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March 30, 2012

PG&E Letter DCL-12-031
U.S. Nuclear Regulatory Commission

10 CFR 50.90

ATTN: Document Control Desk
Washington, DC 20555-0001

Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Response to NRC Request for Additional Information Regarding PG&E Letter DCL-11-072, "License Amendment Request 11-06, Revision to Technical Specification 3.3.5, 'Loss of Power (LOP) Diesel Generator (DG) Start Instrumentation'" dated October 10, 2011

References: 1. PG&E Letter DCL-11-072, "License Amendment Request 11-06, Revision to Technical Specification 3.3.5, 'Loss of Power (LOP) Diesel Generator (DG) Start Instrumentation'" dated October 10, 2011.

Dear Commissioners and Staff:

In Reference 1, Pacific Gas & Electric (PG&E) submitted License Amendment Request (LAR) 11-06 to revise the Operating Licenses to revise Technical Specification (TS) 3.3.5, "Loss of Power (LOP) Diesel Generator (DG) Start Instrumentation," to correct the nonconservative first level undervoltage relays TS limits contained in the current TS SR 3.3.5.3.

On March 1, 2012, the NRC staff requested additional information required to complete the review of LAR 11-06. PG&E's responses to the staff's questions are provided in the Enclosure.

This information does not affect the results of the technical evaluation or the significant hazards consideration determination previously transmitted in Reference 1.

PG&E makes no regulatory commitments (as defined by NEI 99-04) in this letter. This letter includes no revisions to existing regulatory commitments.

If you have any questions, or require additional information, please contact Tom Baldwin at (805) 545-4720.

I state under penalty of perjury that the foregoing is true and correct.

Executed on March 30, 2012.

Sincerely,

James R. Becker
Site Vice President

dngd/4955 SAPN 50462571
Enclosure
cc: Diablo Distribution
cc/enc: Gary W. Butner, Branch Chief, California Department of Public Health
Elmo E. Collins, NRC Region IV
Michael S. Peck, NRC, Senior Resident Inspector
Joseph M. Sebrosky, NRR Project Manager

PG&E Response to NRC Request for Additional Information for DCPP regarding TS 3.3.5

NRC Question 1:

Page 2 in Enclosure PG&E Letter DCL-11-072 of LAR states, "The current TS 3.3.5.3 Surveillance Requirement (SR) contains First Level Undervoltage Relay (FLUR) Technical Specification (TS) limits that are non-conservative for protection of engineered safety features (ESF) components during postulated sustained degraded grid voltage conditions in that some ESF equipment could trip on overcurrent and not be able to restart without operator action." Provide a list of ESF components that could trip on overcurrent due to sustained degraded grid voltage conditions and due to the existing nonconservative FLUR TS limits as stated above. Provide a summary of justification on how the proposed changes in TS SR 3.3.5.3.a for FLUR setpoint would prevent all ESF equipment from tripping on overcurrent and would prevent loss of ESF function.

PG&E Response:

The loads determined to be vulnerable to overcurrent tripping prior to actuation of the undervoltage load shed function and the subsequent separation of the onsite electrical distribution system from offsite power were identified in PG&E letter DCL-10-115, "Licensee Event Report 1-2010-002-00, Potential Loss of Safety-Related Pumps due to Degraded Voltage During Postulated Accidents," dated May 10, 2010. The specific loads are the component cooling water pump motors and the auxiliary saltwater pump motors.

The proposed TS SR 3.3.5.3(a) FLUR setpoint changes shorten the allowable undervoltage protective function time delay for bus voltages between the Second Level Undervoltage Relay (SLUR) setpoint and the Loss of Voltage setpoint. The resulting delays ensure coordination with existing ESF equipment overcurrent protection, without impacting the Loss of Voltage function, and still allow adequate delay for expected short duration disturbances. See the response to Question 2 for a list of calculations.

NRC Question 2:

Page 12 in Enclosure PG&E Letter DCL-11-072 of LAR states, "PG&E has analyzed the coordination between motor overcurrent protection settings and 4.16 kV bus undervoltage protection scheme and verified that the FLUR / Second Level Undervoltage Relay (SLUR) bus undervoltage protection function actuates before individual motor overcurrent protective devices. Thus, a sustained degraded voltage condition will not result in the loss of an ESF function…." Provide a summary and a copy of coordination study demonstrating that the FLUR/SLUR bus undervoltage protection device actuates before individual motor overcurrent protective devices and a sustained degraded voltage condition will not result in the loss of an ESF function.

PG&E Response:

A coordination study between the motor overcurrent relay settings and the 4 kV bus undervoltage protection scheme was performed to ensure that the bus undervoltage protective function actuates before individual motor overcurrent protective devices. To accomplish this, multiple simulations of low voltage operation were performed with the 4 kV vital busses set to selected fixed voltage levels (i.e. represented as an infinite bus). The simulations consisted of both starting and steady state operation of the ESF motors under the FLUR/SLUR allowable voltage conditions for the largest brake horsepower loading condition irrespective of the plant mode of operation.

Studies at 90 percent and 80 percent voltage were already part of the medium voltage 4 kV motor overcurrent setpoint methodology. These voltage values correspond with the minimum continuous and starting voltage ratings, respectively. Additional studies (both starting and running) were performed down to 60 percent to determine the minimum coordination margin. For voltage levels below 60 percent, the FLUR delay time is at the shortest interval and motor locked rotor currents are sufficiently reduced to ensure coordination. Coordination with the proposed FLUR setpoints was achieved for all motors.

Similar to the 4 kV motor overcurrent setpoint methodology, the existing thermal overload (TOL) protection of 460 Volt motors addressed voltages down to 80 percent. Additional studies were performed down to the 60 percent voltage level. For additional margin, the trip time corresponding to lower value obtained from the respective TOL time current curve was reduced by 3.4 seconds (3 seconds account for faster trip due to hot restart, if any) and a coordination margin requirement of 0.4 seconds.

The existing fuse selection criteria for fused motor loads require the fuse to be sized to carry motor locked rotor current for 10 to15 seconds for general purpose motors or 20 to 30 seconds for high inertia motors (e.g. period of time at least 1.5 times greater than the motor acceleration time). For fused non-motor chattering loads (e.g. starter coils and solenoids), the existing fuse selection criteria requires the fuse to carry inrush current for at least 15 seconds. Both criteria exceed the maximum proposed FLUR delay of 10 seconds.

The coordination studies summarized above are documented in the following calculations and attached to this Enclosure:

Attachment 1: Calculation 9000008518-16-1, 4 kV Motors
Attachment 2: Calculation 9000041185-1-0, 460 Volt Motors
Attachment 3: Calculation 9000032529-0-0, Fuse Adequacy Analysis Methodology

NRC Question 3:

Provide a summary and a copy of the coordination study for the largest load and also the most limiting component to show that starting or running these loads do not actuate protective devices and enough margins exist before any thermal damage occurs.

PG&E Response:

Both the largest load and the most limiting component was centrifugal charging pumps at 648 bhp. The minimum margin for coordination between the FLUR limit and the motor overcurrent protective device was 0.53 seconds, under accident loading conditions at 66 percent bus voltage (Reference: Derived from Calculation 9000008518-16-1, Attachment 1 to this Enclosure).

Attachment 1
Calculation 9000008518-16-1, 4 kV Motors

DCPP Form 69-20132 (04/13/10)

CF3.ID4 Attachment 4
Page 1 of 1

Design Calculation Cover Sheet

Unit(s): 1&2 File No.: ______ SAP Calculation No.: 9000008518-16

Design Calculation: ☒ YES ☐ NO System No.: 63 Legacy No.: 170-DC Rev 16A

Responsible Group: EDE Quality Classification: Q

Structure, System or Component: 63

Subject: Basler Class 1E 4kV Motor Overcurrent Relay Setpoints In support of SAPN 50301167 License Amendment Request

Computer/Electronic Calculation: ☒ YES ☐ NO

Computer ID	Application Name and Version	Date of Latest Installation/Validation Test
292307	PowerStation, V5.5.6N	9/05/10
	Including Review of Error Notices	

Calculation Page Index

Calculation Package	Contains pages	No. of pages
Cover Sheet	1	1
Record of revisions	2	1
Reason for Revision	3-4	2
Table of Contents	5	1
List of Attachments	6	1
Calculation body	7-19	13
Appendices	20-94	75
Attachments 1 thru 20	95-171	77
Attachments 21 thru 29	172-7208	7037
Calculation Checklist	7209-7211	3
TOTAL		7211

DCPP Form 69-21457 (04/07/10)

CF3.ID4 Attachment 5
Page 1 of 1

Design Calculation Record of Revisions

SAP Calculation No.: 9000008518-16-01

Legacy No.: 170-DC Rev 16A

Rev No./ Ver. No.	Status	Pages affected	Reason for Revision (Requesting Document No.)	Prepared By	LBIE AD/ Screen	LBIE Eval	Check Method*	LBIE Evaluation Approval		Checked	Supervisor	Registered Professional Engineer	Owner's Acceptance per CF3.ID17
				Initials/ LAN ID/ Date	Yes/ No/ NA	Yes/ No/ NA		PSRC Mtg No.	PSRC Mtg Date	Initials/ LAN ID/ Date	Initials/ LAN ID/ Date	Signature/ LAN ID/ Date	Initials/ LAN ID/ Date
16-1	P	All	See Page 3, and SAPN 50301167 License Amendment Request	DEHF [signature] 5/5/2011	[ ] Yes X No [ ] N/A	[ ] Yes X No [ ] N/A	X A [ ] B [ ] C	N/A	N/A	HAM8 [signature] 5-5-2011	PLJ6 [signature] 5-5-11	DEHF [signature] 5/5/2011	N/A
					[ ] Yes [ ] No [ ] N/A	[ ] Yes [ ] No [ ] N/A	[ ] A [ ] B [ ] C						
					[ ] Yes [ ] No [ ] N/A	[ ] Yes [ ] No [ ] N/A	[ ] A [ ] B [ ] C						
					[ ] Yes [ ] No [ ] N/A	[ ] Yes [ ] No [ ] N/A	[ ] A [ ] B [ ] C						

* Check Method: A = Detailed Check B = Alternate Method (note added pages) C = Critical Point Check

A. Insert PE stamp or seal below:

LICENSED PROFESSIONAL ENGINEER
DAVID EUGENE HARTMAN
NO. E16772
ELECTRICAL
STATE OF CALIFORNIA

: Expires 9/30/2012

5/5/2011

B. Insert stamp directing to the PE stamp or seal:

REASON FOR REVISION

Calculation No. 170-DC

REVISION NO.	DESCRIPTION OF REVISION
0	2/8/90-Initial Issue
1	3/12/90-Add Spare GE RHR Motor; Added pages 80A-E and Attachment 24
2	4/17/90-Add Spare GE Motors; Added pages 80F-80W; Attachment 25 through 28; corrected typo on pages 44, 67, 72, 75
3	5/30/90-Revised settings for CCW PP motor; Revised Sheets 53-58, 86 & 88; Added Attachment 29
4	5/30/90-Revised settings for Spare AFW12 motor; added sheets 88X-88AB & Attachment 30 &31
5	1/24/92-Revised setting and acceleration time for CCW PP motor, sheets 17-22, 54, 56-58
6	4/21/94-Revised pages 31, 33, 34, 35, 88 for ASW motor 12; Added Attachment 32
7	10/4/94-Revised settings for CSP22; Revised page 63, 65, 66 and added page 66A (See AR 0352677); Revised Attachment 9 with 7 pages total
8	2/27/95-Revised calc. per Mech. Eng. Memo CHRON #219798, ASW PP Revised pages 31, 33, 34, 35, 67, 69, 70, 71, 88; Added Attachment 33
9	9/28/95-Completely revised for setting the new Basler Electric Overcurrent Relays. Coordination curves plotted using SKM Power Tools Program CAPTOR Version 4.5. Incorporated Interim Rev. 8A
10	1/10/96-Revised SI PP BHP to 434HP; Revised page 29-33; Added Attachment 11
11	4/11/96-Revised CCP 1-2 pump BHP to 620 HP. Revised page # 17, 18, 19, 20 and Attachment# 11.
12	7/25/96-Created new electronic file for this calc. from the hard copy of Rev. 11. Revised calc. per AR# A0337269 and A0404091. Revised pages 9, 10, 11, 17, 18, 20, 29, 32, 33, 36, 39, 47, 48, 49, 50 & 51.
13	11/4/97-Revised the Time Dial Setting of Unit 2 AFW Pump Overcurrent Relays 51HF9 and 51HH8 per AR# A0446903. Revised Sheets 10, 14 and 16. Added Figure 6.1A.
14	3/17/98-Revised the Time Dial Setting of Unit 2 AFW Pump Overcurrent Relays 51HF9 and 51HH8 from Time Dial 3 to Time Dial 2 per AR# A0446958. Revised Sheets 8, 10, 14 and 16. Deleted Figure 6.1A and references to Electrical Device Lists.
15	7/27/98-Corrected Unit 1 RHR PP motor BKR and Relay numbers from HG7 and HG9 to HG8 and HH11, respectively; Corrected typo. Error 62HH11 to 52HH11 for HRH PP 2-2; Revised paragraph 6.7.10; Revised RHR PP BHP from 425 to 420 and SI PP BHP from 417HP to 434HP per Attachment 11; Revised sheets 9, 10, 11, 14, 20, 26, 33, 39, 44, 47, 48, 49 and 54; Heading of "Device List Input Data" revised to "Component Database Input Data" throughout the calculation; Deleted GE motor data from the Attachments

16	5/05/11-Calculation is re-formatted and revised in it's entirety per CF3.ID4 Rev. 18, and therefore, no revision bars are shown; Incorporated interim change 15A; Deleted References 4.5, 4.7, 4.8 and 4-18; Added References 12.1.1f, 12.1.2a, 12.1.3a; Revised motor models to become the dynamic models presently in references 12.1.2b, 12.1.2c, 12.1.2d and eliminated section related to calculating acceleration time, determining motor short circuit fault contribution and modeling motor as a fixed impedance during acceleration and a constant KVA load during steady state conditions; Expanded motor voltage studies to include motor starting at 75% bus voltage and below; Ran new motor starting cases for all voltage breakpoints and re-plotted TCCs for each voltage studied; Added Assumption 3.4; Added Acceptance Criteria 6.1.4; Added Thermal Limit Curve and Motor Data to Attachment 6;
16A	5/05/11-Calculation is revised to incorporate the impact of changing the existing FLUR bus undervoltage protection scheme in support of License Amendment Request referenced in SAPN 50301167; Added references 12.1.2f, 12.1.4c, 12.1.4d, 12.1.4e

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ATTACHMENTS

1.0 PURPOSE

Provide the setting for the Basler Electric overcurrent relays used in overcurrent protection of 4 kV Class 1E (safety-related) motors that meets both the design criteria established in Section 5.1 and the Acceptance Criteria established in Section 6.0.

2.0 BACKGROUND

Prior to Revision 16, the calculation evaluated setting adequacy at 90%, 80%, 110% and 125% of base voltage. Beginning with Revision 16, additional evaluations are performed to determine setting adequacy at degraded voltage values between 75% and 60% in order to ensure coordination with the Vital 4 kV bus undervoltage protection scheme (i.e. degraded voltage). All motor starts are dynamically simulated in PowerStation Version 5.5.6N (ETAP). The resulting motor acceleration profiles are plotted together with the calculated protective relay settings on time current curves (TCC) generated via ETAP software. ETAP Version 5.5.6N is under SQA control.

3.0 ASSUMPTIONS

3.1 Motor loading shall be equal to brake horsepower (BHP) or motor nameplate data, whichever is higher.

Basis: This is conservative for determining overcurrent protection settings.

3.2 Motor Inrush asymmetry factor is assumed to be 1.76 times maximum inrush for the Time Current Curves plotted in Section 8.

Basis: This is conservative, as the inrush is already adjusted for voltage in the motor starting TCC's (Ref. 12.1.1b, 12.1.1f).

3.3 Motor fault contribution is assumed to be equal to asymmetrical locked rotor amperage at 125% bus voltage.

Basis: These values bound the worst case short circuit contribution for the motors found in Reference 12.1.2c, Design Basis Short Circuit Summary Runs 201 and 204.

3.4 For coordination of FLUR 4 kV Bus undervoltage protection with the 51 device motor overcurrent protection, the FLUR solid state undervoltage relay function is assumed to have the same allowable margin for coordination as the time current range for a standard inverse time overcurrent relay (Ref. 12.1.1f Section 4.4).

Basis: This is conservative since both devices are solid state relays.

4.0 INPUTS

4.1 The following design guidelines were considered when setting phase overcurrent relays for Class 1E 4 kV motors:

4.2 Long-time minimum trip current should be calculated with the margin from 0% to 15%, preferably 1% to 10% above the maximum possible motor continuous current. Margin of the long-time minimum trip current with respect to maximum motor continuous current should be calculated based on the undervoltage, service factor and taking into account the relay/device curve repeatability tolerances and maintenance relay setting tolerances.

4.2.1 Maintenance relay setting tolerance per Reference 12.1.1e is ± 5%.

4.2.2 Per Reference 12.1.4, the repeatability of the Basler overcurrent relays is within ± 2% of setting. Adding 1% margin for design conservatism, makes the repeatability tolerances total to ± 3%.

4.2.3 Margin of minimum instantaneous trip current with respect to maximum motor asymmetrical short-circuit current should be maintain to at least 1%. Calculate margin per guideline of long-time trip setting.

4.2.4 Motor parameters entered into PowerStation are per (Ref. 12.1.2b)

4.2.5 Motor short circuit contribution is per (Ref. 12.1.2c).

4.2.6 DCPP electrical system including all of the 4 kV Class 1E motors are modeled in ETAP. A common model is used for Load Flow, Short Circuit, Motor Starting, and dynamic analysis of offsite power (230 kV) in References 12.1.2c and 12.1.2d. The same dynamic motor models were used as an input to this calculation for the purpose of computing motor acceleration performance.

4.2.7 The motor damage curves incorporated in this calculation have been added to the common ETAP model.

5.0 METHODOLOGY

The settings were calculated in accordance with the design criteria discussed below. Reconciling differences in competing criteria were resolved in favor of completing the safety function of the Class 1E equipment. This would include small variations in motor full load ampere requirements resulting from motor repairs / replacements.

5.1 The following design criteria was considered for setting the phase overcurrent relays of Class 1E (safety-related) 4 kV motors:

5.1.1 90% of motor kV base shall be used as the minimum steady state voltage at the motor terminals (Ref. 12.1.1a, 12.1.2c, 12.1.2d).

5.1.2 80% of motor kV base shall be used as the minimum starting voltage at the motor terminals during normal operating conditions, excluding degraded voltage conditions that result in separation from offsite power due to actuation of undervoltage protection (Ref. 12.1.1a, 12.1.2c, 12.1.2d).

5.1.3 110% of motor kV base shall be used as the maximum (running and starting) voltage at the motor terminals except during motor starting after bus transfer (Ref. 12.1.2c, 12.1.2d).

5.1.4 125% of nominal bus kV shall be used as the maximum starting voltage at the motor terminals during motor restart under bus transfer condition (Ref. 12.1.1a).

5.1.5 Voltages below 75% of nominal bus kV shall be used to aid in determining that motor overcurrent protection does not trip during short term degraded voltage conditions allowed by the vital bus first level undervoltage protection scheme (i.e. FLUR).

5.1.6 75% of nominal bus kV shall be used to aid in determining margin for the vital bus second level undervoltage protection scheme (i.e. SLUR).

5.1.7 Motor safe operating (heating) curve obtained from the vendor shall be verified to ensure the long-time overcurrent settings are in the safe region.

5.1.8 An overcurrent coordination study between motor overcurrent relay settings and incoming supply breaker relay settings shall be performed to establish coordination adequacy per the coordination time intervals given in (Ref. 12.1.1b, 12.1.1c, 12.1.1f). For the coordination study, the vendor supplied minimum/maximum protective device's time-current (TCC) curves are used.

5.2 Low Voltage Common Mode Failure: A coordination study between the motor overcurrent relay settings and the 4 kV bus undervoltage protection scheme shall be performed to ensure that the FLUR/SLUR bus undervoltage protection function actuates before individual motor overcurrent protective devices. This is necessary to preclude a common mode loss of redundant ESF equipment should a low voltage condition be present. To accomplish this, the 4 kV busses were set to several fixed voltage levels (i.e. represented as an infinite bus). Five different "Runs" were done to simulate the motor operating conditions of interest. The runs consisted of both starting and steady state operation of the ESF motors under the FLUR/SLUR allowable voltage conditions.

5.2.1 Run ESF-Mtr-90:

Bus voltage was fixed at 90% of motor kV base rating to evaluate worst case steady state conditions where the motor is expected to run continuously. Steady state current was identified to determine margin for the Long Time minimum trip setting.

5.2.2 Run ESF-Mtr-125:

Bus voltage was fixed at 125% of nominal bus kV, which is the maximum expected bus voltage under bus transfer conditions. The motors were started to determine margin for motor inrush. After steady state was reached, bus voltage was step changed to 100% of nominal bus kV to determine margin for the Long Time minimum trip setting.

5.2.3 Run ESF-Mtr-110

The following motors had damage curves that extended below the 51 device TOC trip value: Unit 1 and Unit 2 CCP1, CCP2, RHRP1 and RHRP2. For these motors, bus voltage was set to provide greater than or equal to 110% of motor terminal voltage at the motor terminals. This was done to determine the intersection of the initial symmetrical locked rotor current and the trip curve/damage curve in order to establish margin between the damage curve and locked rotor amperage.

5.2.4 Run ESF-Mtr-75:

This run started the motors at 75% of nominal bus kV. Motor starting terminal voltage was verified to be less than or equal to 80% of motor kV base rating. Motor current was identified at 20 seconds, which corresponds to the time the second level undervoltage relay (SLUR) is asserted under these conditions to determine margin for tripping on undervoltage. After steady state conditions were reached, bus voltage was step changed to 65% of nominal bus kV to determine motor performance during degraded voltage conditions.

5.2.5 Run ESF-Mtr-60:

This run started and ran the motors at 60% of nominal bus kV. The time to trip was identified, to determine margin for the first level undervoltage relay (FLUR) to operate prior to the motors tripping on the Long Time minimum trip setting.

5.3 Loss of Function (FLUR/SLUR) Margin: The time to trip the First Level undervoltage protection (FLUR) device 27H(F,G,H)T1(A,B,C) is modeled in Reference 12.1.2f as three discrete bus voltage ranges associated with three fixed time delays. The Second

Level undervoltage protection (SLUR) is a specific bus voltage with a fixed time delay. Margin between the 4 kV bus undervoltage relay actuation and the 50/51 device actuation was determined by comparing specific trip times and bus voltage levels for the motor 50/51 devices with respect to the bus undervoltage curves.

The FLUR is modeled in Reference 12.1.2f as described in Table 5.3.1:

Table 5.3.1 FLUR 4 kV Bus Undervoltage Function

27 Device ID /FLUR Function	4 kV % Bus Voltage (Δv)	Trip Time (Δt)
FLUR Function	(Δv) > 80%	No Trip
27H(F,G,H)T1A	75% < (Δv) < = 80%	10 seconds
27H(F,G,H)T1B	65% < (Δv) < = 75%	6 seconds
27H(F,G,H)T1C	(Δv) < = 65%	4 seconds

Bus voltages were obtained at critical times during motor starting and compared to the Δt at that voltage to determine whether the relay was challenged, and if it reset without asserting the FLUR function.

A degraded voltage condition coincident with a postulated design basis accident is considered credible and taken to occur at the same time as the design basis accident. In order for this to occur, the degraded voltage event must happen immediately after a successful transfer to offsite power, because the transfer can only take place if offsite power 4 kV source is initially at an acceptable voltage level. All actions the electric power system is designed to automatically initiate are assumed to occur as designed.

FLUR trip times for bus voltages between 60% and 75% were calculated in increments of 2%, and the resultant trip times were compared to trip times for estimated motor locked rotor current by using the 60% locked rotor current as the base, and scaling it by the ratio of the change in per unit voltage (e.g., 2% increase in voltage resulted in a 2% increase in locked rotor current). This indicated that margin decreased for bus voltages between 60% and 66%. Therefore, additional ETAP runs were performed to establish margin:

5.3.1 Run ESF-Mtr-66A:

Bus voltage was fixed at 66% with design basis accident loading for all ESF motors. TCCs from this Run for Unit 1 CCP1, CCWP3, and RHRP2 were added to Appendix 1 because these 50/51 devices had the least margin from Run ESF-Mtr-60. The results were evaluated in order to determine margin between the 50/51 devices and the bus undervoltage protection (FLUR/SLUR).

5.3.2 Run ESF-Mtr-66N:

Under non-accident conditions, bus transfer will occur with the motors loaded to non accident loading levels, and any running pumps will re-energize at the same time the bus is re-energized from offsite power. The worst case starting transient will occur if the motors came to a stop prior to being re-energized, so the following run was done to start the motors under non accident conditions:

Bus voltage was fixed at 66% with non accident loading for all ESF motors. TCCs from this run for Unit 1 CCP1, CCWP3, and RHRP2 were added to Appendix 1 because these 50/51 devices had the least margin from Run ESF-Mtr-60. The results were evaluated in order to determine margin between the 50/51 devices and the bus undervoltage protection (FLUR/SLUR).

5.3.3 Run ESF-Mtr-67A:

In order to establish that margin is increasing, a run was done at a bus voltage of 67%. Since accident loading and non accident loading were the same for the motor with the least margin (CCWP3), from Run ESF-Mtr-66A(N), only accident loading was considered.

Bus voltage was fixed at 67% with accident loading for all ESF motors. TCCs from this run for Unit 1 CCP1, CCWP3, and RHRP2 were added to Appendix 1 because these 50/51 devices had the least margin from Runs ESF-Mtr-66A and ESF-Mtr-66N. The results were evaluated in order to determine margin between the 50/51 devices and the bus undervoltage protection (FLUR/SLUR).

5.3.4 Run ESF-Mtr-68A:

An additional run was done to determine that all motors transitioned from starting to steady state values.

Bus voltage was fixed at 68% with accident loading for all ESF motors. TCCs from this run for Unit 1 CCP1, CCWP3, and RHRP2 were added to Appendix 1 because these 50/51 devices had the least margin from Runs ESF-Mtr-66A and

ESF-Mtr-66N. The results were evaluated in order to determine margin between the 50/51 devices and the bus undervoltage protection (FLUR/SLUR).

6.0 ACCEPTANCE CRITERIA

The relay settings shall conform to the following:

6.1 Instantaneous overcurrent pickup shall be set so that relay does not trip on the following events (Ref. 12.1.1b):

6.1.1 During the motor starting inrush period.

6.1.2 When the motor contributes to a fault during an external short circuit condition.

6.1.3 Upon automatic bus transfer.

6.1.4 Prior to FLUR/SLUR undervoltage protective function actuation (Ref. 12.1.4a).

6.2 The acceptable minimum margin for coordinating inverse time overcurrent relays is 0.3-0.4 seconds (Ref. 12.1.1b, 12.1.1c, 12.1.1f).

6.3 The acceptable minimum margin for coordinating solid state relays for time current ranges is 0.25 seconds (Ref. 12.1.1f and Assumption 3.4).

6.4 As a minimum, 4 kV motor overcurrent relay settings shall meet the following criteria to address margin:

6.4.1 Long Time Settings: Long-time trip current shall maintain at least 1% margin with respect to motor running current under worst BHP and minimum voltage conditions.

Basis: Given the maximum continuous steady state current of the motor, relay time overcurrent settings (TOC) should be set so that with the worst possible maintenance tolerance and repeatability error of the device, it will yield at least 1% margin. With 0% margin, the relay will be very close to tripping but will not trip.

% Margin (TOC) = ((Min. Relay Trip Current / Max. Steady. State Current)-1)x100

The minimum (TOC) relay trip current shall be determined by the following:

Min. Relay Trip Current (TOC) = (Max. Motor Steady State Current)x(MT)x(RE)

Where,

MT = (Maintenance Tolerance) (Ref. 4.2.1)

RE = (Repeatability Error) (Ref. 4.2.2)

6.4.2 Instantaneous Settings: Instantaneous trip (IT) current shall maintain at least 1% margin with respect to motor maximum asymmetrical starting inrush current under worst possible maximum voltage conditions

Basis: Given the maximum asymmetrical inrush current of the motor, relay instantaneous setting be set so that with the worst possible maintenance tolerance and repeatability error of the device, it will yield at least 1% margin under worst BHP and maximum voltage conditions.

With 0% margin, the relay will be very close to tripping but will not trip.

% Margin (IT) = ((Min. Relay Trip Current / Max. Transient Current)-1)x100

6.5 Coordination: Coordination between motor feeder breaker overcurrent relay settings and incoming feeder breaker overcurrent relay settings will be based on the highest motor overcurrent trip current for a given bus. This represents the worse case, and if it coordinates, then it is concluded that all other motor overcurrent relays on the subject bus are coordinated.

7.0 CALCULATION

Motor starting plots versus relay Time Current Curves (TCCs) used to evaluate the calculated settings were all generated by PowerStation software package. Refer to Appendix 2 for the individual setting calculation worksheets. Both calculated values and dynamic simulations were used to determine the device settings.

8.0 RESULTS

A summary of the device setpoints are contained in Tables 8-1 and 8-2:

Table 8-1 Unit 1 4kV Class 1E Motor 50/51 Device Setting Summary
Basler Model BE1-50/51B-107

Motor ID	50/51Device ID	CT Ratio	Tap Setting	Time Dial Setting	Inst. Setting (Amps)	Curve ID
1-AFWP3	51HF9	20.0	4.8	2.0	43	L
1-AFWP2	51HH8	20.0	4.8	2.0	43	L
1-CCP1	51HF11	30.0	3.5	0.9	31	L
1-CCP3	51HG11	30.0	3.5	1.0	35	L
1-CCP2	51HG9	30.0	3.5	0.9	31	L
1-SIP1	51HF15	15.0	4.8	1.5	35	L
1-SIP2	51HH15	15.0	4.8	1.5	35	L
1-RHRP1	51HG8	15.0	4.8	1.0	42	L
1-RHRP2	51HH11	15.0	4.8	1.0	42	L
1-CSP1	51HG7	15.0	4.6	0.8	43	L
1-CSP2	51HH9	15.0	4.6	0.8	43	L
1-CCWP1	51HF12	15.0	4.9	1.0	43	L
1-CCWP2	51HG12	15.0	4.9	1.0	43	L
1-CCWP3	51HH12	15.0	4.9	1.0	43	L
1-ASWP1	51HF8	15.0	5.2	1.5	48	L
1-ASWP2	51HG6	15.0	5.2	1.5	48	L

Table 8-2 Unit 2 4kV Class 1E Motor 50/51 Device Setting Summary Basler Model BE1-50/51B-107						
Motor ID	**50/51Device ID**	**CT Ratio**	**Tap Setting**	**Time Dial Setting**	**Inst. Setting (Amps)**	**Curve ID**
2-AFWP3	51HF9	20.0	4.8	2.0	43	L
2-AFWP2	51HH8	20.0	4.8	2.0	43	L
2-CCP1	51HF11	30.0	3.5	0.9	31	L
2-CCP3	51HG11	30.0	3.5	1.0	35	L
2-CCP2	51HG9	30.0	3.5	0.9	31	L
2-SIP1	51HF15	15.0	5.0	1.5	35	L
2-SIP2	51HH15	15.0	5.0	1.5	35	L
2-RHRP1	51HG8	15.0	4.8	1.0	42	L
2-RHRP2	51HH11	15.0	4.8	1.0	42	L
2-CSP1	51HG7	15.0	4.6	0.8	43	L
2-CSP2	51HH9	15.0	4.6	0.8	50	L
2-CCWP1	51HF12	15.0	4.9	1.0	43	L
2-CCWP2	51HG12	15.0	4.9	1.0	43	L
2-CCWP3	51HH12	15.0	4.9	1.0	43	L
2-ASWP1	51HF8	15.0	5.2	1.5	48	L
2-ASWP2	51HG6	15.0	5.2	1.5	48	L

9.0 MARGIN ASSESSMENT

9.1 Motor Protection (50/51 Device) Margin: Calculated margin is given in Appendix 2.

9.1.1 Margin was also established by comparing the calculated settings to the ETAP simulations contained in Appendix 1 where the selected setting resulted in negative calculated margin (see Sections 5.2.1, 5.2.2, 5.2.3, 5.2.4 and 5.2.5 for a description of the different simulations).

9.2 FLUR Coordination with Motor Overcurrent Protection

9.2.1 Run ESF-Mtr-60:

For this run, Load sequencing timers begin loading the first ESF loads, (Centrifugal Charging Pumps 1 and 2) at 1.5 seconds post-transfer, assuming worst case timer uncertainty of -0.5 seconds (Ref.12.1.1a Table 4.3-3) (nominal sequencing timer setpoint is 2.0 seconds). FLUR time to trip is 4 seconds. Therefore, at 60% bus voltage, the 50/51 device for Centrifugal Charging Pumps 1 and 2 will trip at 8.5 seconds (7+1.5), yielding 4.5 seconds of margin between the FLUR trip time and the motor overcurrent protection trip time.

9.2.2 Run ESF-Mtr-66A:

The minimum trip time was for CCP1 at 8.0 seconds (6.5+1.5). For this value, the FLUR trips at 6 seconds yielding 2 seconds of margin between the FLUR trip time and the motor overcurrent protection trip time.

9.2.3 Run ESF-Mtr-66N:

CCWP3 had the least margin, with the 50/51 device tripping at 7.4 seconds. For this value, the FLUR trips at 6 seconds yielding 1.4 seconds of margin between the FLUR trip time and the motor overcurrent protection trip time.

9.2.4 Run ESF-Mtr-67A:

The results show CCP1 had the least margin tripping at 8.0 seconds (6.5+1.5) seconds. The FLUR trips at 6 seconds yielding 2 seconds of margin between the FLUR trip time and the motor overcurrent protection trip time. The CCWP3 had increased margin with respect to the FLUR time to trip.

9.2.5 Run ESF-Mtr-68A:

The results show that all 50/51 devices came to steady state at 68% bus voltage and had increased margin with respect to the FLUR time to trip. Between 67% and 68% bus voltage, there is a negligible change in margin.

9.3 SLUR Coordination with Motor Overcurrent Protection

9.3.1 For sustained degraded voltage below the SLUR trip avoidance limit of 92.55% bus voltage, the SLUR function will terminate the undervoltage in 20 seconds. For a 4kV bus voltage of 75%, all ESF motors are in steady state and will not trip on overcurrent at 20 seconds. There is ample margin for continued steady state operation past 20 seconds to eliminate the need for other than a qualitative statement (Refer to Appendix 1 TCC's for 75% Bus Volts). For voltages above the maximum FLUR trip setting and below the SLUR trip avoidance limit, there will be increased margin above that at 75% bus voltage, and the SLUR will continue to terminate the undervoltage condition in 20 seconds. Thus, all 50/51 devices are coordinated with the SLUR.

10.0 CONCLUSIONS

The settings determined in the calculation conform to the design and acceptance criteria.

11.0 IMPACT EVALUATIONS

None

12.0 REFERENCES

12.1 Input References

12.1.1 DCM / Standards / Maintenance Procedures

a. DCM S-63, 4160 Volt System, Rev. 15A

b. ANSI/IEEE Standard 242-1986, IEEE Recommended Practice for Protection and Coordination of Industrial Power Systems.

c. IEEE Paper on "Standardization of Benchmarks for Protective Device Time-Current Curves", IEEE Transactions on Industry Applications, Vol. 1A-22, No. 4, July/August 1986

d. EPRI, Power Plant Electrical Reference Series on "Motors", 1987

e. MPE-50.55, "Electrical Maintenance Procedure, Basler Type BE1-50/51B Overcurrent Relay Maintenance, Units 1 and 2

f. DCM T-18, Electrical System Protection, Rev. 11A

12.1.2 Calculations

a. Calculation 9000040769, Rev. 0, (M-1141) Maximum EDG Mechanical Loading

b. Calculation 9000033440, Rev. 6, (357F-DC) Guidelines for Motor Data Entered Into ETAP Database

c. Calculation 9000033359 Rev. 13A, (357A-DC) Units 1&2 Load Flow, Short Circuit and Motor Starting

d. Calculation 9000033535, Rev. 9, (359-DC) Determination of 230 kV Grid Voltage Limits for DCPP System Operating Instruction O-23

e. Calculation 9000006090 Rev. 8, (114-DC) Protective Relay Settings for 4kV Class 1E Bus and Feeders

f. Calculation 9000041128 Rev. 0, (357S-DC) Units 1 & 2 4.16 kV Bus FLUR and SLUR Setpoint Calculation

12.1.3 Component Database / Drawings / Design Change Notices (DDN)

a. SAP Functional Location (FLOC) Component Database

b. Motor Time-Current and Thermal Limit, DC-663210-331-1

c. DDN 2000000113, Replacement of Positive Displacement Pump, Unit 1

12.1.4 Miscellaneous

a. Basler Publication 9 2520 00 991, Rev. 0, 663332-80

b. SAPN 50301167, LTCA CDBI: Unanalyzed Condition 230 kV

c. Letter, NRC to PG&E, dated December 14, 2009, "Technical Specification Interpretation of 230 Kilovolt System Operability (TAC Nos. ME0711 and ME0712)"

d. Letter, NRC to PG&E, dated July 7, 2010, "Response to the Pacific Gas and Electric Company Request For Diablo Canyon Power Plant Technical Specification Interpretation of the 230 Kilovolt System Operability (TAC Nos. ME3346 and ME3347)"

e. SAPN 50289590, Review of 230 kV Conformance With the Design and Licensing Basis

12.2 Output References

12.2.1 None

12.3 Other

12.3.1 Drawings

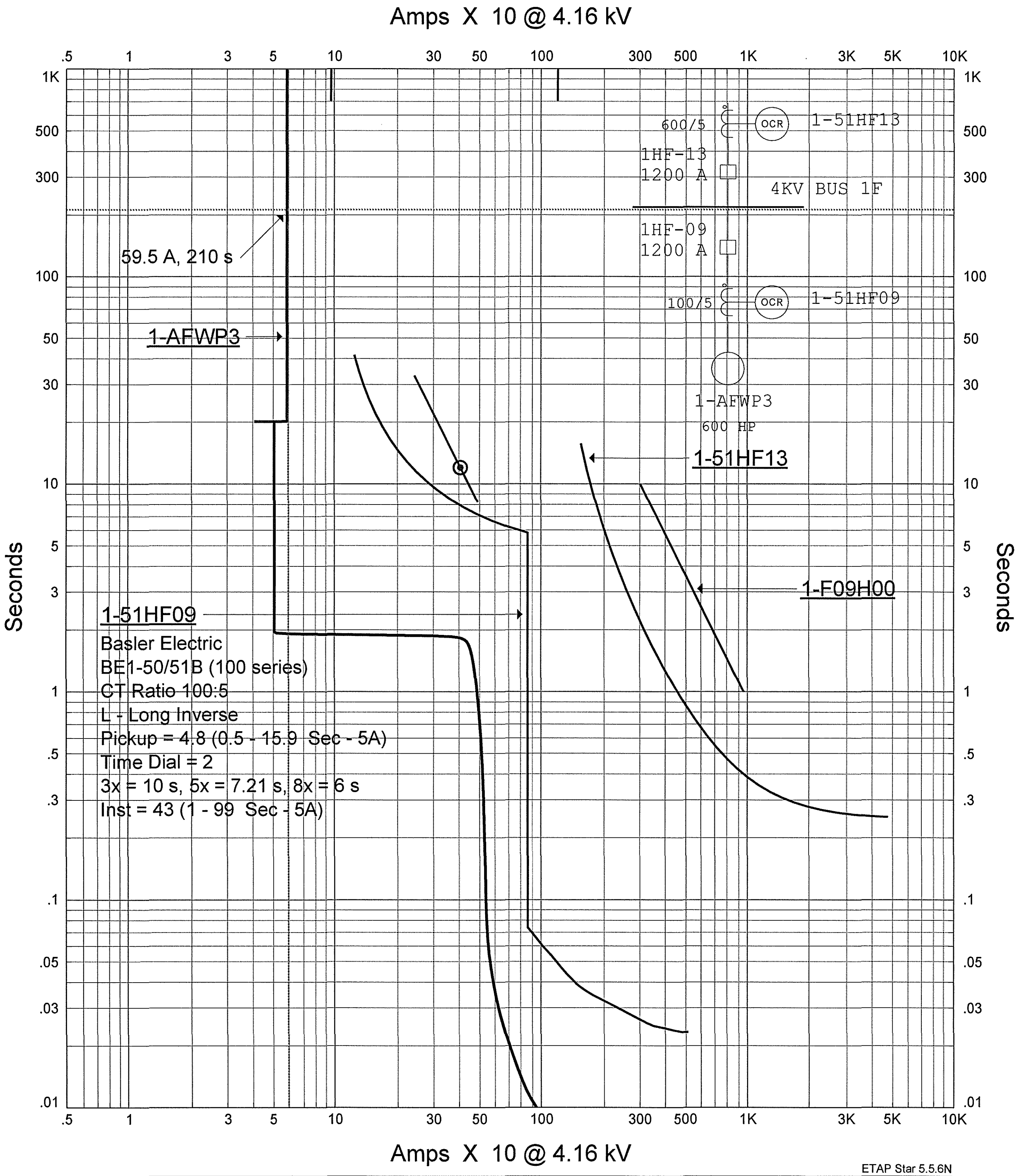
a. Single Line Diagram, 4160 Volt System, Unit 1, 437533, Rev. 40

b. Single Line Diagram, 4160 Volt System Bus Section F, Unit 2, 441229, Rev. 17

c. Single Line Diagram, 4160 Volt System Bus Sections G and H, Unit 2, 441230, Rev. 26

13.0 ENCLOSURES AND ATTACHMENTS

See the Table of Contents.

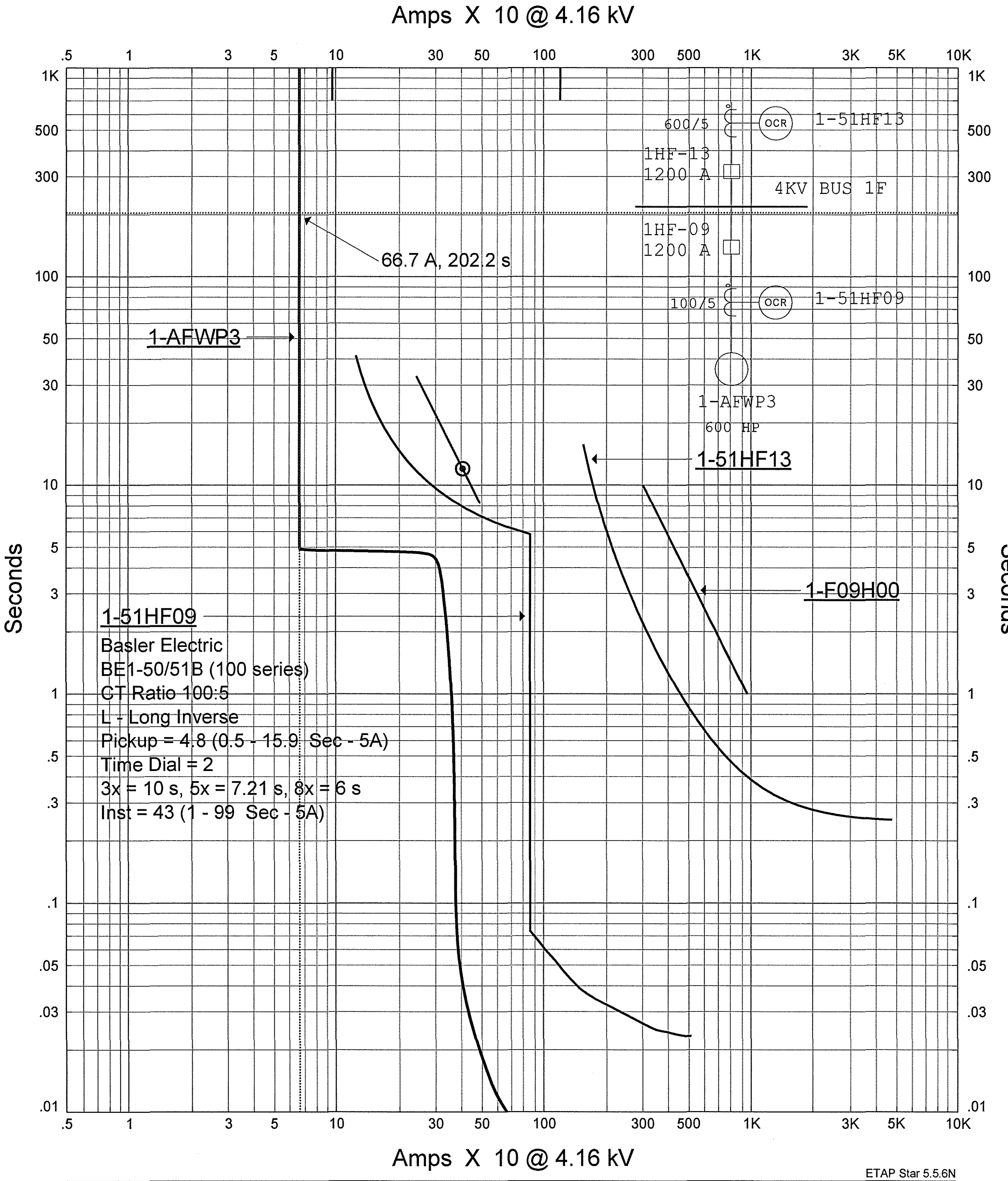


125% Bus Volts Start	**AFW3**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-125

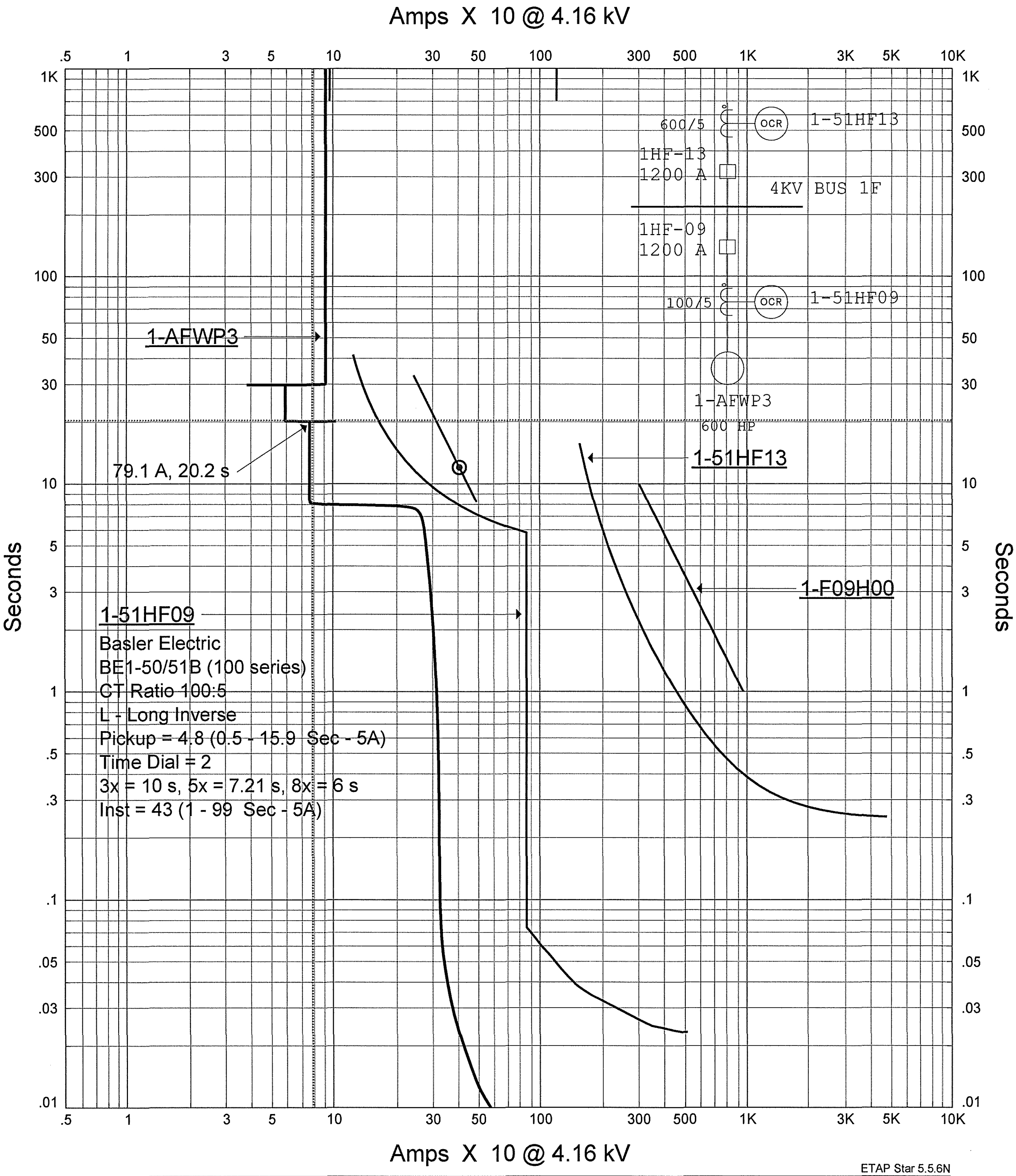


90% Mtr. Term. Volts Start	**AFW3**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



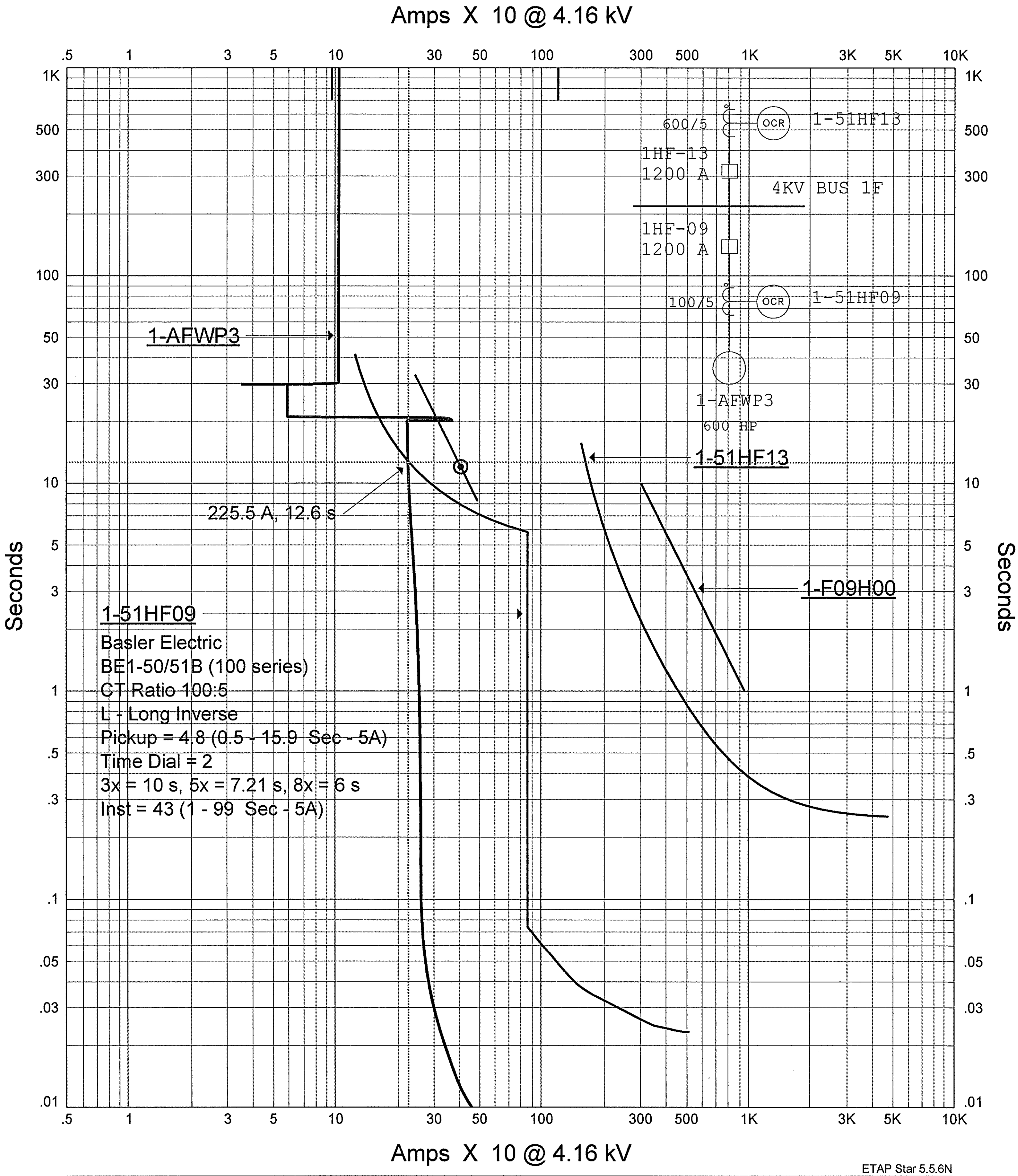
ETAP Star 5.5.6N

75% Bus Volts Start	**AFW3**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-75

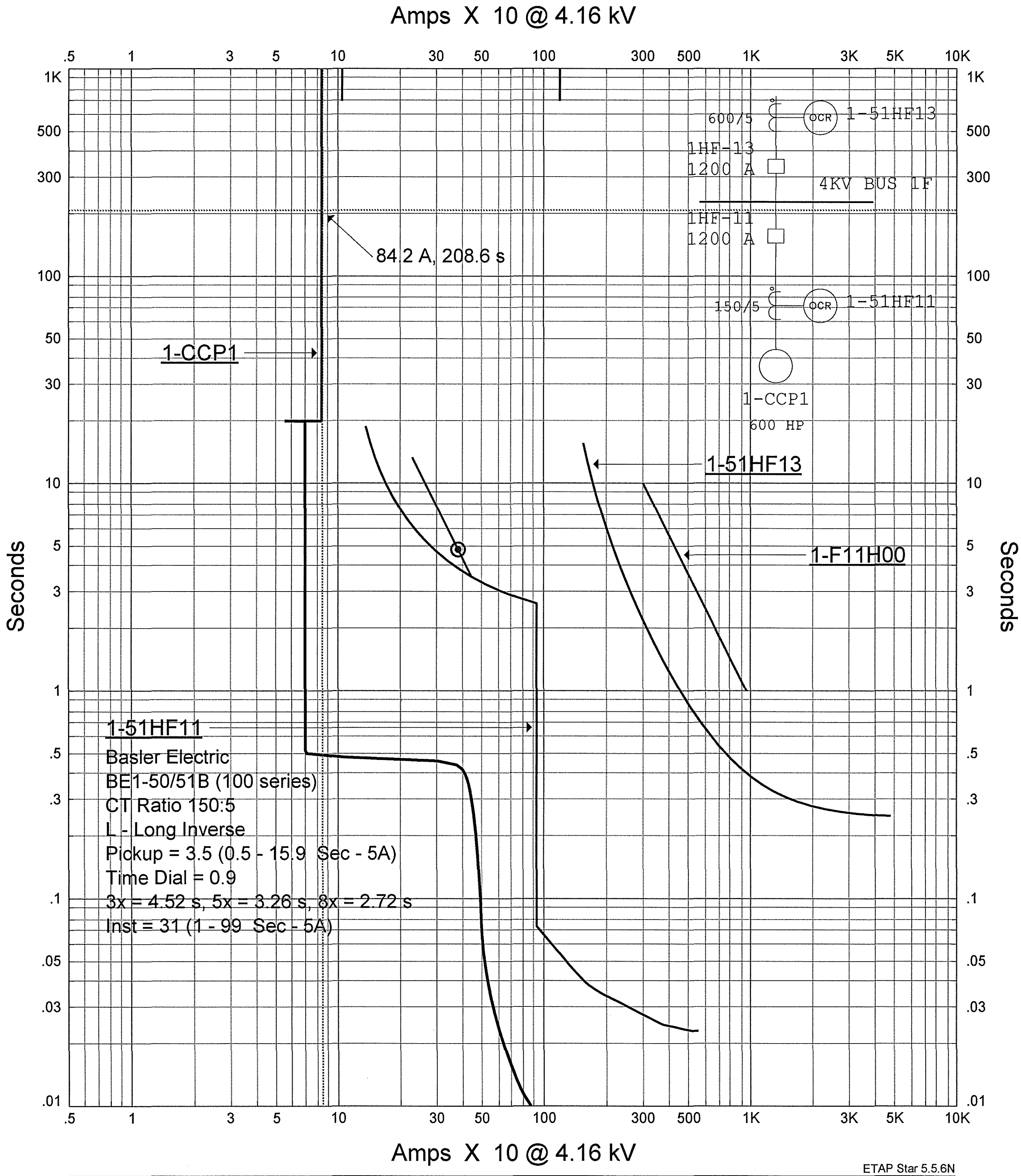


60% Bus Volts Start	**AFW3**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-60

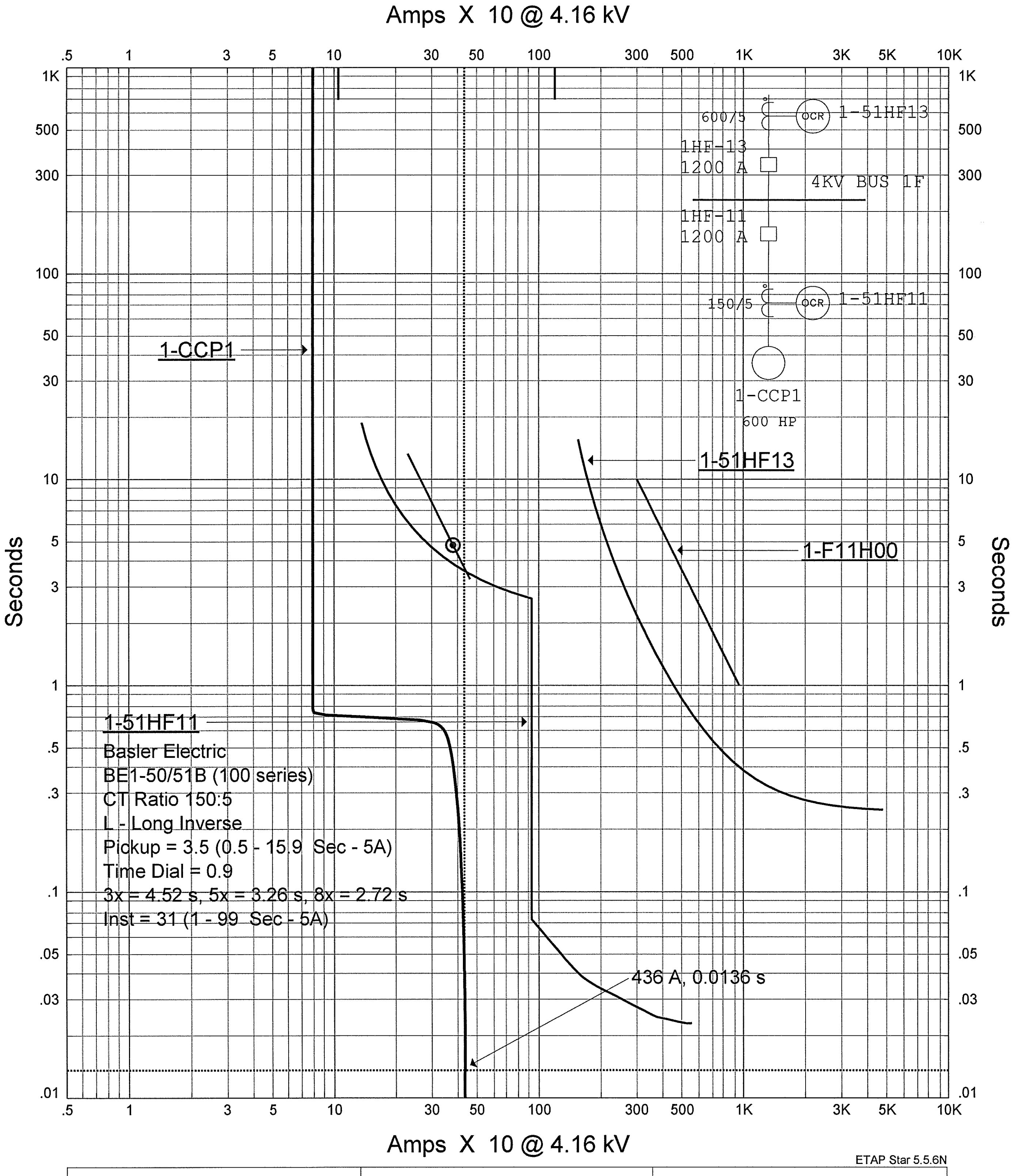


125% Bus Volts Start	**CCP1**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF Mtr 125



