EA COVER SHEET

EA-FC-95-027 Rev. No. 0 EA Page No. 1 Total Pages 87

EA TITLE: Diesel Generator Offnormal Loading Due to a Full Speed Start ETP-6.5-DGT

QA CATEGORY:	REPORT TYPE:
[x] CQE [ ] Fire Protection [ ] Non CQE [ ] Limited CQE	[ ] Revision [ ] Analytical Report [x] Special

Does this change require a DBD Revision?	Does this analysis identify any potentially reportable conditions?	Does this change require a USAR Revision?
[ ] YES [x] NO	[ ] YES [x] NO	[ ] YES [x] NO

INITIATION:

Responsible PED Department DEN Electrical/I&C

Responsible Department Head [signature] Date 10/2/95

Preparer R. F. Mehaffey Date 9/22/95

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

PED Department No. 356 Due Date 10/20/95

ENGINEERING ANALYSIS TYPE:

Electrical Equipment Qualification (EEQ)	[ ]	Computer Code Error Analysis (CCE)	[ ]
Seismic Equipment Qualification (SEQ)	[ ]	Nuclear Mat'l Accountability (NMA)	[ ]
Core Reload Analysis (CRA)	[ ]	Operations Support Analysis (OSA)	[x]
Fire Protection Analysis (FPA)	[ ]	USAR Justification (USJ)	[ ]
Cable Separation Analysis (CSA)	[ ]		
Associated Circuits Analysis (ACA)	[ ]		
Safe Shutdown Analysis (SSA)	[ ]		
OTHER: _____	[ ]		

* Only required when independent review authorization is required.

DISTRIBUTION:

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PREPARATION/REVIEW:

Preparer(s) Gary A Bell / R F Mahaffey / 10/2/95
Signature Date

Reviewer(s) REBrad / John C Adam / 10/2/95
Signature Date

Independent Reviewer(s) REBrad / John C Adam / 10/2/95
Signature Date

AFFECTED DOCUMENTS:

Title	Revision	Responsible Division/Dept

AFFECTED SYSTEM/EQUIPMENT:

System	Tag No.(s)
EE	DG-1, DG-2

RECORD OF REVISION	
Rev. No.	Description/Reason for Change
0	Initial Issue

PRODUCTION ENGINEERING DIVISION
QUALITY PROCEDURE FORM

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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?	✓		
7. 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)?			✓

	YES	NO	N/A
14. Is the EA free of unconfirmed references and assumptions?	✓		

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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 Revisions 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 and 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: ____

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[signature] 10/2/95 SWEC

Reviewer(s) Signature / Date Department/Organization

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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?	✓		
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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?	✓		
7. 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)?			✓

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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 Revisions 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.

	YES	NO	N/A
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? See comment on next page	*		

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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: 24. See answer to question 25.
26. This review does not include a detailed review of the implementation of the computer model used to predict plant response.
27. This condition has already been reported via LER 95-06.

John C. Adam, 10/2/95, DEN - Elec / I&C
Reviewer(s) Signature / Date / Department/Organization

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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: ______________________________

John C. Adams / 10/2/95 DEN - Elec / I&C

Independent Reviewer(s) Signature / Date Department/Organization

COMMENT FORM

EA-FC- 95-027 Rev. No. 0 Page No. ____

Reviewer ____ Organization ____ Page ____ of ____

EA Title ____

Date ____

Comment Number	Comment Type Code*	Page	Comment	**	Resolution

COMMENT TYPE CODES*
*Editorial (ED) System Interaction/
*Technical (TC) Design Change (DCC)

RESOLUTION CATEGORY**
1=Resolution Required
2=Nonmandatory Recommendation

TABLE OF CONTENTS

1.0 Purpose

1.1 Event Description From IR 950579

Following a reactor trip at 11:15 August 24, 1995 each diesel started as designed. DG-2 accelerated to the correct idle speed (500 rpm) but DG-1 accelerated to 900 rpm. DG-1 should not have accelerated DG-1 to full speed. The full speed signal generated by low 4160V bus voltage had not actuated. DG-1 was shut down at approximately 11:45. The problem that caused DG-1 to accelerate to full speed was determined to be that the governor was in the full speed position. The governor had been left in the full speed position on a previous test and not returned to the idle speed position.

1.2 Analysis Purpose

This analysis is to assess the ability of DG-1 to accelerate the ESF 4160V and 480V loads in an off normal sequence following a DBA and a subsequent grid degraded voltage. The sequence of events of concern is a DBA (Large Break LOCA) requiring automatic ESF response (Safety Injection Actuation Signal-SIAS and Containment Spray Actuation Signal-CSAS) followed by an Offsite Power Low Signal-OPLS actuation due to a degraded offsite power condition. The OPLS occurs after the final ESF load (VA-7C) on ESF Train A has begun to accelerate to full speed.

If the engine governor is mispositioned, DG-1 can be operating at full speed and reenergizes the 4160V and 480V buses before the 480V Load Center undervoltage time/voltage relays and associated fixed time delay relays have time to initiate the 480V Load Center load shed. The operating 480V Load Center loads would load as DG dead loads (at the time of DG breaker closure.) Dead loads could include both ESF loads and non-safety loads such as an Air Compressor and Condenser Vacuum Pump.

2.0 Scope

The scope of this analysis is to provide a best estimate of the event using a computer model of DG-1 and its associated electrical distribution system to find the affect of the off normal loading sequence. The best estimate model will use the nominal ESF Load Sequencer times (see Attachment 8.1) to determine the affect of the loads on DG-1.

3.0 Inputs/References

3.1 EA-FC-92-072 Diesel Generator Transient Analysis

3.2 EA-FC-93-027 Loss of Voltage IAV Relay Setpoints

3.3 EA-FC-91-142 Calibration Procedure Setpoint Determination in Support of MR-FC-89-013 (480V Load Center Breaker Setpoints and Time vs. Current Curves)

3.4 G.E. Letter E.I. Hersh to Bob Mehaffey 8/15/78 Diesel Generator Exciter

3.5 FC03382 Diesel Generator LOCA Loads Revisions 4 and 8

3.6 OP-ST-ESF-0002 Diesel Generator No. 1 and Diesel Generator No. 2 Auto Operation

3.7 EPRI TR-102814 A Methodology for Determining an EDG's Capability to Start Its Emergency Loads

3.8 EAR94-017 OPLS Relay Timing Accuracy

3.9 Drawings:

161F597 Sheet 8 (9808) ESF Auto Close Circuit
0223RD455 Sheet 10 (9953) DG-1 Breaker Close/Trip Circuit
11405-E-13 Sheet 4 (57238) Bus 1A3 Voltage Relaying
11405-E-18 Sheet 1 (12254) Bus 1B3A, 1B3A-4A Voltage Relaying

3.10 IR 950579 DG-1 Full Speed Start, LER 95 06

3.11 ERF Archival Dump DG-1 Voltage Point Y3257 Reactor Trip at 11:15 August 24, 1995 DG-1 Time to Full Speed Estimate

3.12 IAV and Fixed Delay 4160V and 480V Calibration Procedures (typical)

SP-CP-08-1A3-IAV
SP-CP-08-480-1B3A-4A

3.13 USAR Table 14.15-2 Large Break LOCA Sequence of Events

3.14 SP-CP-08-DEVAR-1A3 OPLS time delay

3.15 Gould Shawmut Amp-trap Fuse Data A25X100

3.16 OP-ST-ESF-0009 Channel "A" Safety Injection, Containment Spray and Recirculation Actuation Signal Test

3.17 DG-1 Auto Operation Plot from EA-FC-92-072

4.0 Assumptions

4.1 This analysis is intended to provide a best estimate of the response of DG-1 to the off normal load sequence. The sequencer timers will be at the nominal setpoint.

4.2 See the Analysis Section 5.0 for specific assumptions.

4.3 MCC contactors drop out on loss of voltage (virtually instantaneously) and are not of concern in this analysis.

5.0 Analysis

5.1 Sequence of Events

An investigation was performed to find which of the sequences of events could result in the Diesel Generator being loaded in an off normal sequence. The sequence of events of concern is a DBA (Large Break LOCA) requiring full ESF response (both Safety Injection and Containment Spray) and a Loss of Offsite Power (LOOP) at some point in time. There are three possible scenarios:

1 Large Break LOCA coincident with a Loss of Offsite Power-the

Diesel Generator governor is mispositioned allowing acceleration to 900 rpm at the maximum rate. See Table 1 Attachment 8.1.

2 Large Break LOCA with a subsequent Loss of Offsite Power-the Diesel Generator governor is mispositioned allowing acceleration to 900 rpm at the maximum rate. See Table 2 Attachment 8.1.

3 Large Break LOCA with a subsequent Degraded Offsite Power-the Diesel Generator governor is mispositioned allowing acceleration to 900 rpm at the maximum rate. See Table 3 Attachment 8.1.

The data in Attachment 8.1 (based on EAR 94-017) was used to find the maximum HPSI flow to the core time. Although the subsequent analysis uses nominal times the data in Attachment 8.1 serves to identify the sequence of events of concern. Attachment 8.1 Table 4 provides the normal response to a LBLOCA coincident with a LOOP where the Diesel Generator goes to idle speed. Table 3 of Attachment 8.1 can be used to find the off normal sequence of events. Attachment 8.7 provides excerpts of the data used in Attachment 8.1.

The off normal sequence (with governor mispositioned) is a LBLOCA where at some point into the DBA when all ESF loads have sequenced on the offsite power, the offsite power Voltage degrades to the OPLS setpoint. After the OPLS time delay the offsite power is tripped, the Diesel Generators given a full speed signal(although already running at 900 rpm), the ESF load sequencers reset, and the 4160V Load Shed initiated.

The design of the ESF associated electrical system requires that if offsite power is lost the 480V Load Centers must remain deenergized for a nominal 2.2 seconds to allow the GE IAV undervoltage time/Voltage relays and associated Agastat fixed time delay relays time to operate. This time delay to deenergize the buses is provided by the time required for the Diesel Generator to accelerate from idle speed to full speed, see Attachment 8.1.

The under Voltage relays trip the 480V Load Centers' rotating loads to both reduce the total load expected on the Diesel Generator (by tripping the non-safety related loads) and allow proper ESF load resequencing on the Diesel Generator. The OPLS setpoint is designed to maintain 90% of rated motor Voltage on the 480V distribution system.

Ninety percent (90%) motor voltage is such that, if the OPLS setpoint were to be reached, the 480V bus Voltage would remain well above the IAV relay operating range. Attachment 8.2 provides a discussion of relay setting and relay curves for the 480V IAV relays.

If DG-1 is operating at full speed, due to engine governor mispositioning, the time to reenergize the electrical distribution system (480V Load Centers and 4160V Bus) is expected to be a nominal one second. The time delays associated with Diesel Breaker closure are 4160V breaker load shed (virtually instantaneous) and a fixed delay of second. The nominal one second is less than the time required for the undervoltage time/Voltage relays and associated fixed time delay relays to initiate the 480V Load Center load shed. Operating 480V Load Center loads would load as DG dead loads. These loads would include both ESF loads and non-safety loads such as an Air Compressor and Condenser Vacuum Pump.

Attachment 8.3 compares the sequence of events for the normal response to a DBA-OPLS-DG ESF loading and the off normal sequence described above. The time delays for the relays are bounding maximum delays (the nominal one second breaker closure delay is bounded by an assumed 2-second delay in the sequence of events). The time for DG acceleration to full speed is taken from test data.

5.2 Diesel Generator Load Model

The off normal load model for DG-1 consists of altering the DG-1 transient analysis model from EA-FC-92-072 to:

1. Have all 480V Load Center ESF Loads start at T=0, the DG breaker closure time. The loads are SI-2A, AC-3A, SI-2C, CH-1A, AC-3C, VA-3A, SI-3A, and VA-7C.

2. Model air compressor CA-1A and Condenser Vacuum Pump FW-8A

as starting at T=0. This model depicts the plant for most of the eight days of concern. See Attachment 8.4 for the operating data.

The DG-1 transient analysis model from EA-FC-92-072 is considered conservative. The data from diesel generator load calculation FC03382 shows a load reduction from revision 5 used as the basis for EA-FC-92-72 to the present expected loading as determined in Revision 8. The model used for this analysis has not been revised to reduce the DG loading.

The model and analysis was performed using Electrical Transient Analyzer Program (ETAP). ETAP is a Personal Computer based application developed and sold by Operations Technology, Inc. of Irivine. CA. ETAP version 6.5, serial no. 920MAHAPPD licensed to Omaha Public Power District was used. The program was run on an Intel 486DX processor using Microsoft Corp. MS-DOS version 6.00 operating system.

5.3 Computer Model Result

5.3.1 Initial Model

The initial computer model run was as described in Section 5.2. See Attachment 8.5 for the computer model time versus Voltage plots.

480V Load Center bus voltage plots show that the 480V bus Voltage does not recover in sufficient time to prevent the operation of the 480V Load Center load shed. The off normal starting sequence model must be further refined to account for operation of the 480V Load Centers' load shed relays.

5.3.2 Revised Model

The sequence of events is defined in Attachment 8.3 Table 2. The 480V Load Center load shed occurs approximately 1.2 seconds after DG Breaker closure. Bus voltage decay may increase this time delay a small percentage. The 480V bus voltages do not recover to a point high enough to pick up the IAV relays. See Attachment 8.2 for additional discussion on the IAV relays.

The 1.2 seconds is based on total time for the IAV relay to operate on loss of voltage (1.2 seconds) and the nominal fixed time delay of one second less the nominal DG output breaker closure delay time of one second. Any additional time required for voltage decay and relay time uncertainty is accounted for by the difference in the 1.2 seconds after output breaker closure and the first load group breaker closure time. From the timer surveillance data of 9/28/95 the earliest load group 1 breaker closure occurs at 2.8 second, see Attachment 8.7. This allows approximately 1.6 second margin for uncertainties while keeping the model valid. During the 1.6 second margin, time the 480V Bus voltage remains low assuring a 480V Load Center load shed. Data from the ESF DG Auto Operation refueling surveillance test indicates bus voltage decay is complete in 0.5 seconds however IAV relay operation begins in approximately 0.1 seconds, see Attachment 8.7 for the DG-1 test data. The voltage decay time is not considered significant. The model is considered valid for the eight days in question.

Each ESF breaker circuit is equipped with an undervoltage load shed bypass from the sequencer circuit. The undervoltage load shed would be removed at the time the sequencer closes the breaker (B relay contacts are used from the same relay that closes the breaker.) This circuit normally prevents breaker tripping from possible 480V bus Voltage transients during ESF motor starting. The bypass circuit will also serve to prevent a trip free condition in the event the bus Voltage has not cleared the IAV 480V Load Center Load Shed signal.

The computer model was revised from that described in Section 5.2 by making the following changes:

1. Circuit breakers were placed between each 480 Volt motor and the bus that feeds them.

2. At t=1.2 seconds after generator breaker closure, all of the 480 Volt loads are disconnected from their respective 480 Volt busses.

3. The breaker for each 480 Volt ESF motor is then closed at the normal load sequence time.

The ETAP software has limits to the number of switching events that can be simulated with it's Dynamic Stability module. This limit allows simulation of 18 seconds of the event after generator breaker closure.

5.4 Revised Model Results

The ETAP model results show that DG-1 would start and successfully operate the ESF 4160V and 480V loads associated with ESF Train A. Bus voltages would be depressed at generator breaker closure causing the 480 volt busses to trip on undervoltage. The sequenced ESF loads would then start at their normal time.

Plots of generator, bus and motor parameters were compared to the results of the original study, EA-FC-92-072. The comparison shows that after the 480 Volt motors are shed at 1.2 seconds after generator breaker closure, all of the parameters match the original study from 3 seconds (first load sequence time) to 18 seconds where the analysis ends.

5.4.1 Affect on ESF Motor Acceleration Time

The 480V Load Center and 4160V ESF motor acceleration times remain the same as those analyzed in EA-FC-92-072. Motor Operated Valves modeled in EA-FC-92-072 have already been opened by the offsite power. The initial low Voltage on the buses is not a factor for the MOV's.

Concentrated boric acid pump CH-4A and the Control Room HVAC unit are the remaining significant dead loads. Their start is delayed by 1.2 seconds. The delay is not considered critical.

The concentrated boric acid pump is use to supply the suction of Charging Pumps. The first Charging Pump sequences on at the second load group (8 seconds) allowing adequate time for the boric acid pumps to accelerate. There is also available a gravity feed independent of the boric acid pumps.

The 1.2 second delay in Control Room HVAC is not expected to result in any significant Control Room heat up. The Control Room's pressure is not expected to change significantly, as such, in leakage of radioactive gases is not expected.

The off normal sequence of events begins reloading the ESF equipment approximately 8 seconds earlier than the normal sequence. The off normal sequence does not have the 8 second idle to full speed acceleration time.

5.4.2 Motor Current Transients

Motor transient currents during the 1.2 seconds following the DG-1 breaker closure are not high and would not trip the supply breaker. Motor starting currents are proportional to motor terminal voltage. The motor voltages are low, reducing the motor current well below locked rotor current.

5.4.3 Motor Starts - Thermal Damage

The off normal sequence of events would have exposed the motors to one additional start. This start would have occurred on initial DG-1 Breaker closure. This "start" is of short duration, approximately 1.2 seconds. The additional start is truncated when the 480V Load Center IAV relay load shed occurs. Motor terminal voltage during this start is low (typically less than 50% Voltage. The reduced motor terminal voltage reduces motor starting current, minimizing motor winding heating. Motors would not have been expected to be damaged by this additional start attempt.

5.4.4 Affects on the Diesel Generator Exciter

The Diesel Generator Exciter is rated for 149 amps @ 175V operation for 1 minute. The demand placed on the exciter during the 1.2 seconds before the 480V Load Center load shed actuation is not expected to damage the exciter. In the off normal sequence, neither the magnitude, or the duration excitation voltage peaks are more severe than normal sequence starting transients during the initial 1.2 seconds after generator breaker closure.

The exciter is equipped with a field current forcing circuit that allows higher exciter output for motor starting and faulted conditions. The field current forcing adds a self excitation current to the normal solid state exciter output when the generator terminal voltage is low. The field forcing component is additive to the normal exciter output and is added after the exciter protective fuses. The exciter goes to maximum output plus current forcing on the normal sequencing of the ESF loads. In the off normal sequence, neither the magnitude, or the duration excitation voltage peaks are more severe than normal sequence starting transients during the initial 1.2 seconds after generator breaker closure. Note: The DG-1 generator over current protection is bypassed in an emergency start, as such a generator output breaker trip is not expected.

5.4.5 Affects on the Generator

The affect on the Generator is I^2t (current squared time) heating caused by the additional 1.2 second off normal transient. This heating is not considered significant because of its short duration (from Attachment 8.6 the field current that drives the generator current is well below the the first load group field current.) The worst case winding mechanical stresses are a result of the magnetic stress of a bolted fault on the on the generator terminals. The bolted fault is more severe than the load impedance current limiting off normal load case.

5.4.6 Diesel Engine Mechanical Loading

Mechanical loading of the engine at the time of generator breaker closure is minimal due to the low output voltage. Motor torque decreases with the inverse of the motor voltage squared which keeps the engine loading minimal for the initial 1.2 seconds.

5.5 Model Conservatism

The ESF system associated with DG-1 has in it certain conservatism's. The conservatism ensures that the results of the DG-1 load model are correct.

The DG-1 model includes the operation of the motor operated valves that are automatically repositioned in a DBA. These valves would have already been repositioned on offsite power before the initiation of OPLS. The loads would not be present on DG-1.

5.6 ETAP Computer Program Verification

The ETAP computer program is a commercial program. Its adequacy for use in a Safety Related analysis is verified by its use in a test case. This test case consists of a comparison of the results of an ETAP transient load calculation of the FCS ESF system as it operates in the refueling outage AUTO Operation surveillance test with the actual data recorded during that test. The results of this comparison are contained in EA-FC-92-072 Diesel Generator Transient Analysis. Results of this verification show that ETAP provides conservative results.

