	0.000			C-10271-E	NORMALLY OFF
MCC-4A2	MCC-4A2-C01	VA-80B	YES	4.360	0.000			11405-E-49 SH. 4	
MCC-4A2	MCC-4A2-C03	WD-8B	YES	11.000	0.000			11405-E-35 SH. 5	
MCC-4A2	MCC-4A2-C04	CH-4B	NO	26.300	0.000			11405-E-51 SH. 6	
MCC-4A2	MCC-4A2-C2L	FH-14	NO	0.000	0.000			C-10271-E	NORMALLY OFF
MCC-4A2	MCC-4A2-C2R	HE-10	NO	0.000	0.000			11405-E-65	NORMALLY OFF
MCC-4A2	MCC-4A2-D01	VA-35B	YES	49.900	0.000			11405-E-34 SH. 1	
MCC-4A2	MCC-4A2-D03	VA-40B	YES	49.900	0.000			11405-E-34 SH. 3	
MCC-4A2	MCC-4A2-D2L	AI-102/103	NO	21.800	0.000			627-D-8184 SH. 1	
MCC-4A2	MCC-4A2-D2R	VA-67/68/69	YES	23.600	0.000			11405-E-48 SH. 6	
MCC-4A2	MCC-4A2-E01	EE-16	NO	33.000	0.000			D50734 SH. 2	
MCC-4A2	MCC-4A2-E02	HCV-258	NO	0.000	0.298			11405-E-42 SH. 6	
MCC-4A2	MCC-4A2-E03A	EE-33	YES	7.500	0.000			C-4066	
MCC-4A2	MCC-4A2-E03B	VA-81B	NO	0.000	0.995			02030	
MCC-4A2	MCC-4A2-E03C	EE-37	NO	0.000	6.750			9-4154	
MCC-4A2	MCC-4A2-E04	FW-52	YES	8.780	0.000			4778 435 208-010	
MCC-4B1	MCC-4B1-A02	PCV-102-2	NO	0.000	0.000			11405-E-199	
MCC-4B1	MCC-4B1-A05	TIB-4B-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-4B1	MCC-4B1-A4L	WELDING RECEPTS	NO	0.000	0.000			11405-E-93 SH. 1	USED INTERMITTENTLY
MCC-4B1	MCC-4B1-A4R	EE-4P	NO	0.000	0.000			IDF-1104W	
MCC-4B1	MCC-4B1-B01	HTRS-BNK3-GRP8	YES	75.000	0.000			11405-E-45	
MCC-4B1	MCC-4B1-C01	HTRS-BNK3-GRP9	YES	75.000	0.000			11405-E-45	
MCC-4B2	MCC-4B2-A02	XFMR-AUX-FEED-2	YES	1.500	0.000			11405-E-314	
MCC-4B2	MCC-4B2-A03	VA-8B	YES	12.900	0.000			13007.39-ESK-6A	
MCC-4B2	MCC-4B2-A05	RE-057	NO	0.497	0.000			11405-E-264 SH. 3	

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-4B2	MCC-4B2-A06	VA-151B	YES	82.400	0.000			11405-E-45	
MCC-4B2	MCC-4B2-B01	FW-30B	YES	0.497	0.000			11405-E-262 SH. 1	
MCC-4B2	MCC-4B2-B02	HCV-1150B	NO	0.000	0.000			11405-E-262 SH. 1	NORMALLY OFF
MCC-4B2	MCC-4B2-B03	CF-6	YES	0.557	0.000			11405-E-342 SH. 1	
MCC-4B2	MCC-4B2-B04	VA-90	YES	50.600	0.000			13007.39-ESK-6C	
MCC-4B2	MCC-4B2-C01	ST-4B	YES	8.780	0.000			11405-E-260 SH. 3	
MCC-4B2	MCC-4B2-C02	MOV-D2	NO	0.000	0.000			11405-E-260 SH. 3	NORMALLY OFF
MCC-4B2	MCC-4B2-C03	VD-1B	NO	0.000	26.300			11405-E-341 SH. 1	
MCC-4B2	MCC-4B2-D01	AC-9B	YES	82.400	0.000			11405-E-45	
MCC-4B2	MCC-4B2-D02	VA-186B	NO	0.000	4.470			11405-E-275 SH. 1	
MCC-4B2	MCC-4B2-D03	MOV-B-A1	NO	0.000	0.000			11405-E-265 SH. 1	NORMALLY OFF
MCC-4B2	MCC-4B2-D04	MOV-B-A5	NO	0.000	0.000			11405-E-265 SH. 1	NORMALLY OFF
MCC-4B2	MCC-4B2-D05	MOV-B-C3	NO	0.000	0.000			11405-E-265 SH. 1	NORMALLY OFF
MCC-4B2	MCC-4B2-D06	MOV-B-C7	NO	0.000	0.000			11405-E-265 SH. 1	NORMALLY OFF
MCC-4B2	MCC-4B2-E01	VA-165B	NO	1.090	0.000			11405-E-275 SH. 3	
MCC-4B2	MCC-4B2-E02	VA-165D	NO	1.090	0.000			11405-E-275 SH. 3	
MCC-4B2	MCC-4B2-E03	VA-155F	NO	1.090	0.000			11405-E-275 SH. 3	
MCC-4B2	MCC-4B2-E04	VA-165H	NO	1.090	0.000			11405-E-275 SH. 3	
MCC-4B2	MCC-4B2-E05	MOV-B-B2	NO	0.000	0.000			11405-E-265 SH. 3	NORMALLY OFF
MCC-4B2	MCC-4B2-E06	MOV-B-B6	NO	0.000	0.000			11405-E-265 SH. 3	NORMALLY OFF
MCC-4B2	MCC-4B2-E07	MOV-B-D4	NO	0.000	0.000			11405-E-265 SH. 3	NORMALLY OFF
MCC-4B2	MCC-4B2-E08	MOV-B-D8	NO	0.000	0.000			11405-E-265 SH. 3	NORMALLY OFF
MCC-4C1	MCC-4C1-A01	HTRS-BNK4-GRP10	YES	75.000	0.000			11405-E-45	
MCC-4C1	MCC-4C1-B01	HTRS-BNK4-GRP11	YES	75.000	0.000			11405-E-45	
MCC-4C1	MCC-4C1-C01	HTRS-BNK4-GRP12	YES	75.000	0.000			11405-E-45	
MCC-4C1	MCC-4C1-D01	HCV-312	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-4C1	MCC-4C1-D02	HCV-333	NO	0.000	2.420	12		11405-E-29 SH. 3	
MCC-4C1	MCC-4C1-D03	HCV-1104	NO	0.000	17.100		14	11405-E-26 SH. 3	
MCC-4C1	MCC-4C1-D04	T1B-4C-CLG-FANS	NO	0.750	0.000			11405-E-75	
MCC-4C1	MCC-4C1-E01	HCV-321	NO	0.000	1.690	12		11405-E-29 SH. 3	
MCC-4C1	MCC-4C1-E02	HCV-2974	NO	0.000	0.696			11405-E-51 SH. 1	
MCC-4C1	MCC-4C1-E03	HCV-1384	NO	0.000	0.000	60		11405-E-26 SH. 3	
MCC-4C1	MCC-4C1-E04	HCV-1386	NO	0.000	17.100		14	11405-E-28 SH. 3	

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LOAD SHED INFORMATION FOR DIESEL GENERATOR DG-2

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	MOV / TIME CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-4C1	MCC-4C1-F01	RC-3D-SPACE-HTR	NO	4.500	0.000			11405-E-32 SH. 5	
MCC-4C1	MCC-4C1-F02	RC-3D-1	NO	1.490	0.000			11405-E-32 SH. 3	
MCC-4C1	MCC-4C1-F03	HCV-1042C	NO	0.000	0.298		110	11405-E-44 SH. 4	
MCC-4C1	MCC-4C1-F05	EE-4R	NO	0.000	0.000			11405-E-75	
MCC-4C2	MCC-4C2-A02	WD-14B	YES	13.000	0.000			11405-E-35 SH. 7	
MCC-4C2	MCC-4C2-A03	DW-43B	YES	34.300	0.000			11405-E-45	
MCC-4C2	MCC-4C2-B01	VA-63B	NO	9.330	0.000			11405-E-34 SH.9	
MCC-4C2	MCC-4C2-B02	WD-12B	YES	0.888	0.000			11405-E-47	
MCC-4C2	MCC-4C2-B03	WD-26B	YES	6.700	0.000			11405-E-45	
MCC-4C2	MCC-4C2-C01	WD-40B	YES	0.950	0.000			11405-E-37 SH. 3	
MCC-4C2	MCC-4C2-C02	WD-41B	YES	0.950	0.000			11405-E-37 SH. 5	
MCC-4C2	MCC-4C2-C03	WD-27B	YES	0.950	0.000			11405-E-37	
MCC-4C2	MCC-4C2-D01	WD-5B	YES	11.000	0.000			11405-E-47 SH. 4	
MCC-4C2	MCC-4C2-D02	SL-28	NO	0.000	0.497			13007.54-ESK-6A	
MCC-4C2	MCC-4C2-D03	VD-18B	NO	0.000	0.953			11405-E-30 SH. 8	
MCC-4C2	MCC-4C2-D04	SL-30	NO	0.000	0.497			13007.54-ESK-6A	
MCC-4C2	MCC-4C2-E01	HCV-347	NO	0.000	3.730		82	11405-E-51 SH. 2	NORMALLY CLOSED
MCC-4C2	MCC-4C2-E02	HCV-383-4	NO	0.000	1.590	25		11405-E-29 SH. 6	
MCC-4C2	MCC-4C2-E03	MPP-20	NO	0.000	5.000			11405-E-10	
MCC-4C2	MCC-4C2-E04	CH-13	YES	0.497	0.000			11405-E-42 SH. 1	
MCC-4C2	MCC-4C2-E06	CH-3	YES	0.298	0.000			B-23866-414-303	
MCC-4C2	MCC-4C2-F01	AC-13B	YES	12.600	0.000			11405-E-4[illegible] SH. 8	
MCC-4C2	MCC-4C2-F03	HE-8	NO	0.000	0.000			2419-4	NORMALLY OFF
MCC-4C2	MCC-4C2-F04	RM-061/062	NO	9.200	0.000			904654	
MCC-4C2	MCC-4C2-F05	AC-5B	YES	33.200	0.000			11405-E-45	
MCC-4C3	MCC-4C3-A02	EE-26-1B	YES	8.780	0.000			11405-E-257 SH. 3	
MCC-4C3	MCC-4C3-A05	VA-151D	YES	82.400	0.000			11405-E-45	
MCC-4C3	MCC-4C3-B01	LO-13B	NO	50.600	0.000			11405-E-258 SH. 1	
MCC-4C3	MCC-4C3-B03	WELDING RECEPTS	NO	0.000	0.000			11405-E-283	USED INTERMITTENTLY
MCC-4C3	MCC-4C3-B04	WELDING RECEPTS	NO	0.000	0.000			11405-E-282	USED INTERMITTENTLY
MCC-4C3	MCC-4C3-C01	ST-6B	YES	43.900	0.000			11405-E-257 SH. 3	
MCC-4C3	MCC-4C3-C02	WELDING RECEPTS	NO	0.000	0.000			11405-E-281	USED INTERMITTENTLY
MCC-4C3	MCC-4C3-C03	WELDING RECEPTS	NO	0.000	0.000			11405-E-282	USED INTERMITTENTLY

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-4C3	MCC-4C3-C04	WELDING RECEPTS	NO	0.000	0.000			11405-E-283	USED INTERMITTENTLY
MCC-4C3	MCC-4C3-D01	VA-158B	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-D02	VA-158J	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-D03	VA-158D	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-D04	VA-158L	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-D05	VD-7B	NO	21.100	0.000			11405-E-269 SH. 1	
MCC-4C3	MCC-4C3-D06	VD-5B	NO	4.550	0.000			11405-E-264 SH. 1	
MCC-4C3	MCC-4C3-E01	VA-158F	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-E02	VA-158N	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-E03	VA-158P	YES	6.700	0.000			11405-E-275 SH. 3	
MCC-4C3	MCC-4C3-E04	LO-13D	NO	15.000	0.000			11405-E-258 SH. 3	
MCC-4C3	MCC-4C3-E05	CF-7B	YES	1.490	0.000			11405-E-342 SH. 1	
MCC-4C3	MCC-4C3-E06	WELDING RECEPTS	NO	0.000	0.000			11405-E-280	USED INTERMITTENTLY
MCC-4C3	MCC-4C3-F01	Fw-30C	YES	0.497	0.000			11405-E-262 SH. 1	
MCC-4C3	MCC-4C3-F02	HCV-1150C	NO	0.000	0.000			11405-E-252 SH. 1	NORMALLY OFF
MCC-4C3	MCC-4C3-F04	ST-14	YES	50.000	0.000			11405-E-259 SH. 3	
MCC-4C4	MCC-4C4-A01	CW-2B	NO	2.330	0.000			11405-E-267 SH. 3	
MCC-4C4	MCC-4C4-A02	CW-7	YES	0.995	0.000			11405-E-268 SH. 1	
MCC-4C4	MCC-4C4-A03	LP-19	NO	11.300	0.000			11405-E-311	
MCC-4C4	MCC-4C4-B01	CW-2D	NO	2.330	0.000			11405-E-267 SH. 3	
MCC-4C4	MCC-4C4-B02	CW-2F	NO	2.330	0.000			11405-E-267 SH. 3	
MCC-4C4	MCC-4C4-B03	TIC-4B	NO	11.300	0.000			177B2371 SH. 17	
MCC-4C4	MCC-4C4-C01	CW-14B	NO	0.000	4.940			11405-E-266 SH. 3	
MCC-4C4	MCC-4C4-C02	CW-14D	NO	0.000	4.940			11405-E-266 SH. 3	
MCC-4C4	MCC-4C4-C03	CW-14F	NO	0.000	4.940			11405-E-266 SH. 3	
MCC-4C4	MCC-4C4-C04	HCV-1905C	NO	6.060	0.000			11405-E-266 SH. 1	NORMALLY OFF
MCC-4C4	MCC-4C4-D01	SW-2B	YES	1.990	0.000			11405-E-269 SH. 3	
MCC-4C4	MCC-4C4-D03	WELDING RECEPTS	NO	0.000	0.000			11405-E-299	USED INTERMITTENTLY
MCC-4C4	MCC-4C4-D04	CW-4B	NO	0.000	4.360			11405-E-268 SH. 1	
MCC-4C4	MCC-4C4-D05	VD-2B	NO	0.000	6.700			11405-E-268 SH. 3	
MCC-4C4	MCC-4C4-D06	FP-6B	NO	0.000	4.660			11405-E-340 SH. 3	
MCC-4C4	MCC-4C4-D07	AC-12B	YES	1.490	0.000			11405-E-334 SH. 3	
MCC-4C4	MCC-4C4-DA6	VA-185	NO	3.930	0.000			B-4092	

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BUS NUMBER	BREAKER NUMBER	TAG NUMBER	LOAD SHED	LOAD (KW)	INTERMITTENT LOAD (KW)	MOV / TIME OPEN	CLOSE	SCHEMATIC DRAWING	COMMENTS
MCC-4C4	MCC-4C4-E02	HCV-1905B	NO	0.000	0.000			11405-E-266 SH. 1	
MCC-4C4	MCC-4C4-E03	CW-15B	NO	0.000	0.000			11405-E-266 SH. 3	
MCC-4C4	MCC-4C4-E04	CW-15C	NO	0.000	0.000			11405-E-268 SH. 3	

Total Not Load Shed Intermittent Load : 208.6

Total Not Load Shed Continuous Load : 594.4

Total Sequential Load : 1824.3

Total Load on DG-2 : 2418.7 KW

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2.0 EXPECTED CONTAINMENT FAN LOADING

The expected percentage (%) of nameplate loading for the containment ventilation fans VA-3A, VA-3B, VA-7C, and VA-7D is a function of atmospheric density within containment. The loading is expected to follow the containment pressure profile. The graph on the next page shows the expected containment profile (two cases are shown) and an expected time load curve. The curve loading extremes are bounded by full load at maximum DBA pressure and 50% load at normal pre-DBA environmental conditions. For the purposes of this calculation, the minimum post-DBA load will be assumed to be 75% for conservatism.

Fan curves are available from the vendors test report, Joy Manufacturing Performance an Sound Level Test of Joy Axivane Fans, 07/24/70. This document can be retrieved from the DBD database, WIP 61095. Quality of the document is too poor to be reproduced and included in this calculation. The curves show that motor nameplate horsepower exceeds the maximum fan required bhp. Therefore, this calculation uses the motor nameplate for conservatism.

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ESTIMATED CONTAINMENT COOLING FAN/LOAD AS A FUNCTION OF CONTAINMENT PRESSURE

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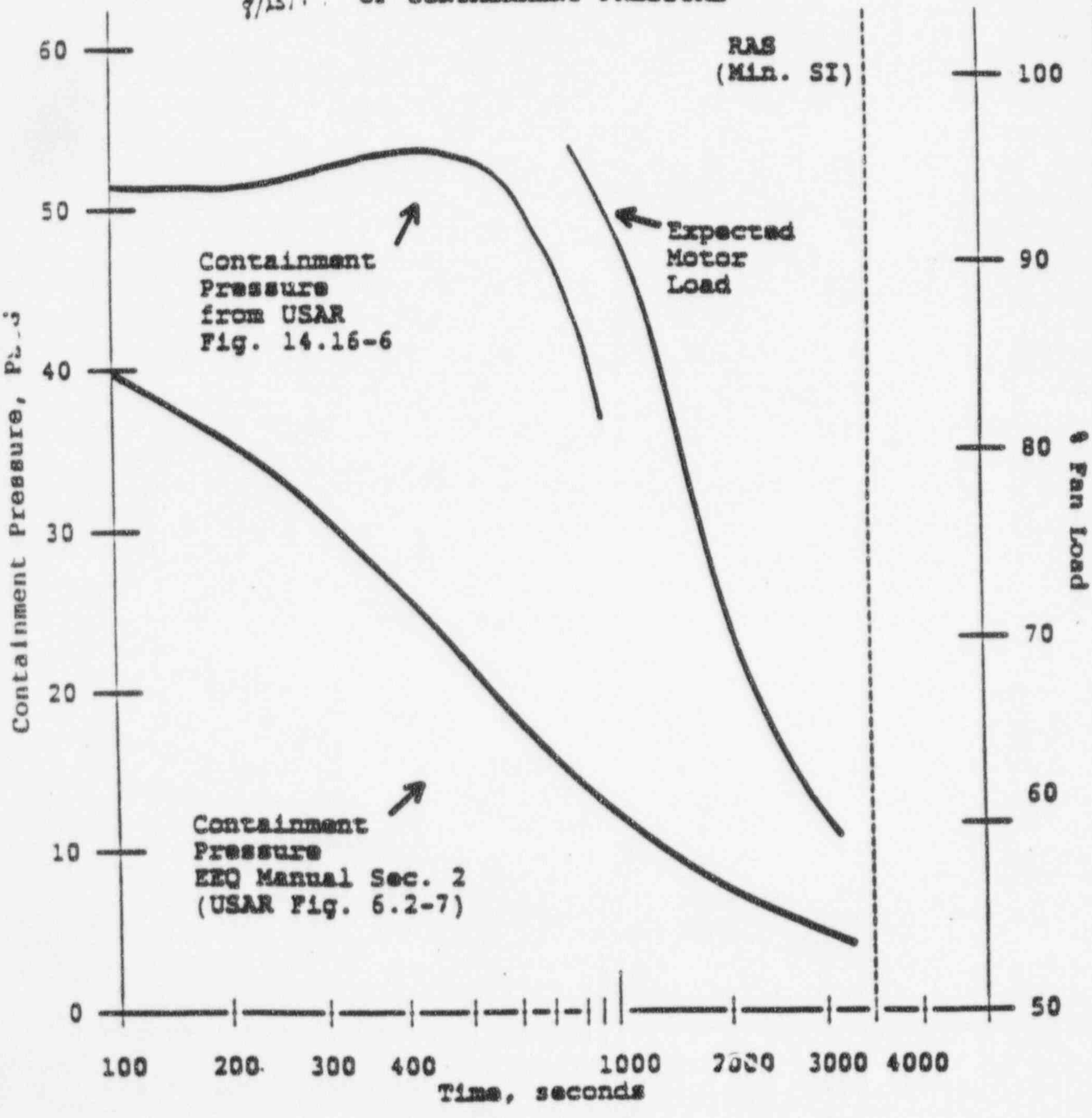

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3.0 INCREASED LOADING ON DG-1 DUE TO SI-3A HP INCREASE

Due to MR-FC-90-53, the SI-3A containment spray pump will require an additional bhp due to the one pump, one header configuration (refer to Attachment B). Looking at the marked up USAR Figure 14.16-2 (Attachment A), at 0 seconds into the LOCA, containment pressure is expected to be approximately 55 psig (60 psig will be used as the 0 second pressure for conservatism). At 2000 seconds into the LOCA, containment pressure is expected to be approximately 17.5 psig. At 3740 seconds into the LOCA, containment pressure is expected to be approximately 10.6 psig. From Attachment B-6, and using linear interpolation, the following is obtained:

Seconds into Accident	Containment Pressure (psig)	Approximate bhp required from SI-3A	Equivalent KW at 92% eff.
0	60	319	258.7
2000	17.5	336.8	273.1
3740	10.6	338.8	274.7
5000	0.0	343.0	278.1

Similar to the situation with SI-3A, the containment spray pumps SI-3B and SI-3C will require additional bhp over the motor nameplate rating with two pump and two header operation and with the contianment pressure of 0 psig. From Attachment D-1 a following values are obtained:

Seconds into Accident	Containment Pressure (psig)	Approximate bhp required from SI-3/B/C	Equivalent KW at 92% eff.
0	60	295	239.2
5000	0.0	325	263.5

For conservatism, nameplate value of 300 hp will be used at time equal 0 sec. and maximum horsepower (325 hp) reqired at 2000 seconds.

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4.0 SEQUENTIAL LOADS BASED ON BRAKE HORSEPOWER REQUIREMENTS

Operating points are plotted on the vendor pump curves to determine the sequential load at worst case DBA conditions. The pump curves and bases for each operating point is included as Attachment C.

The postulated "worst case" DBA condition for a diesel generator is a depressurized large break LOCA with loss of offsite power and failure of the redundant diesel generator.

The calculated KW values have been incorporated into the load shed information tables for DG1 and DG2.

Low Pressure SI Pumps SI-1A (DG-1) & SI-1B (DG-2)

Nameplate	Horsepower	300
	Service factor	1.15
	Efficiency	90%
	Power factor	0.88

Assume all four loop injection valves open prior to redundant diesel failure. Operating LPSI pumps will be in worst case, 309 hp as determined by CE per telecon with B. VanSant of OPPD.

$$KW = \frac{309\ HP \times 0.746\ KW/HP}{.90} = 256.1\ KW$$

High Pressure SI Pumps SI-2A, SI-2B, SI-2C

Nameplate	Horsepower	300
	Service factor	1.15
	Efficiency	93%
	Power factor	0.89

Assume all eight injection valves open prior to the redundant diesel failure.

SI-2A and SI-2C on DG-1 will not go to runout because there are two pumps on one header. Pump operating point has not been confirmed by CE. Therefore this calculation is based on the worst condition which is same bhp as SI-2B.

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SI-2B on DG-2 will go to runout. Based on pump curve the maximum brake horsepower is 300 HP.

$$KW = \frac{300\ HP \times 0.746\ KW/HP}{0.93} = 240.6\ KW$$

Containment Spray Pumps SI-3A, SI-3B, SI-3C

Nameplate		
	Horsepower	300
	Service factor	1.15
	Efficiency	92%
	Power factor	0.90

SI-3A (DG-1), see Section 3.0 of this calculation.

SI-3B and SI-3C (DG-2), operating with two headers available will have a combined flow of 4400 GPM assumed equally distributed from pump curves using recirc flow of 2200 GPM the pumps require 300 HP.

$$KW = \frac{300\ HP \times 0.746\ KW/HP}{0.92} = 243.3\ KW$$

Charging Pumps CH-1A (DG-1) , CH-1B & CH-1C (DG-2)

Nameplate		
	Horsepower	75
	Service factor	1.15
	Efficiency	89%
	Power factor	0.82

Charging pumps are positive displacement pumps. Using a conservative discharge pressure of 200 psig the required power is 15 horsepower.

$$KW = \frac{15\ HP \times 0.746\ KW/HP}{0.89} = 12.6\ KW$$

Note: If RCS pressure were assumed higher, the horsepower requirements for the LPSI would drop compensating for increase in charging requirements.

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CCW Pumps AC-3A (DG-1), 3B (DG-2), and 3C (DG-1)

Nameplate	Horsepower	250
	Service factor	
	Efficiency	92.5%
	Power factor	0.86

Based on 2 CCW pump operation, loss of instrument air and loss of B power. Reference S&W calculation 17321.01-PM-33 Rev. 1 run CL1A0.WR3.

AC-3A & 3C (DG-1)

$$KW = \frac{270 \times 0.746\ KW/HP}{0.925} = 217.8\ KW$$

Based on 1 CCW pump operation loss of instrument air and loss of A power. Reference S&W calculation 17321.01-PM-33 Rev. 1 run CL1AB.WR1.

AC-3B (DG-2)

$$KW = \frac{260 \times 0.746\ KW/HP}{0.925} = 209.7\ KW$$

Raw Water Pumps AC-10A, AC-10B, AC-10C and AC-10D

Nameplate	Horsepower	200
	Service factor	
	Efficiency	91%
	Power factor	0.87

AC-10A and 10C operating with 3 CCW heat exchangers, minimum river water elevation, loss of B power. Reference S&W calculation 17321.01-PM-41 Rev. 0.

AC-10A and 10C (DG-1)

$$KW = \frac{190\ HP \times 0.746\ KW/HP}{0.91} = 155.8\ KW$$

AC-10B and 10D operating with 3 CCW heat exchanges, minimum river water elevation, loss of A power. Reference S&W calculation 17321.01-PM-41 Rev. 0.

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AC-10B and 10D (DG-2)

$$KW = \frac{\underline{190\ HP \times 0.746\ KW/HP}}{0.91} = 155.8\ KW$$

Containment Vent Fans VA-3A, 3B, 7C and 7D

See Section 2.0 of this calculation for determination of operating horsepower.