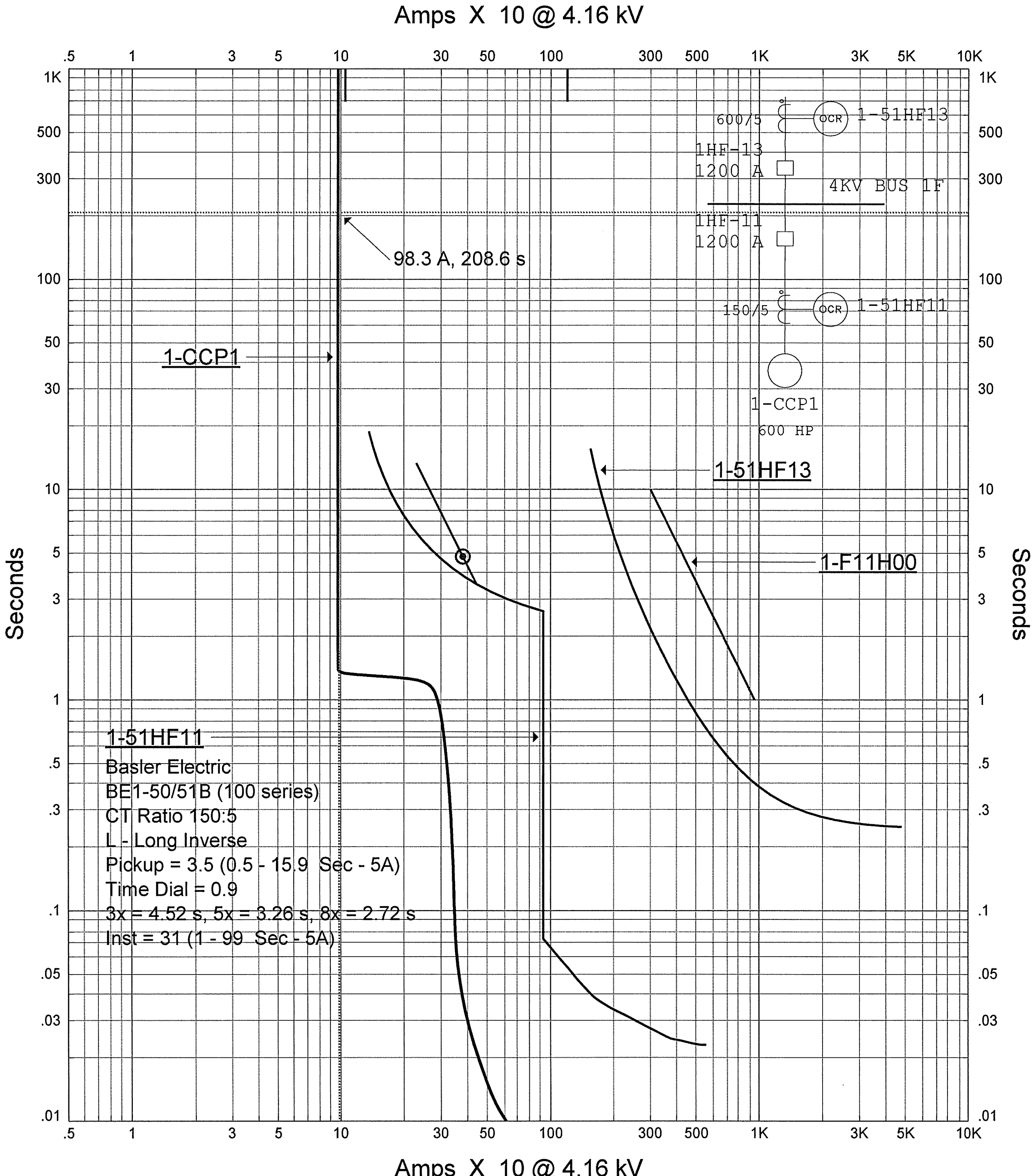
ETAP Star 5.5.6N

110% Mtr Term. Volts Star	**CCP1**	110% Mtr Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/06/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF Mtr 110



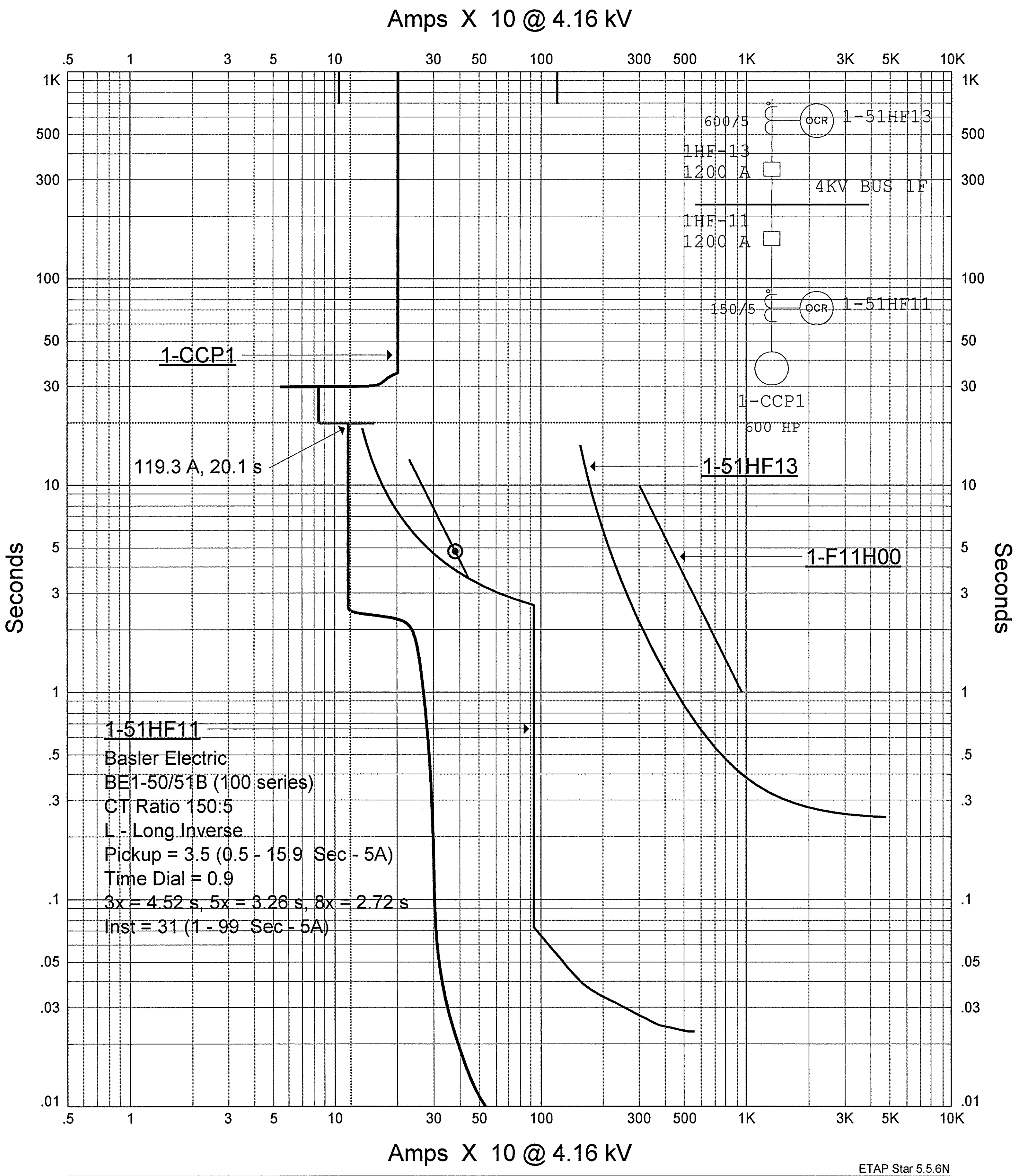
ETAP Star 5.5.6N

90% Mtr. Term. Volts Start	**CCP1**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF Mtr 90

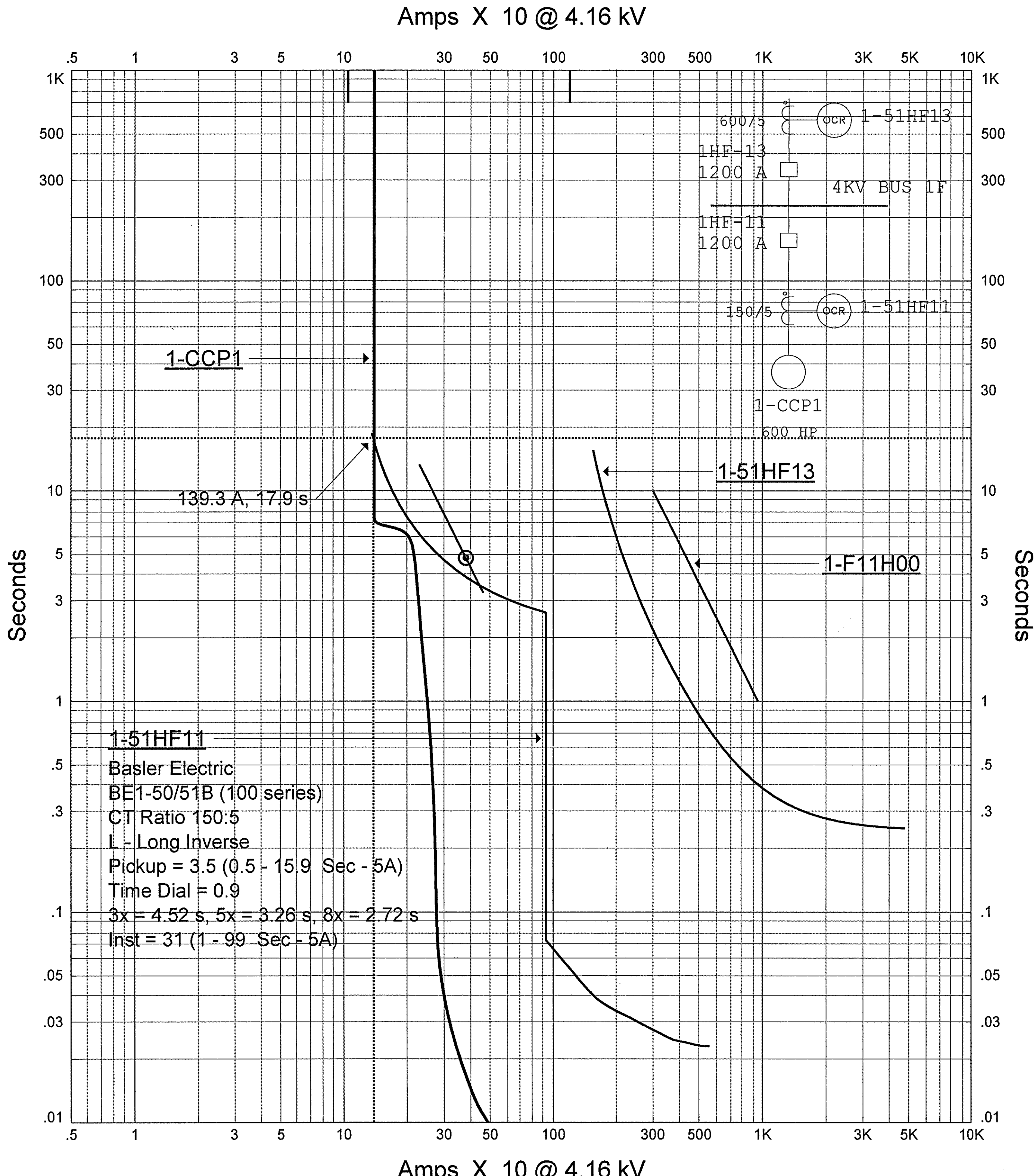


75% Bus Volts Start	**CCP1**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF Mtr 75



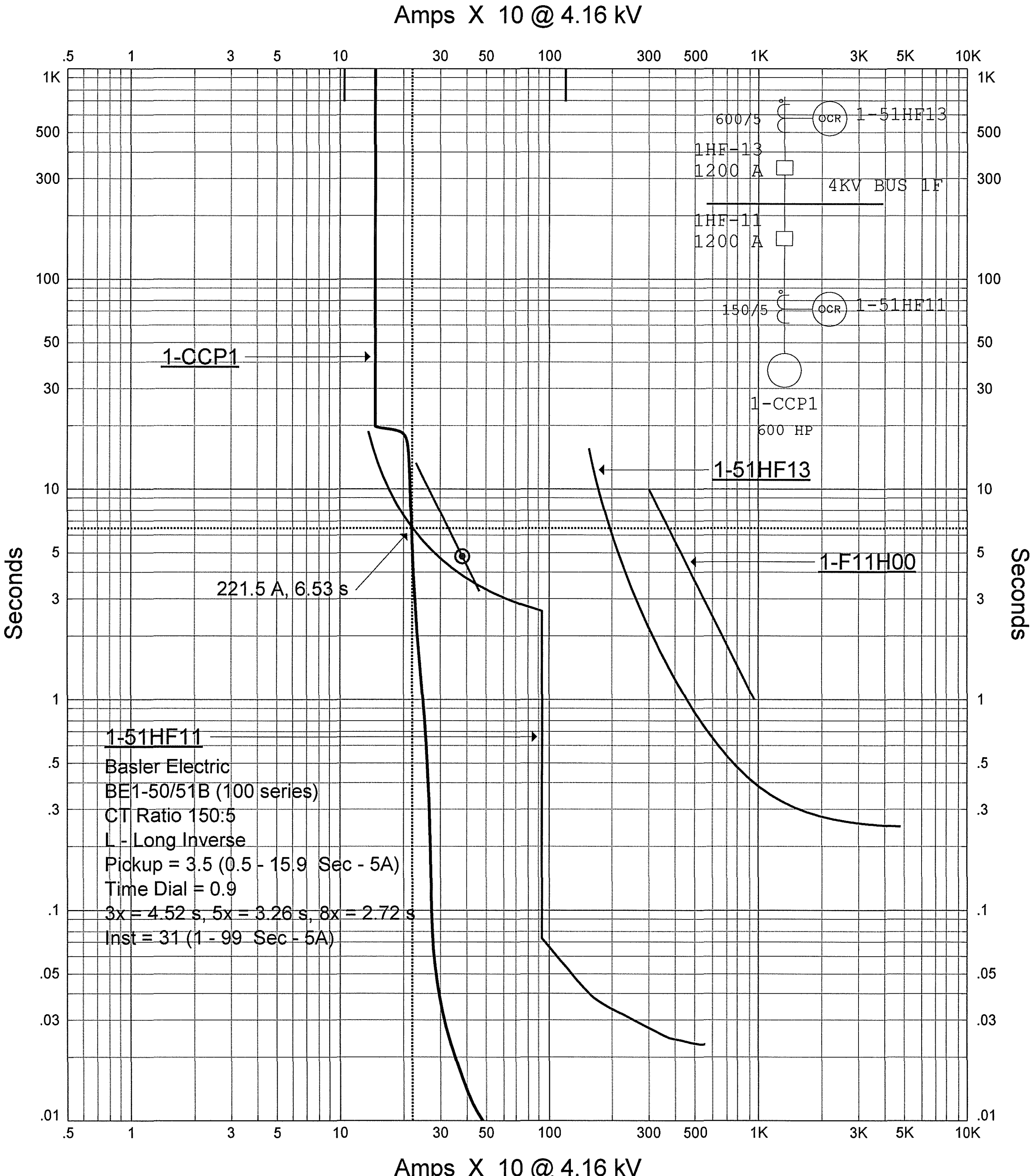
ETAP Star 5.5.6N

68% Bus Volts Start	**CCP1**	68% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF Mtr 68A



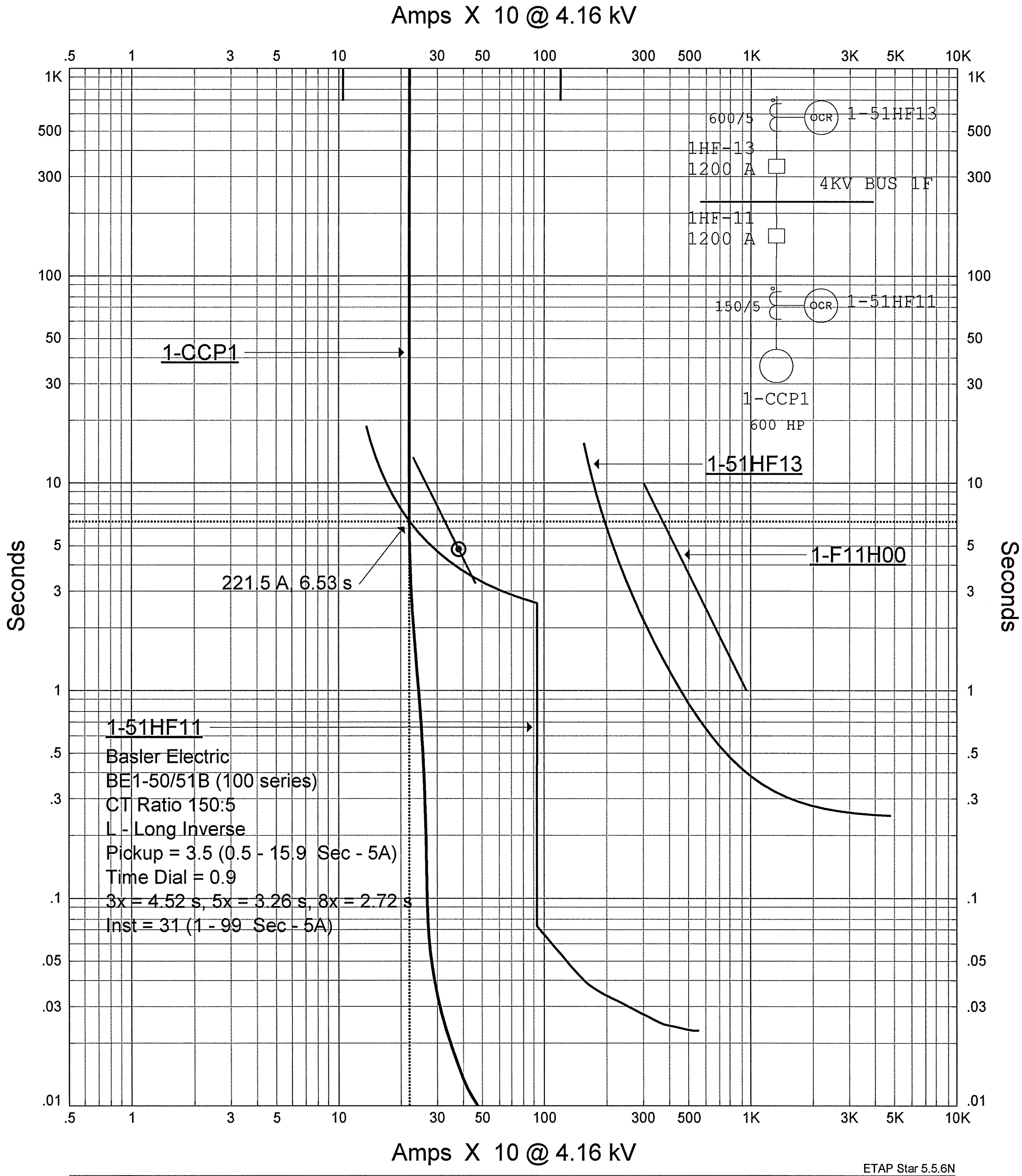
ETAP Star 5.5.6N

67% Bus Volts Start	**CCP1**	67% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR Run ESF Mtr 67A

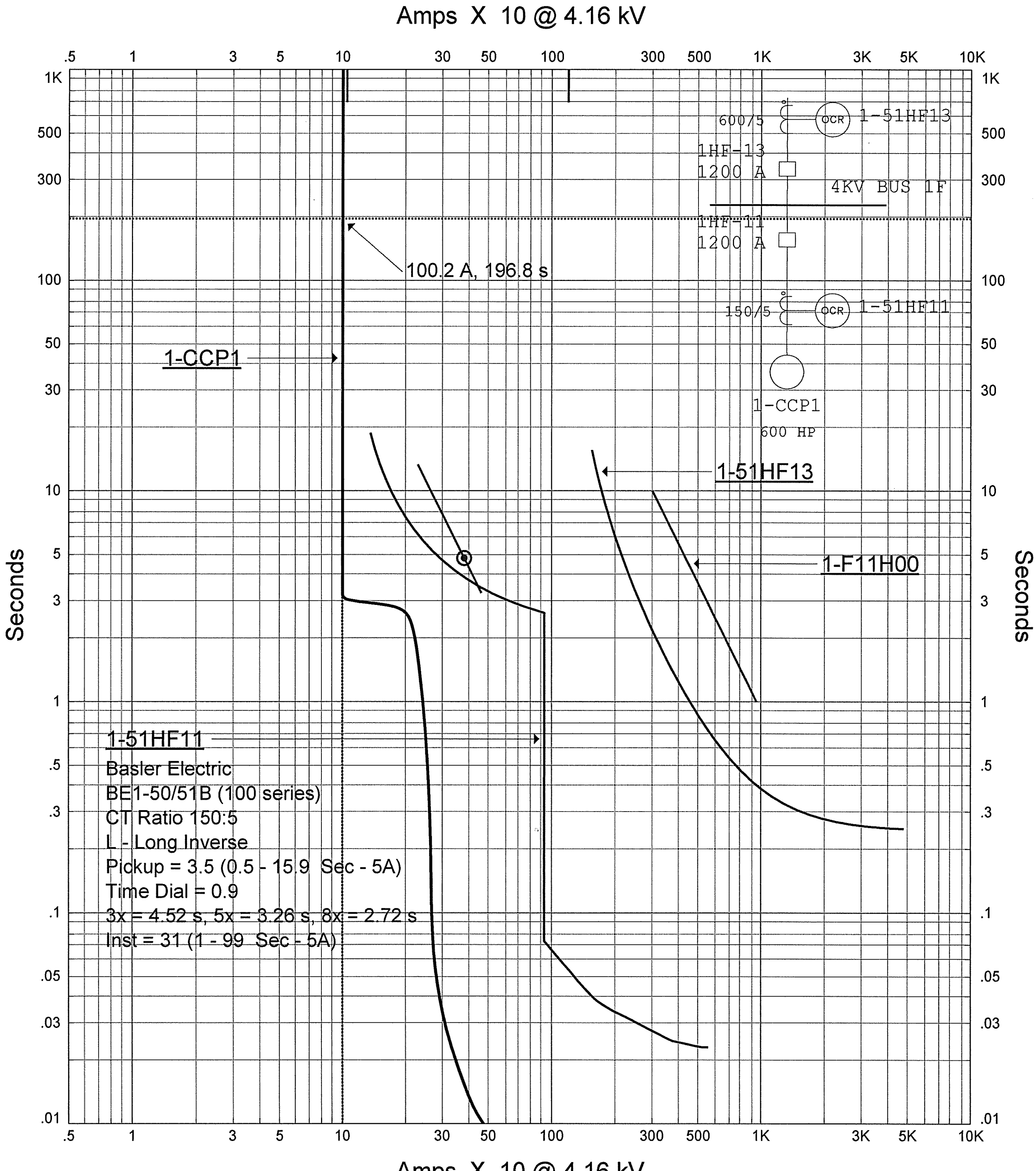


66% Bus Volts Start	**CCP1**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR Run ESF Mtr 66A

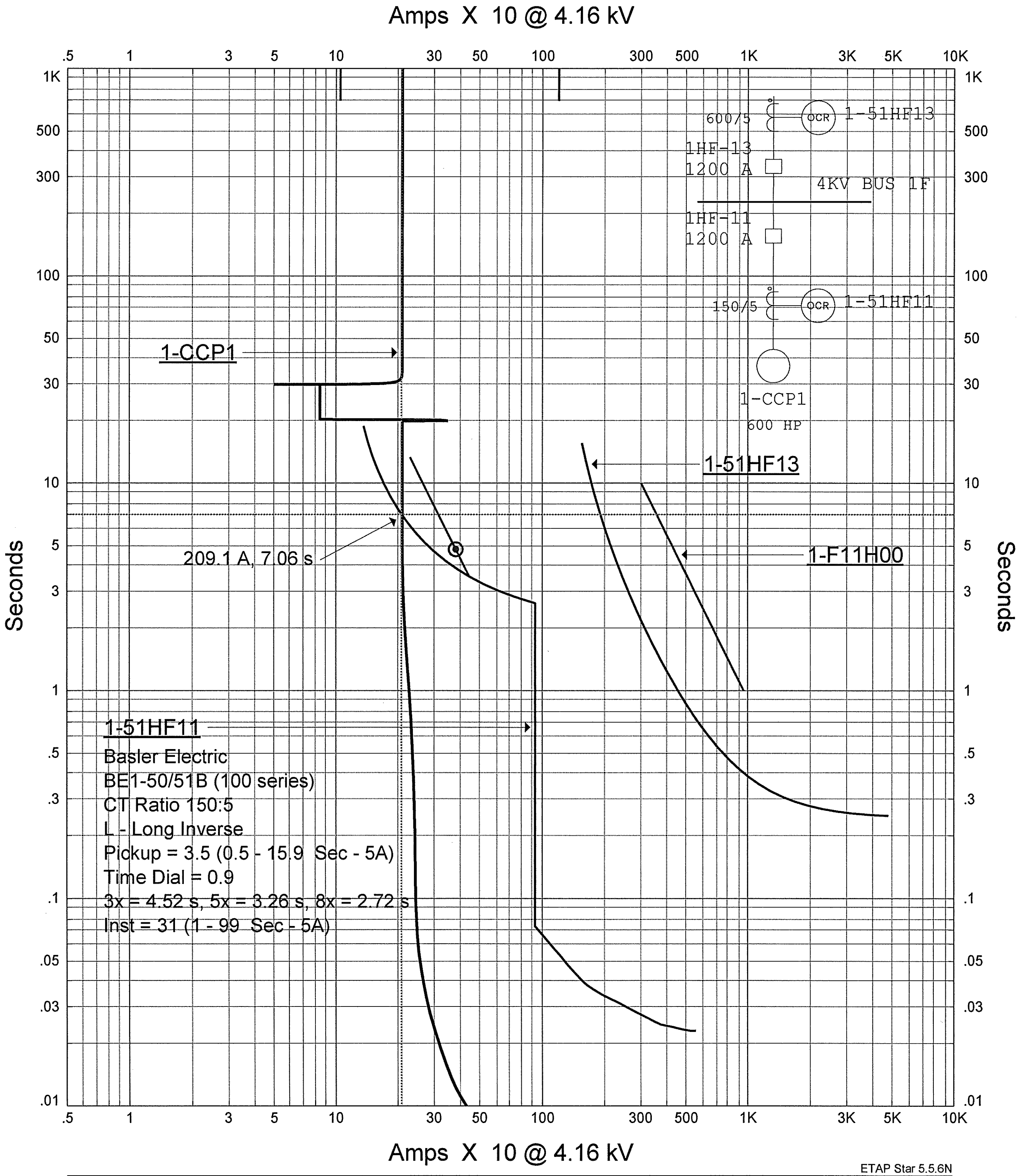


66% Bus Volts Start	**CCP1**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR Run ESF Mtr 66N

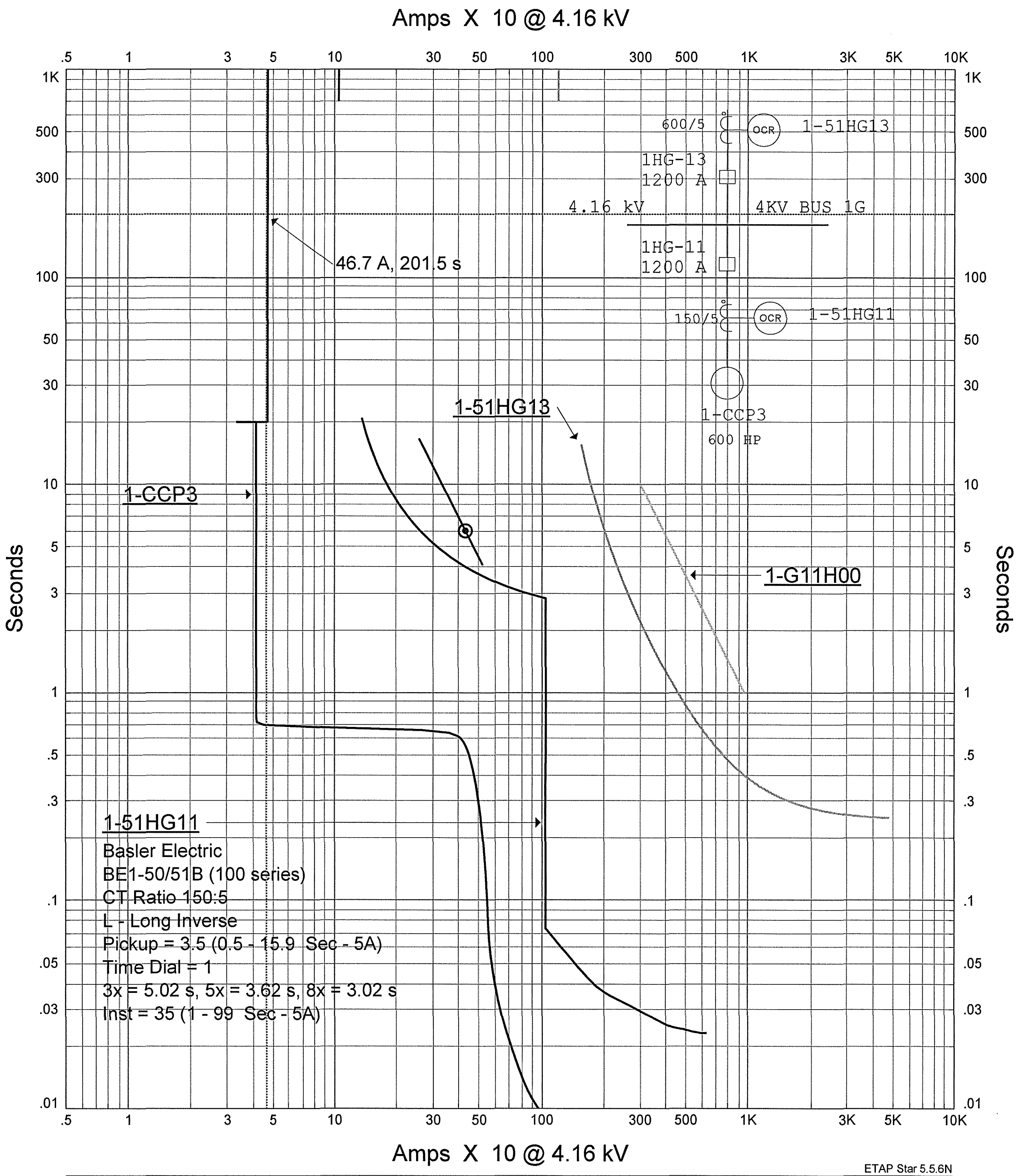


60% Bus Volts Start	**CCP1**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF Mtr 60

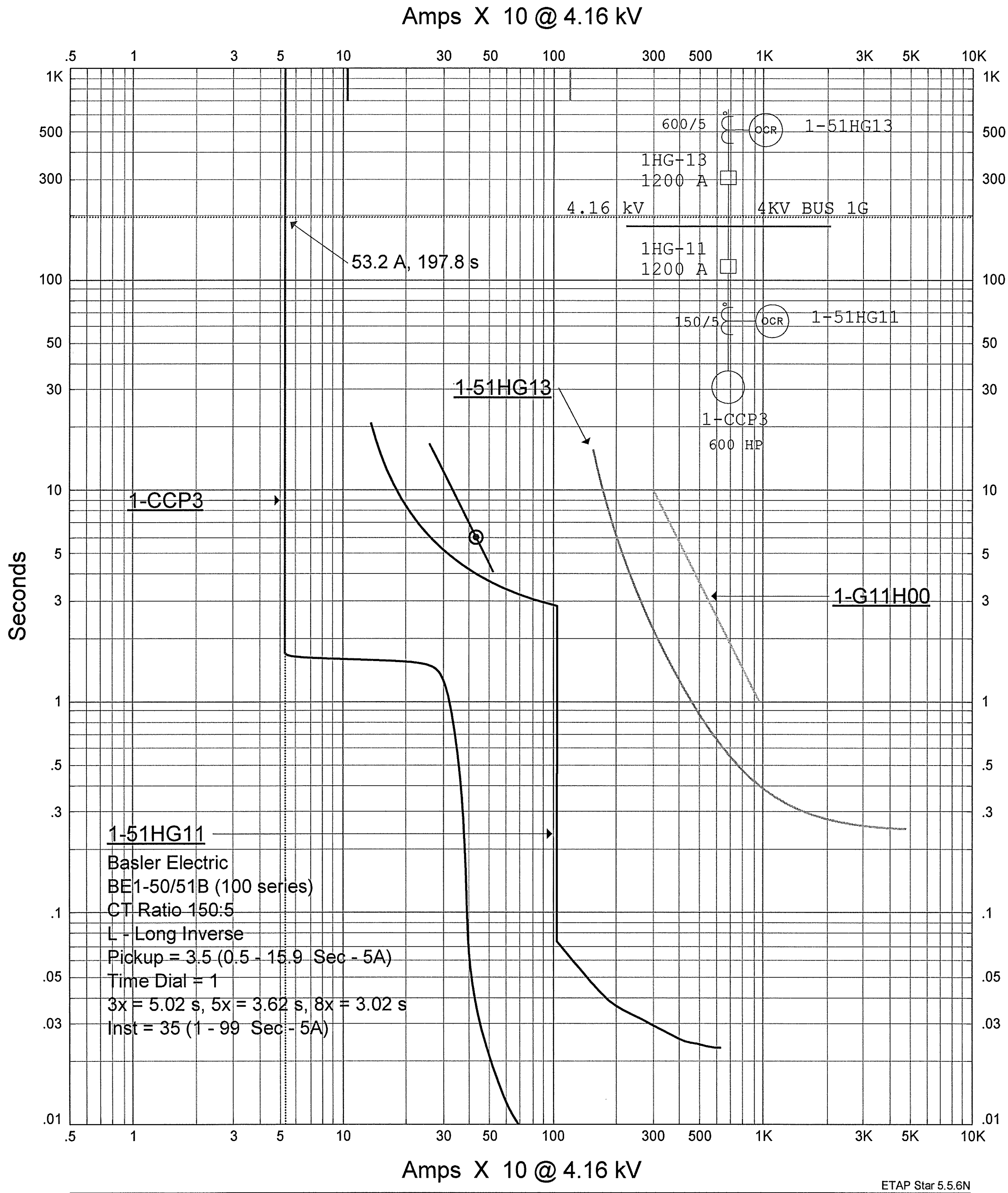


125% Bus Volts Start	**CCP3**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-125



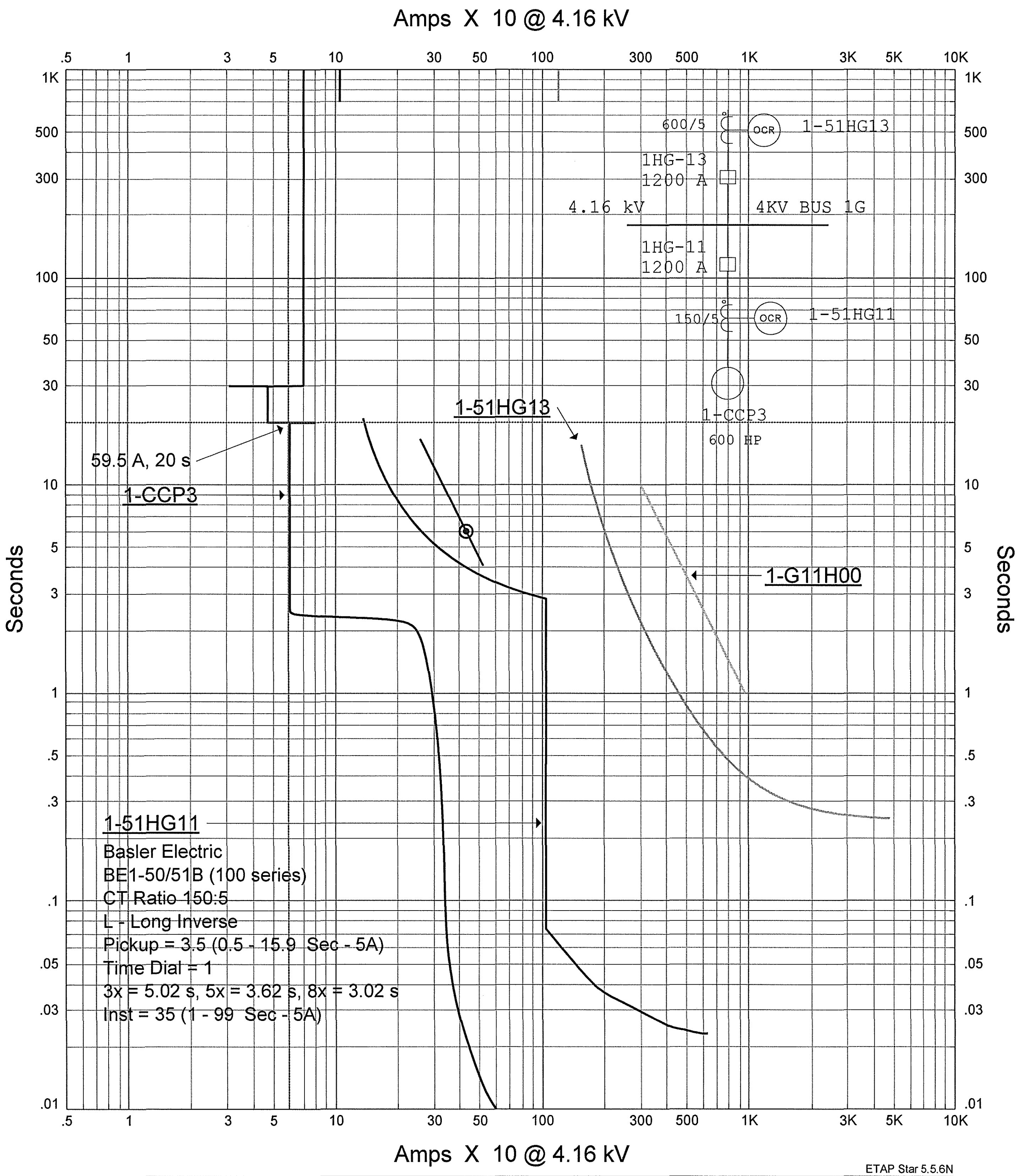
ETAP Star 5.5.6N

90% Mtr. Term. Volts Start	**CCP3**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



ETAP Star 5.5.6N

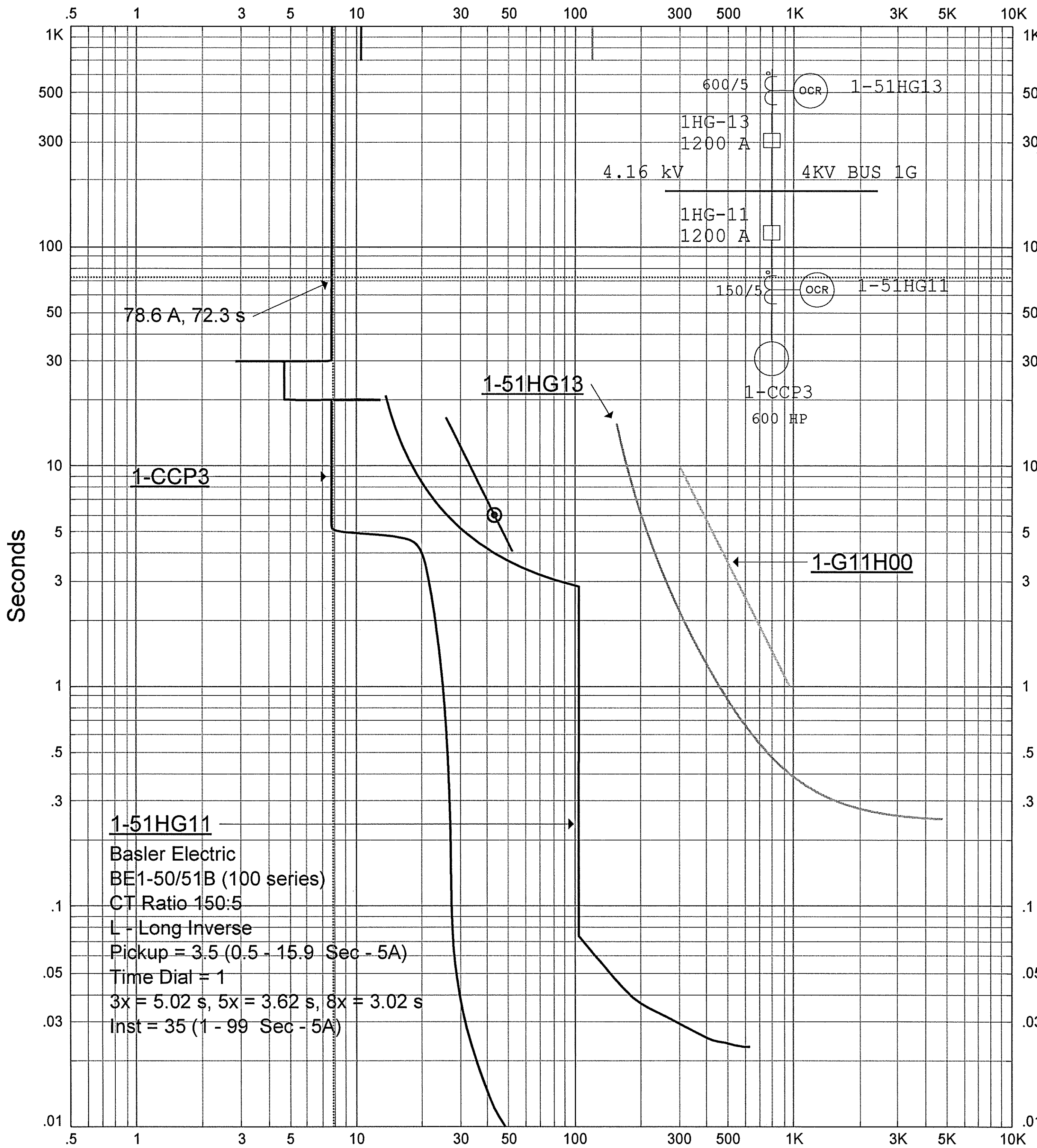
75% Bus Volts Start	**CCP3**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-75

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Amps X 10 @ 4.16 kV



Amps X 10 @ 4.16 kV

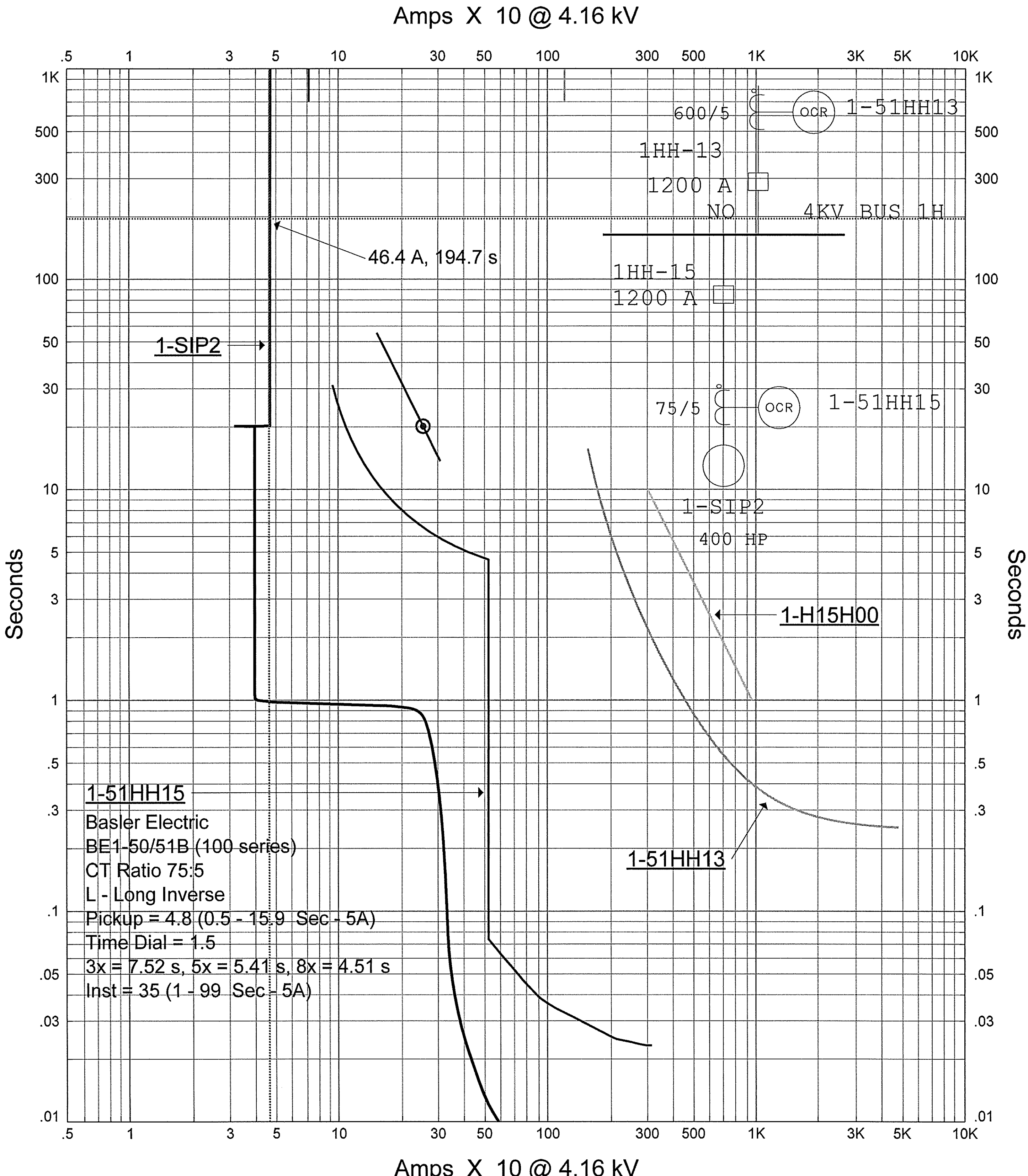
ETAP Star 5.5.6N

60% Bus Volts Start	**CCP3**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-60

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



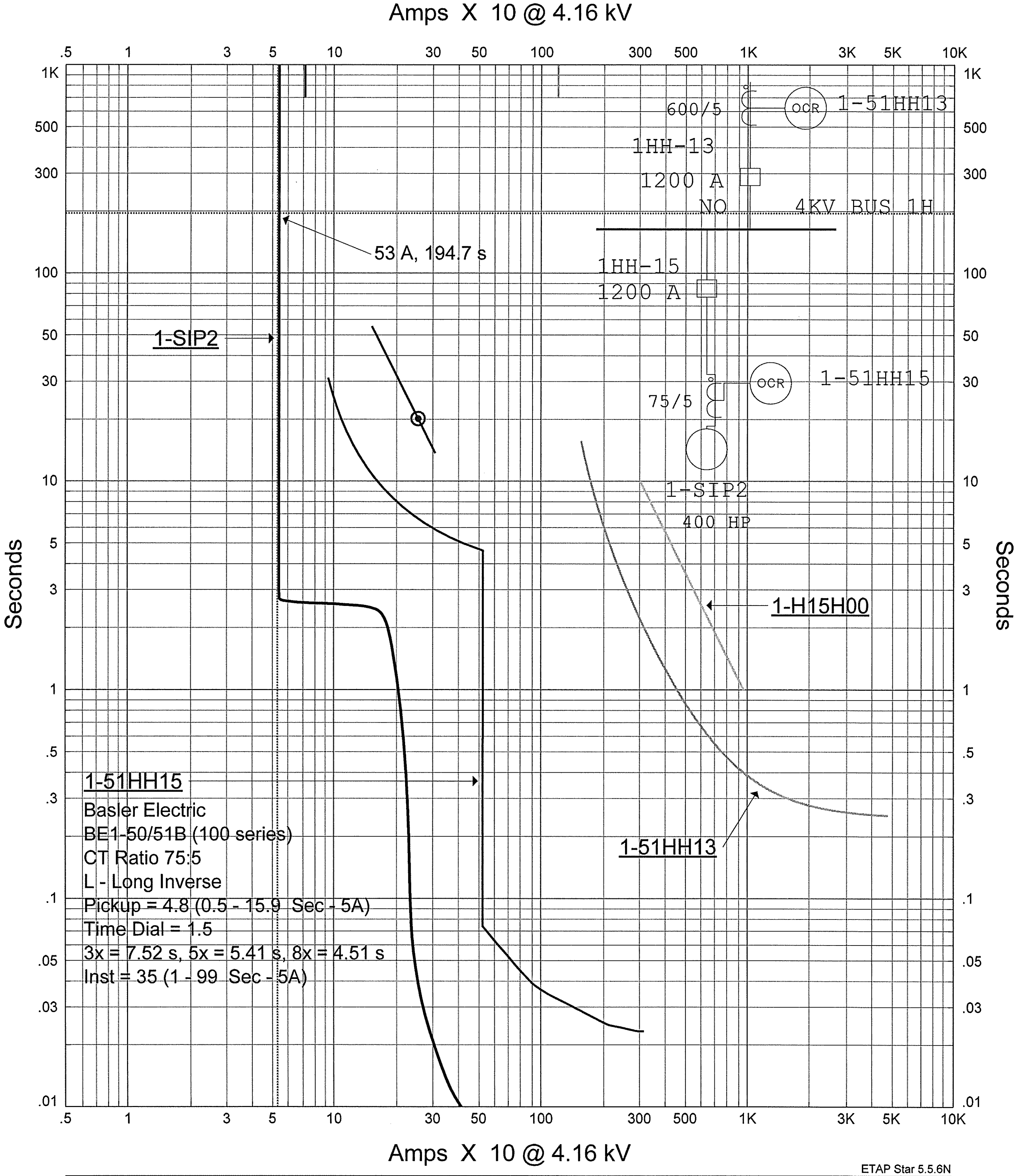
ETAP Star 5.5.6N

125% Bus Volts Start	**SIP2**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-125

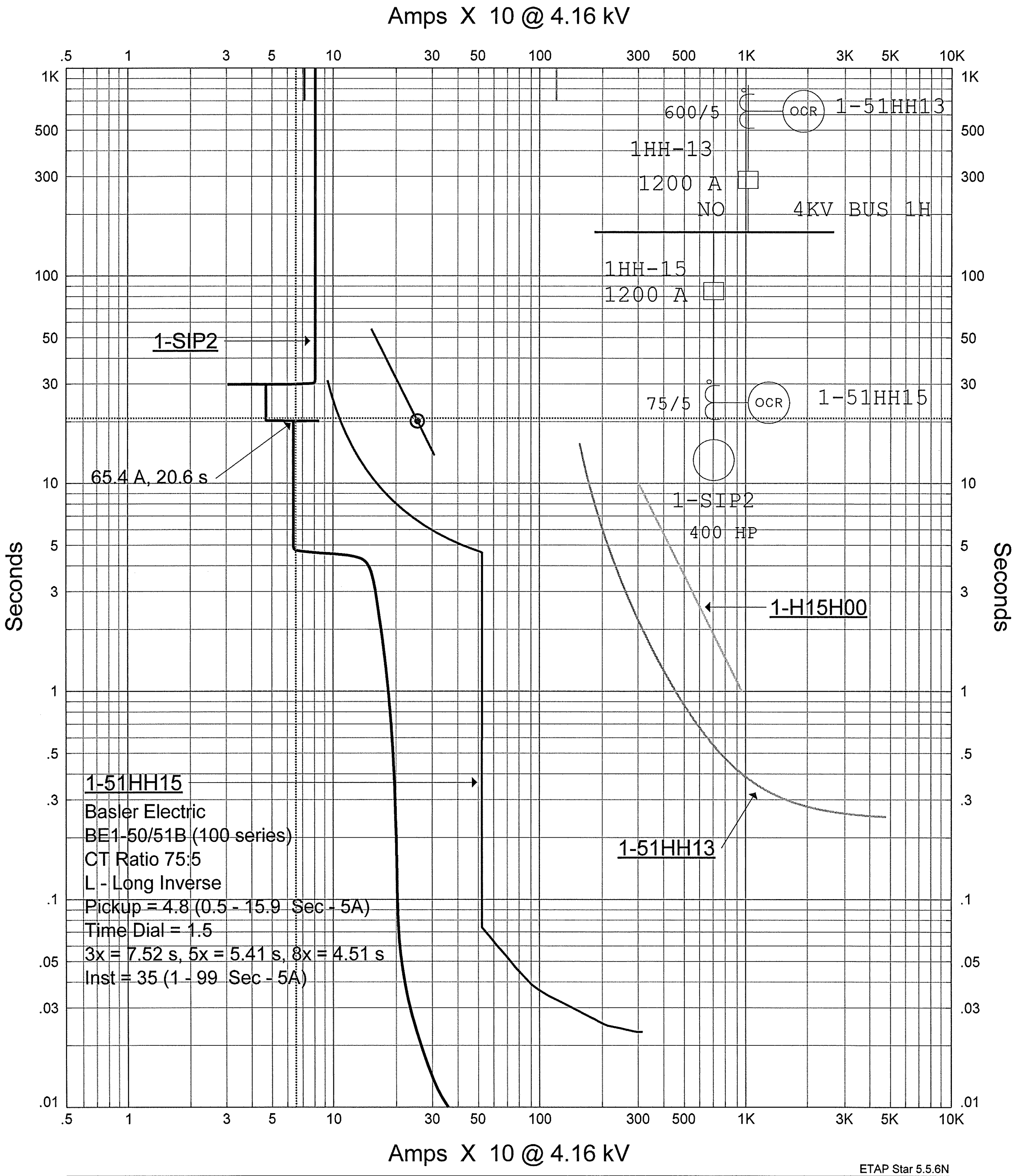


90% Mtr. Term. Volts Start	**SIP2**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

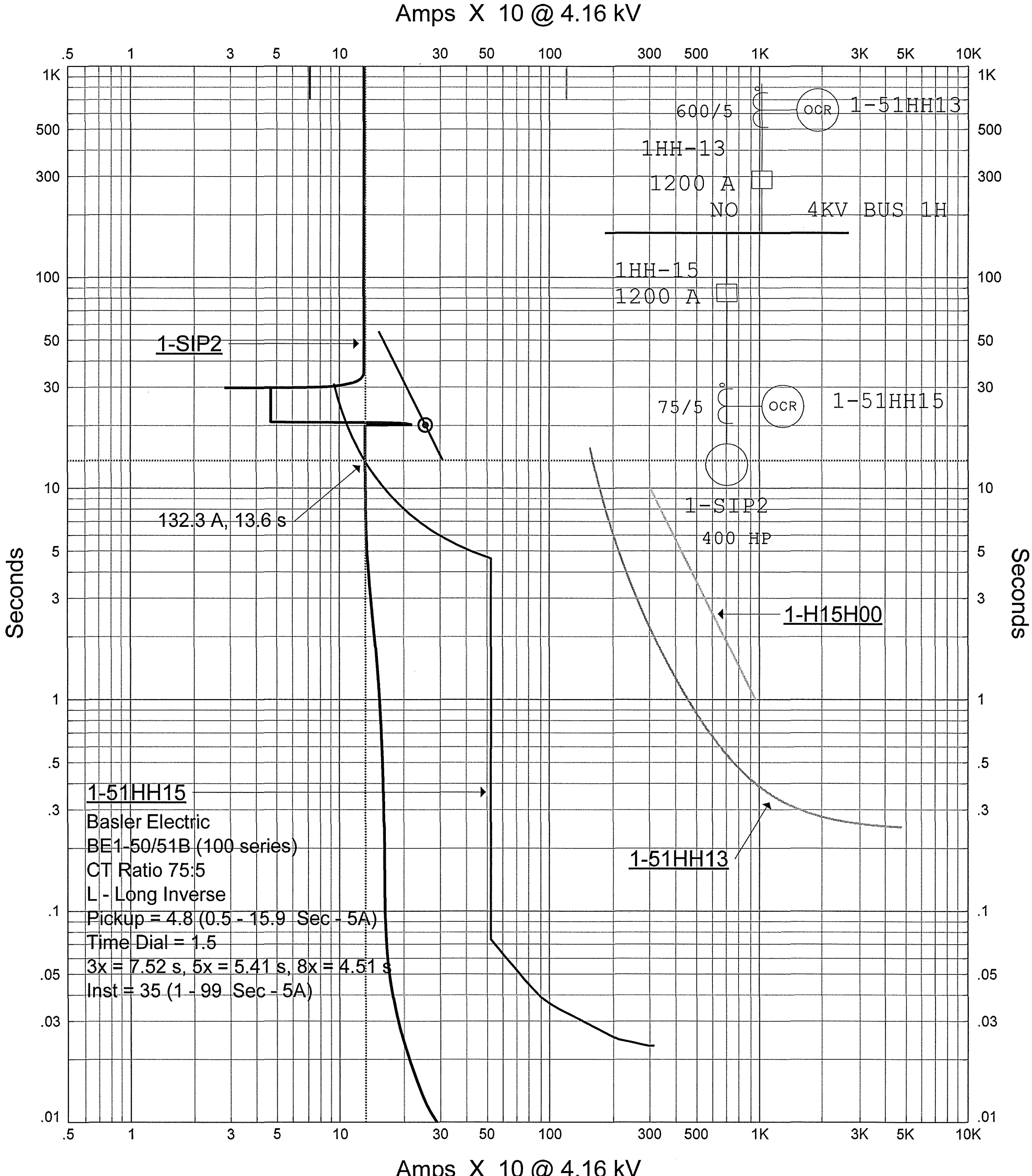
Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



75% Bus Volts Start	**SIP2**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI
Run ESF-Mtr-75

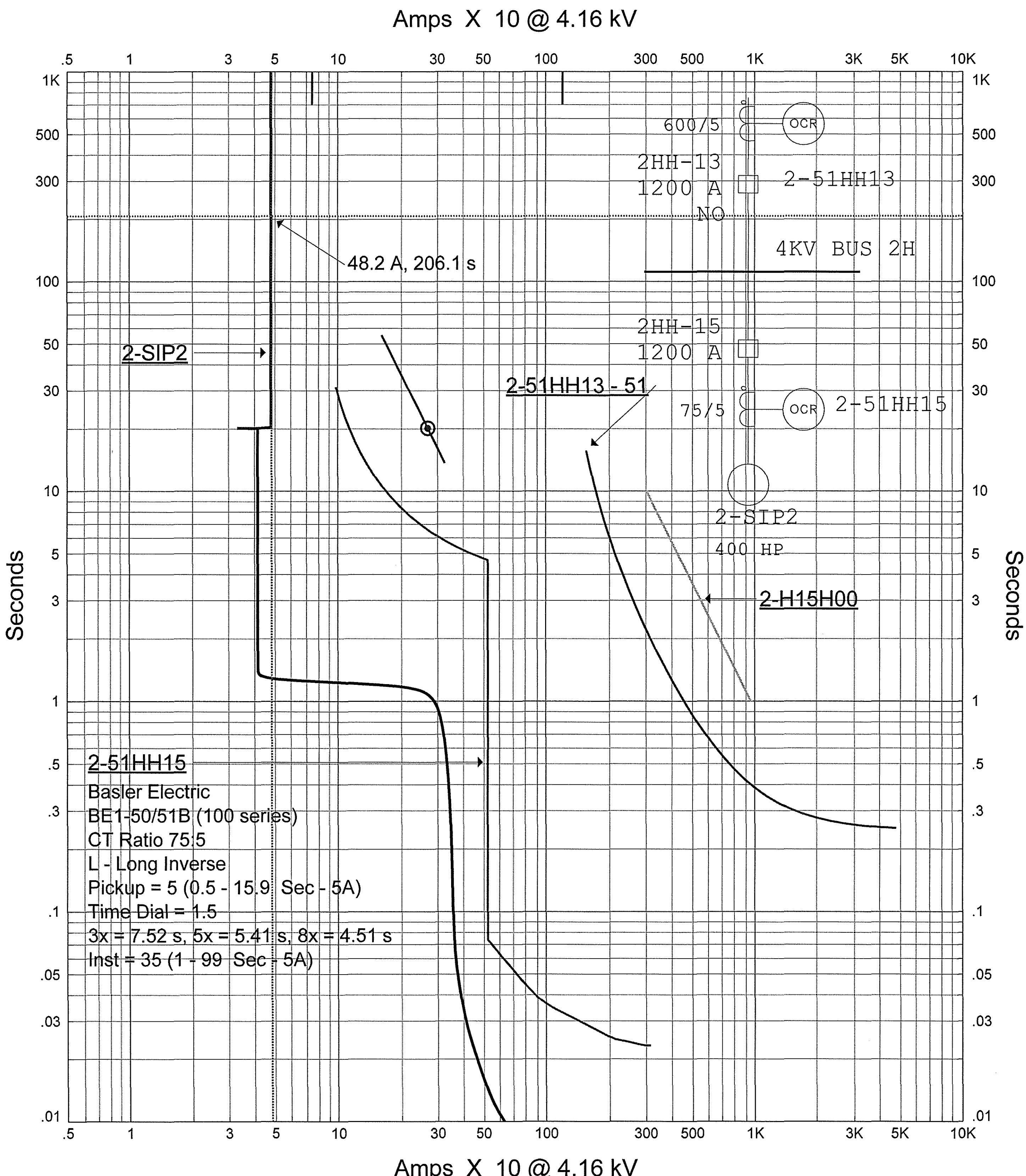
Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