In addition to the FCS model verification the program has also been verified in EPRI TR-102814.

Electrical equivalent circuits for the compressor and vacuum pump motors were determined using the ETAP parameter estimation module. This same module was used and validated by EA-FC-92-072.

ETAP standard speed-torque characteristics for the air compressor and the vacuum pump were used to model the driven equipment. The air compressor was modeled as a reciprocating compressor. The vacuum pump is modeled as a centrifugal compressor.

6.0 Results and Conclusions

DG-1 and the ESF equipment supplied by DG-1 were operable during time when the DG-1 governor was positioned at the full speed setting.

7.0 Design Basis and/or Licensing Basis Changes

This analysis is for an off normal condition. The event was reported to the NRC in LER 95 06. There is no change to the Design or Licensing Basis because of this analysis.

8.0 List of Attachments

8.1 DBA Sequence of Events to Define Off Normal Sequence

Table 1 LBLOCA Coincident LOOP DG Governor Set at 900 RPM

Table 2 LBLOCA followed by OPLS Due to a Loss of Offsite Power Actuated during HPSI Start DG Governor Set at 900 RPM

Table 3 LBLOCA followed by OPLS Actuated during HPSI Start DG Governor Set at 900 RPM

Table 4 LBLOCA Coincident LOOP

8.2 480V IAV Relays Setting and Voltage vs Time Curve

8.3 Sequence of Events for:

Table 1 Expected Normal Response to a DBA-OPLS-DG ESF Loading

Table 2 Off Normal Response Sequence Loading including expected 480V Load Center Load Shed

Table 3 Comparison of the Sequence of Events for the Expected Response and the Off Normal Response Sequence Loading

8.4 Equipment Operating Data

8.5 Computer Model Results All - ESF Equipment, CA-1A and FW-8A Starting

8.6 Computer Model Results ESF Equipment 480V Load Shed After DG Breaker Closure

8.7 Miscellaneous Input Data

OP-ST-ESF-0002 Diesel Generator No. 1 and Diesel Generator No. 2 Auto Operation Excerpt

ERF Archival Dump DG-1 Voltage Point Y3257 Reactor Trip at 11:15 August 24, 1995 DG-1 Time to Full Speed Estimate

IAV and Fixed Delay 4160V and 480V Calibration Procedures (typical) Excerpts

SP-CP-08-1A3-IAV
SP-CP-08-480-1B3A-4A

USAR Table 14.15-2 Large Break LOCA Sequence of Events

SP-CP-08-DEVAR-1A3 OPLS time delay Excerpt

Gould Shawmut Amp-trap Fuse Data A25X100

OP-ST-ESF-0009 Channel "A" Safety Injection, Containment Spray and Recirculation Actuation Signal Test

DG-1 Auto Operation Plot from EA-FC-92-072

8.8 G.E. Letter E.I. Hersh to Bob Mehaffey 8/15/78 Diesel Generator Exciter

Attachment 8.1

DBA Sequence of Events to Define Off Normal Sequence

Table 1 LBLOCA Coincident LOOP DG Governor Set at 900 RPM

Table 2 LBLOCA followed by OPLS Due to a Loss of Offsite Power Actuated during HPSI Start DG Governor Set at 900 RPM

Table 3 LBLOCA followed by OPLS Actuated during HPSI Start DG Governor Set at 900 RPM

Table 4 LBLOCA Coincident LOOP

Table 1 Off Normal Respnse Time Line to Deliver HPSI Water to the Core to Meet USAR Section 14-15 Assumptions Time Delays Maximized		
LBLOCA Coincident LOOP **DG Governor Set at 900 RPM**		
Time Into Event LBLOCA Coincident LOOP	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec.
T=2 sec.	SIAS Actuates-LOOP Assumed Here	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start to Full Speed	SIAS Assume for DG Start
T=5.15 sec.	480V Load Shed	IAV UV 1.6 sec+1.05 sec. fixed delay (cal data)+0.5 decay (assumed original design)
T=6.16 sec.	4160V Load Shed	IAV UV 1.6 sec+2.06 sec. fixed delay (cal data)+0.5 decay (assumed original design)
T=10.2 sec.	DG's Accelerate to Full Speed	Governor Left at full speed 8.2 sec from 8/24/95 data
T=12.2 sec.	DG's Breakers Close	2 sec bounds AC-XX relay, 1 sec setpoint from 161F597 sh. 8
T=15.7 sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec. (test max limit)
T=18.7 sec.	HPSI Pump Accelerates	3 sec Based on Test and Calc Data
T=20.7 sec.	HPSI Pipe Fill-HPSI to Core Begins	Expected ECCS Performance
T=31.57 sec.	**HPSI Required Delivery to the Core**	**USAR Table 14.15-2**

Table 2 Off Normal Respnse Time Line to Deliver HPSI Water to the Core to Meet USAR Section 14-15 Assumptions Time Delays Maximized		
LBLOCA followed by OPLS Due to a Loss of Offsite Power Actuated during HPSI Start **DG Governor Set at 900 RPM**		
Time Into Event LBLOCA followed by LOOP during HPSI Start	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start to Full Speed	SIAS Assume for DG Start
T=5.5 sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec. (test max limit)
T=5.5 sec.	Offsite Power Lost	Assumption for worst case HPSI Delay
T=7.1 Sec.	DG Full Speed Signal Loss of Voltage	IAV Loss of Voltage 2.1 sec (1.6 relay on 95% curve+0.5 voltage decay)
T=8.65 sec.	480V Load Shed	IAV UV 1.6 sec + 1.05 sec. fixed delay + 0.5 sec voltage decay
T=9.66 sec.	4160V Load Shed	IAV UV 1.6 sec+2.06 sec. fixed delay (cal data)+0.5 decay (assumed original design)
T=10.2 sec.	DG's Accelerate to Full Speed	Governor Left at full speed 8.2 sec from 8/24/95 data
T=11.5 sec. (6 sec. delay)	OPLS Duplicates DG full speed Start and 4160V Load Shed	6 sec. used to bound OPLS Relays max delay of 4.75 sec
T=12.2 Sec.	DG's Breakers Close	2 sec bounds AC-XX relay, 1 sec setpoint
T=15.7 Sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec. (test max limit)
T=19 Sec.	HPSI Pump Accelerates	Based on Test and Calc Data 3 Sec
T=21 Sec.	HPSI Pipe Fill-HPSI to Core Begins	Expected ECCS Performance
T=31.57 sec.	**HPSI Required Delivery to the Core**	**USAR Table 14.15-2**

Table 3 Off Normal Respnse Time Line to Deliver HPSI Water to the Core to Meet USAR Section 14-15 Assumptions Time Delays Maximized		
LBLOCA followed by OPLS Actuated during HPSI Start **DG Governor Set at 900 RPM**		
Time Into Event LBLOCA followed by OPLS Actuated during HPSI Start	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start to Full Speed	SIAS Assume for DG Start
T=5.5 sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec. (test max limit)
T=5.5 sec.	OPLS Setpoint Reached Relay begins to time out	Assumption for worst case HPSI Delay
T=10.2 sec.	DG's Accelerate to Full Speed	Governor Left at full speed 8.2 sec from 8/24/95 data
T=11.5 sec. (6 sec. delay)	OPLS Actuation - 4160V Load Shed	6 sec. used to bound OPLS Relays max delay of 4.75 sec
T=13.5 Sec.	DG's Breakers Close	2 sec bounds AC-XX relay, 1 sec setpoint
T=14.65 sec.	480V Load Shed	IAV UV 1.6 sec + 1.05 sec. fixed delay + 0.5 sec voltage decay
T=19.5 Sec.	DG's Accelerate to Full Speed	8 sec. from OPLS used from ESF Testing
T=21.5 Sec.	DG's Breakers Close	2 sec bounds AC-XX relay, 1 sec setpoint
T=25 Sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec (test max limit)
T=28 Sec.	HPSI Pump Accelerates	Based on Test and Calc Data
T=30 Sec.	HPSI Pipe Fill-HPSI to Core Begins	Expected ECCS Performance
T=31.57 sec.	**HPSI Required Delivery to the Core**	**USAR Table 14.15-2**

Table 4 Normal Response Time Line to Deliver HPSI Water to the Core to Meet USAR Section 14-15 Assumptions Time Delays Maximized		
LBLOCA Coincident LOOP		
Time Into Event LBLOCA Coincident LOOP	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec.
T=2 sec.	SIAS Actuates-LOOP Assumed Here	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start	SIAS Assume for DG Start
T=4.1 Sec.	DG Full Speed Signal Loss of Voltage	IAV Loss of Voltage 2.1 sec (1.6 relay on 95% curve+0.5 voltage decay)
T=5.15 sec.	480V Load Shed	IAV UV 1.6 sec+1.05 sec. fixed delay (cal data)+0.5 decay (assumed original design)
T=6.16 sec.	4160V Load Shed	IAV UV 1.6 sec+2.06 sec. fixed delay (cal data)+0.5 decay (assumed original design)
T=12 sec.	DG's Accelerate to Full Speed	10 Second Start Ready to Load at Voltage based on surviellance criteria
T=14 sec.	DG's Breakers Close	2 sec bounds AC-XX relay, 1 sec setpoint from 161F597 sh. 8
T=17.5 sec.	HPSI Breaker Closes	First Load Group Sequencer Time Delay 3.5 sec. (test max limit)
T=20.5 sec.	HPSI Pump Accelerates	Based on Test and Calc Data
T=22.5 sec.	HPSI Pipe Fill-HPSI to Core Begins	Expected ECCS Performance
T=31.57 sec.	**HPSI Required Delivery to the Core**	**USAR Table 14.15-2**

Attachment 8.2

480V IAV Relays Setting and Voltage vs Time Curve

IAV Relay Setting Evaluation

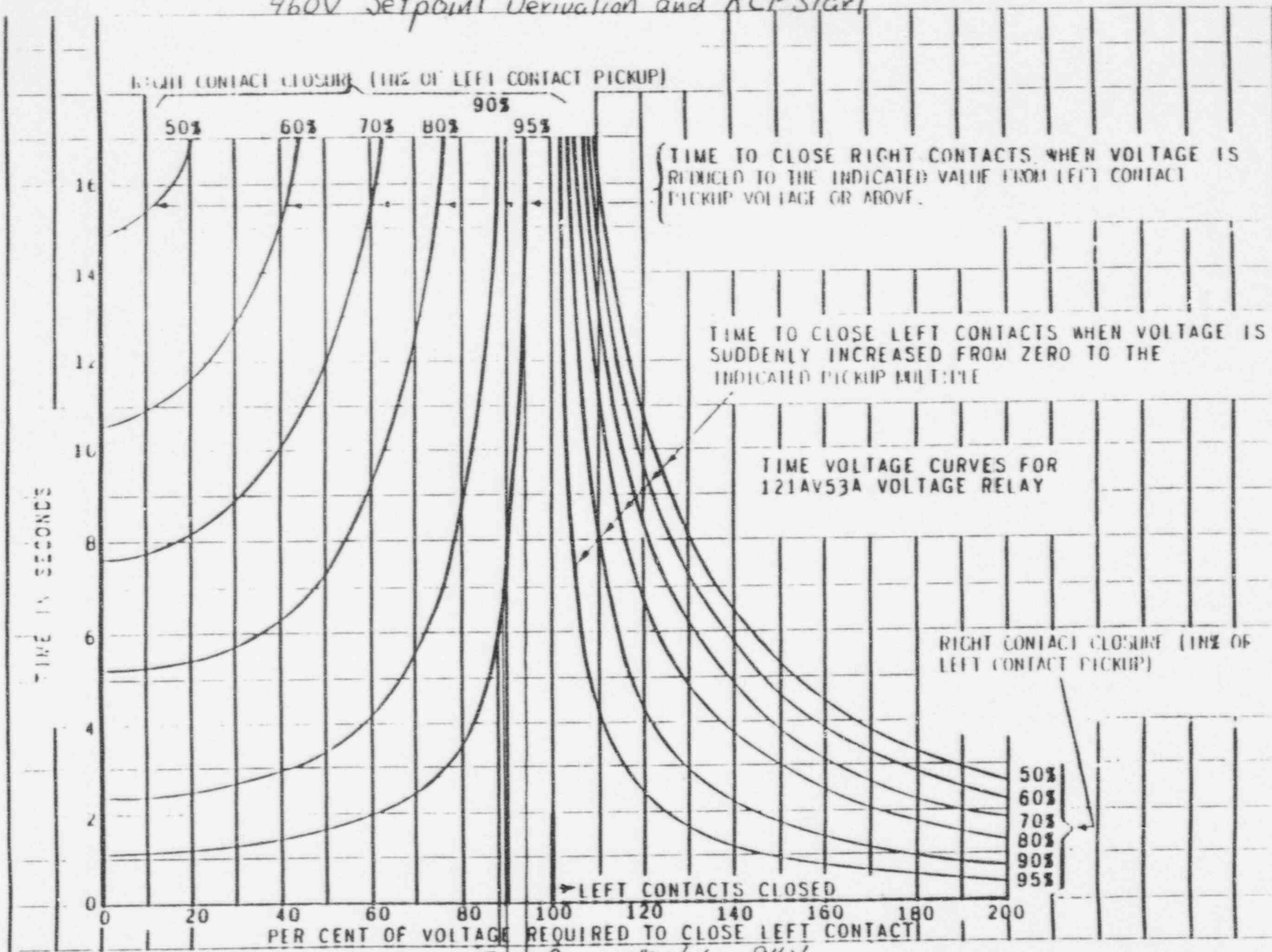
The basis for the IAV Undervoltage Relay settings are provided in EA-FC-93-027 Loss of Voltage IAV Relay Setpoints. The IAV relay setpoints are designed to prevent motor winding accelerated aging damage in the event of low bus voltage. Low bus voltages will cause high motor currents.

To determine the IAV trip time the actual bus voltage must be scaled to the IAV relay 100% voltage setpoint. This is accomplished through a series of steps to scale 480V bus voltage to Percent Voltage Required to Close the Right Contact. The IAV right contact is the undervoltage contact used at FCS for equipment protection. The left contact is the overvoltage contact use at FCS for annunciation.

The 480V bus voltage is first divided by the potential transformer ratio to obtain the IAV relay input voltage. The 480V load center PT ratio is 480V to 120V or 4 to 1. The IAV input voltage is then divided by the 100% IAV voltage setpoint. From EA-FC-93-027 the setpoint selected is 94 volts. At this voltage the IAV relay will not trip. After the percent IAV relay voltage is found the relay curve (next page) is used to determine the trip time. The FCS relays are adjusted to their most sensitive curve setting of 95%. On a total loss of voltage the relay will trip in 1.2 seconds (bounding value.) The second curve attached to this discussion provides a direct relation of IAV relay trip time plus the 1 second fixed Agastat relay to the 480V bus voltage in percent of 480V.

The relay trip curves are only valid for decreasing voltage. In the case where voltage is increasing as the Diesel Generator energizes the bus, the relay resets only after the voltage has increase above the nominal 100% level.

460V Setpoint Derivation and RCP Start



72% of 460V trip at 5.9 Sec
PT Ratio 4:1, 88% on IAV Scale
84V Check Point is 89.4% in 6.9 Sec

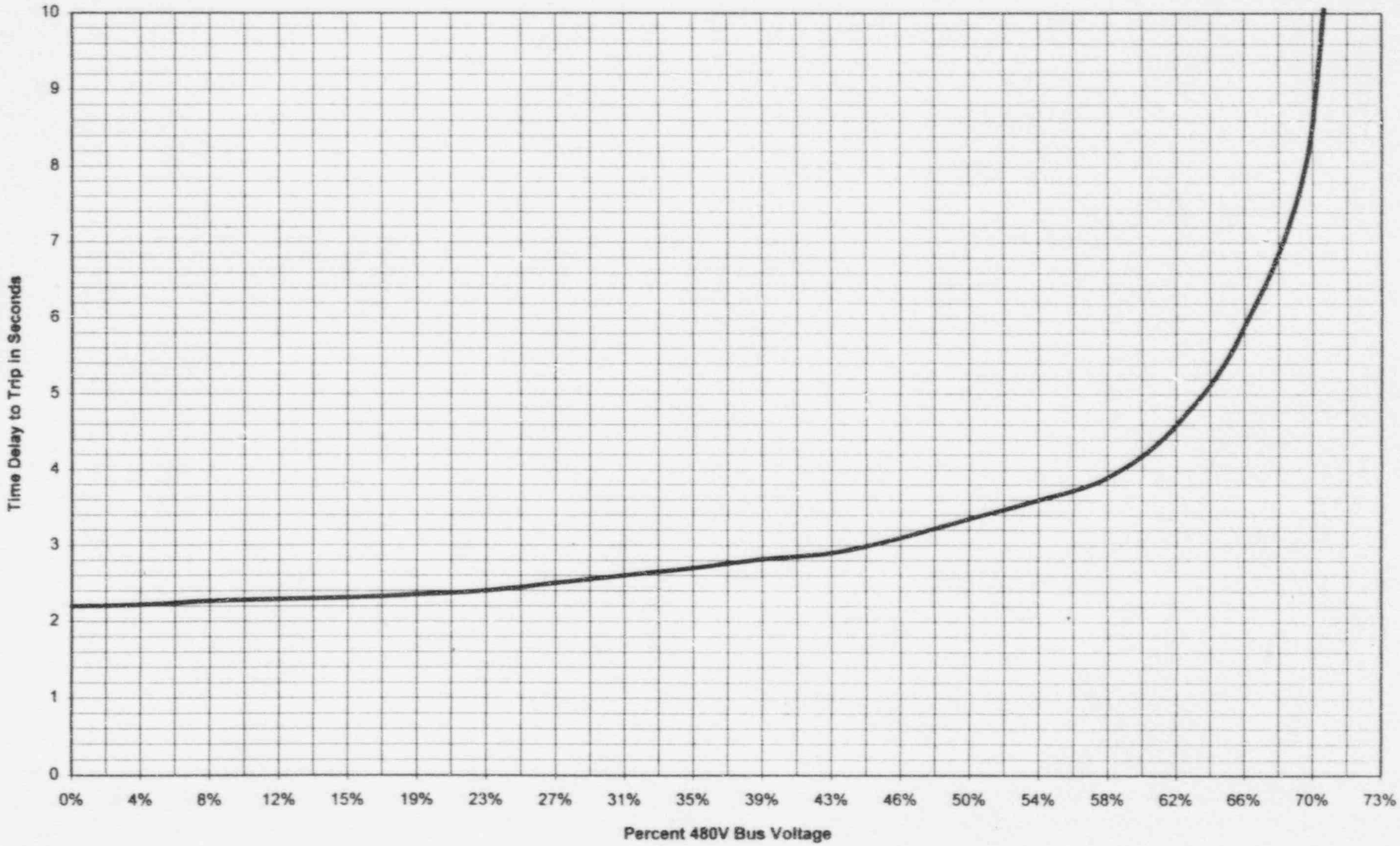
100% Value 94V
15 sec RCP Start Check Point 14% of scale or 88.36V on 353.4V or 76.8% of 460V

* Figure 13 (K-6306849-4) Time Voltage Curves for Type-IAV53A, -IAV53B, -IAV53K, and -IAV53L Relays (± 15% Tolerance)

* Revised since last issue

EA-FC-92-027, R0, pg 77

IAV Relay 95% Curve Plus Fixed Time Delay



Attachment 8.3

Sequence of Events for:

Table 1 Expected Normal Response to a DBA-OPLS-DG ESF Loading

Table 2 Off Normal Response Sequence Loading including expected 480V Load Center Load Shed

Table 3 Comparison of the Sequence of Events for the Expected Response and the Off Normal Response Sequence Loading