		VA-3A/B	VA-7C/D
Nameplate	Horsepower	250	125
	Service factor		
	Efficiency	95%	93.2%
	Power factor	0.88	0.88

VA-3A (DG-1)

$$KW = \frac{250\ HP \times 0.746\ KW/HP}{0.95} = 196.3\ KW$$

VA-7C (DG-1)

$$KW = \frac{125\ HP \times 0.746\ KW/HP}{0.93.2} = 100.1\ KW$$

VA-3B (DG-2)

$$KW = \frac{250\ HP \times 0.746\ KW/HP}{0.95} = 196.3\ KW$$

VA-7D (DG-2)

$$KW = \frac{125\ HP \times 0.746\ KW/HP}{0.93.2} = 100.1\ KW$$

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Auxiliary Feedwater Pump FW-6 (DG-1)

Nameplate	Horsepower	250
	Service factor	
	Efficiency	91%
	Power factor	0.87

FW-6 operates at 254 GPM at a TDH of 2403 feet, reference calculation 17321.01-PM-9 Rev. 2, from the pump curve the expected power required is 240 HP.

$$KW = \frac{240\ HP \times 0.746\ KW/HP}{0.91} = 196.7\ KW$$

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5.0 UNIT SUBSTATION TRANSFORMER LOSSES

Transformer losses will be estimated based on the vendors factory test data of no load and full load losses. Losses will be estimated as the sum of the no load loss plus the ratio of the square of the current to the square of the full load current as follows:

Total Losses = No load losses + [Current^2/FLA^2]* full load losses

FLA for 1000 KVA, 4.16 KV transformer = 138.8 amps

From the Westinghouse test data from MR-FC-84-105 Attachment E, (cartridge 1552, frames 841 through 847) the following no load/full load losses are taken

Transformer	Serial #	No Load Loss (KW)	Load Loss (KW)
T1B-3A	DAV36530201	2.7	7.7
T1B-3B	DAV36530202	2.6	7.7
T1B-3C	DA36530401	2.6	7.7
T1B-4A	DA36530301*	2.7	7.7
T1B-4B	DA36530203	2.6	7.7
T1B-4C	DA36530302*	2.7	7.7

*Test data not available, use highest value of similar transformer

The current through each transformer will be estimated as the sum of the currents of each ESF pump connected to the particular transformer plus one-third of the diesel generator dead load amps. Transformer amps are estimated as follows:

Dead Load Amps for DG-1

$$\frac{302.1\ \text{KW}}{(4.16\ \text{KV})(.80)(3)^{1/2}} = 52\ \text{Amps}$$

T1B-3A LOAD AMPS (DG-1)

Dead Load I = 1/3 x 51 = 17A

SI-2A

$$I = \frac{240.6\ KW}{(4.16\ KV)(.89)(3)^{1/2}} = 37.5A$$

SI-2C

$$I = \frac{240.6\ KW}{(4.16\ KV)(.89)(3)^{1/2}} = 37.5A$$

CH-1A

$$I = \frac{12.6\ KW}{(4.16KV)(.82)(3)^{1/2}} = 2.1A$$

VA-3A

$$I = \frac{196.3\ KW}{(4.16KV)(.88)(3)^{1/2}} = 31.0A$$

Total 125.1

T1B-3B LOAD AMPS (DG-1)

Dead Load

$I = 1/3 * 51 = 17A$

AC-3A

$$I = \frac{217.8\ KW}{(4.16KV)(.86)(3)^{1/2}} = 35.1A$$

Total 52.1Amps

T1B-3C LOAD AMPS (DG-1)

Dead Load $I = 1/3 * 51 = 17A$

EA-90-062 REV. 3 ~~PEI~~ pjg 9-19-95

CALC. PAGE NO. 38

ALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	EC03382 Rev. No. 3

REF. NO.

SI-3A

$$I = \frac{258.7\text{ KW}}{(4.16\text{KV})(.90)(3)^{1/2}} = 39.9\text{A}$$

AC-3C

$$I = \frac{217.8\text{ KW}}{(4.16\text{KV})(.86)(3)^{1/2}} = 35.1\text{A}$$

VA-7C

$$I = \frac{98.2\text{ KW}}{(4.16\text{KV})(.88)(3)^{1/2}} = 15.5\text{A}$$

Total 107.5A

The equipment load and no load loss are combined together and results in the total loss for each transformer.

I^2R Losses for Transformer T1B-3A

$$\underline{2.7} + \frac{(125.1)^2}{(138)^2} \times \underline{7.7} = \underline{9.0}$$

I^2R Losses for Transformer T1B-3B

$$\underline{2.6} + \frac{(52.1)^2}{138^2} \times \underline{7.7} = \underline{3.7}$$

I^2R Losses for Transformer T1B-3C

$$\underline{2.6} + \frac{(107.5)^2}{138^2} \times \underline{7.7} = \underline{7.3}$$

EA-90-062 REV. 3 pjc 9-19-95

CALC. PAGE NO. 39

ALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
FC03382
Rev. No. 3

REF. NO.

<u>Total Dead Load for DG-1</u>

T1B-3A	9.0 KW
T1B-3B	3.7 KW
T1B-3C	7.3 KW
	20.0 KW

Loss values for T1B-3A,3B,3C have been entered into the Load Shed Information Summaries for DG1, section 1.0 of the calculation

Dead Load Amps for DG-2

$$\frac{594.9}{(4.16KV)(.80)(3)^{1/2}} = 103 \text{ Amps}$$

T1B-4A Load Amps (DG-2)

Dead Load $I = 1/3 \times 103 = 34A$

AC-3B

$$I = \frac{209.7}{(4.16KV)(.86)(3)^{1/2}} = 33.8A$$

Total 67.8A

T1B-4B Load Amps (DG-2)

Dead Load $I = 1/3 \times 103 = 34A$

SI-3C

$$I = \frac{243.6 \text{ KW}}{(4.16KV)(.90)(3)^{1/2}} = 37.6A$$

SI-3B

$$I = \frac{243.6 \text{ KW}}{(4.16KV)(.90)(3)^{1/2}} = 37.6A$$

CH-1C

$$I = \frac{12.6\ KW}{(4.16KV)(.82)(3)^{1/2}} = 2.1A$$

VA-7D

$$I = \frac{98.2\ KW}{(4.16KV)(.88)(3)^{1/2}} = 15.5A$$

Total $\overline{926.8A}$

T1B-4C Load Amps (DG-2)

Dead Load $I = 1/3 \times 102 = 34A$

SI-2B

$$I = \frac{240.6\ KW}{(4.16KV)(.89)(3)^{1/2}} = 37.5A$$

VA-3B

$$I = \frac{196.3\ KW}{(4.16KV)(.88)(3)^{1/2}} = 31.0A$$

CH-1B

$$I = \frac{12.6\ KW}{(4.16KV)(.82)(3)^{1/2}} = 2.1A$$

Total $\overline{104.6A}$

The equivalent load and dead amps are added together and results in the total load for each transformer.

I^2R Losses for Transformer T1B-4A

$$\underline{2.7} + \frac{(67.8)^2}{(138)^2} \times \underline{7.7} = 4.6$$

EA-90-062 ~~REV~~ pjc 9-19-95
REV. 3

CALC. PAGE NO. 41

ALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED—QP—3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO. FC03382

Rev. No. 3

REF. NO.

I^2R Losses for Transformer T1B-4B

$$\underline{2.6} + \frac{(126.8)^2}{(138)^2} \times \underline{7.7} = 9.1$$

I^2R Losses for Transformer T1B-4C

$$\underline{2.7} + \frac{(104.6)^2}{(138)^2} \times \underline{7.7} = 7.1$$

Total Dead Load for DG-2

T1B-4A	4.6 KW
T1B-4B	9.1 KW
T1B-4C	7.1 KW
	20.8 KW

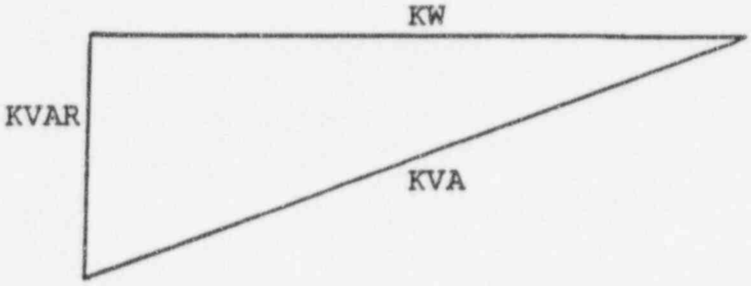
Loss values for T1B-4A,4B,4C have been entered into the Load Shed Information Summaries for DG21, section 1.0 of the calculation

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	EC03382 Rev. No. 3

REF. NO.

6.0 DETERMINE DG LOAD POWER FACTOR

Load KWs are tabulated in Section 1.0. KVAR is determined from nameplate horsepower and power factor. The calculated KVAR will not change significantly for lightly loaded or motors operating in the service factor range. KVAR determined by:



$$KVA = \frac{KW}{pf}$$

$$KVA^2 = KW^2 + KVAR^2$$

therefore:

$$KVAR = KW[1/pf^2 - 1]^{1/2}$$

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED–QP–3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
FC03382

Rev. No. 3

REF. NO.

DG-1 LOAD POWER FACTOR

LOAD	NAMEPLATE KW	PF	LOAD KW	LOAD KVAR
Dead Load	302.1	0.80	302.1	226.6
AC-10C	164.0	0.87	155.8	92.9
FW-6	205.0	0.91	196.7	93.4
SI-1A	248.7	0.88	256.1	134.2
AC-10A	164.0	0.87	155.8	92.9
SI-2A	240.6	0.89	240.6	123.3
CH-1A	62.9	0.82	12.6	43.9
VA-3A	196.3	0.88	196.3	106.0
SI-2C	240.6	0.89	240.6	123.3
AC-3A	201.6	0.86	217.8	119.6
SI-3A	243.3	0.90	258.7	117.8
VA-7C	100.1	0.88	100.1	53.0
AC-3C	201.6	0.86	217.8	119.6
			2551.0	1446.5

$$\text{LOAD POWER FACTOR} = \cos(\tan^{-1}[\text{KVAR}/\text{KW}])$$

$$= \cos(\tan^{-1}[1446.5/2551.0])$$

$$= \underline{.87}$$

EA-90-062

DG-2 LOAD POWER FACTOR

LOAD	NAMEPLATE KW	PF	LOAD KW	LOAD KVAR
DEAD LOAD	594.4	0.80	594.4	445.8
AC-10B	164.0	0.87	155.8	92.9
AC-10D	164.0	0.87	155.8	92.9
SI-1B	248.7	0.88	256.1	134.2
SI-3C	243.3	0.90	243.3	117.8
VA-7D	100.2	0.88	100.1	53.0
CH-1C	62.9	0.82	12.6	43.9
AC-3B	201.6	0.86	209.7	119.6
SI-3B	243.3	0.90	243.3	117.8
SI-2B	240.6	0.89	240.6	123.3
CH-1B	62.9	0.82	12.6	43.9
VA-3B	196.3	0.88	196.3	106.0
			2420.6	1491.1

LOAD POWER FACTOR $= \cos(\tan^{-1}[\text{KVAR}/\text{KW}])$

$= \cos(\tan^{-1}[1491.1/2420.6])$

$= \underline{.85}$

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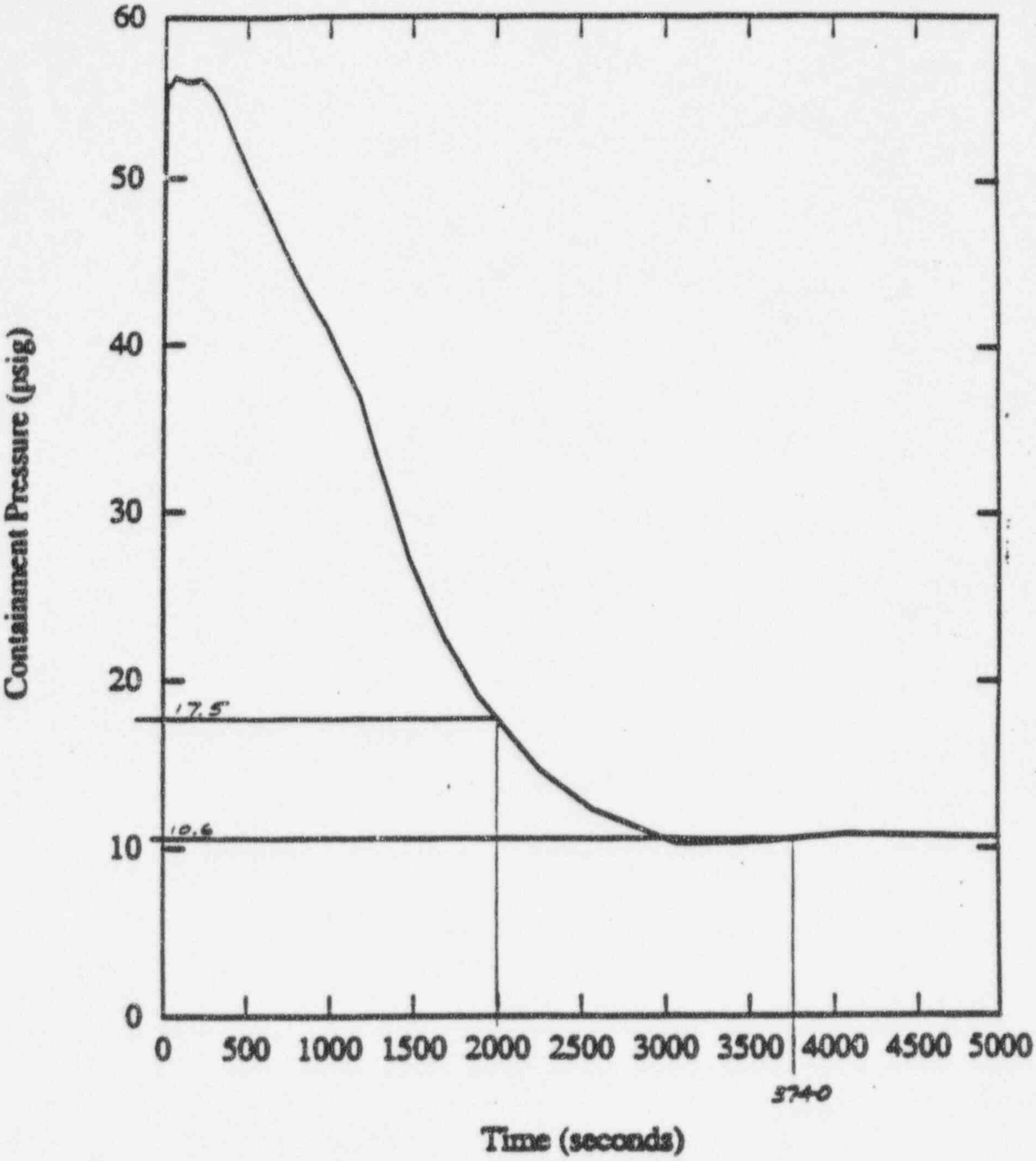
REV. 3

~~REV 2~~ pjw 9-19-95

EA-90-062

FC03382, Rev. ~~2~~3

ATTACHMENT A



Long-Term Pressure Response Loss of Coolant Accident	**Omaha Public Power District Fort Calhoun Station-Unit No. 1**	**Figure** 14.16-2

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EA-90-062 REV. 3
~~REV 2~~ gjc 9-19-95

FC03382, Rev. ~~2~~ 3
ATTACHMENT B-1

ABB
ASEA BROWN BOVERI

October 2, 1990
O-MPS-90-079

Mr. R. L. Phelps
Omaha Public Power District
7W/EP-1
444 South 16th Street Mall
Omaha, Nebraska 68102-2247

Subject:	Analysis of the Ft. Calhoun Containment Spray System

References:

(A) CE Letter O-MPS-90-078, Same Subject, R. W. Bradshaw to R. L. Phelps (OPPD) dated September 29, 1990

(B) OPPD Containment Spray System Analysis, CE Calculation 602438-MPS-5CALC-001

(C) CE Letter OPPD-90-054, Same Subject, D. K. Sentell to W. O. Weber (OPPD) dated August 16, 1990

(D) OPPD telecopy dated September 30, 1990

Enclosure:

(1) Containment Spray Flow Rate for the B Containment Spray Header Case "1 Header, 1 Heat Exchanger, 1 Pump" with one Spray Nozzle Missing

Dear Mr. Phelps:

Combustion Engineering has provided an analysis of the flow rates in the Containment Spray System at the Fort Calhoun Station under various post accident conditions using "as-built" plant configuration data. High Confidence results of that analysis were provided in Reference (A). The purpose of this letter is to provide additional information about the method used to obtain those results, the effect of the missing spray nozzle in the B Containment Spray Header, and other issues raised during previous phone conversations. These are provided as high confidence information having been reviewed by a Qualified Reviewer. Final Quality Assurance of all analyses is expected to be completed by October 12, 1990.

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ATTACHMENT B-2

~~REV 2~~ pjc 9-19-95

1. One Pump/One Header Hydraulic Analysis

Reference (A) summarized the results of a one pump/one header and one pump/two header hydraulic analysis. The method used to arrive at those results and the additional results of Enclosure (1) are identical to that employed in the C-E calculation of containment spray flow rate based upon "reference-design" plant configuration data. That calculation, Reference (B), is a recorded calculation in accordance with the Combustion Engineering Quality Assurance Procedure Manual QAM-101 and was transmitted to OPPD by Reference (C). As Reference (A) illustrates, the values obtained using the "as-built" input data are consistent with the values obtained in Reference (B) using the "reference-design" input data.

The results shown in both Reference (A) and Enclosure (1) were calculated with each of the three Containment Spray pumps' minimum recirculation line isolated. This assumption in these analyses is a significant difference from the current system alignment.

The results shown in Reference (A) for the "as-built" plant configuration were developed for the purpose of evaluating the performance of the Containment Spray Pump with respect to the service factor allowance of the motor. Therefore, the objective was to determine both the lowest and the highest values of expected pump flow rate by defining the two cases Flow(1) and Flow(2). The results given in Reference (A) are for the A Containment Spray Header. The B Containment Spray Header differs from the A Header due to: (1) a missing spray nozzle, and (2) the presence of two additional valves. The results for the B Containment Spray Header flow rates for the case of "1 Header, 1 Heat Exchanger, 1 Pump" are provided in Enclosure (1) of this letter. The net effect of the differences in the existing conditions of the headers is that the B header has a slightly larger flow rate.

Enclosure (1) indicates that expected pump motor performance will be within the range of acceptable BHP with consideration for the service factor rating of the pump (300 nominal BHP plus 1.15% service factor limit giving 345 BHP). Enclosure (1) assumes that the three Containment Spray pump minimum recirculation manual valves are closed. Evaluations with these valves open show results which are unacceptably high with respect to the motor service factor limit and unacceptably low with respect to the containment overpressure protection. Discussions with the motor vendor, General Electric Co., have indicated that the pump motor can run continuously for up to 60 days at the 345 BHP service factor limit.

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~~REV 2~~ pjc 9-19-95

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ATTACHMENT B-3

2. Containment Transient Analysis

When evaluating the Containment Spray flow rate with respect to the Containment Building post accident design pressure the values shown in Enclosure (1) must be corrected to account for the effectiveness of the flow. The flow rate through the location with the missing nozzle cannot be credited due to the lack of dispersion and those nozzles which are blocked by existing ventilation duct work cannot be credited as well. The results shown in Enclosure (1), when corrected for the above issues, have been reviewed with respect to the criteria for post accident containment design pressure protection and have been found to be acceptable. The acceptance criteria for containment peak pressure protection is a function of both spray flow rate and SIRWT temperature. As a bounding minimum, an atomized spray flow rate of at least 2085 gpm at a SIRWT temperature of less than 117 degrees F will be required to maintain containment pressure less than 60 psig during the course of a design basis LOCA.

3. SIRWT Level Sensitivity

C-E has evaluated the effects of maximum SIRWT level on the maximum flow rate values tabulated in Enclosure (1). The conclusion is that the SIRWT level would have to be greater than 10 feet above the current minimum technical specification operating limit before the established maximum flow rate limit of 3200 gpm is exceeded. OPPD will verify this to be acceptable by reviewing as-built SIRWT drawings.

4. System Orifice Installation

C-E performed an initial review of the feasibility of incorporating an orifice in the piping leading to the A and B containment spray headers. This was to prevent the containment spray pump motor from exceeding its service factor load limit in the case where one pump supplied two headers. Preliminary evaluations conclude that the orifice would need to provide a Cv of 347 resulting in a 47 psid pressure drop at 1600 gpm. Qualitative evaluations indicate that it is feasible to incorporate the orifice without inducing cavitation. Several issues would need to be addressed, however, to fully evaluate the acceptability of this approach. Specifically, orifice sizing, location, and stress requirements would have to be quantitatively addressed. Additionally, the pipe loading induced by the flow induced forces would have to be assessed prior to implementation.

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5. Pump Degradation Evaluation

C-E evaluated the containment spray pump test data provided in Reference (D). The data for the pump in question were compared to the analysis assumptions and were found to fall within the 5% degradation assumption.

6. Spray Nozzle Performance

An evaluation was performed to identify the affect of Enclosure (1) on the expected nozzle performance. Of particular concern was the expected droplet size that is determined by nozzle flow and differential pressure. Conversations with the nozzle manufacturer have indicated that an expected drop size for the flows of Enclosure (1) would be on the order of 1800 microns. The C-E Containment Transient code CONTRANS does not specifically address spray drop size in the thermal hydraulic calculations of the post LOCA containment atmosphere. The analysis is driven principally by the spray thermal efficiency which is specified as a function of the steam/air mass ratio in the containment. The spray efficiency model within the code is based on a spray drop mean diameter of 1080 microns and a conservative (low) drop fall height of 20 feet. While spray flow rate does not have a strong affect on the overall thermal efficiency, spray drop size does. ORNL studies have shown, however, that 100% thermal efficiency is obtained in full size containment buildings (typical fall height in excess of 90 feet) for drop sizes in the range of 500 to 4000 microns. For this reason, the expected drop size of 1800 microns is satisfactory from a thermal hydraulics perspective.

7. Three Pumps, One Header Hydraulic Evaluation

The case of three pumps operating to supply one header with spray flow was evaluated. Such a case would result if both emergency diesel generators operated, a header isolation valve failed to open, and all three pumps started. This configuration may have been a concern if the system was to be throttled in some manner to address the one pump two header case. The resulting head and flow conditions without system throttling, however, are such that they improve the overall system performance with higher system flow rate and pump work distributed across three pumps. A similar configuration was analyzed in the "reference-design" calculation as one of the design basis configurations. No further analysis of this configuration was completed in support of this project nor is it deemed necessary.

If you have any questions regarding this analysis or if we can be of further assistance, please do not hesitate to call me at (203) 285-5443 or Mr. Frank Ferraraccio at (203) 285-3893.

Sincerely,

COMBUSTION ENGINEERING, INC

Richard W Bradshaw

Richard W. Bradshaw
Manager, Plant Systems

Distribution:

- K. Holthaus (OPPD)
- W. Weber (OPPD)
- L. Philpot (CE)
- F. Ferraraccio (CE)
- D. Sentall (CE)

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EA -90-062

REV. 3

~~REV~~ 2 pjc 9-19-95

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ATTACHMENT B-6

ENCLOSURE (1)
O-MPS-90-079

CONTAINMENT SPRAY FLOW RATES for the B CONTAINMENT SPRAY HEADER CASE "1 HEADER, 1 HEAT EXCHANGER, 1 PUMP" WITH ONE SPRAY NOZZLE MISSING

Containment Pressure psig / ft.	Flow(1) (gpm)	Flow(2) (gpm)	BHP(1)	BHP(2)
0 / 0	3040	3175	337	343
15 / 35	2900	3040	336	337
30 / 70	2740	2890	330	336
45 / 105	2560	2740	319	330
60 / 140	2380	2560	315	319

NOTES

(1) Assumes low SIRWT level and degraded pump performance of 5% to minimize expected flow rate.

(2) Assumes minimum technical specification level in the SIRWT and nominal pump performance to maximize expected flow rate.

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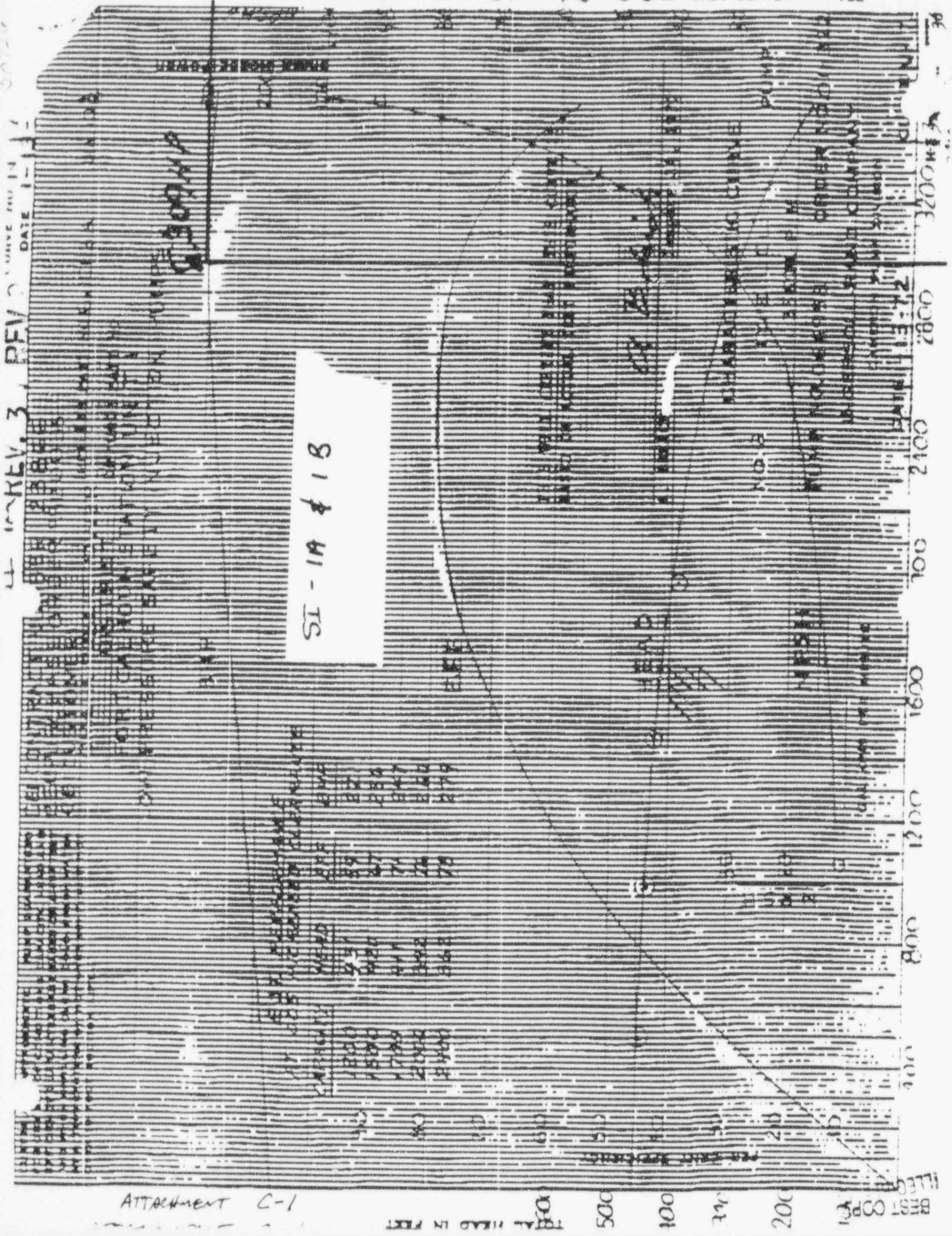
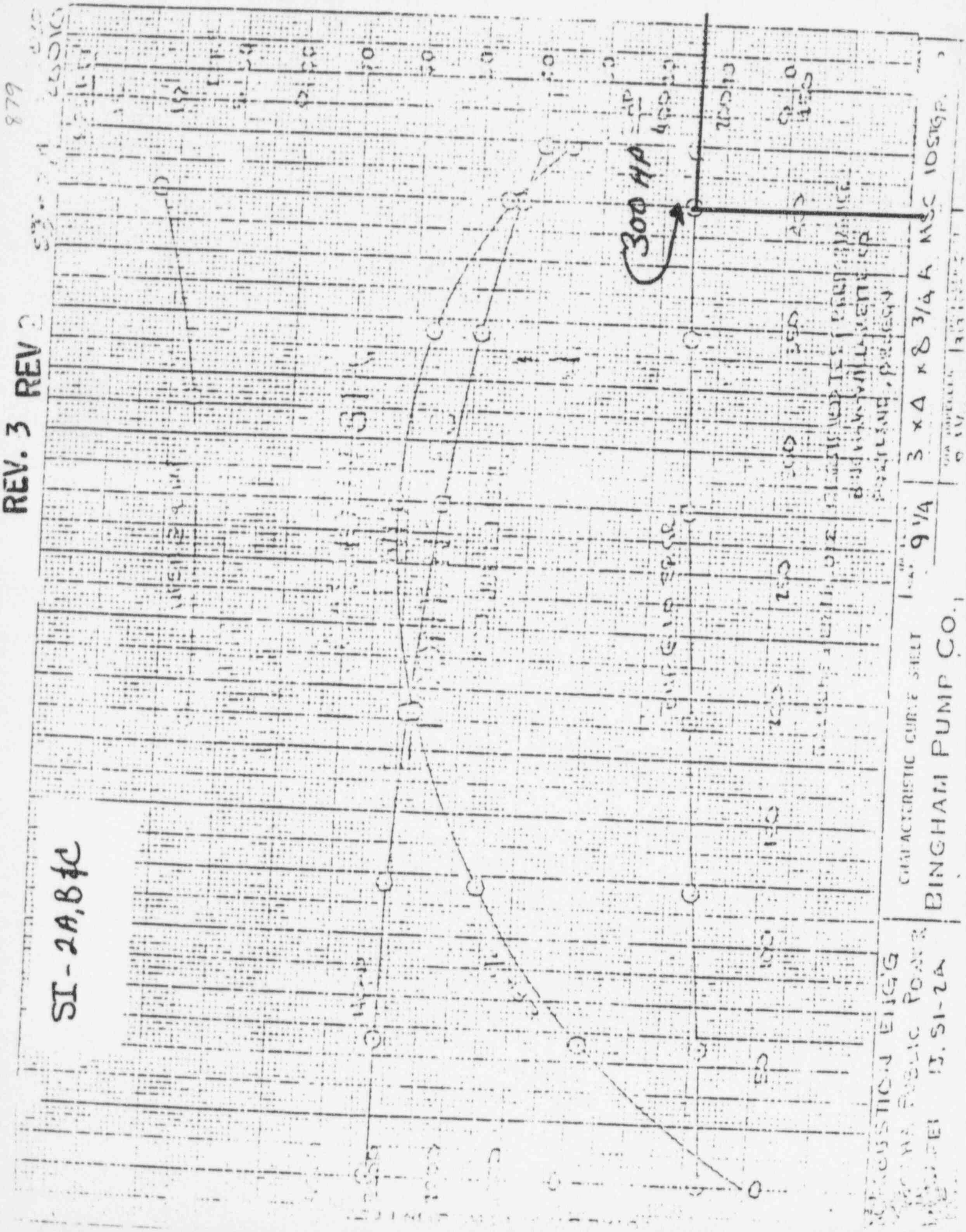
MAR-07-1991 11:03 FROM OPPD ENERGY PLAZA **EA-90-062** REV3 SWEC-DENVER P.02