60% Bus Volts Start	**SIP2**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI
Run ESF-Mtr-60

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

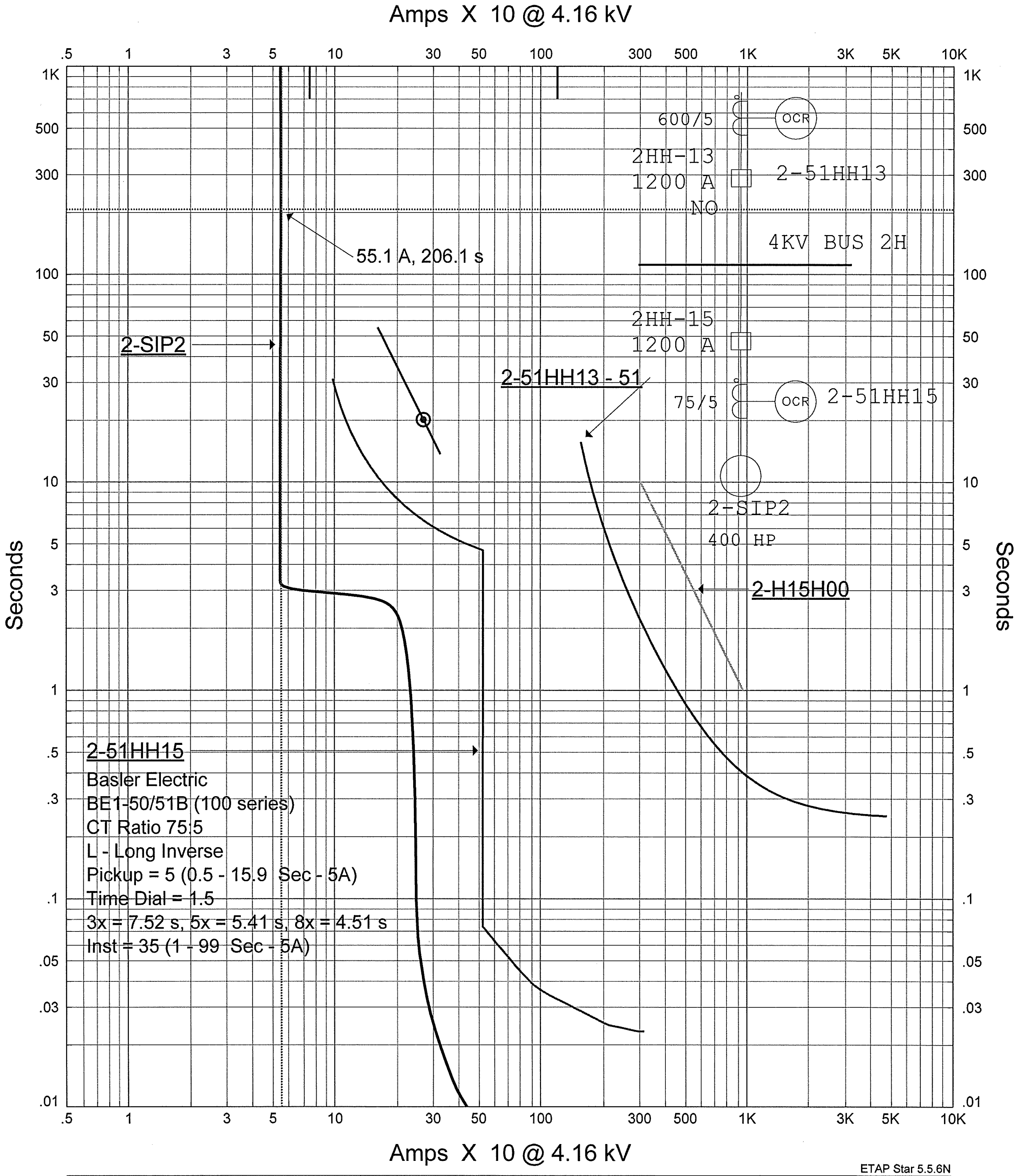


125% Bus Volts Start	**2-SI2**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-125

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



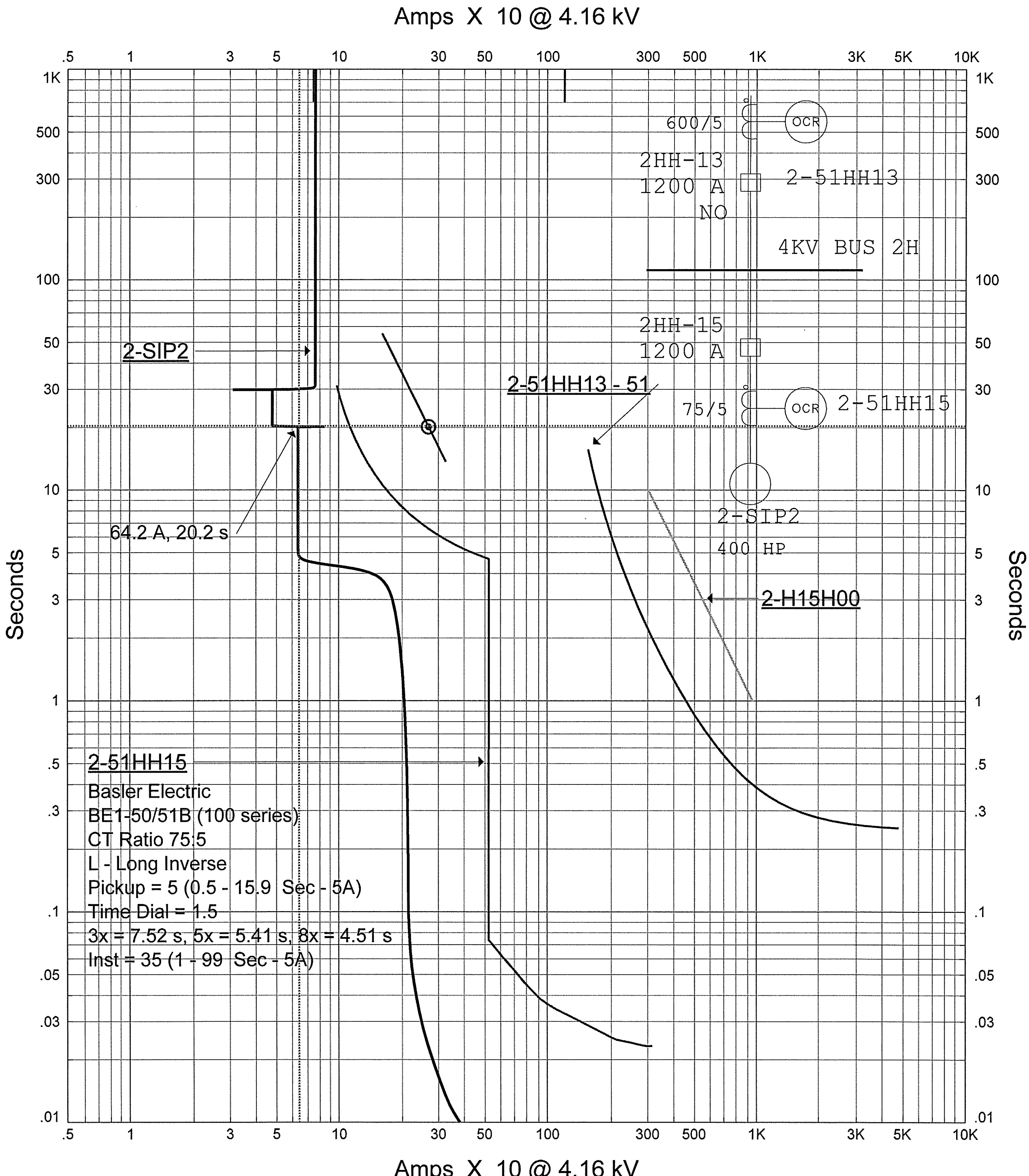
ETAP Star 5.5.6N

90% Mtr. Term. Volts Start	**2-SI2**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-90

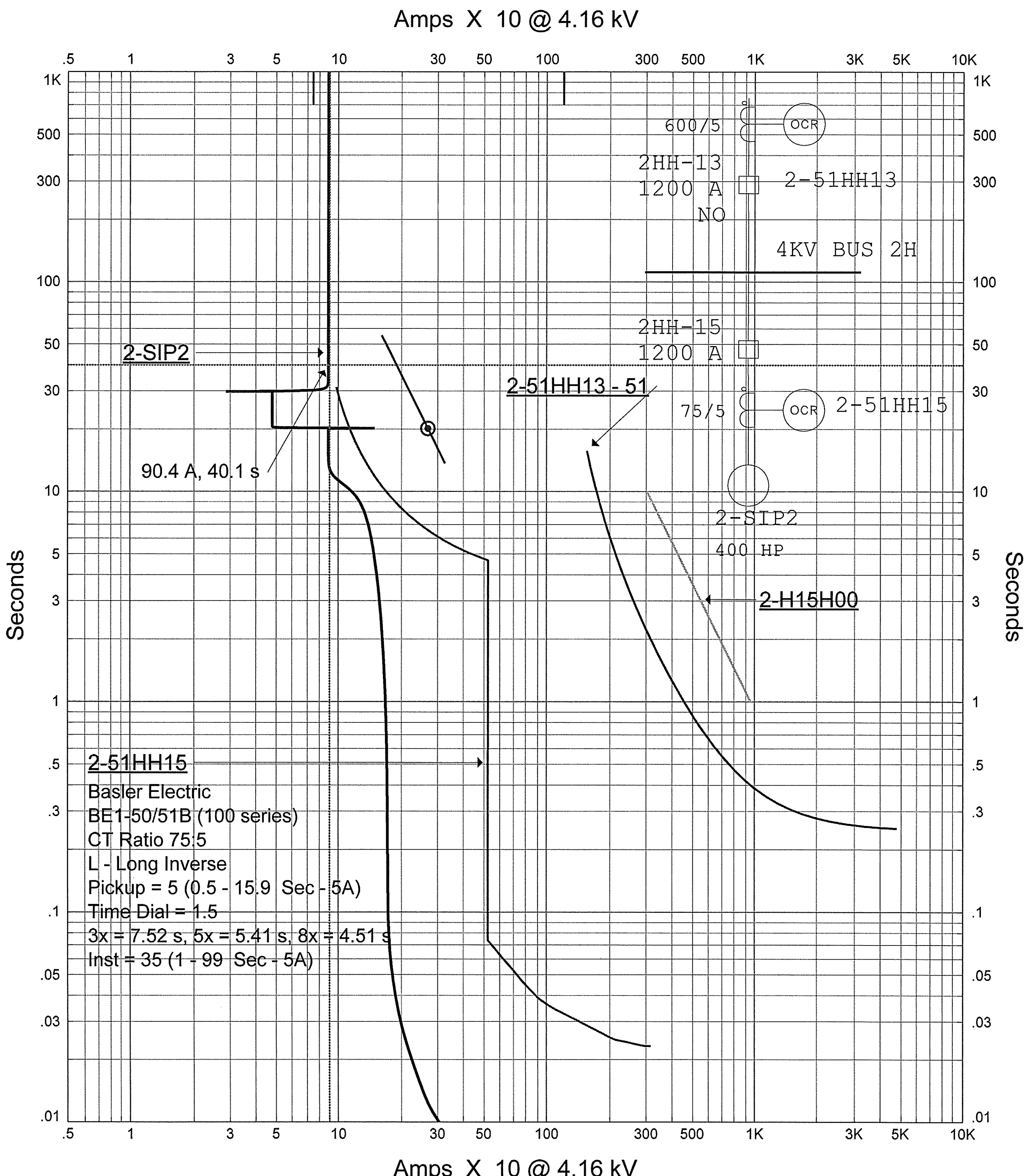
Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



75% Bus Volts Start	**2-SI2**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI
Run ESF-Mtr-75

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

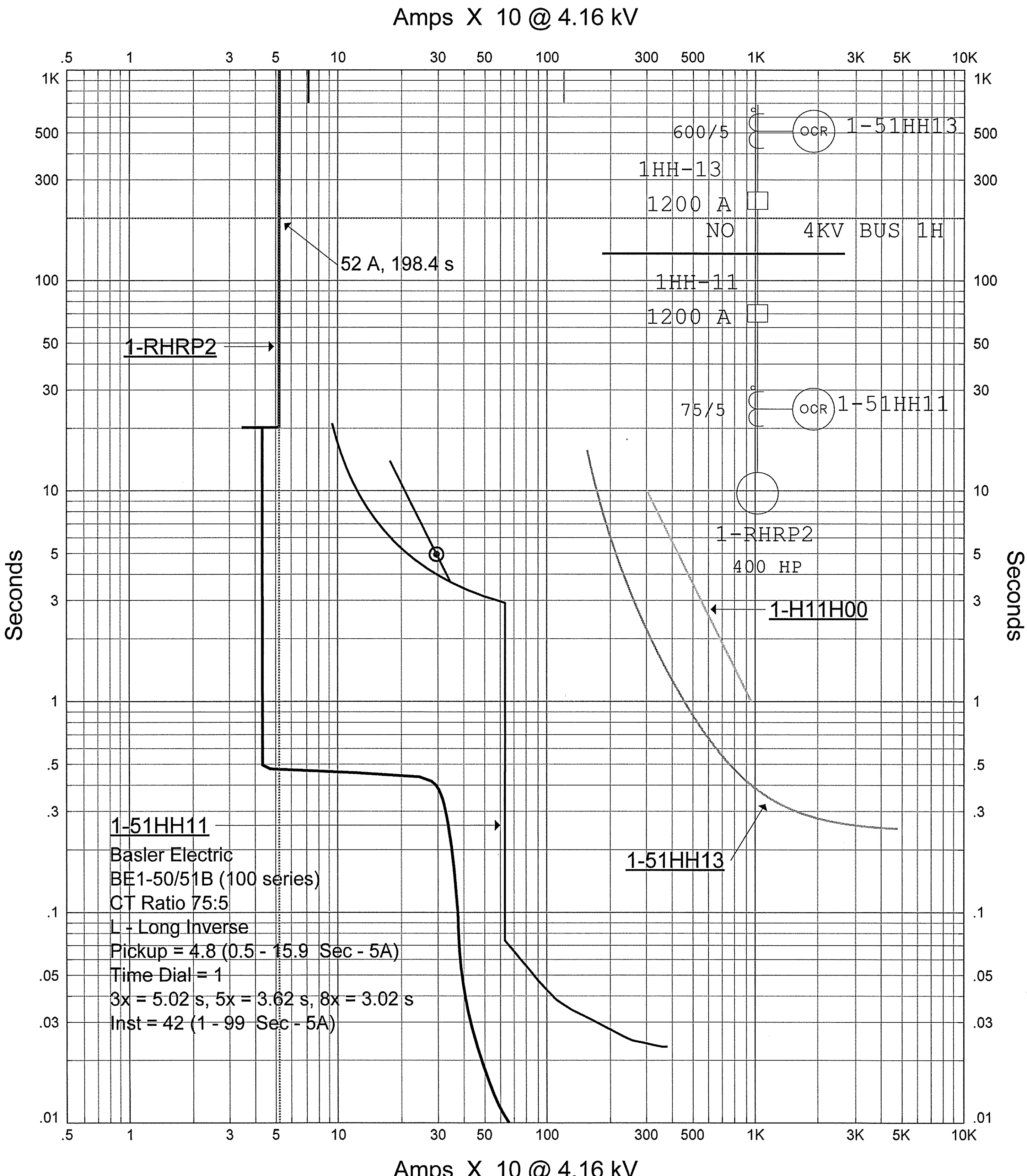


60% Bus Volts Start	**2-SI2**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-60

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



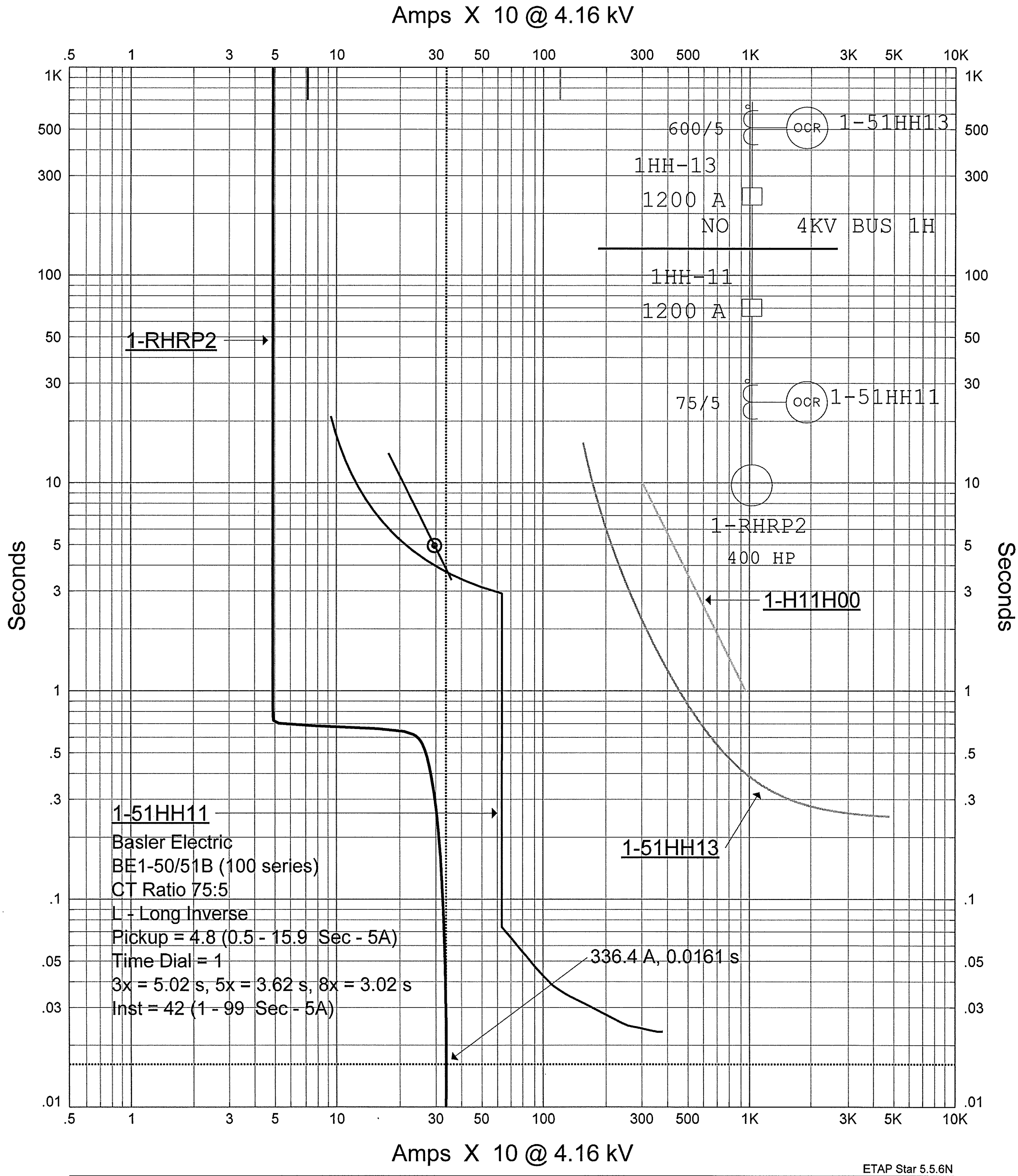
ETAP Star 5.5.6N

125% Bus Volts Start	**RHRP2**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-125

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



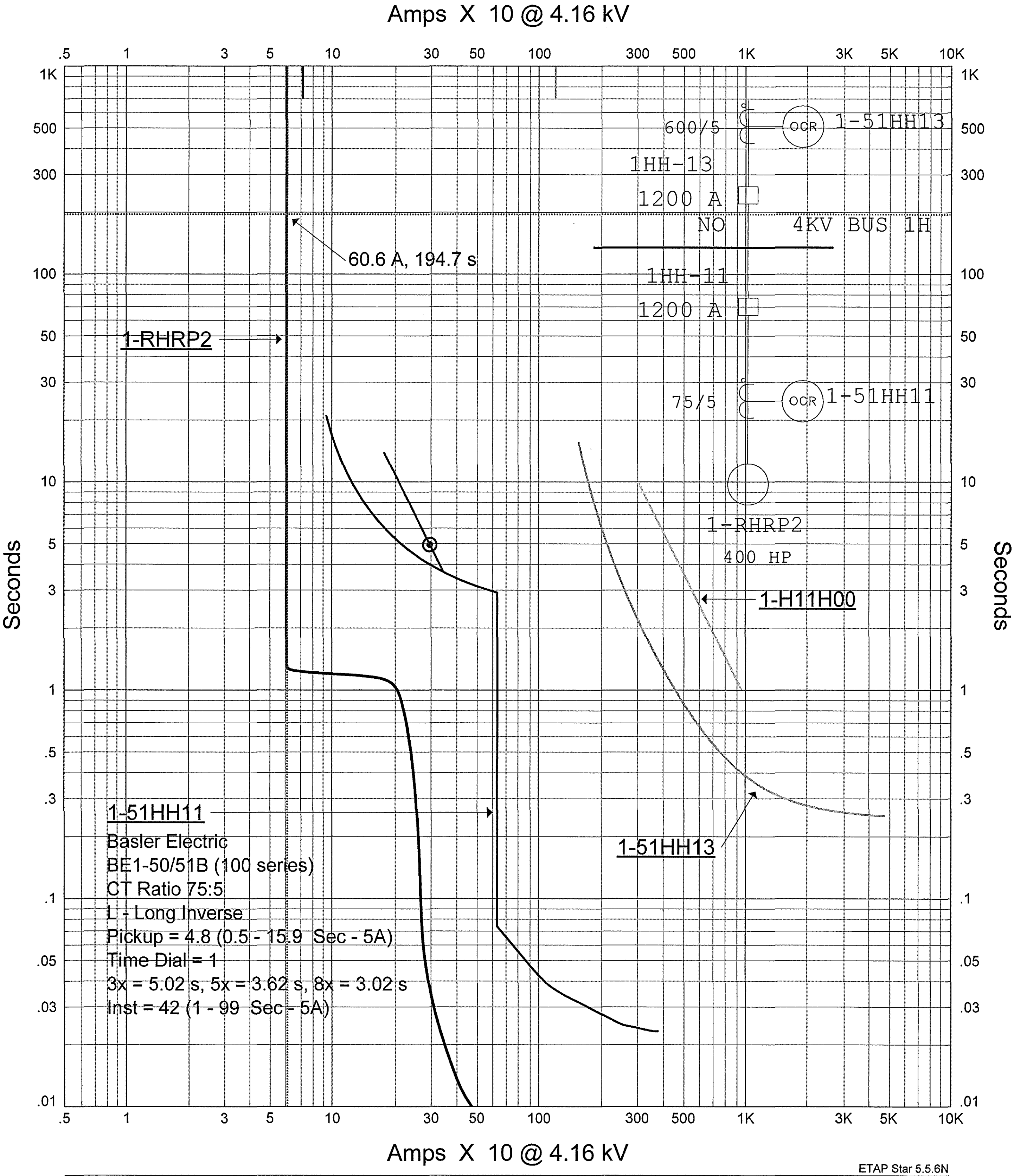
ETAP Star 5.5.6N

110% Mtr.Term Volts Start	**RHRP2**	110% Mtr.Term Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-110

Date: 02/06/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

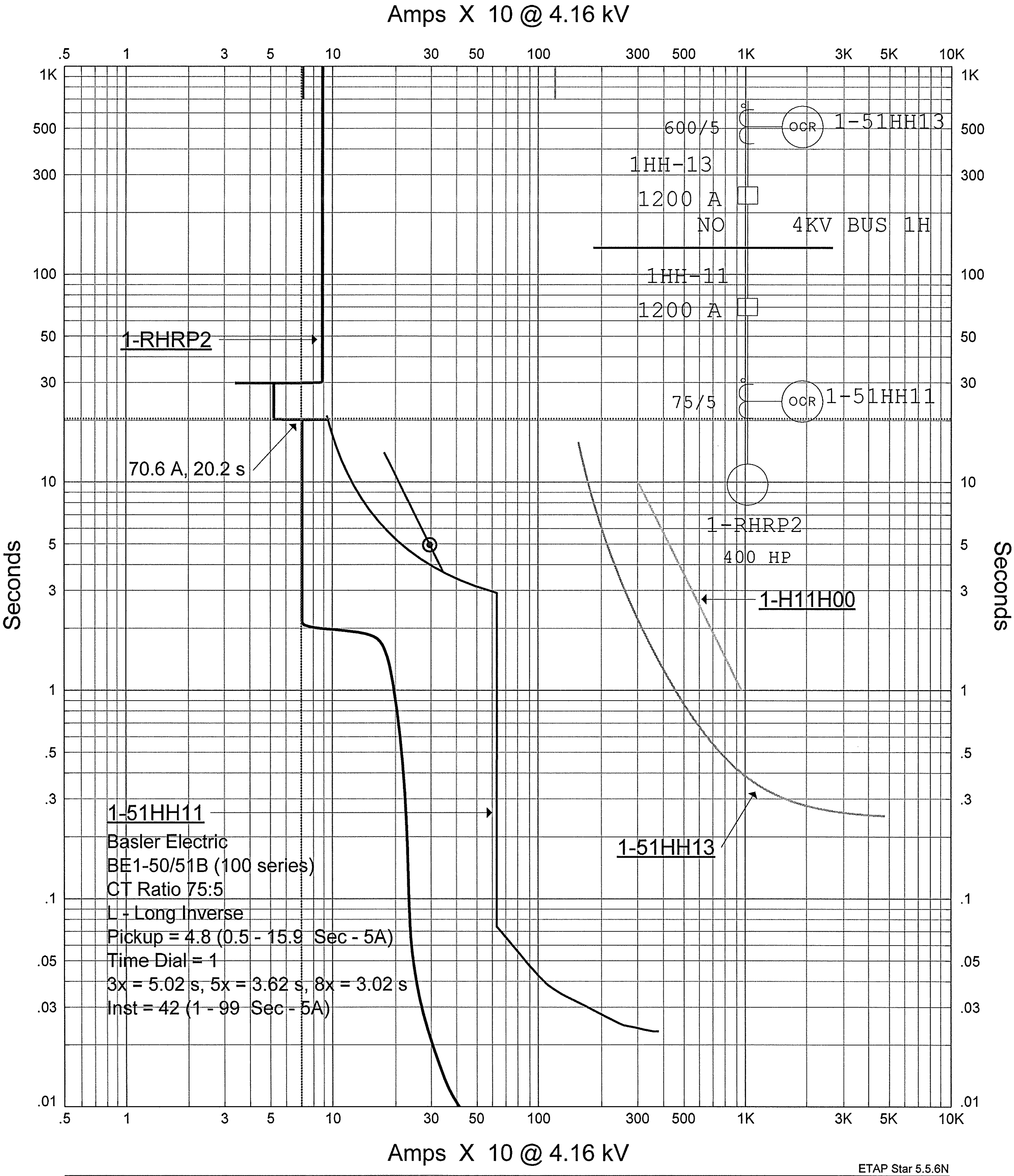


90% Mtr. Term. Volts Start	**RHRP2**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

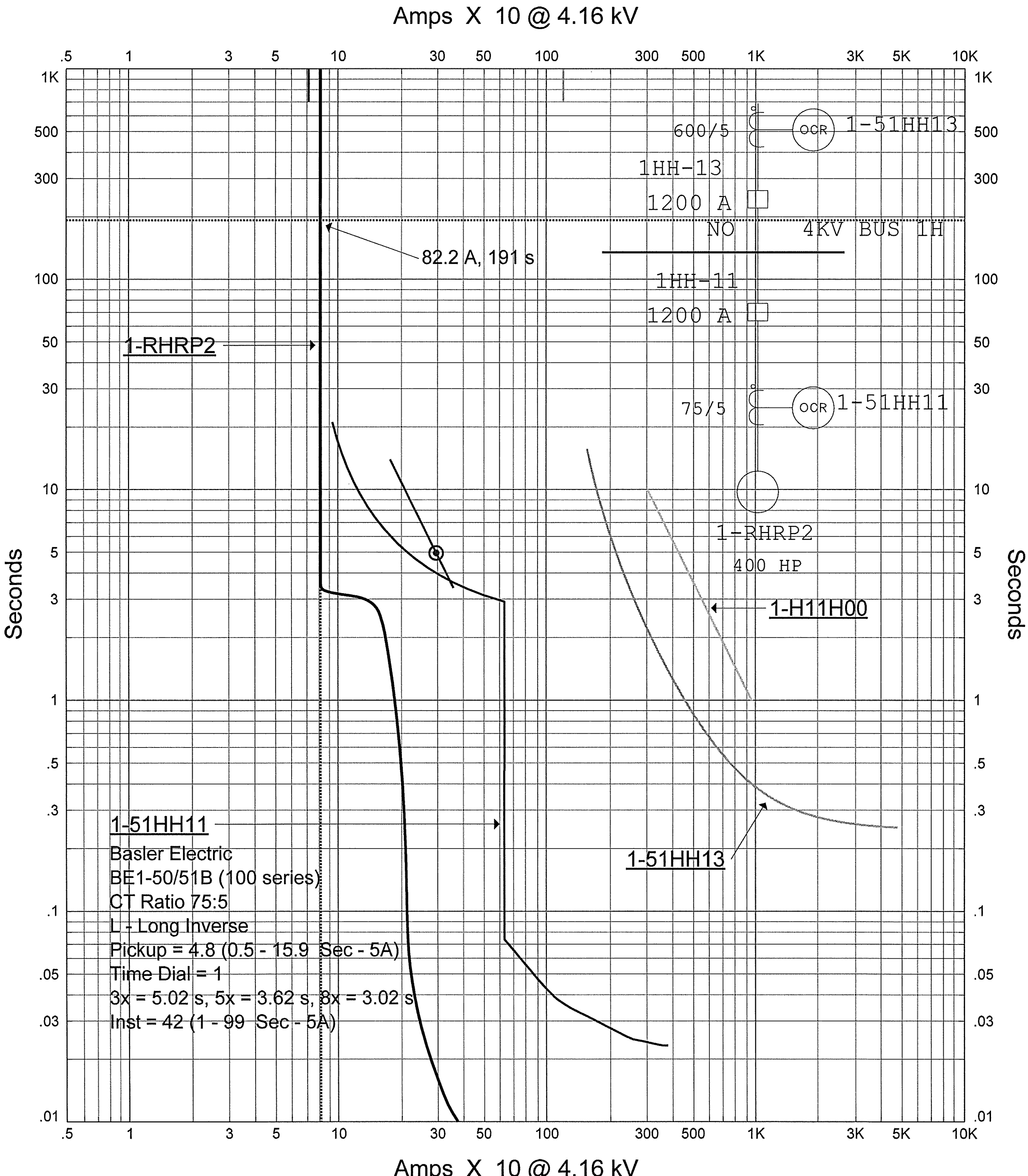
Objective: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



75% Bus Volts Start	**RHRP2**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI
Run ESF-Mtr-75

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



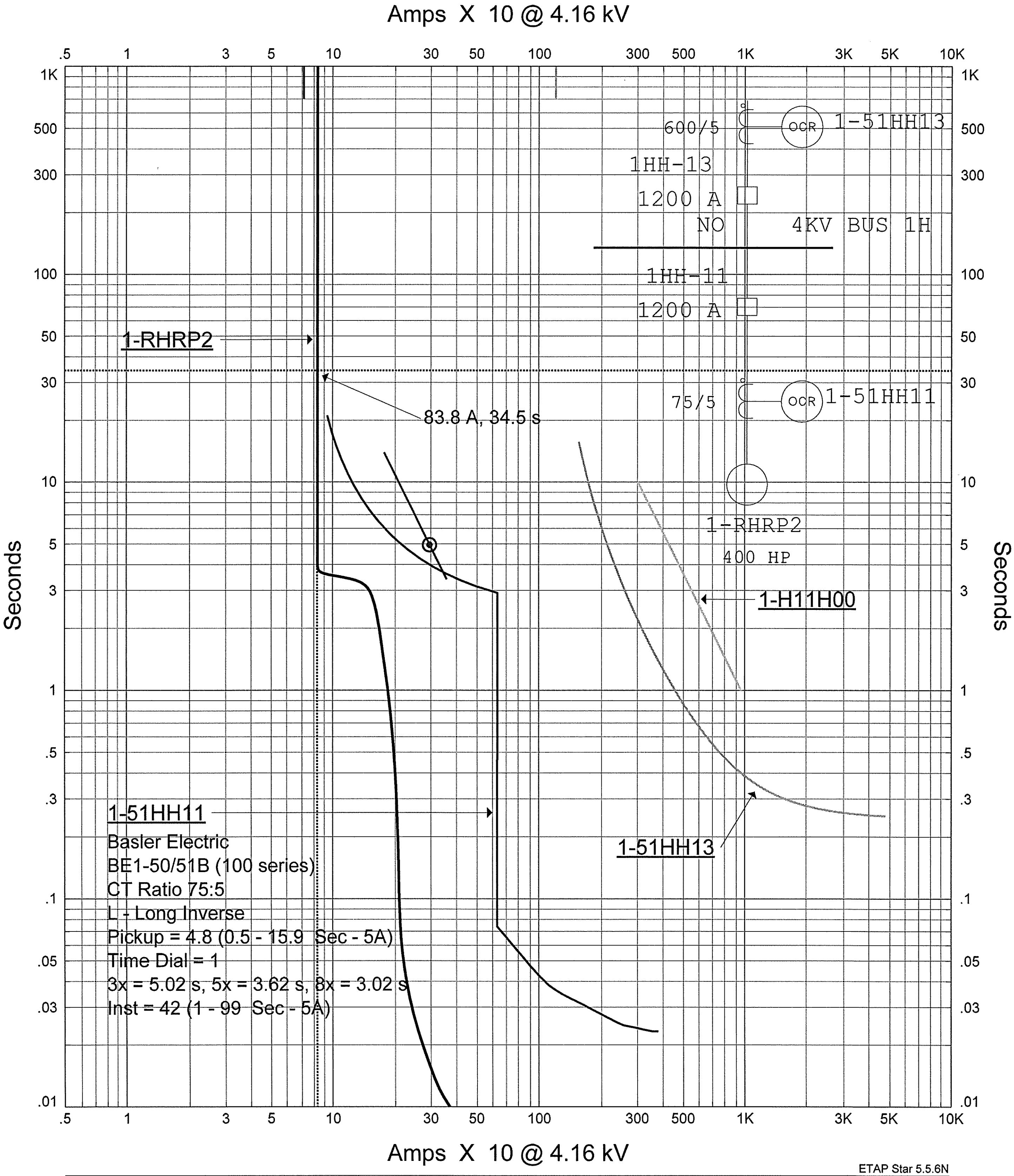
ETAP Star 5.5.6N

68% Bus Volts Start	**RHRP2**	68% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-68A



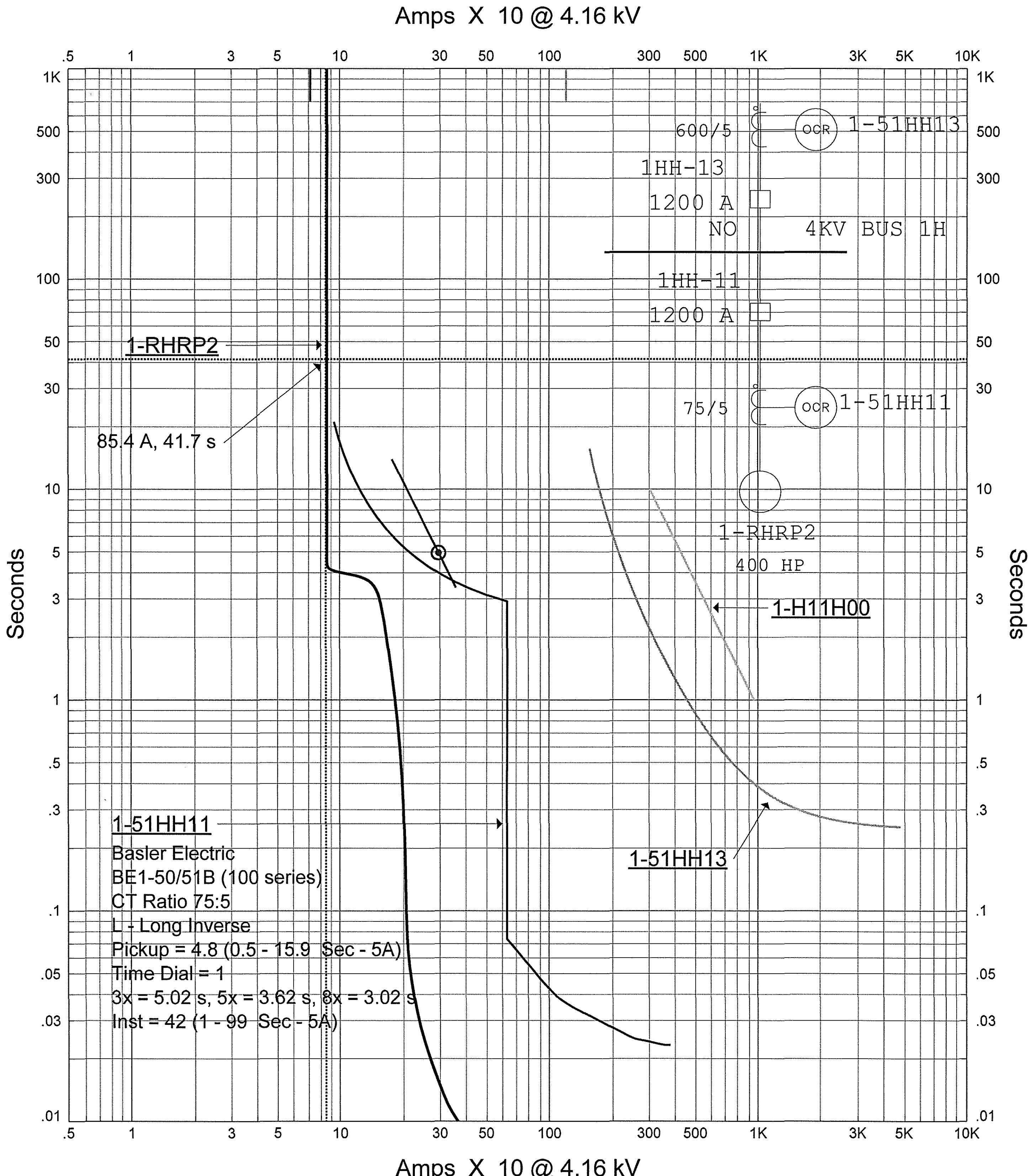
ETAP Star 5.5.6N

67% Bus Volts Start	**RHRP2**	67% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-67A



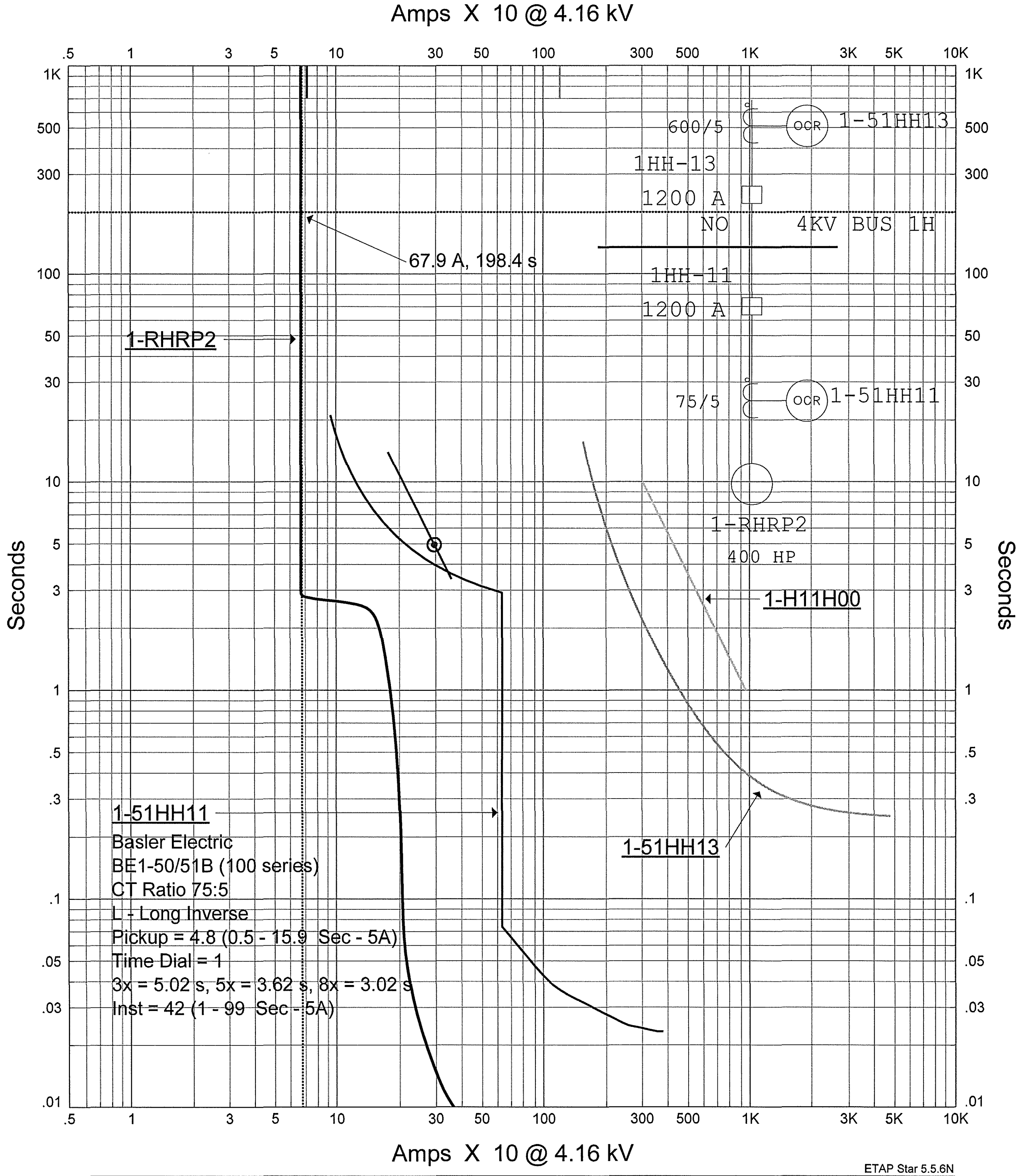
ETAP Star 5.5.6N

66% Bus Volts Start	**RHRP2**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-66A

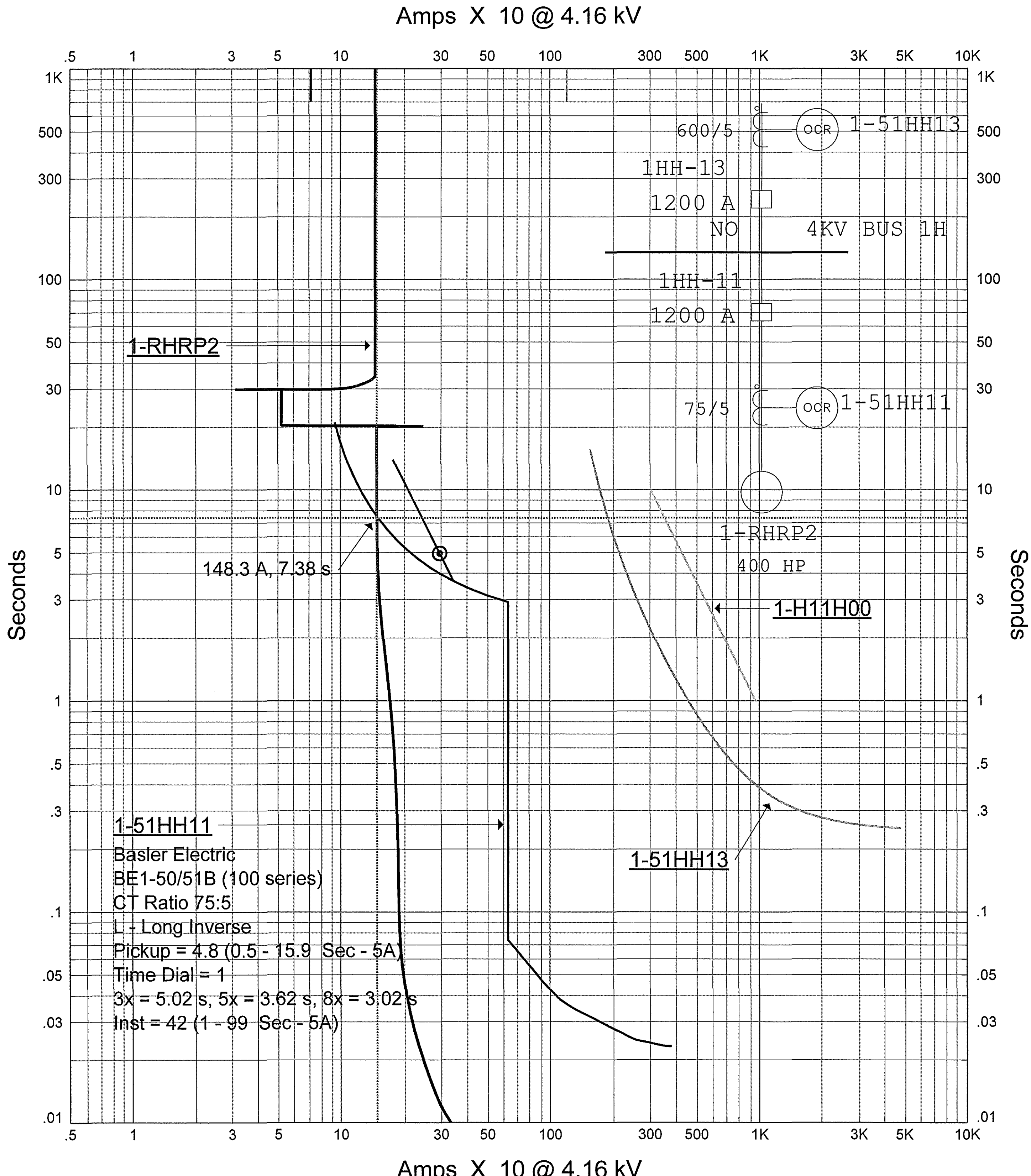


66% Bus Volts Start	**RHRP2**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-66N



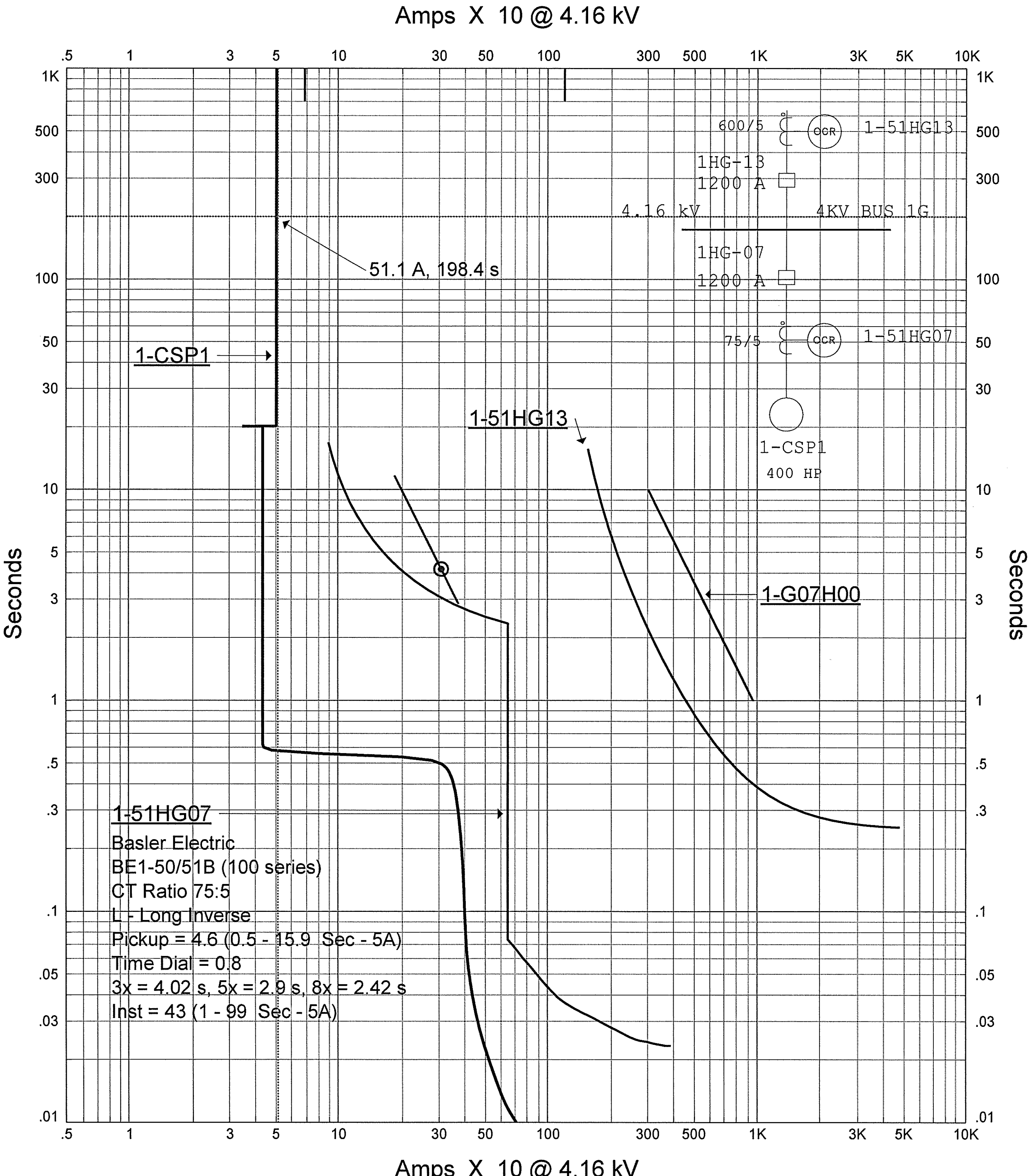
ETAP Star 5.5.6N

60% Bus Volts Start	**RHRP2**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-60

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

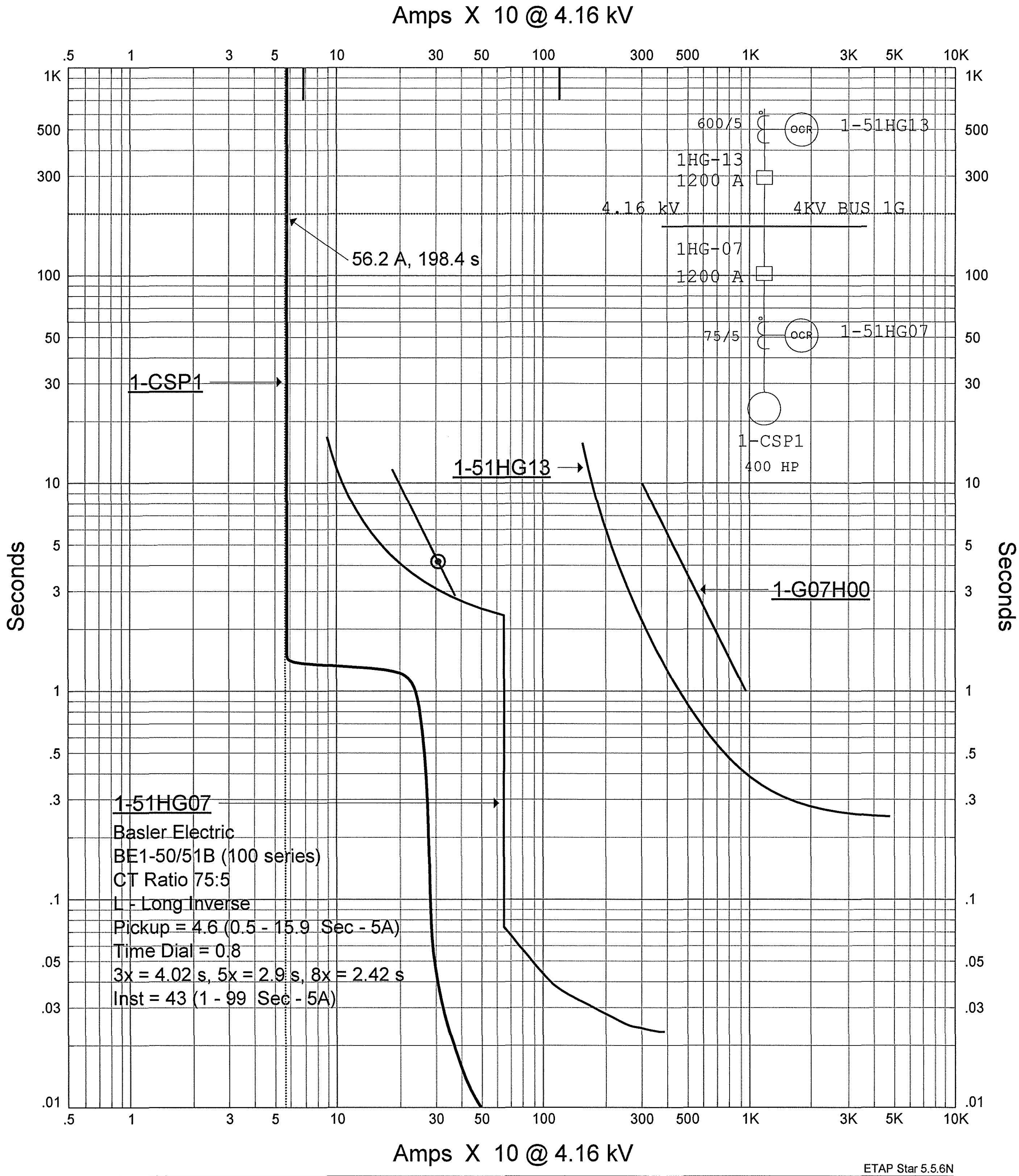


125% Bus Volts Start	**CSP1**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-125



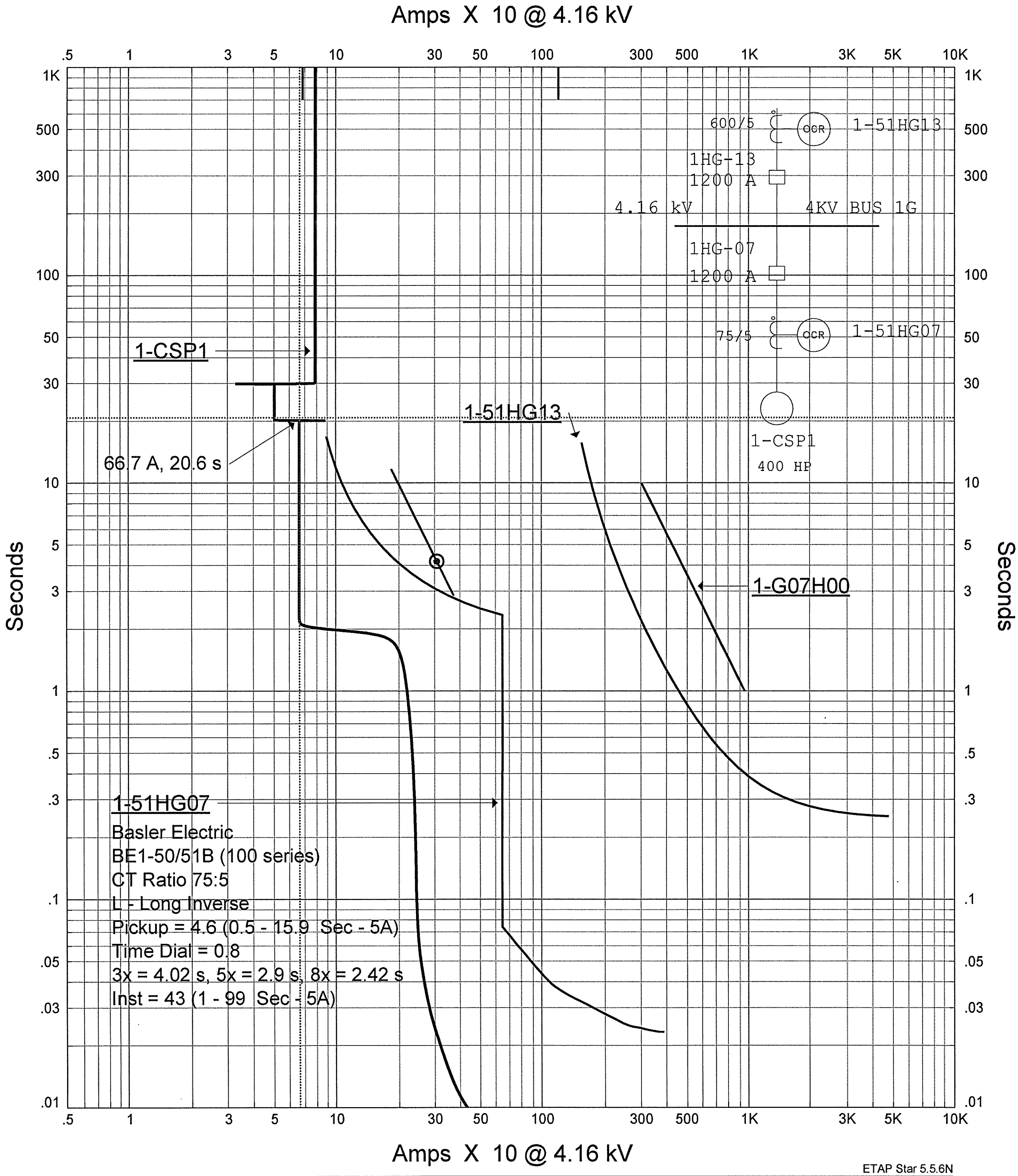
ETAP Star 5.5.6N

90% Mtr. Term. Volts Start	**CSP1**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90