Table 1 EA-FC-95-027 Diesel Generator Offnormal Loading Due to a Full Speed Start		
Expected ResponseTime Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal		
LBLOCA followed by OPLS Actuation During VA-7C Start		
Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start	SIAS Assume for DG Start
T=5 sec.	DG's Accelerate to Idle 3 sec	estimation-not a critical value
T=5.0 sec. to T=48 sec. ESF Loads sequence on offsite power	Load Group 1, 3 sec. SI-!A, AC-10A, SI-2A, AC-3A Load Group 2, 8 sec. SI-2C, CH-1A, AC-3C Load Group 3, 18 sec. AC-10C, VA 3A, Load Group 4, 31 sec. FW-6, SI-3A, Load Group 5, 48 sec. VA-7C	Nominal Load Group Times from OP-ST-ESF-0002
T=50 sec.	OPLS Setpoint Reached Relay begins to time out	Assumption for After Start of the Last ESF Load VA-7C
T=54.5 sec. (4.5 sec. delay)	OPLS Actuation-DG Full Speed Signal, 4160V Load Shed	OPLS Relays calibration setpoint
T=56.7 sec.	480V Load Shed	IAV UV 1.2 sec + 1 sec. fixed delay =2.2 sec.
T=62.5 Sec.	DG's Accelerate to Full Speed	8 sec. from OPLS used from ESF Testing
T=63.5 Sec.	DG's Breakers Close	AC-XX relay, 1 sec setpoint
T=63.5 sec.	First Load Group Sequencers Operate	3.0 sec. maximum time delay
T=71.5 Sec.	Second Load Group Sequencers Operate	8 sec. nominal maximum time delay
T=81.5 Sec.	Third Load Group Sequencers Operate	18 sec. nominal time delay
T=94.5 Sec.	Fourth Load Group Sequencers Operate	31 sec. nominal time delay
T=111.5 Sec.	Fifth Load Group Sequencers Operate	48 sec. nominal time delay

Table 2 EA-FC-95-027 Diesel Generator Offnormal Loading Due to a Full Speed Start		
Off Normal Response Time Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal		
LBLOCA followed by OPLS Actuation During VA-7C Start **DG Governor Set at 900 RPM**		
Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start	SIAS Assume for DG Start
T=5.0 sec. to T=48 sec. ESF Loads sequence on offsite power	Load Group 1, 3 sec. SI-1A, AC-10A, SI-2A, AC-3A Load Group 2, 8 sec. SI-2C, CH-1A, AC-3C Load Group 3, 18 sec. AC-10C, VA 3A, Load Group 4, 31 sec. FW-6, SI-3A, Load Group 5, 48 sec. VA-7C	Nominal Load Group Times from OP-ST-ESF-0002
T=10.2 sec.	DG's Accelerate to Full Speed	Governor Left at full speed 8.2 sec from 8/24/95 data
T=50 sec.	OPLS Setpoint Reached Relay begins to time out	Assumption for After Start of the Last ESF Load VA-7C
T=54.5 sec. (4.5 sec. delay)	OPLS Actuation - 4160V Load Shed	OPLS Relays calibration setpoint
T=55.5 Sec.	DG's Breakers Close	AC-XX relay, 1 sec setpoint
T=56.7 sec.	480V Load Shed	IAV UV 1.2 sec + 1 sec. fixed delay =2.2 sec.
T=58.5 sec.	Load Group 1, 3 sec. SI-1A, AC-10A, SI-2A, AC-3A	3.0 sec. maximum time delay
T=63.5 Sec.	Load Group 2, 8 sec. SI-2C, CH-1A, AC-3C	8 sec. nominal maximum time delay
T=73.5 Sec.	Load Group 3, 18 sec. AC-10C, VA-3A	18 sec. nominal time delay
T=86.5 Sec.	Load Group 4, 31 sec. FW-6, SI-3A	31 sec. nominal time delay
T=103.5 Sec.	Load Group 5, 48 sec. VA-7C	48 sec. nominal time delay
off normal		

Table 3 EA-FC-95-027 Diesel Generator Offnormal Loading Due to a Full Speed Start

Expected ResponseTime Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal

LBLOCA followed by OPLS Actuation During VA-7C Start

Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start	SIAS Assume for DG Start
T=5 sec.	DG's Accelerate to Idle 3 sec	estimation-not a critical value
T=5.0 sec. to T=48 sec. ESF Loads sequence on offsite power	Load Group 1, 3 sec. SI-1A, AC-10A, SI-2A, AC-3A Load Group 2, 8 sec. SI-2C, CH-1A, AC-3C Load Group 3, 18 sec. AC-10C, VA-3A, Load Group 4, 31 sec. FW-6, SI-3A, Load Group 5, 48 sec. VA-7C	Nominal Load Group Times from OP-ST-ESF-0002
T=50 sec.	OPLS Setpoint Reached Relay begins to time out	Assumption for After Start of the Last ESF Load VA-7C
T=54.5 sec. (4.5 sec. delay)	OPLS Actuation-DG Full Speed Signal, 4160V Load Shed	OPLS Relays calibration setpoint
T=56.7 sec.	480V Load Shed	IAV UV 1.2 sec + 1 sec. fixed delay =2.2 sec.
T=62.5 Sec.	DG's Accelerate to Full Speed	8 sec. from OPLS used from ESF Testing

Off Normal Response Time Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal

LBLOCA followed by OPLS Actuation During VA-7C Start DG Governor Set at 900 RPM

Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=0 sec.	Event Starts	Large Break LOCA
T=1 sec.	SIAS Setpoint Reached	RCS Depresurizes 1 sec. (USAR .6 sec.)
T=2 sec.	SIAS Actuates	Relay Actuation Delay 1 sec. (USAR delay from LOCA 0.97 sec.)
T=2 Sec.	DG's Start	SIAS Assume for DG Start
T=5.0 sec. to T=48 sec. ESF Loads sequence on offsite power	Load Group 1, 3 sec. SI-1A, AC-10A, SI-2A, AC-3A Load Group 2, 8 sec. SI-2C, CH-1A, AC-3C Load Group 3, 18 sec. AC-10C, VA-3A, Load Group 4, 31 sec. FW-6, SI-3A, Load Group 5, 48 sec. VA-7C	Nominal Load Group Times from OP-ST-ESF-0002
T=10.2 sec.	DG's Accelerate to Full Speed	Governor Left at full speed 8.2 sec from 8/24/95 data
T=50 sec.	OPLS Setpoint Reached Relay begins to time out	Assumption for After Start of the Last ESF Load VA-7C
T=54.5 sec. (4.5 sec. delay)	OPLS Actuation - 4160V Load Shed	OPLS Relays calibration setpoint
T=55.5 Sec.	DG's Breakers Close	AC-XX relay, 1 sec setpoint
T=56.7 sec.	480V Load Shed	IAV UV 1.2 sec + 1 sec. fixed delay =2.2 sec.
T=58.5 sec.	First Load Group Sequencers Operate	3.0 sec. maximum time delay

Table 3 EA-FC-95-027 Diesel Generator Offnormal Loading Due to a Full Speed Start

Expected ResponseTime Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal		
LBLOCA followed by OPLS Actuation During VA-7C Start		
Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=63.5 Sec.	DG's Breakers Close	AC-XX relay, 1 sec setpoint
T=63.5 sec.	First Load Group Sequencers Operate	3.0 sec. maximum time delay
T=71.5 Sec.	Second Load Group Sequencers Operate	8 sec. nominal maximum time delay
T=81.5 Sec.	Third Load Group Sequencers Operate	18 sec. nominal time delay
T=94.5 Sec.	Fourth Load Group Sequencers Operate	31 sec. nominal time delay
T=111.5 Sec.	Fifth Load Group Sequencers Operate	48 sec. nominal time delay
	Not Applicable Times	

Off Normal Response Time Line to Have Full ESF in Operation Maximizing DG-1 Load, Time Delays Nominal		
LBLOCA followed by OPLS Actuation During VA-7C Start **DG Governor Set at 900 RPM**		
Time Into Event - LBLOCA followed by OPLS Actuation	Description	Discussion of Data
T=63.5 Sec.	Second Load Group Sequencers Operate	8 sec. nominal maximum time delay
T=73.5 Sec.	Third Load Group Sequencers Operate	18 sec. nominal time delay
T=86.5 Sec.	Fourth Load Group Sequencers Operate	31 sec. nominal time delay
T=103.5 Sec.	Fifth Load Group Sequencers Operate	48 sec. nominal time delay
	Off Normal Sequence Times	

Attachment 8.4

Equipment Operating Data

	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	
Time	0152							0458									
CA-1A																	
Time	0153															0435	
CA-1C	Off, to standby																
Time	0300															0310	
FW-8A																	

= Equipment in service

Attachment 8.5

Computer Model Results All - ESF Equipment, CA-1A and FW-8A Starting

TRANSIENT STABILITY PLOTS
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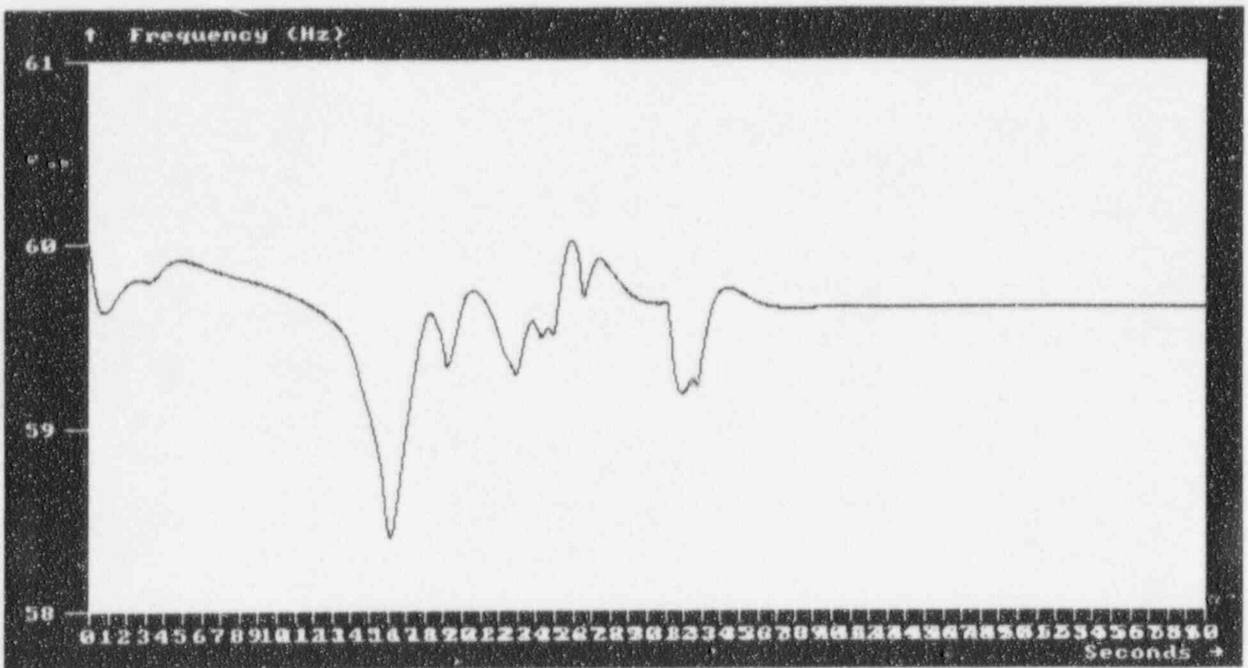
Project: OPPD ETAP 6.5 Page:
Location: FORT CALHOUN STATION
Project#: .8031 Date: 09-30-1995
Engineer: STONE & WEBSTER ENGRG CORP Study Case #: FCSDG1T3

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED EA-FC-95-027
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Synchronous Generator # 815: D1



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TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T3

Page:

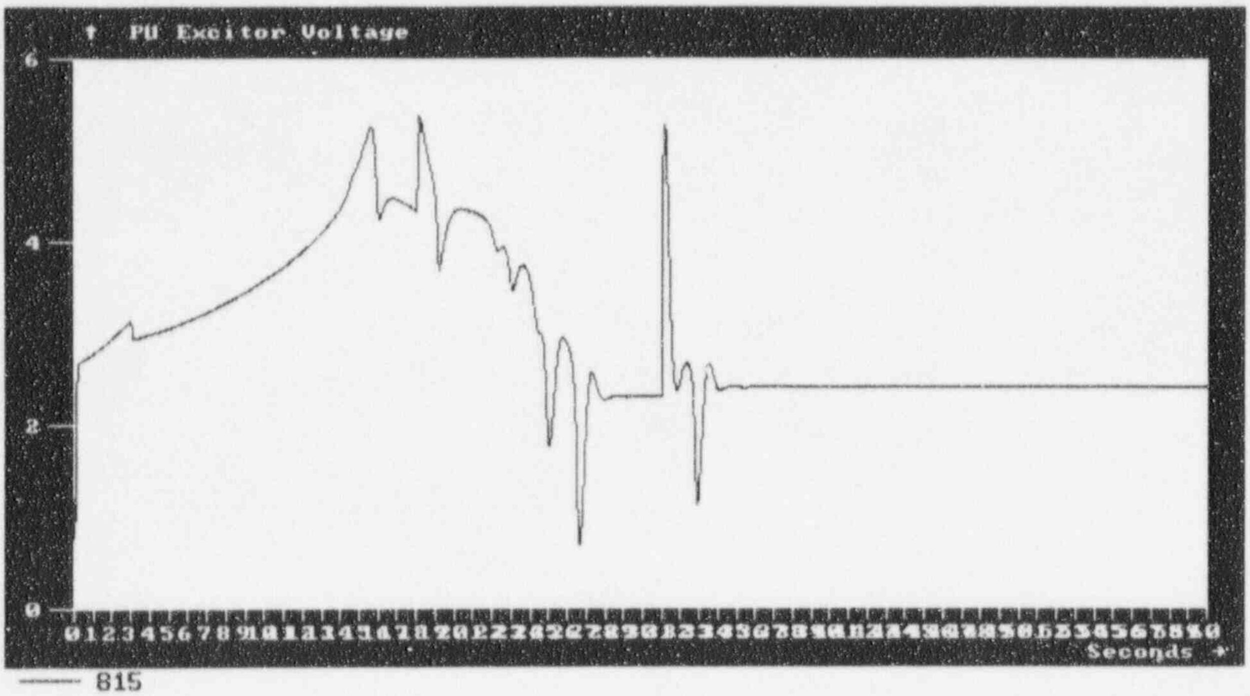
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Synchronous Generator # 815: D1



TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T3

Page:

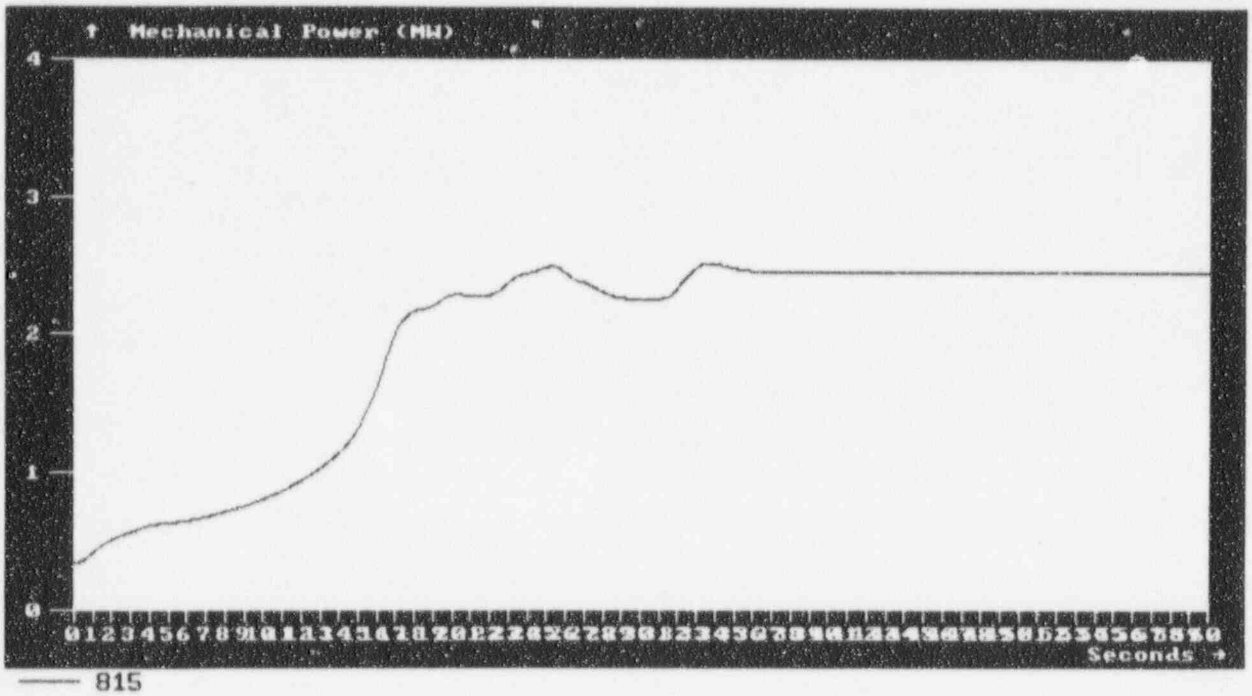
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3   Plot Filename: FCSDG1T3

Synchronous Generator # 815: D1



TRANSIENT STABILITY PLOTS
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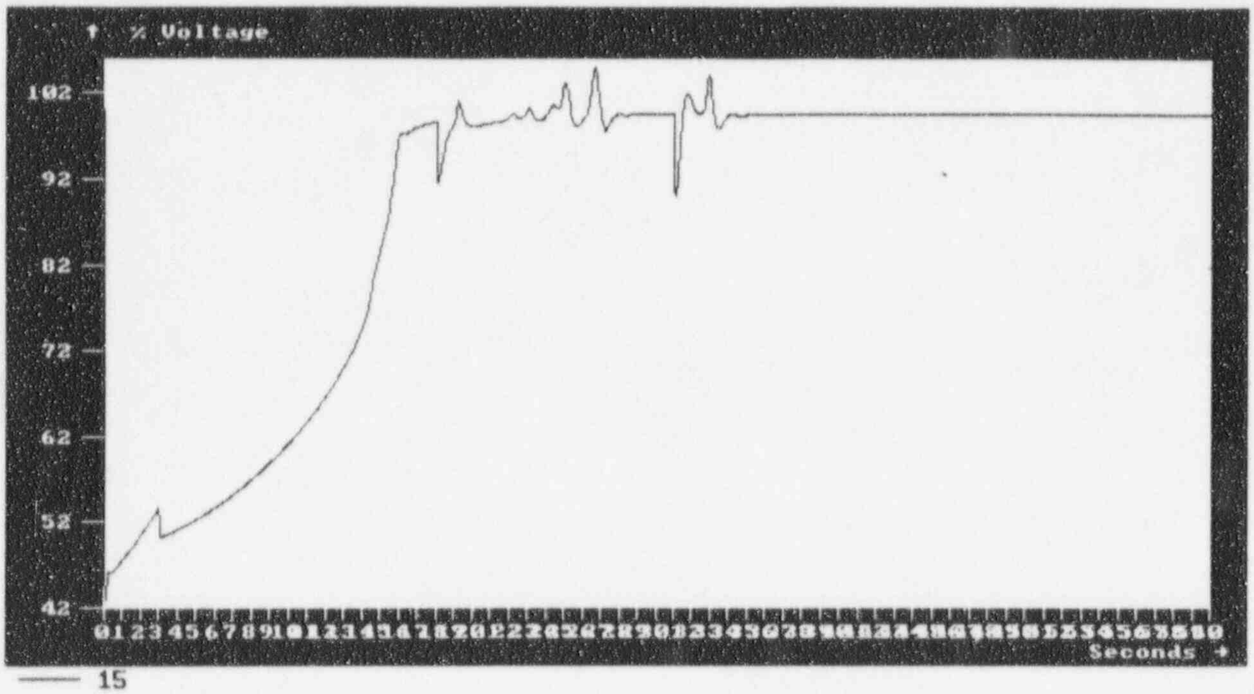
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T3
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec
EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3   Plot Filename: FCSDG1T3