ATTACHMENT C-1

ATTACHMENT C-2

EA-90-062

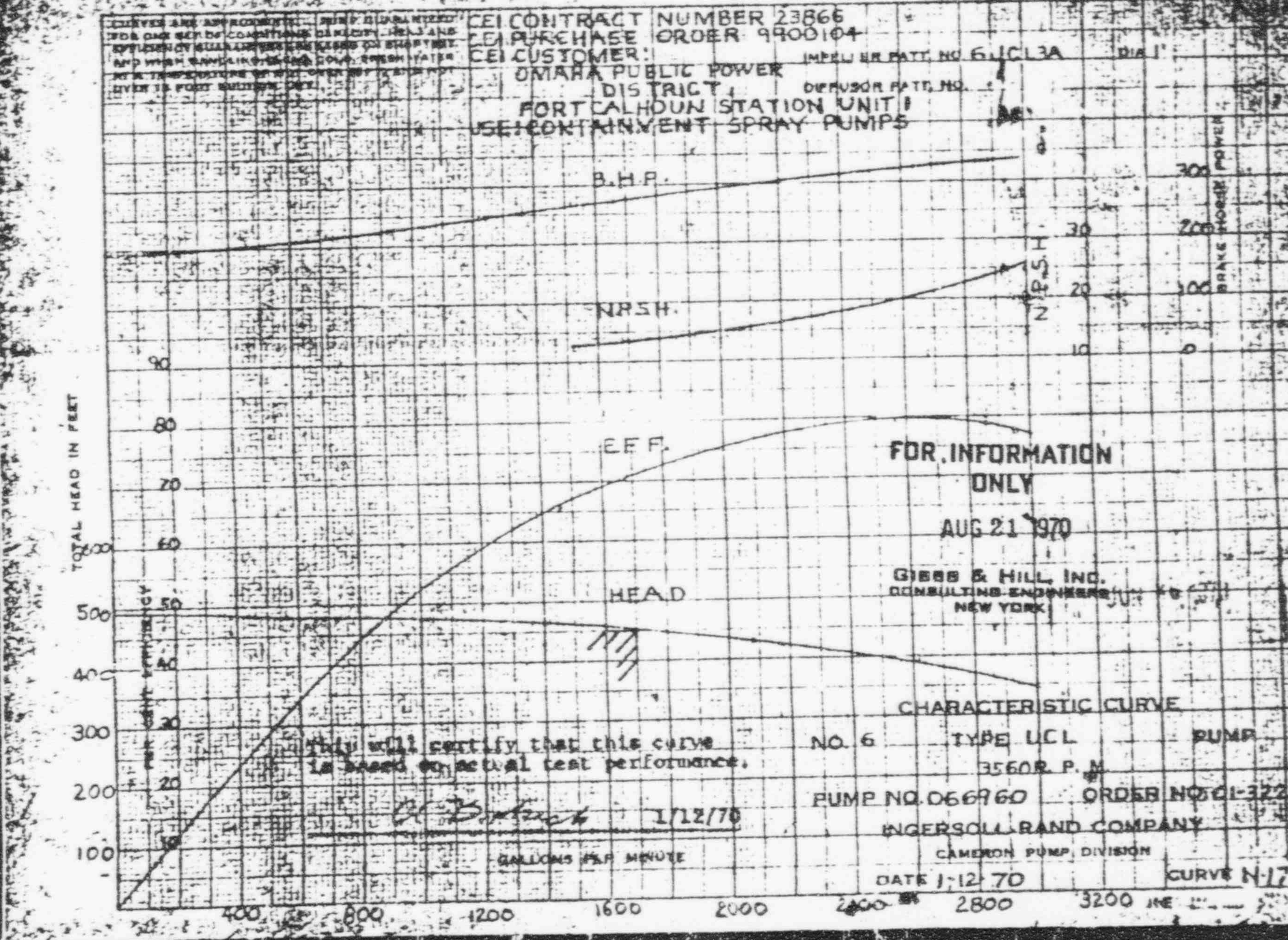


EA-FC-90-062 REV3
Attachment G-3

CURVE NO. N-171
DATE 1-12-70

CEI CONTRACT NUMBER 23866
CEI PURCHASE ORDER 9900104
CEI CUSTOMER:
OMAHA PUBLIC POWER DISTRICT
FORT CALHOUN STATION UNIT I
USE: CONTAINMENT SPRAY PUMPS

IMPELLER PATT. NO 6-UCL3A DIA 1"
DIFFUSOR PATT. NO.



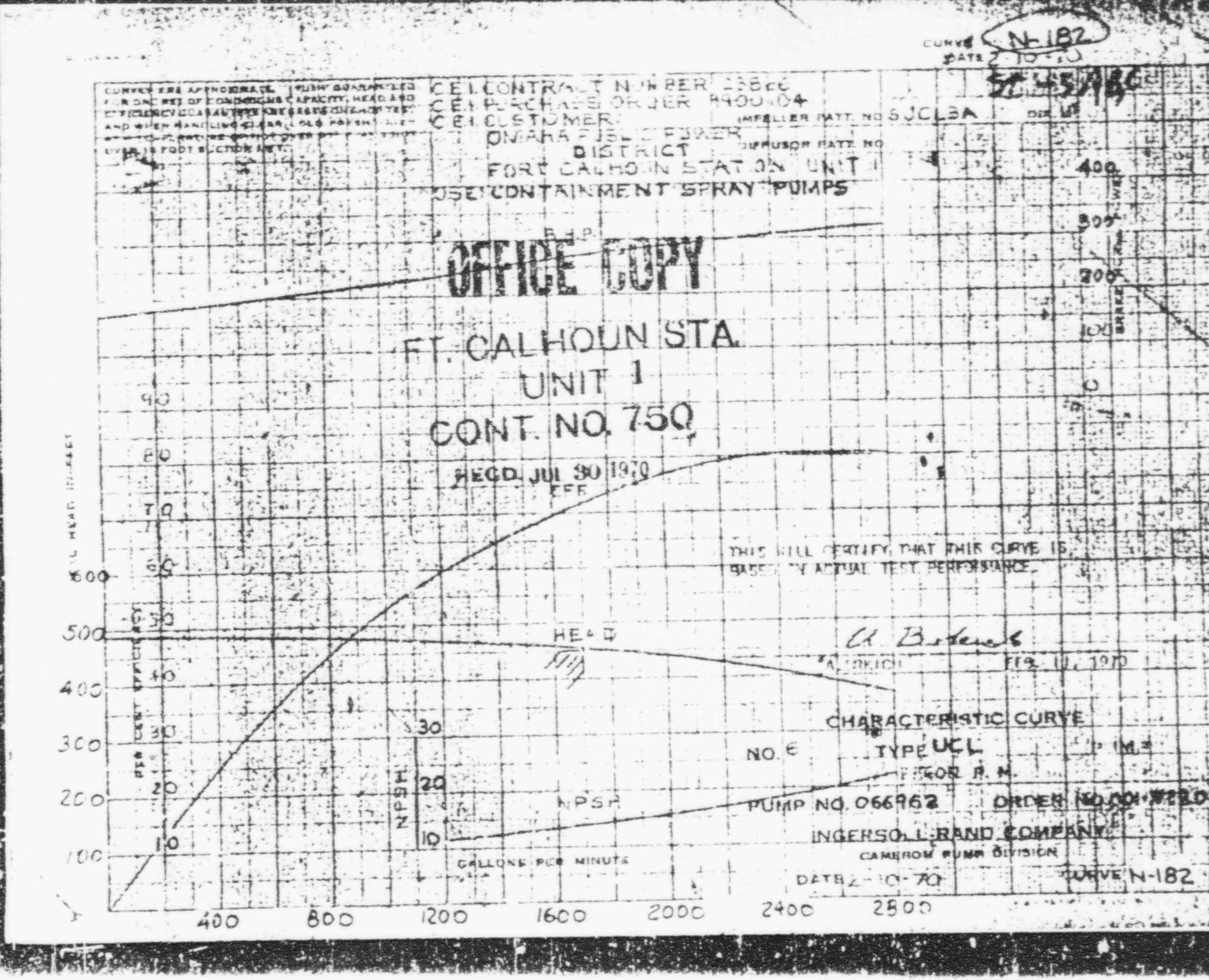
This will certify that this curve is based on actual test performance.

1/12/70

FOR INFORMATION ONLY
AUG 21 1970
GIBBS & HILL, INC.
CONSULTING ENGINEERS
NEW YORK

CHARACTERISTIC CURVE
NO. 6 TYPE UCL PUMP
3560 R. P. M.
PUMP NO. 066960 ORDER NO. 01-32206
INGERSOLL-RAND COMPANY
CAMERON PUMP DIVISION
DATE 1-12-70 CURVE N-171

EA-FC-90-062 REV3
ATTACHMENT C-4
SI-3A,B,C



ILLEGIBLE

CUSTOMER Peter Kiewit Sons PROPOSAL NO. 07-21861 ITEM 8 SPECIAL NOTES 0969693	**DESIGN CONDITIONS** GPM 3425 EFF 81% T. H. (FT) 210 BHP SG. RPM 1750 DRIVER 250 HP Motor	**Ingersoll-Rand** DRAWN BY DATE 6-23-70	CURVE 8SE3A 4-7/8 PUMP 8X18SE Curves are approximate. Pump is guaranteed for one set of conditions. Capacity, head and efficiency guarantees are based on shop test and when handling clear, cold, fresh water at a temperature of not over 85 degrees and not over 15' suction lift.

11405

AC-3A & C

EA-90-062

ATTACHMENT-C-5

53717

EA-FC-90-062 REV 3
ATTACHMENT C-6 AC-3B

6 POOR QUALITY

CUSTOMER [illegible]
PROPOSAL NO. [illegible] ITEM [illegible]
SPECIAL NOTES
0269624

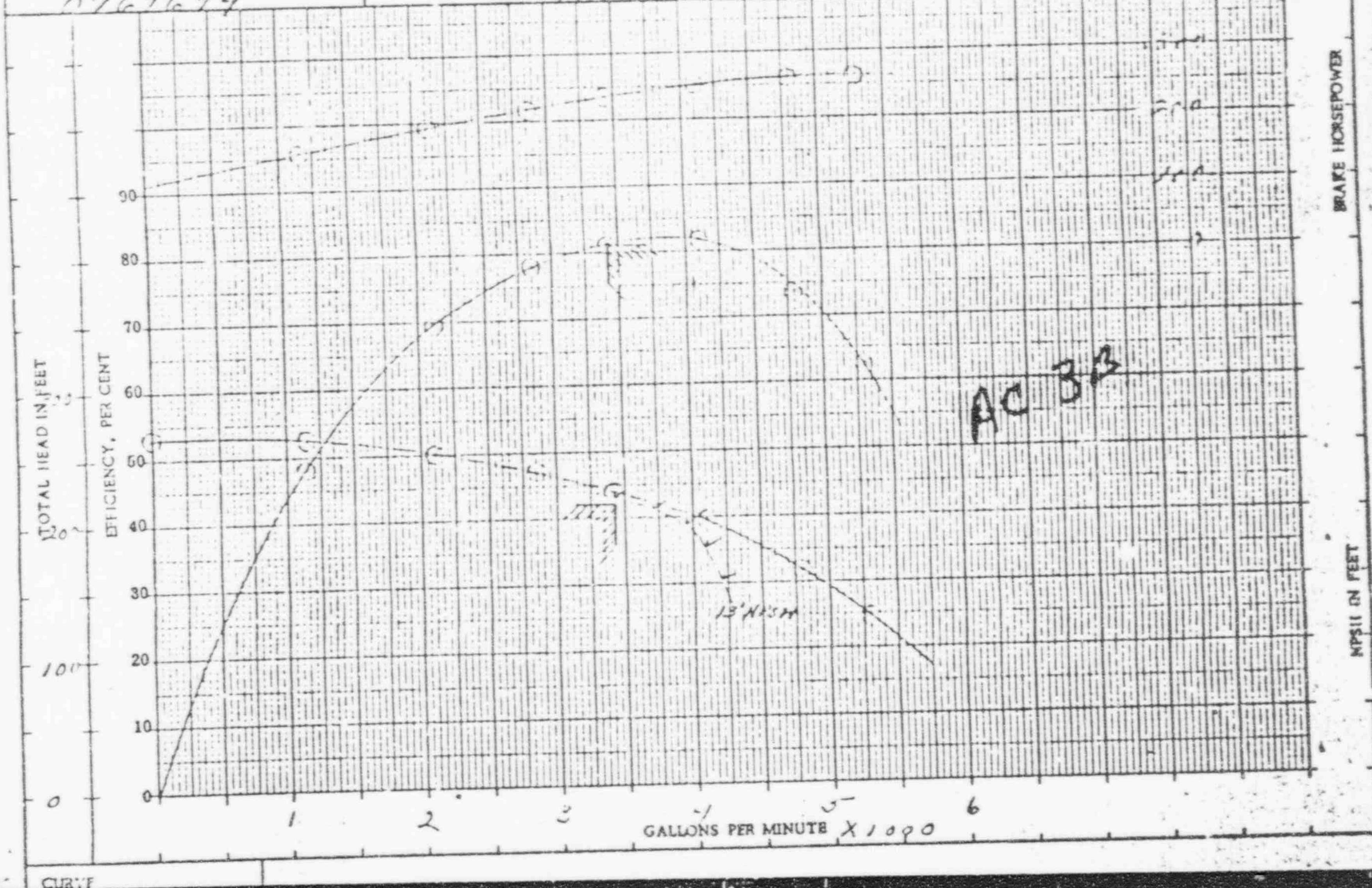
DESIGN CONDITIONS
GPM [illegible] EFF [illegible]
T. H. (FT.) [illegible] BHP SG.
RPM [illegible] DRIVER [illegible] HP

Ingersoll-Rand

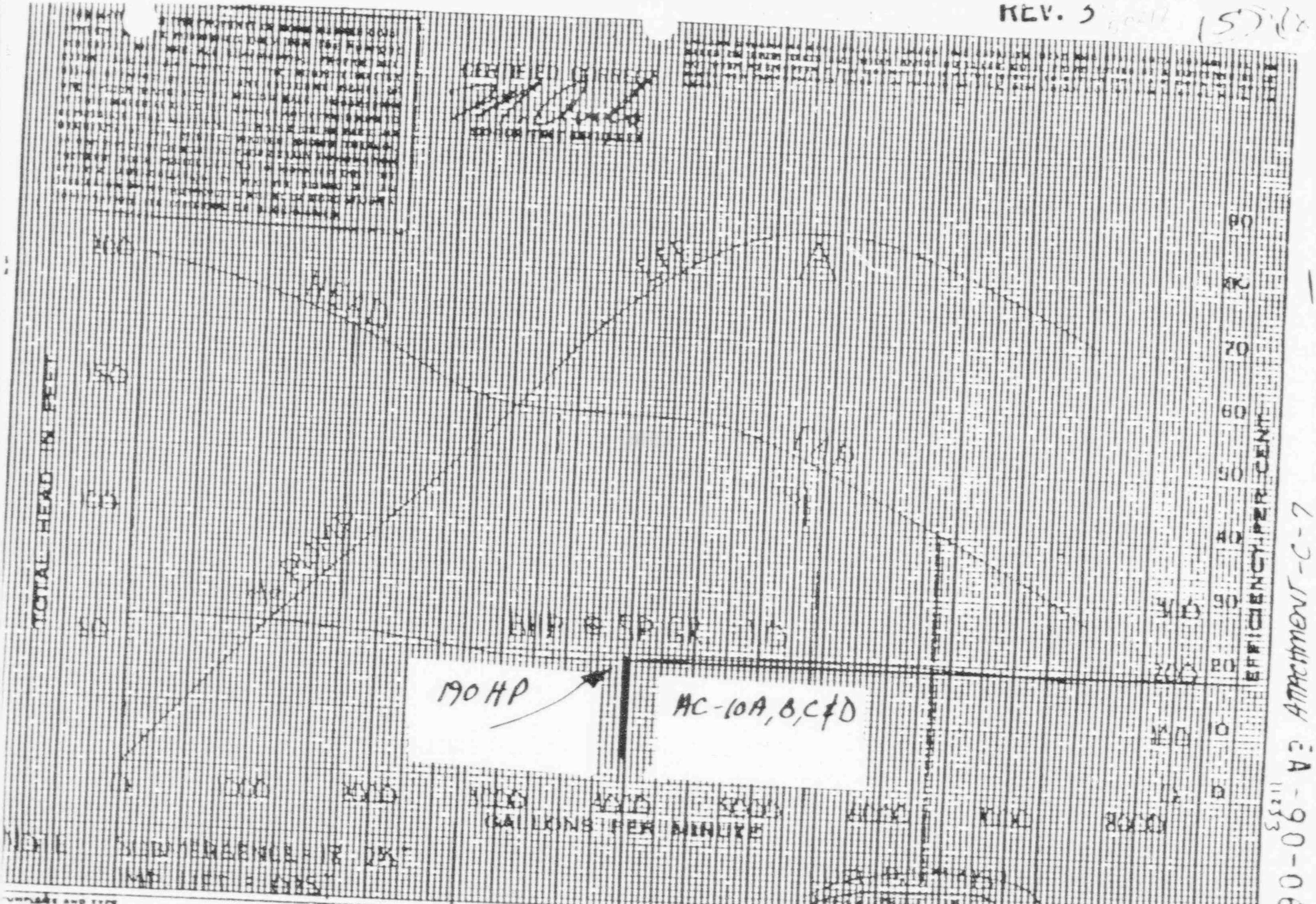
DRAWN BY
DATE [illegible]-22-[illegible]

CURVE [illegible]
PUMP [illegible]

Curves are approximate. Pump is guaranteed for one set of conditions. Capacity, head and efficiency guarantees are based on shop test and when handling clear, cold, fresh water at a temperature of not over 85 degrees and not over 15' suction lift.



REV. 5 (5)



190 HP

AC-10A, B, C & D

28 RXI 2STG. VERT. CIRC.	RPM 1183	ASSEMBLY NO. 1F-6991 FACTORY NO. 191-H-0470	IMPELLER NO. R-2789 DATE 9-30-70	12 3/4 DATA BY E.J.S.	UNDER 1 STG. DRAWN BY E.J.S.	BYRON JACKSON TEST T-319

ATTACHMENT-C-7 EA-90-062
11233

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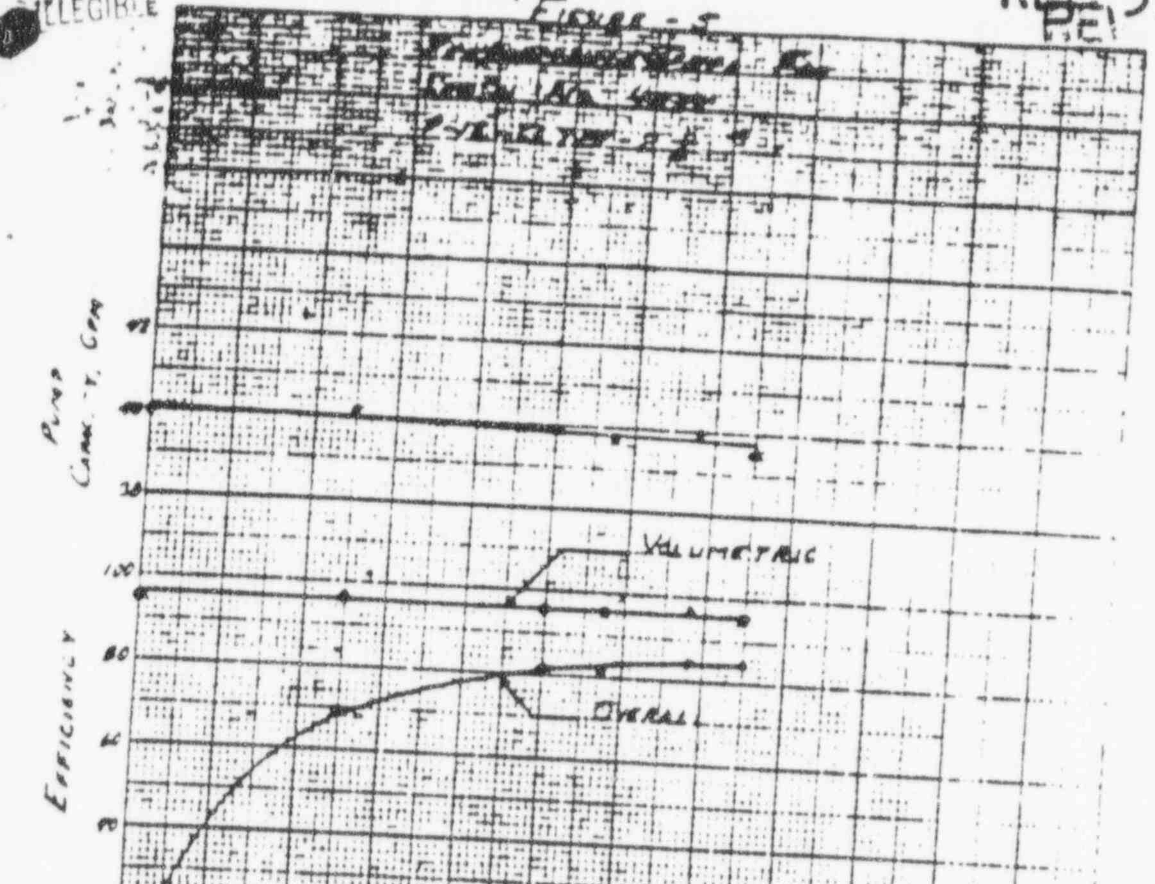
EA-90-062 REV 3



CH-1A, 1B & 1C

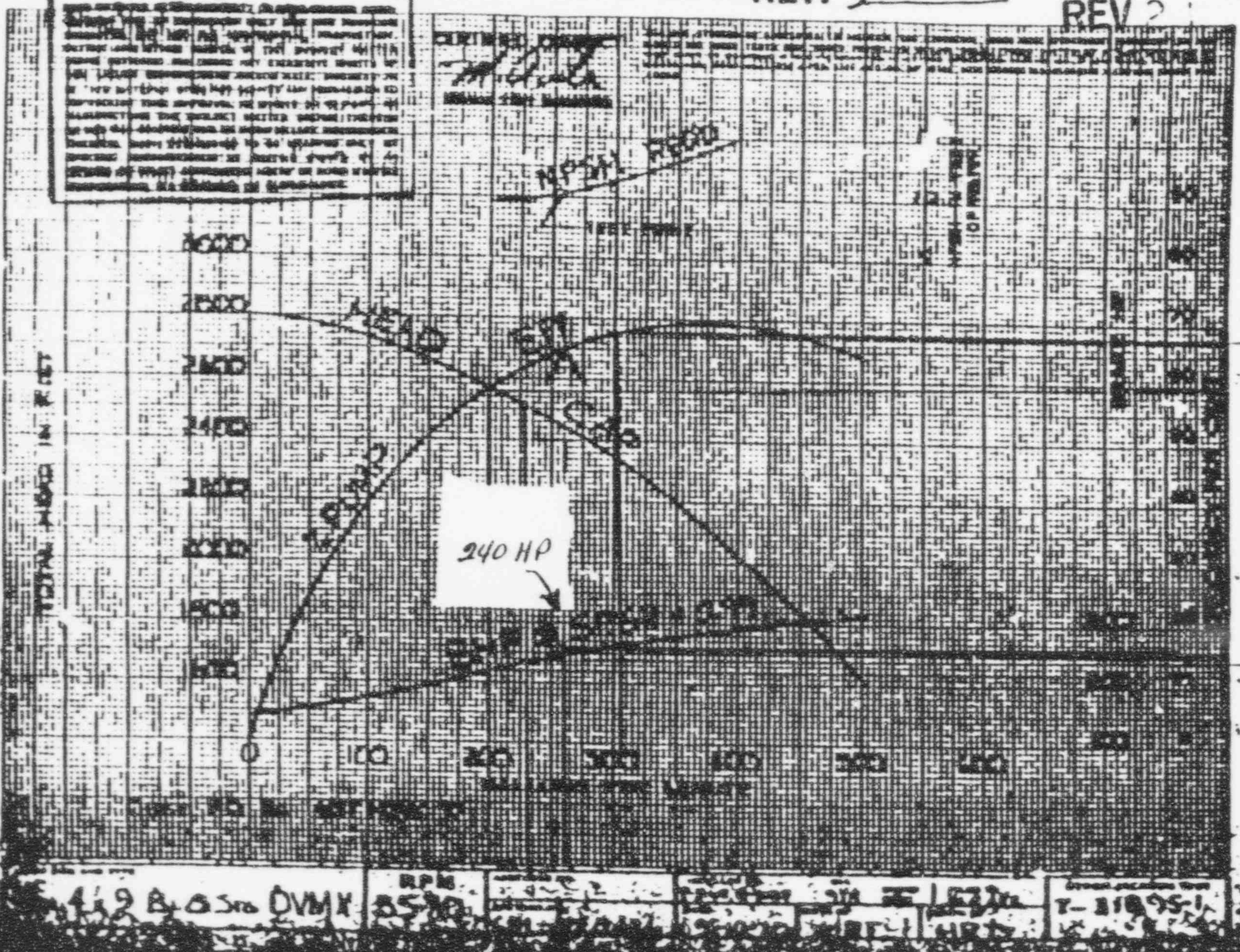
ATTACHMENT - C-8

EA-90-062 BYRON JACKSON REV. 3FW-6

50211
50686

1/ POOR QUALITY

ILLEGIBLE



ATTACHMENT - C-9

001671

FC03382 Rev 3
ATTACHMENT D-1

EA-90-062
~~REV 2~~ pjs 9-19-95

Memorandum

REV. 3

PED-FC-91-1762

DATE: March 21, 1991

FROM: B. J. Van Sant

TO: R. F. Mehaffey

SUBJECT: Motor Horsepower Estimate for SI-3B and C pump operation

Per your request, DEN-Mechanical has performed an informal calculation to determine the motor horsepower requriements for the containment spray pumps. We have analyzed the performance of the B and C pumps operating through two heat exchangers and two spray headers.