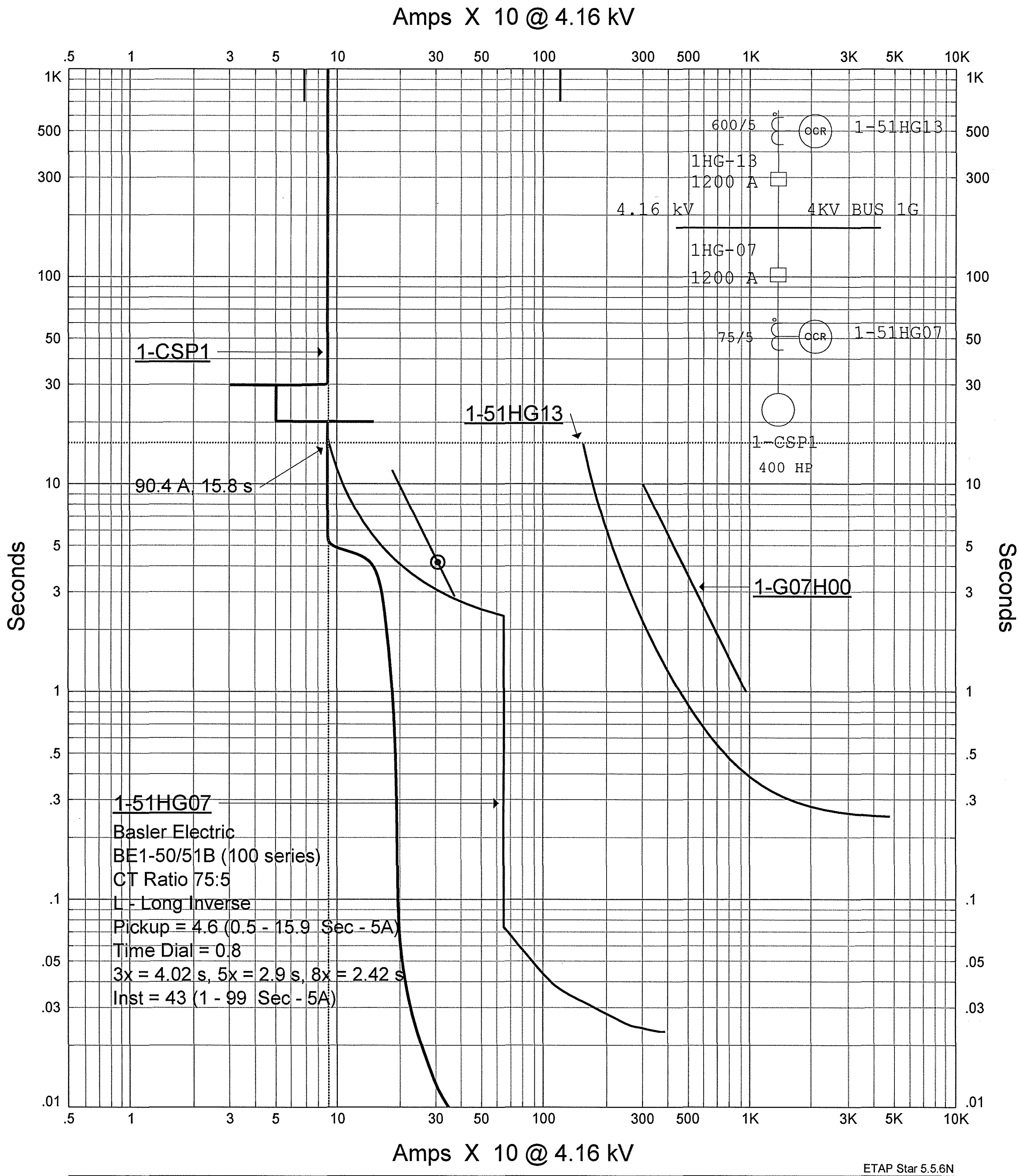


75% Bus Volts Start	**CSP1**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-75

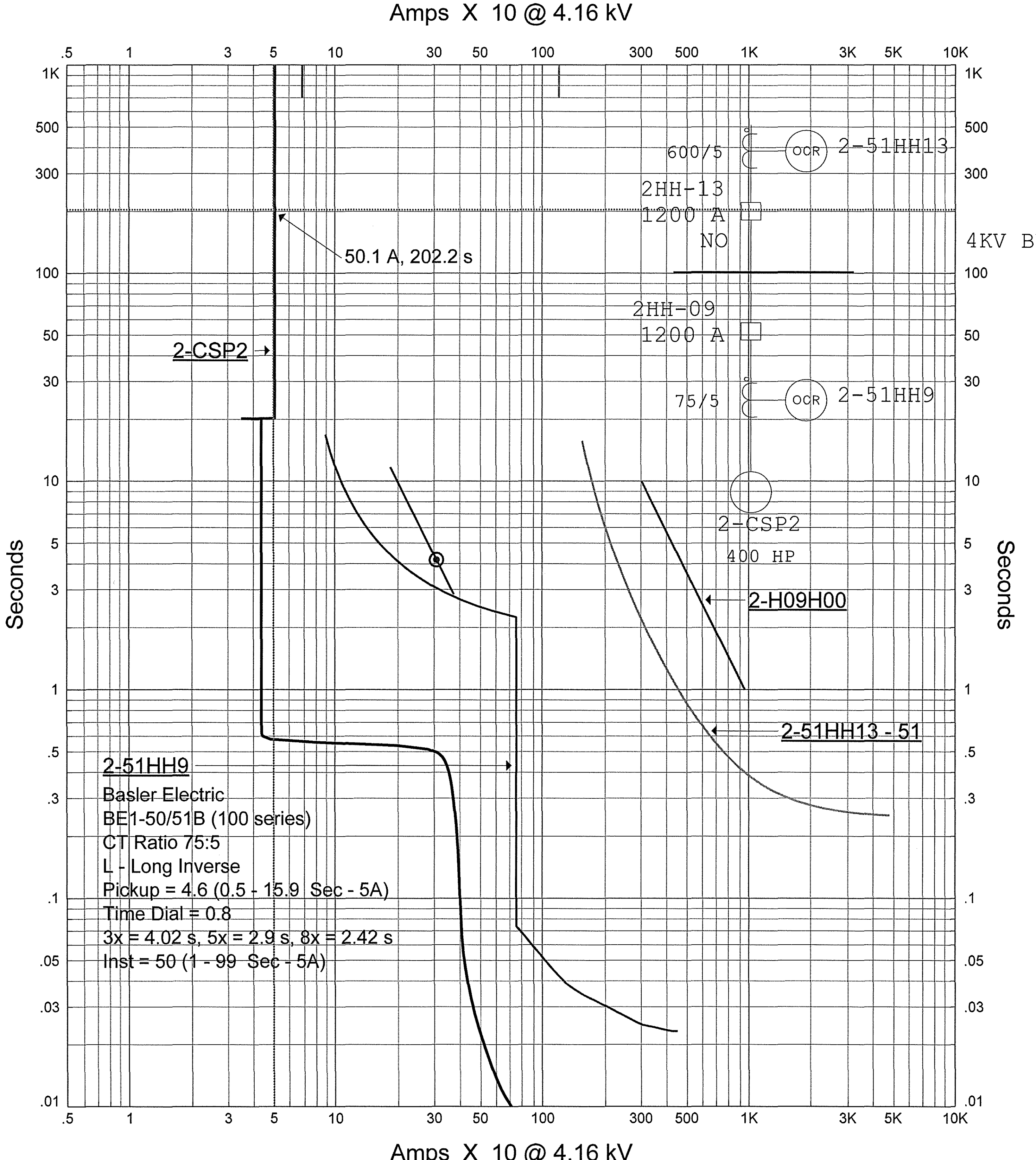


60% Bus Volts Start	**CSP1**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-60

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

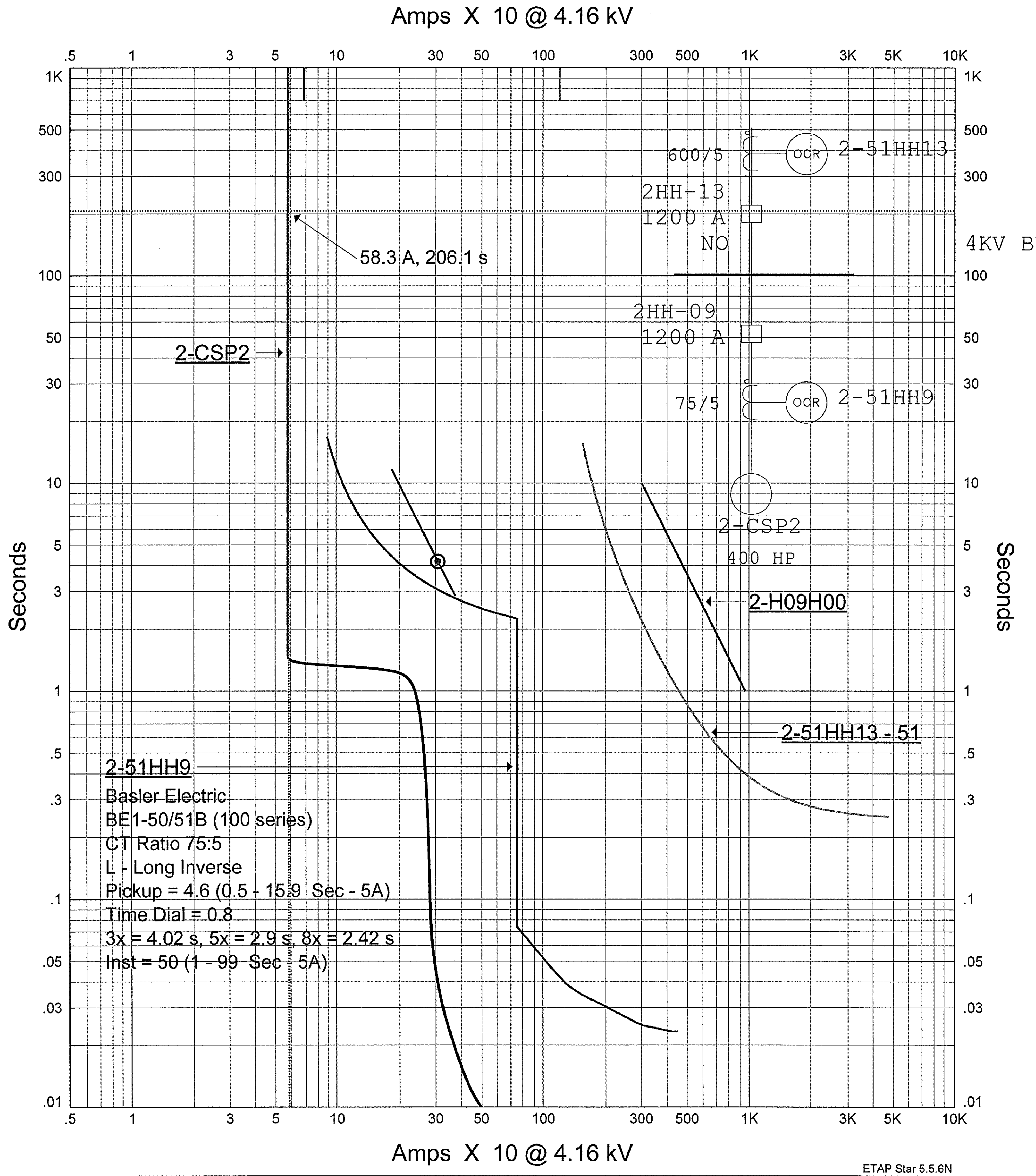


125% Bus Volts Start	**2-CS2**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-125

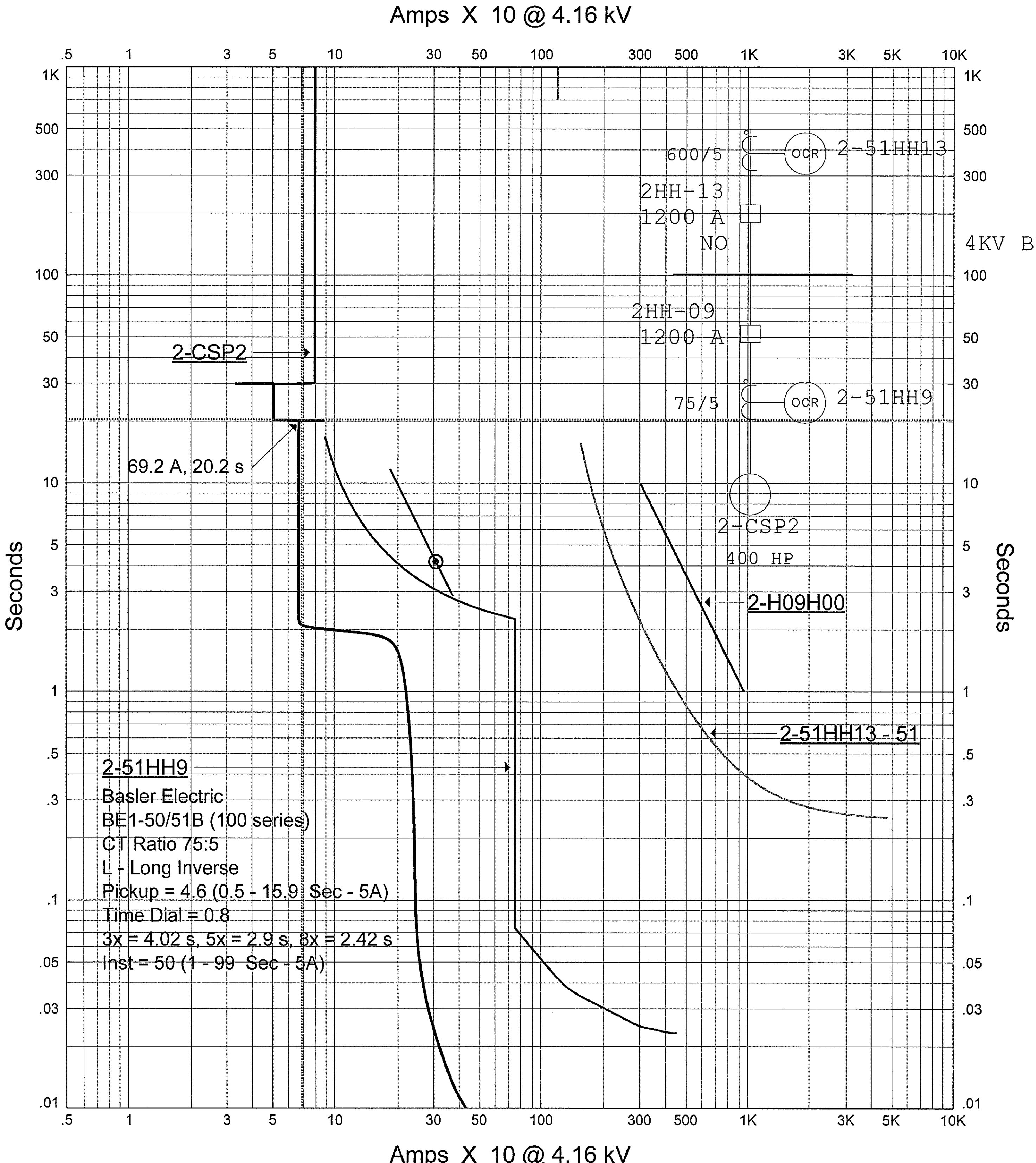


90% Mtr. Tem. Volts Start	**2-CS2**	90% Mtr. Tem. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



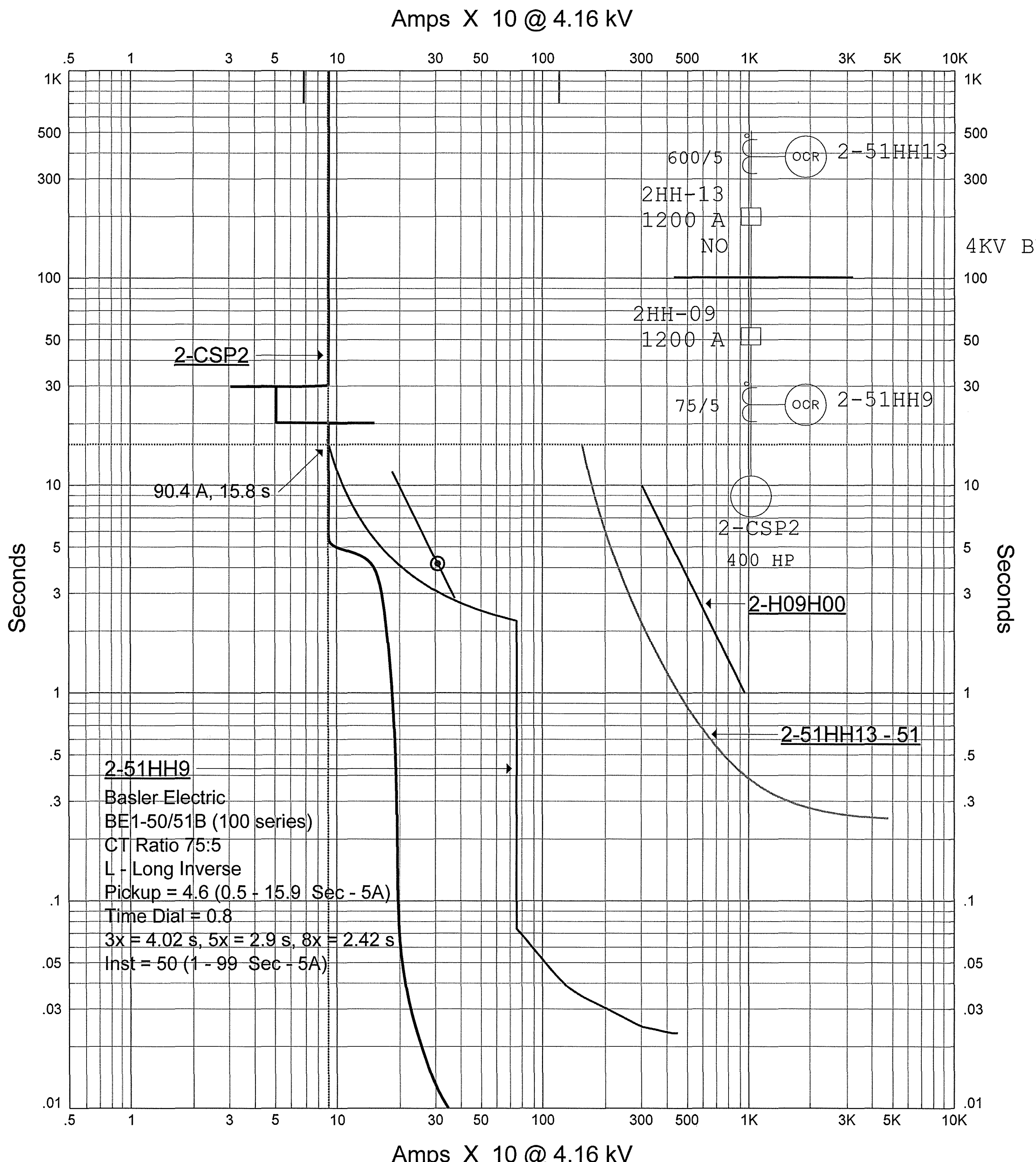
ETAP Star 5.5.6N

75% Bus Volts Start	**2-CS2**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-75



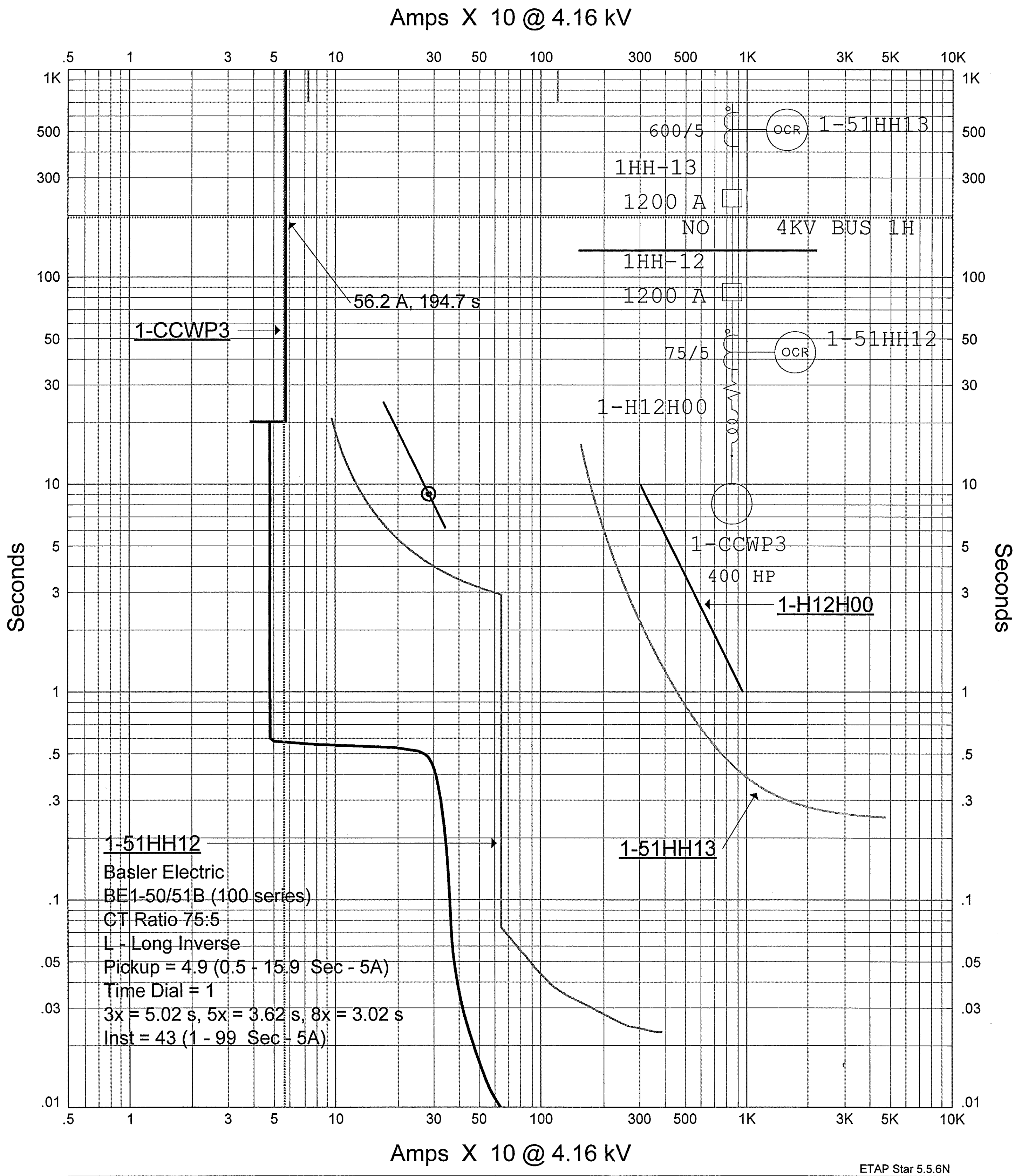
ETAP Star 5.5.6N

60% Bus Volts Start	**2-CS2**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/05/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-60

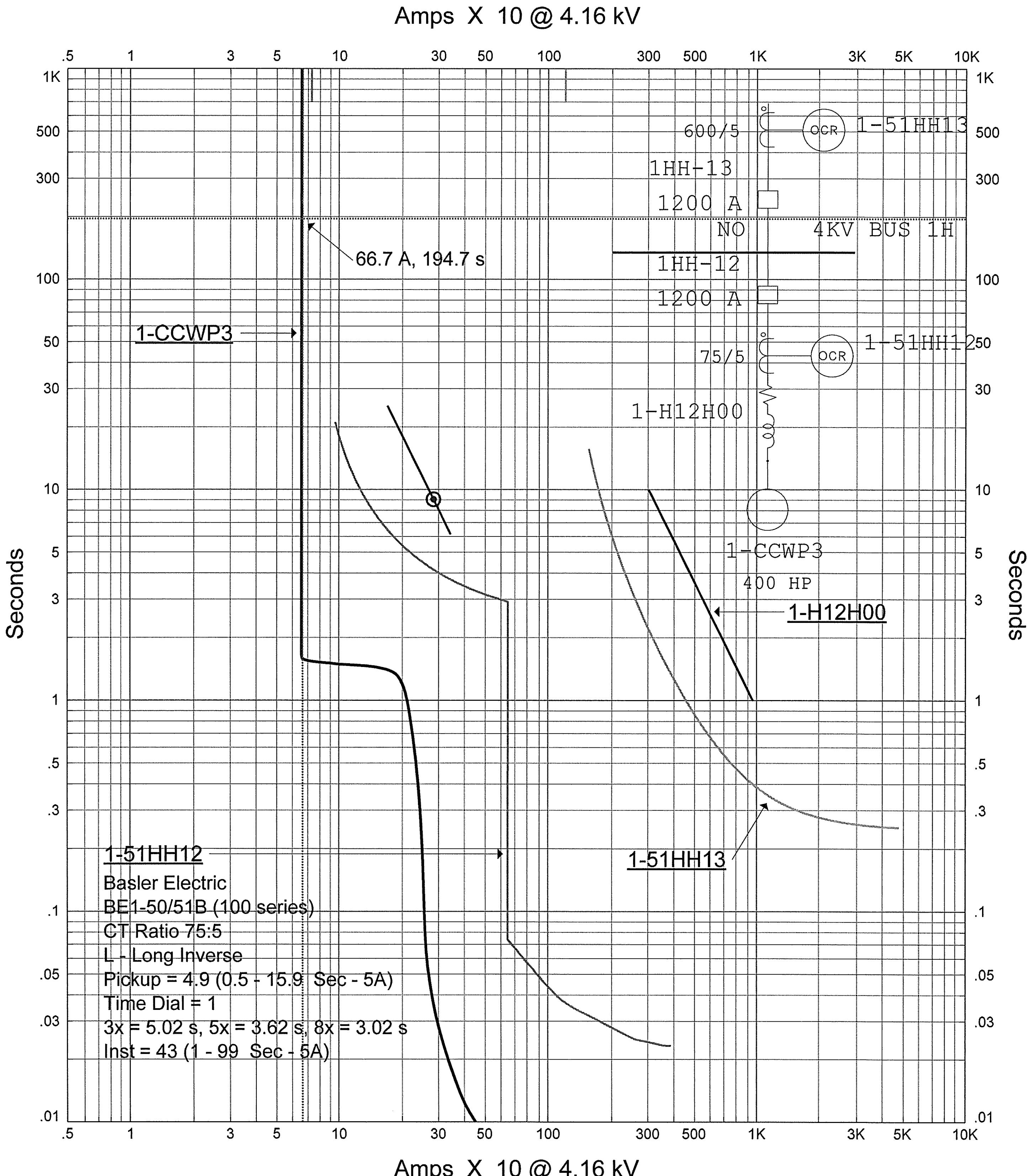


125% Bus Volts Start	**CCWP3**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-125

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

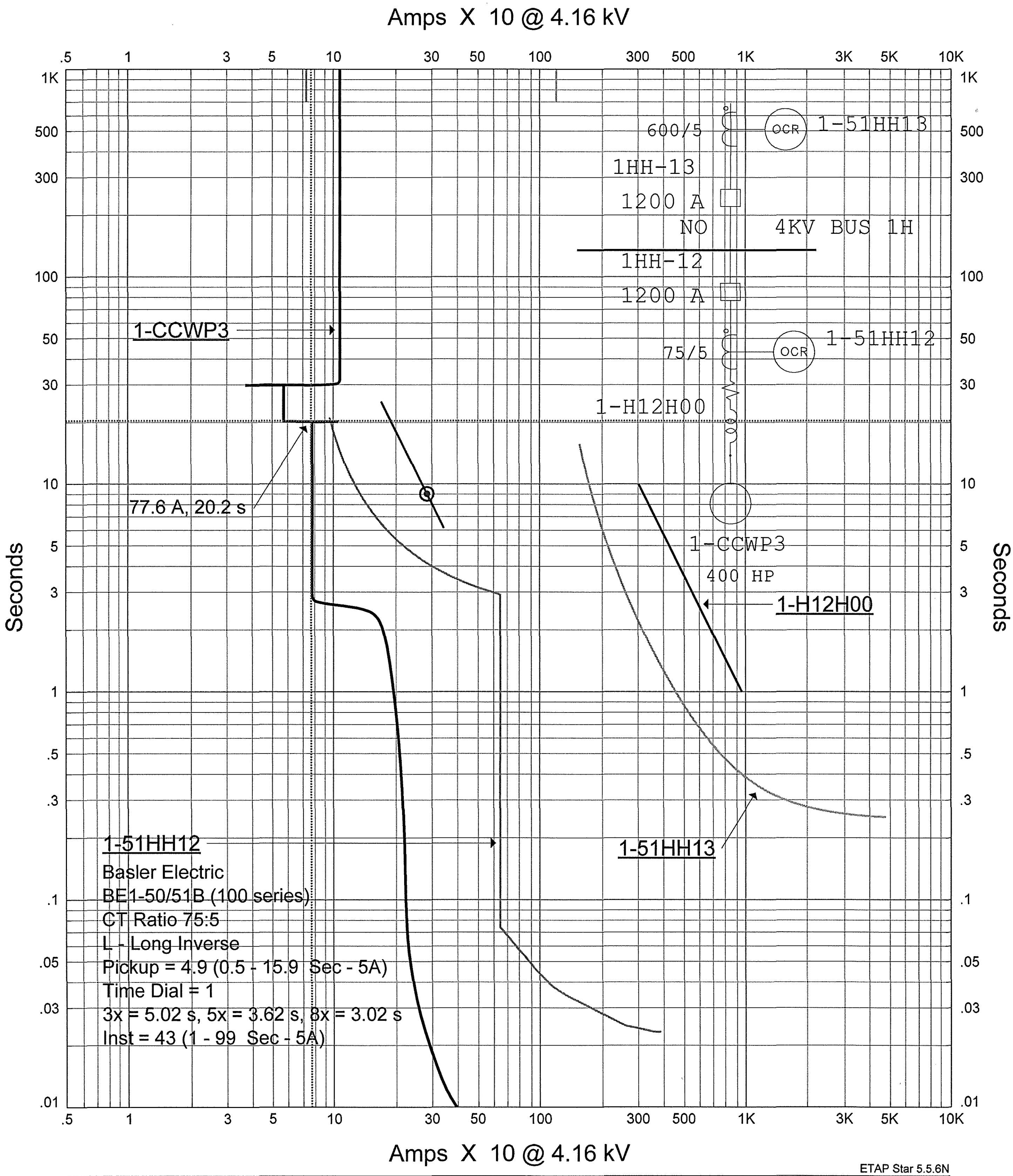


90% Mtr. Term. Volts Start	**CCWP3**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90

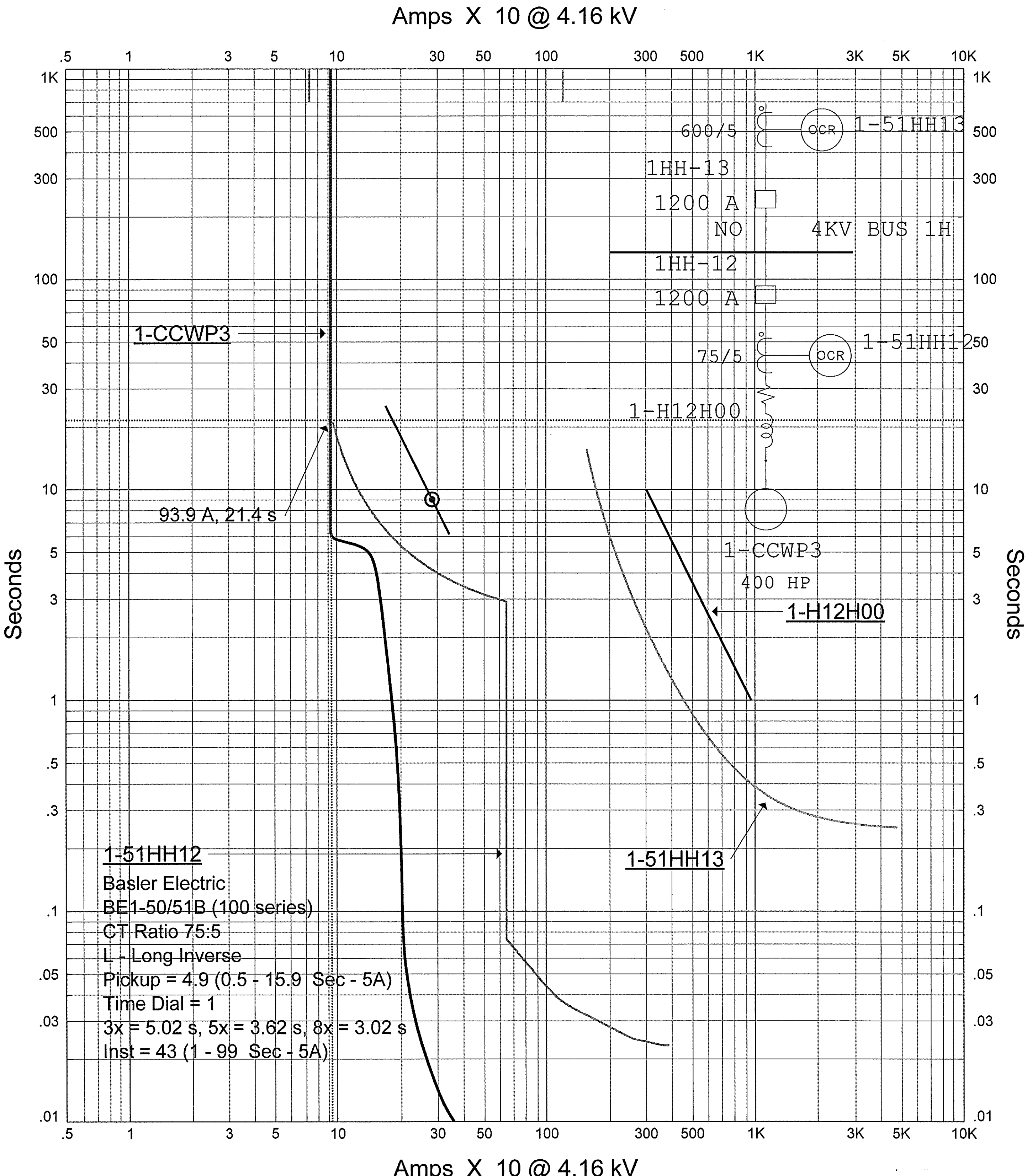


75% Bus Volts Start	**CCWP3**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-75



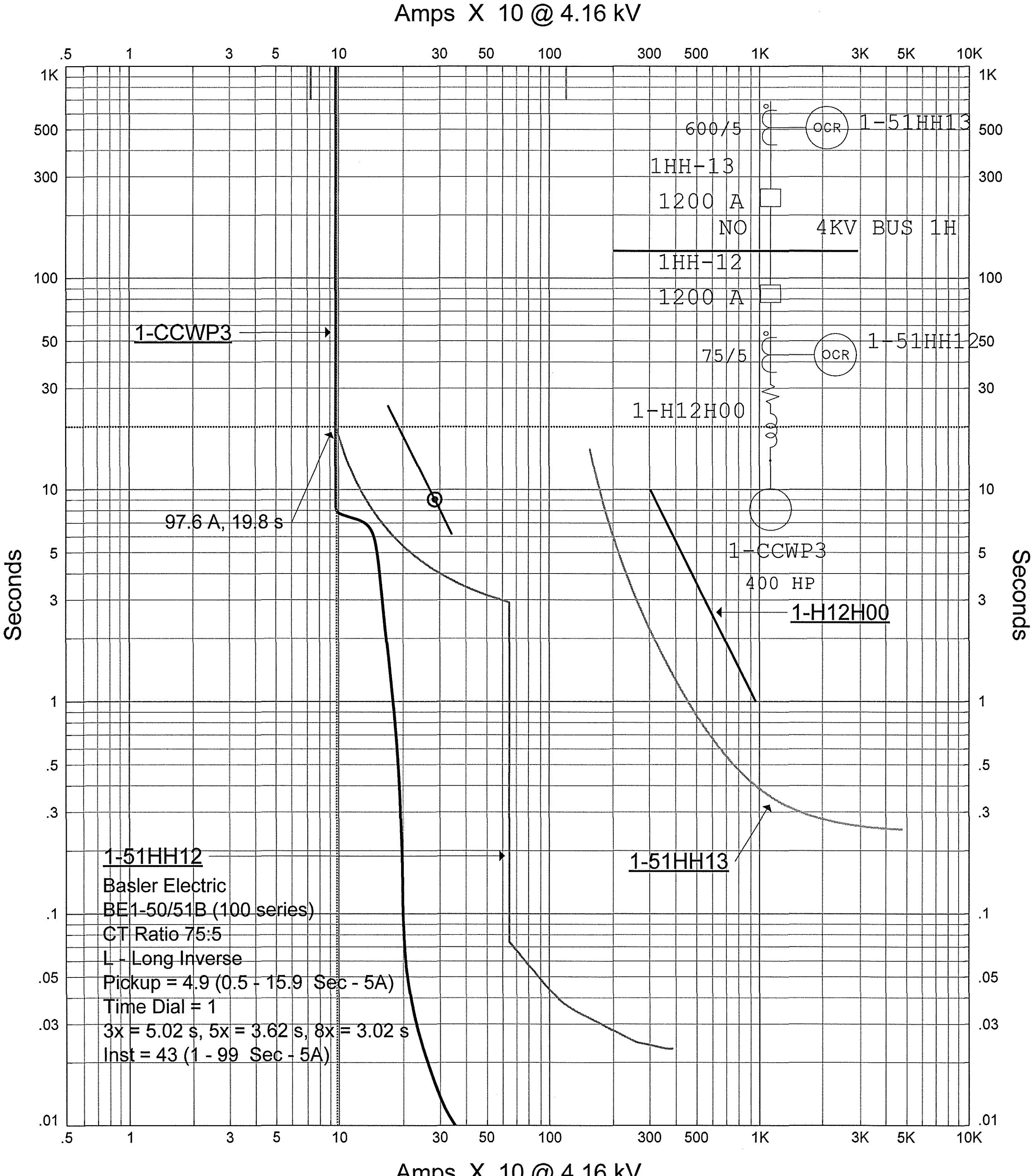
ETAP Star 5.5.6N

68% Bus Volts Start	**CCWP3**	68% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-68A



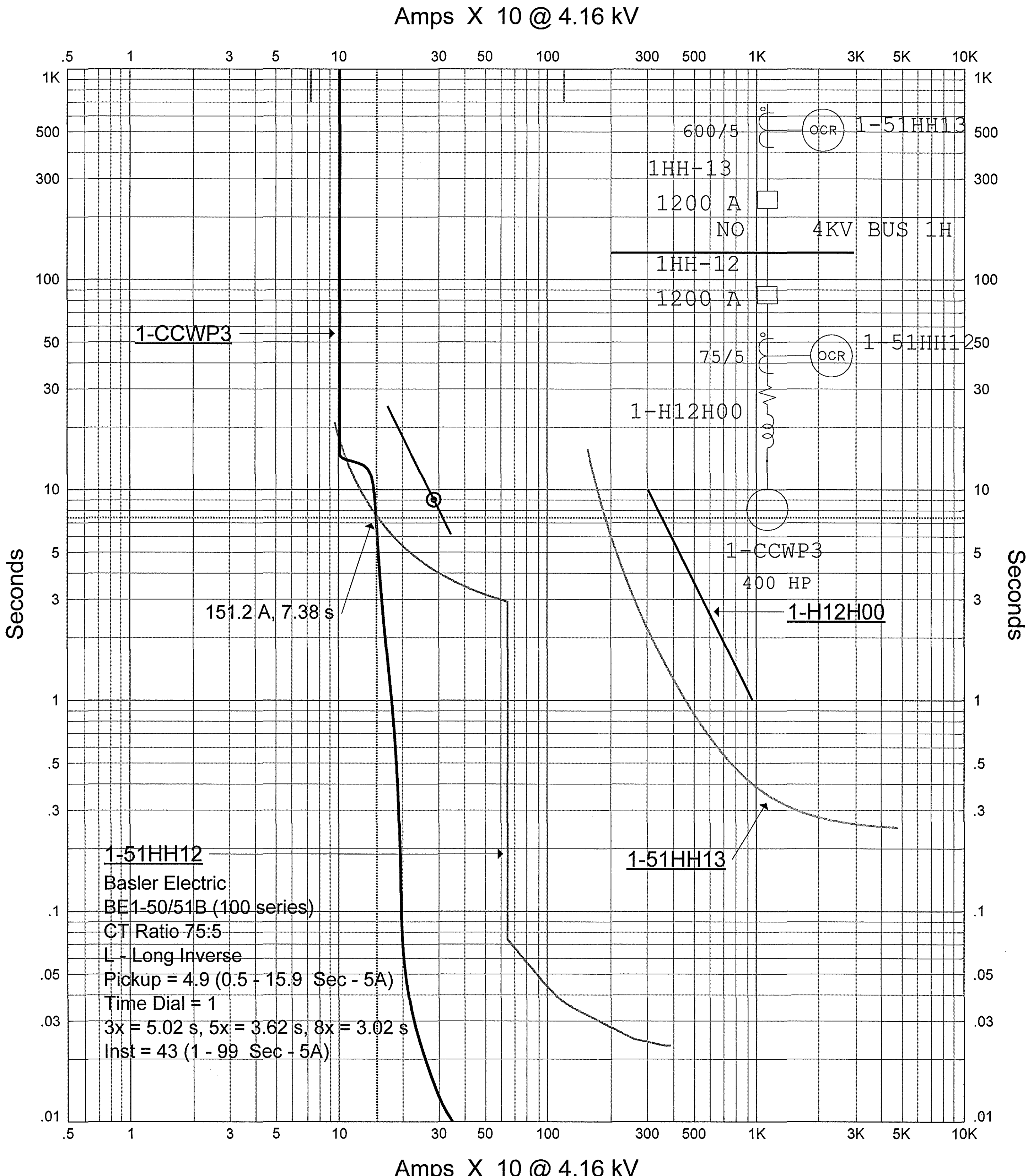
ETAP Star 5.5.6N

67% Bus Volts Start	**CCWP3**	67% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and FLUR
Run ESF-Mtr-67A



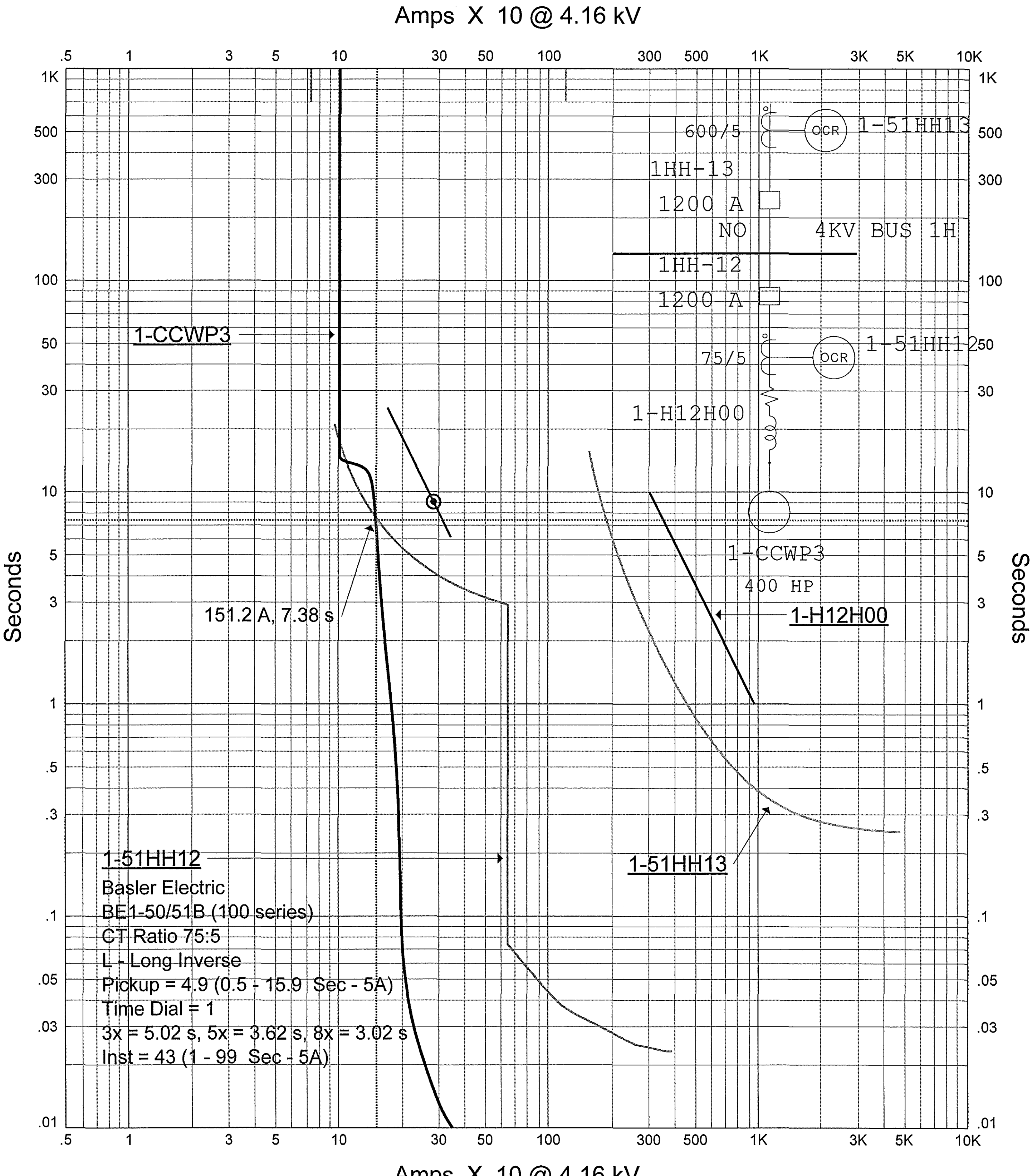
ETAP Star 5.5.6N

66% Bus Volts Start	**CCWP3**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and the FLUR
Run ESF-Mtr-66A



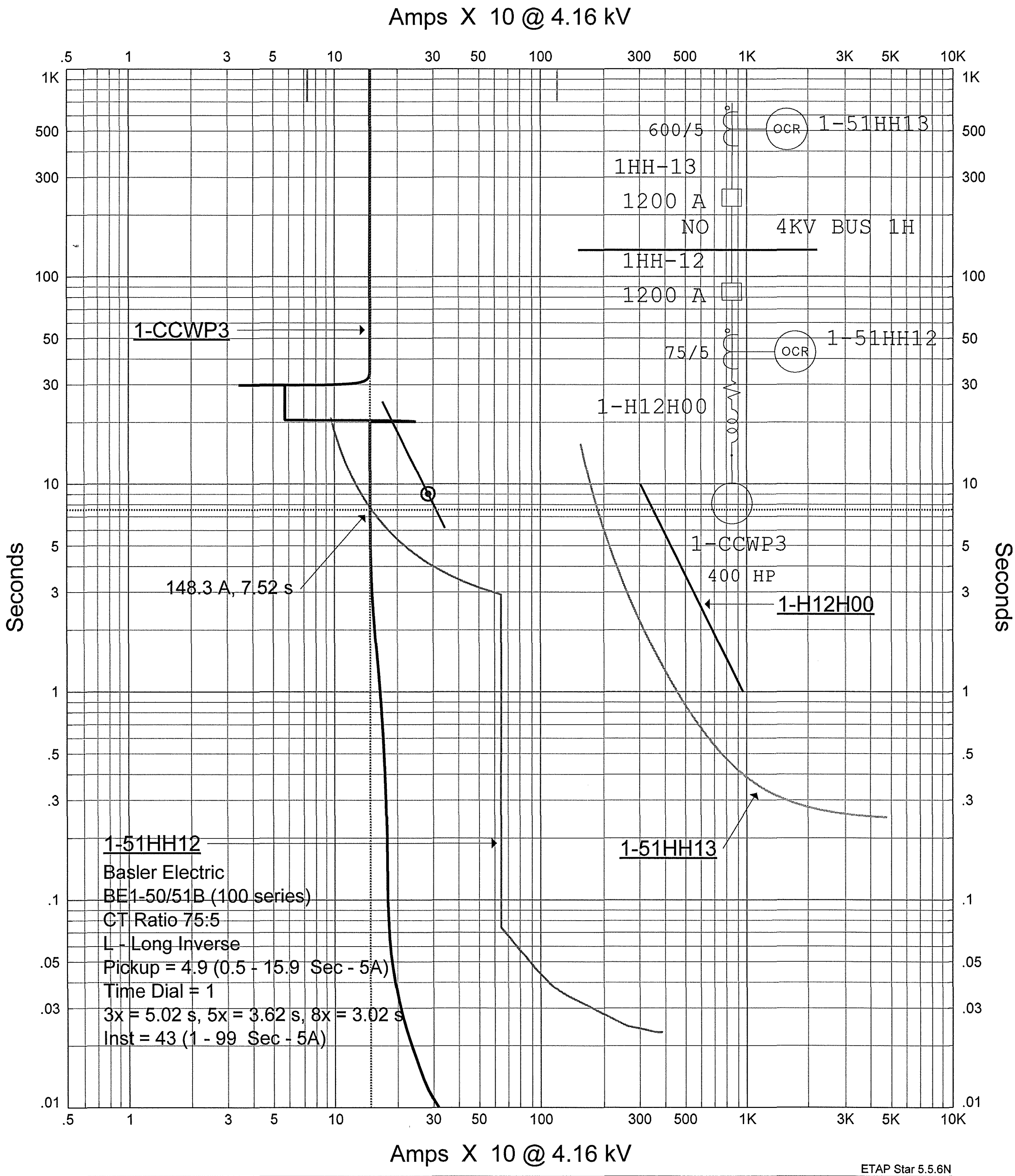
ETAP Star 5.5.6N

66% Bus Volts Start	**CCWP3**	66% Bus Volts Run

Project: Calc 170-DC Rev 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/15/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Objective: Determine Margin Between Motor Protection and the FLUR
Run ESF-Mtr-66N

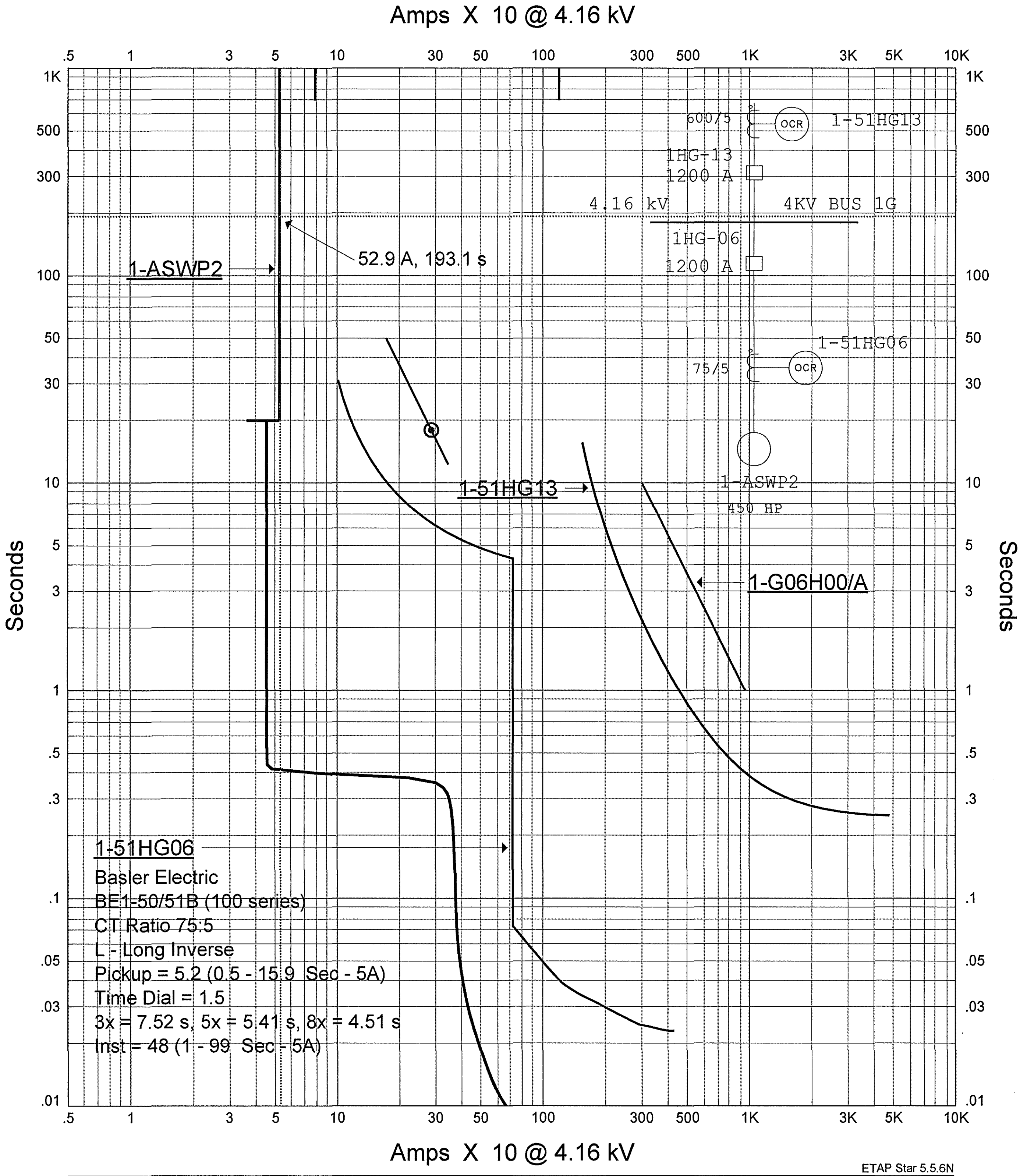


60% Bus Volts Start	**CCWP3**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-60



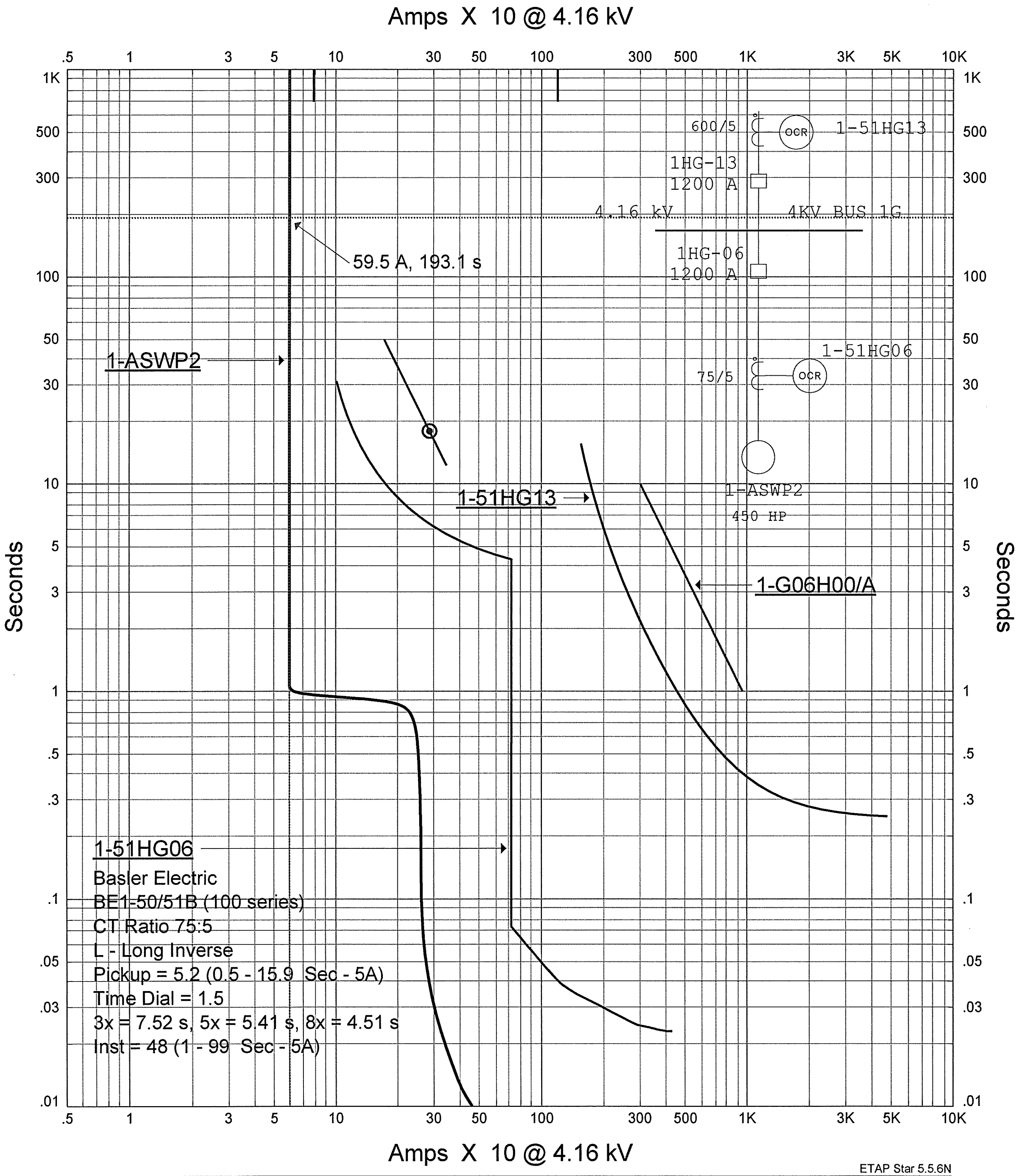
ETAP Star 5.5.6N

125% Bus Volts Start	**ASWP2**	100% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-125

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase



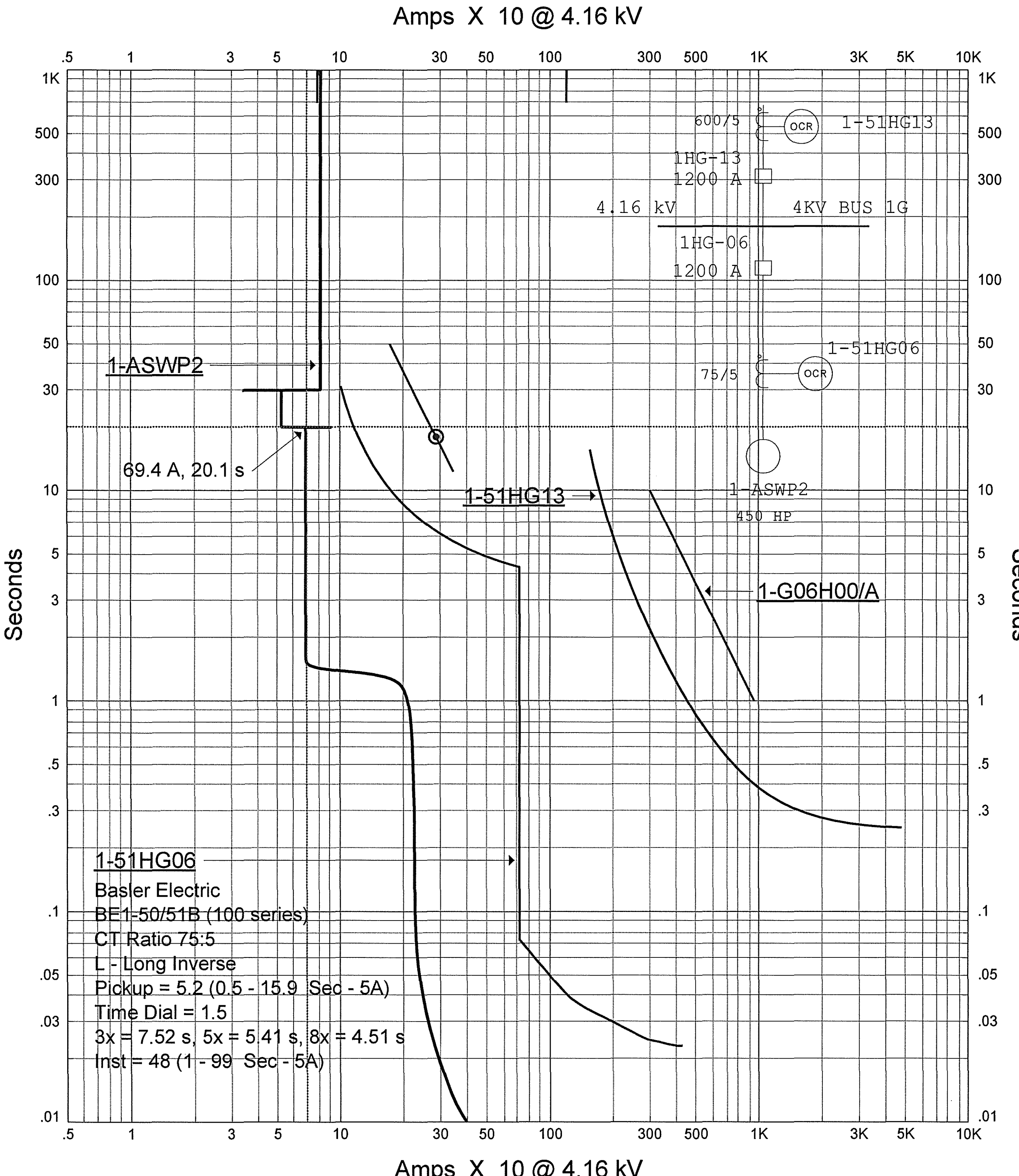
ETAP Star 5.5.6N

90% Mtr. Term. Volts Start	**ASWP2**	90% Mtr. Term. Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/02/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Object: Verify ESF Motors Run Continuously at 90% Mtr. Term. Voltage Without Tripping
Run ESF-Mtr-90



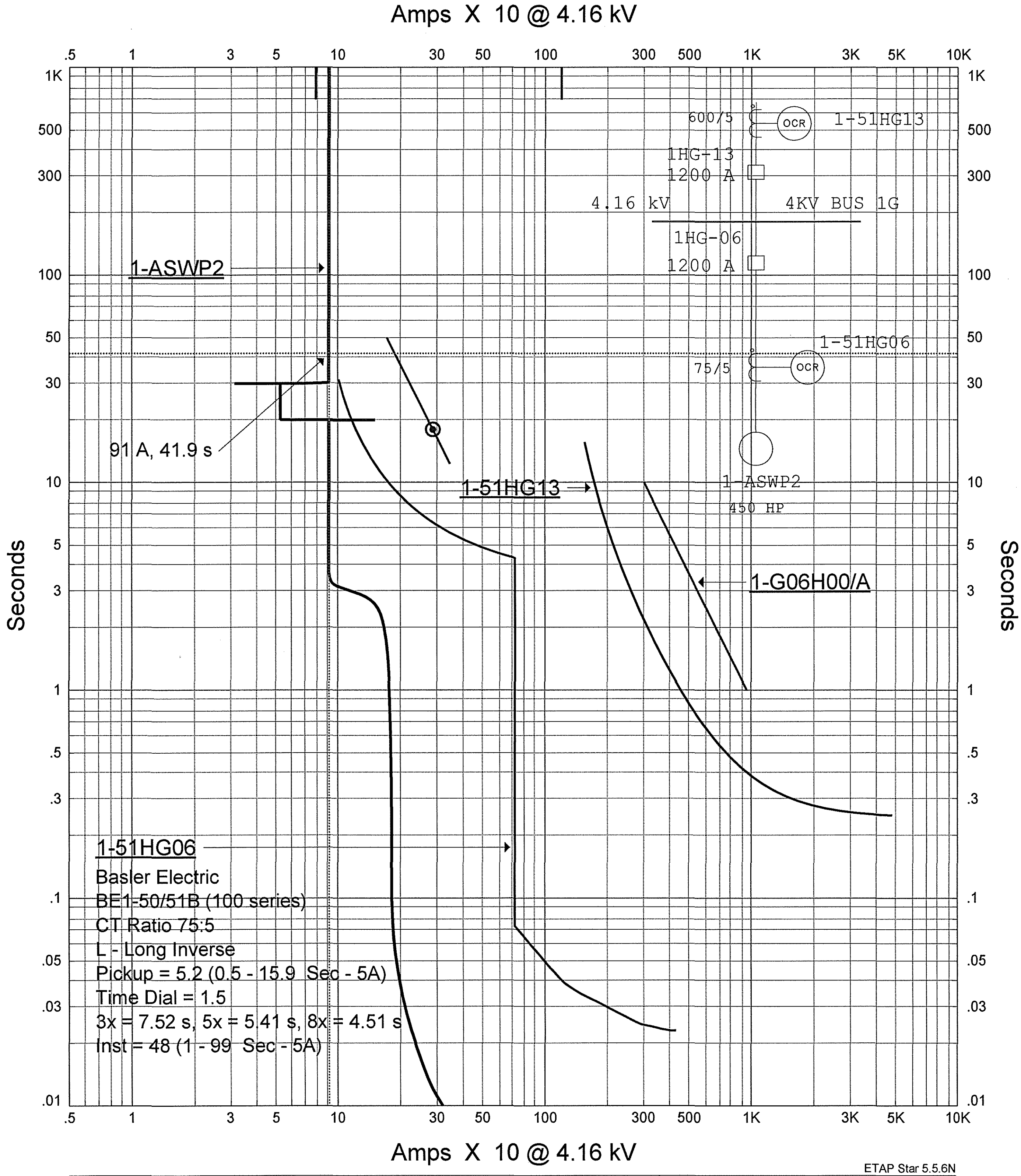
ETAP Star 5.5.6N

75% Bus Volts Start	**ASWP2**	65% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

Run ESF-Mtr-75



60% Bus Volts Start	**ASWP2**	60% Bus Volts Run

Project: Calc 170-DC Rev. 16
Location: Diablo Canyon Power Plant
Contract:
Engineer: Design Engineering
Filename: S:\ETAP\Calcs\359\359R9\Runs\DCPP20101118.OTI

Run ESF-Mtr-60

Date: 02/01/2011
SN: PACIFICG&E
Rev: ESF Motor Start
Fault: Phase

50/51 Device Setting Calculation
Auxiliary Feedwater Pumps

BHP=600 (worst case loading)
All motors have same characteristics, therefore this setting applies all Auxiliary Feedwater Pumps for both Unit 1 and Unit 2

$CTR := 20$ (CT Ratio is 100:5)

$HP := 600$ (Nominal Horsepower)

$SF := 1.0$ (Motor Service Factor)

$BHP := 600$ (Brake Horsepower)

$FLAnom := 74.7$ (Nominal Full Load Amps)

$FLA := FLAnom\cdot\left(\frac{BHP}{HP}\right) = 74.7$ (Brake Horsepower Full Load Amps)

$LRA := 422.2$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 83$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA\cdot 1.1 = 464.42$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA\cdot 1.25 = 527.75$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$$TOCmin := FLAmax\cdot MT\cdot RE = 89.765$$

$$TAPmin := \frac{TOCmin}{CTR} = 4.488$$ **Select TOC set @ 4.8 amps**

$$TOC := CTR\cdot 4.8 = 96$$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right]\cdot 100 = 15.663$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 2.0** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps will not be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 803.632$ **Select IT set @ 43 amps**

$IT := CTR \cdot 43 = 860$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 7.014$$

Conclusion:
Based on the maximum motor BHP, the selected time overcurrent element (TOC) setting provides and acceptable margin of 15.7%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 7.0%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Centrifugal Charging Pumps 1 and 2

BHP=648 (worst case loading)
All motors have same characteristics, therefore this setting applies for Centrifugal Charging Pumps 1 and 2 for both Unit 1 and Unit 2

$CTR := 30$ (CT Ratio is 150:5)

$HP := 600$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 648$ (Brake Horsepower)

$FLAnom := 75.9$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 87.285$ (Motor Service Factor Full Load Amps)

$LRA := 399.7$ (Nominal Locked Rotor Amps)

$FLAmax := \left(\frac{FLA}{0.9}\right) = 96.983$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 439.67$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 499.625$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 104.887$

$TAPmin := \frac{TOCmin}{CTR} = 3.496$ **Select TOC set @ 3.5 amps**

$TOC := CTR \cdot 3.5 = 105$

$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 8.266$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 0.9** provides coordination, will not cause nusiance tripping during motor starting and is at motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these Centrifugal Charging pumps may be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 125% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA2 \cdot MT \cdot RE = 864.551$ **Select IT set @ 31 amps**

$IT := CTR \cdot 31 = 930$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 7.57$$

Conclusion:

Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 8.3%.