Bus # 15: 1A3



TRANSIENT STABILITY PLOTS
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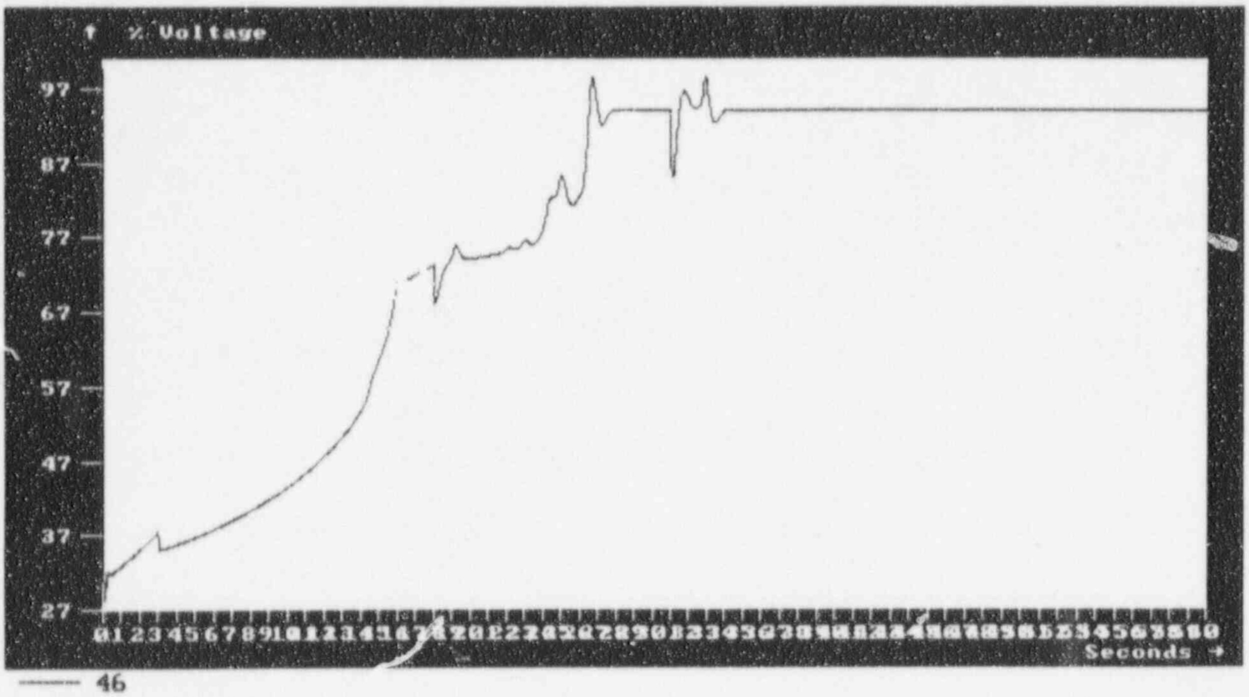
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T3
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec
EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Bus # 46: BUS 1B3A

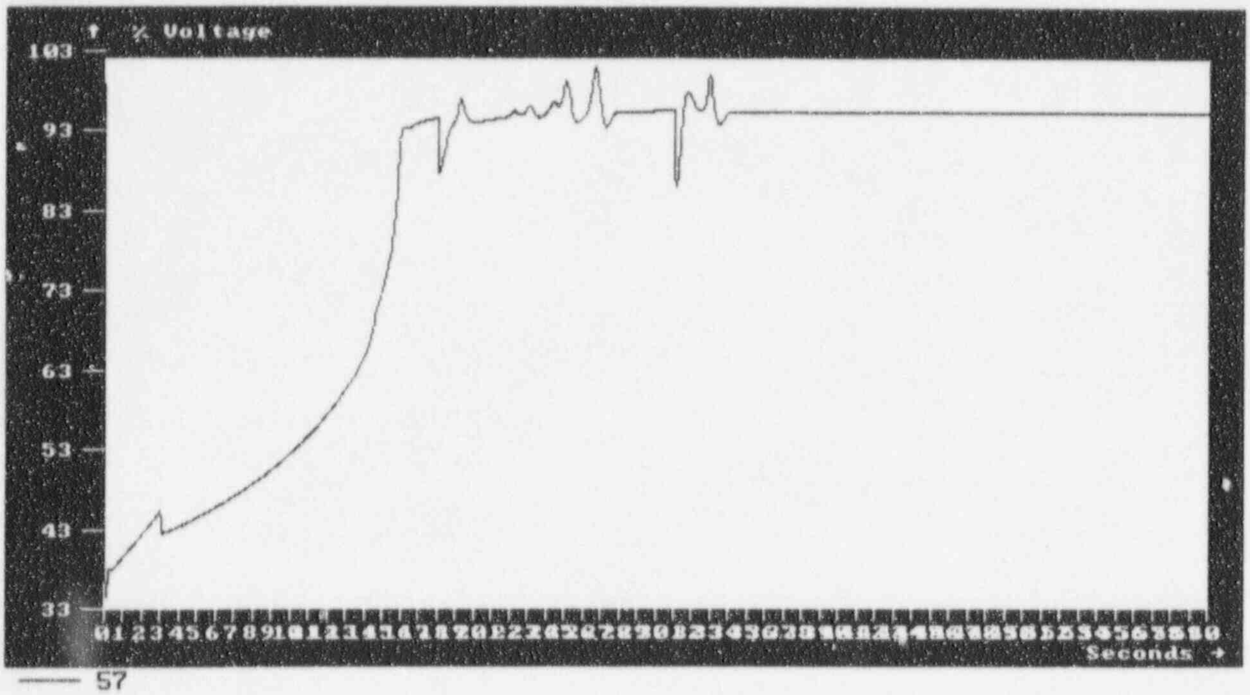


DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Bus # 57: BUS 1B3B



TRANSIENT STABILITY PLOTS
eeeeeeeeeeeeeeeeeeeeeeeeee
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T3

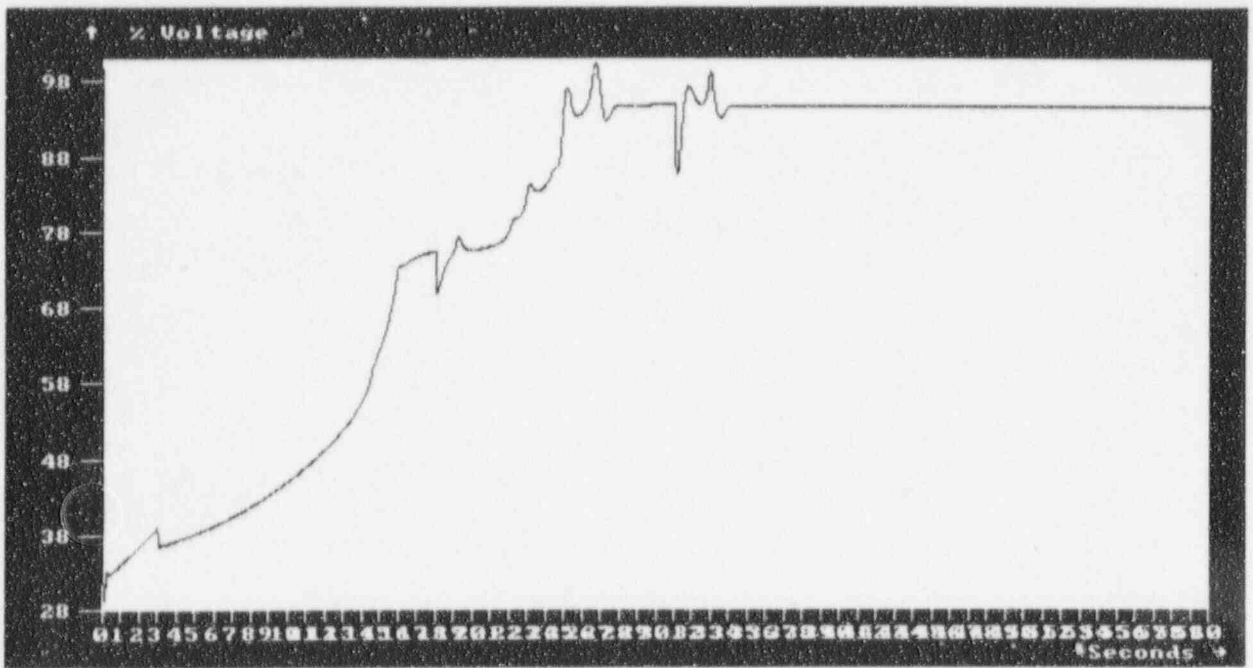
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Bus # 71: BUS 1B3C



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Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T3

Page:

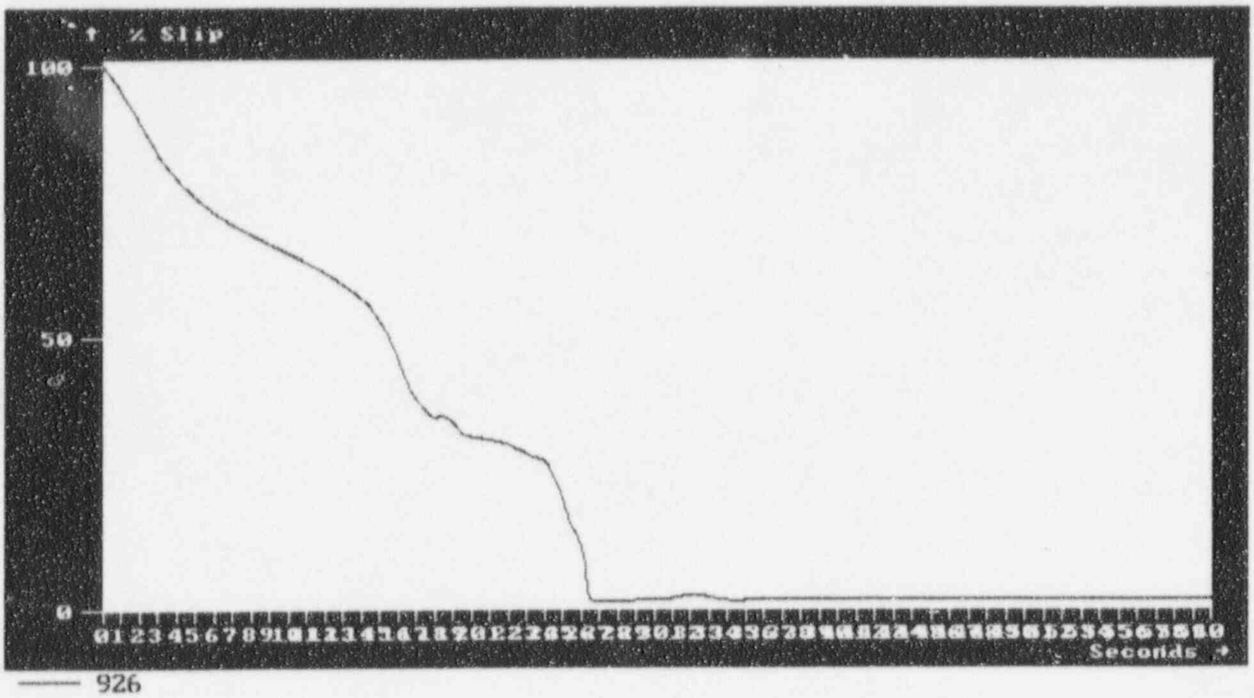
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Induction Motor # 926: SI-2A



TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T3

Page:

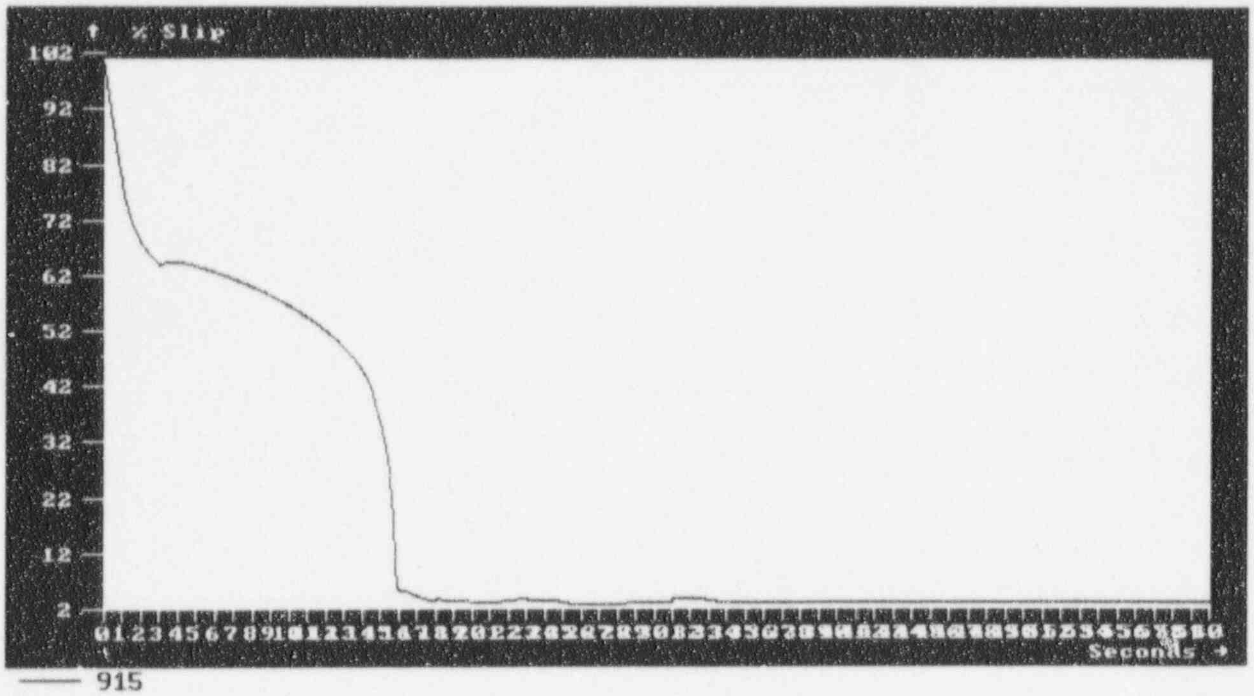
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Induction Motor # 915: AC-3A

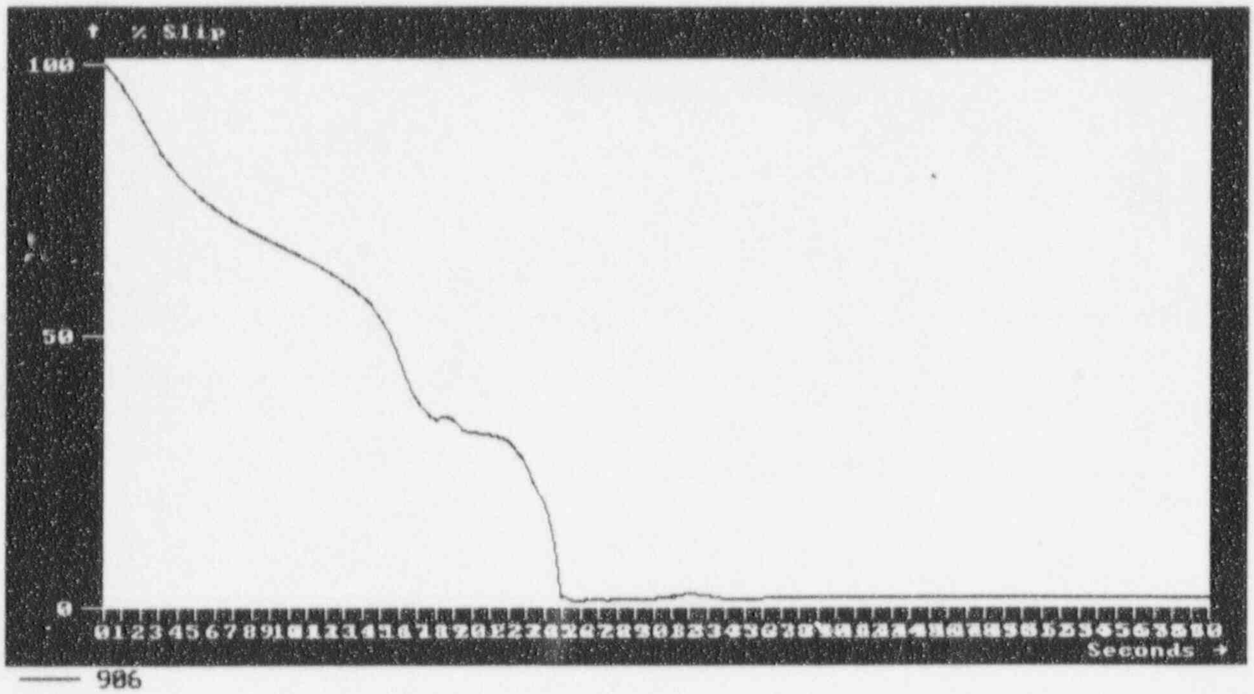


DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec

EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3 Plot Filename: FCSDG1T3

Induction Motor # 906: SI-3A

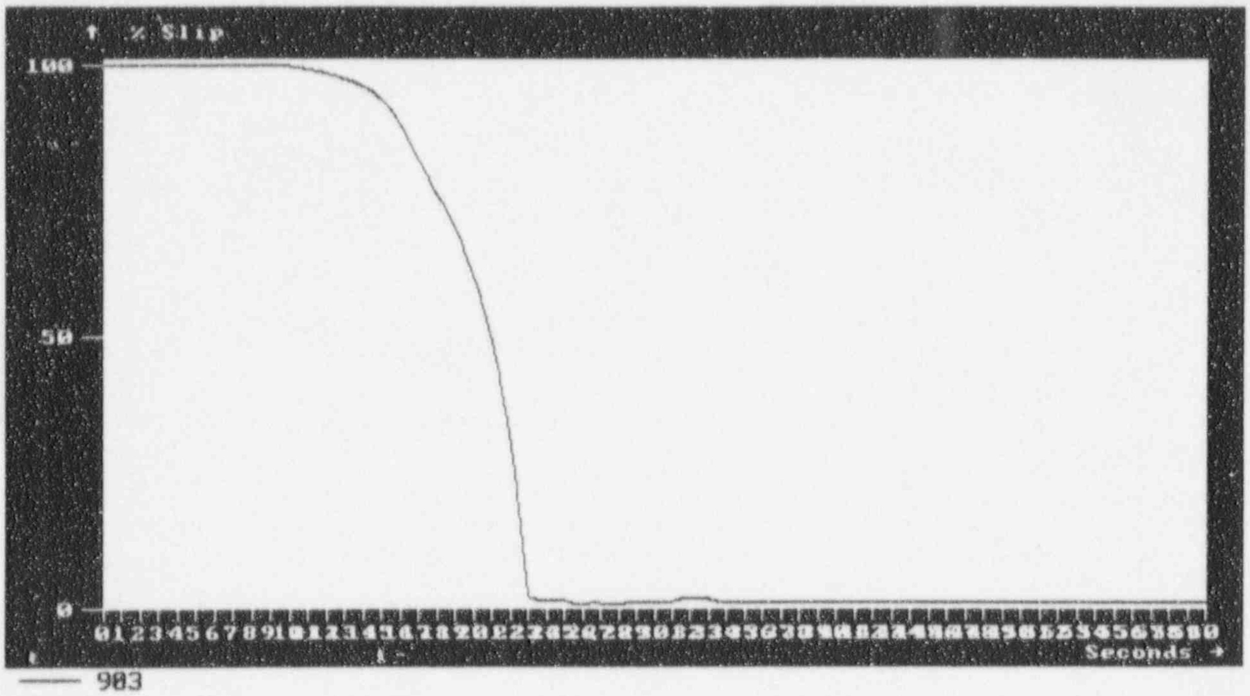


Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Date: 09-30-1995
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T3