The results of the analysis show the pumps to supply 2650 GPM each at 0 psig in containment. At 60 psig the pumps will suppyh 2125 GPM each. The motor horsepower per pump is 325 and 295, respectively.

The analysis assumed the SIRWT was at Technical Specification minimum. This is conservative since the level will drop during the accident. The analysis also assumed nominal pump performance. This is also conservative since the actual pump performance is slightly degraded.

Although the analysis was informal, it has been checked. The analysis was based on resistance values derived in the Combustion Engineering's (C-E) calculation for Spray Pump performance. Those resistance values were used to develop system curves for the two header, two pump hydraulic model. The head curves for the two pumps were combined, and the intersection with the system curves for 0 psig and 60 psig containment pressure were plotted.

C-E is performing a design basis calculation to verify the values given here. DEN-Electrical will be notified of any changes at that time.

If you have any questions, contact Jon Ressler at extension 2426.

B. J. Van Sant
Supervisor - Mechanical Engineering
Production Engineering

c: R. L. Phelps
J. L. Skiles
R. E. Lewis
R. G. Eurich
R. P. Clemens
J. S. Ressler
PED Library

FC-84-105

FC 003382
REV 3
Attach E-1

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```
                        CERTIFIED TRANSFORMER TEST REPORT

GENERAL ORDER: 54X2-9399                  SHOP ORDER: DAV3653 MN29446MKC
 STOMER: OMAHA PPD               PURCHASER'S ORDER NUMBER: MN29399MKC
3-PHASE     60 HERTZ      COOLANT- AIR         SUB/PHASE POLARITY

WINDING HIGH VOLTAGE                              WINDING LOW VOLTAGE
 1000 KVA                                          1000 KVA
 4160 VOLTS DELTA                                  480 VOLTS DELTA
TAPS:  4360  4260  4160  4055  3950
------------------------------------------------------------------------------
RESISTANCES, LOSSES, IMPEDANCE, AND REGULATION CORRECTED TO 100 DEGREE C.
RESISTANCES, EXCITING CURRENT, LOSSES AND IMPEDANCES ARE BASED ON NORMAL
RATING, UNLESS OTHERWISE STATED.  LOSSES AND REGULATION ARE BASED ON WATTMETER
MEASUREMENTS.  FOR THREE-PHASE TRANSFORMERS, THE RESISTANCES ARE THE SUM OF
THE THREE PHASES IN SERIES.
------------------------------------------------------------------------------
                    : RESISTANCES IN :   AT 100% RATED       : 04160 TO    480  :
                    : OHMS           :        VOLTAGE        :  1000 KVA        :
:  SERIAL   : TEST  : W I N D I N G  : %EXCITING : NO LOAD   : LOAD LOSS :      :
:  NUMBER   : DATE  :  H.V.  :  L.V. : CURRENT   : LOSS WATT: WATTS      :%IMP  :
DAV[illegible]530101  110185  .59405   .00591  0.5988        2565    7759     6.60 :
DAV[illegible]530[illegible]01  1107[illegible]  .57652   .00591  0.5977        2609    7661     6.55 :
DAV3653[illegible]    11078   .58556   .00590  0.5[illegible]        2550    7606     6.90 :
DAV36530[illegible]  111385  .57643   .00595  0.5900        2619    7703     [illegible].75 :
DAV36530401  111385  .57[illegible]   .00587  0.5424        2647    7702     [illegible].71 :
------------------------------------------------------------------------------
                              :              :          : TOTAL LOSS        .
                  AVERAGE     :    .6034     :    2610  :  10311         :
                  GUARANTEE   :              :          :           MIN 5.
   ------------------------------    --------------------------------------
                             REGULATION

     POWER FACTOR 100%                              80%
     AVERAGE        1.188                           6.116
   ------------------------------   ------------------------------------
                    TEMPERATURE [illegible] TEST
AVERAGE RISE IN DEGREE C., COM[illegible]       [illegible]     SHUTDOWN OF TRANSFORMER
SERIAL NO. DAV36530101 WITH [illegible]       [illegible]     LOADED AS FOLLOWS:
HV WINDING    3950 VOLTS  146.[illegible] AMPS [illegible] LV WINDING   480 VOLTS  [illegible].8 AMPS
UNTIL CONSTANT TEMPERATURE WAS REACHED
                       WINDING RISE
                       BY RESISTANCE
                      IRON    LOAD
              LOAD    RISE    RISE   GUAR     TOTAL     [illegible]     TEMP
              100%    25.0    46.2    60       55.1
              133%    13.9    55.0    80       62.6