Based on 125% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 7.6%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Appendix 1 indicates that the the motor thermal damage curve partially extends below the selected setting of the motor overcurrent relay. An additional study was done to determine the intersection of the steady state locked rotor current at 110% of motor terminal voltage with the motor thermal damage curve and 51 device trip curve, which is the maximum expected steady state voltage. This condition could only occur if the motor rotor was prevented from turning with 110% voltage applied, and under these conditions, the motor would not be capable of performing its safety function. Any condition less severe would result in the motor acceleration curve shifting to the left and would result in daylight between the acceleration curve and the motor damage curve.

For the 0.9 Time Dial setting, the intersection of the 110% motor terminal voltage study puts the intersection of the motor LRA, the trip curve and the motor damage curve roughly at the same point. There is daylight between the motor damage curve and the trip curve if the 0.8 Time Dial Setting is used, however lowering the time dial setting would provide less margin for the acceleration transient and would also reduce the margin between the motor 51device and the bus undervoltage protection by about one second.

Providing as much margin as possible between bus undervoltage protection and motor protection ensures that there is no loss of safety function due to tripping the motor on its overcurrent protection prior to seperating from degraded voltage on bus undervoltage protection. Providing as much margin as possible for the motor to successfully accelerate under less than ideal conditions (e.g., off nominal frictional forces, tight bearing) also ensures there is no loss of safety function due to tripping the motor on its overcurrent protection.

The selected setting resolves these differences in these conflicting criteria in favor of completing the safety function and therefore is acceptable.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Centrifugal Charging Pump 3

BHP=600 (worst case loading)
Both motors have same characteristics, therefore this setting applies for Centrifugal Charging Pump 3 for both Unit 1 and Unit 2

$CTR := 30$ (CT Ratio is 150:5)

$HP := 600$ (Nominal Horsepower)

$SF := 1.0$ (Motor Service Factor)

$BHP := 600$ (Brake Horsepower)

$FLAnom := 73.8$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot \left(\frac{BHP}{HP}\right) = 73.8$ (Brake Horsepower Full Load Amps)

$LRA := 447.0$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 82$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 491.7$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 558.75$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 88.683$

$TAPmin := \frac{TOCmin}{CTR} = 2.956$ **Select TOC set @ 3.5 amps**

$TOC := CTR \cdot 3.5 = 105$

$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 28.049$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.0** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps may be started under bus transfer conditions
under any plant operating modes, maximum starting current will be based on 125% voltage at the motor terminals.

$\text{Asym} := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$\text{ITmin} := \text{Asym}\cdot\text{LRA2}\cdot\text{MT}\cdot\text{RE} = 966.861$ **Select IT set @ 35 amps**

$\text{IT} := \text{CTR}\cdot 35 = 1.05 \times 10^{3}$

$$\%\text{MarginIT} := \left[\left(\frac{\text{IT}}{\text{ITmin}}\right) - 1\right]\cdot 100 = 8.599$$

Conclusion:

Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 28.1%.

Based on 125% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 8.6%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Unit 1 Safety Injection Pumps 1 and 2

BHP=400 (worst case loading)
The motors have same characteristics, therefore this setting applies for both Safety Injection Pumps for Unit 1

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 400$ (Brake Horsepower)

$FLAnom := 51.0$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 58.65$ (Motor Service Factor Full Load Amps)

$LRA := 265.4$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 65.167$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 291.94$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 331.75$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 70.478$

$TAPmin := \frac{TOCmin}{CTR} = 4.699$ **Select TOC set @ 4.8 amps**

$TOC := CTR \cdot 4.8 = 72$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 10.486$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.5** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps will not be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 505.173$ **Select IT set @ 35 amps**

$IT := CTR \cdot 35 = 525$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 3.925$$

Conclusion:

Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 10.5%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 3.9%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Unit 2 Safety Injection Pumps 1 and 2

BHP=400 (worst case loading)
The motors have same characteristics, therefore this setting applies for both Safety Injection Pumps for Unit 2

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 400$ (Brake Horsepower)

$FLAnom := 51.9$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 59.685$ (Motor Service Factor Full Load Amps)

$LRA := 280.0$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 66.317$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 308$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 350$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 71.721$

$TAPmin := \frac{TOCmin}{CTR} = 4.781$ **Select TOC set @ 5.0 amps**

$TOC := CTR \cdot 5.0 = 75$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 13.094$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.5** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps will not be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 532.963$ **Select IT set @ 35 amps**

$IT := CTR \cdot 35 = 525$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = -1.494$$

Conclusion:
Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 13.1%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides a negative margin of -1.5%.
Justification: Refer to Appendix 1 TCC Curve for Unit 2 Safety Injection pumps starting at 125% Bus Voltage. Based on starting inrush of 125% from an infinite bus (worst case transient inrush), the motor model shows that the asymmetry lasts for less than 0.1 seconds and there is considerable margin relative to the instantaneous region of the curve during that period. Further, at greater than 0.1 seconds the minimum margin is on the order of 175 amps. Increasing this setting would encroach on the margin for coordination with the upstream breaker which is not desirable, and therefore this setting is acceptable.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Residual Heat Removal Pumps

BHP=424 (worst case loading)
All motors have similar characteristics. The worst case brake horsepower and locked rotor amperage was used. Therefore, this setting applies for Component Cooling Water pumps for both Unit 1 and Unit 2

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 424$ (Brake Horsepower)

$FLAnom := 50$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 57.5$ (Motor Service Factor Full Load Amps)

$LRA := 307.6$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 63.889$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 338.36$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 384.5$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 69.096$

$TAPmin := \frac{TOCmin}{CTR} = 4.606$ **Select TOC set @ 4.8 amps**

$TOC := CTR \cdot 4.8 = 72$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 12.696$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.0** provides coordination, will not cause nusiance tripping during motor starting and is at the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps will not be started under bus transfer conditions
under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 585.498$ **Select IT set @ 42 amps**

$IT := CTR \cdot 42 = 630$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 7.601$$

Conclusion:

Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 12.7%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 7.6%

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker. It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Appendix 1 indicates that the the motor thermal damage curve partially extends below the selected setting of the motor overcurrent relay. An additional study was done to determine the intersection of the steady state locked rotor current at 110% of motor terminal voltage with the motor thermal damage curve and 51 device trip curve, which is the maximum expected steady state voltage. This condition could only occur if the motor rotor was prevented from turning with 110% voltage applied, and under these conditions, the motor would not be capable of performing its safety function. Any condition less severe would result in the motor acceleration curve shifting to the left and would result in daylight between the acceleration curve and the motor damage curve.

For the 1.0 Time Dial setting, the intersection of the 110% motor terminal voltage study puts the intersection of the motor LRA, the trip curve and the motor damage curve roughly at the same point. There is daylight between the motor damage curve and the trip curve if the 0.9 Time Dial Setting is used, however lowering the time dial setting would provide less margin for the acceleration transient and would also reduce the margin between the motor 51device and the bus undervoltage protection by about one half second.

Providing as much margin as possible between bus undervoltage protection and motor protection ensures that there is no loss of safety function due to tripping the motor on its overcurrent protection prior to seperating from degraded voltage on bus undervoltage protection. Providing as much margin as possible for the motor to successfully accelerate under less than ideal conditions (e.g., off nominal frictional forces, tight bearing) also ensures there is no loss of safety function due to tripping the motor on its overcurrent protection.

The selected setting resolves these differences in these conflicting criteria in favor of completing the safety function and therefore is acceptable.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Unit 1 Containment Spray Pumps 1 and 2 and Unit 2 Containment Spray Pump 1

BHP=440 (worst case loading)
The motors have similar characteristics therefore this setting applies for each Containment Spray Pump listed above.

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 440$ (Brake Horsepower)

$FLAnom := 51.6$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 59.34$ (Motor Service Factor Full Load Amps)

$LRA := 320.4$ (Nameplate Locked Rotor amps)

$FLAmax := \frac{FLA}{0.9} = 65.933$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 352.44$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 400.5$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 71.307$

$TAPmin := \frac{TOCmin}{CTR} = 4.754$ **Select TOC set @ 4.6 amps**

$TOC := CTR \cdot 4.6 = 69$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 4.651$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 0.8** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps will not be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 609.862$ **Select IT set @ 43 amps**

$IT := CTR \cdot 43 = 645$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 5.762$$

Conclusion:
Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 4.7%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 5.8%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Unit 2 Containment Spray Pump 2

BHP=440 (worst case loading)
The existing instantaneous trip setting differs from the other three Containment Spray Pumps and is evaluated for acceptability below.

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$BHP := 440$ (Brake Horsepower)

$FLAnom := 51.6$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot \left(\frac{BHP}{HP}\right) = 56.76$ (Brake Horsepower Full Load Amps)

$LRA := 320.4$ (Nameplate Locked Rotor amps)

$FLAmax := \frac{FLA}{0.9} = 63.067$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 352.44$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 400.5$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 68.207$

$TAPmin := \frac{TOCmin}{CTR} = 4.547$ **Select TOC set @ 4.6 amps**

$TOC := CTR \cdot 4.6 = 69$

$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 9.408$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 0.8** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these motors will not be started under bus transfer conditions
under any plant operating modes, maximum starting current will be based on 110% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA1 \cdot MT \cdot RE = 609.862$ **Select IT set @ 50 amps**

$IT := CTR \cdot 50 = 750$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 22.979$$

Conclusion:

Based on the maximum motor BHP the selected time overcurrent element (TOC) setting provides and acceptable margin of 9.4%.

Based on 110% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 23.0%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Component Cooling Water Pumps

BHP=424 (worst case loading)
All motors have same characteristics with the exception of locked rotor amperage, and so the worst case LRA was used for all settings. Therefore, this setting applies for Component Cooling Water pumps for both Unit 1 and Unit 2

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.15$ (Motor Service Factor)

$BHP := 424$ (Brake Horsepower)

$FLAnom := 52.8$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot (1.15) = 60.72$ (Motor Service Factor Full Load Amps)

$LRA := 295.4$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 67.467$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 324.94$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 369.25$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 72.965$

$TAPmin := \frac{TOCmin}{CTR} = 4.864$ **Select TOC set @ 4.9 amps**

$TOC := CTR \cdot 4.9 = 73.5$

$$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 8.943$$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.0** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps may be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 125% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA2 \cdot MT \cdot RE = 638.95$ **Select IT set @ 43 amps**

$IT := CTR \cdot 43 = 645$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 0.947$$

Conclusion:
Based on the motor Service Factor, the selected time overcurrent element (TOC) setting provides and acceptable margin of 8.9%.

Based on 125% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 0.9%.

Justification: Refer to Appendix 1 TCC Curve for Component Cooling Water pumps starting at 125% Bus Voltage. Based on starting inrush of 125% from an infinite bus (worst case transient inrush), the motor model shows that the asymmetry lasts for less than 0.1 seconds and there is considerable margin relative to the instantaneous region of the curve during that period. Further, at greater than 0.1 seconds the minimum margin is on the order of 250 amps. Increasing this setting would encroach on the margin for coordination with the upstream breaker which is not desirable, and therefore this setting is acceptable.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

50/51 Device Setting Calculation
Auxiliary Saltwater Pumps

BHP=464 (worst case loading)
All motors have the same BHP. Unit 1 ASWP2 is rated 450 HP Nominal, and the others are rated 400 HP Nominal. Scaling Full Load Amps for the 400 HP motors results in the highest running current, and using Locked Rotor Amps for the 450 HP motor results in the highest starting current, and these values were used in this evaluation. This setting applies for Auxiliary Saltwater pumps for both Unit 1 and Unit 2

$CTR := 15$ (CT Ratio is 75:5)

$HP := 400$ (Nominal Horsepower)

$SF := 1.0$ (Motor Service Factor)

$BHP := 464$ (Brake Horsepower)

$FLAnom := 54.0$ (Nominal Full Load Amps)

$FLA := FLAnom \cdot \left(\frac{BHP}{HP}\right) = 62.64$ (Brake Horsepower Full Load Amps)

$LRA := 300.2$ (Nominal Locked Rotor Amps)

$FLAmax := \frac{FLA}{0.9} = 69.6$ (FLA @ 90% Motor Terminal Voltage)

$LRA1 := LRA \cdot 1.1 = 330.22$ (LRA @ 110% Motor Terminal Voltage)

$LRA2 := LRA \cdot 1.25 = 375.25$ (LRA @ 125% Motor Bus Voltage During Bus Transfer)

$MT := 1.05$ (Maintenance Tolerance per Ref. 4.1.1)

$RE := 1.03$ (Repeatability Error per Ref. 4.1.2)

Inverse Time Unit (TOC) Tap Settings:

$TOCmin := FLAmax \cdot MT \cdot RE = 75.272$

$TAPmin := \frac{TOCmin}{CTR} = 5.018$ **Select TOC set @ 5.2 amps**

$TOC := CTR \cdot 5.2 = 78$

$\%MarginTOC := \left[\left(\frac{TOC}{FLAmax}\right) - 1\right] \cdot 100 = 12.069$

Based on the Time Current curves generated from the ETAP Runs described in Section 5.1, **Time Dial Setting (TDS) set @ 1.5** provides coordination, will not cause nusiance tripping during motor starting and is below the motor thermal limit curve.

Instantaneous Unit (IT) Tap Settings:

Since these pumps may be started under bus transfer conditions under any plant operating modes, maximum starting current will be based on 125% voltage at the motor terminals.

$Asym := 1.6$ (Asymmetrical offset factor for motor starting inrush)

$ITmin := Asym \cdot LRA2 \cdot MT \cdot RE = 649.333$ **Select IT set @ 48 amps**

$IT := CTR \cdot 48 = 720$

$$\%MarginIT := \left[\left(\frac{IT}{ITmin}\right) - 1\right] \cdot 100 = 10.883$$

Conclusion:
Based on the maximum motor BHP, the selected time overcurrent element (TOC) setting provides and acceptable margin of 12.1%.

Note: Motors are operating over their service factor. However, this is acceptable based on Attachment 13 which states that operation at 465 BHP does not exceed the design limits of the motors.

Based on 125% of the motor nameplate voltage, the selected instantaneous unit (IT) setting provides an acceptable margin of 10.9%.

Based on the TCC curves for asymmetrical locked rotor current at 125% of bus voltage, the motor will not trip when contributing current to an external fault upstream of the motor feeder breaker.

It is concluded from the coordination curves in Appendix 1 that the motor overcurrent relay will not trip during motor acceleration and that this setting will coordinate with the upstream feeder breaker.

Additionally, Appendix 1 indicates that the selected setting of the motor overcurrent relay is below the motor thermal damage curve.

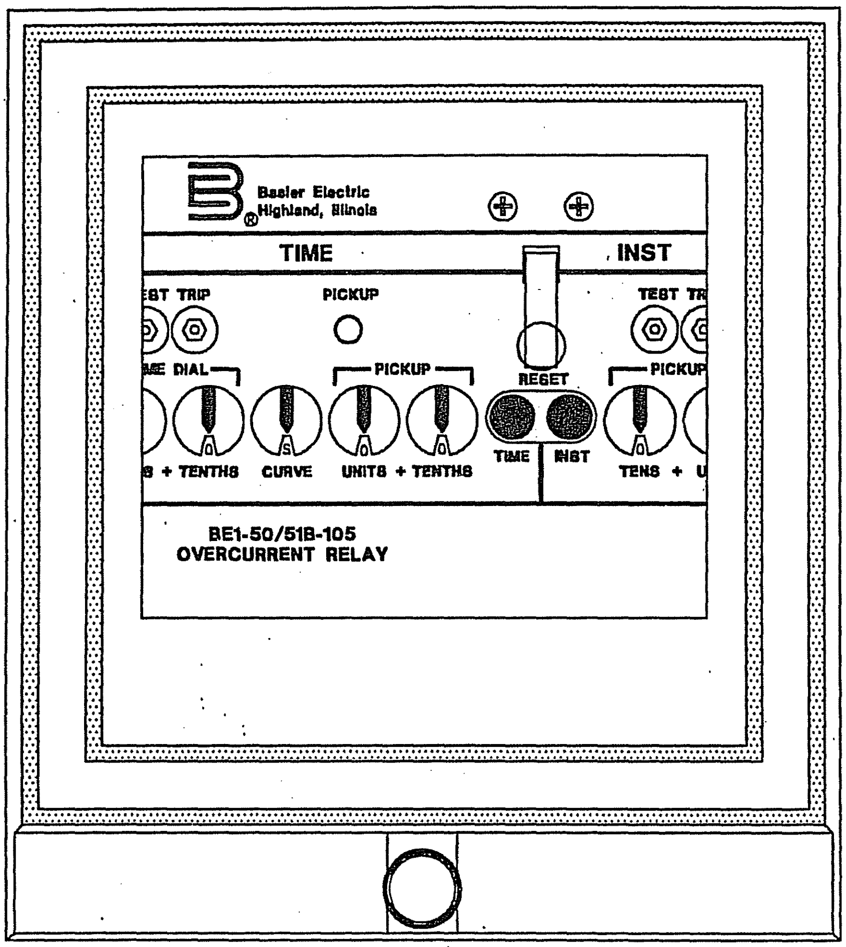
Refer to calculation 900006090 Rev. 8 (114-DC), Protective Relay Settings for Class 1E 4kV Bus and Feeders for upstream breaker setting calculation.

ATTACHMENT # 1 CALC # 170-DC
Rev. 9
Sht. 1 of 6

INSTRUCTION MANUAL

FOR

OVERCURRENT RELAY BE1-50/51B



D1144–03
5–11–92

Basler Electric
Highland, Illinois

Publication: 9 2520 00 991
Revision: E

SECTION 1

GENERAL INFORMATION

DESCRIPTION

BE1-50/51B Overcurrent Relays are microprocessor based, non-directional phase or ground relays that monitor the magnitude of a single phase ac current to provide accurate instantaneous and time overcurrent protection for 50 Hz or 60 Hz power systems. One model covers ten popular time characteristics and a wide range of pickup settings.

APPLICATION

The wide range of pickup settings and front panel selectable time characteristics permit applications involving coordination with fuses, reclosers, cold load pickup, motor starting, and fixed time requirements. BE1-50/51B Overcurrent Relays have the following standard features.

- Independent time and instantaneous elements.
- A secure method to manually trip the breaker at the relay front panel.
- Direct reading front panel controls.
- Zero pickup setting for safety during installation.
- Time characteristics extend to a pickup multiple of 40.
- Rugged draw-out construction with steel case.
- Magnetic latching targets retain indication without power.
- Built-in accuracy eliminates internal adjustments.
- Minimum transient overreach.

Individual models are available for 1 ampere and 5 amperes sensing input currents and installed in A1 or S1 cases. BE1-50/51B Overcurrent Relays may be tested without removing the relay from the case. Shorting contacts are provided for all current inputs when the connection plug or relay chassis is removed from the relay case. Figure 1-1 shows the front panel of the BE1-50/51B Overcurrent Relay, in an S1 case.

BE1-50/51B Overcurrent Relays have many advantages over other overcurrent relays. The five primary advantages are:

- Time characteristics are defined by equations and graphs.
- Field selectable time characteristics.
- Very low burden.
- Self powered from the sensed current.
- Continuous automatic calibration.

MODEL NUMBERS

Model number variations in the BE1-50/51B Overcurrent Relays are specified by a three digit extension to the model number. Table 1-1 provides model number, case style, and sensing current input ranges for the BE1-50/51B Overcurrent Relays. Jumper placement provides for system operating frequencies of 50 or 60 hertz and selects instantaneous element delays. Additional jumper placement provides for either instantaneous or decaying reset characteristics. The locations and description of these jumpers is provided in Section 2.

Table 1-1. BE1-50/51B Overcurrent Relays

Model Number	CT Secondary 50/60 Hz	Case Style	Sensing Input Range (Amperes)	
			TIME	INST
BE1-50/51B-101	1 A	A1	0.1 - 3.18	0.2 - 19.8
BE1-50/51B-102	1 A	S1 (Projection Mount)	0.1 - 3.18	0.2 - 19.8
BE1-50/51B-103	1 A	S1 (Semi-Flush Mount)	0.1 - 3.18	0.2 - 19.8
BE1-50/51B-105	5 A	A1	0.5 - 15.9	1.0 - 99.0
BE1-50/51B-106	5 A	S1 (Projection Mount)	0.5 - 15.9	1.0 - 99.0
BE1-50/51B-107	5 A	S1 (Semi-Flush Mount)	0.5 - 15.9	1.0 - 99.0

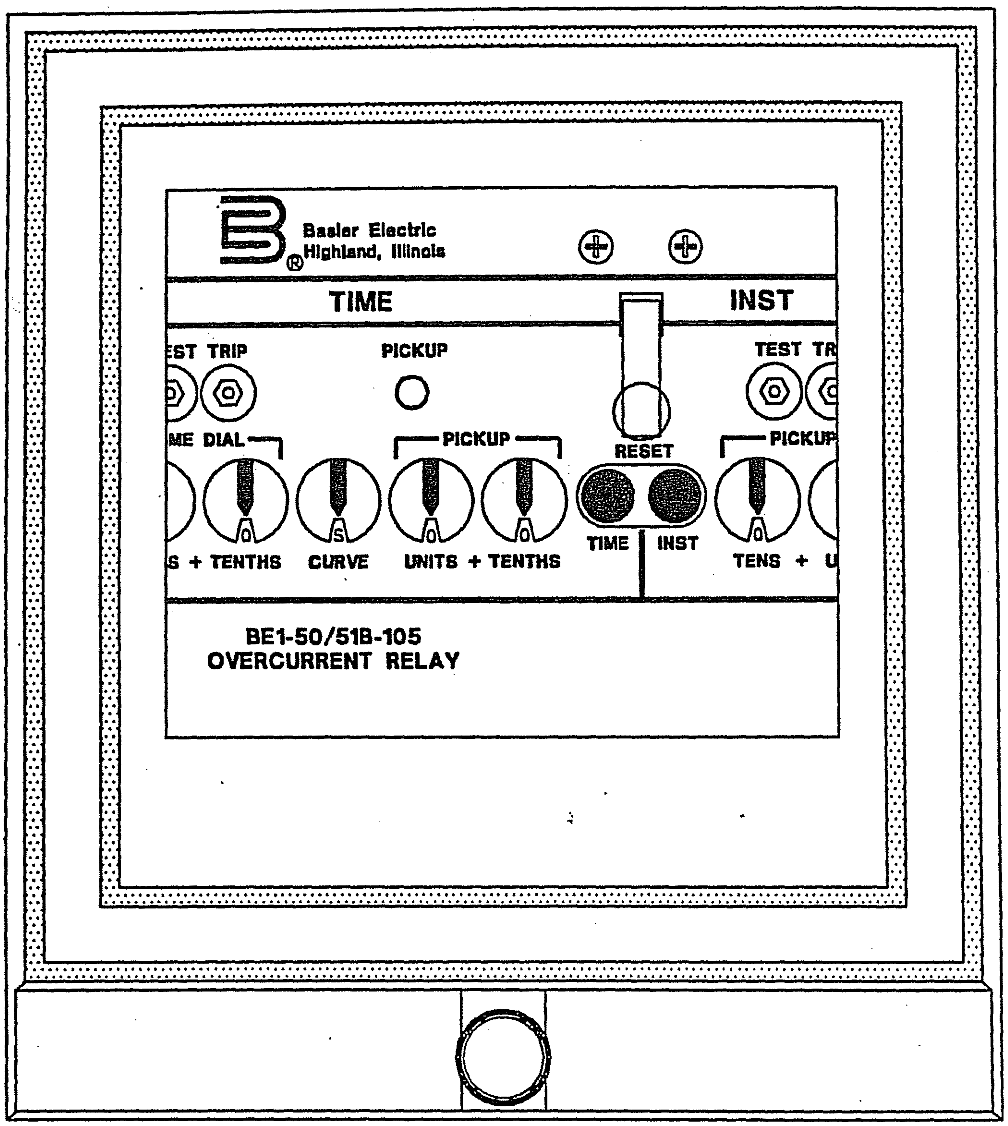


Figure 1-1. BE1-50/51B Overcurrent Relay, S1 Case

SPECIFICATIONS

BE1-50/51B Overcurrent Relays are available with the following features and capabilities.

Current Sensing Input	
(1 Ampere Unit)	Continuous current: 2.8 amperes. One second current: 80 amperes.
(5 Ampere Unit)	Continuous current: 14 amperes. One second current: 400 amperes.
TIME PICKUP Range	Setting the TIME PICKUP below the minimum pickup (0.1 on the 1 ampere unit and 0.5 on the 5 ampere unit), places the relay in the most sensitive state and may be used as a safety setting.
(1 Ampere Unit)	0.1 to 3.18 amperes in 0.02 ampere steps.
(5 Ampere Unit)	0.5 to 15.9 amperes in 0.1 ampere steps.
TIME Dropout	Dropout occurs at not less than 95% of pickup value.
TIME PICKUP	
Accuracy	±2% at settings of 0.1 amperes or more on the 1 ampere unit and 0.5 or more on the 5 ampere unit.
Frequency Response	A change of ±5 hertz from the nominal 50/60 hertz current causes less than 0.5% change in the current required for pickup.
TIME DIAL Range	
(1 Ampere Unit)	0.0 to 9.9, in 0.1 steps.
(5 Ampere Unit)	0.0 to 9.9, in 0.1 steps.
INST PICKUP Range	Setting the INST PICKUP below the minimum pickup (0.2 on the 1 ampere unit and 1.0 on the 5 ampere unit), places the relay in the most sensitive state and may be used as a safety setting.
(1 Ampere Unit)	0.2 to 19.8 amperes in 0.2 ampere steps.
(5 Ampere Unit)	1 to 99 amperes in 1 ampere steps.
INST Dropout	Dropout occurs at not less than 95% of pickup value.
INST PICKUP	
Accuracy	±2% at settings of 0.2 amperes or more on the 1 ampere unit and 1.0 or more on the 5 ampere unit.
Frequency Response	A change of ±5 hertz from the nominal 50/60 hertz current causes less than 0.5% change in the current required for pickup.
INST Transient Response	Less than 10% overreach with system time constants up to 40 milliseconds
Burden	Burden is non-linear. (Figure 1-2 illustrates the device burden.)
(1 Ampere Unit)	At 0.1 amperes, Z = 120 ohms. At 1.0 ampere, Z = 5 ohms.
(5 Ampere Unit)	At 0.5 amperes, Z = 4.8 ohms. At 5.0 amperes, Z = .2 ohms.

ATTACHMENT # 1 CALC # 170-DC Rev. 9 Sht. 5 of 6

Table 1-2. Time Characteristic Curve Constants

Curve Type	Constants				
	A	B	C	N	K
S	0.2663	0.03393	1.000	1.2969	0.028
L	5.6143	2.18592	1.000	1.000	0.028
D	0.4797	0.21359	1.000	1.5625	0.028
M	0.3022	0.12840	1.000	0.5000	0.028
I	8.9341	0.17966	1.000	2.0938	0.028
V	5.4678	0.10814	1.000	2.0469	0.028
E	7.7624	0.02758	1.000	2.0938	0.028
B	1.4636	0.00000	1.000	1.0469	0.028
C	8.2506	0.00000	1.000	2.0469	0.028
F	0.0000	1.00000	0.000	0.0000	0.000

Curve Type:

S = Short Inverse
D = Definite Time
I = Inverse
E = Extremely Inverse
B = BS142 Very Inverse

L = Long Inverse
M = Moderately Inverse
V = Very Inverse
F = Fixed Time
C = BS142 Extremely Inverse

Curves B and C are defined in British Standard BS142

Time characteristic curve equation.

$$T = \frac{AD}{M^N - C} + BD + K$$

CHARACTERISTIC CURVES

Figures 1-6 through 1-14 illustrate the characteristic curves that are programmed into the nonvolatile memory of this relay. To order full-size drawings of these characteristic curves, contact Customer Service Department of the Power Systems Group, Basler Electric, and request publication number 9 2520 00 999. This publication contains nine full size characteristic curves on transparent paper (vellum).

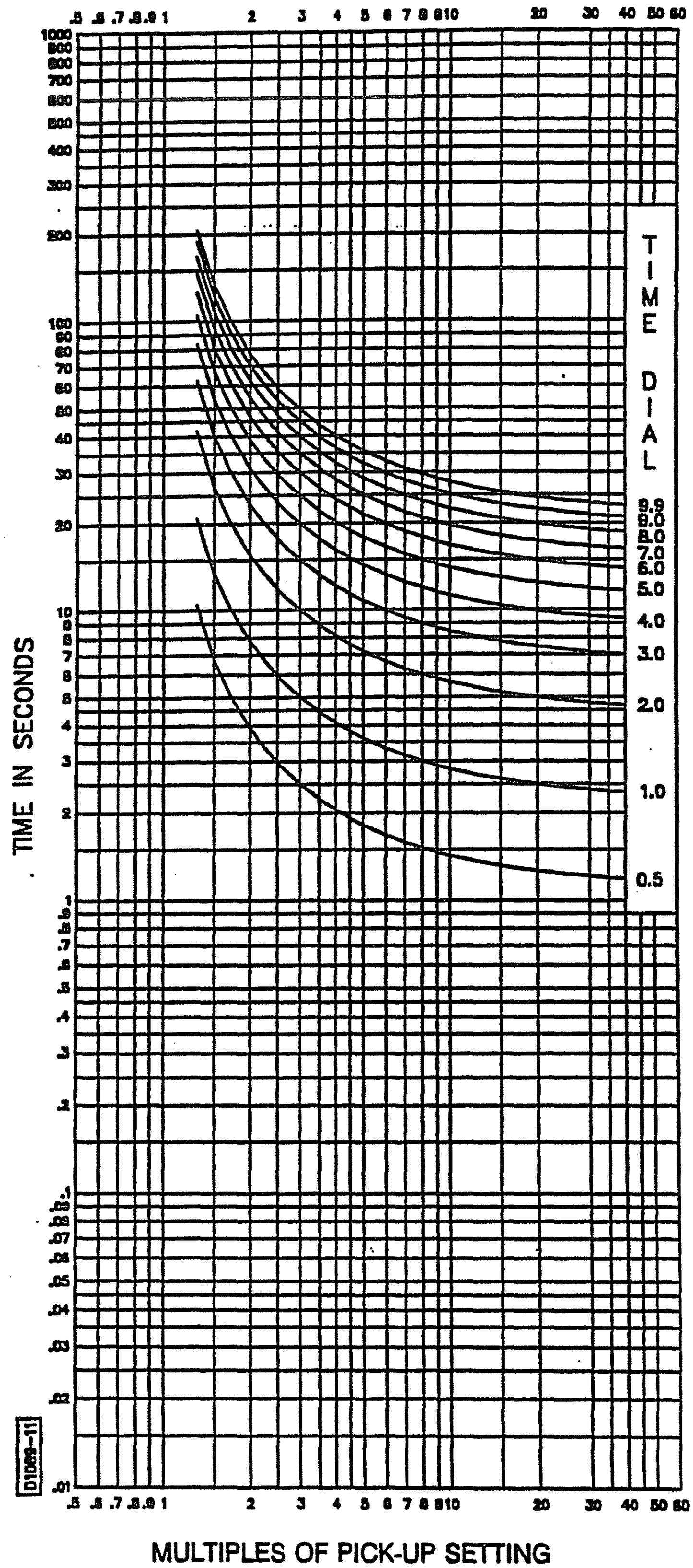


Figure 1-7. Time Characteristic Curve L (Long Inverse)

4KV MOTOR PUMP IDENTIFICATION	MANUFACTURER	BRAKE HORSE POWER	START TIMES CALCULATED (%VOLTAGE) 80%	100%	TESTED (STP P-23) LO	HI
AUXILIARY FEEDWATER	LOUIS ALLIS	600	6.87	3.24	2.59	3.16
CENTRIFUGAL CHARGING	WESTINGHOUSE	650	3.23	1.64	1.42	1.49
CENTRIFUGAL CHARGING - SPARE	GENERAL ELECTRIC	650	8.89	2.12	NOTE 1	
~~RECIPROCATING CHARGING~~	~~WESTINGHOUSE~~	~~200~~	~~2.41~~	~~1.24~~	~~NOTE 2~~	
CONTAINMENT SPRAY	WESTINGHOUSE	440	1.64	0.91	0.78	0.89
CONTAINMENT SPRAY- SPARE	GENERAL ELECTRIC	440	NO START (3)	1.07	NOTE 1	
AUXILIARY SALTWATER (11,21,22)	WESTINGHOUSE	450	2.18	1.07	0.90	1.07
AUXILIARY SALTWATER (12)	WESTINGHOUSE	450	1.3	0.67	*	*
AUXILIARY SALTWATER - SPARE	GENERAL ELECTRIC	450	2.74	0.72	NOTE 1	
COMPONENT COOLING WATER	LOUIS ALLIS	435	2.79	1.17	0.99	1.12
RESIDUAL HEAT REMOVAL	WESTINGHOUSE	420	2.23	1.17	1.00	1.17
RESIDUAL HEAT REMOVAL - SPARE	GENERAL ELECTRIC	420	2.37	1.19	NOTE 1	
SAFETY INJECTION	WESTINGHOUSE	417	3.69	1.84	1.72	1.75
SAFETY INJECTION - SPARE	GENERAL ELECTRIC	417	4.49	1.84	NOTE 1	
SAFETY INJECTION (UNIT 2)	RELIANCE	417	4.52	2.40	1.73	1.95

15A

ATTACHMENT # 2

NOTES:
1. SPARE MOTOR, NO TEST DATA IS AVAILABLE.
~~2. NON-CLASS 1E MOTOR, NO TEST DATA AVAILABLE.~~
3. SEE LAST PARAGRAPH OF CONCLUSION, PAGE 5.

15A

GENERAL COMMENTS:
o ALL INFORMATION IS FOR BOTH UNITS UNLESS NOTED.
* SEE ATTACHED VENDOR TEST DATA (ACCELERATION TIME)

~~CALC # 156-DC REV. 3 PG 4 OF 130~~

CALC# 170-DC Rev. 15A Sht. 1 of 1

ATTACHMENT# 3

CALC#170-DC
Rev. 9
Sht. 1 of 6

AUXILIARY FEED WATER PUMP

June 12, 1978

Mr. Julius Herbst
Pacific Gas and Electric Co.
77 Beale Street; Rm. 1819
San Francisco, CA 94106

Dear Julius:

Attached are four copies of the test report and curves of the motor that we have tested and rerated from 500 to 600 HP on original serial number 0269781HK02 now changed to 0-205900-001.

From the test data you will see that the motor meets the Nema STD. MG1-20.40 for temperature rise and MG1-20.41 for starting and breakdown torques.

I am returning the motor with a new nameplate showing the 600 HP rating and will send new Namplates for the other motors with the rerate horsepower.

Yours truly,

Thomas Gavin
Service Engineer
Product Service Dept.

TG/db

6/28/78 am

Talked to Mr. Schreiber
He will get to me Info
concerning the starting
capability of the motor
with 90% of voltage.

ATTACHMENT # 3

CALC# 170-DC
Rev. 9
Sht. 2 of 6

THE LOUIS ALLIS CO.

A DIVISION OF LITTON INDUSTRIES

REPORT OF TEST – INDUCTION MOTOR
(UNWITNESSED)

Date of Test 4-21-78

Purchaser PACIFIC GAS & ELECTRIC CO.

AUXILIARY FEEDWATER PUMP

Purchaser's Order No. 4R25114

Serial No. AR8205900

Rating

HP Output	Full-Load Speed–RPM	Phase	Cycles	Volts	Amperes Full Load	Time Rating	
600	3560	3	60	4000	75	Cont.	

Temperature Rise

Conditions of Test				Temperature Rise – Deg. C				
				Stator		Rotor		
Hours Run	Line Volts	Line Amperes	Cooling Air Deg. C	Core By Thermometer method	Windings (Cross Out Two) By Resistance Method ~~By Embedded Detector~~ ~~By Thermometer Method~~	Core By Thermometer Method	Windings (Cross Out One) By Resistance Method By Thermometer Method	Collector Rings
3.0	4150	72.1	25°	35.5°	59.7°	---	---	--
Witnessed Heat Run @ 600 HP.								

Characteristics

Slip – Per Cent	Amperes Running Light	Resistance at 25 C (between lines) Ohms: Stator Between Terminals	Resistance at 25 C (between lines) Ohms: Rotor Between Rings	Secondary Volts at Standstill	Secondary Amperes per Ring at Full Load
.44	17.1	.70206	--	----	------

Torque and Starting Current

Break-Down Torque Lbs. at 1 ft. radius	Locked Rotor Torque Lbs. at 1 ft. radius with * volts applied	Starting Current Amperes (locked rotor) with * volts applied
1035 lbs.ft. @ 2790 volts	735	402.8

* 95.5% volts

High-Potential Tests

Volts A-c for ____ Sec.	
Stator	Rotor
--	--

Efficiencies and Power Factor

Efficiency, Per Cent			Power Factor, Per Cent		
Full Load	¾ Load	½ Load	Full Load	¾ Load	½ Load
95.5	95.7	95.3	90.5	89.7	85.8

Notes:

Data from test on this motor.
(this or duplicate)

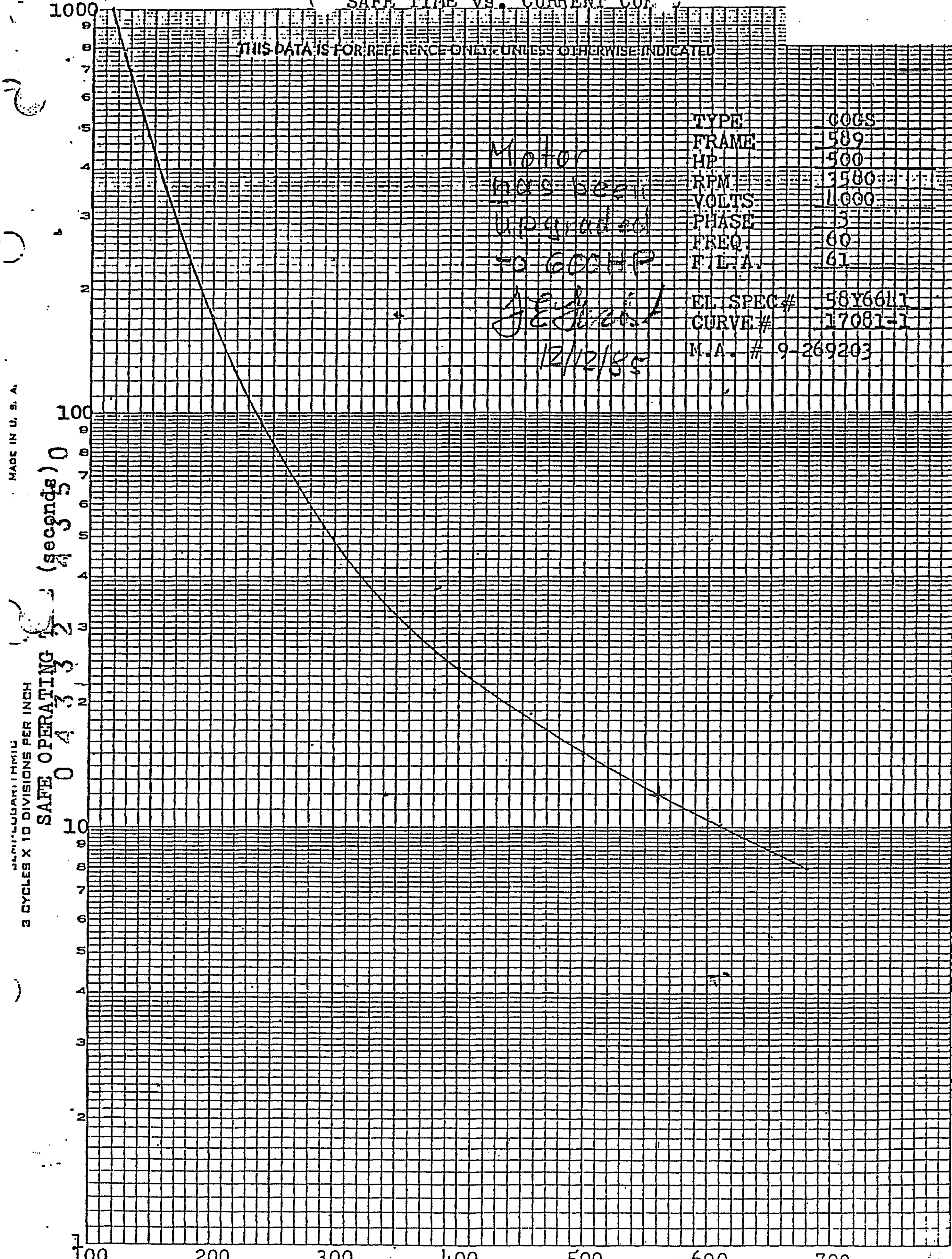
Approved by: [signature] Date 5/12/78

4

0 4 3 3 4 3 4 9

ATTACHMENT # 3 CALC# 170-DC Rev. 9
Sht. 3 of 6

THE LOUIS ALLIS CO., MILWAUKEE, WISCONSIN 53201
SAFE TIME vs. CURRENT CU...



ATTACHMENT # 3 CALC# 170-DC
Rev. 9
SHT. 4 of 6

Byron Jackson Pump Division
100 Bush Street, Suite 1910
San Francisco, California 94101
Telephone 415/956-5150
Telex 172-487

BORG WARNER

017877

15 April 1983

Pacific Gas & Electric
%Bechtel Power Corporation
P.O. Box 3965
San Francisco, Calfiornia 94119

Attention: F.J. Dan

Subject: PG&E Diablo Canyon Unit 1
Byron Jackson Pump S/N 691-S-0994/5

Reference: Your Letter Dated 25 January 1983

Gentlemen:

Please find the attached two (2) copies of the 80% and 100% voltage acceleration time current curves and the thermal limit curves for the motors sold with Byron Jackson's auxiliary feed pumps, S/N 691-S-0994/5.

We trust this information will meet your requirements.

Sincerely,

David Falkowski/map

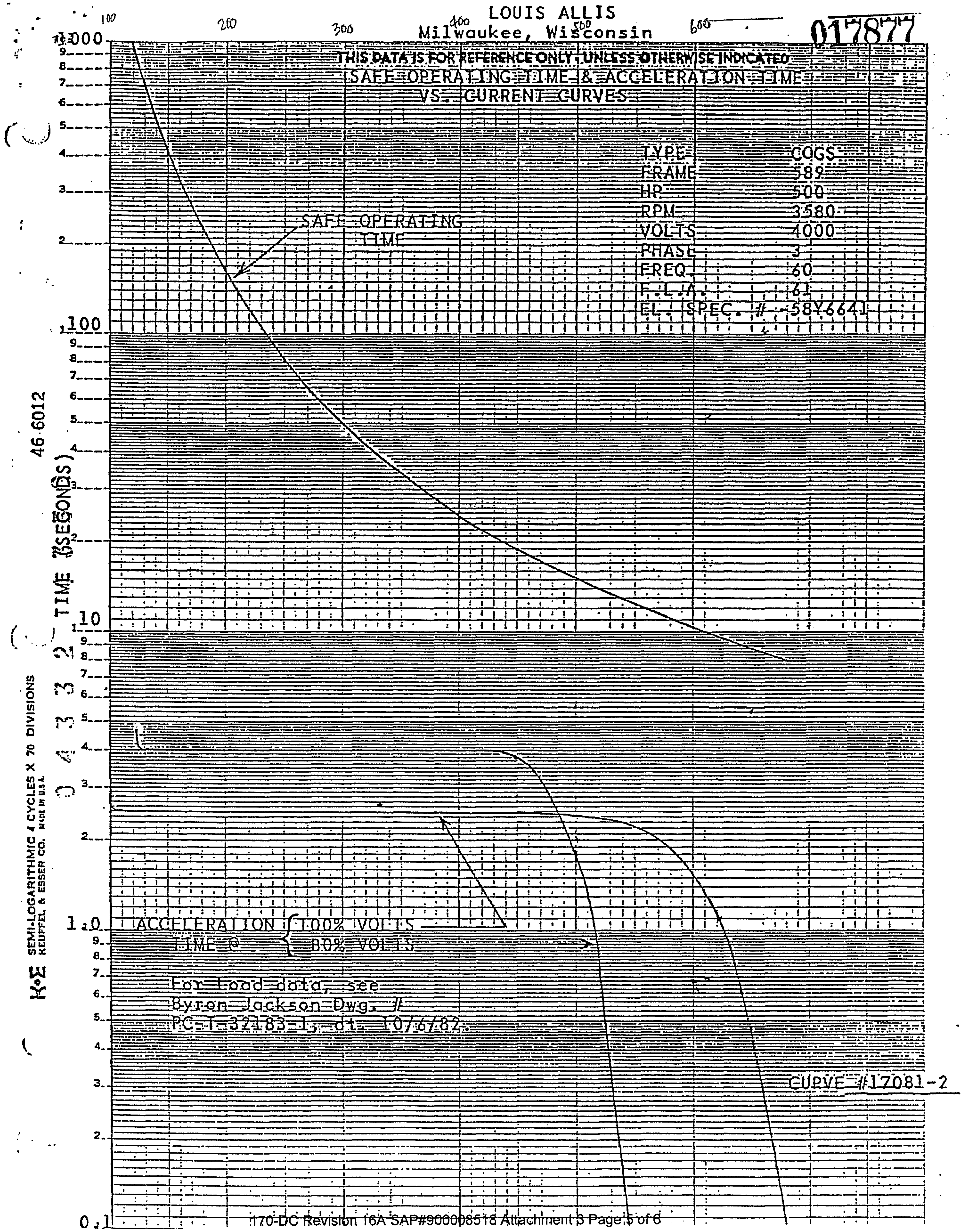
David Falkowski
Sales Engineer

DF/map

Attachments

0433435 1

ATTACHMENT # 3 CALC# 170-DC
Rev. 9
Sht. 5 of 6



ATTACHMENT # 3 CALC# 170-DC Rev 9
SHT. 6 of 6

JEH 4-7-82
Nameplate Data
from Field Trip.

AUX FEED WTR PP 12A

SER#	9269203002RR		
TYPE	COGX	FRAME	589SU
HP	600	RPM	3680
V	4000	PHASE	3
Hz	60	SERV.F.	1.00
°CR	70	DUTY	CONT
CODE	E		
A	75		

AUX FEED WTR PP 13

SER#	9269203001RR	
TYPE	COGX	✓
HP	✓	
V	✓	
Hz	✓	
°CR	✓	
CODE	✓	
A	75	

✓ SAME AS PP 12

0433243553

ATTACHMENT # 4 SHT. 1 of 5 CALC# 170-DC Rev. 9

INDUCTION MOTOR DATA SHEET

CY5802547

also called Centrifugal Charging Pump

PROJECT: PUMP/PKG ~~Reactor Coolant~~ UNIT — 2 — P.O. NO. ~~&F~~ F 43442

DATE 3/21/74

SPEC No: ~~[illegible]~~

~~Reactor Charging~~

DATA FURNISHED BY SELLER

Charging/Safety Injection Pump		MAKE	Westinghouse
TYPE		FRAME NO.	5808
NO. OF UNITS 2 PUMP/~~[illegible]~~	TOTAL 2	HORSEPOWER	600
MOUNTING	Horizontal	SERVICE FACTOR	1.15
ELEC. CHARACTERISTICS	4000 V. 3 PH 60 CY	FULL LOAD RPM	1779
SYNCH. SPEED, RPM	*	FULL LOAD AMP	76.0
HORSEPOWER		LOCKED ROTOR AMP	402.
SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	107
ENCLOSURE	Open Drip Proof	PULL-OUT TORQUE, % F.L.	224
INSULATION CLASS	B	EFF.-FULL LOAD, %	94.2
INSULATION TREATMENT	Thermalastic Epoxy	EFF.-3/4 LOAD, %	94.3
AMBIENT TEMP.-C		EFF.-1/2 LOAD, %	93.9
STATOR TEMP RISE-C		P.F.-FULL LOAD, %	90.3
BEARING TYPE		P.F.-3/4 LOAD, %	89.6
BEARING TEMP RELAY		P.F.-1/2 LOAD, %	85.7
BEARING THERMOCOUPLE	See Appendix "C" ?	P.F.-LOCKED ROTOR	27.2
HALF COUPL. OR SHEAVE MTD. BY		SPACE HTRS., TOTAL WATTS	NONE
ROTATION*		RADIAL BEARING-TYPE	SPLIT SLEEVE
WK² OF DRIVEN EQUIP.		THRUST BEARING-TYPE	NA
SPEED-TORQUE DRIVEN EQUIP.		BEARING SERVICE-HR.	NA
OVERSIZE COND. BOX	Max. Oversize	NORMAL BRG. OPER. TEMP-C	15°C Rise above ambient
COND. BOX LOCATION*		NET WEIGHT-LB.	See Outline
SPACE HEATERS, VOLTAGE, PHASE	None	OIL COOL. SYS. REQ'D	NA
END BELLS		BRG. OIL PRESS. RANGE, PSI	NA
TERMINAL LUGS/TYPE		BRG. OIL REQ'D EA. BRG. GPM	NA
STATOR HIGH TEMP DEVICE		NAME PLATE CODE LETTER	E
ADJUSTABLE SLIDE RAILS		PERMISSIBLE STARTS PER HR:	
SOLEPLATES		MOTOR AT AMBIENT TEMP	4
PROJECT ELEV., FT.		MOTOR AT RATED TOTAL TEMP	2
SHAFT (HOLLOW, SOLID)		TYPE SEALED INSUL. SYS.	
COUPLING (STD.-RELEASE)		DESCRIPTION OF INSUL. SYS.	
SOLID, NONREVERSING		Torque-Speed Curves	JH116
ADJUSTABLE FLEXIBLE		Motor Outline Dwg.	
VERT. MAX DOWNTHRUST			
VERT. MAX UPTHRUST			
VERT. MIN UPTHRUST			
VERT. MIN DOWNTHRUST			
(WITH MOTOR RUNNING)		NOTE: Attention S. Libroth	
SIDE THRUST		Westinghouse N.E.S., Penn Center Site, shall	
MAX REVERSE SPEED		be on the manufacturer's distribution list	
DRAIN PLUG AND VENT		for Motor Outline Drawings and Torque-Speed	
AIR INTAKE SCREENS		Curves.	

NOTES:

ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY

ITEMS ... APPLY TO VERTICAL MOTORS ONLY

* See attached documents.

REMARKS:

ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY

INDICATE IF DATA IS ESTIMATED

Data is calculated

~~CALC. NO.~~ ~~REV.~~ ATTACHMENT # 4. SH. 1 OF 5

PG&E
62-3406 (5/77)

ATTACHMENT #4
CALC. # 170-DC
Rev. 9
SH. 2 OF 5

UNIT 1

MOTOR NAMEPLATE DATA

CHARGING PUMP 1-1

WESTINGHOUSE LIFE-LINE B

HP	600
MODEL	HSDP
POLES	4, 3PH, 60 HZ
VOLTS	4000
F.L. AMPS	75
RPM	1779
INSULATION	CLASS B
AMB.	40°C
FRAME	5808-B
TIME	CONT. 80°C RISE AT 1.15 SERVICE FACTOR
STYLE	69F43439
SERIAL NO.	3S-70

CHARGING PUMP 1-2

SAME

SERIAL NO. 4S-70

CHARGING PUMP 1-3

WESTINGHOUSE LIFE-LINE A

HP	200
MODEL	ABDP
VOLTS	4000
AMPS	26
RPM	1777
INSULATION	CLASS B
MAX. AMB.	40°C
FRAME	506 US
SERVICE FACTOR	1.15
LOCKED KVA CODE	E+
STYLE NO.	70F57575
SERIAL NO.	2S-71

0431324367

INDUCTION MOTOR DATA SHEET

WESTINGHOUSE FORM 5400?