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec
EA-FC-95-027
Attachment 8.5

Data Filename: FCSDG1T3   Plot Filename: FCSDG1T3

Induction Motor # 903: CA-1A



Attachment 8.6

Computer Model Results ESF Equipment 480V Load Shed After DG Breaker Closure

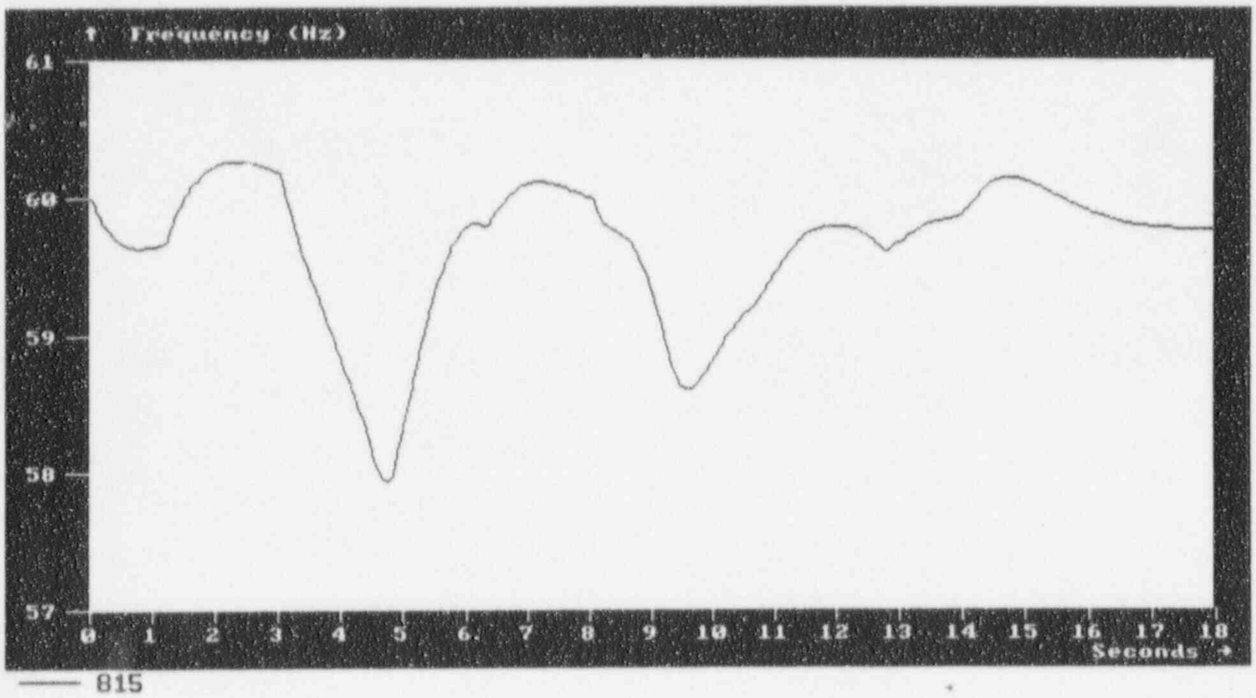
TRANSIENT STABILITY PLOTS
eeeeeeeeeeeeeeeeeeeeeeeeeeeee

Project: OPPD ETAP 6.5 Page:
Location: FORT CALHOUN STATION
Project#: .8031 Date: 09-30-1995
Engineer: STONE & WEBSTER ENGRG CORP Study Case #: FCSDG1T4

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED EA-FC-95-027
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 s Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Synchronous Generator # 815: D1

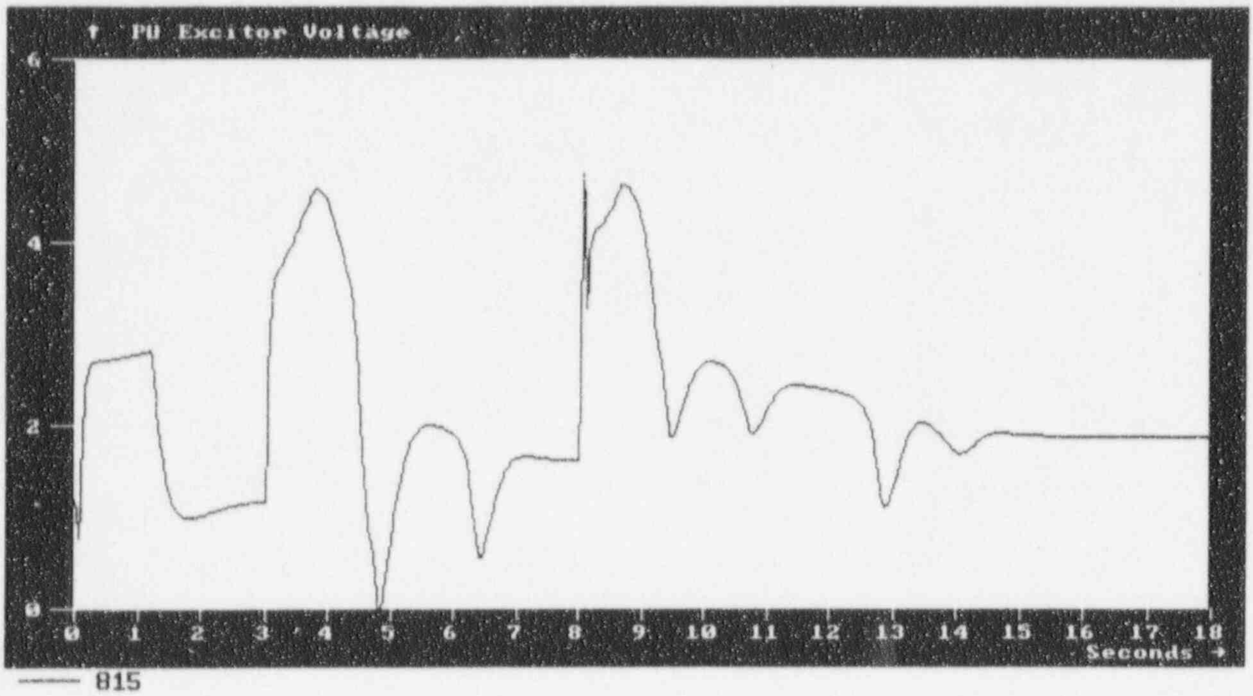


DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4   Plot Filename: FCSDG1T4

Synchronous Generator # 815: D1



TRANSIENT STABILITY PLOTS

ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T4

Page:

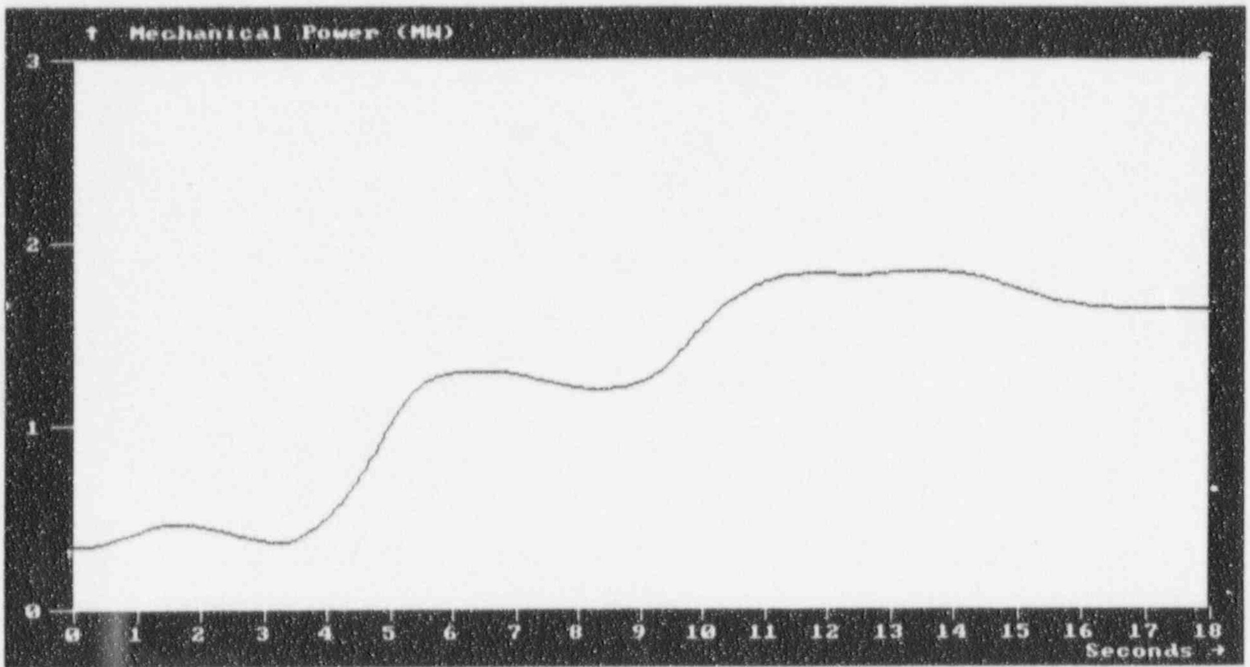
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4   Plot Filename: FCSDG1T4

Synchronous Generator #   815: D1



—— 815

TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Page:
Date: 09-30-1995

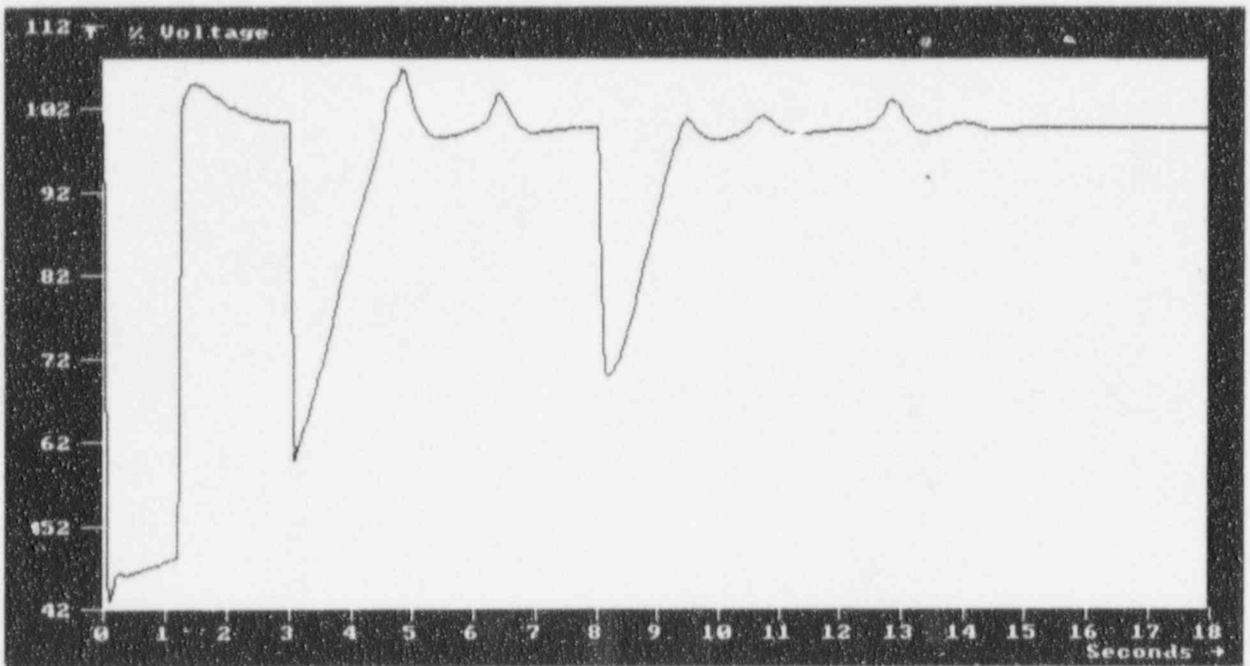
Study Case #: FCSDG1T4

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4   Plot Filename: FCSDG1T4

Bus #   15: 1A3



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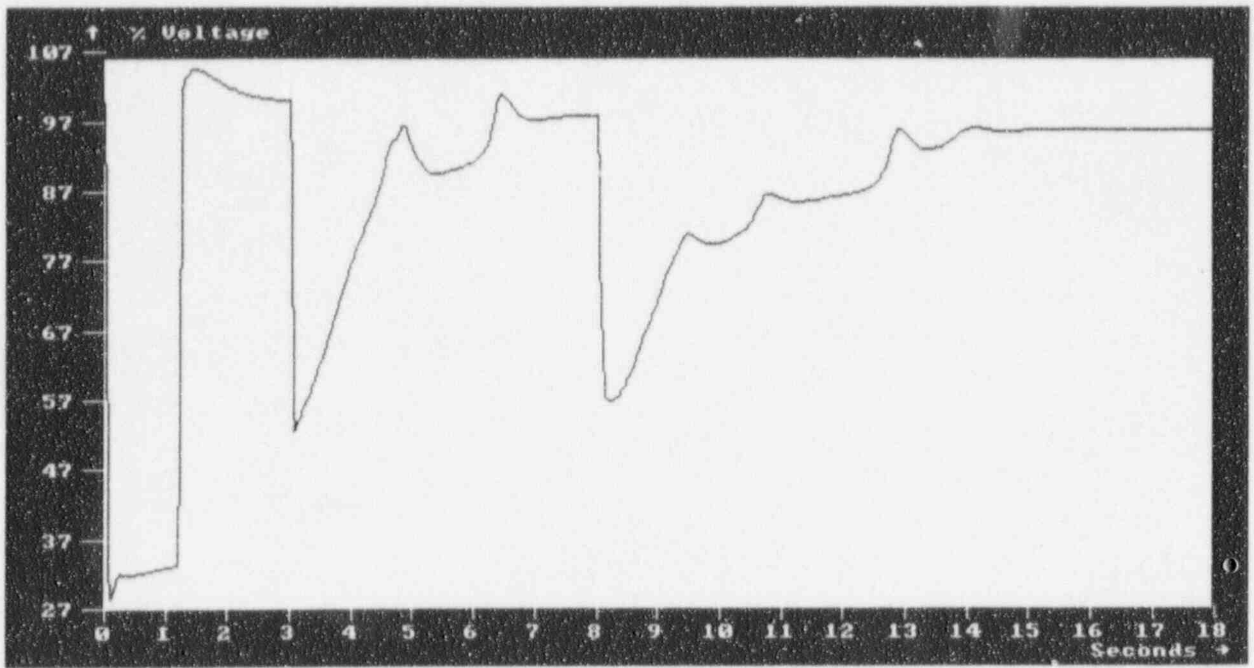
DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED EA-FC-95-027
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Bus # 46: BUS 1B3A



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TRANSIENT STABILITY PLOTS
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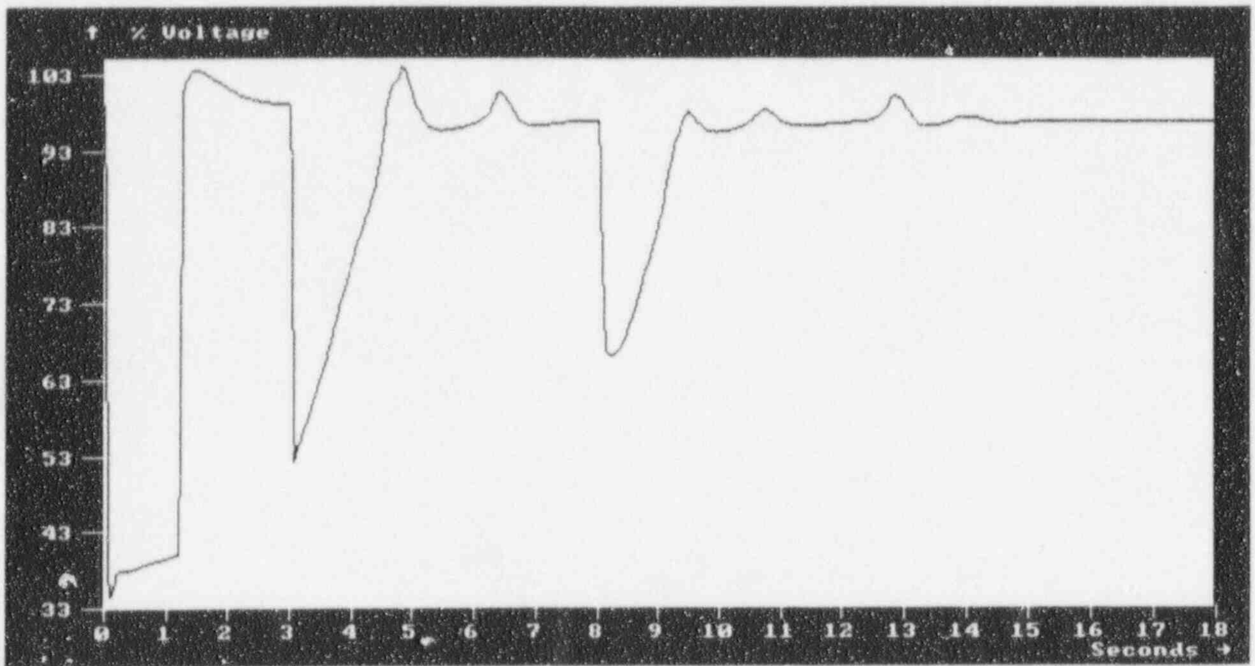
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T4
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec
EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Bus # 57: BUS 1B3B



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TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Study Case #: FCSDG1T4

Page:

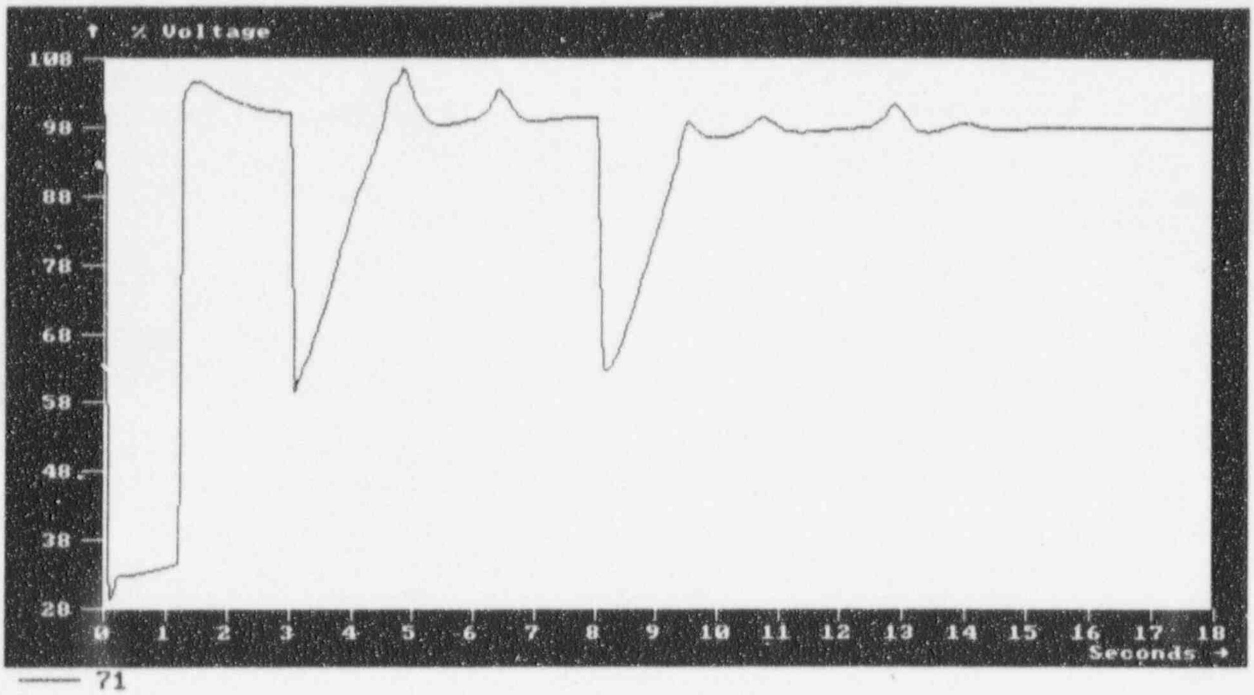
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Bus # 71: BUS 1B3C