           DATE 11/14/65 APPROVED BY ______________                  ------
                                         PAGE   1 OF           PAGES
```

REV. 3 1

~~REV~~

pja
9-19-95

EA-90-062

[illegible] FC 84-10

STOMER: OMAHA PPD PURCHASER'S ORDER NUMBER: MN29399MKC

BEST COPY

FC038 DAS

FC03382
REV 3
ATTACH E-2

pjc 9-19-95

~~REV 2~~

INSULATIONS TEST

APPLIED POTENTIAL TEST (VOLTAGE IS APPLIED BETWEEN EACH WINDING AND ALL OTHER WINDINGS CONNECTED TO CORE AND GROUND)

WINDING	RATED VOLTS	TEST VOLTAGE APPLIED	DURATION OF TEST
H.V.	04160	12 KV	60 SECONDS
L.V.	480	4 KV	60 SECONDS

INDUCED POTENTIAL TEST: TWO TIMES RATED VOLTAGE ACROSS THE FULL WINDING AT 180 HERTZ FOR 7200 CYCLES.

EA -90-062

SERIAL 0203 & 0401 TEST RESULT ADDED.

REV. 3

I HEREBY CERTIFY THAT THIS IS A TRUE REPORT BASED ON FACTORY TESTS MADE IN ACCORDANCE WITH THE LATEST TRANSFORMER TEST CODE C57 OF THE AMERICAN STANDARDS ASSOCIATION; AND THAT EACH TRANSFORMER WITHSTOOD THE ABOVE INSULATION TESTS.

DATE 11/14/85 APPROVED BY Lloyd Allen

[illegible] 0 8 4 3

COPY SUBMITTED
BEST COPY

FC-84-105

FCO3382
REV 3
ATTACH E-3

CERTIFIED TRANSFORMER TEST REPORT

GENERAL ORDER: 54X2-9399 SHOP ORDER: DAV3653 MN29446MKC
CUSTOMER: OMAHA PPD PURCHASER'S ORDER NUMBER: MN29399MKC
3-PHASE 60 HERTZ COOLANT- AIR SUB/PHASE POLARITY

WINDING HIGH VOLTAGE
1000 KVA
4160 VOLTS DELTA
TAPS: 4360 4260 4160 4055 3950

WINDING LOW VOLTAGE
1000 KVA
480 VOLTS DELTA

REV. 3

EA-90-062 ~~REV~~ pgc 9-19-95

IMPULSE TEST

SERIAL NUMBER TESTED	*WAVE TYPE	BUSHING	HORIZONTAL SWEEP MICROSEC/CM	KV/CM	VERTICAL DEFLECTION (CM)	KV	OSCILLOGRAM
DAV3653O101	RWE	H1	5	9.10	1.700	15.47	1
	RWI	H1	10				2
	CW	H1	1	16.20	1.700	30.94	3
	CW	H1	1	18.20	1.700	30.94	4
	FWE	H1	5	18.20	1.700	30.94	5
	FWI	H1	10				6
	RWE	H2	5	9.10	1.700	15.47	7
	RWI	H2	10				8
	CW	H2	1	16.20	1.700	30.94	9
	CW	H2	1	18.20	1.700	30.94	10
	FWE	H2	5	18.20	1.700	30.94	11
	FWI	H2	10				12
	RWE	H3	5	9.10	1.700	15.47	13
	RWI	H3	10				[illegible]
	CW	H3	1	18.20	1.700	30.94	15
	CW	H3	1	18.20	1.700	30.94	16
	FWE	H3	5	18.20	1.700	30.94	17
	FWI	H3	10				18
	RWE	X0/1/2/3	5	9.10	.550	5.01	19
	CW	X0/1/2/3	1	18.20	.550	10.01	20
	CW	X0/1/2/3	1	16.20	.550	10.01	21
	FWE	X0/1/2/3	5	18.20	.550	10.01	22

*CW = CHOPPED WAVE, RW = REDUCED WAVE, FW = FULL WAVE, I = CURRENT, E = VOLTS

DATE 11/14/85 APPROVED BY Lloyd Allen

~~REV 2~~ 9-19-95
REV. 3

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.2
EA -90-062

page 1

A. Derating Curves For EMD Diesels

B. Letter From Ted Fryar of M-K to Randy Mueller, Dated 2/21/80

pjc 9-19-95

~~REV 2~~ EA-90-062

REV. 3

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.2a

page 1a

Derating Curves for EMD Diesels

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pjc
~~REV 2~~ 9-19-95

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.2a-1

MORRISON-KNUDSEN COMPANY, INC.
[illegible]

POST OFFICE BOX [illegible]
ROCKY MOUNT, NORTH CAROLINA [illegible]
[illegible]
[illegible]

EA -90-062

SENT.: ________
DATE: ________
TIME: ________

REV. 3

TELECOPY

DATE: August 24, 1989

COMPANY: Omaha Public Power

ATTENTION: Mr. Brian Perry

REFERENCE: Elevated Diesel Generator Water Temp.

TELECOPY NUMBER: 402-533-6747

THIS IS PAGE 1 OF 2.

FROM: Harry Falter

IF YOU DO NOT RECEIVE ALL PAGES LISTED, PLEASE CALL OUR WORD PROCESSING DEPT., (919)977-2720, EXT. 212.

Attached is a data sheet that shows the engine jacket water alarm set @ 208°F and shutdown @ 215°F. Long operation @ temperatures over 208°F may reduce the life of the cylinder heads.

NOTE: FOR WATER TEMPERATURE IN EXCESS OF 190°F REQUIRES POWER DERATION PER CURVE (200 to 210°F) WITH AMBIENT AIR (COMBUSTION AIR) TEMPERATURES ABOVE 90°F.

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.2a-2

DIESEL GENERATOR DERATION CURVES

~~REV 2~~ pjc 4-1995 EA-90-062

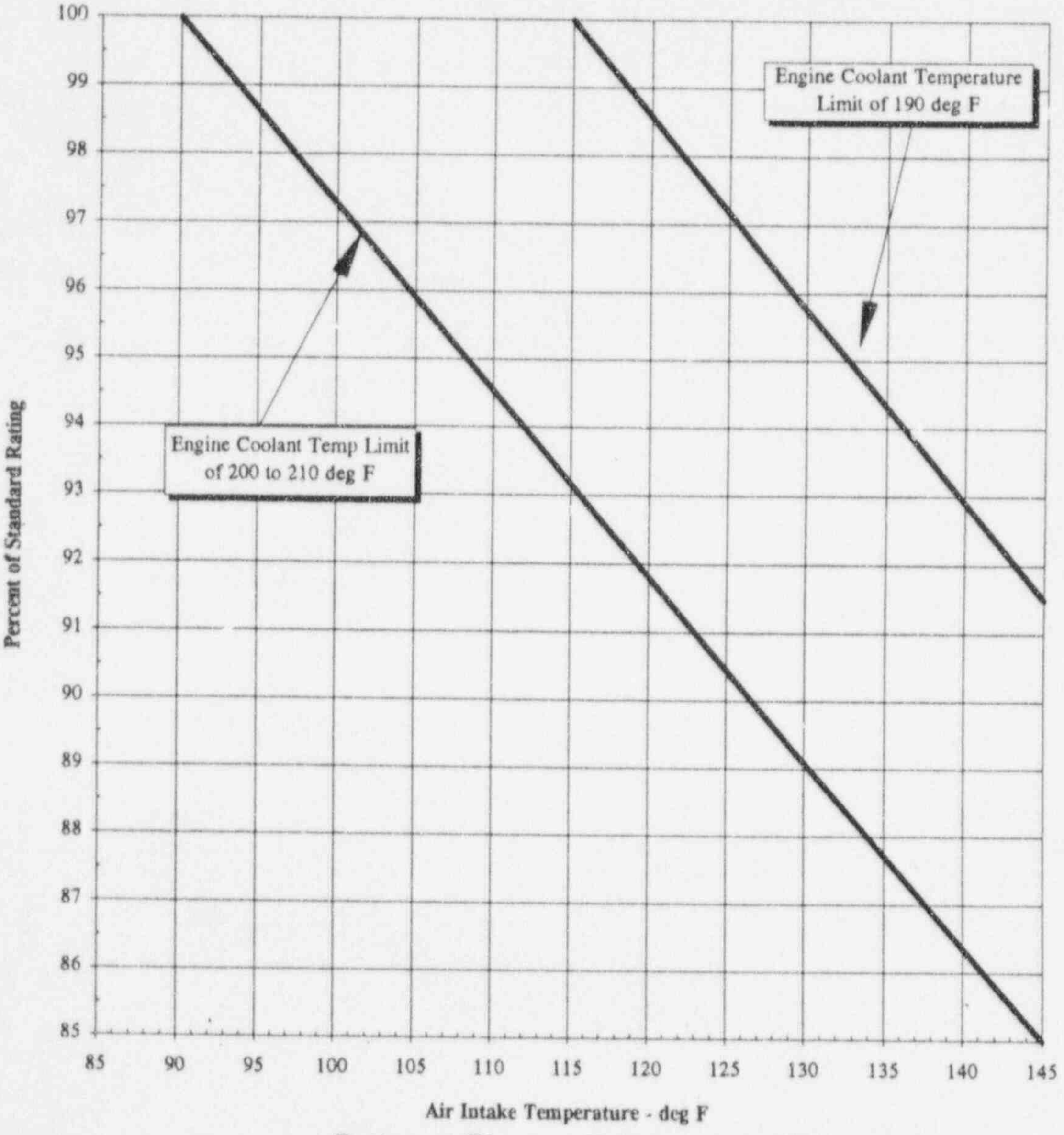
REV. 3

ENGINE TEMPERATURE SWITCH NOMINAL SETTINGS

Switch	Pickup	Dropout
ETS 1	208° F.	198° F.
ETS or ETS 2	215° F.	205° F.

ETS 1 — Hot engine alarm SC. HC. S.
ETS — Hot engine alarm MD. LD.
ETS 2 — Hot engine shutdown SC. HC. S.

The D/G @ Omaha is equivalent to an "S" UNIT



Rating at Elevated Temperature (°F)
For EMD 645E4,

pjc 9-19-95
~~REV 2~~ EA -90-062

REV. 3

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.2b

Letter From Ted Fryar of M-K to Randy Mueller, Dated 2/21/80

CREATORS OF ELECTRICAL
POWER SUPPLY SYSTEMS

POWER SYSTEMS
A MORRISON-KNUDSEN DIVISION

101 GELO ROAD / POST OFFICE BOX 1928
ROCKY MOUNT NORTH CAROLINA 27801
PHONE (919) 977-2720 / TWX (510) 929-0725

DRW#: 40 REEL#___
☐ QA CONST. REC.
☒ DB REF.
☐ N/A
INITIAL: ___

EA-FC-90-062 REV3

ATTACHMENT 8.26-1

February 21, 1980

Omaha Public Power District
Fort Calhoun Nuclear Plant
Fort Calhoun, Neb.

Attention: Mr. Randy Mueller

Reference: P.O. #46079 Reg. #91332
PSD IWO 5256

Gentlemen:

Supplementing my letter dated January 22, 1980 I am pleased to enclose the data sheets prepared from the information we had to rate your standby Diesel Generators.

The ratings with a 50/50 solution of water and ethylene glycol in the engine jacket water cooling system are:

KW Ratings	90oF	100oF	110oF
Continuous (*)	2402 KW	2330 KW	2257 KW
2000 HRS/YEAR	2654 KW	2583 KW	2510 KW
4 HRS/YEAR	2800 KW	2727 KW	2654 KW
1/2 HR/YEAR	2853 KW	2781 KW	2709 KW

(*) This rating is to DEMA standards and therefore may be operated at a 10% overload for two (2) hours in a twenty four (24) hour peroid.

If we may be of further service by working with you to increase the capacity of the generator sets, please let me know.

Thank you for the oppurtunity to work with Omaha Public Power District.

Very truly yours,

POWER SYSTEMS
A MORRISON-KNUDSEN DIVISION

Ted Fryar
Manager, Technical Services

TF:wp

cc: Mr. Wayne Steele - OPPD - Purchasing Dept.
Harry Falter, PSD, Eng. Dept.
Rao Kattoju, PSD, Eng. Dept.
Milton Sharpe, PSD, Sales Dept.

POWER SYSTEMS
DIVISION OF MORRISON-KNUDSEN COMPANY, INC

P. O. BOX 1928 • ROCKY MOUNT, NORTH CAROLINA 27801

EA-FC-90-062 REV 3
ATT 8.26-2

ALL 645 TURBOCHARGED ENGINES - (900 RPM)

EMERGENCY STANDBY DUTY

These ratings apply to Emergency Standby Applications ONLY.

	2000 Hr/Yr	200 Hr/Yr	4 Hr/Yr	1/2 Hr/Yr
20-645E4	3950 BHP	4100 BHP	4150 BHP	4225 BHP
16-645E4	3320 BHP	3420 BHP	3485 BHP	3520 BHP
12-645E4	2425 BHP	2500 BHP	2525 BHP	2574 BHP

The above ratings are not cumulative and are not subject to overload.

1/76

EA-FC-90-062 Rev ?

Att 8.2b-3

Diesel Generator System Rating:

Engine Derating Factors

Radiator Fan Drive	80HP
Gener[illegible] Cooling Fan	20HP
50/50 G[illegible]col Solution in Cooling Water	180HP
	280HP

Engine Air Intake Ambient

90°F - None
Derate for 100°F - 100 HP
Derate for 110°F - 200 HP

Engine Ratings @ 90°F or below

	Continuous	2000 HR	4 Hour	1/2 HR
Engine	3600	3950	4150	4225
Deratings	- 280	280	280	280
	3320	3670	3870	3945
BHP/KW	x.746	x.746	x.746	x.746
	2476 KW	2737	2887	2942
Gen eff.	x .97	x .97	x .97	x .97
	2402 KW	2654	2800	2853

Engine Ratings @ 100°F

	Continuous	2000 HR	4 Hour	1/2 HR
Engine	3600 BHP	3950	4150	4225
Deratings	380 BHP	380	380	380
	3220 BHP	3570	3770	3845
	x.746	x.746	x.746	x.746
	2402 KW	2663	2812	2868
Gen eff.	x .97	x .97	x .97	x .97
	2330 KW	2583	2727	2781

Engine Ratings @ 110°F

	Continuous	2000 HR	4 Hour	1/2 HR
Engine	3600 BHP	3950	4150	4225
Deratings	480 BHP	480	480	480
	3120 BHP	3470	3670	3745
	x.746	x.746	x.746	x.746
	2327 KW	2588	2737	2793
Gen eff.	x .97	x .97	x .97	x .97
	2257	2510	2654	2709

EA-FC-90-062 REV3
ATT 8.26-4

Note: The continuous rating also has per DEMA standards the capability of at 10% above the rated load for 2 hours in any 24 hour period. The other ratings do not have an overload factor.

Generator Ratings @ 110°F air intake temperature or below:

Continuous	2600 KW
2000 HR	2860 KW

Diesel Engine Generator System Ratings at OPPD (Fort Calhun) assuming 50/50 Glycol Solution:

Amount @ Air Intake to Diesel Engine		90°F	100°F	110°F
Continuous	-	2402 KW	2330 KW	2257 KW
2000 HR	-	2654 KW	2583 KW	2510 KW
4 HR	-	2800 KW	2727 KW	2654 KW
1/2 HR	-	2853 KW	2781 KW	2709 KW

POWER SYSTEMS DIVISION

IWO 5256
OPPD ORDER 460.

EA-FC-90-062 REV3
ATT 8.26-5

DATA SHEETS

Engine Data:

Manufacturer - Electro Motive Division of General Motors Corp.
Model - 20-645E4, 2 cycle
Serial Nos. - 70C11052 and 70C11016
Engine Speed - 900 RPM
Continious Rating - 3600 BHP @ 90°F and less than 7200 ft altitude
Speed Control - Woodward UG-8 Gov. Part No. 8520-205 Serial Nos. 975804, 975805

Generator Data:

Manufacturer - Electro Motive Division, General Motors Corp.
Model - A20C2
Serial Nos. - 70C11024 and 70C11066
Generator Speed - 900 RPM
Voltage - 4160 volt
Continuious Rating - 3250 KVA/2600 KW
2000 Hour Rating - 3575 KVA/2860 KW
Power Factor - .8
Air Cooled - Mechanical Blower
Ratings given @ - 85°C Stator and 60°C Rotor max temperature

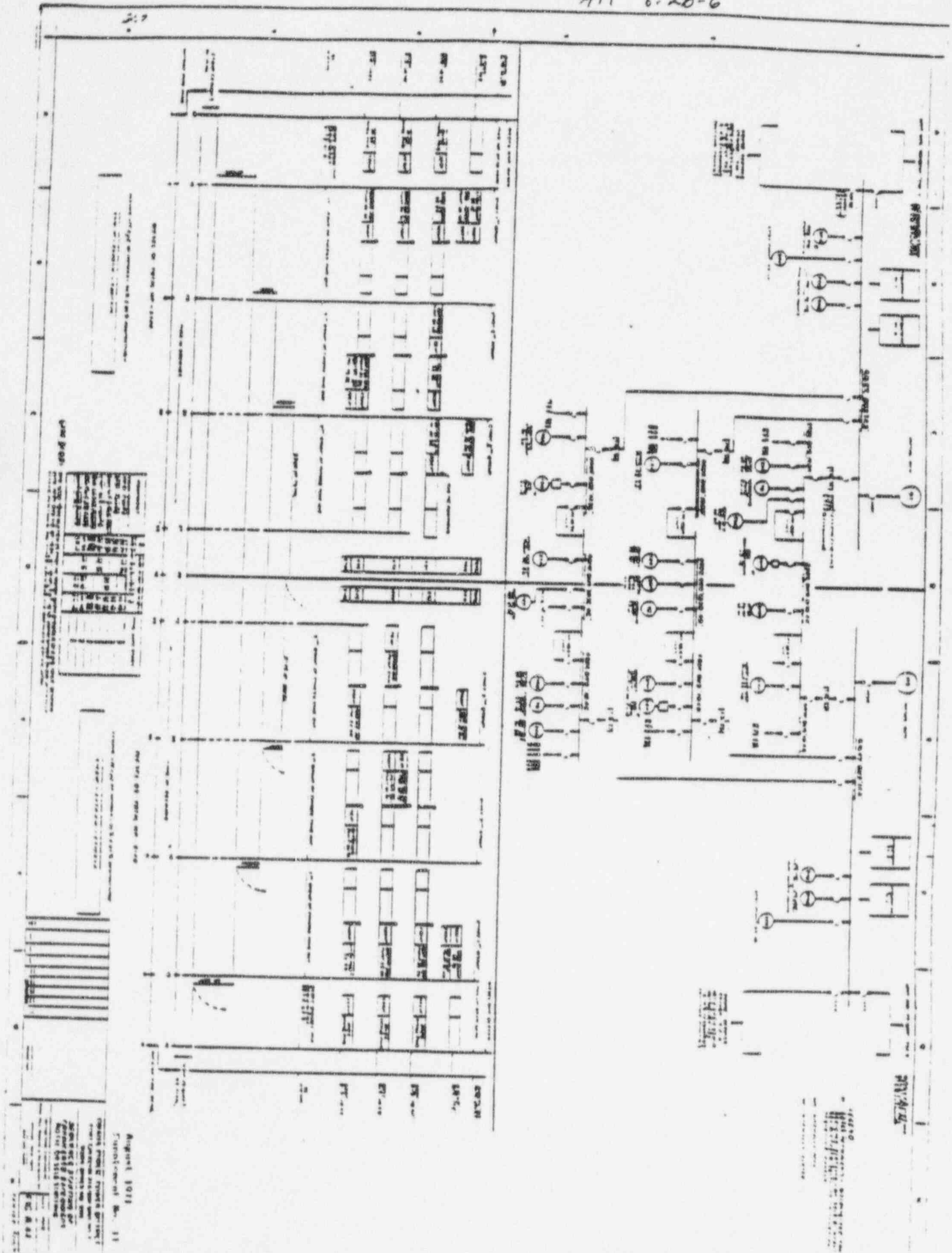
Radiator Data:

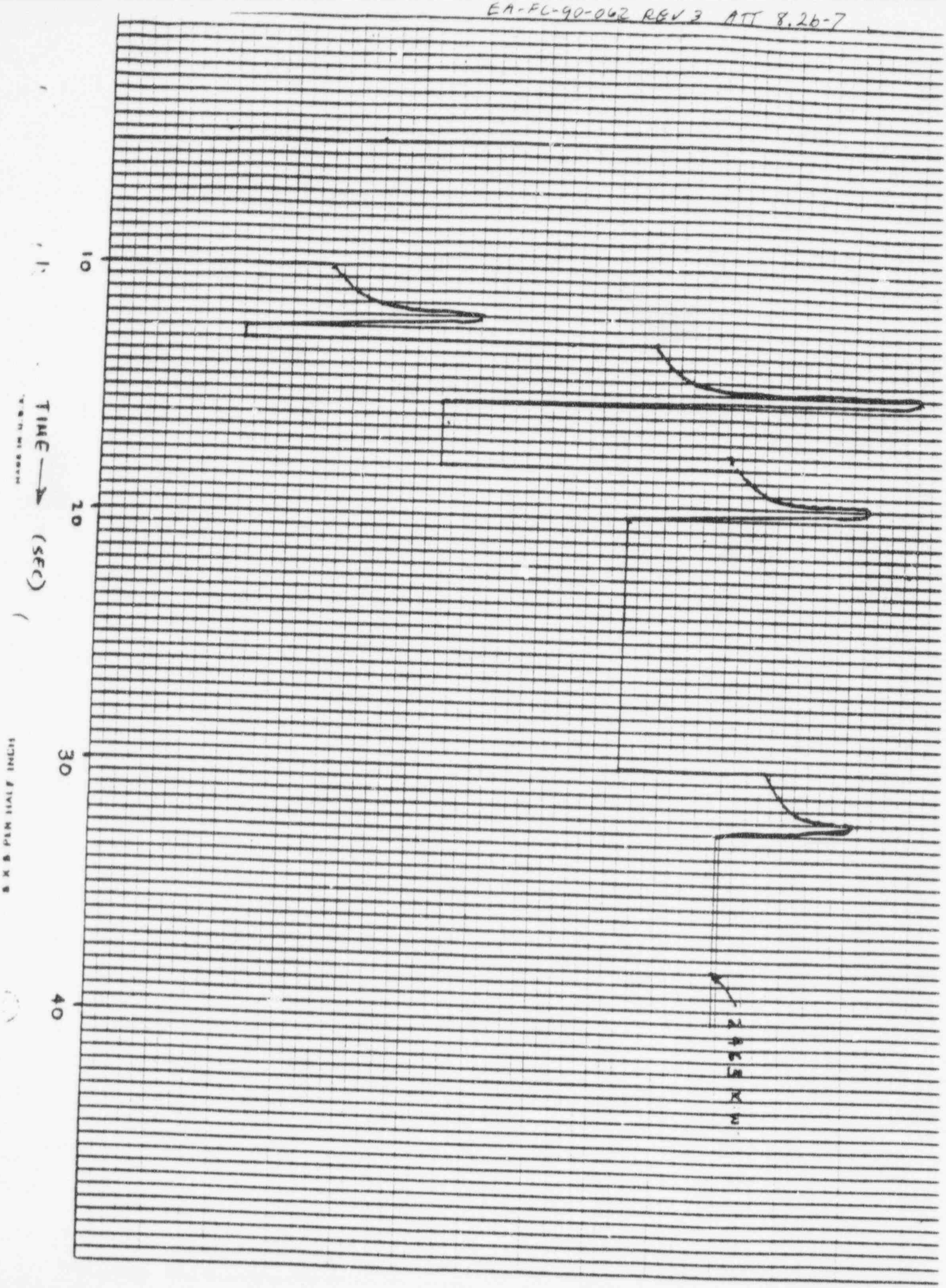
Manufacturer - Young Radiator Company
Model - D242007 HC1310
Serial Nos. - YM6312 and YM6313
Fan and Gear Box
  Manufacturer - Western Gear Corp.
  Model - BSV-117
  Serial Nos. - 3004 and 3003
  Ratio - 1.5 : 1
  Service HP - 104

Generator Exciter - Regulator

Manufacturer - General Electric Co.
Model - Static 3S7930S8212A11
Current Forcing Device - 3S7932YA
AC Regulation Device - 3S7932MA196A1
DC Regulation Device - 3S7932MA197A1

EA-FC-90-062 REV J
ATT 8.26-6




10
20
30
40
TIME ⟶ (SEC)
2463 KW
5 X 5 PER HALF INCH

EA-FC-90-062 REV 3
ATT 8.26-8

LOADING SUMMARY
(Both Diesel Start)

STEP NO	TIME SEC.	H.P.	START KW	PULL IN KW	PRIOR LOAD ON UNIT KW	TOTAL LOAD ON UNIT		FINAL LOAD ON UNIT KW
						START KW	PULL IN KW	
1	10	750	900	1500	0	900	1500	560
2	13	1350	1620	2700	560	2180	3260	1567
3	18	750	900	1500	1567	2467	3067	2127
4	30	450	540	900	2127	2667	3027	2463

LOADING SEQUENCE BOTH DIESELS START

ASSUMPTIONS FOR LOAD MODEL CALCULATIONS

Acceleration time for each motor is 2.5 seconds. For the purpose of K.W. calculation each H.P. is considered equal to one KVA. Thus, 750 H.P. MOT = 750 KVA Load.

Start Power Factor = 0.2
Start in Rush Current = 6 times rated current
Start KW = 6 x KVA x 0.2 = (1.2 x KVA) K.W.
Pull in KW = 2 x Rated KVA = (2 x KVA) K.W.

LOAD BLOCK #1 750 H.P. = 750 KVA.

Start KW = 1.2 x 750 = 900 KW
Pull in KW = 2 x 750 = 1500 KW

Load on Unit at End of Step #1 = 750 H.P. = 750 x 0.746 = 560 KW.

LOAD BLOCK #2 1350 H.P.

Start KW = 1350 x 1.2 = 1620 KW
Pull in KW = 350 x 2 = 2700 KW

Load on Unit at Start of #2 = 1620 + 560 = 2180 KW
Load on Unit at Pull In of #2 = 2700 + 560 = 3260 KW
Load at End of Step #2 = 560 + 1350 x .746 = 1567 KW

LOAD BLOCK #3 ----- 750 H.P. (Same as Step #1)

Start KW = 900 KW
Pull In KW = 1500 KW

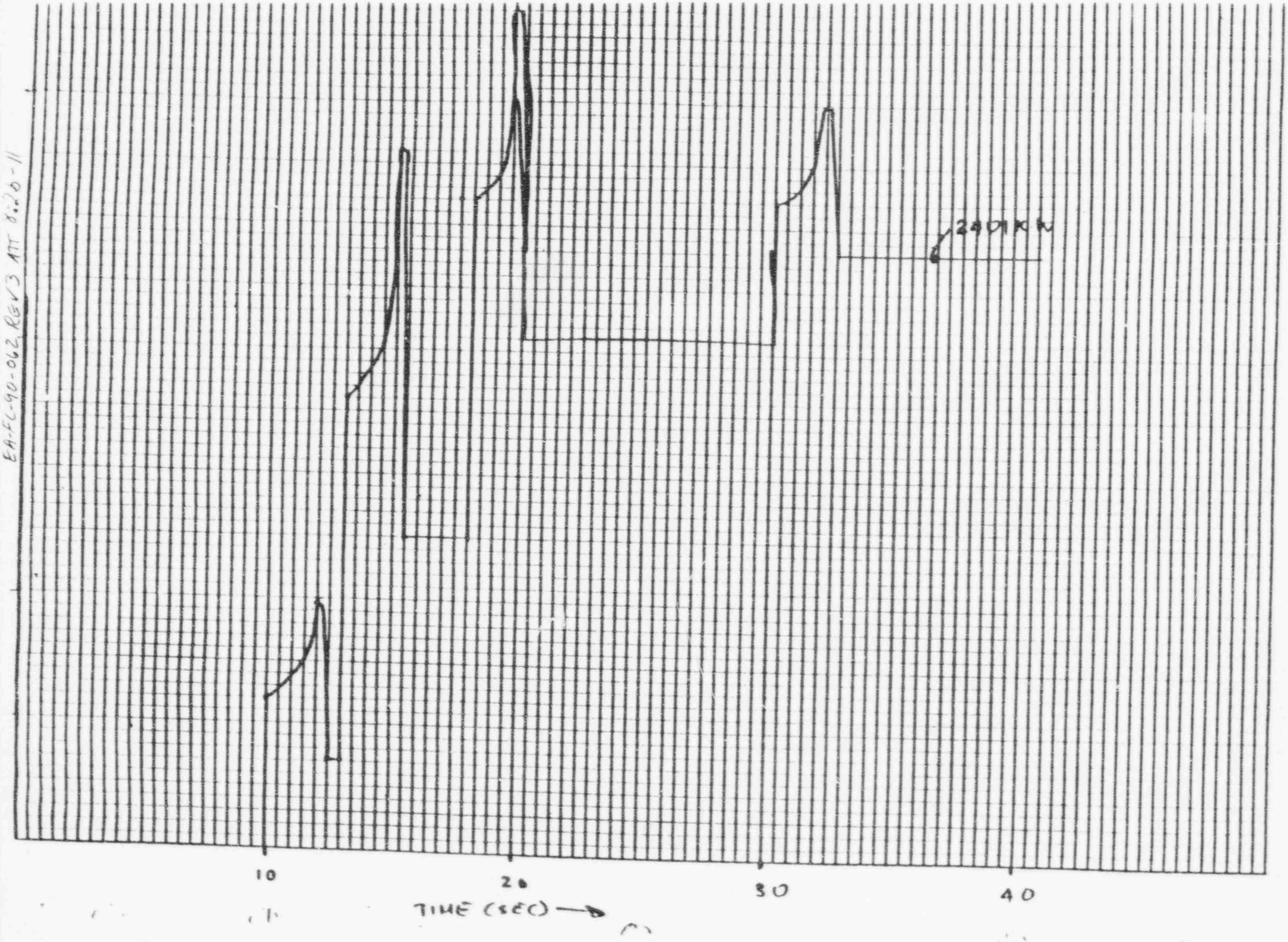
Load on Unit at Start of Step #3 = 1567 + 900 = 2467 KW
Load on Unit at Pull In of Step #3 = 1567 + 1500 = 3067 KW
Load at End of Step #3 = 1567 + 75 x .746 = 2127 KW

LOAD BLOCK #4 --------------- 450 H.P.

Start KW = 450 x 1.2 = 540 KW
Pull in KW = 450 x 2 = 900 KW

Load on Unit at Start of Step #4 = 2127 + 540 = 2667 KW
Load on Unit at "Pull In" of Step #4 = 2127 + 900 = 3027 KW
Load on Unit at End of Step #4 = 2127 + 450 x .746 = 2463 KW

EA-FC-90-062 REV 3
ATT 8.2b-10


10
20
30
40
TIME (SEC) →
2401KW

SEQUENCE OF LOADING - ONE DIESEL STARTING

Assumptions for making Load Model Calculations are the same as in the previous case.

LOAD BLOCK #1 480 H.P.

Start KW = 480 x 1.2 = 576 KW
Pull in KW = 480 x 2 = 960 KW

Load on Unit at Start of Step #1 = 576 KW
Load on Unit at Pull in of Step #1 = 960 KW
Load on Unit at End of Step #1 = 480 x .746 = 358 KW

LOAD BLOCK #2 --------- 1225 H.P.

Start KW = 1225 x 1.2 = 1470 KW
Pull in KW = 1225 x 2 = 2450 KW

Load on Unit at Start of Step #2 = 358 + 1470 = 1828 KW
Load on Unit at Pull in of Step #2 = 358 + 2450 = 2808 KW
Load on Unit at End of Step #2 = 350 + 1225 x 0.746 = 1264 KW

LOAD BLOCK #3 --------------- 1050 H.P.

Start KW = 1050 x 1.2 = 1260 KW
Pull in KW = 1050 x 2 = 2100 KW

Load on Unit at Start of Step #3 = 1264 + 1260 = 2524 KW
Load on Unit at Pull In of Step #3 = 1264 +2100 = 3364 KW
Load on Unit at End of Step #3 = 1264 + 1050 x .746 = 2047 KW

LOAD BLOCK #4 -------------- 475 H.P.

Start KW = 475 x 1.2 = 570 KW
Pull in KW = 475 x 2 = 950 KW

Load on Unit at Start of Step #4 = 2047 + 570 = 2617 KW
Load on Unit at Pull in of Step #4 = 2047 + 950 = 2997 KW
Load on Unit at End of Step #4 = 2047 x .746 = 2401

LOADING SUMMARY (ONE DIESEL ONLY START)

STEP NO	TIME SEC	H.P.	START KW	PULL IN KW	PRIOR LOAD ON UNIT KW	TOTAL LOAD ON UNIT START KW	PULL IN KW	FINAL LOAD ON UNIT KW
1	10	480	576	960	0	576	960	358
2	13	1225	1470	2450	358	1828	2808	1264
3	18	1050	1260	2100	1264	2524	3364	2047
4	30	475	570	950	2047	2617	2997	2401

EA-90-062

Rjc 9-19-95
~~REV~~

REV. 3 1

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.3

Diesel Generator Nameplate Data

EA-90-062

REV. 3

~~REV –~~ pjc 9-19-95

DIESEL GENERATOR NAMEPLATE DATA
(Data Applicable for Both Generators)

Model Number	A-20-C2
Serial Number	70-C1-1034
Continuous Rating:	
Volts	2400/4160
Current (Amps)	782/452
KVA	3250
Frequency (Hz)	60
Phase	3
Power Factor	0.8
RPM	900
Temperature Rise (°C):	
Stator-Therm	85
Rotor-Res	60
KVA Peaking	3575, 2000Hr/Yr
Temperature Rise Peaking (°C):	
Stator-Therm	105
Rotor-Res	70
Rotation	CCW @ BRG END
Insulation Class:	
Stator	H
Rotor	F
Excitation Volts	144
Excitation Amps	100
Phase Sequence	1,3,2

NOTE: The above information was obtained from actual nameplate by RSK on July 2, 1990.

pjc 9-19-95

~~RE [illegible]~~

EA -90-062

REV. 3

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.4

EMD Specification Sheet [illegible] Generator

CALC 16472.67-DM-OCY ATTACHMENT 4.0 Pg 1 of 1

EA-FC-90-062 REV 3

ATTACHMENT 8.4-1

GENERATOR CHARACTERISTICS

	60 Cycle		50 Cycle	
TYPE OF SERVICE	Peaking	Base Load	Peaking	Base Load
MODEL	A-20	A-20	A-20	A-20
RATING - KW	2750	2500	2300	2100
KVA	3440	3125	2875	2625
P.F.	0.8	0.8	0.8	0.8
ARMATURE CURRENT - AMPERES				
Wye	477	434	399	365
Delta	826	751	691	632
Stator Temperature Rise - °C.	70.0	56.0	47.0	39.0
TERMINAL VOLTAGE				
Wye	4160	4160	4160	4160
Delta	2400	2400	2400	2400
SPEED - RPM	900	900	750	750
REACTANCES - PER UNIT @ RATED KVA BASE				
Direct Axis Synchronous, X_d	1.76	1.60	1.267	1.159
Quadrature Axis Synchronous, X_q	1.06	0.963	0.760	0.695
Direct Axis Transient, X_d'	0.462	0.420	0.277	0.253
Direct Axis Subtransient, X_d''	0.298	0.271	0.1775	0.1625
Negative Sequence, X_2	0.2325	0.211	0.225	0.2055
Zero Sequence, X_o	0.117	0.106	0.1077	0.0995
TIME CONSTANTS - SECONDS @ 75°C.				
Direct Axis Transient Open Circuit, T_{do}'	4.340	4.340	4.340	4.340
Direct Axis Subtransient Short Circuit, T_d''	0.017	0.017	0.018	0.018
Direct Axis Transient Short Circuit, T_d'	0.654	0.654	0.620	0.620
SHORT CIRCUIT RATIO	0.62	0.68	1.04	1.14
BALANCED T.I.F.	14	14	10	10
REGULATION AT RATED LOAD - PER CENT	43.1	40.65	35.67	27.26
SYNCHRONIZING COEFFICIENT - KW/RADIAN				
Full Load	5870	5660	6240	5960
No Load	3250	3250	3780	3780
FIELD DATA				
Resistance at 75°C. (Ohms)	1.292	1.292	1.292	1.292
Excitation At No Load, Rated Voltage (Amps)	39.2	39.2	55.0	55.0
Excitation At Rated Load and Voltage (Amps)	105.1	97.67	130.22	120.79
Field Temperature Rise - °C.	60.0	50.0	91.0	80.0
EFFICIENCY - RATED KVA AND P.F.	97.21	97.26	96.50	96.54
TOTAL WEIGHT - POUNDS	18,100	18,100	18,100	18,100
Stator	9,000	9,000	9,000	9,000
Rotor	8,100	8,100	8,100	8,100
End Housing and Bearing	1,000	1,000	1,000	1,000
WR^2 - lb. ft.^{2}	12,830	12,830	12,830	12,830
TYPICAL CHARACTERISTIC CURVE, See Section 2	Page 11	Page 12	Page 13	Page 14