UNIT 2

CY58022-L7

PROJECT PGE/PEG

S.O. NO. 69F43439

FURNISHED BY

DATE 2/21/69 BY L. E. Ringgold

WORK OR ITEM NO. SPIN No: [redacted]/PEGCSAPCH

PURCHASER'S REQUIREMENTS	DATA FURNISHED BY SELLER Calculated
SERVICE Charging/Safety Injection Pump	MAKE Westinghouse
TYPE	FRAME NO. 5808
NO. OF UNITS [redacted]/2 PEG TOTAL 2	HORSEPOWER 600
MOUNTING Horizontal	SERVICE FACTOR 1.15
ELEC. CHARACTERISTICS 4000 V. 3 PH 60 CY	FULL LOAD RPM 1779
SYNCH. SPEED, RPM	FULL LOAD AMP 76.0
HORSEPOWER	LOCKED ROTOR AMP 402
SERVICE FACTOR 1.15	STARTING TORQUE, % F.L. 107
ENCLOSURE Open Drip Proof	PULL-OUT TORQUE, % F.L. 224
INSULATION CLASS B	EFF.-FULL LOAD, % 94.2
INSULATION TREATMENT Thermalastic Epoxy	EFF.-3/4 LOAD, % 94.3
AMBIENT TEMP-C	EFF.-1/2 LOAD, % 93.4
STATOR TEMP RISE-C	P.F.-FULL LOAD, % 90.3
BEARING TYPE	P.F.-3/4 LOAD, % 89.6
BEARING TEMP RELAY	P.F.-1/2 LOAD, % 85.7
BEARING THERMOCOUPLE See Appendix "C"	P.F.-LOCKED ROTOR 27.2
HALF COUPL. OR SHEAVE MTD. BY	SPACE HTRS., TOTAL WATTS NONE
ROTATION*	RADIAL BEARING-TYPE SPLIT SLEEVE
WK² OF DRIVEN EQUIP.	THRUST BEARING-TYPE NA
BRKWY. TORQ. DRVN. EQUIP.	BEARING SERVICE-HR. NA
OVERSIZE COND BOX Max. Oversize	NORMAL BRG. OPER. TEMP-C 15°C Rise above ambient
COND. BOX LOCATION*	NET WEIGHT-LB. See Outline
SPACE HEATERS, VOLTAGE, PHASE None	OIL COOL. SYS. REQ'D NA
... IT END BELLS	BRG. OIL PRESS. RANGE, PSI NA
TERMINAL LUGS, TYPE	BRG. OIL REQ'D EA. BRG. GPM NA
STATOR HIGH TEMP DEVICE	NAME PLATE CODE LETTER E
ADJUSTABLE SLIDE RAILS	PERMISSIBLE STARTS PER HR:
SOLEPLATES	MOTOR AT AMBIENT TEMP 4
PROJECT ELEV., FT	MOTOR AT RATED TOTAL TEMP 2
SHAFT (HOLLOW SOLID)	TYPE SEALED INSUL. SYS.
COUPLING (SELF-RELEASE)	DESCRIPTION OF INSUL. SYS.
(SOLID, NONREVERSING	Torque-Speed Curves JH168
ADJUSTABLE, FLEXIBLE	Motor Outline Dwg.
VERT. MAX DOWNTHRUST	
VERT. MAX UPTHRUST	
VERT. MIN UPTHRUST	
VERT. MIN DOWNTHRUST	
(WITH MOTOR RUNNING)	NOTE: Attention S. Libroth
SIDE THRUST	Westinghouse N.E.S., Penn Center Site, shall
MAX REVERSE SPEED	be on the manufacturer's distribution list
DRAIN PLUG AND VENT	for Motor Outline Drawings and Torque-Speed
AIR INTAKE SCREENS	Curves.
REMARKS:	REMARKS:
ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY	ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY
ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY	INDICATE IF DATA IS ESTIMATED
* See attached documents.	Data is calculated

ATTACHMENT #4 SH. 3 OF 5

ATTACHMENT NO. 4
CALC. #170-DC REV. 9

UNIT 2

SH. 4 OF 5

MOTOR NAMEPLATE DATA

CHARGING PUMP 2-1

WESTINGHOUSE LIFE-LINE D
HP 600
MODEL HSDP
FRAME 5808Z
POLES 4
SUPPLY 3 ϕ, 60 HZ
VOLTS 4000
F.L. AMPS 75
RPM 1779
INSULATION CLASS B
AMBIENT 40°C
TIME CONT. 90°C RISE AT 1.15 SERVICE FACTOR
STYLE 69F43439
SERIAL NO. 1S-70
LOCKED KVA CODE F

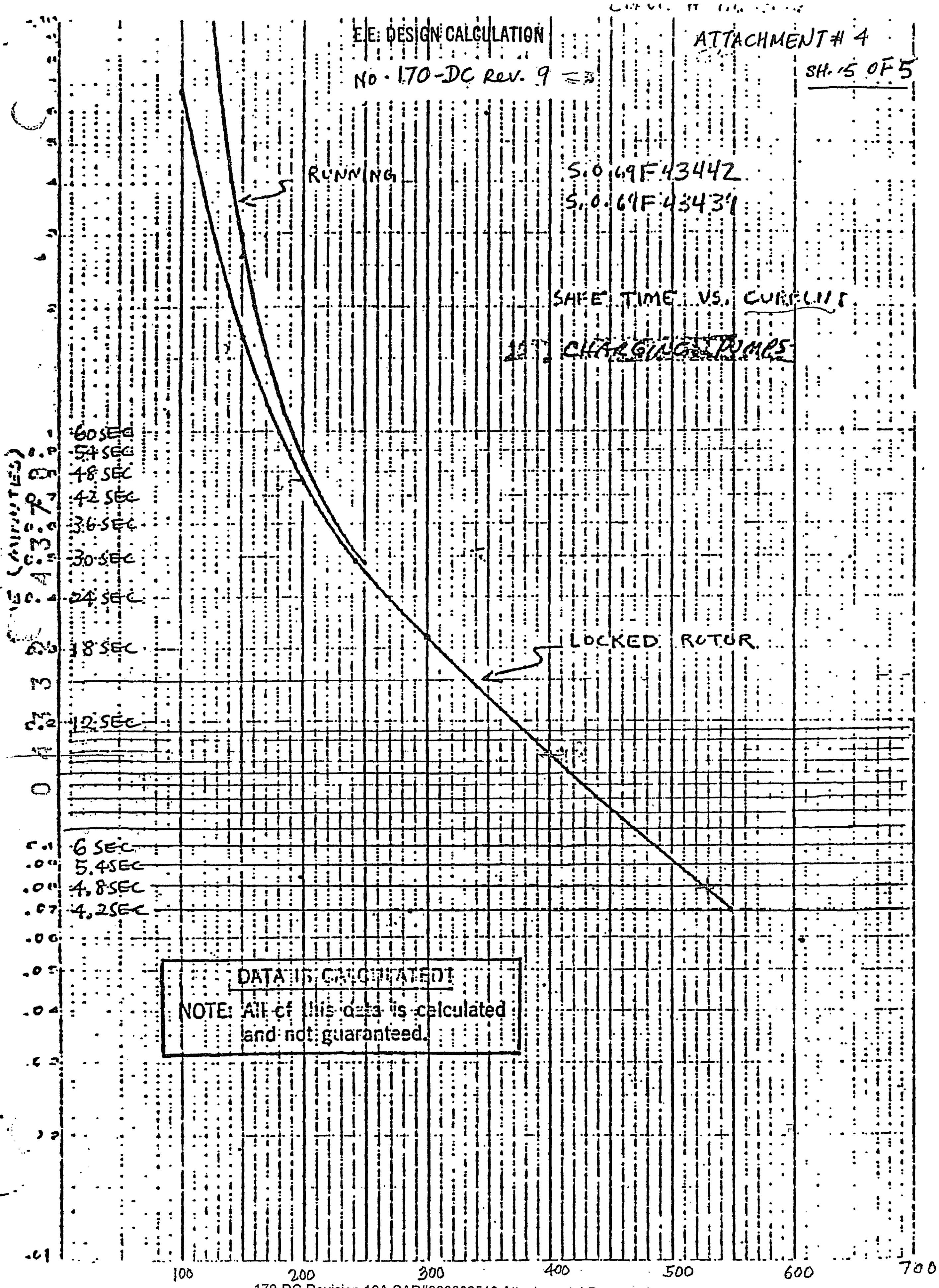
CHARGING PUMP 2-2

SAME
SERIAL NO 2S-70
(NAMEPLATE MISSING, DATA TAKEN UNDER ORT TEST ON 9-21-76)

CHARGING PUMP 2-3

WESTINGHOUSE LIFE-LINE A
HP 200
MODEL ABDP
FRAME 506US
POLES 4
SUPPLY 3 ϕ, 60 HZ
VOLTS 4000
AMPS 26
RPM 1777
LOCKED KVA CODE E
INSULATION CLASS B
AMBIENT 40°C
TIME CONT. 90°C AT 1.15 SERVICE FACTOR

STYLE 70F57575
SERIAL NO. 1S-71


E.E. DESIGN CALCULATION
No. 170-DC Rev. 9
ATTACHMENT # 4
SH. 5 OF 5
RUNNING
S.O. 69F43442
S.O. 69F43439
SAFE TIME VS. CURRENT
CHARGING PUMPS
LOCKED ROTOR
60 SEC
54 SEC
48 SEC
42 SEC
36 SEC
30 SEC
24 SEC
18 SEC
12 SEC
6 SEC
5.4 SEC
4.8 SEC
4.2 SEC
DATA IS CALCULATED
NOTE: All of this data is calculated and not guaranteed.
100
200
300
400
500
600
700

DC-663213-23-1

MECHANICAL ENGINEERING

THE LOUIS ALLIS CO.
427 East Stewart Street
Milwaukee, Wisconsin

PACIFIC GAS AND ELECTRIC CO
APPROVED FOR CONSTRUCTION
RECORDED
AUG 3 1 1970
DEPARTMENT OF ENGINEERING

REPORT OF ROUTINE TESTS
INDUCTION MOTOR

Purchaser WILLAMETTE IRON & STEEL

Date of Test 6/6/70
Manufacturer's Order No. 9-269161
Purchaser's Order No. 8785

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.5	60	Cont.	COGX	588Su

\# 9269161001

TEST CHARACTERISTICS

Identification	No Load Volts	No Load Frequency	No Load Speed	No Load Amp	No Load Kw	Resistance (Ohms) at 23° C Stator Between Terminals	Resistance (Ohms) at 23° C Rotor Between Rings	Wound Rotor Open Circuit Voltage	High-potential Test
#	4360	60	1200	21.4	10.	1.3806	-----	---	9000 v. @ 1 min.
	1050	60	1200	3.3	1.8				
	1035	60	Locked	66.8	28.				

Notes:
Data on test from this motor.
(this or duplicate)

Approved by [signature] Date 6/9/70

NEMA Standard 11-14-1957.

NEMA MG1-20.47 (Aug. 1963)
M3188-12/64

58X6620

0 4 7 3 2 0 4 3 7

ATTACHMENT # 5
CALC. # 170-DC
Rev. 9
SH. 1 OF 9

THE LOUIS ALLIS CO.
427 East Stewart Street
Milwaukee, Wisconsin

0 4 3 4 3 3 3

REPORT OF ROUTINE TE...

INDUCTION MOTOR

Purchaser
WILLAMETTE IRON & STEEL

Date of Test 6-11-70
Manufacturer's Order No. 9-269161
Purchaser's Order No. 8785

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.5	60	Cont.	COGX	588Su

9269161002

TEST CHARACTERISTICS

Identification	No Load					Resistance (Ohms) at 21C		Wound Rotor Open Circuit Voltage	High-potential Test
	Volts	Frequency	Speed	Amp		Stator Between Terminals	Rotor Between Rings		
*	4300	60	1200	20.	8.8	1.3806	-----	---	9000 v. @1 min.
	1025	60	1200	3.2	1.8				
	1025	60	Locked	66.3	26.8				
			VIBRATION	READING					
			FRONT	BACK					
	HORIZONTAL		.00028	.0005					
	VERTICAL		.00021	.00041					
	AXIAL		.00008	.00006					

Notes:
Data on test from this motor.
(this or duplicate)

Approved by [signature] Date 6-15-70

NEMA Standard 11-14-1957.

NEMA MG1-20.47 (Aug. 1963)
M3181-12/64

58Y06620-0000

ATTACHMENT #5
CALC. # 170-DC
Rev. 9

SH. 2 OF 9

THE LOUIS ALLIS CO.
427 East Stewart Street
Milwaukee, Wisconsin

REPORT OF ROUTINE TESTS

INDUCTION MOTOR

Purchaser
WILLAMETTE IRON & STEEL

Date of Test 6-18-70
Manufacturer's Order No. 9-269161
Purchaser's Order No. 8785

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.5	60	Cont.	COGX	588Su

* 9269161003

TEST CHARACTERISTICS

Identification	No Load					Resistance (Ohms) at 22C		Wound Rotor Open Circuit Voltage	High-potential Test
	Volts	Frequency	Speed	Amp	Kw	Stator Between Terminals	Rotor Between Rings		
*	3990	60	1200	15.8	6.8	1.3662	-----	---	9000 v. @ 1 min.
	950	60	1200	3.1	1.84				
	940	60	Locked	61.	24.				

Notes:
Data on test from this (this or duplicate) motor.

Approved by [signature] Date 6/22/70

NEMA Standard 11-14-1957.

.MA MG1-20.47 (Aug. 1963)
...185—12/64

ATTACHMENT #~~X~~ 5
CALC. # 170-DC
Rev. 9

SH. 3 OF 9

427 East Stewart Street
Milwaukee, Wisconsin

REPORT OF ROUTINE TESTS

INDUCTION MOTOR

Purchaser
WILLAMETTE, IRON & STEEL

Date of Test 6-23-71
Manufacturer's Order No. 9-259161
Purchaser's Order No. 8735

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.2	60	Cont.	[illegible]	5808U

* 9269161004

TEST CHARACTERISTICS

Identification	No Load					Resistance (Ohms) at 27°C		Wound Rotor Open Circuit Voltage	High-potential Test
	Volts	Frequency	Speed	Amp	Kw	Stator Between Terminals	Rotor Between Rings		
*	4210	60	1200	21.8	8.8	1.381	---	--	9000 Volts
	1005	60	1200	3.2	1.52				1 min.
	990	60	Locked	63.0	24.8				

PACIFIC GAS AND ELECTRIC CO.
APPROVED FOR CONSTRUCTION
RECORDED
JUN 19 1972
DEPARTMENT OF ENGINEERING

DC-663213-54-1
DC-663213-53-1
DC-663213-52-1

0 4 3 3 4 3 0

MECHANICAL ENGINEERING

Notes:
Data on test from this motor.
(this or duplicate)

Approved by [signature] Date 6/1/71

NEMA Standard 11-14-1957

NEMA MG1-20.47 (Aug. 1963)
MD103-12/61

58Y6620

ATTACHMENT # ~~6~~ 5
CALC. # 170-DC
Rev. 9

SH. 4 OF 9

THE LOUIS ALLIS CO.
427 East Stewart Street
Milwaukee, Wisconsin

MECHANICAL ENGINEERING

REPORT OF ROUTINE TESTS

INDUCTION MOTOR

Purchaser
WILLAMETTE IRON & STEEL

Date of Test 6-11-71
Manufacturer's Order No. 9-269161
Purchaser's Order No. 8785

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.5	60	Cont.	COGX	588SU

* 9269161005

TEST CHARACTERISTICS

Identification	No Load Volts	No Load Frequency	No Load Speed	No Load Amp	No Load Kw	Resistance (Ohms) at 28C Stator Between Terminals	Resistance (Ohms) at 28C Rotor Between Rings	Wound Rotor Open Circuit Voltage	High-potential Test
*	4290	60	1200	22.4	9.0	1.3832	---	--	9000 v. for 1 min.
	1025	60	1200	3.2	1.52				
	1015	60	Locked	65.0	26.0				

DC-66213-53-1

0 4 3 3 4 3 1

...S AND ELECTRIC CO.
...ROVED FOR CONSTRUCTION
RECORDED
JUN 19 1972
DEPARTMENT OF ENGINEERING

Notes:
Data on test from this motor.
(this or duplicate)

Approved by [signature] Date 6-18-71

NEMA Standard 11-14-1957

NEMA MG1-20.47 (Aug. 1963)
113125—12/64

ATTACHMENT # 5
CALC. # 170-DC
Rev. 9

SH. 5 OF 9

CC

THE LOUIS ALLIS CO.
427 East Stewart Street
Milwaukee, Wisconsin

REPORT OF ROUTINE TESTS

INDUCTION MOTOR

Purchaser

WILLAMETTE IRON & STEEL

Date of Test 6-11-71
Manufacturer's Order No. 9-269161
Purchaser's Order No. 8785

RATING

Hp	Speed	Phase	Frequency	Volts	Amperes	Temp. Rise	Time Rating	Type	Frame
400	1185	3	60	4000	52.5	60	Cont.	COGX	588SU

* 9269161006

TEST CHARACTERISTICS

Identification	No Load Volts	No Load Frequency	No Load Speed	No Load Amp	No Load KW	Resistance (Ohms) at 25C Stator Between Terminals	Resistance (Ohms) at 25C Rotor Between Rings	Wound Rotor Open Circuit Voltage	High-potential Test
*	4220	60	1200	21.0	8.6	1.3885	---	--	9000 v. for
	1005	60	1200	3.2	1.52				1 min.
	1000	60	Locked	63.0	25.2				

DC-66213-54-1

0 4 3 3 2 4 3 2

MECHANICAL ENGINEERING

...IC GAS AND ELECTRIC CO.
APPROVED FOR CONSTRUCTION
RECORDED
JUN 1 9 1972
DEPARTMENT OF ENGINEERING

Notes:
Data on test from this motor.
(this or duplicate)

Approved by [signature] Date 6-18-71

NEMA Standard 11-14-1957

NEMA MG1-20.47 (Aug. 1963)
H3185-12/64

58Y6620

ATTACHMENT # ~~X~~ 5
CALC. # 170-DC
Rev. 9

SH. 6 OF 9

THE LOUIS ALLIS CO.
A DIVISION OF LITTON INDUSTRIES

REPORT OF TEST — INDUCTION MOTOR

Date of Test 6-24-70

Purchaser WILLAMETTE IRON & STEEL

Purchaser's Order No. 8785

SERIAL No. 9269.61001

Rating

HP Output	Full-Load Speed-RPM	Phase	Cycles	Volts	Amperes Full Load	Time Rating	TYPE FRAME
400	1185	3	60	4000	52.5	Cont.	COGX 588Su

Temperature Rise

Conditions of Test				Temperature Rise — Deg. C				
				Stator		Rotor		
Hours Run	Line Volts	Line Amperes	Cooling Air Deg. C	Core By Ther-mometer method	Windings (Cross Out Two) By Resistance Method * By Embedded Detector ~~By Thermometer Method~~	Core By Ther-mometer Method	Windings (Cross Out One) By Resistance Method By Ther-mometer Method	Collector Rings
4.5	4013	60.3	23	62	72.6 *67	---	---	---
	SERVICE FACTOR HEAT RUN @ 463 H.P.							

Characteristics

Slip — Per Cent	Amperes Running Light	Resistance at 28 C (between lines) Ohms — Stator Between Terminals	Resistance at 28 C (between lines) Ohms — Rotor Between Rings	Secondary Volts at Standstill	Secondary Amperes per Ring at Full Load
.71	15.6	1.404	---	-----	------

Torque and Starting Current

Break-Down Torque Lbs. at 1 ft. radius	Locked Rotor Torque Lbs. at 1 ft. radius with ~~-%~~ volts applied	Starting Current Amperes (locked rotor) with ~~-%~~ volts applied
1308 @2300v	1590	268.2

* 91.5

High-Potential Tests

Volts A-c for 60 Sec. — Stator	Rotor
9000	---

Efficiencies and Power Factor

Efficiency, Per Cent			Power Factor, Per Cent		
Full Load	¾ Load	½ Load	Full Load	¾ Load	½ Load
94.9	95.0	94.4	86.0	83.0	75.4

Notes:
Data from test on this (this or duplicate) motor.

THE LOUIS ALLIS CO.
MILWAUKEE, WIS.
CERTIFIED TEST DATA

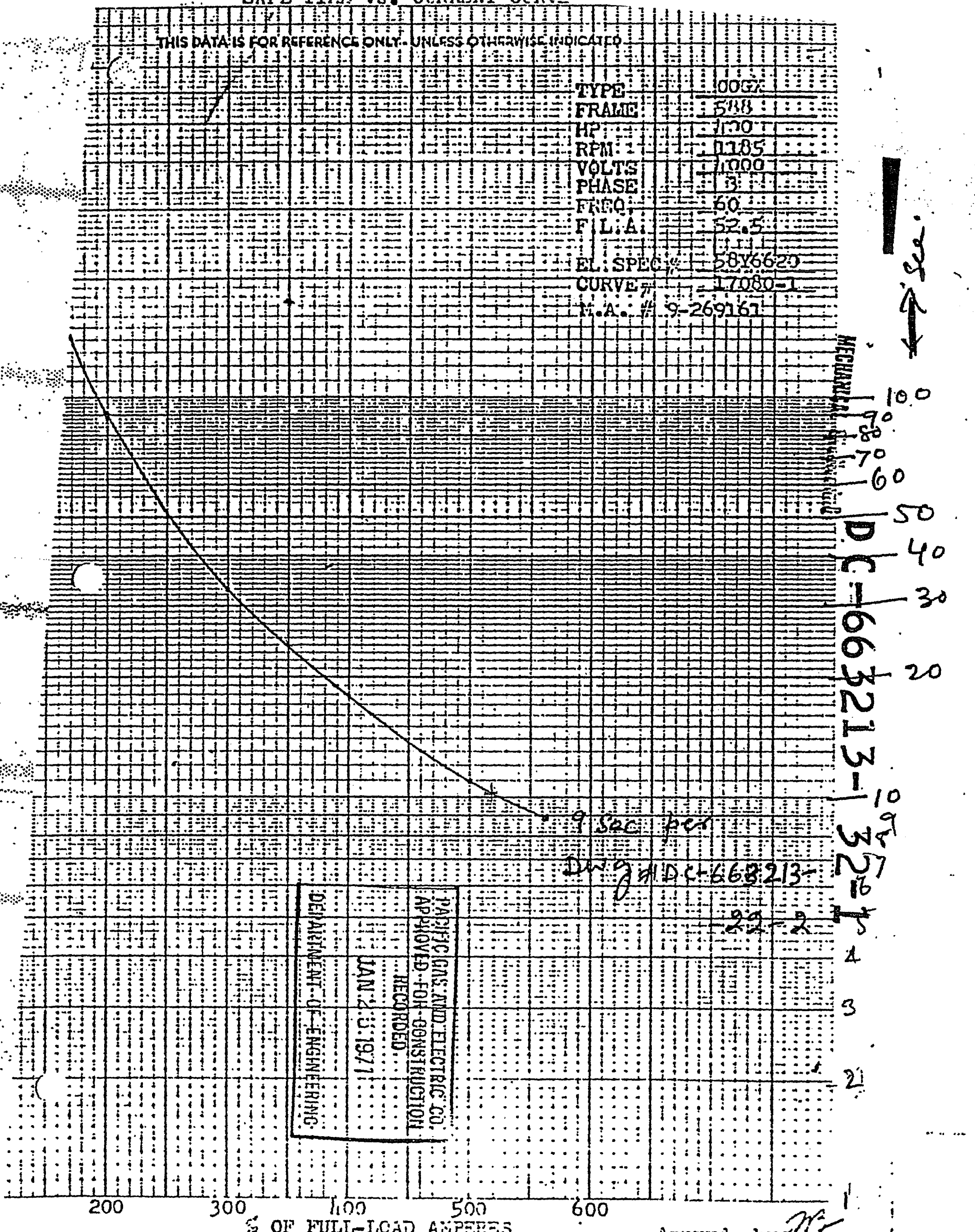
Approved by [signature] Date 6-26-70

NEMA Standard MG1-1967

M3126 — Rev. 1 — 4/70

ATTACHMENT # ~~X~~ 5
CALC. # 170-DC
Rev. 9
SH. 7 OF 9

THE LOUIS ALLIS CO.
SAFE TIME vs. CURRENT CURVE



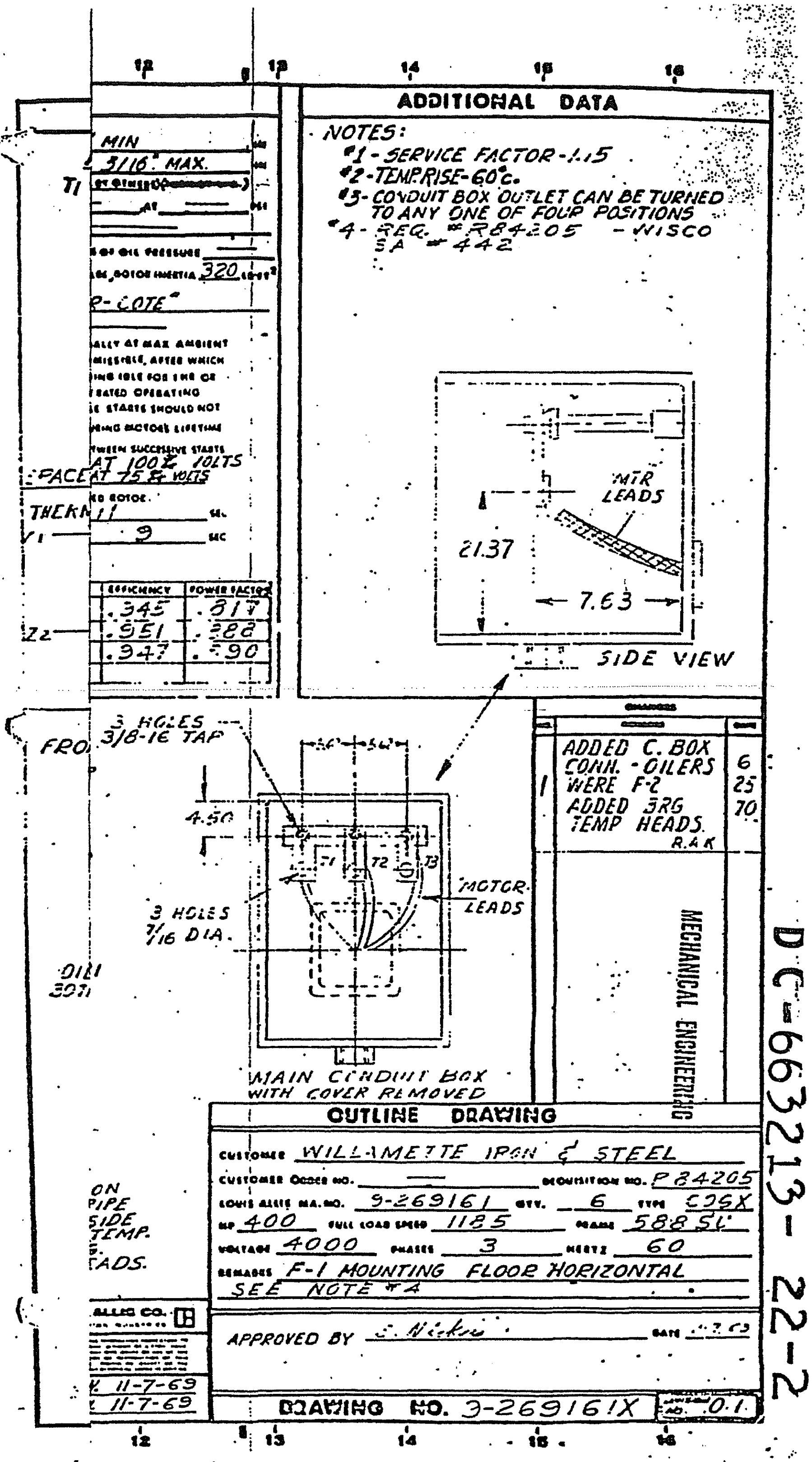
Apprvd. by

ATTACHMENT # 5

CALC. # 170-DC

Rev. 9

SH. 8 OF 9



ATTACHMENT # ~~6~~ 5

CALC. # 170-DC

Rev. 9

SH. 9 OF 9

PROJECT PGE/PEG S.O. NO. 72-S-618; 72-S-621

FURNISHED BY DATE 2/21/69 BY L. E. Ringgol

MARK OR ITEM NO. SPIN NO: PGESIAPSI/PEGSIAPSI

PURCHASER'S REQUIREMENTS	DATA FURNISHED BY SELLER
SERVICE High Head Safety Injection	MAKE Westinghouse
TYPE	FRAME NO. 509-US
NO. OF UNITS 2 PGE/2 PEG TOTAL 4	HORSEPOWER 400
MOUNTING Horizontal	SERVICE FACTOR 1.15
ELEC. CHARACTERISTICS 4000 V. 3 PH 60 CY	FULL LOAD RPM 3555
SYNCH. SPEED, RPM	FULL LOAD AMP 56.7 50.7
HORSEPOWER	LOCKED ROTOR AMP 259 259
SERVICE FACTOR 1.15	STARTING TORQUE, % F.L. 87
ENCLOSURE Open Drip Proof	PULL-OUT TORQUE, % F.L. 204
INSULATION CLASS B	EFF.-FULL LOAD, % 94.2
INSULATION TREATMENT Thermalastic Epoxy	EFF.-3/4 LOAD, % 94.1
AMBIENT TEMP-C	EFF.-1/2 LOAD, % 93.4
STATOR TEMP RISE-C	P.F.-FULL LOAD, % 89.7
BEARING TYPE	P.F.-3/4 LOAD, % 89.3
BEARING TEMP RELAY	P.F.-1/2 LOAD, % 85.8
BEARING THERMOCOUPLE See Appendix "C"	P.F.-LOCKED ROTOR 21.4
HALF COUPL. OR SHEAVE MTD. BY	SPACE HTRS., TOTAL WATTS --
ROTATION*	RADIAL BEARING-TYPE Sleeve
WK^2 OF DRIVEN EQUIP.	THRUST BEARING-TYPE --
BRKWY. TORQ. DRVN. EQUIP.	BEARING SERVICE-HR. 100,000
OVERSIZE COND. BOX Max Oversize	NORMAL BRG. OPER. TEMP-C 80 Deg C Total
COND. BOX LOCATION*	NET WEIGHT-LB. 2200
SPACE HEATERS, VOLTAGE, PHASE None	OIL-COOL. SYS. REQ'D --
SPLIT END BELLS:	BRG. OIL PRESS. RANGE, PSI --
TERMINAL LUGS, TYPE	BRG. OIL REQ'D EA. BRG. GPM --
STATOR HIGH TEMP DEVICE	NAME PLATE CODE LETTER D
ADJUSTABLE SLIDE RAILS	PERMISSIBLE STARTS PER HR.
SOLEPLATES	MOTOR AT AMBIENT TEMP Per customer's spec.
PROJECT ELEV., FT.	MOTOR AT RATED TOTAL TEMP.
SHAFT (HOLLOW, SOLID)	TYPE SEALED INSUL. SYS. Mica Epoxy
COUPLING (SELF-RELEASE)	DESCRIPTION OF INSUL. SYS. " "
SOLID, NONREVERSING	Torque-Speed Curves
ADJUSTABLE, FLEXIBLE	Motor Outline Dwg.
VERT. MAX DOWNTHRUST	
VERT. MAX UPTHRUST	
VERT. MIN UPTHRUST	
VERT. MIN DOWNTHRUST	
(WITH MOTOR RUNNING)	
SIDE THRUST	NOTE: Attention S. Libroth
MAX REVERSE SPEED	Westinghouse N.E.S., Penn Center Site,
DRAIN PLUG AND VENT	shall be on the manufacturer's dist-
AIR INTAKE SCREENS	ribution list for Motor Outline Drawing
	and Torque-Speed Curves.
REMARKS:	REMARKS:
ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY	ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY
ITEMS 38-42 APPLY TO VERTICAL MOTORS ONLY	INDICATE IF DATA IS ESTIMATED
* See attached documents	
* VIEWED FROM END OPPOSITE COUPLING END	

0432139

ATTACHMENT # ~~8~~ 6
CALC. # 170-DC
Rev. 9

SH. 1 OF 6

UNIT 1 only

MOTOR NAMEPLATE DATA

SAFETY INJECTION PUMP 1-1

WESTINGHOUSE LIFE-LINE A
HP 400
MODEL ABDP
FRAME 509US
VOLTS 4000, 3 PH, 60HZ
AMPS 50.7
RPM 3555
INSULATION CLASS B
MAX. AMB. 40
SERVICE FACTOR 1.15
LOCKED KVA CODE E
STYLE NO. 725621
SERIAL NO. 2725621

SAFETY INJECTION PUMP 1-2

SAME
SERIAL NO. 1725621

0 4 3 2 4 4 0 0 0 1 0 5 1 4 0 3 3

ATTACHMENT #6
CALC. # 170-DC
Rev. 9

SH. 2 OF 6

RELIANCE ELECTRIC

24701 Euclid Avenue, Cleveland, Ohio 44117

REPORT OF TEST
For Induction Motor

Purchaser: Con Edison — Date of Test 1-28-82
Serial No. 1XF-883020 — Purchaser's Order No. 1-13914
Model No. A-1
Specification EI-4066-77
Attn: Mr. R.D. Etzler — Equipment Nos. SIPP2-1, SIPP2-2
Diablo Canyon Power Plant — Report of Complete Test

Nameplate Rating

Rated HP	Service Factor	Rated Speed r/min	Phase	Frequency Hz	Volts	Amperes	Type	Frame
400	1.15	3546	3	60	4000	53	P	E5008S

Temperature Rise

	Conditions of Test				Temperature Rise °C					
					Stator		Rotor			
					Windings			Windings		
	Hours Run	Line Volts	Line Amperes	Cooling Air, °C	*By Resist. Method	*By Method		*By Method		
FULL LOAD	7.0	3948	51.9	27	61		N/A			
1.15 S.F.	6.0	3976	59.3	28	79		N/A			

Characteristics

Rated Slip, percent	No-Load Line Current, amperes	Secondary Volts at Standstill	Secondary Amperes per Ring at Rated Load	Resistance at 25°C (between lines) ohms
1.2	10.6	N/A	N/A	Prim. 1.032 Sec. N/A

Torque and Starting Current

Break-Down Torque in lb-ft** with 96 % volts applied	Locked-Rotor Torque in lb-ft** with 92 % volts applied	Starting Current Amperes (locked rotor) with 92 % volts applied
1250	410	246

High Potential Tests

Volts a-c for 60 Sec	
Stator	Rotor
9000	N/A

Efficiencies and Power Factor

Efficiency, Percent			Power Factor, Percent		
Rated Load	75 Percent Load	50 Percent Load	Rated Load	75 Percent Load	50 Percent Load
94.6	94.6	93.8	89.7	88.9	85.8

Notes:

Data from test on this motor. (this or duplicate) — Data by: K.L. Lechner

*Indicate method as:
Thermometer
Thermocouple
Resistance
Embedded Detector

**Indicate ...

Approved by [signature] J.H. DULAS — Date 2/03/82

RE 1202V2 Printed in U.S.A.

0432440

ATTACHMENT #6
CALC. # 170-DC
Rev. 9

SH. 3 OF 6

0 4 3 3 2 4 4 0 3

QA SYSTEM 04 REPORT 5246

SAFETY INJECTION SYS.
DRT # 9.1

PACIFIC GAS AND ELECTRIC COMPANY
STATION CONSTRUCTION DEPARTMENT
DIABLO CANYON PROJECT

COMPOSITE ANALYSIS OF OSCILLIGRAMS FOR MOTOR STARTS

400 hp

CLASS-1

GM 167027

Diablo Canyon Unit 1 Switch No. 52-HF15 Equipment SAFETY INJECTION PP #1-1

Compiled By E. HAYNES Date of Test 2-13-75

1. Starting Current: A Phase 237 B Phase 237 C Phase 225
2. Time From Start To Steady Running Current: 87.8 Cycles — 1.46 sec
3. Running Current: A Phase 28.4 B Phase 28.4 C Phase 28.4
4. Bus Potential: Before Start 4235 During Start 4235 Running 4235

REMARKS: RECORD NO. 56

ATTACHMENT NO. 26
CALC. NO. 170-DC
SH. 5 OF 6

E-14 (10-24-74)

0 4 3 3 2 4 4 0 4

5247

SAFETY INJECTION SYSTE
DRT # 9.1

PACIFIC GAS AND ELECTRIC COMPANY
STATION CONSTRUCTION DEPARTMENT
DIABLO CANYON PROJECT

COMPOSITE ANALYSIS OF OSCILLIGRAMS FOR MOTOR STARTS

CLASS-1

GM 167027

Diablo Canyon Unit 1 Switch No. 52H1115 Equipment. SAFETY INJECTION PP #1-2

Compiled By E. HAYNES Date of Test 2-13-75

1. Starting Current: A Phase 231 B Phase 237 C Phase 231
2. Time From Start To Steady Running Current: 86.6 Cycles —
3. Running Current: A Phase 28.8 B Phase 28.8 C Phase 28.5
4. Bus Potential: Before Start 4240 V. During Start 4230 V. Running 4240 V.

REMARKS: RECORD NO. 57

ATTACHMENT NO. 6
CALC. NO. 170-DC
SH. 6 OF 6

E-14 (10-24-74)

WESTINGHOUSE ELECTRIC CORPORATION
Heavy Industry Motor Division
Round Rock, Texas 78664

198573

INDUCTION MOTOR DATA

Shop Order: 17562 LN General Order: MA 49225

Customer: WESTINGHOUSE PITTSBURGH NSID

Rating

HP: 400 Voltage: 4000 Amperes: 51 Service Factor 1.15

Phases: 3 Hertz: 60 F.L. Speed: 3562 RPM

Temp. Rise: 70 °C By 1.15 Insulation Class: F

Frame: 509 Locked KVA Code: F

Performance

Load	S. F.	1.00	0.75	0.50	0.25
% Efficiency	94.0	94.1	94.0	93.1	
% Power Factor	90.4	90.4	89.3	84.9	

Rated Torque: 590 lb.-ft. Starting Torque: 73 %

Breakdown Torque: 274 % Pull-Up Torque: 73 % @ 0 % Speed

Locked Rotor Current: 310 Amps 607 % F. L. Slip: 1.06 %

Circuit Constants

Per Unit on Output KVA Base

Transient Reactance, X'_d: .14565 X/R: _____

Sub-Transient Reactance, X''_d: .14400 PAM Motors Only

Open Circuit Time Constant, T'_{do}: 1.03 Sec Switching Time Delay

Short Circuit Time Constant, T': .0425 Sec Low-to-High Speed: _____ S

Engineer: T.Nguyen Date: 8/3/92

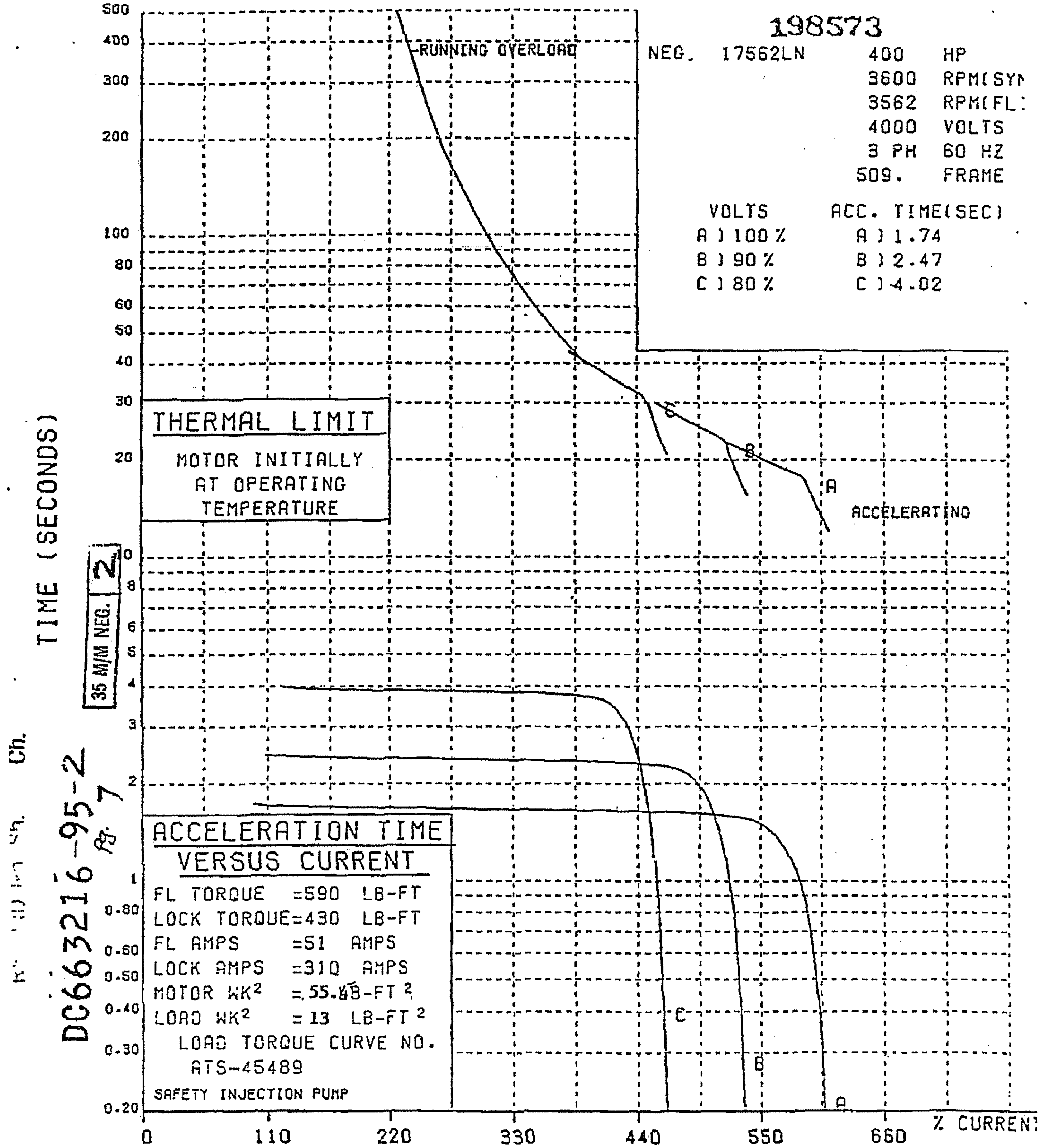
Approval: _____ Revision 01 Date: _____

FORM # HIMD-297

Pg. 3

TIME - CURRENT AND THERMAL LIMIT CURVES

CUSTOMER: NSID/PACIFIC GAS & ELEC. ENGINEER: T.NGUYEN



WESTINGHOUSE MOTOR COMPANY ROUND ROCK, TEXAS

SIGNATURE: T. Nguyen DATE: 9/ 1/92 CURVE NO. C10C

INDUCTION MOTOR DATA SHEET   PG-2200527   Goulds Pump

WESTINGHOUSE FORM 54082

No.	Item	Purchaser's Requirements	Item	Data Furnished by Seller
1	PROJECT	PGE/PEG	S.O. NO.	69F45004
2	FURNISHED BY		DATE	2/21/69 BY L. E. Ringgold
3	MARK OR ITEM NO.	SPIN No: PGES1APCS/PEGS1APCS		
4	PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER	Calculated Data
5	SERVICE	Containment Spray Pumps	MAKE	Westinghouse
6	TYPE		FRAME NO.	5009S
7	NO. OF UNITS	2 PGE/2 PEG TOTAL 4	HORSEPOWER	400
8	MOUNTING	Horizontal	SERVICE FACTOR	1.15
9	ELEC. CHARACTERISTICS	4000 V. 3 PH 60 CY	FULL LOAD RPM	1780
10	SYNCH. SPEED, RPM		FULL LOAD AMP	51.6
11	HORSEPOWER		LOCKED ROTOR AMP	320
12	SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	129
13	ENCLOSURE	Open Drip Proof	PULL-OUT TORQUE, % F.L.	271
14	INSULATION CLASS	B	EFF.-FULL LOAD, %	93.8
15	INSULATION TREATMENT	Thermalastic Epoxy	EFF.-3/4 LOAD, %	94.0
16	AMBIENT TEMP-C		EFF.-1/2 LOAD, %	93.4
17	STATOR TEMP RISE-C		P.F.-FULL LOAD, %	88.9
18	BEARING TYPE		P.F.-3/4 LOAD, %	86.5
19	BEARING TEMP RELAY		P.F.-1/2 LOAD, %	79.7
20	BEARING THERMOCOUPLE	See Appendix "C"	P.F.-LOCKED ROTOR	30.7
21	HALF COUPL. OR SHEAVE MTD. BY		SPACE HTRS., TOTAL WATTS	NONE
22	ROTATION*		RADIAL BEARING-TYPE	SPLIT SLEEVE
23	WK^2 OF DRIVEN EQUIP.		THRUST BEARING-TYPE	NA
24	BRKWY. TORQ. DRVN. EQUIP.		BEARING SERVICE-HR.	NA
25	OVERSIZE COND. BOX	Max. Oversize	NORMAL BRG. OPER. TEMP-C	15°C Rise above ambient
26	COND. BOX LOCATION*		NET WEIGHT-LB.	See Outline
27	SPACE HEATERS, VOLTAGE, PHASE	None	OIL COOL. SYS. REQ'D	NA
28	SHAFT END BELLS		BRG. OIL PRESS. RANGE, PSI	NA
29	TERMINAL LUGS, TYPE		BRG. OIL REQ'D EA. BRG. GPM	NA
30	STATOR HIGH TEMP DEVICE		NAME PLATE CODE LETTER	F
31	ADJUSTABLE SLIDE RAILS		PERMISSIBLE STARTS PER HR:	
32	SOLEPLATES		MOTOR AT AMBIENT TEMP	4
33	PROJECT ELEV., FT.		MOTOR AT RATED TOTAL TEMP	2
34	SHAFT (HOLLOW, SOLID)		TYPE SEALED INSUL. SYS.	Thermalastic
35	COUPLING (SELF-RELEASE)		DESCRIPTION OF INSUL. SYS.	
36	SOLID, NONREVERSING		Torque-Speed Curves	JH049
37	ADJUSTABLE, FLEXIBLE		Motor Outline Dwg.	
38	VERT. MAX DOWNTHRUST			
39	VERT. MAX UPTHRUST			
40	VERT. MIN UPTHRUST			
41	VERT. MIN DOWNTHRUST			
42	(WITH MOTOR RUNNING)			
43	SIDE THRUST		NOTE: Attention S. Libroth	
44	MAX REVERSE SPEED		Westinghouse N.E.S., Penn Center Site, shall	
45	DRAIN PLUG AND VENT		be on the manufacturer's distribution list	
46	AIR INTAKE SCREENS		for Motor Outline Drawings and Torque-Speed	
47			Curves.	
48				
49				
50				
51				
52	REMARKS:		REMARKS:	
53	ALL PERFORMANCE DATA BASED ON NORMAL RATED		ALL PERFORMANCE DATA BASED ON NORMAL RATED	
54	VOLTAGE AND FREQUENCY		VOLTAGE AND FREQUENCY	
55	ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY		INDICATE IF DATA IS ESTIMATED	
56	* See attached documents		Data is calculated	
57				
58				
59				
60	* VIEWED FROM END OPPOSITE COUPLING END			

ATTACHMENT # ~~8~~ 7

CALC. # 170-DC

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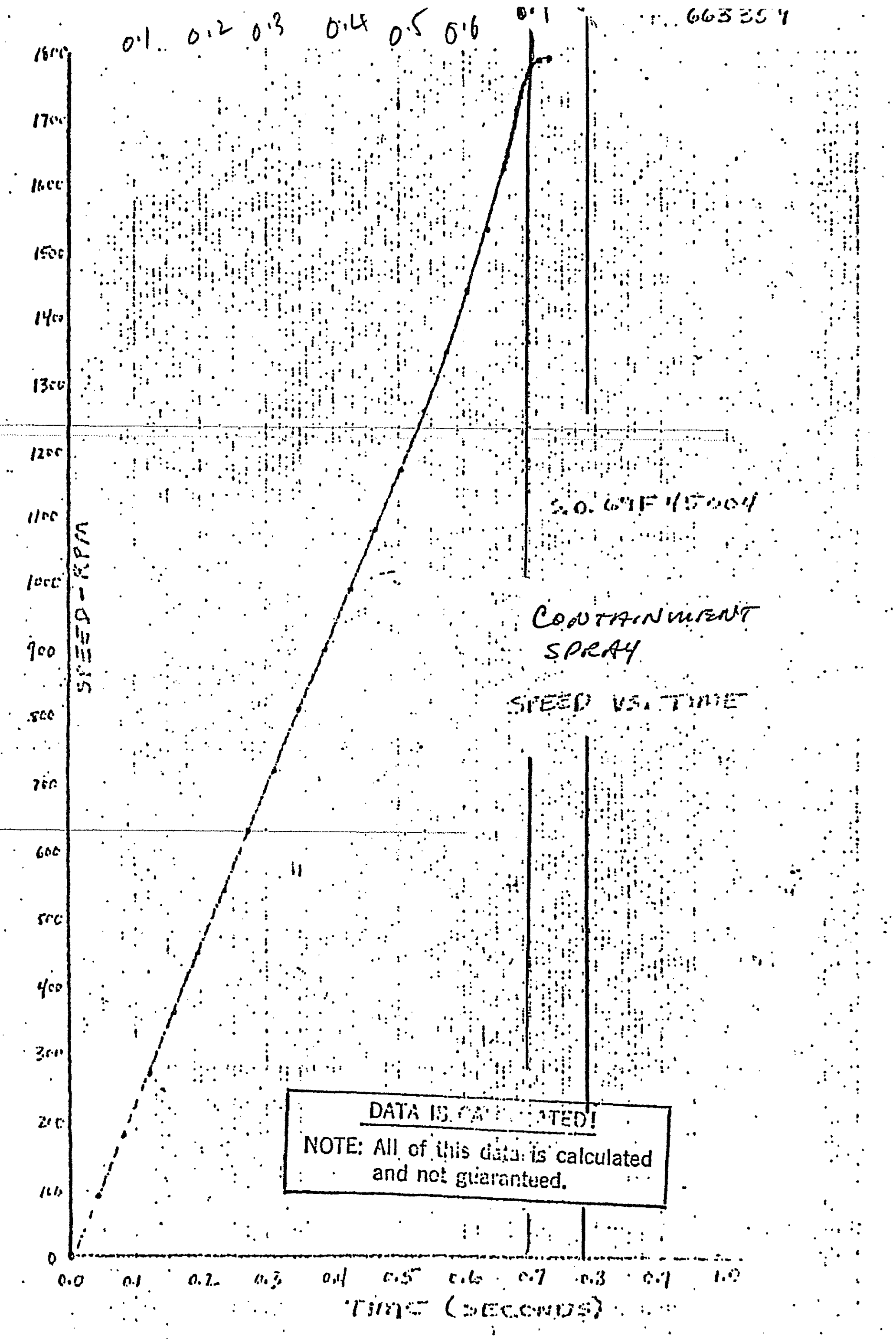

R.C Schellman 2-5-71 663759

ATTACHMENT # 7

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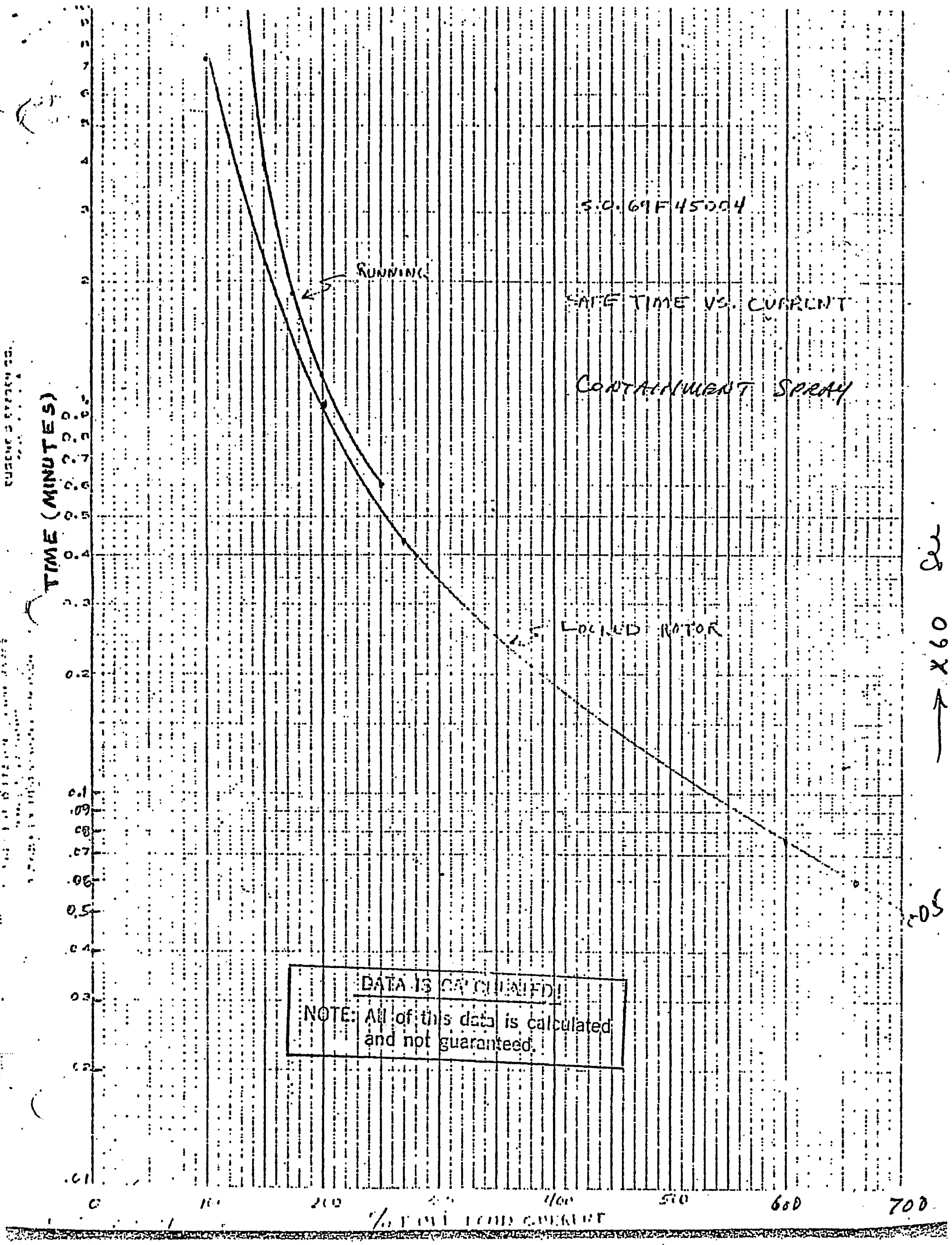
SH. 2 OF 7



ATTACHMENT # 7

CALC. # 170-DC

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ATTACHMENT (B)
SHT 1 OF 10

TEST REPORT
WESTINGHOUSE MOTOR COMPANY
ROUND ROCK, TEXAS

CSP MOTOR
S.O. 17564LN1
for
Pacific Gas & Electric
Diablo Canyon Power Plant

(V.P. 663076-44-1)

COORDINATION			
CK	DISCIPLINE	CKD BY	DATE
	ELECTRICAL		9/8/93
	MECHANICAL		
	I & C		
	CIVIL/STR.		
	CIVIL/ARCH.		

PACIFIC GAS & ELECTRIC CO.
APPROVED FOR CONSTRUCTION
ENGINEERING DEPARTMENT
DATE 9-8-93
BY Albert Wong

The following test report is true and correct record of data obtained from tests made at the Westinghouse Motor Company, Round Rock, Texas. The Data has been reviewed, and compared to both customer contracted and Westinghouse standards. Any discrepancy from either of these is listed in parenthesis and end noted. The Test data has been evaluated and approved by the Test and Design Engineer.

9/8/93
The higher efficiency and powerfactor is acceptable from load flow considerations.
BHA

THE NEW MOTOR HAS HIGHER ILRL AS COMPARED TO THE EXISTING MOTOR. ~~THE~~ IIT SETTING OF UNIT-2 OC RELAYS NEEDS TO BE CHANGED IF THIS MOTOR IS USED IN UNIT-2. UNIT-1 SETTINGS ARE ACCEPTABLE
Paul Gi

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CALC. NO. 170-DC, Rev. 9
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ATTACHMENT (B)
SHT 2 OF 10

WESTINGHOUSE MOTOR COMPANY

HORIZONTAL INDUCTION MOTOR TEST REPORT PAGE NO. 1

DATE - AUGUST 12 1993 GENERAL ORDER NO. -
CUSTOMER - PACIFIC GAS & ELECT. S.O. - 17564LN1

FRAME - 5009S TYPE - LF S.F. - 1.15 H.P. - 400
STATOR NO. - AC5246 ROTOR NO. - AE1328 ENCLOSURE ODP VOLTS - 4000
POLES - 4 PHASE - 3 HERTZ - 60 AMPS - 51 *
RPM - 1780

STATOR RES. AT 25 DEG C
(1.2666)
(1.2666)
(1.2677)

STATOR CONN - WYE

AIR GAP MEASUREMENTS

	FRONT	REAR
Top left	0.037	0.035
Top right	0.035	0.037
Center	0.036	0.037
Bottom left	0.035	0.035
Bottom right	0.035	0.040

SPECIFIED AIR GAP .044

PHASE ROTATION T1 T2 T3 CW

PER DRAWING NO. - 5D97119
MAGNETIC CENTER - 6.310 FLOAT IN - 6.210 FLOAT OUT - 6.460

	HZ	V 1-2	V 2-3	V 3-1	A1	A2	A3	K-WATT
N.LOAD INPUT	60	4002.	4001.	3996.	13.3	13.3	13.3	7.0

VIBRATION DATA DISPLACEMENT - MILS PEAK-TO-PEAK (UNFILTERED)

	FRONT BRACKET	REAR BRACKET	REAR SHAFT
H	0.014 MILS	0.010 MILS	0.280 MILS
V	0.012 MILS	0.015 MILS	0.160 MILS
A	0.008 MILS	0.004 MILS	

BEARING TEMPERATURE DATA, DEG C - BEARING SENSOR - TEST

TIME	AMBIENT TEMP	FRONT BEARING TEMP	REAR BEARING TEMP
1445	23.5	36.4	40.9
1515	23.7	39.8	43.5
1545	24.1	41.1	45.0
1615	24.6	41.7	45.4
1645	25.0	42.2	45.6
1715	25.3	42.5	46.0
1745	25.5	42.6	46.2

* FLA (51 AMP) is A DESIGN/CALC VALUE. ACTUAL TEST FLA IS USED FOR EVALUATION (SHT 5 OF 10).

FINAL BEARING TEMPERATURES, DEG C -	FRONT	REAR
MEASURED TEMPERATURE (TOTAL)	42.6	46.2
AMBIENT AIR TEMPERATURE	25.5	25.5
TEMPERATURE RISE	17.1	20.7

CUSTOMER - PACIFIC GAS & ELECT. S.O. - 17564LN1

ATTACHMENT NO. 7
CALC. NO. 170-DC, REV. 9
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INDUCTION MOTOR
METHOD F PER IEEE STD. 112-1984

CUSTOMER PACIFIC GAS & ELECT. SHOP ORDER 17564LN1
ROTOR SERIAL NO AE1328 STATOR SERIAL NO AC5246
FRAME 5009S TYPE LF HORSEPOWER 400.
VOLTAGE 4000. SYN SPEED 1800. RATED SPEED 1780. FREQ. 60.

SUMMARY OF TESTS

NO LOAD TEST (AT RATED VOLTAGE)		LOCKED ROTOR TEST AT 15.0 HZ	
LINE CURRENT (AMPS)	13.3	VOLTAGE (VOLTS)	208.
POWER INPUT (KW)	6.96	LINE CURRENT (AMPS)	51.0
RES.,HOT, L-L, (OHMS)	1.3360	POWER INPUT (KW)	11.20
FRICTION + WINDAGE (KW)	1.55	RES.,HOT,L-L, (OHM)	1.5920 WDG.TEMP= 91.6 C

COLD MOTOR TEST		LOCKED ROTOR, 68% RATED VOLTS 60. HZ	
RESISTANCE,L-L,(OHMS)	1.2523	VOLTAGE (VOLTS)	2720.
AMB. TEMP. (DEG.C)	22.0	LINE CURRENT (AMPS)	234.7
		POWER INPUT (KW)	375.5
		RES., HOT L-L, (OHM)	1.59200

LOCKED ROTOR, RATED CURRENT AT 60.HZ	
VOLTAGE (VOLTS)	809.
LINE CURRENT (AMPS)	51.0
POWER INPUT (KW)	34.36
RES., HOT, L-L, (OHM)	1.5920

RPE-E7824 REV 0
ATTACHMENT (B)
SHT 5 OF 10

TEMPERATURE CONSTANTS 234.5

INPUT STRAY LOAD LOSS 3.84 KW AT 400. HP

X1 = 54.76 PERCENT X2 = 45.24 PERCENT

LOCKED REFERENCE VALUES (RES. IN OHMS FOR Y CONN. - PER PHASE -)

HZ	AMP	R1	R2	X1	X2	X1+X2	XM	WH
15.0	51.0	0.7960	0.6706	4.1093	3.3953	7.5046	170.2618	5058.
60.0	234.7	0.7960	1.5343	3.4724	2.8690	6.3414	170.8952	5058.
60.0	51.0	0.7960	3.7934	4.4395	3.6681	8.1075	169.9335	5058.

SLIP= 1.11 % AT 400.0 HP AND 105.0 DEG.C -WMC EXCEPTION TO IEEE STD. 112
R2 FOR THIS SLIP IS = 0.5263

X1 FOR PULL OUT POINT= 3.2142 X2 FOR PULL OUT POINT= 2.6557

STRAY LD LOSS = 3.84 KW AT 46. SEC.AMPS.(IT) OR 50. PRI.AMPS.(I)

SUMMARY OF CHARACTERISTICS

LOAD (PER UNIT)	0.25	0.50	0.75	1.00	1.25	1.50	3.27
HORSEPOWER	100.	200.	300.	400.	500.	600.	1307.
SPEED RPM	1795.	1790.	1785.	1780.	1774.	1768.	1639.
LINE CURRENT	18.	27.	38.	50.	62.	76.	266.
EFFICIENCY %	90.77	93.98	94.53	94.33	93.78	93.02	73.34
POWER FACTOR %	65.6	83.9	89.6	91.6	92.1	91.9	72.2
SLIP (PER UNIT)	0.0027	0.0054	0.0082	0.0111	0.0143	0.0177	0.0892

ATTACHMENT NO. 7
CALC-170-DC REV. 9
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INDUCTION MOTOR
METHOD F PER IEEE STD. 112-1984
PROGRAM HH9702TL, 12/30/86

CUSTOMER PACIFIC GAS & ELECT. SHOP ORDER 17564LN1
ROTOR SERIAL NO AE1328 STATOR SERIAL NO AC5246
FRAME 5009S TYPE LF HORSEPOWER 400.
VOLTAGE 4000. SYN SPEED 1800. RATED SPEED 1780. FREQ. 60.