TRANSIENT STABILITY PLOTS
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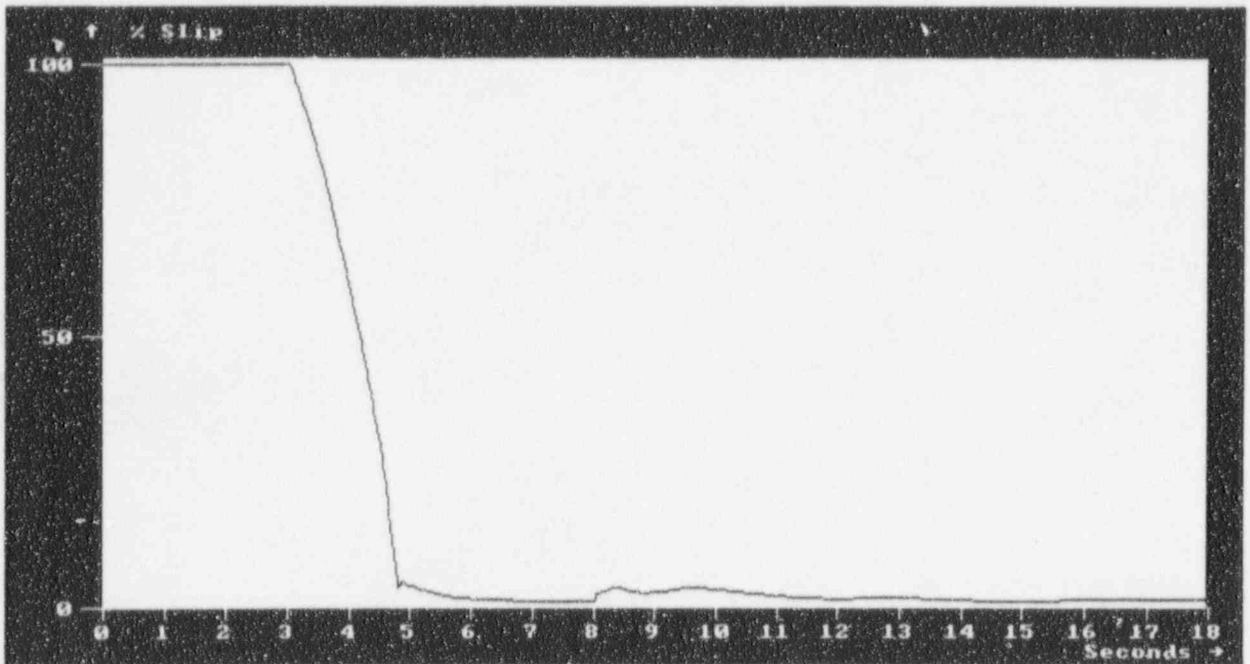
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T4
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED — EA-FC-95-027
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec — Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Induction Motor # 928: SI-1A



—— 928

TRANSIENT STABILITY PLOTS
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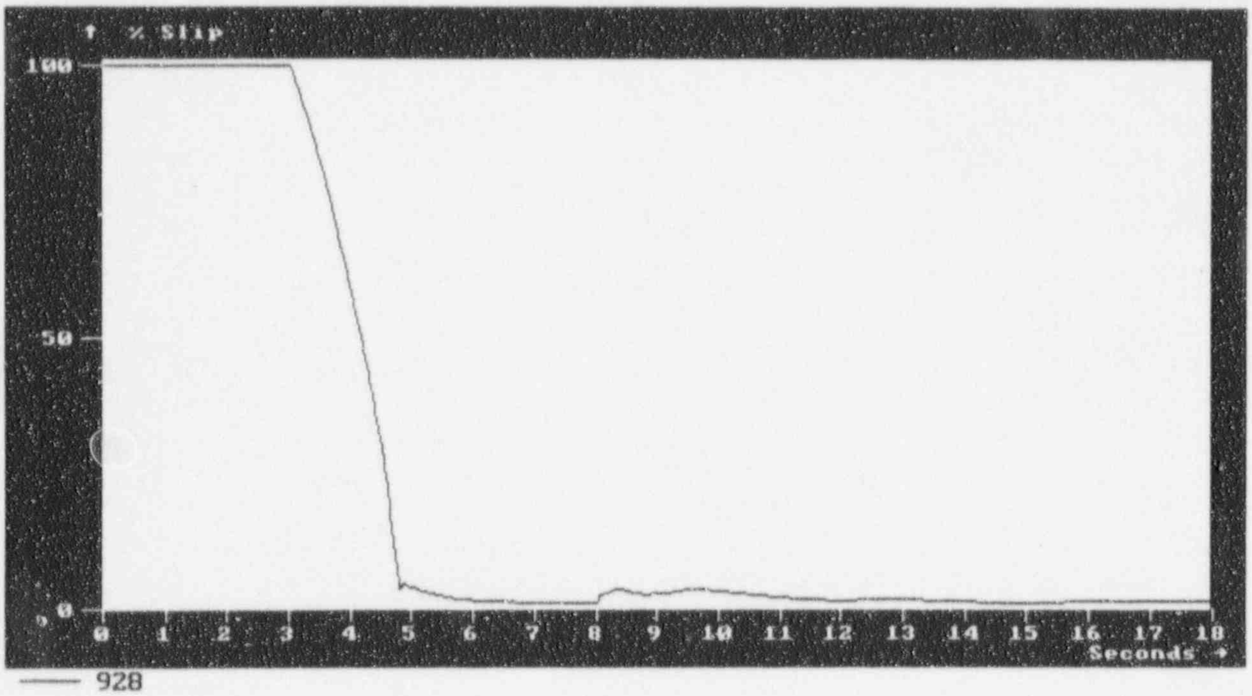
ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP
Study Case #: FCSDG1T4
Page:
Date: 09-30-1995

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec
EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Induction Motor # 928: SI-1A

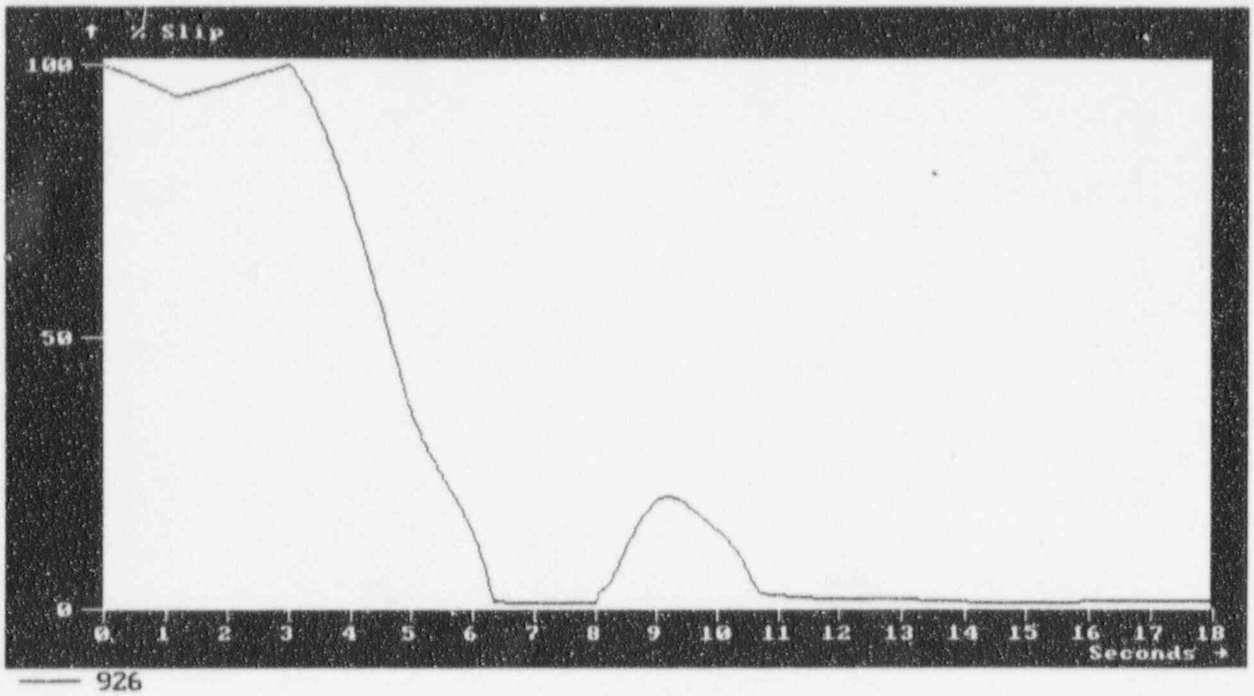


DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Induction Motor # 926: SI-2A



TRANSIENT STABILITY PLOTS
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ETAP 6.5

Project: OPPD
Location: FORT CALHOUN STATION
Project#: .8031
Engineer: STONE & WEBSTER ENGRG CORP

Page:

Date: 09-30-1995

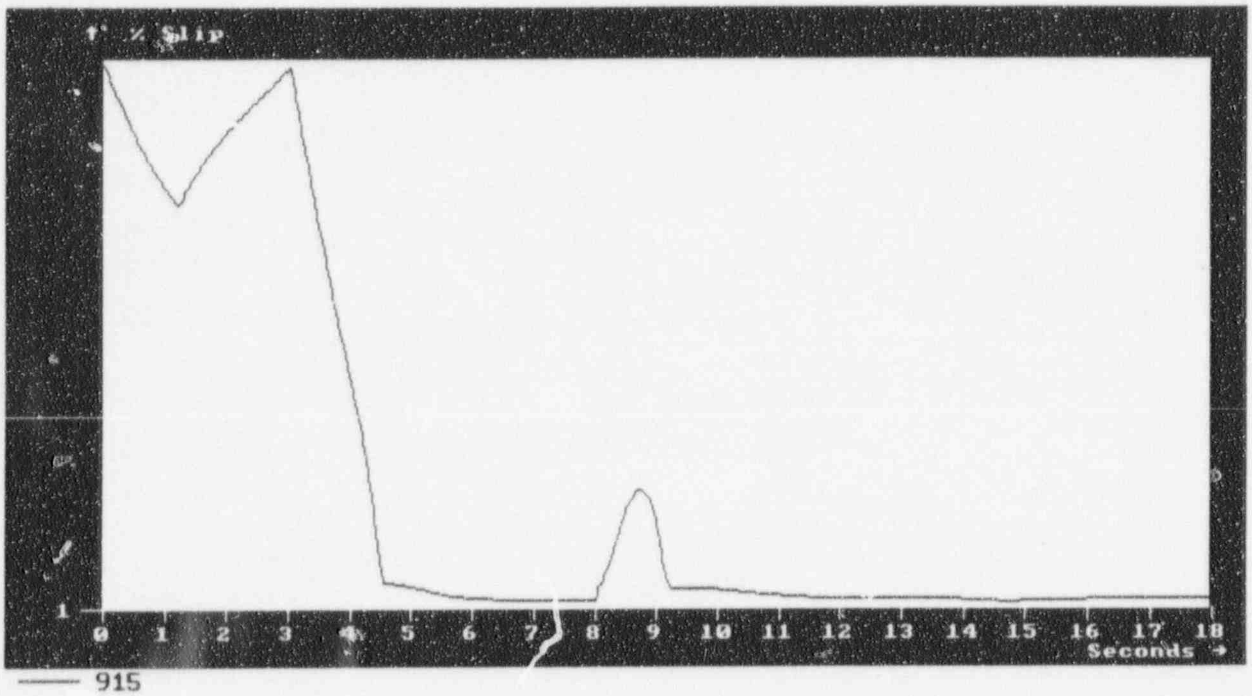
Study Case #: FCSDG1T4

DG 1 LOADING TRANSIENT ANALYSIS - W/O 480 LOAD SHED
DEAD LOAD/480V ESF LOADS/CA-1A/FW-8A @ T=0 sec & UNDERVOLTAGE LOAD SHED @ T=1.2 sec

EA-FC-95-027
Attachment 8.6

Data Filename: FCSDG1T4 Plot Filename: FCSDG1T4

Induction Motor # 915: AC-3A



Attachment 8.7

Miscellaneous Input Data

OP-ST-ESF-0002 Diesel Generator No. 1 and Diesel Generator No. 2 Auto Operation Excerpt

ERF Archival Dump DG-1 Voltage Voltage Point Y3257 Reactor Trip at 11:15 August 24, 1995 DG-1 Time to Full Speed Estimate

IAV and Fixed Delay 4160V and 480V Calibration Procedures (typical) Excerpts

SP-CP-08-1A3-IAV
SP-CP-08-480-1B3A-4A

USAR Table 14.15-2 Large Break LOCA Sequence of Events

SP-CP-08-DEVAR-1A3 OPLS time delay Excerpt

Gould Shawmut Amp-trap Fuse Data A25X100

OP-ST-ESF-0009 Channel "A" Safety Injection, Containment Spray and Recirculation Actuation Signal Test Excerpt

DG-1 Auto Operation Plot from EA-FC-92-072 Excerpt

Test Coordinator in the Control Room

INITIALS

7.34 Verify the following equipment received an Auto Start Signal AND record the sequence values.

Number	Set Point	Computer Point	Computer Time
SI-1A	2.0 to 3.5 sec.	D1084	________
AC-10A	2.0 to 3.5 sec.	D1023	________
SI-2A	2.0 to 3.5 sec.	D1020	________
AC-3A	2.0 to 3.5 sec.	D1024	________
SI-2C	7.5 to 11.0 sec.	D1015	________
CH-1A	7.5 to 11.0 sec.	D1019	________
AC-3C	7.5 to 11.0 sec.	D1022	________
AC-10C	15.0 to 21.0 sec.	D1021	________
VA-3A	15.0 to 21.0 sec.	D1026	________
FW-6	28.5 to 33.5 sec.	D1028	________
SI-3A	28.5 to 33.5 sec.	D1025	________
VA-7C	44.0 to 50.0 sec.	D1027	________

____

Completed by________________________________

ARCHIVAL FILE DUMP

CURRENT TIME: 16:36:59 PAGE: 1 CURRENT DATE: 8/24/1995

FILE NAME	FILE TYPE	RECORDING PERIOD	POINT RANGE	STARTING DATE/TIME	ENDING DATE/TIME
TPS3MN	TRANSIENT	1.000	200-949	8/24/1995 11:13:43	8/24/1995 11:16:46

Start at 11:13:43.36 from post trip log →

Field Flash → (at 11:13:49.1)

NAME	Y3261	Y3262	Y3257	Y3258	Y3287C	Y3287D	Y3287A	Y3287B
UNITS	HZ	HZ	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS
			DG1	DG2				
11:13:43.1	60.332	60.334	-1.0248	-0.51240	4304.2	4291.9	4146.3	4093.1
11:13:43.6	60.332	60.334	-1.0248	-0.51240	4304.2	4291.9	4144.3	4093.1
11:13:44.1	60.333	60.334	-1.5372	-2.5620	4283.7	4267.3	4144.3	4093.1
11:13:44.6	60.332	60.334	-1.5372	-0.51240	4000.8	3957.8	3990.6	3927.0
11:13:45.1	60.333	60.334	-1.0248	-0.51240	4000.8	3957.8	3990.6	3927.0
11:13:45.6	60.333	60.333	-1.0248	-0.51240	3976.2	3937.3	3984.4	3920.9
11:13:46.1	60.332	60.333	-1.0248	0.00000	3974.2	3937.3	3984.4	3920.9
11:13:46.6	60.327	60.333	-1.0248	0.51240	3974.2	3935.2	3984.4	3920.9
11:13:47.1	60.327	60.329	3.5868	0.51240	3974.2	3935.2	3984.4	3920.9
11:13:47.6	60.318	60.316	12.810	8.7108	3970.1	3933.2	3980.3	3918.8
11:13:48.1	60.308	60.304	12.810	19.984	3970.1	3933.2	3980.3	3918.8
11:13:48.6	60.190	60.304	23.570	24.595	3966.0	3935.2	3978.3	3920.9
11:13:49.1	60.190	60.307	170.12	24.595	3966.0	3935.2	3978.3	3920.9
11:13:49.6	60.253	60.309	921.30	25.620	3972.1	3931.1	3982.4	3916.8
11:13:50.1	59.893	60.310	921.30	24.595	3974.2	3935.2	3984.4	3920.9
11:13:50.6	60.078	60.310	1902.0	24.083	3976.2	3939.3	3986.5	3922.9
11:13:51.1	60.078	60.310	3240.4	24.083	3976.2	3939.3	3986.5	3922.9
11:13:51.6	59.980	60.310	3812.3	24.595	3978.3	3941.4	3988.5	3927.0
11:13:52.1	59.689	60.310	3812.3	23.058	3980.3	3943.4	3990.6	3929.1
11:13:52.6	59.468	60.311	3949.6	23.570	3980.3	3945.5	3994.7	3929.1
11:13:53.1	59.468	60.311	3976.2	23.570	3984.4	3945.5	3994.7	3929.1
11:13:53.6	59.489	60.311	3984.4	24.083	3986.5	3945.5	3996.7	3931.1
11:13:54.1	59.327	60.311	3984.4	23.058	3986.5	3947.5	3996.7	3933.2
11:13:54.6	59.303	60.311	3986.5	23.570	3986.5	3947.5	3996.7	3933.2
11:13:55.1	59.303	60.312	3986.5	23.570	3988.5	3949.6	3998.8	3933.2
11:13:55.6	59.353	60.311	3986.5	23.058	3988.5	3949.6	3998.8	3935.2
11:13:56.1	59.194	60.311	3986.5	22.546	3988.5	3953.7	3998.8	3937.3
11:13:56.6	59.402	60.311	3988.5	22.546	3988.5	3953.7	3998.8	3937.3
11:13:57.1	59.402	60.311	3988.5	23.058	3990.6	3953.7	4000.8	3939.3
11:13:57.6	59.242	60.311	3988.5	22.546	3990.6	3953.7	4000.8	3937.3
11:13:58.1	59.285	60.311	3988.5	23.058	3990.6	3955.7	4000.8	3939.3
11:13:58.6	59.285	60.311	3988.5	23.058	3990.6	3955.7	4000.8	3939.3
11:13:59.1	59.328	60.311	3988.5	23.570	3992.6	3955.7	4002.9	3941.4
11:13:59.6	59.190	60.311	3988.5	22.546	3992.6	3955.7	4002.9	3941.4
11:14: 0.1	59.406	60.311	3990.6	23.058	3992.6	3957.8	4002.9	3941.4
11:14: 0.6	59.406	60.311	3990.6	23.058	3992.6	3957.8	4002.9	3941.4
11:14: 1.1	59.242	60.311	3990.6	23.058	3994.7	3957.8	4004.9	3943.4
11:14: 1.6	59.296	60.311	3990.6	22.546	3994.7	3959.8	4007.0	3943.4
11:14: 2.1	59.328	60.311	3990.6	23.058	3996.7	3959.8	4007.0	3943.4
11:14: 2.6	59.328	60.312	3990.6	23.058	3996.7	3959.8	4007.0	3943.4
11:14: 3.1	59.185	60.311	3990.6	22.546	3996.7	3957.8	4007.0	3943.4
11:14: 3.6	59.401	60.311	3990.6	22.546	3996.7	3957.8	4007.0	3943.4
11:14: 4.1	59.231	60.312	3990.6	23.570	3996.7	3957.8	4007.0	3945.5
11:14: 4.6	59.231	60.311	3990.6	23.570	3996.7	3959.8	4007.0	3945.5
11:14: 5.1	59.299	60.312	3992.6	22.546	3996.7	3959.8	4007.0	3943.4
11:14: 5.6	59.323	60.312	3992.6	23.058	3994.7	3957.8	4004.9	3943.4