POWER UNIT CAPABILITY CURVE, See Section 2	Page 15	Page 15	Page 16	Page 16

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Attachment 8.5

Tables From the "Standard Handbook for Electrical Engineers"

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REV 3
[illegible]
ATT 8.5-1

The temperature rise for motors operating at any other ambient temperature T_a than 40°C shall not exceed the values,

For items, a, b, e, f, i: Temperature rise = $0.9\,(T_h - T_a)$
For items c, d, g, h: Temperature rise = $0.965\,(T_h - T_a)$

where T_h, the hot-spot temperature is given by the following table:

Class	*Items a and f*	*All other items*
A	115°C	105°C
B	140°C	130°C
F	165°C	155°C
H		180°C

Preferred values of ambient temperature above 40°C are 50°C, 65°C, 90°C, 115°C.

TABLE 20-7. Temperature Rise for Single-Phase and Polyphase Induction Motors

	Class of insulation system			
	A	B	F	H
Integral horsepower				
All motors with 1.15 service factor or higher	70°C	90°C	115°C	
Totally-enclosed fan-cooled motors	60°C	80°C	105°C	125°C
Totally-enclosed non-ventilated motors	65°C	85°C	110°C	135°C
Motors with encapsulated windings, 1.0 service factor	65°C	85°C	110°C	
All other motors	60°C	80°C	105°C	125°C
Fractional horsepower				
Open motors with 1.15 service factor or higher	70°C	90°C	115°C	
Totally-enclosed non-ventilated and fan-cooled	65°C	85°C	110°C	135°C
Any motor in frame smaller than 42 frame	65°C	85°C	110°C	135°C
All other open motors	60°C	80°C	105°C	125°C

NOTE: Based on ambient temperature of 40°C, 3300-ft altitude. Temperature determined by the resistance method.

The time ratings for single-phase and polyphase induction motors shall be 5, 15, 30, 60 min, and continuous. All short-time ratings are based upon a load test which shall commence when the windings and parts of the motor are within 5°C of the ambient temperature.

80. Service Factor. General-purpose fractional- and integral-horsepower motors are given a "service factor," which allows the motor to deliver greater than rated horsepower, without damaging its insulation system. The motor is operated at rated voltage and frequency. The standard service factors are 1.4 for motors rated $\frac{1}{20}$ to $\frac{1}{8}$ hp; 1.35 for $\frac{1}{6}$ to $\frac{1}{3}$

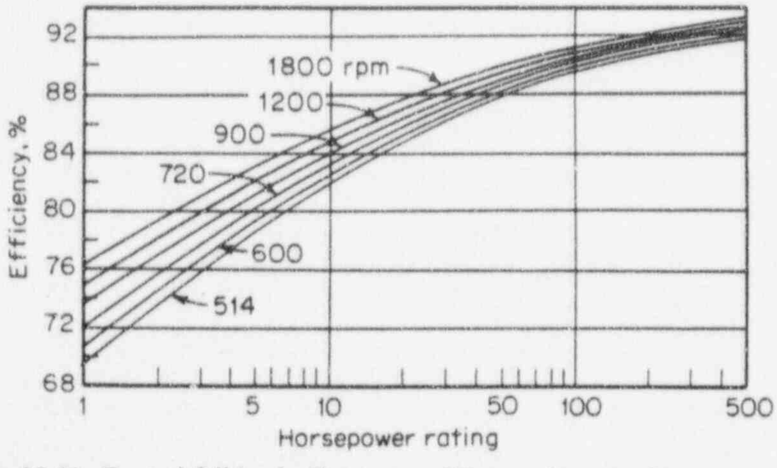

Fig. 20-41. Typical full-load efficiencies of Design B squirrel-cage motors.

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Attachment 8.6

G. E. Letter, Dated 7/20/90

EA-90-062

~~PREV~~ pic 9-19-95 REV. 3

[illegible]

July 20, 1990
RDR #90/28

Mr. G. P. Schwartz
Acting Manager - Electrical/I&C Engineering
Omaha Public Power District
444 South 16th Street Mall
Omaha, Nebraska 68102-2247

SUBJECT: GE Static Exciter 3S7930SA212A11

REFERENCE: G.P. Schwartz Letter PED-FC-90-2415
to R.D. Royal Dated July 16, 1990

Dear Mr. Schwartz:

GE Nuclear Energy has forwarded Omaha Public Power District's (OPPD) request per the referenced letter to the appropriate GE Business Operation, GE Drive System, Salem, Virginia, technically responsible for the subject static exciter. GE Drive System after review of OPPD's request offers the following:

- The subject Exciter System was originally manufactured and shipped by the Wayneboro, Virginia Plant 20 years ago. This business moved to Salem, Virginia 10 years ago.
- No technical data folder is available for this exciter in the files.
- It is most likely the exciter was a special application for this diesel generator vendor.
- The exciter panel supplied by GE was placed in an enclosure along with other support equipment to comprise the Emergency Diesel Generator (EDG) vendor's total system.

Because of the aforementioned, GE cannot provide OPPD with a cost quotation as requested in the referenced letter, since we have no technical data upon which to base an investigation. However, it is our opinion the open exciter panel as originally supplied by GE will have no problem working in a 50 degrees C ambient temperature.

GE recommends OPPD contact the EDG vendor and obtain heat run data on the total system to get the appropriate answers they seek.

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~~REV~~ PJC 9-19-95

REV. 3

If you have additional questions or comments, please advise.

Sincerely,

R. D. Royal
Manager Electrical/I&C Services
Nuclear Services Department
Central Territory

RDR/MAS

cc: P. Vovk - OPPD
D. Brager - GE

EA-90-062

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Attachment 8.7

REV. 3

Letter From GM-EMD and R. F. Mehaffey, Dated 8/16/90

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Attachment 8.7-1

~~REV~~ pjc 9-19-95 REV. 3

RECORD OF TELEPHONE COMMUNICAT

M.R. No.: EA-FC-90-062 and CID 900617/01 File No.: PED-FC-90-2481

Date: 8/16/90 Time: 3:00 p.m. Telephone No.: (708) 387-5818

Party Calling: M. J. Fleckenstein EMD (Company Name)

Party Answering: R. F. Mehaffey OPPD (Company Name)

Subject: Emergency Diesel Generators at FCS

Telecon Summary: (Including Decisions and Commitments)

I called Marty to discuss in more detail why EMD judged that operation of OPPD's Emergency Diesel Generators above the 2000 hr. KW output rating was acceptable.

Marty stated that these ratings were developed in and came into effect in 1966 in response to requests for information about the output capabilities of these engines in emergency applications. The ratings were based on a knowledge and review of temperature within the engine and at the cylinder head. This is supported by experience with the engine.

Action Required:

None

Distribution:

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Attachment 8.8

A. Data Sheets, Projected Performance and Deratings at 110°F Ambient, DG-1 and DG-2

B. Revised Diesel Generator Available KW/Required KW vs. Time Plots Utilizing Calc. FC03382, Rev. 3, DG-1 and DG-2

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9-19-95

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Attachment 8.8a

Data Sheets, Projected Performance and Deratings at 110°F Ambient, DG-1 and DG-2

DG-1 DERATING AT 110°F AMBIENT

Time Start	Outdoor Ambient (1)	Turbo Inlet (2)	ΔT Turbo (3)	Assumed JW at 110°F (4)	Predicted Turbo at 110°F (5)	Derate % (6)	Derate Power (KW) (7)	Req'd Load (KW) (8)
0.0	86	91	8	125	118	100	2784	2551
10	88	93	8	174	118	99	2756	2531
20	87	94	10	208	120	92.2	2567	2512
30	88	97	12	208	122	91.2	2539	2492
40	88	98	13	208	123	91	2533	2492
50	89	98	12	208	122	91.2	2539	2492
60	89	99	13	208 (9)	123	91	2533	2237
70	89	100	14	208	124	90.5	2520	2237
90	89	100	14	208	124	90.3	2514	2237
120	89	101	15	208	125	90.2	2511	2237

1. Measured outdoor ambient temperature obtained during diesel test run (6-25-90).
2. Measured turbocharger air inlet temperature obtained during diesel test run (6-25-90) fan unit VA-52A in "Off" position.
3. ΔT Turbo = (Turbo inlet air temp + 1.32°F) - (Measured outdoor ambient - 1.62°F) See Sections 6.7.1 and 6.7.2 for explanation.
4. Historical heat - up rate with AMOT valves fully open approximately 15 minutes into diesel run. Att. 8.9, (Radiator Vendor anticipated heat removal capabilities of unit) implies that JW temperatures should be lower than this at 110°F ambient. JW outlet gauge for DG-1 has a 2°F uncertainty (Reference 4.8) that was not applied to this value for this reason.
5. Predicted turbo inlet temperatures at 110°F = 110°F + ΔT turbo (3). This includes uncertainties as defined in (3) above.
6. Deration chart, Attachment 8.2, determined these values.
7. Deration percent applied to gross available KW of 2784 KW (2654 KW + 130 KW (see Section 6.9.2).
8. LOCA load profile based on calculation FC03382 Rev. 3.
9. At 3740 seconds into a LOCA event, load on the diesel generator drops significantly. As less heat is generated by the engine, JW temperatures will decline proportionately, but are shown constant in this example.

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DG-2 DERATING AT 110°F AMBIENT

Time	Outdoor Ambient (1)	Turbo Inlet (2)	ΔT Turbo (3)	Assumed JW at 110 (4)	Predicted Turbo at 110°F (5)	Derate % (6)	Derate Power (KW) (7)	Req'd Load (KW) (8)
0.0	89	97	11	128	121	98.5	2742	2421
10	89	100	14	164	124	97.2	2706	2410
20	89	103	17	208	127	90	2506	2399
30	89	105	19	208	129	89.2	2483	2388
40	90	106	19	208	129	89.2	2483	2388
50	90	109	22	208	132	88.5	2464	2388
60	90	110	23	208(9)	133	88.2	2455	2131
70	90	109	22	208	132	88.5	2464	2131
90	90	110	23	208	133	88.2	2455	2131
120	90	113	26	208	136	87.5	2436	2131

1. Measured outdoor ambient temperature obtained during diesel test run (7-17-90).
2. Measured turbocharger air inlet temperature obtained during diesel test run (7-17-90) fan unit VA-52B in "Off" position.
3. ΔT Turbo = (Turbo inlet air temp + 1.32°F) - (Measured outdoor ambient - 1.62°F) See Sections 6.7.1 and 6.7.2 for explanation.
4. Historical heat - up rate with AMOT valves fully open approximately 15 minutes into diesel run. Att. 8.9, (Radiator Vendor anticipated heat removal capabilities of unit) implies that JW temperature should be lower than this at 110°F ambient. JW outlet gauge for DG-2 has a 1°F uncertainty (Reference 4.8) that was not applied to this value for this reason.
5. Predicted turbo inlet temperatures at 110°F = 110°F + ΔT turbo (3). This includes uncertainties as defined in (3) above.
6. Deration chart, Attachment 8.2, determined these valves.
7. Deration percent applied to gross available KW of 2784 KW (2654 KW + 130 KW (see Section 6.9.2).
8. LOCA load profile based on calculation FC03382 Rev. 3.
9. At 3740 seconds into a LOCA event, load on the diesel generator drops significantly. As less heat is generated by the engine, JW temperatures will decline proportionately, but are shown constant in this example.

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~~REV 2~~

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Attachment 8.8b

Revised Diesel Generator Available KW/Required KW vs. Time Plots

Utilizing Calc. No. FC03382, Rev. 3, DG-1 and DG-2

~~REV 2~~

DG-1 LOAD PROFILE

REV. 3

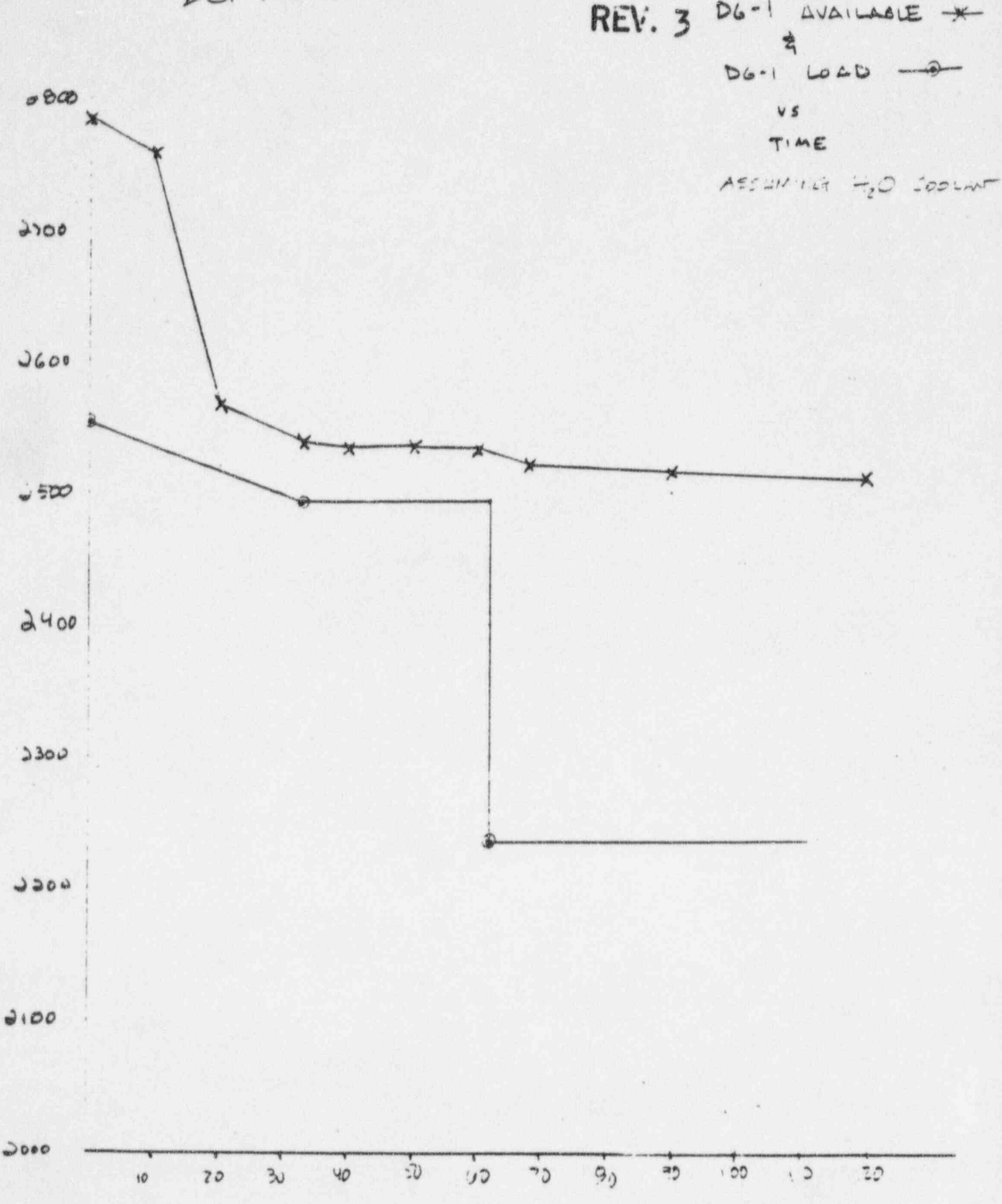

FIGURE 1

DG-2 LOAD PROFILE

~~REV~~ pjc 4-19-95

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DG-2 AVAILABLE-DERATED —x
&
DG-2 LOAD REQUIRED —•
VS
TIME
ASSUMING H_2O COOLANT

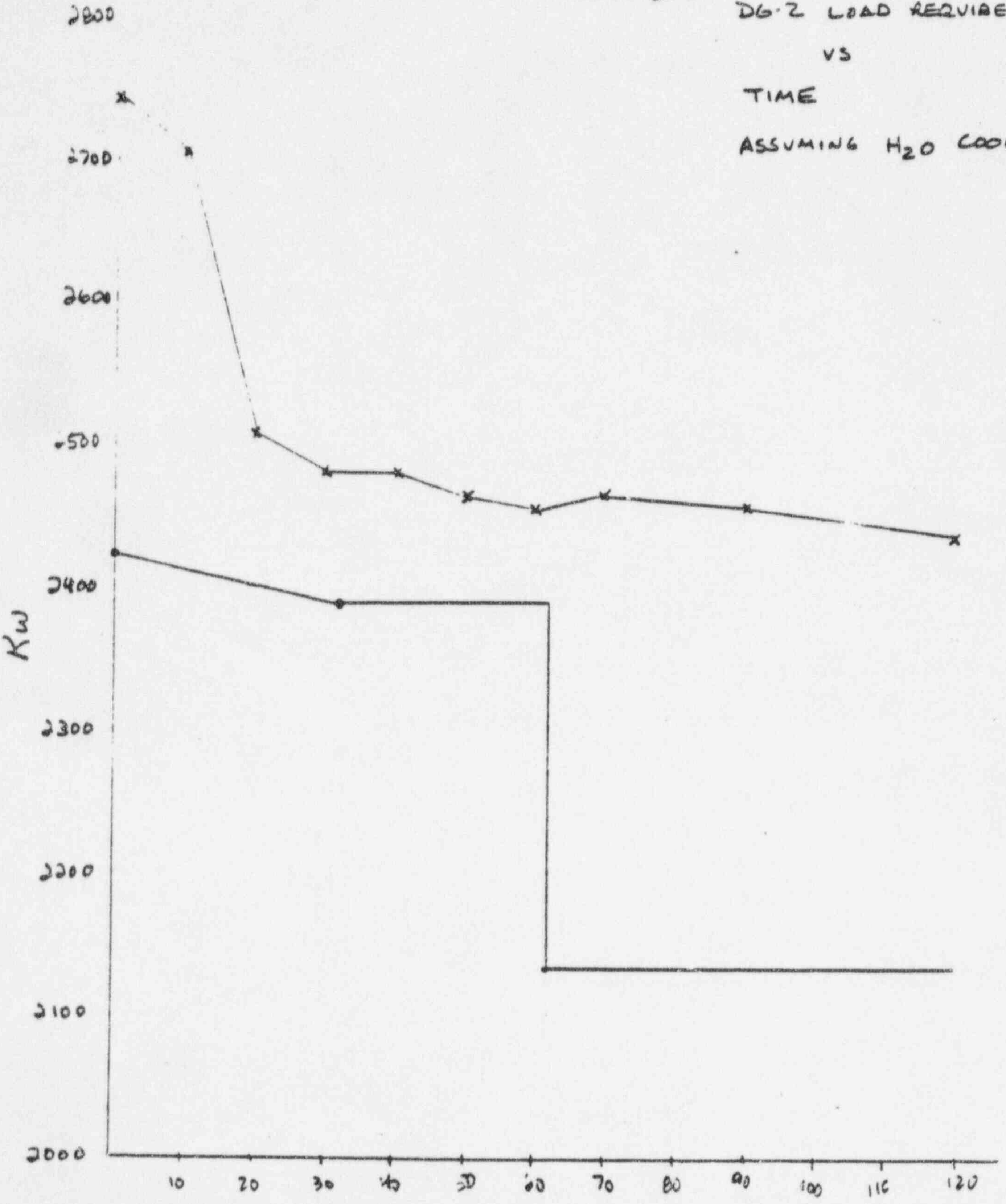

FIGURE 2

A. Young Radiator Company Radiator Performance Analysis

B. Telecon Between M-K Power Systems and D. G. Borcyk, Dated 4/19/91

C. Calculated Heat Inputs to Engine Coolant

D. Delivered Air vs. Required Air Analysis

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REV. 3

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Attachment 8.9a

Young Radiator Company Radiator Performance Analysis

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Rev. ~~2~~ 3
Attachment 8.9a-1

Young
RADIATOR COMPANY

2825 Four Mile Road, Racine, Wisconsin 53404
Telephone: 414-639-1010 • EasyLink: 627-53531
TWX: 910-271-2397 • Telex: 26-4435
Telefax: 414-639-1013

Rjy 4-19-95
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EA-90-062 REV. 3

FACSIMILE TRANSMISSION

TRANSMIT TO:

FAX NO. 402-636-3946

C.C.

NAME DAN BORCYK TITLE

COMPANY OMAHA PUBLIC POWER CITY OMAHA STATE NE ZIP

NUMBER OF PAGES BEING TRANSMITTED, INCLUDING THIS COVER 1

HEAT LOAD : 120,970 Btu/m
COOLANT, FLOW, TEMP IN : WATER, 1100 GPM, 208°F
ALTITUDE : 1007 ft
RADIATOR FACE AREA : 105.1 ft² RAD TUBE LENGTH : 11.25 ft

°F T AIR IN	-WATER- AIRFLOW REQ SCFM		IWG SP	fpm FACE VEL	ESTIMATED SYSTEM TOTAL RESISTANCE IWG STD AIR
103°	76,457		.39	727	1.22
108°	81,097		.43	771	1.30
113°	86,336	93,316	.48	821	1.45
118°	92,294	100,426	.54	878	1.65
123°	99,200	107	.61	943	1.85

TRANSMISSION FROM:

NAME TOM TILLER TITLE

☒ RACINE, WI
414-639-1013

☐ LEXINGTON, TN
901-968-3617

☐ CENTERVILLE, IA
515-856-8634

FORM NO. 3613 REV. 6/89

DATE 4/15/91 TIME : AM PM

P.1

APR 15 '91 09:58

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9-19-95

REV. 3

	Young's Model Parameters for FC Units	Achievable Parameters
Air Flow (SCFM)	93,000	101,774 DG-1 101-531 DG-2 See Table III and Attachment 8.9d
Coolant Flow (gpm) Water	1,100	1096 minimum observed
Heat Rejection (BTU/min)	120,970	123,536 DG-1 See Attachment 8.9c 118,780 DG-2 See Attachment 8.9c
Coolant Temp to Radiator (°F)	208	208 acceptable for emergencies
Air Temp to Radiator (°F)	115°F	110°F maximum

The higher achievable air flow will result in lower DG water jacket outlet temperatures. The lower ambient air temperature to the radiator (110°F) will also result in lower DG water jacket outlet temperatures. The lower DG water jacket outlet temperature would be offset slightly by the 2.1% increased heat rejection of DG-1. Therefore it can be concluded from the Young Radiator analysis model and actual test parameters that 208°F DG water jacket temperature can be achieved with 110°F ambient outside air temperature.

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Attachment 8.9b

Telecon Between M-K Power Systems and D. G. Borcyk, Dated 4/19/91

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EA-FC-90-062
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Attachment 8.9b-1

REV. 3

RECORD OF TELEPHONE COMMUNICATION

M.R. NO. 91-004 FILE NO. PED-FC-91-1808

DATE: 4/19/91 TIME: 1400 TELEPHONE NO. (919) 977-2720

PARTY CALLING: Dan Borcyk DJB (NAME) OPPD (COMPANY)

PARTY ANSWERING: Wesley Batchelor (NAME) MK Power Systems (COMPANY)

SUBJECT: Diesel Generator Heat Rejection Rate

TELECON SUMMARY (Including Decisions & Comments)

Dan called Wes Batchelor to pursue Rich Ronning's concern of whether or not the 33 Btu/MIN./BHP heat rate used in the Young Radiator heat transfer analysis included heat input from the lube oil cooler.

Wes confirmed that this number includes all engine related heat loads (including L. O. Cooler) and is the number used for sizing radiators.

ACTION REQUIRED: None

DISTRIBUTION:

c: R. R. Ronning
PED Library

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Attachment 8.9c

Calculated Heat Inputs to Engine Coolant

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Attachment 8.9c-1

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CALC. PAGE NO. ______

CALCULATION PREPARATION, REVIEW AND APPROVAL
FORM PED-QP-3.4 Form Page No. 1 of 1

PRODUCTION ENGINEERING DIVISION
CALCULATION SHEET

CALCULATION NO.
FC ______
Rev. No. ______

REF. NO.

DG-1 CALCULATED HEAT INPUT INTO ENGINE COOLANT

ATT. 8

IN THE EVENT OF A LOCA COINCIDENT WITH A LOSS OF OFFSITE POWER, DG-1 IS LOADED TO 2551 KW. APPROXIMATELY 2000 SECONDS (33 MINUTES) INTO THE EVENT, THE LOAD IS REDUCED TO 2491.8 KW. ASSUMING A COLD START, AND USING DATA OBTAINED FROM DIESEL TESTS (RUN 7-16-90 & 7-17-90) THE ENGINE IS STILL WARMING UP DURING THIS ENTIRE PERIOD, AFTER WHICH, A "STEADY-STATE" CONDITION FOR JACKET WATER OUTLET TEMPERATURE IS ATTAINED. AT RAS, 3790 SECONDS INTO THE EVENT, THE LOAD IS FURTHER REDUCED TO 2237.3 KW.

TO ANALYZE THE LONG-TERM HEAT REMOVAL CAPABILITIES OF THE DIESEL GENERATOR RADIATOR COOLING SYSTEM, WHILE STILL MAINTAINING CONSERVATISM, THE 2491.8 KW LOAD WILL BE USED IN THE FOLLOWING CALCULATION.

HEAT INPUT

2491.8 KW	GENERATOR LOAD	
÷ 0.97	GENERATOR EFFICIENCY	
2568.9 KW		
÷ 0.746	KW TO BHP CONVERSION	
3443.5 BHP		
+ 80 HP	FOR RADIATOR FAN DRIVE	ATT. 8.2
3523.5 BHP		
+ 20 HP	FOR GENERATOR COOLING FAN	
3543.5 BHP		

REV

RJC 9-19-95 ~~REV 2~~ REV. 3

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Attachment 8.9c-2

EA-90-062

CALC. PAGE NO. ______

CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED—QP—3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	FC ______ Rev. No. ______

REF. NO.