SOLUTION OF EQUIVALENT CIRCUIT

PULOAD	0.25	0.50	0.75	1.00	1.25	1.50	3.27
SLIP	0.00266	0.00535	0.00816	0.01111	0.01427	0.01771	0.08924
R2	0.5263	0.5263	0.5263	0.5263	0.5263	0.5263	0.5263
R2/S	197.7217	98.3300	64.5281	47.3675	36.8778	29.7119	5.8977
X2	3.395	3.395	3.395	3.395	3.395	3.395	2.656
Z2SQ	39105.41	9680.32	4175.40	2255.21	1371.50	894.32	41.83
G2	0.00506	0.01016	0.01545	0.02100	0.02689	0.03322	0.14097
GFE	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
G	0.0054	0.0105	0.0158	0.0213	0.0272	0.0336	0.1413
-B2	0.000087	0.000351	0.000813	0.001506	0.002476	0.003797	0.063479
BM	0.00588	0.00588	0.00588	0.00588	0.00588	0.00588	0.00588
-B	0.00597	0.00624	0.00670	0.00739	0.00836	0.00968	0.06936
YSQ	0.000065	0.000149	0.000294	0.000510	0.000811	0.001220	0.024779
RG	83.2923	70.4385	53.6803	41.8477	33.5693	27.5113	5.7027
R1	0.5725	0.5725	0.5725	0.5725	0.5725	0.5725	0.5725
R	83.8647	71.0109	54.2528	42.4202	34.1418	28.0837	6.2751
XG	92.2952	41.8672	22.7742	14.4946	10.3098	7.9373	2.7993
X1	4.1093	4.1093	4.1093	4.1093	4.1093	4.1093	3.2142
X	96.4045	45.9765	26.8836	18.6039	14.4192	12.0466	6.0134
Z	127.7776	84.5955	60.5482	46.3204	37.0618	30.5584	8.6913
I1	18.	27.	38.	50.	62.	76.	266.
I2	11.	23.	34.	46.	59.	72.	261.
INPUT KW	82.18	158.76	236.78	316.34	397.70	481.19	1329.15
SEC. KW	76.58	152.49	229.34	307.20	386.25	466.70	1205.05
PRIM I2R KW	0.56	1.28	2.50	4.27	6.67	9.81	121.25
CORE LOSS KW	5.04	5.00	4.94	4.87	4.78	4.68	2.85
SEC I2R KW	0.20	0.82	1.87	3.41	5.51	8.27	107.54
F+W LOSS KW	1.55	1.55	1.55	1.55	1.55	1.55	1.55
WLL KW	0.23	0.92	2.11	3.84	6.21	9.31	121.11
TOTAL KW	7.58	9.56	12.96	17.94	24.72	33.61	354.29
OUTPUT KW	74.60	149.20	223.81	298.39	372.98	447.58	974.85
EFF (%)	90.77	93.98	94.53	94.33	93.78	93.02	73.34
PF (%)	65.63	83.94	89.60	91.58	92.12	91.90	72.20
HP OUTPUT	100.	200.	300.	400.	500.	600.	1307.
SPEED(RPM)	1795.	1790.	1785.	1780.	1774.	1768.	1639.
TORQ,LB-FT	292.7	586.9	882.9	1180.7	1480.5	1782.8	4188.1

PULL OUT TORQUE= 3.55
STATOR I2R = 4.27 NO LOAD STAI2R = 0.35 ROTOR I2R = 3.41
STARTING TORQUE AT RATED VOLTS = 1682. LB FT (142.44 % RUNNING TORQUE)
INRUSH CURRENT AT RATED VOLTS = 382.3 (PER UNIT= 7.50)

RPE-E7824 REV 0
ATTACHMENT (B)
SHT 6 OF 10

(Rev. 11/6/67) 290600/03

Calculated Data Sheet For Induction Motors

Pacific Gas & Electric Co. Station Diablo Canyon Site Unit No. 1 & 2

Specification No. 8758 Function Auxiliary Salt Water Pumps

Quantity 4 Manufacturer Westinghouse Type LLD

Hp 400 Volts 4000 Phase 3 Cycles 60 Serv. Factor /1.00

NEMA Design B Frame Size 5809 Sync. rpm 900 No. of Poles 8

Enclosure Type WP-1 Cooling -- Space Heater 200 Watts

Insulation Class B Temp. Rise 80 °C by Res. No. of Leads 3

Windings Connected Series Wye Dielectric Test 9000 Volts, a-c @ 1 min.

Bearing Types Spherical Roller Lubrication oil

Shaft Dir. (H or V) V Rotation CCW Coupling Type

Weight: Stator 2400 lb | WK^2: Rotor 517 lb-ft²

Weight: Rotor 2200 lb | Max. Allowable Load 8,500 lb-ft²

Maximum Down Thrust 6500 lb ~~Effdr.~~ or T.C. In Stator Yes Bearings Yes

Running Characteristics At Rated Frequency & Voltage

Load - %	0	25*	50*	75*	100	115*	Pull out
Speed - rpm			894	890	887	884	842
Torque - ft-lb			1175	1770	2368	2731	5190
Current - amp	18.7		31	41	54	62	180
Power Factor - %			74.6	82.7	85.6	86.2	70
Efficiency - %	0		93.5	93.6	93.1	92.6	X

Starting Characteristics At Rated Frequency

Speed		Input At 80% Rated Voltage			Input At 100% Rated Voltage		
% Sync.	Rpm	Amp	P.f. - %	Torque** ft-lb	Amp	P.f. - %	Torque** ft-lb.
0 (Locked	0 Rotor)	252	30		320	31.3	
25*							
50*	894	35	85.8		31	74.6	
75*	890	50	87.9		41	82.7	
Pull in	877	69	86.2		54	85.6	

* Over 50 hp only. ** Output Torque plus Accelerating Torque.

Date: 1-21-70 Vendor: [signature] - Westinghouse

ATTACHMENT NO. ~~#~~ 8

CALC. # 170-DC Rev. 9

SH. 1 OF 10

04373244

DC-663030-21-1

Westinghouse Electric Corporation

MECHANICAL ENGINEERING FILE COPY

Quality Assurance Data Package

Motors P030333 L7
1S69F46612
2S69F46612
1S69F46613
2S69F46613

Bingham-Willamette Company
Order 46523
Pumps 290600, 290601, 290602, & 290603

Pacific Gas and Electric Company
Auxiliary Salt Water Pumps
Diablo Canyon 1 and Diablo Canyon 2

400 HP, 3 phase 60 hertz, 4000 volts

900 RPM Vertical Solid Shaft 5809P24 frame

Stator RTD, Space Heaters

Oversized Main Lead Conduit Box With Stand Off Insulators and Busses

(69F46612 serial 1 tested as 72L10526)
(69F46612 serial 2 tested as 72L10525)

J. A. Rooks
J. A. Rooks
Portland Office
October 19, 1972

Caution:
Drawings in this manual
may not reflect the
"As Built" condition.
Refer to the appropriate
recorded supplier
drawing.

ATTACHMENT NO. 8

CALC. NO. 170-DC Rev. 9

SH. 2 OF 10

0433244 5

WESTINGHOUSE ELECTRIC CORPORATION
MOTOR DIVISION, BUFFALO, N.Y.

REPORT OF COMMERCIAL TESTS — INDUCTION MOTOR

DATE	Original	S.O. NO.	G.O. NO.	PURCHASER'S ORDER NO.
10/5/72	69F46612 #2	72L10525	PO-46577-L7	

PURCH. b ngham Pump Co.

NAME PLATE DATA

H.P.	SPEED	PHASE	FREQ.	VOLTS	AMPS.	TYPE	FRAME	TEMP. RISE	TIME RATING	DESIGN (LETTER)	LOCKED KVA CODE LETTER
400	887	3	60	4000	54	VSW1	5809 P24	80	Cont.		F

TEST CHARACTERISTICS

SERIAL NO.	NO LOAD VOLTS	NO LOAD FREQ.	NO LOAD SPEED	NO LOAD AMPS.		LOCKED ROTOR VOLTS	LOCKED ROTOR FREQ.	LOCKED ROTOR AMPS.			OPEN CIRCUIT VOLTAGE (WOUND ROTOR)	DIELECTRIC TEST

Full load heat run OK

Percent Slip OK

No load running current OK

Checking of current balance OK

Pull out torque OK

Locked rotor current OK

Starting torque OK

Efficiency at full 3/4 and 1/2 load OK

Power factor at full, 3/4 and 1/2 load OK

Winding resistance measurements OK

High potential test OK

TESTS ON (THIS) / DUPLICATE MOTOR

APPROVED BY J. N. Hibbard ENGINEER DATE 10-6-72

ATTACHMENT NO. ~~X~~ 8

CALC. NO. 170-DC Rev. 9

SH. 3 OF 10

0433244[illegible]

Orig. S.O. 69F45512
Serial No.2

Westinghouse Electric Corporation

BUFFALO, N.Y.

Date 10/5/72

Purchaser Bingham Pump Co. Stock Order No. 72L10525

G.O. No. PO 45577-L7 H.P. 400 Volts 4000 Phase 3 Class B Insulation

Apparatus 5809P24 8 Poles 887 R.P.M. 60 Cycles

Serial No.	1	XX1	3	COMMENTS
Amperes Per Terminal at no load 4000 Volts	16.17	16.7		Stator Res. @ 25°C
Watts Input at no load	5088	6458		T1-T2 - 1.683
Stator Res. (T-T) at 75° C - ohms	2.07	Test taken in Vertical position with oil lubr. bearings		T1-T3 - 1.683
Starting Winding Res. at 75° C - ohms				T2-T3 - 1.682
Rotor Res. (bet rings) at 75° C - ohms				
LOSSES IN WATTS AT FULL LOAD				Vibration
Stray Load Loss	3127			Top .00015
Stator I^2R Loss	8179			Bottom .000023
Rotor I^2R Loss	3943			
Core Loss	3351			Current Balance
Friction and Windage Loss	900			No Load
% Efficiency - Full Load	93.9			16.25-15.88-16.38
- ¾ Load	94.4			Full load (Approx.)
- ½ Load	94.5			53.5 - 52.7 - 52.5
% Power Factor Full Load	87.0			Heaters
- ¾ Load	84.8			120 Volts
- ½ Load	77.1			2.10 Amps
R.P.M. at Full Load	888			
Amperes Per Term. at full load	52.7			
KW input at full load	317.9			
Amperes per Term-Rotor locked 4000 V	298			
KW input - Rotor locked	636			
Max. Sec. Volts between rings				
Sec. Amps per ring at full load				
Full Load Torque (F.L.T.) in lb. ft.	2364			
Max. Torque in % of F.L.T.	246.2			
Starting Torque in % of F.L.T.	(120.6)			
~~XXXXXXXXXX~~ % Slip	1.33			
Balance Tested	OK			
Stator Ins Tested 9000 V 60 Sec.	OK			
Rotor Ins Tested V Sec.				
TEMPERATURE TESTS				
Length of Test in hours	5.00			
Volts	4000			
% Normal Full Load Amp.	99.8			
Temp. Rise in degrees C — Stator Copper by	51.5			
Stator Iron	47			
Stator ~~Rotor~~ Copper by thermocouple	28			
Rotor Iron				
Room temperature in °C	27			
Stator slot thermocouples 1	29			
2	44			
3	43			
4	40			
Curve Nos. 5	48			
6	21			

(Column 1, written vertically: Test taken in horiz. position with greased bearings)

The above is a true and correct record of data obtained from tests made at the works of Westinghouse Electric Corporation.

REPORT OF TESTS ON INDUCTION MOTORS
FORM 2953K

Signed J. N. Hebbard Engineer

0432447

ATTACHMENT No. ~~2K~~ 8
CALC. NO. 170-DC Rev. 9

SH. 4 OF 10

WESTINGHOUSE ELECTRIC CORPORATION
MOTOR DIVISION, BUFFALO, N.Y.

REPORT OF COMMERCIAL TESTS — INDUCTION MOTOR

DATE	Original	S.O.NO.	G.O.NO.	PURCHASER'S ORDER NO.
10/5/72	69F45612-1	72L10526	PO 46577-L7	

PURCHASER: Bingham Pump Company

NAME PLATE DATA

H.P.	SPEED	PHASE	FREQ.	VOLTS	AMPS.	TYPE	FRAME	TEMP. RISE	TIME RATING	DESIGN (LETTER)	LOCKED KVA CODE LETTER
400	887	3	60	4000	54	VSW1	5809 P24	80	Cont.		F

TEST CHARACTERISTICS

SERIAL NO.	NO LOAD / LOCKED ROTOR (VOLTS, FREQ., SPEED, AMPS. / VOLTS, FREQ., AMPS.)	OPEN CIRCUIT VOLTAGE (WOUND ROTOR)	DIELECTRIC TEST
	Full-Load heat run OK		
	Percent Slip OK		
	No load running current OK		
	Checking of current balance OK		
	Pull out torque OK		
	Loaded rotor current OK		
	Starting torque OK		
	Efficiency at full, 3/4 and 1/2 load OK		
	Power factor at full, 3/4 and 1/2 load OK		
	Winding resistance measurements OK		
	High potential test OK		

TESTS ON (THIS) DUPLICATE MOTOR

APPROVED BY Jn Hibbard ENGINEER DATE 10-6-72

ATTACHMENT NO. ~~X~~8

CALC NO. 170-DC Rev. 9

SH. 5 OF 10

Orig. S.O. 69F-56612 Ser. #1

Westinghouse Electric Corporation

BUFFALO, N.Y.

Date 10/5/72

Purchaser Bingham Pump Company — Stock Order No. 72L10526

G.O. No. PO 46577-L7 H.P. 4000 Volts 4000 Phase 3 Class B Insulation

Apparatus 5809P24 8 Poles 887 R.P.M. 60 Cycles

Ser. No.	1	XX 1	3	COMMENTS
Amperes Per Terminal at no load 4000 Volts	16.52	16.77		Stator Res. @ 27°C
Watts Input at no load	5188	7374		
Stator Res. (T-T) at 75° C - ohms	2.019			T1 T2 - 1.706
Starting Winding Res. at 75° C - ohms				T2 T3 - 1.706
Rotor Res. (bet rings) at 75° C - ohms				T1 T3 - 1.706
LOSSES IN WATTS AT FULL LOAD				
Stray Load Loss	2401			
Stator I^2R Loss	8267			Vibration
Rotor I^2R Loss	3913			Top - .00075
Core Loss	3419			Bottom - .0001
Friction and Windage Loss	900			
% Efficiency - Full Load	94.0			Current Balance
- ¾ Load	94.8			No Load
- ½ Load	94.9			16.25 - 16.45 - 16.85
				Full Load (Approx.)
% Power Factor Full Load	87.2			52.2 - 52.9 - 53.5
- ¾ Load	84.9			
- ½ Load	77.1			Heaters
				120 Volts 2.0 amps.
R.P.M. at Full Load	888.5			
Amperes Per Term. at full load	52.5			
KW input at full load	317.3			
Amperes per Term-Rotor locked 4000 V	291			
KW Input - Rotor locked	651.4			
Max. Sec. Volts between rings				
Sec. Amps per ring at full load				
Full Load Torque (F.L.T.) in lb. ft.	2364			
Max. Torque in % of F.L.T.	258			
Starting Torque in % of F.L.T.	121			
% Slip	1.28			
Balance Tested	OK			
Stator Ins Tested 9000 V 60 Sec.	OK			
Rotor Ins Tested V Sec.				
TEMPERATURE TESTS				
Length of Test in hours	7.00			
Volts	4000			
% Normal Full Load Amp.	100.4			
Temp. Rise in degrees C — Stator Copper by Rise	50			
Stator Iron	47.5			
Stator Copper by thermocouple	31			
Rotor Iron	27			
Room temperature in °C				
Stator slot thermocouples 1	38			
2	38			
3	55			
4	54			
Curve Nos. 5	45			
6	55			

(Column 1: Test taken in horiz. position with greased bearings.)
(Column XX 1: Test taken in vertical position with oil lubr. bearings.)

The above is a true and correct record of data obtained from tests made at the works of Westinghouse Electric Corporation.

REPORT OF TESTS ON INDUCTION MOTORS
FORM 2958K

Signed J. N. Hibbard Engineer

0437449

ATTACHMENT NO. 8
CALC. NO. 170-DC Rev. 9

SH. 6 OF 10

FORM 24030

WESTINGHOUSE ELECTRIC CORPORATION

MOTOR DIVISION, BUFFALO, N.Y.

REPORT OF COMMERCIAL TESTS — INDUCTION MOTOR

DATE	STYLE NO.	S.O. NO.	G.O. NO.	PURCHASER'S ORDER NO.
10/5/72		69F46613	PO-30333-L7	

PURCHASER: Pacific Gas & Electric

NAME PLATE DATA

H.P.	SPEED	PHASE	FREQ.	VOLTS	AMPS.	TYPE	FRAME	TEMP. RISE	TIME RATING	DESIGN (LETTER)	LOCKED KVA CODE LETTER
400	887	3	60	4000	54	VSW1	5809P24	80	Cont.		F

TEST CHARACTERISTICS

SERIAL NO.	NO LOAD VOLTS	FREQ.	SPEED	AMPS.		XXXXX	XXXX	XXXX	Ser. #1	#2	OPEN CIRCUIT VOLTAGE (WOUND ROTOR)	DIELECTRIC TEST
	Full Load heat run								OK	OK		
	Percent slip								OK	OK		
	No-Load running current								OK	OK		
	Checking of current balance								OK	OK		
	Pull-out torque								OK	OK		
	Locked-rotor current								OK	OK		
	Starting Torque								OK	OK		
	Efficiency at full, 3/4 and 1/2 load								OK	OK		
	Power factor at full, 3/4 and 1/2 load								OK	OK		
	Winding Resistance Measurements								OK	OK		
	High Potential test								OK	OK		

TESTS ON (THIS) DUPLICATE MOTOR

APPROVED BY J. N. Hibbard ENGINEER DATE 10-6-72

ATTACHMENT NO. ~~#~~8
CALC. NO. 170-DC
Rev. 9

0 4 3 3 2 1 4 2 0

SH. 7 OF 10

Westinghouse Electric Corporation
BUFFALO, N.Y.

AUX SW PUMPS

Date 10/5/72

Purchaser Pacific Gas & Electric
Stock Order No. 69F46613

... No. PO-30333-L7 H.P. 400 Volts 4000 Phase 3 Class B Insulation

Apparatus 5809P24 8 Poles 887 R.P.M. 60 Cycles

Serial Number	1	1	#2	2	COMMENTS
					Ser.#1
Amperes Per Terminal at no load 4000 Volts	17.3	17.4	.87	16.1	Stator Res.@ 27°C
Watts Input at no load	6477	7574	5786	7373	T1T2 - 1.705
Stator Res. (T-T) at 75° C - ohms	2.02		2.053		T1T2 - 1.706
Starting Winding Res. at 75° C - ohms					T1T3 - 1.706
Rotor Res. (bat rings) at 75° C - ohms					
LOSSES IN WATTS AT FULL LOAD					Vibration
Stray Load Loss	1977		1778		Top -.00026
Stator I^2R Loss	8362		8529		Bottom -.00006
Rotor I^2R Loss	3617		3544		
Core Loss	4644		4049		Current Balance
Friction and Windage Loss	800		900		No Load
% Efficiency - Full Load	93.9		94.1		17.38-17.5-16.98
- ¾ Load	94.5		94.5		Full Load (Approx.
- ½ Load	94.1		94		52.6-52.9-53
% Power Factor Full Load	86.6		87.8		Heaters
- ¾ Load	83.9		85.4		120 Volts
- ½ Load	76.1		77.7		2.07 Amps.
RPM at Full Load	889		890		
Amperes Per Term. at full load	53		52.13		Ser.#2
KW input at full load	317.8		317.2		Stator Res. @ 27°C
Amperes per Term-Rotor locked V	303.5		302.5		T1T2 - 1.735
KW input - Rotor locked	675.6		679.6		T1T2 - 1.735
Max. Sec. Volts between rings					T2T3 - 1.734
Sec. Amps per ring at full load					
Full Load Torque (F.L.T.) in lb. ft.	2362		2361		Vibration
Max. Torque in % of F.L.T.	248		239		Top .0013
Starting Torque in % of F.L.T.	124.3		132.3		Bottom .00011
~~[struck out]~~ % Slip	1.22		1.11		
Balance Tested	OK		OK		Current Balance
Stator Ins Tested 9000 V 60 Sec.	OK		OK		No Load
Rotor Ins Tested V Sec.					15.85-16-15.75
TEMPERATURE TESTS					Full Load (Appro
Length of Test in hours	6.00		7.00		52.3-52.4-52.8
Volts	4000		4000		
% Normal Full Load Amp.	99.5		100.9		Heaters
Temp. Rise in degrees C — Stator Copper by Res.	51.2°C		50.5		120 Volts
Stator Iron	46		48		2.05 Amps.
Stator ... Copper by thermocouple	32		[illegible]		
Rotor Iron					
Room temperature in °C	25		31		
Stator slot thermocouples (Rise) 1	49		42		
2	41		41		
3	32		33		
4	44		39		
...e Nos. 5	42		36		
6	48		37		

Test taken in horiz. position with greased bearings (Ser. 1)
Test taken in vertical position with oil lubr. bearings (Ser. 1)
Test taken in horiz. position with grease lubr. brgs. (Ser. 2)
Test taken in vertical position with oil lubr. bearings (Ser. 2)

The above is a true and correct record of data obtained from tests made at the works of Westinghouse Electric Corporation.

REPORT OF TESTS ON INDUCTION MOTORS
FORM 2958 K

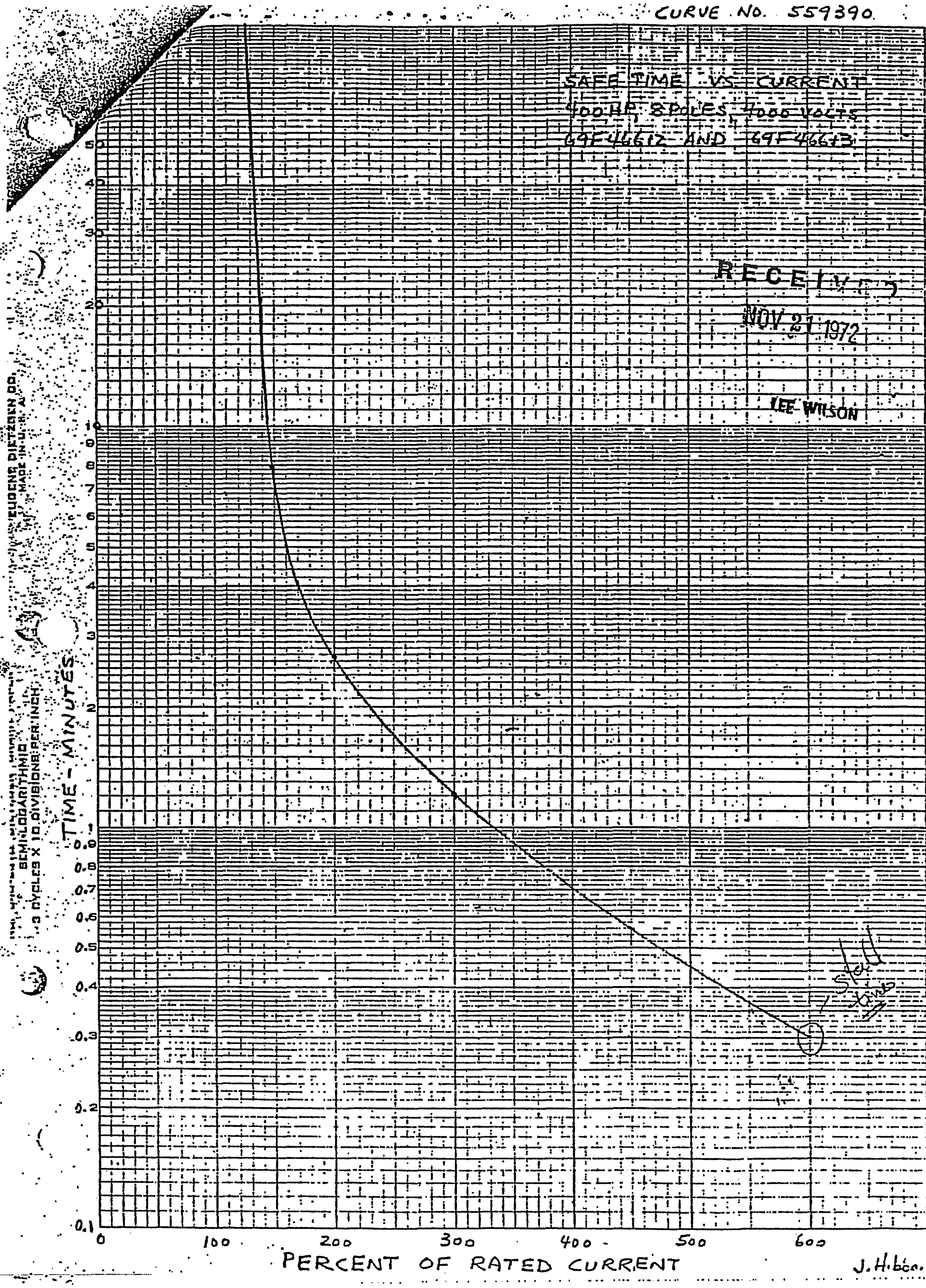
Signed J. N. Hibbard Engineer

0 4 3 3 2 4 4 2 1

ATTACHMENT No. 8
CALC. NO. 170-DC
Rev. 9

SH. 8 OF 10

CURVE NO. 559390.



J. Hibbons 11/8/

AUX SALTWATER PP

ATTACHMENT NO. ~~A~~ 8
CALC. NO. 170-DC
Rev. 9

SH. 9 OF 10

Bingham-Willamette Company

A DIVISION OF GUY F. ATKINSON COMPANY

EST. 1921 CABLE: TELEX-036-684 • TWX-910-464-8031 ASW EST. 1966

Main Offices and Factory — 2800 N.W. FRONT AVENUE • PORTLAND, OREGON 97210

PLEASE REPLY TO:
BINGHAM-WILLAMETTE COMPANY
1311 CANAL BOULEVARD
RICHMOND, CALIFORNIA 94804
PHONE (415) 233-7500

November 17, 1972

Pacific Gas and Electric Company
Mr. D. V. Kelly, Chief Mechanical and Nuclear Engineer
77 Beale Street
San Francisco, California. 94106

RECEIVED
NOV 21 1972
LEE WILSON

Attention: Mr. P. G. Antiochos

Subject: ~~Auxiliary Salt Water Pumps and Motor Drivers~~
Diablo Canyon Site, Units 1 and 2
Your Purchase Orders 4R-8758 and 4R-8758A
Our Sales Orders 290600/603

Gentlemen:

In response to your letter to us of August 23, 1972, relative to the motors, attached please find several copies of Westinghouse "~~Safe Time vs. Current~~" curve no. 559390, supplemented by the following information obtained from Westinghouse relative to accelerating times:

Pump Discharge Valve OPEN		
	100 % Voltage	0.81 seconds
	85 % Voltage	1.38 seconds
	80 % Voltage	1.72 seconds
Pump Discharge Valve CLOSED		
	100 % Voltage	0.71 seconds
	85 % Voltage	1.09 seconds
	80 % Voltage	1.33 seconds

In partial response to your letter to us of November 9, 1972, in which you ask for additional motor information, we attach copies of Westinghouse letter dated November 14, 1972. The microfilm negatives of the motor outline dimensinn drawing are in transit and will be forwarded early next week.

MECHANICAL & NUCLEAR ENGINEERING
PASS ☐ FILE ☐
DISPOSITION: 1 YEAR / AFTER 2, 3 YEARS — DISCARD ☐ ENG. FILE ☐ REVIEW ☐ BY
NOV 20 1972

Very truly yours,

BINGHAM-WILLAMETTE COMPANY
A Division of Guy F. Atkinson Company

David G. Seabury

DVK WKB TJD PDH EHM POP WHO
GAA DLB JRD JDH TEM DLP WJS
PGA WHC LJE RPH RPM JVR GAT
AFA JRC JPF LRK TVM JWB WHW
CPA BC WHF JL EPM ARB AQW
RED MCC JBG RML VHN DMB RCW
DDB SMD TDG MLL JDO MHN NLT

OTHER MANUFACTURING FACILITIES — SHREVEPORT, LA. — BURNABY, B. C. — PENISTONE, ENGLAND

0 4 3 3 4 4 3

ATTACHMENT No. ~~7~~ 8
CALC. No. 170-DC Rev. 9

SH. 10 OF 10

INDUCTION MOTOR DATA SHEET
WESTINGHOUSE FORM 54062

1 PROJECT PGE/PEG NY 31737L7, Item E S.O. NO. 69F46532
2 FURNISHED BY DATE 2/21/69 BY L. E. Ringgold
3 MARK OR ITEM NO. SPIN No: PGEACAPRH/PEGACAPRH

No.	PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER	
4	SERVICE	Residual Heat Removal	MAKE	Westinghouse
5	TYPE		FRAME NO.	5010P24
7	NO. OF UNITS	2 PGE/2 PEG TOTAL 4	HORSEPOWER	400
8	MOUNTING	Horizontal	SERVICE FACTOR	1.15
9	ELEC. CHARACTERISTICS	4000 V. 3 PH. 60 CY	FULL LOAD RPM	1778
10	SYNCH. SPEED, RPM		FULL LOAD AMP	50
11	HORSEPOWER		LOCKED ROTOR AMP	304
12	SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	111
13	ENCLOSURE	Open Drip Proof	PULL-OUT TORQUE, % F.L.	238
14	INSULATION CLASS	B	EFF.-FULL LOAD, %	94.0
15	INSULATION TREATMENT	Thermalastic Epoxy	EFF.-3/4 LOAD, %	94.4
16	AMBIENT TEMP-C		EFF.-1/2 LOAD, %	94.2
17	STATOR TEMP RISE-C		P.F.-FULL LOAD, %	91.6
18	BEARING TYPE		P.F.-3/4 LOAD, %	90.9
19	BEARING TEMP RELAY		P.F.-1/2 LOAD, %	87.3
20	BEARING THERMOCOUPLE	See Appendix "C"	P.F.-LOCKED ROTOR	29.4
21	HALF COUPL. OR SHEAVE MTD. BY		SPACE HTRS., TOTAL WATTS	None
22	ROTATION*		RADIAL BEARING-TYPE	Ball
23	WK^2 OF DRIVEN EQUIP.		THRUST BEARING-TYPE	Ball
24	BRKWY. TORQ. DRVN. EQUIP.		BEARING SERVICE-~~HR.~~ Yrs.	25 Average
25	OVERSIZE COND. BOX	Max. Oversize	NORMAL BRG. OPER. TEMP-C	185°
26	COND. BOX LOCATION*		NET WEIGHT-LB.	
27	SPACE HEATERS, VOLTAGE, PHASE	None	OIL COOL. SYS. REQ'D	
28	SPLIT END BELLS		BRG. OIL PRESS. RANGE, PSI	
29	TERMINAL LUGS, TYPE		BRG. OIL REQ'D EA. BRG. GPM	
30	STATOR HIGH TEMP DEVICE		NAME PLATE CODE LETTER	F
31	ADJUSTABLE SLIDE RAILS		PERMISSIBLE STARTS PER HR:	
32	SOLEPLATES		MOTOR AT AMBIENT TEMP	4
33	PROJECT ELEV., FT.		MOTOR AT RATED TOTAL TEMP	2
34	SHAFT (HOLLOW, SOLID)		TYPE SEALED INSUL. SYS.	Thermalastic Expoxy
35	COUPLING (SELF-RELEASE)		DESCRIPTION OF INSUL. SYS.	
36	SOLID, NONREVERSING		Torque-Speed Curves	
37	ADJUSTABLE, FLEXIBLE		Motor Outline Dwg.	
38	VERT. MAX DOWNTHRUST		Speed Torque #557933	
39	VERT. MAX UPTHRUST			
40	VERT. MIN UPTHRUST			
41	VERT. MIN DOWNTHRUST			
42	(WITH MOTOR RUNNING)			
43	SIDE THRUST			
44	MAX REVERSE SPEED		NOTE: Attention S. Libroth	
45	DRAIN PLUG AND VENT		Westinghouse N.E.S., Penn Center Site shall	
46	AIR INTAKE SCREENS		be on the manufacturer's distribution list	
47			for Motor Outline Drawings and Torque Speed	
48			Curves.	
49				
50				
51				
52	REMARKS:		REMARKS:	
53	ALL PERFORMANCE DATA BASED ON NORMAL RATED		ALL PERFORMANCE DATA BASED ON NORMAL RATED	
54	VOLTAGE AND FREQUENCY		VOLTAGE AND FREQUENCY	60 H2
55	ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY		~~INDICATED~~ DATA IS ~~ESTIMATED~~ calculated	
56	* See attached documents			
57				
58				
59				
60	* VIEWED FROM END OPPOSITE COUPLING END			

ATTACHMENT NO. ~~8~~ 9
CALC. NO. 170-DC Rev. 9

SH. 1 OF 5

UNIT 1

MOTOR NAMEPLATE DATA

RESIDUAL HEAT REMOVAL PUMP 1-2

WESTINGHOUSE	LIFE-LINE D
H.P.	400
MODEL	VSWI
FRAME	5010P24
POLES	4
SUPPLY	3 Ø 60 HZ
VOLTS	4000
F.L. AMP	50
RPM	1778
INSUL.	CLASS B
AMB.	40°C
TIME	CONT. 90°C RISE AT 1.15 SERVICE FACTOR
STYLE	69F46532
LOCKED	KVA CODE F
SERIAL	1S-70

RESIDUAL HEAT REMOVAL PUMP 1-1

SAME	
SERIAL	2S-70

ATTACHMENT NO. ~~18~~ 9

CALC. NO. 170-DC, Rev. 9

SH. 2 OF 5

UNIT 2

MOTOR NAMEPLATE DATA

RESIDUAL HEAT REMOVAL PUMP 2-1

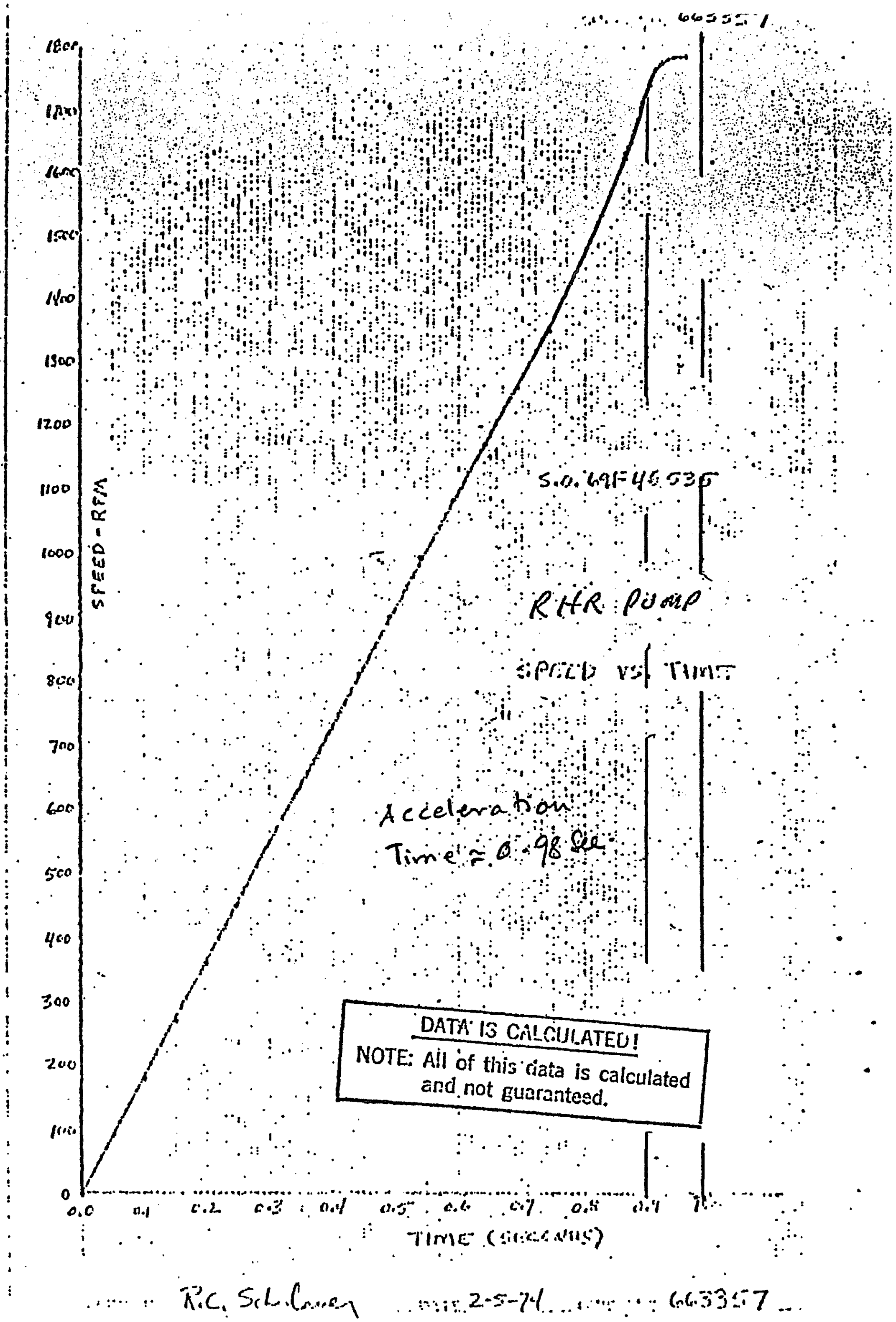
WESTINGHOUSE	LIFE-LINE D
HP	400
MODEL	VSWI
FRAME	5010P24
POLES	4
SUPPLY	3 PH, 60 HZ
VOLTS	4000
F.L. AMPS	50
RPM	1778
INSULATION CLASS	B
AMBIENT	40°C
TIME	CONT. 90°C RISE AT 1.15 SERVICE FACTOR
STYLE	69F46535
LOCKED	KVA CODE F
SERIAL	1S-70

RESIDUAL HEAT REMOVAL PUMP 2-2

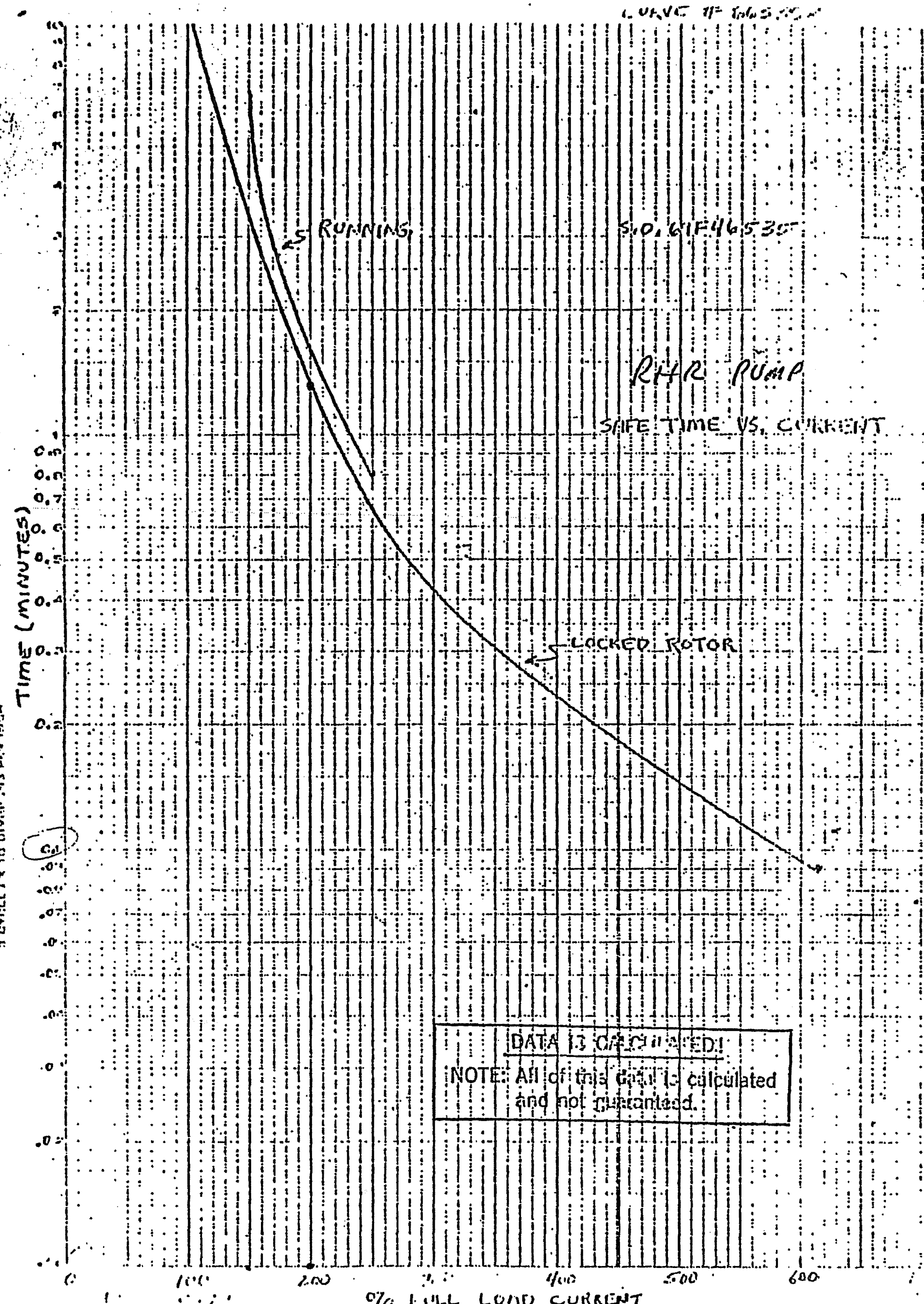
SAME
SERIAL NO. 2S-70

ATTACHMENT NO. ~~18~~ 9
CALC. NO. 170-DC, Rev. 9

SH. 3 OF 5



ATTACHMENT NO. ~~8~~ 9
CALC. NO. 170-DC, Rev. 9



ATTACHMENT NO. ~~15~~ 9

CALC. NO. 170-DC, Rev. 9

SH. 5 OF 5

No.	Item	Value
1	PROJECT	% BIGGE DRAYAGE COMPANY
	S.O. NO.	C-8104-B
2	FURNISHED BY	UNION PUMP COMPANY
	DATE	4-7-72
	BY	
3	MARK OR ITEM NO.	SPIN & PCCCSAPFD & FEGCSAPFD

No.	PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER	
5	SERVICE	COOLANT CHARGE PUMP [illegible]	MAKE	WESTINGHOUSE
6	TYPE	HORIZONTAL INDUCTION	FRAME NO.	506 US
7	NO. OF UNITS	2	HORSEPOWER	(200)
8	MOUNTING	HORIZONTAL - FOOT	SERVICE FACTOR	1.15
9	ELEC. CHARACTERISTICS	4000V. 3 PH 60 CY	FULL LOAD RPM	1737
10	SYNCH. SPEED, RPM	1800	FULL LOAD AMP	27.0
11	HORSEPOWER	200	LOCKED ROTOR AMP	142
12	SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	104
13	ENCLOSURE	OPEN DRIP-PROOF	PULL-OUT TORQUE, % F.L.	234
14	INSULATION CLASS	B	EFF.-FULL LOAD, %	92.2
15	INSULATION TREATMENT	THERMALASTIC EPOXY	EFF.-3/4 LOAD, %	92.4
16	AMBIENT TEMP-C	40	EFF.-1/2 LOAD, %	91.6
17	STATOR TEMP RISE-C	90	P.F.-FULL LOAD, %	86.6
18	BEARING TYPE	SPLIT SLEEVE	P.F.-3/4 LOAD, %	84.0
19	BEARING TEMP RELAY	YES	P.F.-1/2 LOAD, %	76.5*
20	BEARING THERMOCOUPLE	YES	P.F.-LOCKED ROTOR	30.9*
21	HALF COUPL. OR SHEAVE MTD. BY	UNION PUMP CO.	SPACE HTRS., TOTAL WATTS	NONE
22	ROTATION*	CW	RADIAL BEARING-TYPE	SPLIT SLEEVE
23	WK[2] OF DRIVEN EQUIP.	PUMP- 6_ LB.-FT.[2]	THRUST BEARING-TYPE	NA
24	BRKWY. TORQ. DRVN. EQUIP.	(GYROL)-NEGLIGIBLE	BEARING SERVICE-HR.	NA
25	OVERSIZE COND. BOX	NO MAX. OVERSIZE *	NORMAL BRG. OPER. TEMP-C	15° C. RISE ABOVE AM
26	COND. BOX LOCATION*	F-1 (RT. HAND)	NET WEIGHT-LB.	(2000) SEE OUTLINE
27	SPACE HEATERS, VOLTAGE, PHASE	NONE	OIL COOL. SYS. REQ'D	NA
28	SPLIT END BELLS	NO	BRG. OIL PRESS. RANGE, PSI	NA
29	TERMINAL LUGS, TYPE	WESTINGHOUSE STANDARD	BRG. OIL REQ'D EA. BRG. GPM	NA
30	STATOR HIGH TEMP DEVICE	YES	NAME PLATE CODE LETTER	E
31	ADJUSTABLE SLIDE RAILS	NONE	PERMISSIBLE STARTS PER HR:	
32	SOLEPLATES	NONE	MOTOR AT AMBIENT TEMP	4
33	PROJECT ELEV., FT.	BELOW 3,000 FT.	MOTOR AT RATED TOTAL TEMP	2
34	SHAFT (HOLLOW, SOLID)	----	TYPE SEALED INSUL. SYS.	THERMALA
35	COUPLING (SELF-RELEASE)	----	DESCRIPTION OF INSUL. SYS.	THERMALA
36	SOLID, NONREVERSING	----		
37	ADJUSTABLE, FLEXIBLE	----		
38	VERT. MAX DOWNTHRUST	----		
39	VERT. MAX UPTHRUST	----	SPEED TORQUE CURVE JM728	
40	VERT. MIN UPTHRUST	----		
41	VERT. MIN DOWNTHRUST	----		
42	(WITH MOTOR RUNNING)	----		
43	SIDE THRUST	----	DATA IS CALCULATED.	
44	MAX REVERSE SPEED	----		
45	DRAIN PLUG AND VENT	NONE		
46	AIR INTAKE SCREENS	NONE		
47				
48				
49				
50				
51				
52	REMARKS:		REMARKS:	
53	ALL PERFORMANCE DATA BASED ON NORMAL RATED		ALL PERFORMANCE DATA BASED ON NORMAL RATED	
54	VOLTAGE AND FREQUENCY		VOLTAGE AND FREQUENCY	
55	ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY		INDICATE IF DATA IS ESTIMATED	
60	* VIEWED FROM END OPPOSITE COUPLING END			

Deleted Reference

PACIFIC GAS AND ELECTRIC CO.
APPROVED FOR CONSTRUCTION
RECORDED
AUG 1 8 1972
DEPARTMENT OF ENGINEERING

ATTACHMENT NO. ~~15~~ 10
CALC. # 170-DC REV. 9

PG&E
62-3408 (5/77)

SH 2 OF 3

UNIT 1

MOTOR NAMEPLATE DATA

CHARGING PUMP 1-1

WESTINGHOUSE LIFE-LINE B
HP 600
MODEL HSDP
POLES 4, 3PH, 60 HZ
VOLTS 4000
F.L. AMPS 75
RPM 1779
INSULATION CLASS B
AMB. 40°C
FRAME 5808-E
TIME CONT. 80°C RISE AT 1.15 SERVICE FACTOR
STYLE 69F43439
SERIAL NO. 3S-70

CHARGING PUMP 1-2

SAME
SERIAL NO. 4S-70

CHARGING PUMP 1-3

WESTINGHOUSE LIFE-LINE A
HP 200
MODEL ABDP
VOLTS 4000
AMPS 26
RPM 1777
INSULATION CLASS B
MAX. AMB. 40°C
FRAME 506US
SERVICE FACTOR 1.15
LOCKED KVA CODE E
STYLE NO. 70F57575
SERIAL NO. 2S-71

Deleted Reference

ATTACHMENT NO. 10
CALC. # 170-DC
REV # 9

04773 4477

PG&E
62-3408 (5/77)

UNIT 2

MOTOR NAMEPLATE DATA

CHARGING PUMP 2-1

WESTINGHOUSE LIFE-LINE D

HP	600	
MODEL	HSDP	
FRAME	5808Z	CHARGING PUMP 2-2
POLES	4	
SUPPLY	3 ∅, 60 HZ	SAME
VOLTS	4000	SERIAL NO. 2S-70
F.L. AMPS	75	(NAMEPLATE MISSING, DATA
RPM	1779	TAKEN UNDER DRT TEST
INSULATION CLASS	B	ON 9-21-76)
AMBIENT	40°C	
TIME	CONT. 90°C RISE AT 1.15 SERVICE FACTOR	
STYLE	69F43439	
SERIAL NO.	1S-70	
LOCKED KVA CODE	F	

0 4 3 3 0 4 4 7 2

CHARGING PUMP 2-3

WESTINGHOUSE LIFE-LINE A

Deleted Reference

HP	200		
MODEL	ABDP		
FRAME	506US		
POLES	4		
SUPPLY	3 ∅, 60 HZ		
VOLTS	4000	STYLE	70F57575
AMPS	26	SERIAL NO.	1S-71
RPM	1777		
LOCKED KVA CODE	E		
INSULATION CLASS	B		
AMBIENT	40°C		
TIME	CONT. 90°C AT 1.15 SERVICE FACTOR		

ATTACHMENT NO: 10
CALC. NO. 170-DC
Rev. 9

ATTACHMENT # 11 CALC. # 170-DC
SHT. 1 OF 3 Rev. 9

Memorandum

164101

Date: January 17, 1991 File #: 140.124, 128.160

To: NECS - ELECTRICAL ENGINEERING

From: NECS - NUCLEAR SYSTEMS

Subject: Worst Case BHP of Class I Pumps

Ref: 1) Memo, T. P. Lee to NECS Electrical, dated November 14, 1989, CHRON #140288
2) Memo, G. A. Tidrick to NECS Electrical, dated November 1, 1990, CHRON #160228
3) A/R A0211934

PG&E

T. F. FETTERMAN:

The attached Table summarizes the BHP of all Class I pumps under the Nuclear Group's cognizance and supersedes the Table attached to Reference No. 1. This completes our action to provide you with the BHP's of Class I pumps under our cognizance for your verification of overload setpoints.

The BHP of the Containment Spray pump which was not provided in References 1 and 2 are now provided in the attached Table. The BHP of the Safety Injection Pump is revised, as shown in the attached Table, to account for the higher density of fluid from the Refueling Water Storage Tank as discussed in Reference 3.

If you have any questions, please contact Masa Nakao (223-9797) or Kris Narayan (3-9962).

Garry A. Tidrick
GARRY A. TIDRICK

KNarayan(3-9962):jfm

cc:	TRaldwin	333/A7101
	MBasu	333/A9090
	RSBreed	333/A7076
	AKar	333/A9088
	TPLee	333/A7009
	MNakao	333/A7090
	BSmith	333/A9090

ClPmps.BHP

Project: Diablo Canyon Unit ( ) 1 ( ) 2 (✓) 1 & 2

CALC. 170-DC REV. 10.

CALC. NO. M-829
REV. NO. 12
SHEET NO. 2 OF 57

SUBJECT Worst case BHP

ATTACHMENT # 11, SH. 2 of 31

MADE BY KRIS NARAYAN DATE 11-14-89 CHECKED BY [signature] DATE 11/14/89
Rev 1 Kris Narayan 1-15-91 [signature] 1/17/91
Rev 2 [signature] 10-10-95 [signature] 10/17/95

SUMMARY OF RESULTS.

NO.	PUMP	BHP	REFERENCE / COMMENTS
1	RHR PUMP	420	663217-18-1, SH. 1 OF ATT.
2	REACTOR COOLANT PUMP	SEE NOTE 1	663207-40-1, SH. 2,3 OF ATT
3	CENTRIFUGAL CHARGING PUMP	650	663210-110 , SH. 4 OF ATT.
4	BORIC ACID TRANSFER PUMP	13	663210-108-1, SH. 5 OF ATT. RPM 3500
5	MAKEUP WATER SYSTEM PUMP	31	663062-25-1, SH. 6 OF ATT.
6	CONTAINMENT SPRAY PUMP	440	CALC M-71 (Rev 1)
7	SPENT FUEL PUMP	90/75	663211-24-1, SH. 7 OF ATT; 663211-87-1, SH. 8 OF ATT.
8	SAFETY INJECTION PUMP	~~417~~ 434	~~663216-57-1, SH. 9 OF ATT.~~ 663216-86 (via SK-19602-2 of FCT 19602) (SH. 12 of ATT.) (Rev 1)
9	POSITIVE DISPLACEMENT CHARGING PUMP	200	663210-143-10, SH. 10 OF ATT (DATA SHEET OF MOTOR)
10	CHARGING PUMP AUX. LUBE OIL PUMP	2	SEE SHT. 5 OF CALC.

NOTE 1: ACCORDING TO THE REFERENCE THE MAX. INPUT TO MOTOR IS 5900 KW.

DIABLO CANYON POWER PLANT
ELECTRICAL LOAD CHANGE REQUEST FORM (ELCR)

(120Vac, 480Vac, 4.16 & 12KVac)

Requested By: ALEX TELEGIN Date: 4/9/96 DCN/FCT/AT-MM-AR No.: A0 391188 AE03 BLI No.: ——

Unit: 1 Voltage: 4 KV System No.: 08 System Description: Chemical and Volume Control System

ADD OR DELETE	CIRCUIT BKR NO.	EQUIP./ DEV. NO.	DESCRIPTION	LOAD (SPECIFY KVA OR HP) CONNECTED	STARTUP	NORMAL	OUTAGE	LOCA	REFERENCE DRAWING NOS.
Add	52HG9	Reactor Charging pp. (Centrifugal)	CCP 1-2		~~460~~	460 HP	620 HP	620 HP	663210-273

NOTES:
1. FOR MOTOR LOADS, COMPLETE THE ATTACHED MOTOR DATA SHEET.
2. SUBMIT DCN COVER PAGE, SCHEMATIC/SINGLE LINE DIAG. & OTHER APPLICABLE DRAWINGS INCLUDING VENDOR DRAWINGS.

ADDITIONAL COMMENTS AND BRIEF DESCRIPTION OF OPERATION

Station Black-Out: CCP 1-2 worst case BHP is 460 hp.

FOR LOAD TABULATION PERSONNEL ONLY DATE RECEIVED: 4/9/96 ELCR NO.: 4KVAC-6

CALCULATION REVISION REQUIRED? (X) YES ( ) NO SEE SHEET 2 FOR DETAILED REVIEW. *: The existing calculation 96-DC, Rev 11 uses 650 HP as the worst case BHP for CCP 1-2.

APPLICABLE CALCULATION NO.: 96-DC

APPROVED: (X) YES ( ) NO RESPONSIBLE SYSTEM ENGINEER [signature] DATE: 4/9/96

GRP LEADER: N/A DATE: / / DIRECTOR: ____ DATE: / /

ELCR INCORPORATED IN CALC. NO.: ____ REV. NO.: ____ BY: ____ DATE: / /

CALC # 170-DC
REV. 11
ATTACHMENT No. 11
SH. 3 of 3

[redacted]

151424

Date: May 22, 1990 **File #:** 116.30, 119.51, 140.063

To: T. F. Fetterman

From: R. B. Clark

Subject: Maximum Break Horsepower

CALC. NO. 170-DC
REV. NO. ~~8~~ 9
ATTACHMENT ~~29~~ 12
SHT. 1 of 1

T. F. Fetterman:

In response to your letter regarding the device setpoint calculation, dated September 25, 1989, we completed the requested worst case brake horsepower review. The results of the review for the AFW, CCW, and ASW system pumps are included in the table below.

Equip. Tag	Equipment Description	Max. Brk. H.P	Reference
AFWP2	Aux. Feedwater Pump	600hp	Calc. M-854
AFWP3	Aux. Feedwater Pump	600hp	Calc. M-854
CCWAP1	CCW Aux Lube Oil Pump	0.2hp	Calc. M-854
CCWAP2	CCW Aux Lube Oil Pump	0.2hp	Calc. M-854
CCWAP3	CCW Aux Lube Oil Pump	0.2hp	Calc. M-854
CCWP1	Component Cooling Water Pump	435hp	Calc. M-854
CCWP2	Component Cooling Water Pump	435hp	Calc. M-854
CCWP3	Component Cooling Water Pump	435hp	Calc. M-854
ASP1	Auxiliary Saltwater Pump	450hp	Calc. M-854
ASP2	Auxiliary Saltwater Pump	450hp	Calc. M-854

SEE ATTACH #13 FOR LATEST BHP FOR ASW PP. (9)

Please contact Usama Farradj at 3-9726 if you have any questions.

R.B. Clark

Rich Clark

DGHowland:wtp

cc:	UAFarradj	333/A7075
	JCKelly	333/A7074
	SNSabharwal	333/A7080
	BDSmith	333/A9090
	KMSweeney	333/A7069
	MRTresler	333/A1409
	RCWebb	333/A1416

ATTACHMENT # 13 CALC# 170-DC
SHT. 1 OF 1 Rev. 9

Memorandum

cc: MXB KAW/AW

AR A0337853 has been initiated to track calculation update. TLT.

219798

PG&E

Date: April 21, 1994

To: NES ELECTRICAL ENGINEERING

From: NES MECHANICAL SYSTEMS

Subject: Brake Horsepower for Auxiliary Saltwater Pumps

NES ELECTRICAL ENGINEERING
APR 22 1994
TFF BMG SEM KAW BKL MJA
MXB JCR LAH PRC RCW CGR
Please Handle Comment Route Prepare Reply Info File
LOG # ______ DUE DATE ______

TOM FETTERMAN:

The intent of this memorandum is to transmit NES Mechanical reanalyses of the normal operation brake horsepower requirement for the Auxiliary Saltwater (ASW) pumps. The content supersedes the information contained in our letter dated April 17, 1991 (Chron # 169378) in regards to the ASW pumps. The results of the reanalyses are provided below:

> Auxiliary Saltwater - 465 BHP
> (References: DC 663030-61-1, Calc. M-854, Rev. 2, Chron memo #216543)

The ASW pump brake horsepower requirement for normal flow conditions, calculated in M-854, Rev. 2, is approximately 450 HP. This value was calculated using a pump performance curve supplied by the pump vendor, which was not test certified for the DCPP ASW pumps.

Verification of the BHP requirements for both normal and maximum flow conditions was performed by ASW motor test data from test procedure TP TB-9409 conducted in February 1994 on all four ASW pumps. The results of these tests indicate that the ASW pumps operate in the range of 440 to 460 HP. As documented in your letter dated February 11, 1994, the test results also indicated the ASW pump motors are capable of operating at a brake horsepower up to 465 HP without exceeding their design limits.

The value of 465 HP is the maximum BHP for the ASW pump motors for the configuration of one ASW pump supplying one or two CCW heat exchangers. This value should be used to update electrical design bases documents.