ARCHIVAL FILE DUMP

CURRENT TIME: 16:37:27 PAGE: 2 CURRENT DATE: 8/24/1995

FILE NAME	FILE TYPE	RECORDING PERIOD	POINT RANGE	STARTING DATE/TIME	ENDING DATE/TIME
TPS3MN	TRANSIENT	1.000	200-949	8/24/1995 11:13:43	8/24/1995 11:16:46

NAME	Y3261	Y3262	Y3257	Y3258	Y3287C	Y3287D	Y3287A	Y3287B
UNITS	HZ	HZ	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS	VOLTS

CALIBRATION OF THE OVER AND UNDERVOLTAGE IAV RELAYS
AND AGASTATS LOCATED IN BUS 1A3 CONTROL CIRCUIT

Steps 7.2 through 7.7: IAV53 Relays

27-1/1A3 and 27-2/1A3		TAP	PU V. LEFT CONT	DO V. RT. CONT	DO TIME SEC.	DO TIME TEST VOLTAGE
SETTINGS ISSUED	OPT	93	98.00	93.00	≤ 5.9	118-87VAC
	MIN	N/A	96.10	91.28	4.0	N/A
	MAX	N/A	99.66	94.84	5.9	N/A
OPPD # 88 27-1	AF					118-87VAC
	AL					118-87VAC
OPPD # 89 27-2	AF					118-87VAC
	AL					118-87VAC

TEST EQUIP NAME:	ID NUMBER	CERT DATE	DUE DATE

(relay tested by) (date)

CALIBRATION OF THE OVER AND UNDERVOLTAGE IAV RELAYS
AND AGASTATS LOCATED IN BUS 1A3 CONTROL CIRCUIT

Steps 7.8 through 7.15: Test of Agastats

27T1/1A3 AND 27T2/1A3		TIME DIAL	PU TIME SEC
SETTINGS ISSUED	OPT	2.0 *	2.00
	MIN	N/A	1.94
	MAX	N/A	2.06
27T1 1A3	AF		
	AL		
27T2 1A3	AF		
	AL		

* : INFORMATION ONLY

TEST EQUIP NAME:	ID NUMBER	CERT DATE	DUE DATE

_______________________ (relay tested by)   __________ (date)

CALIBRATION OF THE PROTECTIVE
RELAYS FOR 480-1B3A-4A BUS

Page 4 of 5

Steps 7.2 through 7.7

27-1/1B3A-4A and 27-2/1B3A-4A		TAP	PU V. LEFT CONT	DO V. RT. CONT	DO TIME SEC.	DO TIME TEST VOLTAGE	DO TIME SEC.	DO TIME TEST VOLTAGE
SETTINGS ISSUED	OPT	93	94.00	89.30	7.0	115-84VAC	1.2	115-0VAC
	MIN	N/A	93.5	88.8	4.5	N/A	0.4	N/A
	MAX	N/A	94.5	89.8	9.5	N/A	2.0	N/A
OPPD # 122 27-1	AF					115-84VAC		115-0VAC
	AL					115-84VAC		115-0VAC
OPPD # 123 27-2	AF					115-84VAC		115-0VAC
	AL					115-84VAC		115-0VAC

TEST EQUIP NAME: ID NUMBER CERT DATE DUE DATE

_______________ __________ __________ __________

_______________ __________ __________ __________

_______________ __________ __________ __________

_______________________ __________
(relay tested by) (date)

Steps:
7.8
through
7.11

27T1/1B3A-4A		TIME DIAL	PU TIME SEC
SETTINGS ISSUED	OPT	1.0 *	1.00
	MIN	N/A	.95
	MAX	N/A	1.05
27T1 1B3A-4A	AF		
	AL		

* : INFORMATION ONLY

TEST EQUIP NAME: ID NUMBER CERT DATE DUE DATE

_______________ __________ __________ __________

_______________ __________ __________ __________

_______________ __________ __________ __________

_______________________ __________
(relay tested by) (date)

CALIBRATION OF THE OVER AND UNDERVOLTAGE IAV RELAYS
AND AGASTATS LOCATED IN BUS 1A3 CONTROL CIRCUIT

Page 5 of 6

Steps 7.8 through 7.15: Test of Agastats

27T1/1A3 AND 27T2/1A3		**TIME DIAL**	**PU TIME SEC**
SETTINGS ISSUED	OPT	2.0 *	2.00
	MIN	N/A	1.94
	MAX	N/A	2.06
27T1 1A3	AF		
	AL		
27T2 1A3	AF		
	AL		

* : INFORMATION ONLY

TEST EQUIP NAME:	ID NUMBER	CERT DATE	DUE DATE

(relay tested by) (date)

TABLE 14.15-2
FORT CALHOUN LARGE BREAK LOCA ANALYSIS

LARGE BREAK SEQUENCE OF EVENTS

RESULTS	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.4	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.6	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.8
Start	0.0	0.0	0.0
Rx Trip Signal	0.60	0.59	0.59
S.I. Actuation Signal	0.97	0.77	0.67
S.I. Tank Injection	22.80	16.80	14.00
Pump Injection Begins	31.87	31.67	31.57
End of Bypass	28.92	20.59	17.48
End of Blowdown	28.92	20.59	17.48
Bottom of Core Recovery	39.34	31.73	28.52
S.I. Tanks Empty	94.92	90.14	88.01

Note: All times are in seconds.

TABLE 14.15-3
FORT CALHOUN LARGE BREAK LOCA ANALYSIS

BREAK SPECTRUM SENSITIVITY ANALYSIS RESULTS

RESULTS	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.4	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.6	MIN SI FLOW F^T_R = 1.75 DECLG C_D=0.8
Peak Clad Temperature (°F)	1981.	1869.	1815.
Peak Clad Temp. Elevation (Ft.)	9.25	9.25	9.25
Peak Clad Temperature Time (Sec.)	113.9	98.3	86.8
Max Local Zr/H_2O Reaction (%)	2.98	2.88	2.38
Total Zr/H_2O Reaction (%)	<1.0	<1.0	<1.0
Hot Assy. Burst Time (Sec.)	47.4	69.5	61.1
Hot Assy. Burst Elevation (Ft.)	8.75	9.00	8.75
Blockage on Hot Rod (%)	41.0	35.2	38.8

CALIBRATION OF THE DEVAR RELAY AND
ASSOCIATED TIMERS FOR BUS 1A3

Steps 7.5 Test of Agastat 27T1/OPLS-A

27T1/OPLS-A		TIME DIAL	DO TIME SEC
SETTINGS ISSUED	OPT	* 4.5	4.50
	MIN	N/A	4.30
	MAX	N/A	4.75
RELAY CONTACTS 4 - 6	AF		
	AL		

* : INFORMATION ONLY

TEST EQUIP NAME:	ID NUMBER	CERT DATE	DUE DATE

_________________________ (relay tested by)   __________ (date)

CALIBRATION OF THE DEVAR RELAY AND
ASSOCIATED TIMERS FOR BUS 1A3

Steps 7.1 thru 7.3 Test of Devar Relay 27-74/1A3

27-74/1A3 OPPD NO. 3		INTERNAL Relay A1	INTERNAL Relay A2
SETTINGS ISSUED	OPT	114.61	114.61
	MIN	113.97	113.97
	MAX	115.25	115.25
AC VOLTS	AF		
	AL		

Steps 7.4 Test of Agastat 27T1X/OPLS-A

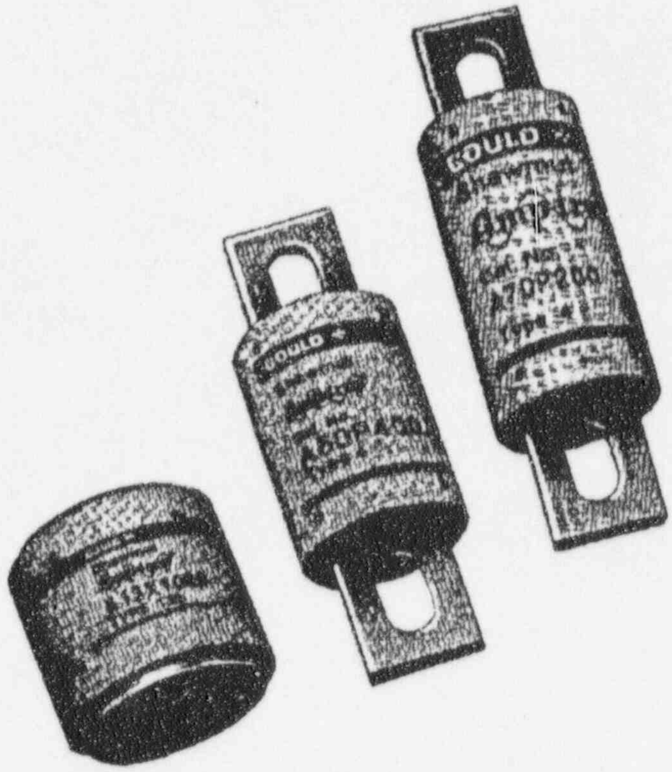
27T1X/OPLS-a OPPD NO. 3		TIME DIAL	DO TIME SEC
SETTINGS ISSUED	OPT	* 10	15.0
	MIN	N/A	14.5
	MAX	N/A	15.5
RELAY CONTRACTS 1 - 5	AF		
	AL		

* : INFORMATION ONLY

Amp-trap®–Form 101

Semiconductor Protection Fuses

A13X/A25X/A50P/A50QS
A60X/A70P/A70Q/A100P



For Semiconductor Protection

Extremely Fast Acting
Current Limiting
130, 250, 500, 600,
700 and 1000 Volts AC
1 to 6000 Amperes
Low I^2t
Controlled Arc Voltage
Blown Fuse Indicator Available
Many are UL Recognized

Amp-trap Form 101 fuses are extremely fast acting fuses which provide protection for diodes, thyristors, triacs and other solid state components and devices. Though intended primarily for short circuit protection, most Form 101 fuses provide a degree of overload protection against currents of approximately 2 times fuse ampere rating and greater. The melting time current curves for these fuses show the range of overload currents over which these fuses will effectively operate. Supplementary overload protection such as gate pulse suppression should be employed to interrupt current levels below those shown on the fuse melting time current curves.

Proper fuse selection is an integral and important part of the equipment design process. For assistance in fuse selection request the Gould Shawmut publication "Semiconductor Fuse Applications". This publication has been written for the designer and discusses in depth the parameters involved in the selection of fuses for semiconductor protection.

In addition to the products shown here, Gould offers standard Form 101 fuses with voltage ratings to 1500 VAC. We maintain the capability of developing custom designs for those applications not adequately served by our standard products

Catalog Number Explanation

Example: A 70 P 400 4 TI

All Form 101 Amp-Trap Fuses — A

Rated Volts - Style*	Code
130 - X, Z	13
250 - X, Z	25
300 - X	30
500 - P, QS	50
600 - X, Z	60
700 - P, Q	70
1000 - P, X, Z	100
1200 - P, X, Z	120
1500 - P, X, Z	150

Style	Code
Fast	X or Z
Faster, Lower I^2t	P
Fastest, Lowest I^2t	Q or QS

Amperes — Rating in Amperes

Common Mounting Types*	Code
Ferrule	1
Ferrule, with midget dims. (1½" x 13/32")	2
Blades, bolt-in	4
Hockey puck, bolt-in	128

Integral Blown-Fuse Indicator	
Trigger Indicator	TI
Trigger Actuator	TA

* For ampere ratings and styles not listed, consult the factory.

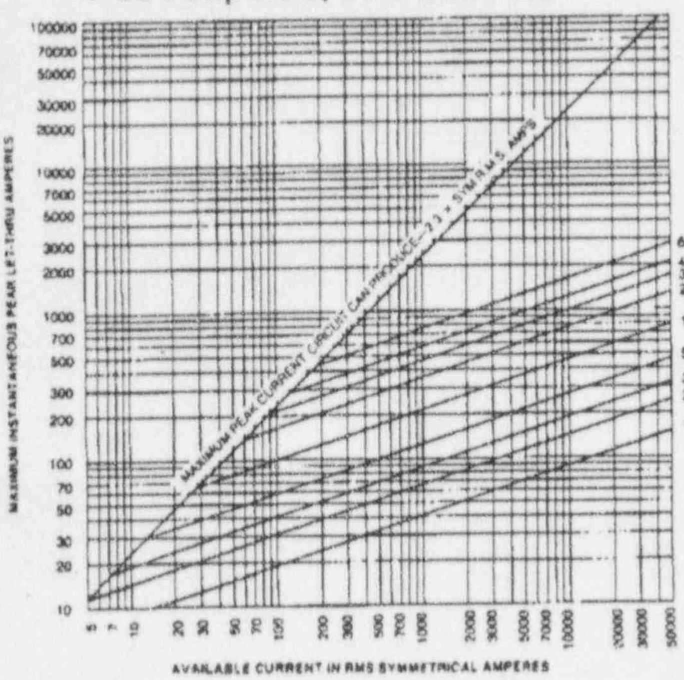
For Form 101 Amp-Trap fuse accessories and fuse blocks, see pages 161 and 162.

Amp-Trap® – Form 101

Semiconductor Protection Fuses

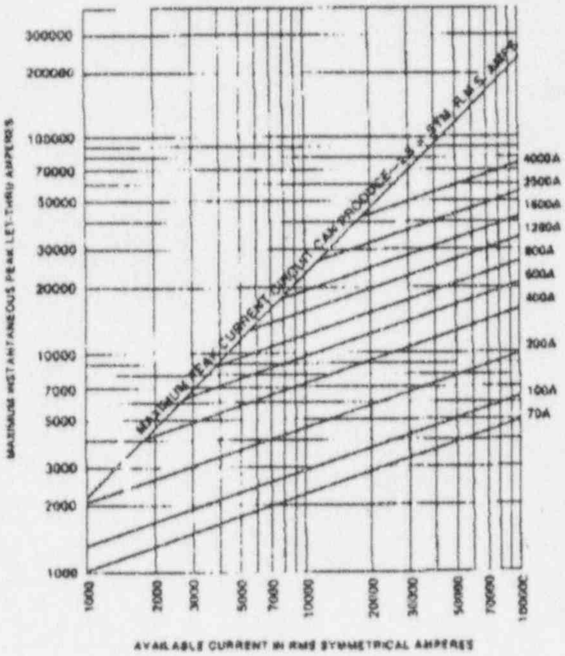
A25X
250 Volts AC

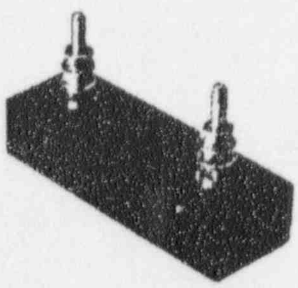
Peak Let-Thru Current Data
A25X Fuses
1-60 Amperes, 250 Volts AC*



*A25X10-30 rated 300 VAC.

Peak Let-Thru Current Data
A25X Fuses
70-4000 Amperes, 250 Volts AC





Single Pole Fuse Blocks⁺
For A25X Fuses

FUSE AMPERE RATING	FUSE BLOCK CATALOG NUMBER
1-30	20306
31-60	P243G
61-100	P243
101-200	P243
201-400	P243G
401-600	P243G

*Dimensions are shown on page 162, except #20306 appears on page 201.

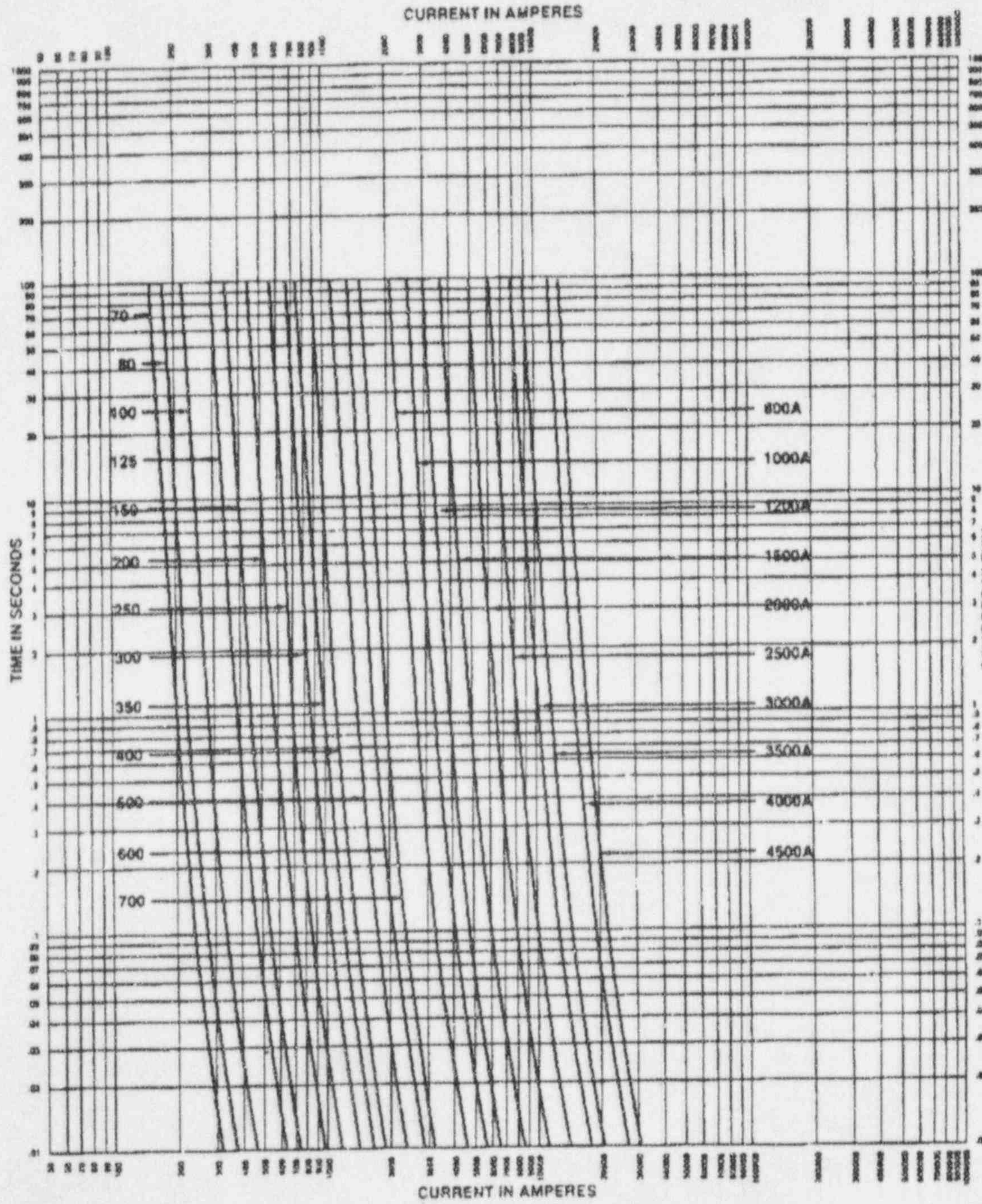
GOULD SHAWMUT

Amp-Trap® – Form 101

Semiconductor Protection Fuses

A25X
250 Volts AC

Melting Time—Current Data—A25X Fuses
70-4500 Amperes, 250 Volts AC



GOULD SHAWMUT

Amp-Trap® – Form 101

Semiconductor Protection Fuses

A25X
250 Volts AC

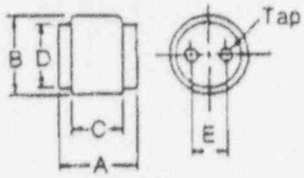


FIG. 4

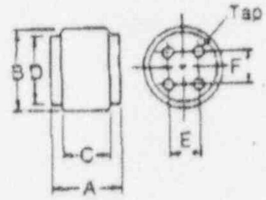


FIG. 5

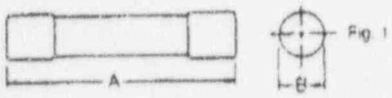


FIG. 1

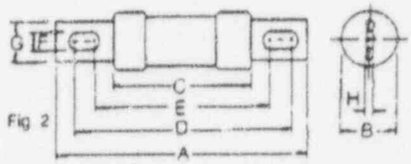


FIG. 2

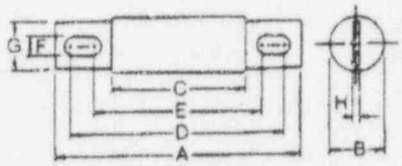


FIG. 3

Dimensions For A25X Fuses—250 Volts AC

FIG.	CATALOG NUMBER	MOUNTING TYPE	DIMENSIONS—INCHES								TAP
			A	B	C	D	E	F	G	H	
1	A25X1-30*	1	2	9/16	—	—	—	—	—	—	—
2	A25X35-60	4	3 3/16	13/16	1 5/8	2 1/2	2 1/4	11/32	23/32	1/8	—
3	A25X70-200	4	3 1/8	1 7/32	1 5/8	2 7/16	2 5/16	5/16	1	3/16	—
3	A25X225-700	4	3 27/32	1 1/2	1 19/32	2 29/32	2 9/32	13/32	1	1/4	—
3	A25X800	4	3 27/32	2	1 19/32	2 29/32	2 9/32	13/32	1 1/2	1/4	—
4	A25X800-1200	128	2 19/32	3	2 11/32	2 1/2	1 1/2	—	—	—	3/8-24-1/2 Deep
5	A25X1500-2500	128	2 19/32	3 1/2	2 11/32	3	1 1/2	1 1/2	—	—	3/8-24-1/2 Deep
5	A25X3000-4500	128	2 19/32	4 1/2	2 11/32	3 3/4	1 1/2	1 1/2	—	—	1/2-20-1/2 Deep