```
  3543.5  BHP
+  200     HP    DERATION ASSOCIATED WITH OPERATION
  3743.5  BHP    @ 110°F                              ATT. 8.2
```

FOR GM-EMD 20-645E4 UNITS, ENGINE RATING @ 110°F FOR 2000 HR/YR OPERATION IS 3950 BHP > 3743.5 BHP, ∴ OK — ATT. 8.2

HEAT CONTRIBUTED TO COOLANT BY ENGINE IS 33 BTU/MIN-BHP — ATT. 8

```
  3743.5  BHP
x 33      BTU/MIN-BHP
  123,536 BTU/MIN
```

YOUNG RADIATOR COMPANY PERFORMED AN ANALYSIS TO PREDICT EXPECTED HEAT REMOVAL CAPABILITIES OF OUR RADIATOR. THE ANALYSIS DETERMINED REQUIRED AIR FLOWS AT VARIOUS INLET AIR TEMPERATURES TO MAINTAIN JACKET WATER TEMPERATURES AT OR BELOW 208°F PER ENGINE MANUFACTURERS RECOMMENDATIONS. — ATT. 8.2

INPUTS TO THE ANALYSIS WERE AS FOLLOWS:
ENGINE COOLANT — H_2O
COOLANT FLOW RATE — 1100 GPM — ATT. 8.2
MAX. COOLANT TEMP — 208°F (JW_{OUT} OF ENGINE)
HEAT INPUT RATE — 120,970 BTU/MIN *

* NOTE: THIS HEAT INPUT RATE WAS DERIVED FROM A PREVIOUS GENERATOR LOAD. INCREASED LOADING ON DG-1 HAS CAUSED THIS NUMBER TO GO UP BY 2.1%

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CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED-QP-3.4 Form Page No. 1 of 1	CALCULATION NO.
PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	FC ______ Rev. No. ______

REF. NO.

DG-2 CALCULATED HEAT INPUT INTO ENGINE COOLANT

DG-2 INITIAL (PEAK) LOAD IN THE EVENT OF A LOCA COINCIDENT WITH A LOSS OF OFFSITE POWER IS 2420.6 KW. AT 2000 SECONDS, THE LOAD IS REDUCED TO 2387.5 KW. AT RAS, 3740 SECONDS INTO THE EVENT, LOAD DROPS TO 2131.4 KW. ATT. 8.1

AS WITH DG-1, THE LOAD AT 2000 SECONDS (2387.5 KW) WILL BE USED IN THE FOLLOWING CALCULATION.

HEAT INPUT

2387.5	KW	GENERATOR LOAD	ATT. 8.2
÷ 0.97		GENERATOR EFFICIENCY	
2461.3	KW		
÷ 0.746		KW TO BHP CONVERSION	
3299.4	BHP		
+ 80	HP	FOR RADIATOR FAN DRIVE	
3379.4	BHP		
+ 20	HP	FOR GENERATOR COOLING FAN	
3399.4	BHP		
+ 200	HP	DERATION ASSOCIATED WITH OPERATION @ 110° F	
3599.4	BHP		

3950 BHP > 3599.4, ∴ OK

HEAT CONTRIBUTED TO COOLANT BY ENGINE IS 33 BTU/MIN - BHP

3599.4
× 33
118,780 BTU/MIN*

* NOTE: THIS NUMBER IS 1.8% LESS THAN THE VALUE SUPPLIED TO YOUNG FOR ANALYSIS.

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Attachment 8.9d

Delivered Air vs. Required Air Analysis

EA-90-062

~~REV.~~ Rjc 9-19-95

REV. 3 J

ATTACHMENT 8.9

A comparison of before and after cleaning air flows, adjusted to a standard temperature of 70°F showed a marked improvement for DG-2 and a lesser improvement for DG-1. See Table 1 below for comparison.

Table 1

AIR FLOW COMPARISON BEFORE AND AFTER CLEANING RADIATORS

FORT CALHOUN STATION EMERGENCY DIESEL GENERATORS

Diesel	Status	Outdoor Ambient Temp	Measured CFM	Corrected Air Flow, SCFM at 70°F
DG-1	Dirty	59	101,356	99,271
DG-1	Clean	33	109,448	101,774*
DG-1	Clean, Temporary Air Deflector in Stack	58 - 70	104,852	103,711
DG-2	Dirty	36	100,799	94,310
DG-2	2nd Cleaning	73	100,972	101,531*

*This comparison also reveals that both units are essentially performing the same, i.e., measured flows are nearly equal.

Radiator fan output at test conditions was adjusted to a standard condition of 70°F to determine base SCFM delivered by the unit. Temperature correction factors were then applied to account for decreased air density at elevated temperature and compared to required flows to maintain jacket water temperatures at or below 208°F. As can be seen from Attachment 8.9d-2 and 8.9d-3, the radiator vendor predicts that the FCS diesel generator radiator configuration is adequate for operation at up to 114°F ambient temperature for DG-1 and 117°F for DG-2.

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Attachment 8.9d-2

EA-90-062 ~~REV~~ REV. 3 – pjc 6-19-95

CALC. PAGE NO. ______

CALCULATION PREPARATION, REVIEW AND APPROVAL **FORM PED-QP-3.4 Form Page No. 1 of 1** **PRODUCTION ENGINEERING DIVISION** **CALCULATION SHEET**	**CALCULATION NO.** **FC** ______ **Rev. No.** ______

REF NO.

FOR DG-1, WITH AIR FLOWS OBTAINED AFTER RADIATOR CLEANING (3-14-91), FLOW ADJUSTED TO STANDARD TEMPERATURE OF 70°F = 101,774 SCFM.

T_{AMB}	C_{TEMP}	SCFM DELIVERED*	SCFM REQ'D**
106	.936	95,260	84,101
107	.935	95,159	85,086
108	.933	94,955	86,071
109	.932	94,853	87,183
110	.930	94,650	88,295
111	.928	94,446	89,406
112	.927	94,344	90,517
113	.925	94,141	91,631
• 114	.924	94,039	92,896
115	.922	93,836	94,160
116	.920	93,632	95,425

* FLOW CORRECTED FOR TEMPERATURE

** FLOWS IN THIS COLUMN REPRESENT YOUNG RADIATOR COMPANY'S CALCULATED REQ'D FLOWS AT VARIOUS TEMPERATURES, INCREASED BY 2.1% (SEE ATT. 8.9c FOR EXPLANATION) AND CORRECTED FOR 1007' ELEVATION

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Attachment 8.9d-3

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CALCULATION PREPARATION, REVIEW AND APPROVAL FORM PED—QP—3.4 Form Page No. 1 of 1 PRODUCTION ENGINEERING DIVISION CALCULATION SHEET	CALCULATION NO. FC ______ Rev. No. ______

REF NO.

FOR DG-2, WITH AIR FLOWS OBTAINED AFTER RADIATOR CLEANING (3-25-91), FLOW ADJUSTED TO STANDARD TEMPERATURE OF 70°F = 101,581 SCFM

T_{amb}	C_{TEMP}	SCFM DELIVERED*	SCFM REQ'D**
106	.936	95,080	80,879
107	.935	94,978	81,826
108	.933	94,775	82,774
109	.932	94,673	83,844
110	.930	94,470	84,914
111	.928	94,267	85,982
112	.927	94,166	87,083
113	.925	93,962	88,122
114	.924	93,861	89,338
115	.922	93,658	90,554
116	.920	93,455	91,770
• 117	.919	93,353	92,985
118	.917	93,170	94,203

* FLOW CORRECTED FOR TEMPERATURE

** FLOWS IN THIS COLUMN REPRESENT YOUNG RADIATOR COMPANY'S CALCULATED REQ'D FLOWS AT VARIOUS INLET TEMPERATURES, DECREASED BY 1.8% (SEE ATT. 8.9C FOR EXPLANATION) AND CORRECTED FOR 1007' ELEVATION.

EA -90-062

~~REV~~ pjc 4-19-95

REV. 3

Letter From R. L. Phelps to R. L. Jaworski and T. L. Patterson, Dated 5/31/91

EA -90-062

~~REV~~ - pf 9-19-95 2

Memorandum

REV. 3

DATE: May 31, 1991 PED-FC-91-1877

FROM: R. L. Phelps

TO: R. L. Jaworski
T. L. Patterson

SUBJECT: Fort Calhoun Station Emergency Diesel Generator Ambient Air Limits

REFERENCES:
1. Engineering Analysis FC-90-062 Rev. 1 "Diesel Generator Upper Temperature Operating Limits"
2. Engineering Analysis FC-90-091 Rev. 0 "Improving the Performance of the Emergency Diesel Generator Jacket Water Cooling System"

The purpose of this memo is to provide high confidence level results of the changes made to the DG cooling systems to raise the ambient air temperature limit. The recent installations of local air conditioning units on the exciter cabinets will allow operation of the exciter at 110°F ambient conditions. The ambient air temperature limitations on the engine, previously established in EA-90-062 Rev. 1 (Ref. 1) are 103°F for DG-1 and 100°F for DG-2 to ensure that the 2000 hr. deration curve was not exceeded.

The engine ambient air temperature limits are increased to 110°F based upon reduction of mechanical load and improved heat transfer associated with changing coolant to treated water together with benefits achieved by cleaning the radiators on both diesels. Specific details regarding the actions taken to increase the ambient air temperature limitation on DG-1 and DG-2 is provided in attachment "A" to this memorandum.

Based on the information that DEN has obtained from MK Power Systems, Young Radiator, Station Engineering and Stone & Webster Engineering, DEN concludes, with a high degree of confidence, that the diesel generators will not be limited by jacket water or turbo charger temperatures at ambient temperatures below 110°F if treated water is used in the Jacket Water system. While this is a high confidence level conclusion, EA-90-062 Rev. 1 must be revised, reviewed and independently reviewed per the requirements of QP-5 "Engineering Analysis Preparation, Review, and Approval" to fully document this conclusion. Although an elevated ambient air condition test is not required due to the documented test data recorded in EA-90-062 Rev. 1 and EA-90-091 Rev. 0, it would lend further credibility to the engineering analysis and ensure that it withstood regulatory scrutiny. Warm weather testing is strongly recommended by DEN to validate the revision to EA-90-062 Rev. 1.

Recommended maintenance and construction activities associated with the near and long term operation of the diesels are provided in Attachment "B".

As previously committed in the DG Temperature Improvements Project, DEN Mechanical expects to formally complete the revision to EA-90-062 and publish it no later than June 15, 1991. In the interim, this memo is considered as support for establishment of diesel generator operability at or below 110°F, if treated water is used in the Jacket Water system. If ethylene gycol is used as a cooling medium, the ambient temperature limit will not increase above the previously established values of 100°F for DG-2 and 103°F for DG-1.

R. L. Phelps
Manager - Design Engineering Nuclear
Production Engineering Division

JLS/KAM/sf

Attachments

c: S. K. Gambhir
J. W. Chase
J. T. O'Connor
T. G. Therkildsen
D. R. Trausch
D. K. Haas
D. G. Borcyk
D. G. Flegle
R. R. Ronning
PED Library

ATTACHMENT "A"

DETAILS OF ACTIONS TAKE BY DEN-MECHANICAL TO INCREASE DG-1 AND DG-2 AMBIENT AIR TEMPERATURE

Effect of Coolant Change on Jacket Water Temperature

EA-90-091 Rev. 0 concluded that there was no improvement in lowering jacket water temperature by replacing 50/50 Glycol coolant medium with a treated water medium. OPPD DEN has since obtained Young Radiator data relating to performance of different coolants. The conclusion in EA-90-091 Rev. 0 is in conflict with anticipated jacket water temperature performance normally expected in this type of equipment. Young Radiator has performed calculations which indicate that the coolant temperature will be maintained at 208°F (using treated water as a coolant) with a design heat input of 120,970 BTU/MIN, a coolant flow of 1100 gpm, and with cooling air entering the radiator at 115°F at a flow rate of 104,852 CFM (93,000 scfm, standard conditions). Because water has a higher specific heat (C_p) (1.0 BTU/lb-°F) than 50/50 Glycol (.85 BTU/lb-°F) and a lower density and viscosity than Ethylene Glycol, a higher temperature limit of 115°F vs. (EA-90-091 Rev. 0) 100°F and 103°F should have been predicted due to improved heat transfer and reduced pumping requirements.

Test data collected in EA-90-062 Rev. 1 was reevaluated by DEN and it has been concluded that the test data collected during operating runs on DG-1 confirms there is a substantial reduction in jacket water temperature when treated water is utilized as a coolant medium. In reevaluation of the test data, data points collected during the first 30 minutes of a diesel run were excluded to ensure that the diesel had reached a steady state condition. Table I summarizes the reevaluation of this test data.

Table I

COMPARISON OF JACKET WATER TEMPERATURES TO AMBIENT AIR TEMPERATURES

DG-1

Test Date	Ambient Air Temp °F	Jacket Water Temp °F	ΔT Jacket Water to Ambient Air	Coolant Flow	Coolant Medium
7/26/89	89	199	110	Not Avail	Glycol
8/23/89	81 - 84	194	110 - 114	Not Avail	Glycol
8/26/89	70	184	114	Not Avail	Glycol
6/25/90	89	188	98	1150	Water

These tests were conducted at identical diesel generator power levels under elevated ambient air temperature conditions. It is apparent in the first three tests that the data is repeatable for ΔT in the Glycol coolant configuration and that a substantial improvement should have been noted in lowering jacket water temperature when water was utilized as a cooling medium.

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pjc 9-19-95

REV. 3

ATTACHMENT "A" (Continued)

EA-90-062 Rev. 1 compares the results of diesel generator DG-2 tests performed before and after coolant replacement. This data is summarized in Table II.

Table II

COMPARISON OF JACKET WATER TEMPERATURES TO AMBIENT AIR TEMPERATURES

DG-2

Test Date	Ambient Air Temp °F	Jacket Water Temp °F	ΔT Jacket Water to Ambient Air	Coolant Flow	Coolant Medium
7/16/90	87	192	105	1096	Glycol
7/17/90	89.5	194	105	975	Water
9/6/90	89	195	106	-	Water

During testing of DG-2 on July 17, 1990, the coolant flow fluctuated repeatedly and was considerably below its expected value of >1100 gpm. DEN suspects that the coolant system may not have been adequately vented following the coolant change, an AMOT valve did not perform as designed during this test, or the flowmeter malfunctioned. As no jacket water flow data is available for subsequent DG-2 tests conducted at elevated ambient air temperatures, this problem may have persisted. It should also be noted that the radiator for DG-1 was not as severely fouled as the radiator for DG-2, and that the fouling factor for DG-2 could have been the dominant element in DG-2's reduced heat transfer capability.

Removal of Debris from Diesel Radiators

DEN has evaluated the benefits of the cleaning that was performed by Fort Calhoun Station maintenance on air flows through the diesel generator radiators. To aid in this evaluation, Station Engineering performed extensive testing of air flows in the diesel radiator exhaust ductwork and supplied DEN with the results. Using raw data, there was no apparent measurable improvement in air flow, however, in order to compare fan flows taken under varying air temperature conditions, the delivered air flow must be corrected to indicate the air flow that would be delivered if the inlet air was at a temperature of 70°F. This correction is required because fan output is a function of air density, i.e., less fan SCFM output occurs at higher temperatures.

Table III summarizes the data collected from testing performed before and after cleaning the radiators on diesel generators DG-1 and DG-2.

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9-19-95

REV. 3

ATTACHMENT "A" (Continued)

Table III

AIR FLOW COMPARISON BEFORE AND AFTER CLEANING RADIATORS

FORT CALHOUN STATION EMERGENCY DIESEL GENERATORS

Diesel	Status	Temp	Measured CFM	Corrected Air Flow, SCFM
DG-1	Dirty	59	101,356	99,271
DG-1	Clean	33	109,448	101,774
DG-1	Clean, Air Deflector in Stack	58 - 70	104,852	103,711
DG-2	Dirty	36	100,799	94,310
DG-2	2nd Cleaning	73	100,972	101,531

With the corrected air flows comparing fan performance at identical operating conditions, the air flow was dramatically improved through DG-2 and reasonably improved through DG-1 after radiator fin cleaning.

EA-90-091 Rev. 0 concludes that a 1°F gain in ambient allowable temperature corresponds to each 1000 SCFM of additional air. This infers that an additional 2°F ambient allowable is gained by cleaning DG-1 and a 7°F gain was achieved on DG-2. This is a very rough correlation, but supports the predicted jacket water temperatures supplied by Young Radiator. The difference in air flows correlates well to the measured difference in jacket water temperature and ambient air temperatures shown in Table I and Table II.

DG-2 showed a 7°F higher ΔT than DG-1, because of loss of air flow and combined with reduction of heat transfer surface area because of fouling.

Efficiency Savings Resulting From Coolant Change

According to literature (documented in EA-90-062 Rev. 1 and EA-90-091 Rev. 0) received from MK Power Systems, OPPD's representative for EMD stationary diesel generating units, a net horsepower savings of 180 bhp can be assumed if the Ethylene Glycol engine coolant is replaced by treated water. This can be converted to an additional 130 KWe to be applied to offset the diesel generator deration curve. The addition of 130 KWe to the rated capacity of 2654 yields 2784 KWe available. In a trial run performed by the DEN Electrical Group with the computer program used to graph attachments 8-6-3 and 8-10-1 of EA-90-091 Rev. 0, the diesels will satisfy the post-LOCA loads if this 2784 KWe power available is applied to the 2000 hr. deration curve. This computer program utilizes the assumptions of EA-90-062 Rev. 1 that the demand occurs only while the diesel is in a cold standby condition and not immediately following a planned surveillance test run of the diesel operating considerations.

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ATTACHMENT "A" (Continued)

Although it is satisfactory to operate the diesels at elevated jacket water temperatures when required to meet emergency demands, it is not recommended that this be done for normal surveillance testing. The jacket water temperature alarm sounds at 200°F, with diesel trip occurring at 208°F. This places the operator in the position of operating equipment in an alarmed condition, which may not be desirable.

FA -90-062

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4-19-95
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ATTACHMENT "B"

RECOMMENDED MAINTENANCE AND CONSTRUCTION ACTIVITIES FOR DG-1 AND DG-2

DEN Mechanical also recommends that these maintenance and construction activities be performed as scheduled:

1. Replace the AMOT valve thermostatic elements to ensure reliability at elevated jacket water temperatures.
2. Replace the radiator cooling fans with units designed for higher output at the differential pressures observed.
3. Upgrade the instrumentation associated with the diesel generator jacket water cooling system (MR-FC-90-005).
4. Establish a Preventive Maintenance Procedure for cleaning the finned surface of the radiators.
5. Change coolant back to 50/50 Glycol to prevent freeze damage after October 15 each year and run treated water from May 15 through October 15 of each year. Until other improvements in cooling air flow can be implemented, the coolant should be changed to treated water in May and returned to 50/50 Glycol in October of every year.

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~~RE~~ pjc 9-19-95

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Rev. ~~2~~ 3
Attachment 8.11

DG-1 Testing - Airflows Before Steam Cleaning, 3/8/91

REV. 3

~~REV 2~~ pjc 9-19-95

59°F

Calculated Flow Rates
DG-1 Before Steam Cleaning, 3-8-91, 25 Degree Pitch

11 SCFM= 2537.78 Temp.= 134.9	21 SCFM= 2742.22 Temp.= 134.5	31 SCFM= 2600 Temp.= 136.5	41 SCFM= 2488.89 Temp.= 136.4	51 SCFM= 1767.78 Temp.= 133.8	61 SCFM= 2055.56 Temp.= 136.2	71 SCFM= 2211.11 Temp.= 135.8	81 SCFM= 2366.67 Temp.= 135.9	91 SCFM= 2633.33 Temp.= 130
12 SCFM= 2727.78 Temp.= 127.3	22 SCFM= 2961.11 Temp.= 130.1	32 SCFM= 2574.44 Temp.= 133.5	42 SCFM= 2267.78 Temp.= 134.7	52 SCFM= 1842.22 Temp.= 135.8	62 SCFM= 2220 Temp.= 135.8	72 SCFM= 2272.22 Temp.= 131.5	82 SCFM= 2483.33 Temp.= 130.1	92 SCFM= 2526.67 Temp.= 120
13 SCFM= 2620 Temp.= 121.2	23 SCFM= 2603.33 Temp.= 126	33 SCFM= 2441.11 Temp.= 131.2	43 SCFM= 2288.89 Temp.= 129	53 SCFM= 1786.67 Temp.= 133.7	63 SCFM= 2144.44 Temp.= 134	73 SCFM= 2117.78 Temp.= 127.8	83 SCFM= 2648.89 Temp.= 125.3	93 SCFM= 2616.67 Temp.= 119
14 SCFM= 2478.89 Temp.= 116.4	24 SCFM= 2561.11 Temp.= 123.4	34 SCFM= 2335.56 Temp.= 125.6	44 SCFM= 2367.78 Temp.= 122.4	54 SCFM= 1466.67 Temp.= 121.9	64 SCFM= 2033.33 Temp.= 127.7	74 SCFM= 2122.22 Temp.= 120.2	84 SCFM= 2477.78 Temp.= 121.1	94 SCFM= 2112.22 Temp.= 119
15 SCFM= 1748.89 Temp.= 111.5	25 SCFM= 2536.67 Temp.= 114.2	35 SCFM= 2161.11 Temp.= 113.1	45 SCFM= 2022.22 Temp.= 115.4	55 SCFM= 1177.78 Temp.= 115.7	65 SCFM= 2010 Temp.= 116.5	75 SCFM= 1700 Temp.= 114.5	85 SCFM= 1944.44 Temp.= 114.2	95 SCFM= 1552.22 Temp.= 115

Total Calculated Flow Rate= 101356 SCFM

Average Temperature 126° F (Outlet)

Average Temperature 59° F (Inlet)

ΔT = 67° F

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Attachment 8.11-1

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Attachment 8.12

REV. 3

DG-1 Testing - Airflows After Steam Cleaning, 3/14/91

33°

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Attachment 8.12-1

DG-1 After Steam Cleaning, 3-14-91, With 25 degree Pitch
Calculated Flow Rates

11 SCFM= 2655.56 Temp.= 107	21 SCFM= 2666.67 Temp.= 107.1	31 SCFM= 2785.56 Temp.= 107.3	41 SCFM= 2765.56 Temp.= 105.8	51 SCFM= 1533.33 Temp.= 105.1	61 SCFM= 2688.89 Temp.= 109.8	71 SCFM= 2755.56 Temp.= 109.1	81 SCFM= 2333.33 Temp.= 108.3	91 SCFM= 2588.89 Temp.= 107.6
12 SCFM= 3038.89 Temp.= 94	22 SCFM= 3313.33 Temp.= 90.3	32 SCFM= 2811.11 Temp.= 97.2	42 SCFM= 2656.67 Temp.= 97.4	52 SCFM= 1840 Temp.= 107.3	62 SCFM= 2403.33 Temp.= 105.6	72 SCFM= 2795.56 Temp.= 97.6	82 SCFM= 2653.33 Temp.= 91.7	92 SCFM= 2688.89 Temp.= 96.7
13 SCFM= 2755.56 Temp.= 78	23 SCFM= 2694.44 Temp.= 81.7	33 SCFM= 2537.78 Temp.= 92.1	43 SCFM= 2520 Temp.= 89	53 SCFM= 1613.33 Temp.= 96	63 SCFM= 2238.89 Temp.= 98.3	73 SCFM= 2577.78 Temp.= 89.8	83 SCFM= 2772.22 Temp.= 82.6	93 SCFM= 2838.89 Temp.= 76.5
14 SCFM= 2405.56 Temp.= 70	24 SCFM= 2068.89 Temp.= 76.9	34 SCFM= 2566.67 Temp.= 80	44 SCFM= 2464.44 Temp.= 78.2	54 SCFM= 1717.78 Temp.= 72.4	64 SCFM= 2105.56 Temp.= 85	74 SCFM= 2572.22 Temp.= 77.3	84 SCFM= 2733.33 Temp.= 76.9	94 SCFM= 2505.56 Temp.= 78.5
15 SCFM= 1611.11 Temp.= 66	25 SCFM= 2593.33 Temp.= [illegible]	35 SCFM= 2122.22 Temp.= 66.8	45 SCFM= 2190 Temp.= 67.8	55 SCFM= 1477.78 Temp.= 65.5	65 SCFM= 1904.44 Temp.= 70.8	75 SCFM= 2166.67 Temp.= 68	85 SCFM= 2181.11 Temp.= 67.3	95 SCFM= 1937.78 Temp.= 66.1

Total Calculated Flow Rate= 109448 SCFM

Average Temperature in Duct = 87.82 Degreees F

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REV. 3

DG-2 Testing - Airflows Before Steam Cleaning, 2/27/91

REV. 3

25 Degree Pitch Before Steam Cleaning, Screen On

Calculated Flow Rates 2/27/91

11 SCFM= 2797.78 Temp.= 122.4	21 SCFM= 2722.22 Temp.= 120.3	31 SCFM= 2260 Temp.= 117.1	41 SCFM= 2382.22 Temp.= 121.1	51 SCFM= 1782.22 Temp.= 120.1	61 SCFM= 2481.11 Temp.= 117	71 SCFM= 2682.22 Temp.= 109.5	81 SCFM= 2772.22 Temp.= 115	91 SCFM= 2477.78 Temp.= 120.5
12 SCFM= 2787.78 Temp.= 108.1	22 SCFM= 2866.67 Temp.= 116.6	32 SCFM= 2544.89 Temp.= 112.4	42 SCFM= 2465.56 Temp.= 117.1	52 SCFM= 1072.22 Temp.= 117.6	62 SCFM= 2275.56 Temp.= 112	72 SCFM= 2850 Temp.= 101.5	82 SCFM= 2777.78 Temp.= 106.6	92 SCFM= 2481.11 Temp.= 115
13 SCFM= 2800 Temp.= 95	23 SCFM= 2791.11 Temp.= 112	33 SCFM= 2730 Temp.= 106.7	43 SCFM= 2177.78 Temp.= 107	53 SCFM= 875.556 Temp.= 110	63 SCFM= 2255.56 Temp.= 110.7	73 SCFM= 2416.67 Temp.= 93.2	83 SCFM= 2683.33 Temp.= 108.5	93 SCFM= 2282.22 Temp.= 89.7
14 SCFM= 2531.11 Temp.= 93.5	24 SCFM= 2614.44 Temp.= 99.5	34 SCFM= 2491.11 Temp.= 92.3	44 SCFM= 2378.89 Temp.= 96.5	54 SCFM= 861.111 Temp.= 96.5	64 SCFM= 1908 Temp.= 99.9	74 SCFM= 1864.44 Temp.= 86.7	84 SCFM= 2027.78 Temp.= 93.1	94 SCFM= 1944.44 Temp.= 86
15 SCFM= 1957.78 Temp.= 89	25 SCFM= 2295.56 Temp.= 89.7	35 SCFM= 1973.33 Temp.= 85.4	45 SCFM= 1984.44 Temp.= 92.3	55 SCFM= 863.333 Temp.= 92.4	65 SCFM= 1811.11 Temp.= 92.1	75 SCFM= 1894.44 Temp.= 86.3	85 SCFM= 2127.78 Temp.= 86.4	95 SCFM= 2066.67 Temp.= 83.6

Total Calculated Flow Rate= 100799 SCFM

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Attachment 8.13-1

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Rev. ~~2~~3
Attachment 8.14

REV. 3

DG-2 Testing - Airflows After Steam Cleaning, 3/25/91

REV. 3

Calculated Flow Rates
96-2 , 3-25-91, After Fin Straightening and Steam Cleaning

11 SCFM= 2581.11 Temp.= 155	21 SCFM= 2807.78 Temp.= 155	31 SCFM= 2478.89 Temp.= 156	41 SCFM= 2597.78 Temp.= 154	51 SCFM= 2266.67 Temp.= 154	61 SCFM= 2706.67 Temp.= 156	71 SCFM= 2356.67 Temp.= 153	81 SCFM= 2597.78 Temp.= 154	91 SCFM= 2691.11 Temp.= 157
12 SCFM= 2561.11 Temp.= 153	22 SCFM= 2716.67 Temp.= 154	32 SCFM= 2342.22 Temp.= 155	42 SCFM= 2388.89 Temp.= 153	52 SCFM= 1348 Temp.= 154	62 SCFM= 2166.67 Temp.= 156	72 SCFM= 2577.78 Temp.= 151	82 SCFM= 2708.89 Temp.= 152	92 SCFM= 2654.44 Temp.= 155
13 SCFM= 2563.56 Temp.= [illegible]	23 SCFM= 2823.33 Temp.= [illegible]	33 SCFM= 2497.78 Temp.= [illegible]	43 SCFM= 2445.56 Temp.= 151	53 SCFM= 1102.22 Temp.= 152	63 SCFM= 2258.89 Temp.= 156	73 SCFM= 2231.11 Temp.= 150	83 SCFM= 2437.78 Temp.= 151	93 SCFM= 2481.11 Temp.= 147
14 SCFM= 2449 Temp.= 145	24 SCFM= 2745.56 Temp.= 148	34 SCFM= 2583.33 Temp.= 151	44 SCFM= 2324.44 Temp.= 147	54 SCFM= 1061.11 Temp.= 149	64 SCFM= 2008.89 Temp.= 153	74 SCFM= 1966.67 Temp.= 148	84 SCFM= 1984.44 Temp.= 148	94 SCFM= 2127.78 Temp.= 145
15 SCFM= 2018.89 Temp.= 142	25 SCFM= 2278.89 Temp.= 143	35 SCFM= 2084.44 Temp.= 143	45 SCFM= 1977.78 Temp.= 143	55 SCFM= 916.667 Temp.= 146	65 SCFM= 1568.89 Temp.= 148	75 SCFM= 1787.78 Temp.= 145	85 SCFM= 1925.56 Temp.= 146	95 SCFM= 1846.67 Temp.= 143

Total Calculated Flow Rate= 100972 SCFM

Average Temperature in Duct = 150.40 Degreees F

EA - ~~REV~~ 062

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.14-1

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~~REV 2~~ 9-19-95

REV. 3

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.15

DG-1 Datalogger Points at 15:46:05

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EA-90-062

ATTACHMENT 8.15-1
EA-FC-90-062
~~Rev. 2~~ pjc 9-19-95
RE\ REV. 3

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END SCAN GROUP 1         30 MAY 91  15:30:36

BEGIN SCAN GROUP 1       30 MAY 91  15:31:30
DG CAB TEMPS

C  41 A1 TOP LEFT           103.31 DEG F
C  42 A2 CNT LEFT           100.40 DEG F
C  43 A3 BOT LEFT           98.856 DEG F
C  44 B1 TOP CENT           104.38 DEG F
C  45 B2 MID CENT           100.65 DEG F
C  46 B3 BOT CENT           96.235 DEG F
C  47 C1 TOP RHT            103.06 DEG F
C  48 C2 CNT RHT            100.38 DEG F
C  49 C3 BTM RHT           98.474 DEG F
C  50 AVG. TEMP.           100.69 DEG F

END SCAN GROUP 1         30 MAY 91  15:31:37

BEGIN SCAN GROUP 1       30 MAY 91  15:36:31
DG CAB TEMPS

C  41 A1 TOP LEFT           103.26 DEG F
C  42 A2 CNT LEFT           100.86 DEG F
C  43 A3 BOT LEFT           100.28 DEG F
C  44 B1 TOP CENT           103.86 DEG F
C  45 B2 MID CENT           100.60 DEG F
C  46 B3 BOT CENT           97.301 DEG F
C  47 C1 TOP RHT            102.71 DEG F
C  48 C2 CNT RHT            100.56 DEG F
C  49 C3 BTM RHT            99.465 DEG F
C  50 AVG. TEMP.           100.99 DEG F

END SCAN GROUP 1         30 MAY 91  15:36:38

BEGIN SCAN GROUP 1       30 MAY 91  15:41:32
DG CAB TEMPS

C  41 A1 TOP LEFT           102.44 DEG F
C  42 A2 CNT LEFT           99.575 DEG F
C  43 A3 BOT LEFT           98.715 DEG F
C  44 B1 TOP CENT           103.09 DEG F
C  45 B2 MID CENT           99.727 DEG F
C  46 B3 BOT CENT           97.169 DEG F
C  47 C1 TOP RHT            101.14 DEG F
C  48 C2 CNT RHT            99.966 DEG F
C  49 C3 BTM RHT            99.063 DEG F
C  50 AVG. TEMP.           100.10 DEG F

END SCAN GROUP 1         30 MAY 91  15:41:39

BEGIN SCAN GROUP 1       30 MAY 91  15:46:05
DG CAB TEMPS

C  41 A1 TOP LEFT           103.28 DEG F
C  42 A2 CNT LEFT           99.943 DEG F
C  43 A3 BOT LEFT           99.063 DEG F
C  44 B1 TOP CENT           103.72 DEG F
C  45 B2 MID CENT           100.07 DEG F
C  46 B3 BOT CENT           97.508 DEG F
C  47 C1 TOP RHT            101.54 DEG F
C  48 C2 CNT RHT            100.23 DEG F
C  49 C3 BTM RHT            99.497 DEG F
C  50 AVG. TEMP.           100.54 DEG F

END SCAN GROUP 1         30 MAY 91  15:46:12

BEGIN SCAN GROUP 1       30 MAY 91  15:46:33
DG CAB TEMPS
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EA-FC-90-062
Rev. 2 3
Attachment 8.16

~~REV 2~~ pjc
9-19-95

REV. 3

DG-2 Datalogger Points at 14:57:27

ATTACHMENT 8.16-1
EA-FC-90-062
~~Rev 2~~ 9-19-95
~~REV 2~~ REV. 3
pjc 9-19-9

EA-90-062

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END SCAN GROUP 1        15 MAY 91  14:51:50

BEGIN SCAN GROUP 1      15 MAY 91  14:52:11
DG CAB TEMPS

   41 A1 TOP LEFT            95.389 DEG F
   42 A2 CNT LEFT            91.379 DEG F
   43 A3 BOT LEFT            91.379 DEG F
   44 B1 TOP CENT            95.183 DEG F
   45 B2 MID CENT            91.868 DEG F
   46 B3 BOT CENT            92.129 DEG F
   47 C1 TOP RHT             96.042 DEG F
   48 C2 CNT RHT             93.206 DEG F
   49 C3 BTM RHT             91.483 DEG F
   50 AVG.TEMP.              93.118 DEG F

END SCAN GROUP 1        15 MAY 91  14:52:16

BEGIN SCAN GROUP 1      15 MAY 91  14:57:12
DG CAB TEMPS

   41 A1 TOP LEFT            94.619 DEG F
   42 A2 CNT LEFT            91.325 DEG F
   43 A3 BOT LEFT            91.543 DEG F
   44 B1 TOP CENT            94.955 DEG F
   45 B2 MID CENT            92.172 DEG F
   46 B3 BOT CENT            91.890 DEG F
   47 C1 TOP RHT             95.748 DEG F
   48 C2 CNT RHT             93.628 DEG F
   49 C3 BTM RHT             91.781 DEG F
   50 AVG.TEMP.              93.074 DEG F

END SCAN GROUP 1        15 MAY 91  14:57:17

BEGIN SCAN GROUP 1      15 MAY 91  14:57:27
DG CAB TEMPS

   41 A1 TOP LEFT            94.530 DEG F
   42 A2 CNT LEFT            91.302 DEG F
   43 A3 BOT LEFT            91.488 DEG F
   44 B1 TOP CENT            94.944 DEG F
   45 B2 MID CENT            92.031 DEG F
   46 B3 BOT CENT            91.747 DEG F
   47 C1 TOP RHT             95.694 DEG F
   48 C2 CNT RHT             93.553 DEG F
   49 C3 BTM RHT             91.738 DEG F
   50 AVG.TEMP.              93.003 DEG F

END SCAN GROUP 1        15 MAY 91  14:57:32
```

Load Off DG

```
BEGIN SCAN GROUP 1      15 MAY 91  15:01:58
DG CAB TEMPS

   41 A1 TOP LEFT            95.185 DEG F
   42 A2 CNT LEFT            92.020 DEG F
   43 A3 BOT LEFT            92.043 DEG F
   44 B1 TOP CENT            95.096 DEG F
   45 B2 MID CENT            92.281 DEG F
   46 B3 BOT CENT            91.609 DEG F
   47 C1 TOP RHT             95.630 DEG F
   48 C2 CNT RHT             93.565 DEG F
   49 C3 BTM RHT             91.890 DEG F
   50 AVG.TEMP.              93.258 DEG F

END SCAN GROUP 1        15 MAY 91  15:02:03

BEGIN SCAN GROUP 1      15 MAY 91  15:02:53
```

EA -90-062

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.17

~~REV~~ pjc
9-19-95

REV. 3

Telecon with Ken Beach

ATTACHMENT 8.17-1
EA-FC-90-062
~~REV 2~~ pjc
9-19-95

EA-90-062

RECORD OF TELEPHONE COMMUNICATION

E. A. NO. 90-062 FILE NO. PED-FC-91-403 REV. 3

DATE: 6-10-91 TIME: 2:00 p.m. TELEPHONE NO. x 6735

PARTY CALLING: P. F. Vovk (NAME) OPPD (COMPANY)

PARTY ANSWERING: K. Beach (NAME) OPPD (COMPANY)

SUBJECT: Uncertainty of Test Equipment Used in Post-Calibration of MR-FC-90-073

TELECON SUMMARY (Including Decisions and Commitments)

The post-mod calibration of test instruments used in T-1 and T-2 of MR-FC-90-073 was a function check of the equipment. The devices used to perform this check have uncertainties of better than ± 1°F (MT-00027, -00001, 08201).

ACTION REQUIRED

Use for revision 2 of EA-FC-90-062.

DISTRIBUTION

PED Library

pjc 9-19-95
~~REV~~

EA-90-062

To Rich Ronning – Function Test of Temperature Devices REV. 3
Used on DG-#1 Test
Acceptance for this test is ± 1°F

2) MT-10107 & MT-10108 w/ Air Probes

ICE PT	32.0	32.1
AMBIENT	73.0	73.2

Ambient measured w/ MT-00001 & 00027

KB 6-6-91

(3) MT-00014

– LAB CONDITIONS AS MEASURED WITH

MT-08201 71.4°F & 43.2% RH

MT-00014 INDICATED 71.4°F & 42.0% R.H.

KB 6-6-91

Re Rich Ronning - Function Test Temperature Devices used on DG-2 test.

REV. 3

Acceptance for this test is ± 1° F.

MT-00075 FLUKE DATA LOGGER w/ HYCAL RTDS, (9 ea.)

MT-50401, 50409, 50415, 50417, 50419, 50421, 50-25, 50426, 50428

MT-00075 w/ HY-CAL RTD's. - ICE PT. CHECK

```
BEGIN SCAN GROUP 1    29 MAY 91  15:20:02
DG CAB TEMPS

C  41 A1 TOP LEFT        32.310 DEG F
C  42 A2 CNT LEFT        31.611 DEG F
C  43 A3 BOT LEFT        32.202 DEG F
C  44 B1 TOP CENT        32.472 DEG F
C  45 B2 MID CENT        31.901 DEG F
C  46 B3 BOT CENT        32.094 DEG F
C  47 C1 TOP RHT         32.009 DEG F
C  48 C2 CNT RHT         32.106 DEG F
C  49 C3 BTM RHT         32.289 DEG F
C  50 AVG.TEMP.         32.110 DEG F

END SCAN GROUP 1      29 MAY 91  15:20:09

STOPPED SINGLE SCAN   29 MAY 91  15:20:10
```

5-29-91

)

MT-10102 w/ Air Probe

(32°F) ICE PT. 32.3

(73.02°F) AMBIENT 73.0 (AMB. MEASURED WITH MT-00001 & MT-00027)

6-6-91

3)

MT-00014

LAB CONDITIONS

AS MEASURED W/ MT-08201 : 71.4° F & 43.2% R.H

MT-00014 INDICATION 71.4°F & 42.0% R.H.