*A25X10-30 rated 300 VAC

Standard Fuse Ampere Ratings* For A25X Fuses

AMPERE RATING	MOUNTING TYPE	AMPERE RATING	MOUNTING TYPE	AMPERE RATING	MOUNTING TYPE
1	1	50	4	500	4
2	1	60	4	550	4
3	1	70	4	600	4, 4TA, 4TI
4	1	80	4	700	4, 128
5	1	90	4	800	4, 4TA, 128
6	1	100	4, 4TI	1000	128, 128TI
7	1	125	4	1200	128
8	1	130	4	1500	128
9	1	150	4, 4TI	1600	128
10	1	175	4	2000	128
12	1	200	4, 4TI	2500	128
15	1	225	4	3000	128
20	1	250	4, 4TI	3500	128
25	1	300	4, 4TI	4000	128
30	1	350	4	4500	128
35	4	400	4, 4TA, 4TI		
40	4	450	4		

*Includes standard ampere ratings and mounting types available in each ampere rating.

ATTACHMENT I

SECTION I

SI-1 SEQUENCER ISOLATION SWITCHES AND TIMERS WITH 86-1/SI-1 TRIPPED

REF COMP. POINT	COMPONENT	SEQUENCE ISOL. SWITCH REQ.	(✓)	[illegible] REQ.	(✓)	TIMER OPERATE LIGHT REQ.	(✓)	TIMER OPER. SIG COMPUTER REQ.	(✓)	COMPUTER ACTUATION SIGNAL TIME REQUIRED (SEC.)	ACTUAL TIME (SEC.)	TIMER OPERATE LIGHT REQ.	(✓)	SEQUENCE ISOL. SWITCH REQ.	(✓)	ON AUTO LIGHT REQ.	(✓)	
084	SI-1A	OFF	✓	ON	✓	ON	✓	YES	✓	2.0 - 3.5 SEC.	3.2	OFF	✓	ON	✓	ON	✓	3.2
023	AC-10A	OFF	✓	ON	✓	ON	✓	YES	✓	2.0 - 3.5 SEC.	2.8	OFF	✓	ON	✓	ON	✓	2.8
020	SI-2A	OFF	✓	ON	✓	ON	✓	YES	✓	2.0 - 3.5 SEC.	2.9	OFF	✓	ON	✓	ON	✓	2.9
024	AC-3A	OFF	✓	ON	✓	ON	✓	YES	✓	2.0 - 3.5 SEC.	2.9	OFF	✓	ON	✓	ON	✓	2.9
1015	SI-2C	OFF	✓	ON	✓	ON	[illegible]	YES	[illegible]	7.5 - 11.0 SEC.	8.2	OFF	✓	ON	✓	ON	[illegible]	8.2
1019	CH-1A	OFF	✓	ON	✓	ON	✓	YES	✓	7.5 - 11.0 SEC.	8.4	OFF	✓	ON	✓	ON	✓	8.4
N/A	CA-1C	OFF	✓	N/A														
1022	AC-3C	OFF	✓	ON	✓	ON	✓	YES	✓	7.5 - 11.0 SEC.	8.3	OFF	✓	ON	✓	ON	✓	8.3
1021	AC-10C	OFF	✓	ON	✓	ON	✓	YES	✓	15.0 - 21.0 SEC.	19.2	OFF	✓	ON	✓	ON	✓	19.2
1026	VA-3A	OFF	✓	ON	✓	ON	✓	YES	✓	15.0 - 21.0 SEC.	18.0	OFF	✓	ON	✓	ON	✓	18.0
1018	*CH-1C	OFF	✓	ON	✓	ON	N/A	YES	N/A	15.0 - 21.0 SEC.	N/A	OFF	✓	ON	✓	ON	N/A	
1028	FW-6	OFF	✓	ON	✓	ON	✓	YES	✓	28.5 - 33.5 SEC.	32.9	OFF	✓	ON	✓	ON	✓	32.[illegible]

* TIMER OPERATE light, ON AUTO light, and TIMER OPERATE SIGNAL TO COMPUTER are operable <u>only</u> if 480V Breaker BT-1B3B is CLOSED. Write N/A in Check Boxes if the breaker is not closed.

Completed by [signature] Operations Date/Time 9-20-95 / 1532

ATTACHMENT 1

SECTION II

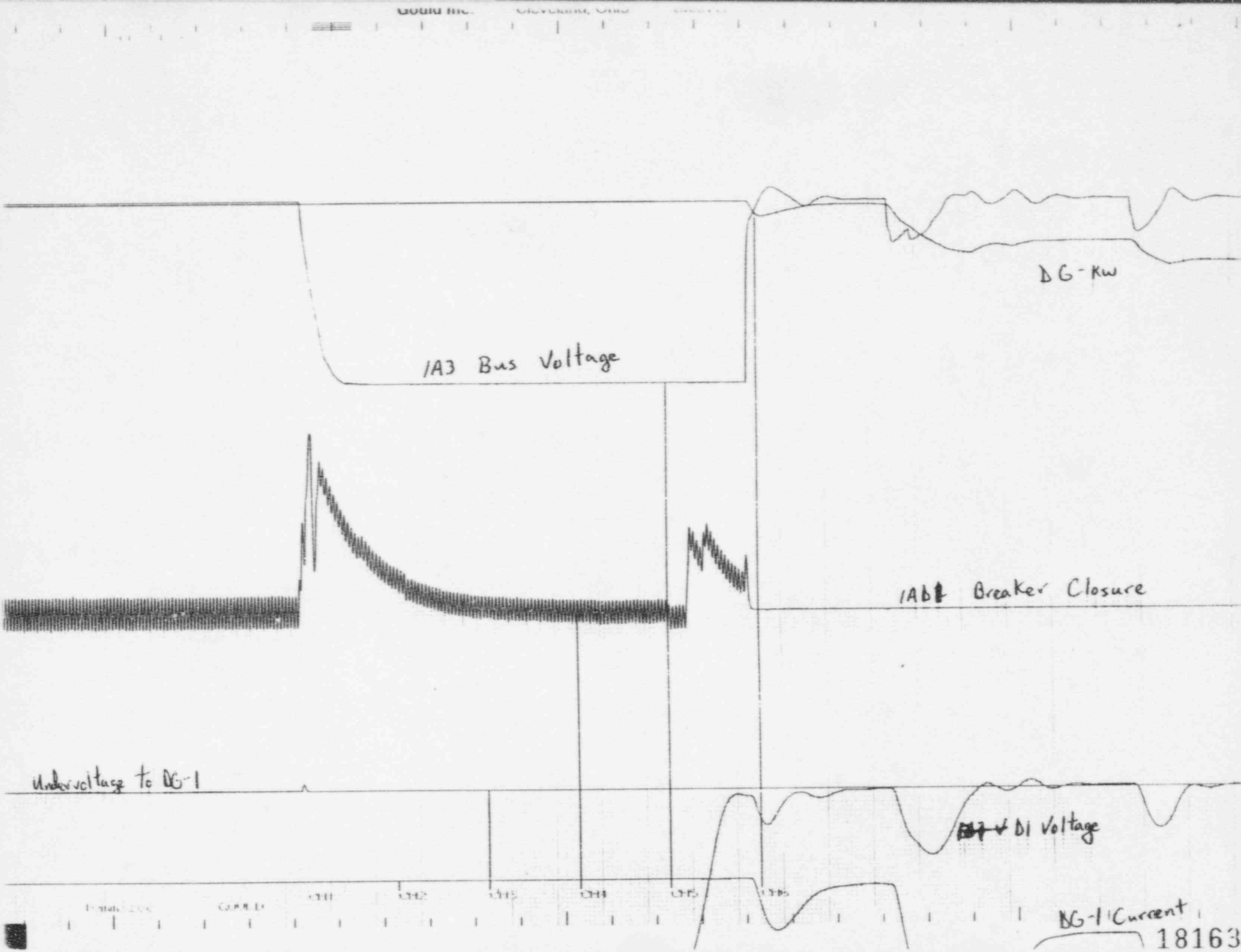
SI-1 SEQUENCE ISOLATION SWITCHES AND TIMERS WITH 86-1/SI-1 AND 86-A/CSAS TRIPPED

ERF COMP. POINT	COMPONENT	SEQ. ISOL. SWITCH REQ.	(✓)	[illegible] REQ.	(✓)	TIMER OPERATE LIGHT REQ.	(✓)	TIMER OPER. SIG COMPUTER REQ.	(✓)	COMPUTER ACTUATION SIGNAL TIME REQUIRED (SEC.)	ACTUAL TIME (SEC.)	TIMER OPERATE LIGHT REQ.	(✓)	SEQUENCE ISOL. SWITCH REQ.	(✓)	ON AUTO LIGHT REQ.	(✓)	
D1025	SI-3A	OFF	✓	ON	✓	ON	✓	YES	✓	28.5 - 33.5 SEC.	31.7	OFF	✓	ON	✓	ON	✓	31.7
N/A	CA-1A	OFF	✓	N/A														
D1017	*SI-3C	OFF	✓	ON	✓	ON	N/A	YES	N/A	36.5 - 39.5 SEC.	N/A	OFF	✓	ON	✓	ON	N/A	
D1027	VA-7C	OFF	✓	ON	✓	ON	✓	YES	✓	44.0 - 50.0 SEC.	49.0	OFF	✓	ON	✓	ON	✓	49.0
D1016	*VA-7D	OFF	✓	ON	✓	ON	N/A	YES	N/A	44.0 - 50.0 SEC.	N/A	OFF	✓	ON	✓	ON	N/A	

* TIMER OPERATE light, ON AUTO light, and TIMER OPERATE SIGNAL TO COMPUTER are operable only if 480V Breaker BT-1B3B is CLOSED. Write N/A in Check Boxes if the breaker is not closed.

Completed by [signature] Date/Time 9-28-95 / 1554
Operations

Reviewed by [signature] 9/28/95 1556
Shift Supervisor



Gould Inc. Cleveland, Ohio
1A3 Bus Voltage
DG-KW
1AD# Breaker Closure
Undervoltage to DG-1
DI Voltage
DG-1 Current
CH1
CH2
CH3
CH4
CH5
CH6
GOULD

18163

Attachment 8.8

G.E. Letter E.I. Hersh to Bob Mehaffey 8/15/78 Diesel Generator Exciter

GENERAL ELECTRIC

INSTALLATION AND SERVICE ENGINEERING DEPARTMENT

GENERAL ELECTRIC COMPANY 8401 WEST DODGE ROAD, SUITE 210
P.O. BOX 14210, OMAHA, NEBRASKA 68114, Phone (402) 397-4500

August 15, 1978

DIESEL GENERATOR EXCITER

Mr. Bob Mehaffey
Omaha Public Power District
Fort Calhoun Nuclear Station
Fort Calhoun, Nebraska 68025

Dear Bob:

On 8/9/78 the above exciter failed again under what we believe to be "similar conditions". On my arrival, the situation was discussed with our Product Design Engineer, Mr. Paul Luck in Salem, Virginia. The following was established:

1. The exciter rating is 100A, 117 volts.
2. One minute rating is 149A, 175 volts.
3. Operation above Item #2 over a longer period of time could produce blowing of fuses in the SCR circuit (100A).

Our next task was to operate the diesel, after the newly installed feference zener was exchanged. The following points were mentioned:

1. Field current (installed a shunt in field lead 200A = 50MV).
2. Field voltage.
3. Regulator voltage (point 60-61).
4. Current across 220 ohm resistor in series with reference zener.

The equipment was operated in parallel with the system for two hours loaded to 2500 KW P.F. of .9 voltage of 4160 to 4170V and 380A. KVAR's within 800 to 1050 range.

All of the monitored points showed satisfactory readings with the field current at 80 amp level and field voltage of 95 to 105V level. Oscilloscope observations across the field and across the SCR's produced normal patterns.

Mr. Bob Mehaffey
August 15, 1978

Our next task was to examine the computer trend readouts from prior operation that produced a failure. The following was established:

a) Prior to paralleling of the diesel, the bus voltage was 4155 volts.

b) On closing the diesel breaker, the bus voltage went up to 4174 and the generator loaded up to 1347 KVAR's (lagging) 314A and 1300KW.

From then on the operation (see attached graph) exhibited a rising characteristic and 50 minutes into the run a fuse blew in the SCR circuit. At that time the last computer reading showed 2051 KVAR, 445 A, 2436 KW and 4186 bus volts. There was no correction made by the operator. To estimate the actual exciter current output, it would be necessary to examine the generator saturation curve or re-duplicate the above condition with a shunt in the field circuit.

In summary, we do not believe that the newly installed zener corrected the situation. The exciter should exhibit drooping characteristics with load. Therefore, the following is suggested at the time of the next run:

a) Reinstall the shunt and monitor field current voltage.

b) After loading the generator to some load (KW) with about 250 to 300 amps output, momentarily short the droop C.T., the observed field current and output amps should <u>increase</u>. Should there be no change in the current, we could suspect the C.T. current and ratio should be verified with a clamp on the meter. Also recheck the droop circuit.

If all tests show correct compensation, it could be desirable to increase the droop compensation taps on the droop transformer (after a shutdown).

Also, Mr. Paul Luck suggested that the max. excitation limit could be energized (i.e. placed in the circuit) by a delay timer (30 seconds to one minute after initial black start) and then set to limit the exciter output to 120 to 125%, i.e. field current.

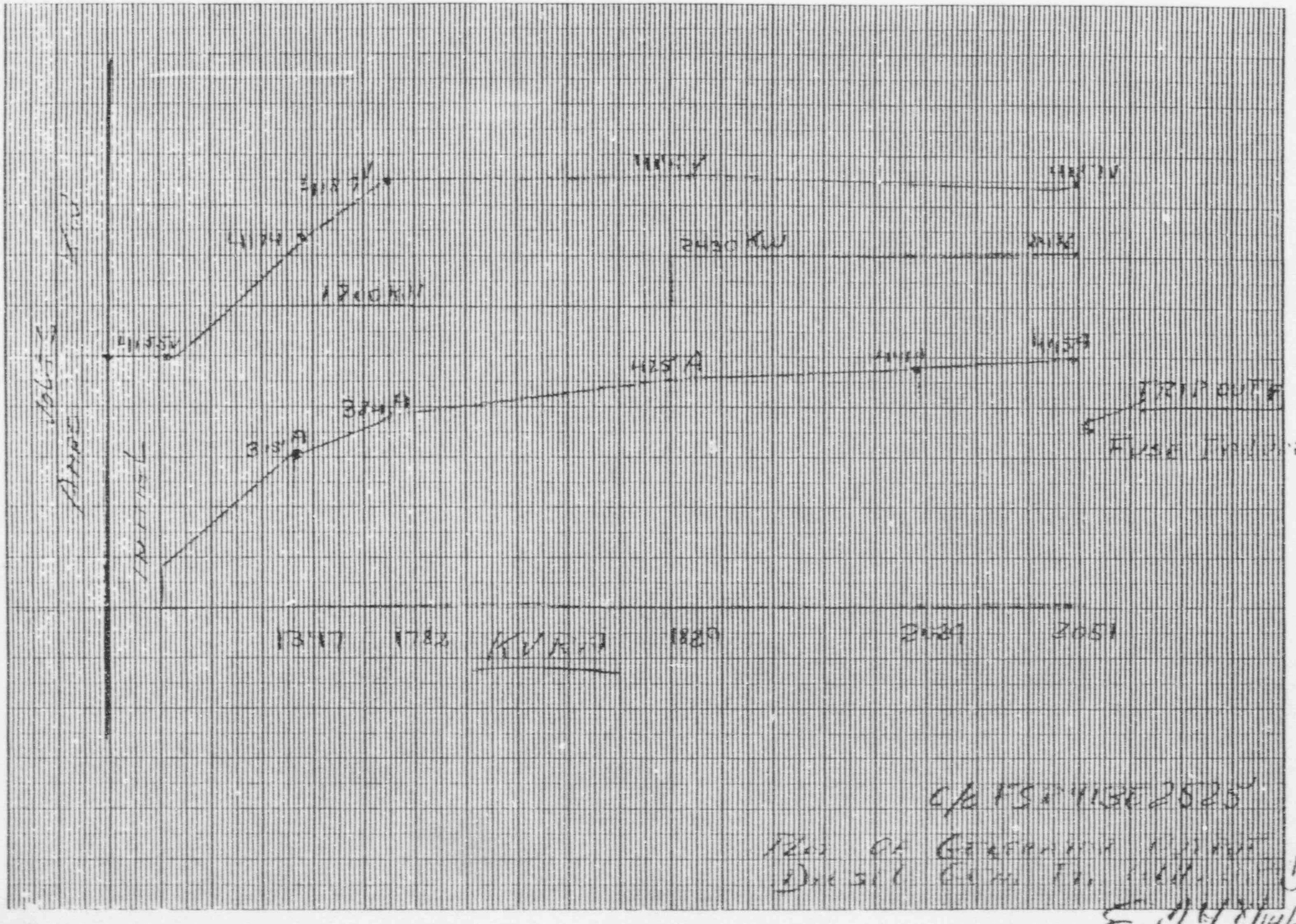
Should you have any questions, do not hesitate to call.

Yours truly,

E. I. HERSH
AREA ENGINEER

EIH/mlm

P.S. The voltage ripple between points 60-61 was calculated in Salem to be normal at one volt. If larger, the series choke should be checked.


Amps
Volts
Initial
4155V
4174
4187V
1740 KW
2430 KW
318A
384A
425A
1317
1782
KVAR
1880
2051
TRIP OUT
Fuse Failure