6-6-91

Pg 1 of 1.

EA-90-062

ATTACHMENT 8.17-4
EA-FC-90-062
~~REV~~ pjc -9-19-95

= Rich Ronning - Function Test of Temperature Devices Used on DG-#1 Test.

REV. 3

Acceptance for this test is ± 1° F.

) MT-00075 Fluke Data Logger w/ HyCal RTD's. (9 ea)

IT- 50401, 50409, 50415, 50417, 50419, 50421, 50423, 50426, 50428

ICE PT.

```
BEGIN SCAN GROUP 1   06 JUN 91  11:43:56
DG CAB TEMPS

C  41 A1 TOP LEFT        32.198 DEG F
C  42 A2 CNT LEFT        31.734 DEG F
C  43 A3 BOT LEFT        32.216 DEG F
C  44 B1 TOP CENT        32.434 DEG F
C  45 B2 MID CENT        31.906 DEG F
C  46 B3 BOT CENT        32.101 DEG F
C  47 C1 TOP RHT         31.561 DEG F
C  48 C2 CNT RHT         32.101 DEG F
C  49 C3 BTM RHT         32.295 DEG F
C  50 AUG.TEMP.         32.061 DEG F

END SCAN GROUP 1      06 JUN 91  11:44:03

STOPPED SINGLE SCAN   06 JUN 91  11:44:04

BEGIN SCAN GROUP 1   07 JUN 91  12:52:39
DG CAB TEMPS         AMBIENT w/ MT-00027, 00001.
                                            MEAS.
C  41 A1 TOP LEFT        73.019 DEG F        ↓
C  42 A2 CNT LEFT        72.855 DEG F
C  43 A3 BOT LEFT        73.462 DEG F
C  44 B1 TOP CENT        73.766 DEG F
C  45 B2 MID CENT        73.256 DEG F
C  46 B3 BOT CENT        73.322 DEG F   73.38F
C  47 C1 TOP RHT         73.277 DEG F
C  48 C2 CNT RHT         73.428 DEG F
C  49 C3 BTM RHT         73.798 DEG F
C  50 AUG.TEMP.         73.354 DEG F

END SCAN GROUP 1      07 JUN 91  12:52:46

STOPPED SINGLE SCAN   07 JUN 91  12:52:47
```

6-6, 6-7-91

Pg 1 of 2

~~REV~~ = pjc
9-19-95

EA-90-062

EA-FC-90-062
Rev. ~~2~~3
Attachment 8.18

REV. 3

A/C Efficiency Data

BEST COPY

EA-90-062

ATTACHMENT 8.18-1
EA-FC-90-062

~~REV~~ rjc 9-19-95

REV. 3

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 2

To SUDHIR KALRA	From ZEKE
Co. OMAHA PPD	Co. MC LEAN MIDWEST
Dept.	Phone #
Fax #	Fax #

—

The purpose of this memo is to help explain why air conditioner capacity is reduced as enclosure temperature is reduced, and to provide Marketing with a "rule-of-thumb" as to the extent of the reduction.

As you know, McLean Midwest air conditioners are normally rated at 125 F ambient and 125 F enclosure return air temperatures. Typically, this condition imposes the highest load on the air conditioner. The basic rule to remember is that any reduction in the return air temperature will cause a reduction in the capacity of the air conditioner.

This is because a reduction in the return air temperature requires a reduction in the evaporator coil temperature, which in turn requires a lower suction pressure in the refrigeration system. A lower suction pressure, in turn, reduces the density of the suction gas being pumped by the compressor. Since the pumping capacity of the compressor is fixed by volume, this reduction in suction gas density means that the compressor is pumping less weight of refrigerant, with a corresponding loss in air conditioning capacity.

The loss of capacity with a reduction in suction pressure (or enclosure return air temperature) is extremely rapid. For best capacity performance and operating efficiency, it is important that the air conditioner operate at the highest suction pressure possible.

A decrease in the ambient temperature will result in an increase in air conditioner capacity, due to the reduction of the head pressure. However, this capacity increase is small compared to the loss of capacity due to the decrease in the suction pressure. For this reason, the net result of reducing both the ambient temperature and the enclosure return air temperature by the same amount is a reduction in air conditioning capacity.

EA-90-062

ATTACHMENT 8.18-2
EA-FC-90-062
pjc 9-19-95 ~~REV~~
Page 2 of 2

REV. 3

McLean Midwest Engineering Standard
Eng. Std. No.: 10-3000-07

UNIT CAPACITY MULTIPLIER

(BASE CAPACITY RATED AT 125/125)

Return Air Temp. (°F)	80°	85°	90°	95°	100°	105°	110°	115°	120°	125°
125°										1.00
120°									0.97	0.92
115°							0.98	0.93	0.88	0.83
110°						0.95	0.90	0.85	0.80	0.75
105°				0.97	0.92	0.87	0.82	0.77	0.72	0.67
100°		0.98	0.93	0.88	0.83	0.78	0.73	0.68	0.63	0.58
95°	0.95	0.90	0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.50
90°	0.87	0.82	0.77	0.72	0.67	.062	0.57	0.52	0.47	0.42
85°	0.78	0.73	0.68	0.63	0.58	0.53	0.48	0.43	0.38	0.33
80°	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30	0.25

Ambient Temperature (°F)

EXAMPLE: To determine estimated cooling capacity, multiply catalog cooling capacity by the factor corresponding to actual ambient and return air temperature conditions.

A unit with catalog capacity of 8000 BTU/hr operating at 90°F return air temperature and 100°F ambient will have an estimated cooling capacity of:

8000 BTU/hr x 0.67 = 5360 BTU/hr

PJC 9-19-95
~~REV~~

EA -90-062

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.19

REV. 3

Graph or Air Temperatures for DG-1 on 6/26/90 (2 pages)

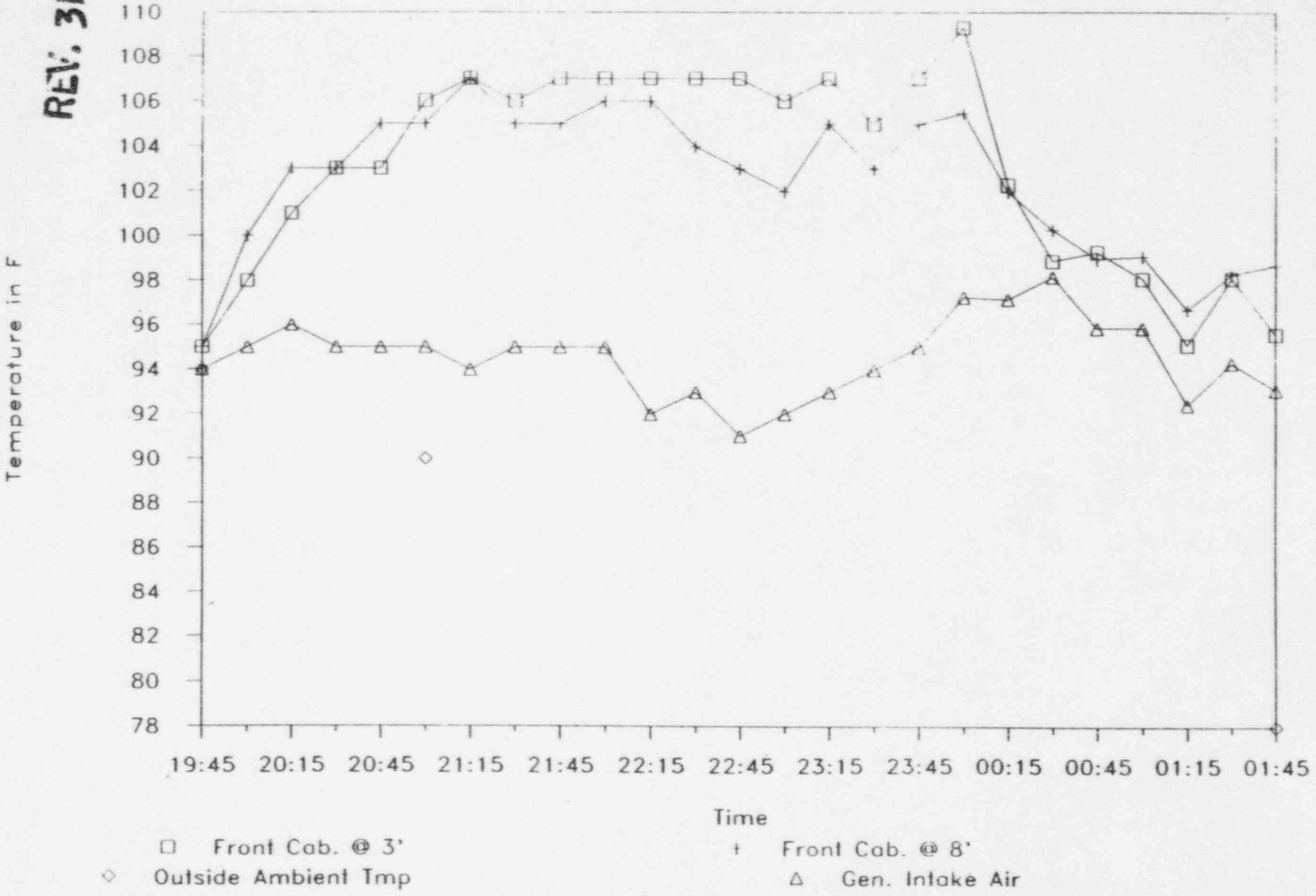
EA-FC-90-062
ATTACHMENT 8.19-1
~~REV~~
Pjc 9-19-95

EA -90-062

REV. 3

DG-1 (6-26-90) MWO OP-ST-DG-0001

Fan: exh(assumed) @19:45, off @00:01



EA-90-062

~~REV~~ 5
Rgc 9-19-95

REV 3

FILE: DIESEL®
This is f[illegible]G-1 (6-26-90) outside cabinet front

Time	3' Logger Point 42	8' Logger Point 46	Outside Ambient	Logger Point 49 Generator Intake
19:45	95.0	95.0	94	94.0
20:00	98.0	100.0		95.0
20:15	101.0	103.0		96.0
20:30	103.0	103.0		95.0
20:45	103.0	105.0		95.0
21:00	106.0	105.0	90	95.0
21:15	107.0	107.0		94.0
21:30	106.0	105.0		95.0
21:45	107.0	105.0		95.0
22:00	107.0	106.0		95.0
22:15	107.0	106.0		92.0
22:30	107.0	104.0		93.0
22:45	107.0	103.0		91.0
23:00	106.0	102.0		92.0
23:15	107.0	105.0		93.0
23:30	105.0	103.0		94.0
23:45	107.0	105.0		95.0
24:00	109.3	105.5		97.3
00:15	102.3	102.0		97.2
00:30	98.9	100.3		98.2
00:45	99.3	99.0		95.9
01:00	98.1	99.1		95.9
01:15	95.1	96.7		92.4
01:30	98.1	98.3		94.3
01:45	95.6	98.7	78	93.1

EA-90-062
~~REV 2~~ pjc
9-19-95

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.20
REV. 3

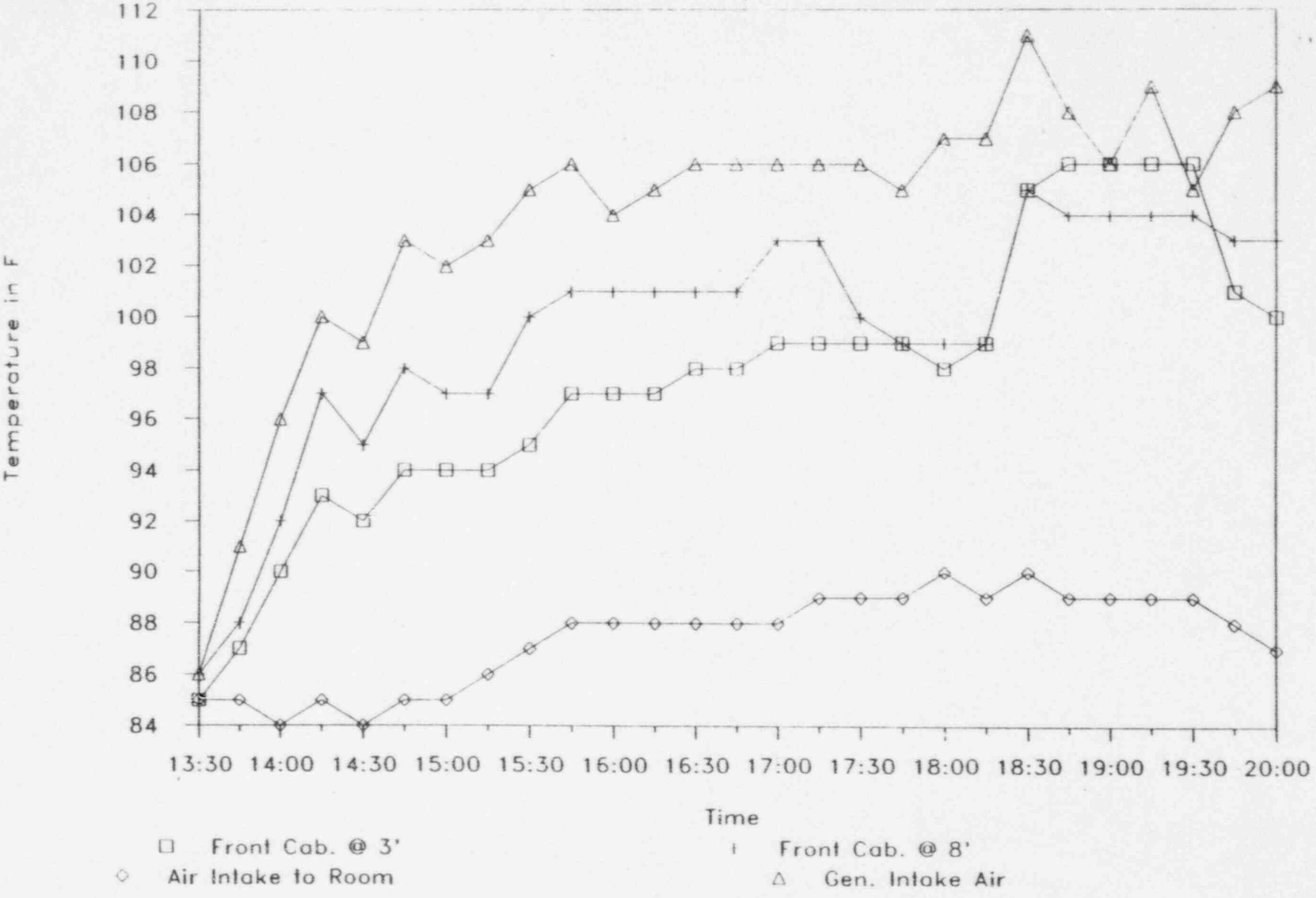
Graph of Air Temperatures for DG-2 on 7/16/90 (2 pages)

EA-FC-90-062
ATTACHMENT 8.20-1

EA-90-062
REV. 3 ~~REV 2~~ pgi 9-19-95

DG-2 (7-16-90) MWO 90 2170

Fan:off@1330,sup@1717,exh@1830,off@1935



EA-90-062

REV. 3 ~~REV~~ Rjc 4-19-95

FILE: DIESEL
This is for DG-2 (7-16-90) outside cabinet front

Time	3' Logger Point 42	8' Logger Point 46	Average Outside Ambient Points 14-19	Logger Point 49 Generator Intake
13:30	85.0	86.0	85	86.0
13:45	87.0	88.0	85	91.0
14:00	90.0	92.0	84	96.0
14:15	93.0	97.0	85	100.0
14:30	92.0	95.0	84	99.0
14:45	94.0	98.0	85	103.0
15:00	94.0	97.0	85	102.0
15:15	94.0	97.0	86	103.0
15:30	95.0	100.0	87	105.0
15:45	97.0	101.0	88	106.0
16:00	97.0	101.0	88	104.0
16:15	97.0	101.0	88	105.0
16:30	98.0	101.0	88	106.0
16:45	98.0	101.0	88	106.0
17:00	99.0	103.0	88	106.0
17:15	99.0	103.0	89	106.0
17:30	99.0	100.0	89	106.0
17:45	99.0	99.0	89	105.0
18:00	98.0	99.0	90	107.0
18:15	99.0	99.0	89	107.0
18:30	105.0	105.0	90	111.0
18:45	106.0	104.0	89	108.0
19:00	106.0	104.0	89	106.0
19:15	106.0	104.0	89	109.0
19:30	106.0	104.0	89	105.0
19:45	101.0	103.0	88	108.0
20:00	100.0	103.0	87	109.0

EA-90-062

Rjf 9-19-95

~~REV 2~~

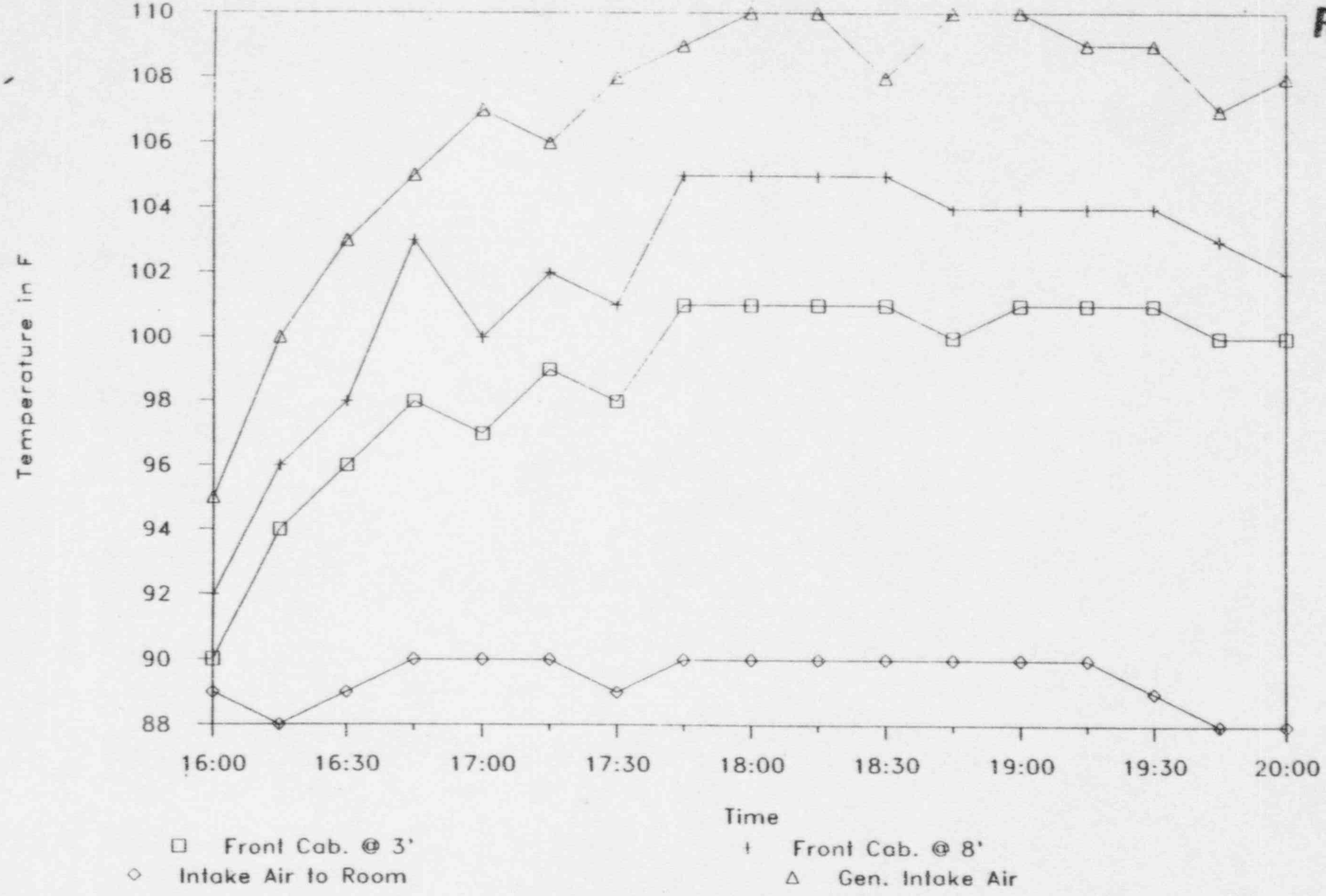
EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.21

REV. 3

Graph of Air Temperatures for DG-2 on 7/17/90 (2 pages)

DG-2 (7-17-90) MWO 90 2110 EA 90-062

Outside Cabinet Front - Fan Off



EA-90-062

~~REV 2~~ pjc
9-14-95

REV. 3

FILE: DIESEL
This is for DG-2 (7-17-90) outside cabinet front

Time	3' Logger Point 42	8' Logger Point 46	Average Outside Ambient Points 14-19	Logger Point 49 Generator Intake
16:00	90.0	92.0	89	95.0
16:15	94.0	96.0	88	100.0
16:30	96.0	98.0	89	103.0
16:45	98.0	103.0	90	105.0
17:00	97.0	100.0	90	107.0
17:15	99.0	102.0	90	106.0
17:30	98.0	101.0	89	108.0
17:45	101.0	105.0	90	109.0
18:00	101.0	105.0	90	110.0
18:15	101.0	105.0	90	110.0
18:30	101.0	105.0	90	108.0
18:45	100.0	104.0	90	110.0
19:00	101.0	104.0	90	110.0
19:15	101.0	104.0	90	109.0
19:30	101.0	104.0	89	109.0
19:45	100.0	103.0	88	107.0
20:00	100.0	102.0	88	108.0

EA-90-062
pjc
9-19-95

EA-FC-90-062
Rev. ~~2~~ 3
Attachment 8.22

REV. 3

Graph of Air Temperatures for DG-1 on 6/25/90 (2 pages)

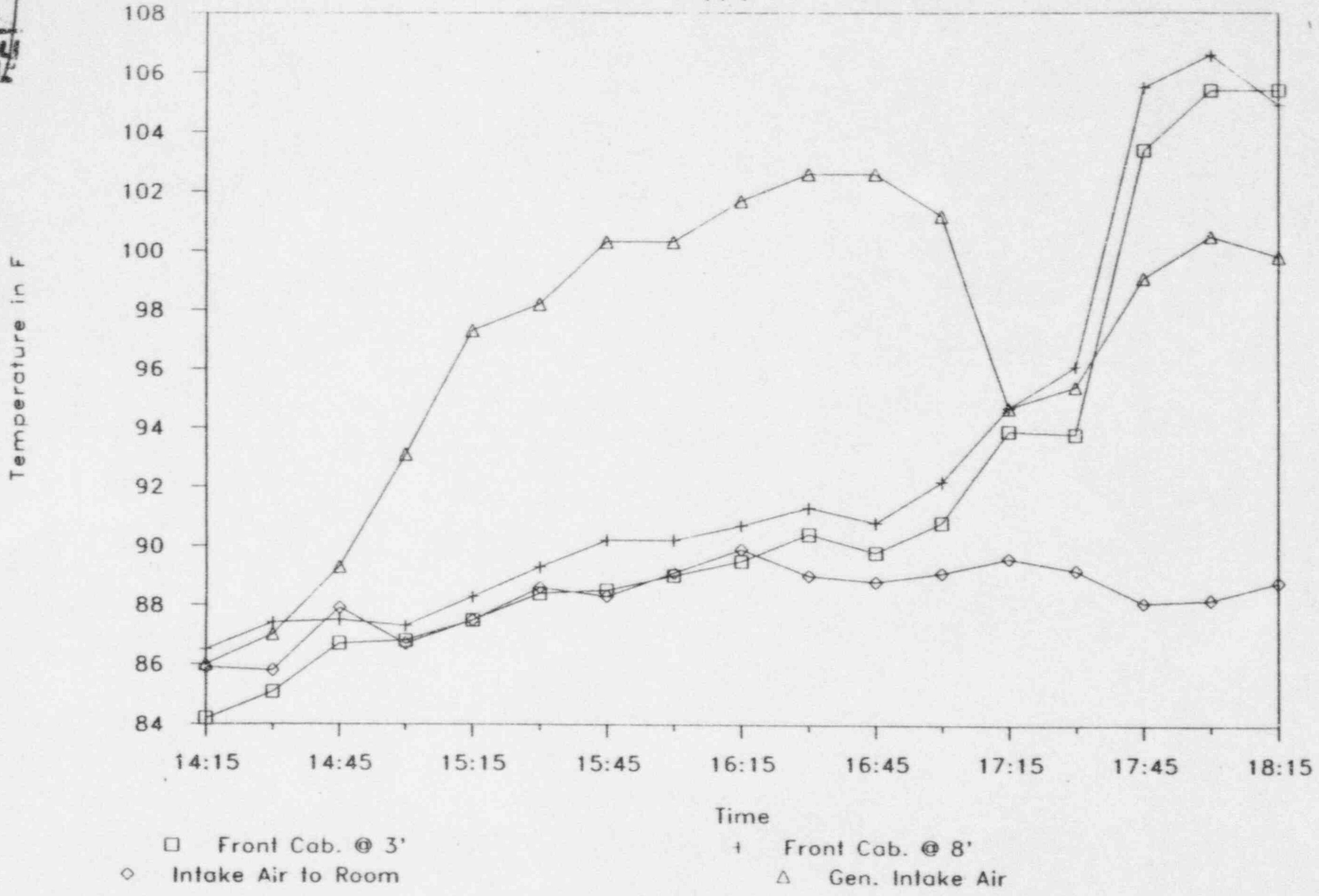
EA -90-062
pej 9-19-95

REV. 3

EA-FC-90-062
ATTACHMENT 8.22-1
~~REV 2~~ pej
9-19-95

DG-1(6-25-90) MWO 90 2171

Fan:off @14:38,supply @17:05,exh @17:41



EA-90-062

~~REV~~ 2 pjc
9-19-95

REV. 3

FILE: DIESEL

This is for DG-1 (6-25-90) outside cabinet front

Time	3' Logger Point 42	8' Logger Point 46	Average Outside Ambient Points 14-19	Logger Point 49 Generator Intake
14:15	84.2	86.5	85.9	86.0
14:30	85.1	87.4	85.8	87.0
14:45	86.7	87.5	87.9	89.3
15:00	86.8	87.3	86.7	93.1
15:15	87.5	88.3	87.5	97.3
15:30	88.4	89.3	88.6	98.2
15:45	88.5	90.2	88.3	100.3
16:00	89.0	90.2	89.1	100.3
16:15	89.5	90.7	89.9	101.7
16:30	90.4	91.3	89.0	102.6
16:45	89.8	90.8	88.8	102.6
17:00	90.8	92.2	89.1	101.2
17:15	93.9	94.7	89.6	94.7
17:30	93.8	96.1	89.2	95.4
17:45	103.4	105.5	88.1	99.1
18:00	105.4	106.6	88.2	100.5
18:15	105.4	104.9	88.8	99.8