Jorge R. del Mazo

JORGE R. DEL MAZO

KSSmith(3-9779):agf

cc:	MDare	DCPP/104/4/47C	CPRhodes	333/A7005
	BMGrosse	333/A9073	DWright	DCPP/116/2
	JCKelly	333/A7076		

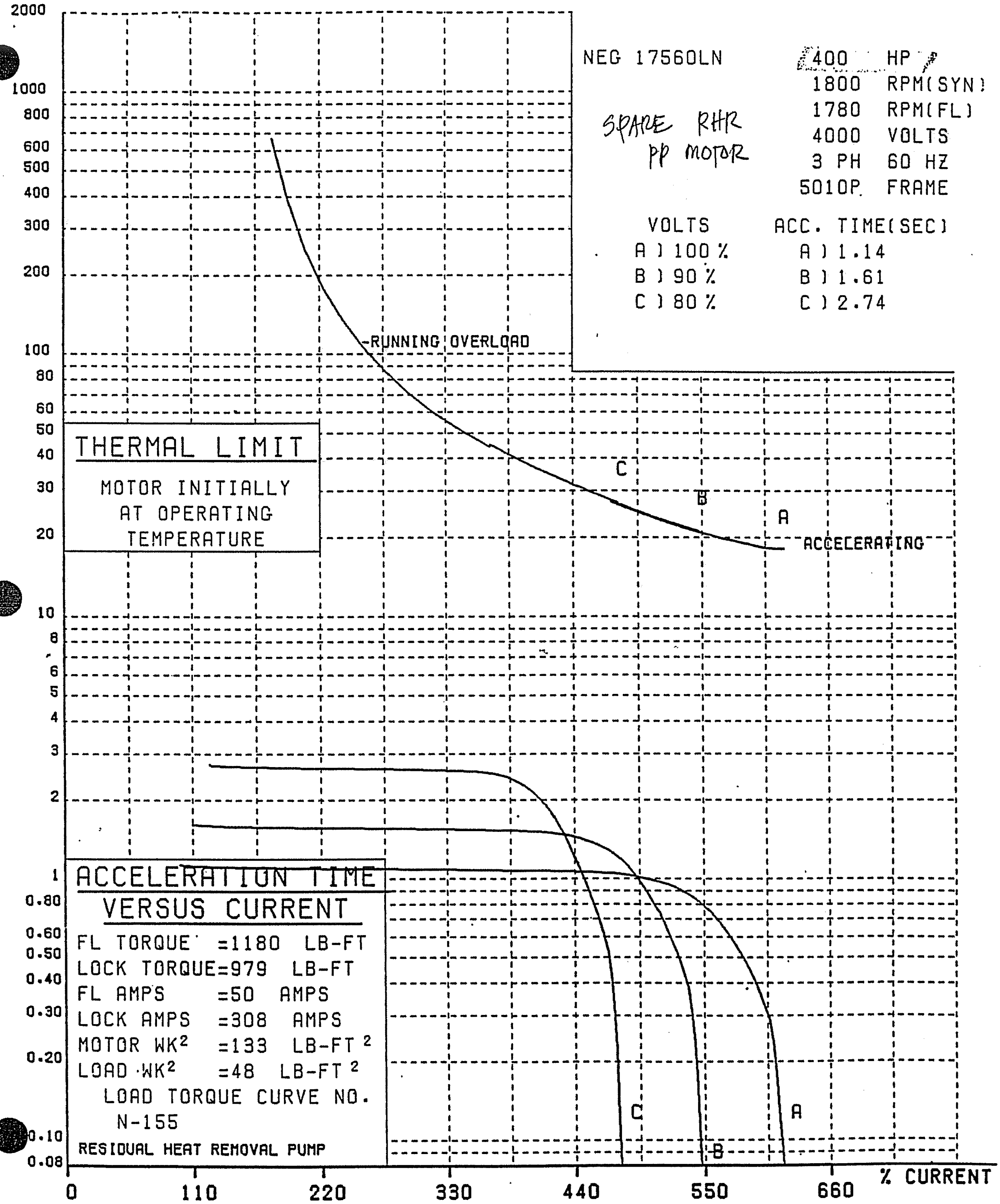
ATTACHMENT # 14 CALC # 170-DC, Rev. 9

SHT. 3 1 OF 42 | 15

SPARE RHR PUMP MOTOR (WH)

TIME - CURRENT AND THERMAL LIMIT CURVES

CUSTOMER: NSD/PACIFIC GAS & ELECTRIC ENGINEER: NGO



WESTINGHOUSE MOTOR COMPANY ROUND ROCK, TEXAS

SIGNATURE: [signature] DATE: 4/24/92 CURVE NO. KN022092

ATTACHMENT # 14

CALC# 170-DC Rev. 9

SHT 2 of 2

SPARE RHR PP MOTOR (WH)

DATE - DECEMBER 2 1992

METHOD F PER IEEE STD. 112-1984
PROGRAM HH9702TL, 12/30/86

CUSTOMER WESTINGHOUSE NSD SHOP ORDER 17560LN1
ROTOR SERIAL NO AE1307 STATOR SERIAL NO AC5217
FRAME 5010P24 TYPE INDUCTION HORSEPOWER 400.
VOLTAGE 4000. SYN SPEED 1800. RATED SPEED 1780. FREQ. 60.

SOLUTION OF EQUIVALENT CIRCUIT

PULOAD	0.25	0.50	0.75	1.00	1.25	1.50	2.84
SLIP	0.00264	0.00530	0.00810	0.01111	0.01441	0.01813	0.07439
R2	0.5181	0.5181	0.5181	0.5181	0.5181	0.5181	0.5181
R2/S	196.0980	97.7530	63.9366	46.6327	35.9652	28.5859	6.9653
X2	3.968	3.968	3.968	3.968	3.968	3.968	3.150
Z2SQ	38470.19	9571.39	4103.63	2190.35	1309.24	832.90	58.44
G2	0.00510	0.01021	0.01558	0.02129	0.02747	0.03432	0.11919
GFE	0.00026	0.00026	0.00026	0.00026	0.00026	0.00026	0.00026
G	0.0054	0.0105	0.0158	0.0216	0.0277	0.0346	0.1194
-B2	0.000103	0.000415	0.000967	0.001812	0.003031	0.004764	0.053905
BM	0.00419	0.00419	0.00419	0.00419	0.00419	0.00419	0.00419
-B	0.00430	0.00461	0.00516	0.00600	0.00722	0.00896	0.05810
YSQ	0.000047	0.000131	0.000278	0.000500	0.000821	0.001276	0.017643
RG	113.5992	79.9949	57.0709	43.0590	33.7691	27.0989	6.7702
R1	0.8932	0.8932	0.8932	0.8932	0.8932	0.8932	0.8932
R	114.4924	80.8881	57.9641	43.9523	34.6623	27.9921	7.6634
XG	91.0843	35.1914	18.5901	11.9977	8.7970	7.0193	3.2929
X1	4.7335	4.7335	4.7335	4.7335	4.7335	4.7335	3.7576
X	95.8178	39.9249	23.3236	16.7312	13.5305	11.7528	7.0505
Z	149.2969	90.2047	62.4806	47.0291	37.2095	30.3593	10.4133
I1	15.	26.	37.	49. ←	62.	76.	222.
I2	11.	23.	35.	47.	60.	74.	218.
INPUT KW	82.19	159.05	237.57	317.96	400.56	485.93	1130.74
SEC. KW	77.58	153.38	230.06	307.73	386.57	466.88	996.76
PRIM I2R KW	0.64	1.76	3.66	6.46	10.32	15.51	131.80
CORE LOSS KW	3.97	3.92	3.85	3.77	3.67	3.55	2.18
SEC I2R KW	0.20	0.81	1.86	3.42	5.57	8.46	74.15
F+W LOSS KW	2.57	2.57	2.57	2.57	2.57	2.57	2.57
WLL KW	0.20	0.79	1.82	3.34	5.44	8.27	72.43
TOTAL KW	7.58	9.85	13.77	19.56	27.57	38.35	283.12
OUTPUT KW	74.60	149.21	223.80	298.40	372.99	447.58	847.61
EFF (%)	90.77	93.81	94.21	93.85	93.12	92.11	74.96
PF (%)	76.69	89.67	92.77	93.46	93.15	92.20	73.59
HP OUTPUT	100.	200.	300.	400.	500.	600.	1136.
SPEED(RPM)	1795.	1790.	1785.	1780.	1774.	1767.	1666.
TORQ,LB-FT	292.7	586.9	882.8	1180.7	1480.8	1783.6	3583.1

PULL OUT TORQUE= 3.03
STATOR I2R = 6.46 NO LOAD STAI2R = 0.20 ROTOR I2R = 3.42
STARTING TORQUE AT RATED VOLTS = 1331. LB FT (112.70 % RUNNING TORQUE)
INRUSH CURRENT AT RATED VOLTS = 327.6 (PER UNIT= 6.55)

WESTINGHOUSE ELECTRIC CORPORATION
Heavy Industry Motor Division
Round Rock, Texas 78664

SPARE SI PUMP MOTOR (WH) **INDUCTION MOTOR DATA**

Shop Order: 17562 LN General Order: MA 49225

Customer: WESTINGHOUSE PITTSBURGH NSID

Rating

HP: 400 Voltage: 4000 Amperes: 51 Service Factor 1.15

Phases: 3 Hertz: 60 F.L. Speed: 3562 RPM

Temp. Rise: 70 °C By 1.15 Insulation Class: F

Frame: 509 Locked KVA Code: F

Performance

Load	S. F.	1.00	0.75	0.50	0.25
% Efficiency	94.0	94.1	94.0	93.1	
% Power Factor	90.4	90.4	89.3	84.9	

Rated Torque: 590 lb.-ft. Starting Torque: 73 %

Breakdown Torque: 274 % Pull-Up Torque: 73 % @ 0 % Speed

Locked Rotor Current: 310 Amps 607 % F. L. Slip: 1.06 %

Circuit Constants

Per Unit on Output KVA Base

Transient Reactance, X'_d: .14565 X/R: ____

Sub-Transient Reactance, X''_d: .14400 PAM Motors Only

Open Circuit Time Constant, T'_{do}: 1.03 Sec Switching Time Delay

Short Circuit Time Constant, T': .0425 Sec Low-to-High Speed: ____ S

Engineer: T. Nguyen Date: 8/3/92

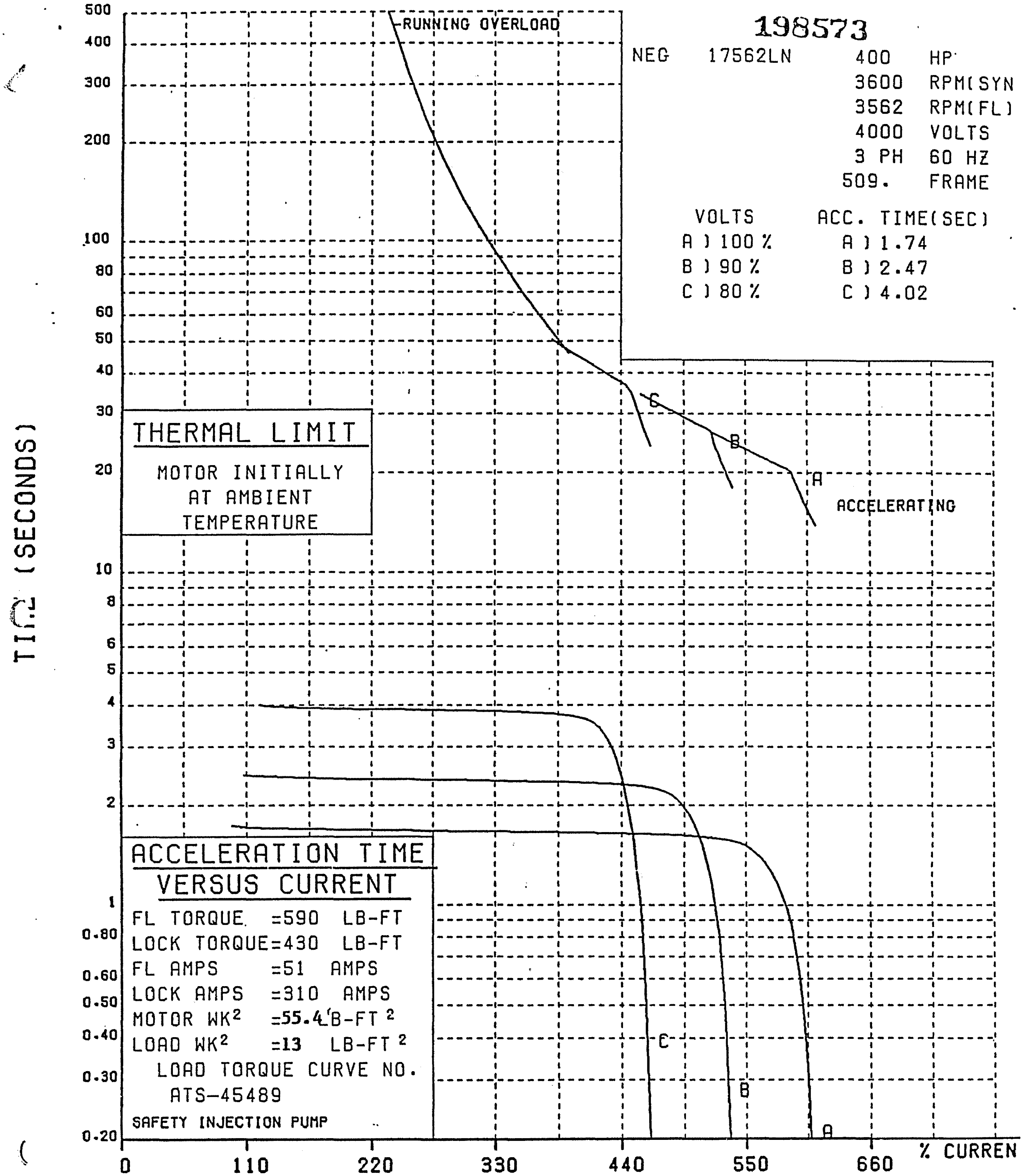
Approval: ____ Revision 01 Date: ____

FORM # HIMD- 297

ATTACHMENT #15 CALC# 170-DC Rev. 9
SPARE SI PUMP MOTOR (WH) sht. ~~5~~ 2 of ~~5~~ 2 /15\

TIME - CURRENT AND THERMAL LIMIT CURVES

CUSTOMER: NSID/PACIFIC GAS & ELEC. ENGINEER: T.NGUYEN



WESTINGHOUSE MOTOR COMPANY ROUND ROCK, TEXAS

SIGNAT T. Nguyen DATE: 9/ 1/92 CURVE NO. C100

ATTACHMENT #16 CALC#170-DC, Rev. 9

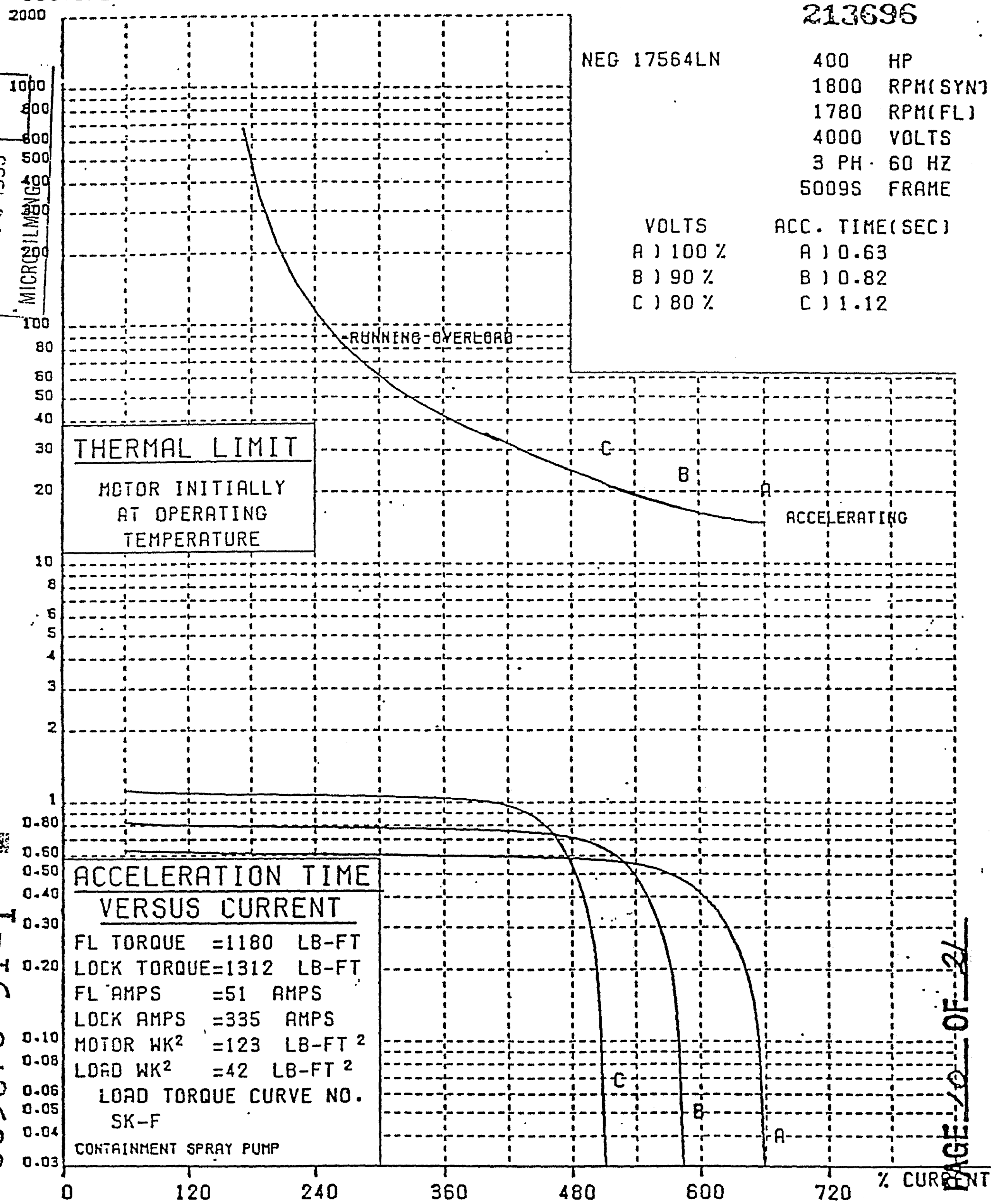
SHT. ~~3~~ 1 of ~~4~~ 2 △15

SPARE CSP MOTOR (WH)

TIME - CURRENT AND THERMAL LIMIT CURVES

CUSTOMER: NSD/PACIFIC GAS & ELECTRIC ENGINEER: NGO

213696



APPROVED FOR MICROFILMING NOV 29 1993

RECORD No. Sh. Ch. 663076-51-1

PAGE 10 OF 21

WESTINGHOUSE MOTOR COMPANY ROUND ROCK, TEXAS

SIGNATURE: [signature] DATE: 5/ 1/92 CURVE NO. KN032792

SPARE - CONTAINMENT SPRAY PP MOTOR (WH)

INDUCTION MOTOR

METHOD F PER IEEE STD. 112-1984
PROGRAM HH9702TL, 12/30/86

CUSTOMER PACIFIC GAS & ELECT. SHOP ORDER 17564LN1
ROTOR SERIAL NO AE1328 STATOR SERIAL NO AC5246
FRAME 5009S TYPE LF HORSEPOWER 400.
VOLTAGE 4000. SYN SPEED 1800. RATED SPEED 1780. FREQ. 60.

SOLUTION OF EQUIVALENT CIRCUIT

PULOAD	0.25	0.50	0.75	1.00	1.25	1.50	3.27
SLIP	0.00266	0.00535	0.00816	0.01111	0.01427	0.01771	0.08924
R2	0.5263	0.5263	0.5263	0.5263	0.5263	0.5263	0.5263
R2/S	197.7217	98.3300	64.5281	47.3675	36.8778	29.7119	5.8977
X2	3.395	3.395	3.395	3.395	3.395	3.395	2.656
Z2SQ	39105.41	9680.32	4175.40	2255.21	1371.50	894.32	41.83
G2	0.00506	0.01016	0.01545	0.02100	0.02689	0.03322	0.14097
GFE	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033	0.00033
G	0.0054	0.0105	0.0158	0.0213	0.0272	0.0336	0.1413
-B2	0.000087	0.000351	0.000813	0.001506	0.002476	0.003797	0.063479
BM	0.00588	0.00588	0.00588	0.00588	0.00588	0.00588	0.00588
-B	0.00597	0.00624	0.00670	0.00739	0.00836	0.00968	0.06936
YSQ	0.000065	0.000149	0.000294	0.000510	0.000811	0.001220	0.024779
RG	83.2923	70.4385	53.6803	41.8477	33.5693	27.5113	5.7027
R1	0.5725	0.5725	0.5725	0.5725	0.5725	0.5725	0.5725
R	83.8647	71.0109	54.2528	42.4202	34.1418	28.0837	6.2751
XG	92.2952	41.8672	22.7742	14.4946	10.3098	7.9373	2.7993
X1	4.1093	4.1093	4.1093	4.1093	4.1093	4.1093	3.2142
X	96.4045	45.9765	26.8836	18.6039	14.4192	12.0466	6.0134
Z	127.7776	84.5955	60.5482	46.3204	37.0618	30.5584	8.6913
I1	18.	27.	38.	50.	62.	76.	266.
I2	11.	23.	34.	46.	59.	72.	261.
INPUT KW	82.18	158.76	236.78	316.34	397.70	481.19	1329.15
SEC. KW	76.58	152.49	229.34	307.20	386.25	466.70	1205.05
PRIM I2R KW	0.56	1.28	2.50	4.27	6.67	9.81	121.25
CORE LOSS KW	5.04	5.00	4.94	4.87	4.78	4.68	2.85
SEC I2R KW	0.20	0.82	1.87	3.41	5.51	8.27	107.54
F+W LOSS KW	1.55	1.55	1.55	1.55	1.55	1.55	1.55
WLL KW	0.23	0.92	2.11	3.84	6.21	9.31	121.11
TOTAL KW	7.58	9.56	12.96	17.94	24.72	33.61	354.29
OUTPUT KW	74.60	149.20	223.81	298.39	372.98	447.58	974.85
EFF (%)	90.77	93.98	94.53	94.33	93.78	93.02	73.34
PF (%)	65.63	83.94	89.60	91.58	92.12	91.90	72.20
HP OUTPUT	100.	200.	300.	400.	500.	600.	1307.
SPEED(RPM)	1795.	1790.	1785.	1780.	1774.	1768.	1639.
TORQ,LB-FT	292.7	586.9	882.9	1180.7	1480.5	1782.8	4188.1

PULL OUT TORQUE= 3.55
STATOR I2R = 4.27 NO LOAD STAI2R = 0.35 ROTOR I2R = 3.41
STARTING TORQUE AT RATED VOLTS = 1682. LB FT (142.44 % RUNNING TORQUE)
INRUSH CURRENT AT RATED VOLTS = 382.3 (PER UNIT= 7.50)

RECORD No. Sh. Ch.

663076-51-1

APPROVED FOR

ATTACHMENT # 17 CALC # 170-DC, Rev. 9

SPARE CCP MOTOR (WH) SHT. ~~*~~ 1 of ~~5~~ 2 15

WESTINGHOUSE ELECTRIC CORPORATION
Heavy Industry Motor Division
Round Rock, Texas 78664

INDUCTION MOTOR DATA

Shop Order: 17563LN General Order: MA 49225

Customer: Pacific Gas & Electric

Rating

HP: 600 Voltage: 4000 Amperes: 75 Service Factor 1.15

Phases: 3 Hertz: 60 F.L. Speed: 1779 RPM

Temp. Rise: 90 °C By Res. @1.15 Insulation Class: F

Frame: 5808 Locked KVA Code: _____

Performance

Load	S. F.	1.00	0.75	0.50	0.25
% Efficiency	93.6	93.8	93.9	93.2	
% Power Factor	91.1	91.5	91.3	88.4	

Rated Torque: 1771 lb.-ft. Starting Torque: 90 %

Breakdown Torque: 230 % Pull-Up Torque: 90 % @ 0 % Speed

Locked Rotor Current: 416 Amps 555 % F. L. Slip: 1.17 %

Circuit Constants

Per Unit on Output KVA Base

Transient Reactance, X'_d: .17854 X/R: _____

Sub-Transient Reactance, X''_d: _____ ~~PAM Motors Only~~

Open Circuit Time Constant, T'_{do}: 1.20 Sec ~~Switching Time Delay~~

Short Circuit Time Constant, T': .0486 Sec ~~Low-to-High Speed:~~ _____ Sec

Engineer: T. Nguyen Date: ~~6/14/92~~ 10/19/92

Approval: _____ Revision ~~01~~ 02 Date: _____

FORM # HIMD-297

RECORD No. Sh. Ch.

DC663210-246-1 Pg. 2

APPROVED FOR JAN 13 1993

ATTACHMENT #17 CALC# 170-DC, Rev. 9

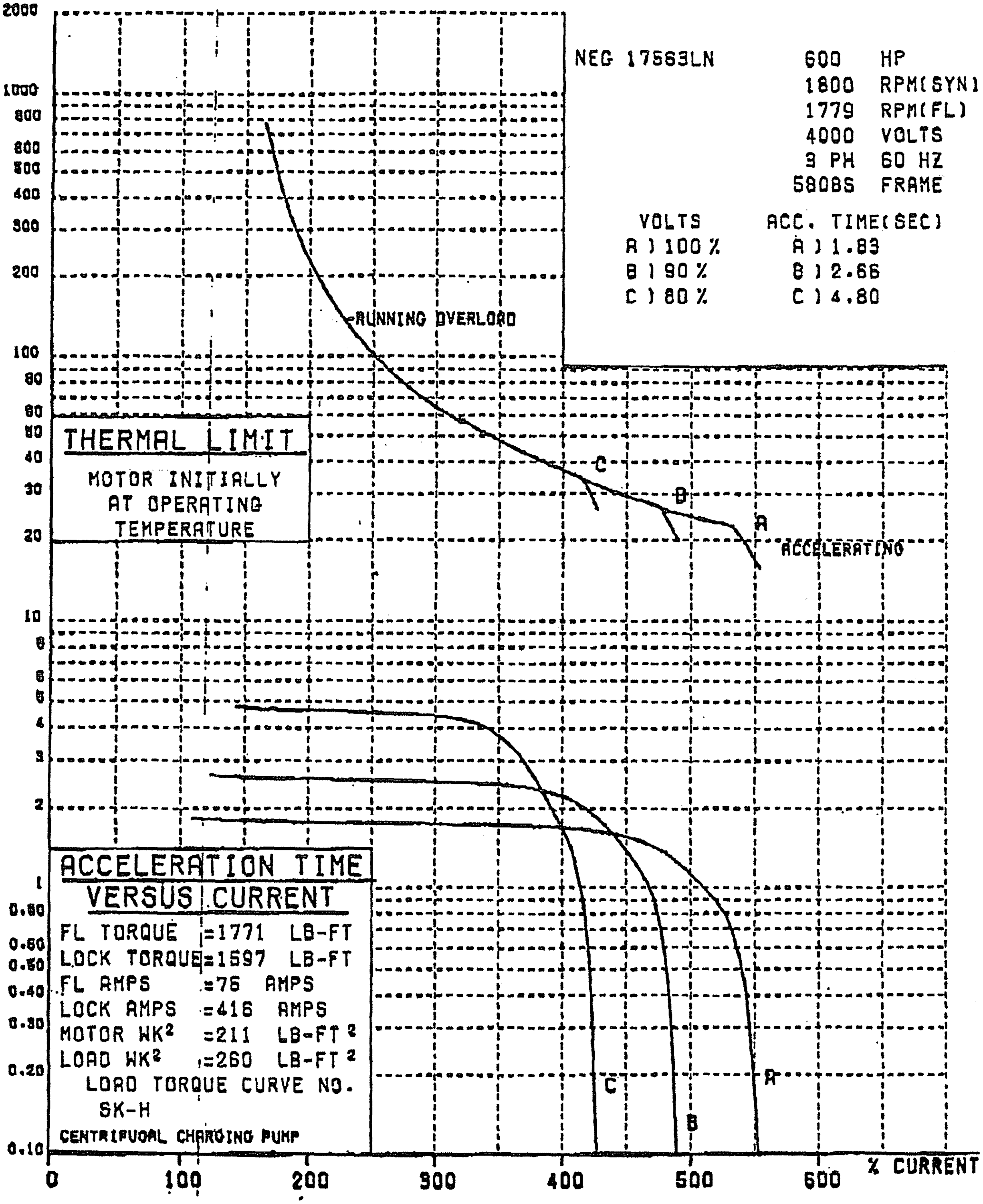
SPARE CCP MOTOR (WH) SHT. ~~5~~ 2 of ~~5~~ 2 (15)

DEC 23 '92 10:40 FROM WRCS MARKETING PAGE.007

512 244 5500 PAGE.004 DEC 22 '92 16:33

TIME - CURRENT AND THERMAL LIMIT CURVES

CUSTOMER: NSID/PACIFIC GAS & ELEC. ENGINEER: T.NGUYEN



DC663210-246-1
Pg 6

WESTINGHOUSE MOTOR COMPANY ROUND ROCK, TEXAS

SIGNATURE: T.Nguyen DATE:12/22/92 CURVE NO. TN121992

12.22.92 03:29 PM * (W) MOTOR COMPANY P04

APPROVED FOR JAN 13 1993

ATTACHMENT # 18

SPARE
ASW MOTOR
(GE)

GENERAL ELECTRIC CO.
COMMERCIAL & INDUSTRIAL MOTOR DEPARTMENT
2000 TAYLOR STREET-FORT WAYNE IN. 46801-2205

15

COMPLETE TEST REPORT
INDUCTION MOTOR

CUSTOMER: GENERAL ELECTRIC CO.
NUCLEAR ENERGY BUS. OP.
175 CURTNER AVE.
SAN JOSE, CA. 95125

TEST REQ NO:...NED-BA-86-145
REPORT NO:.....80DS4089D
DATE OF TEST:..05/03/88
REQN. NO:......205-86F485
COST ORDER NO:.205-86F485
MODEL NO:......5K6511DT8401MHE
SERIAL NO:.....41-5-005

DELETE

NAMEPLATE DATA

RATED HP	:400.0	VOLTS	:4000	AMPERES:	54.2 ←
SERVICE FACTOR	: 1.00	FREQ.(HZ)	: 60	TYPE :	KS
RATED SPEED(RPM)	: 880	PHASE	: 3	FRAME	:L5011VPZ24

CONDITIONS OF TEST

HOURS RUN:	2.0
LINE AMPS:	56.4
COOLING AIR:	25.5 DEG C
SLIP(%):	2.55
VOLTS:	4005
NO LOAD AMPS:	18.8
FREQ.(HZ):	60
HORSEPOWER:	401

TEMPERATURE RISE

STATOR RISE BY RESISTANCE: 75.1 DEG CENT.
RESISTANCE AT 21.7 DEG CENT.: 1.1285 OHMS

RESISTANCE AT SHUT DOWN: 1.5020 OHMS
RESISTANCE AT 120 SEC: 1.4845 OHMS

TORQUE & STARTING CURRENT

LOCKED ROTOR TORQUE: 4218.0 LB. FT. STARTING CURRENT: 321.0 ←
BREAKDOWN TORQUE: 1872.0 LB. FT. AT 2510 V-TEST
BREAKDOWN TORQUE: 4754.0 LB. FT. AT 4000 V-CALC
BREAKDOWN TORQUE: 3043.0 LB. FT. AT 3200 V-CALC

HIGH POTENTIAL TEST 9100 VOLTS FOR 60 SEC.

EFFICIENCIES & POWER FACTOR

				400 HP	460 HP	500 HP
LOAD, PERCENT OF RATED	25	50	75	100	115	125
EFFICIENCY(%)	91.4	93.8	93.9	93.3	92.8	92.3
POWER FACTOR(%)	51.7	72.1	79.8	82.6	83.0	82.9
SPEED (RPM)	896	891	887	881	878	875
LINE CURRENT (AMPS)	23.6	32.6	43.6	56.1	64.3	70.2

DATA FROM TEST ON THIS MOTOR

APPROVED & CERTIFIED BY.......[signature]........ DATE. 5-4-88

ATTACHMENT # 19 CALC #170-DC, Rev. 9
SHT. 1 OF 2

SPARE ASW PUMP MOTOR

WESTINGHOUSE MOTOR COMPANY

VERTICAL INDUCTION MOTOR TEST REPORT PAGE NO. 1

DATE - JUNE 22 1993 GENERAL ORDER NO. -
CUSTOMER - WESTINGHOUSE NSD S.O. - 17561LN1 RETEST

FRAME - 5809P24 TYPE - INDUCTION S.F. - 1.00 H.P. - 450
STATOR NO. - AG5244 ROTOR NO. - AE1284 ENCLOSURE WP1 VOLTS - 4000
POLES - 8 PHASE - 3 HERTZ - 60 AMPS - 60
RPM - 886

STATOR RES. AT 25 DEG C
1.7004
1.7004
1.7014

STATOR CONN - WYE

AIR GAP MEASUREMENTS

```
      * * *                    * * *
0.047*       *0.047   0.047*         *0.047
    *   TOP  *            *  BOTTOM *
    *        *            *         *
    *  0.047 *            *  0.047  *
0.047*       *0.047   0.047*         *0.047
      * * *                    * * *
```

SPECIFIED AIR GAP .046

PHASE ROTATION T3 T2 T1 CCW

PER DRAWING NO. - 5D97103

	HZ	V 1-2	V 2-3	V 3-1	A1	A2	A3	K-WATT
N.LOAD INPUT	60	4001.	4001.	3996.	17.0	16.5	16.4	6.6

VIBRATION DATA DISPLACEMENT - MILS PEAK-TO-PEAK (UNFILTERED)

	TOP BRACKET		BOTTOM BRACKET
H	0.170 MILS	H	0.020 MILS
A	0.060 MILS	A	0.030 MILS

BEARING TEMPERATURE DATA, DEG C - BEARING SENSOR - CUST

TIME	AMBIENT TEMP	TOP BEARING TEMP	BOTTOM BEARING TEMP
1900	26.2	40.5	42.7
1930	26.9	44.2	50.8
2000	27.0	45.3	54.4
2030	26.4	45.8	56.4
2100	26.9	46.0	57.5
2130	27.0	46.6	59.5
2200	26.9	46.6	59.5
2230	26.8	46.3	59.8

FINAL BEARING TEMPERATURES, DEG C -

	TOP	BOTTOM
MEASURED TEMPERATURE (TOTAL)	46.3	59.8
AMBIENT AIR TEMPERATURE	26.8	26.8
TEMPERATURE RISE	19.5	33.0

CUSTOMER - WESTINGHOUSE NSD S.O. - 17561LN1 RETEST

SPARE ASW PUMP MOTOR

INDUCTION MOTOR
METHOD F PER IEEE STD. 112-1984
PROGRAM HH9702TL, 12/30/86

CUSTOMER WESTINGHOUSE NSD SHOP ORDER 17561LN1 RETEST
ROTOR SERIAL NO AE1284 STATOR SERIAL NO AC5244
FRAME 5809P24 TYPE INDUCTION HORSEPOWER 450.
VOLTAGE 4000. SYN SPEED 900. RATED SPEED 886. FREQ. 60.

SOLUTION OF EQUIVALENT CIRCUIT

PULOAD	0.25	0.50	0.75	1.00	1.25	1.50	2.38
SLIP	0.00360	0.00728	0.01122	0.01556	0.02053	0.02658	0.08147
R2	0.6126	0.6126	0.6126	0.6126	0.6126	0.6126	0.6126
R2/S	170.3790	84.2067	54.6187	39.3839	29.8478	23.0464	7.5197
X2	4.536	4.536	4.536	4.536	4.536	4.536	3.639
Z2SQ	29049.58	7111.35	3003.78	1571.67	911.47	551.72	69.79
G2	0.00587	0.01184	0.01818	0.02506	0.03275	0.04177	0.10775
GFE	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
G	0.0061	0.0121	0.0184	0.0253	0.0330	0.0420	0.1080
-B2	0.000156	0.000638	0.001510	0.002886	0.004977	0.008222	0.052142
BM	0.00748	0.00748	0.00748	0.00748	0.00748	0.00748	0.00748
-B	0.00763	0.00812	0.00899	0.01036	0.01245	0.01570	0.05962
YSQ	0.000096	0.000212	0.000421	0.000748	0.001244	0.002013	0.015220
RG	63.9278	57.0130	43.8251	33.8349	26.5249	20.8810	7.0964
R1	0.7684	0.7684	0.7684	0.7684	0.7684	0.7684	0.7684
R	64.6963	57.7815	44.5936	34.6034	27.2933	21.6494	7.8649
XG	79.7613	38.2561	21.3645	13.8535	10.0106	7.8006	3.9172
X1	4.7890	4.7890	4.7890	4.7890	4.7890	4.7890	3.8415
X	84.5502	43.0451	26.1535	18.6425	14.7996	12.5896	7.7587
Z	106.4629	72.0526	51.6971	39.3057	31.0476	25.0439	11.0478
I1	22.	32.	45.	59.	74.	92.	209.
I2	13.	26.	40.	54.	70.	88.	203.
INPUT KW	91.33	178.08	266.97	358.37	453.02	552.29	1031.00
SEC. KW	86.51	172.03	258.76	346.90	436.89	529.47	928.09
PRIM I2R KW	1.08	2.37	4.60	7.96	12.75	19.60	100.73
CORE LOSS KW	3.73	3.68	3.60	3.51	3.38	3.21	2.18
SEC I2R KW	0.31	1.25	2.90	5.40	8.97	14.07	75.61
F+W LOSS KW	2.06	2.06	2.06	2.06	2.06	2.06	2.06
WLL KW	0.22	0.87	2.03	3.77	6.26	9.82	52.75
TOTAL KW	7.40	10.23	15.19	22.68	33.41	48.76	233.34
OUTPUT KW	83.93	167.85	251.78	335.69	419.61	503.52	797.66
EFF (%)	91.89	94.26	94.31	93.67	92.62	91.17	77.37
PF (%)	60.77	80.19	86.26	88.04	87.91	86.45	71.19
HP OUTPUT	113.	225.	338.	450.	562.	675.	1069.
SPEED(RPM)	897.	893.	890.	886.	882.	876.	827.
TORQ,LB-FT	659.1	1323.2	1992.7	2668.4	3352.5	4048.0	6795.8

PULL OUT TORQUE= 2.55
STATOR I2R = 7.96 NO LOAD STAI2R = 0.76 ROTOR I2R = 5.40
STARTING TORQUE AT RATED VOLTS = 2887. LB FT (108.19 % RUNNING TORQUE)
INRUSH CURRENT AT RATED VOLTS = 303.9 (PER UNIT= 5.06)

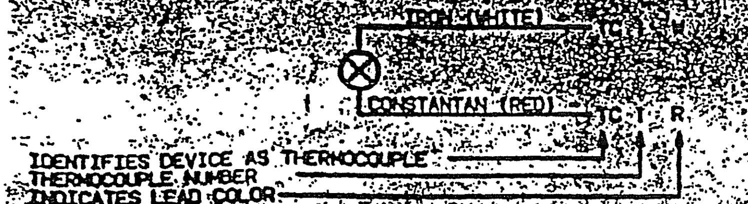
ATTACHMENT # 20 CALC# 170-DC Rev. 9

SHT. 1 of 2

SPARE AFW PUMP MOTOR

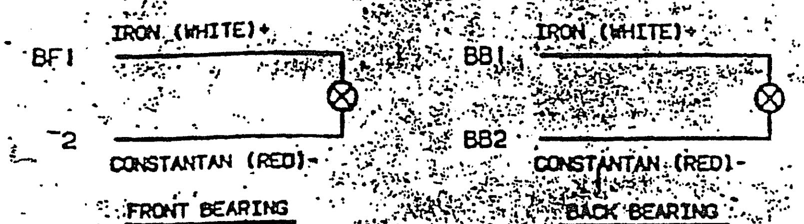
WINDING TEMPERATURE DETECTORS

THERMOCOUPLES ARE SPACED AROUND WINDING SO AS TO PROVIDE TWO (ADJACENT ...) IN EACH PHASE. EACH THERMOCOUPLE HAS ONE WHITE LEAD PLUS ONE RED LEAD.



THERMOCOUPLE NO.	1	2	3	4	5	6
SLOT NO.	3	13	23	33	43	53
PHASE OF WINDING	A	C	B	A	C	B

BEARING TEMPERATURE DETECTOR



TECHNICAL INFORMATION

A.-ENCLOSURE DRIP PROOF

B.-BEARING TYPE AND LUBRICATION SPLIT SLV. BRG. OIL RING LUBRICATED

C.-SCREENS NONE FILTERS NONE

D.-SPACE HEATERS 2 HEATER NO. SEE NOTE #1 RATED AT 120 VOLTS, 135 WATTS TOTAL WATTS 270 CONNECTED FOR OPERATION AT 120 VOLTS.

E.-WINDING TEMPERATURE DETECTORS

(A.)-NUMBER AND TYPE (6) IRON CONSTANTAN THERMOCOUPLES

(B.)-LOCATION EMBEDDED IN SLOTS BETWEEN STATOR COIL SIDES 140

F.-BEARING TEMPERATURE DETECTORS

(A.)-TYPE SEE NOTE #3

(B.)-CONTROL SETTING NORMAL 90 °C, ALARM 95 °C, SHUTDOWN 105 °C

G.-CONDUIT BOX 28.00 X 20.00 X 14.00

H.-PERMISSIBLE CONDUIT BOX ROTATION 4 POSITIONS.

J.-TERMINAL CONNECTORS (SEE NOTE #5

(A.)-FOR MOTOR LEADS T & B "STA-KON"

(B.)-FOR CUSTOMER CABLES SEE SHT. #2

K.-GROUNDING PROVISIONS TWO GRD. PADS ON HSG.

L.-ROTATION CLOCKWISE FACING FRONT END OPPOSITE COUPLING END. (SEE NOTE #4)

M.-SLEEVE BEARING MOTORS

(A.)-LIMITS OF END PLAY .50 MIN. IN.

(B.)-PERMISSIBLE COUPLING END FLOAT .19 MAX IN.

N.-TOTAL WT. 4500 LBS.

ROTOR-SHAFT WT. 975 LBS.

ROTOR INERTIA 140 LB.-FT 2

P.-INSULATION CLASS B "ARMOR COTE"

R.-APPROXIMATE TIME MOTOR CAN WITHSTAND LOCKED ROTOR 20 SECONDS.

S.-PERFORMANCE DATA (TYPICAL)

FULL LOAD AMPS 77

LOCKED ROTOR AMPS 425

LOCKED ROTOR TORQUE 80%

BREAKDOWN TORQUE 200%

LOAD	EFFICIENCY	POWER FACTOR
1/2	.947	.825
3/4	.953	.875
4/4	.952	.885

ADDITIONAL DATA

...ATER: "CHROMALOX" #SSE-1849.

...AINT PPG AQUAPON POLYAMIDE-EPOXY ...H PRIMER.

... CONSTANTAN THERMOCOUPLE ASSEMBLY EACH END. ... SELF-CONTAINED TRA-5 W/P-3 PROCESS CONN. ...2" NPT. CABLE SIZE 3/16" DIA. TR512. IMMERSION ..."A" OF 15 1/4". HOT JUNCTION CLOSED AND ... SPECIALTY - SPRING LOADED ASSEMBLY.

...MOTOR ONLY IN DIRECTION INDICATED.

...EADS INSIDE OF MAIN CONDUIT BOX ARE ...ONGER THAN NORMALLY FURNISHED.

~~ATTACHMENT 30~~ ~~SH 1 of 2.~~

~~CALC NO. 170-DC~~

OUTLINE DRAWING

CUSTOMER PACIFIC GAS & ELECTRIC COMPANY

CUST. ORDER NO. P.O. #711342 REQ. NO. NONE

LOUIS ALLIS MA. NO. AR 6-207374

QTY. 1 TYPE CDGS FRAME SIZE 569 SU

H.P. 600 77 FULL LOAD SPEED 3580 RPM

VOLT 4000 PHASE 3 HERTZ 60

SERVICE FACTOR 1.00

TEMPERATURE RISE 70° C BY RESISTANCE

REMARKS

REVISIONS

DESCRIPTION	DATE	APPROVED

THIS DOCUMENT AND INFORMATION SET FORTH HEREIN ARE THE PROPERTY OF LOUIS ALLIS DIVISION - MAGNETEK INC. ... LOUIS ALLIS DIVISION - MAGNETEK INC.

Louis Allis

PREPARED	ACA 6/5/86	D 01425	AR 6-207374-X
CHECKED	JCW 5/9/86		
APPROVED BY	RAK 6-5-86	SCALE NONE	SHEET 1

ATTACHMENT # 20 CALC # 170-DC Rev. 9

SHT. 2 OF 2

SPARE AFW PUMP MOTOR

CHANGE ORDERS / MWRS	
NUMBER	DATE

VENDOR DEVIATION NUMBER

STATOR DIMENSIONS

Drawing

	V.	H.
Conn. end		
Middle		
Opp. end		

Core length

No. of Slots

Field Center

Slot skew

ROTOR DIMENSIONS

Drawing

V.	H.

Rotor Wt.

Motor Wt.

Rot. on ABC Seq.

Meg. Rdg. 900+

Rel. Hum.

9-10-86

IDLE TEST

	VOLTS	VOLTS	VOLTS	WATTS	WATTS	W1/W2	AMPS	AMPS	AMPS	RPM
	4140	4140	4140		[illegible]		[illegible]	[illegible]	24	3600
	990	990	990		3680		[illegible]	[illegible]	[illegible]	—

WINDING RES.

WDG.	1	2	ROTOR
PH. 1	.59395		
PH. 2	.5994		
PH. 3	.59285		

L.R. 6-178 ROOM TEMP. 25°C

LOCKED TEST

	VOLTS	VOLTS	VOLTS	WATTS	WATTS	W1/W2	AMPS	AMPS	AMPS	
3	985	985	984		38,0[illegible]		105.	107.	106.5	—
2										

TAG. DIAG. \

MIN. START VOLTAGE

SEC. V

BRUSH TENSION

RING 1	RING 2	RING 3
OZ.	OZ.	OZ.
OZ.	OZ.	OZ.

BALANCE

ON RUBBER

WITH ½ KEY

VIB. RDG. 1

VIB. RDG. 2

VIB. RDG. 3

VIB. RDG. 4

VIB. RDG. 5

VIB. RDG. 6

FREON LEAK TEST

CLK. 6

INDICATOR RUNOUT

	FRT.	BK.
FACE		
BORE		
TURN		
SHAFT		

INSP. CLK. 6.

MECHANICAL INSPECTION BEFORE TEST

MOTOR NO. CHECKED

DATE

INLET OIL TEMP. °C.

OIL PSI

FRT. °F BK.

OIL TEMP. OUT

Bearing FRT. 39 °C. Bearing BK. 36 °C.

OIL PTS/MIN.

FRT. BK.

ORD. TEST CRP CH

9000 V. 1 MIN.

PRESS TEST HYDRO.

OK TO FINISH MACH.

BRUSH GRADE

BRAKE TORQUE

NOISE VIB. ELECT.

TESTER DATE

OK'D DATE

ASSEMBLED BY

OK TO CRATE

Insp.

OK TO SHIP

MOTOR SERIAL NO. ARC-207374-001

Design Calculation Checklist

SAP Calc. No.: 9000008518 Part. No.: 16 Version No.: 1
Legacy No.: 170-DC Rev 16A

Item to Verify	Complete (enter N/A if not applicable) Preparer Lan ID	Checker Lan ID
Correct calculation number taken out in SAP - document number, part number, version number.	DEHF	HAM
Originating document is entered in SAP as superior document (e.g., DCP number) and/or on Object Links tab (notification number).	DEHF	HAM
Cover Page		
Calculation number reflects SAP number and Legacy number.	DEHF	HAM
Unit number is entered	DEHF	HAM
Subject clearly stated.	DEHF	HAM
If computer calculation, computer/application/validation information filled in.	DEHF	HAM
Calculation Page Index completed.	DEHF	HAM
Record of Revisions Page		
Rev No., revised pages and reason for revision clearly identified.	DEHF	HAM
Status matches status in SAP (except if it is PI in SAP, status is F here).	DEHF	HAM
Prepared by, checked by and registered professional engineer blocks signed (full signature).	DEHF	HAM
CF3.ID17 block signed if contractor-completed calc.	N/A	N/A
PE stamp block completed.	DEHF	HAM
Calculation Body		
Purpose is clear and includes the requesting document reference (e.g., DCP No).	DEHF	HAM
Background is established clearly so that the reader can understand the situation without going back to the author.	DEHF	HAM
Assumptions are validated or clearly indicated "Preliminary" if verification is required. If preliminary, SAP Notification No.: ______	DEHF	HAM
Inputs validated or clearly indicated "Preliminary" if verification is required. If preliminary, SAP Notification No.: ______	DEHF	HAM
As-built configuration is verified as required (steps 5.3.2d.7 and 5.3.2d.9).	N/A	N/A
Methodology described is concise and clear.	DEHF	HAM
Acceptance criteria provided are clear.	DEHF	HAM
Body of the calculation is clear so that another person can understand the analysis and the logic without going back to the author.	DEHF	HAM
Results provides a precise solution to the stated purpose.	DEHF	HAM

Item to Verify	Complete (enter N/A if not applicable)	
	Preparer Lan ID	Checker Lan ID
Margin assessment includes affect on existing margin (quantitative) or a qualitative assessment.	DEHF	HAM
Margin data recorded using SRM module		N/A
Conclusion includes applicability and limitations.	DEHF	HAM
Impact on other documents is performed (step 5.3.2k).	DEHF	HAM
References are clearly identified as input, output and other references.	DEHF	HAM
Attachments include references not readily retrievable.	DEHF	HAM
All revised pages have the correct calc no, revision/version number (9*xxxx-yyy-zz).	DEHF	HAM
LBIE AD/Screen completed.	N/A	N/A
LBIE evaluation completed, when necessary.	N/A	N/A
Calculation input and output references correctly entered in SAP on Calculation record Object Links tab.	DEHF	HAM
Verification		
Check method A - Independent Review Of Calculation		HAM
Check method B - Alternate Calculation		
• Comparison to a sufficient number of simplified calculations to support the calculation.		N/A
• Comparison to an analysis by an alternate verified method.		
• Comparison to a similar verified calculation.		
• Comparison to test results.		
• Comparison to measured and documented plant data for a comparable design.		
• Comparison to published data and correlation confirmed by industry experience.		
• Other (describe) ______		
Check method C - Critical Point Check		↓
Approval:		
Operations concurrence documented for any operator action(s).	N/A	N/A
Eng director approval to issue design with calc in "Preliminary" status. Ref.: ______	N/A	N/A
Calc Approved/Preliminary has a tracking operation off the closure order and is included on design engineering review requirements. No.: ______	N/A	N/A
PSRC approval if LBIE evaluation is required.	N/A	
PE stamp current for person signing as PE.	DEHF	
Approve as Final.	N/A	

Item to Verify	Complete (enter N/A if not applicable)	
	Preparer Lan ID	Checker Lan ID
Processing Approved Calc:		
Calc status updated in SAP.	DEHF	
Calc Approved/Pending implementation has a tracking operation off the closure order.	N/A	N/A
Working copy of Approved Calculation package is transmitted to document services for filing in Library or if it is not stored in Library, returned to designated storage location.	DEHF	
Copy of the approved revision transmitted to engineering department clerk for transmitting to RMS.	DEHF	

Attachment 2
Calculation 9000041185-1-0, 460 Volt Motors

DCPP Form 69-21593 (02/14/12)

Design Calculation Summary

Block 1: Cover Sheet

Unit(s): 1&2 Legacy No. 357T-DC SAP Calculation No.: 9000041185 Type: E

System No. 64 Responsible Group: EDE Quality Classification: Q

System, Structure,
or Component: Vital 480VAC Motor Thermal Overload Relays

File No.: ____ Binder No: ____ Index No: ____

Subject: 480V Motor & MOV Availability Under Degraded Voltage Condition

Computer/Electronic Calculation: ☐ YES ☒ NO

Computer ID	Application Name and Version	Date of Latest Installation/Validation Test

Working Copy Calculation Page Index

Calculation Package	Contains Pages	No. of Pages
Cover Sheet		1
Signature Sheet		1
Calculation Checklist		1
Calculation Body		9
Attachments	A:1-3, B:1-3, C:1-6, D:1-12, E:1-8, F:1-2	34
Other:		
TOTAL		46

R1

Block 2: Signature Sheet

SAP Calc No. 9000041185 Legacy No. 357T-DC

Part No/Version No	001/00
Status	☒ Final ☐ Superseded ☐ Void ☐ Cancelled ☐ History
Pages Affected	All
Requesting Doc No.	LAR 11-06, DDP 1*803 (U2), DDP 1*429 (U1)
LBIE AD/Screen	☐ Yes ☐ No ☒ N/A *
LBIE Eval	☐ Yes ☐ No ☒ N/A *
Check method*	☒ A = Detailed Check ☐ B = Alternate Method ☐ C = Critical Point Check
PSRC Meeting No	
PSRC Meeting Date	

R1

Prepared By: [signature] / HAM8 Date: 3/22/12
Signature LAN ID

Checked By: [signature] / HPS2 Date: 3/22/12
Signature LAN ID

Registered PE: [signature] / HAM8 Date: 3/22/12
Signature LAN ID

PE Stamp Expiration Date: 12/31/13

Supervisor: Stephen Baker / ~~PLJ6~~ SPB8 Date: 3/22/12
Signature LAN ID SB 3/22/12

Owner's Acceptance
per CF3.ID17: ______ / ______ Date: ______
Signature LAN ID

A. Insert PE stamp or seal below	B. Insert stamp directing to PE stamp or seal
REGISTERED PROFESSIONAL ENGINEER ★ HIGINIO ARIEL MONTOYA ★ E-18248 ★ EXP. 12-31-12 ★ ELECTRICAL ★ STATE OF CALIFORNIA [signature] 3/22/12	

*LBIE Screen covered by DDP 1*803 + DDP 1*429

Block 3: Checklist

Item to Verify	Complete (enter N/A if not applicable)			
	Preparer		Checker	
	LAN ID	Initials	LAN ID	Initials
SAP Entry: Calc number, part number, version number, legacy number, superior document or Reason for calc field on addl data tab	HAM8	HAM	HPS2	HS
Calc Cover Sheet: All applicable field entries complete, computer/application/validation information filled in for computer calculations and working copy calculation page index completed	HAM8	HAM	HPS2	HS
Signature Sheet: Part number, version number, revised pages and reason for revision clearly identified	HAM8	HAM	HPS2	HS
Calculation Body				
Purpose is clear and includes originating document (step 5.3.2a)	HAM8	HAM	HPS2	HS
Background is established clearly (step 5.3.2b)	HAM8	HAM	HPS2	HS
Assumptions are validated or clearly indicated Preliminary if verification is required. SAPN number ____________ (step 5.3.2c)	HAM8.	HAM	HPS2	HS
Inputs are validated or clearly indicated Preliminary if verification is required. SAPN number.____________ (step 5.3.2d)	HAM8	HAM	HPS2	HS
As-Built Configuration is verified, as required (step 5.3.2d.7 and 5.3.2d.10)	HAM8	HAM	HPS2	HS
Methodology described is concise and clear (step 5.3.2e)	HAM8	HAM	HPS2	HS
Acceptance Criteria is clear - developed from design and licensing basis, verified against safety analysis criteria and methodology is consistent with licensing basis (step 5.3.2f)	HAM8	HAM	HPS2	HS
Body of the Calculation is clear regarding analysis and logic for anyone without going back to the author (step 5.3.2g)	HAM8	HAM	HPS2	HS
Results: Provides a precise solution to the stated purpose and provides justification to prepare LBIE for the package (step 5.3.2h)	HAM8	HAM	HPS2	HS
Margin assessment includes quantitative or qualitative assessment on existing margin (step 5.3.2i)	HAM8	HAM	HPS2	HS
Margin data recorded using SRM module (step 5.3.2i.4)	HAM8	HAM	HPS2	HS
Conclusion includes applicability and limitations (step 5.3.2j)	HAM8	HAM	HPS2	HS
Impact on other documents determined (step 5.3.2k)	HAM8	HAM	HPS2	HS
References: Non-retrievable references attached (step 5.3.2l.1) • Linked input, linked output and unlinked other references identified. • Linked references entered on the object links tab (step 5.3.2l.2 and 5.3.2l.3)	HAM8	HAM	HPS2	HS
Attachments for reference only are clearly identified (step 5.3.2m.6)	HAM8	HAM	HPS2	HS
All revised pages have the correct calc number, part number, version number (9*xxxxx-yyy-zz) and legacy number (step 5.2.2e)	HAM8	HAM	HPS2	HS

Design Calculation Template

SAP Calc. No.: 9000041185 Part No.: 001 Version No. 00 Unit: 1 and 2

Legacy No.: 357T-DC

Subject: 480V Motor & MOV Availability Under Degraded Voltage Condition

Table of Contents:

LIST OF ATTACHMENTS

ATTACHMENT NO.	TITLE	NUMBER OF PAGES	
A.	Evaluation of TOL relay heater/FLUR trip time for TMOD 60024240	3	
B.	Evaluation of TOL relay heater/FLUR trip time for DDP 1000000429 & 1000000803.	3	
C.	Evaluation of MODs operability special cases	6	
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Purpose:
The purpose of this engineering calculation is to demonstrate that Thermal Overload (TOL) Relay Heaters for class 1E 460V Motors and MOVs will not trip prior to First Level Under voltage Relay (FLUR) trip during degraded voltage conditions and therefore, will not impact the operability of 460V Motors and MOVs.

Background:
FLUR trip settings were revised under TMOD 60024240 and will be revised again per DDP's 1000000429 (U1) and 1000000803 (U2). This calculation determines that operability of 460V Motors and MOVs is not impacted by these design changes.

Assumptions:
1. Motor Locked Rotor Amps (LRA) are assumed to be 6XNormal Current unless provided by vendor.
2. At 80% (.8*460=368) voltage Motors will start and come to their rated speed & current (see DCM S-64, section 4.3.1.f.2 and PG&E letter to NRC dated 10/3/1977 RLOC 00262-4727).
3. Locked rotor torque values from NEMA standard MG-1 will be used for determining locked rotor torque of motors at degraded voltage conditions. If design class information for motors is not available, then the design class that produces the lower locked rotor torque will be assumed for conservatism. R1

Inputs:
1. Calculation 9*9021(195A-DC), Revision 18, "460V Class 1E Motor Thermal Overload Heater Sizing Calculation"
2. Calculation 9*9093(195B-DC), Revision 20, "Molded Case Circuit Breaker Settings for 460V Class 1E Motors"
3. Calculation 9*33785(366A-DC), Revision 2, "Guidelines for Selecting/Sizing of MCCBs and TOL Relay Heaters"
4. DCM S-64, Revision 11E, "480V System"
5. Procedure AD13.DC1, Revision 35, "Control of the Surveillance Testing Program"
6. National Electrical Manufacturer's Association standard MG1-1998, Revision 2

Methodology:

1. *460V Motors Evaluation:*

    - Per DCM S-64, section 4.3.1.f.2 and RLOC 00262-4727 starting voltage for Motors is 80% of the rated voltage of 460V i.e. 76.6% of 480V Bus. At 80% voltage, motors will accelerate to their rated speed. At rated speed, motors will be at steady state condition. At steady state condition, motor current due to degraded voltage will be 25% higher (1/.8) than at 100% motor voltage, but will not trip TOL relay heater since degraded voltage is limited to 20 seconds or less. Therefore, evaluation at 80% or higher voltage is not required.

      Evaluation for voltages less than 80%(76.6% of 480V) is performed as explained below:

    - In this evaluation all 460V Motors are conservatively considered to be in locked rotor condition for voltages up to 79.9% of 460V i.e. 76.5% of 480V.

    - FLUR trip time used in this evaluation includes instrument uncertainty. Instrument uncertainty for the FLUR trip setting comes from calculation 357R-DC Rev.2 for TMOD conditions and 357S-DC Rev.0 for proposed set-point DDP 1*429.

- Calculate LRA at 60%, 65%, 70%, 72% and 76.5% of 480V.
- Review Time current characteristics (TCC) of TOL relay heaters to determine TOL relay heater trip time based on LRA calculated above. TCC have lower and higher values, conservatively use lower values. TOL relay heater trip time is lower value of TCC curve minus 3 seconds (3 seconds account for faster trip due to hot restart (if any) and coordination margin requirement of 0.4 seconds per DCM T-18).
- Compare the TOL relay heater trip time with FLUR trip time and document results.
- If TOL relay heater trip time is less than FLUR trip time, the following evaluation methods are performed for justifying component availability during a degraded voltage event.
    1. The motor is shown to not be needed during a DBE. R1
    2. A motor that would not be expected to auto start during a DBE would not be in locked rotor conditions during a degraded voltage event. The motor will be evaluated against its running current during degraded voltage.
    3. The motor is shown to accelerate by demonstrating that the reduced locked rotor torque at degraded voltage is greater than the torque necessary to accelerate the load and overcome motor losses.
- See attachments A & B for details.

2. *460V Motors Operated Valves (MOVs) Evaluation:*

Per procedure AD13.DC1, TOL relays are bypassed for the MOVs which are required to AUTO operate during accident scenarios. Attachment 7.8 of the procedure AD13.DC1, lists the TOL relays for MOVs which are bypassed. Since MOVs which are required to operate on AUTO are bypassed, the remaining MOVs are either not required to operate or manual action is required to operate them. Therefore, operability of the MOVs is not challenged by the FLUR design change and no evaluation is required.

Acceptance Criteria:
Trip time for TOL relay heater shall be more then the FLUR trip time during degraded voltage condition.

Body of Calculation:
See attachment A for comparison of TOL relay heater trip with FLUR trip settings established per TMOD number 60024240.

See attachment B for comparison of TOL relay heater trip with FLUR trip settings proposed under DDP 1000000429.

Results:

<u>Evaluation of changes made per T-MOD 60024240:</u>

Review of the attachment A indicates that margin between TOL relay heater trip and FLUR trip time increases as voltage decreases. Review of attachment A indicates that TOL relay heater trip time is greater than FLUR trip time and will not result in loss of equipment function except the following. These exceptions are evaluated below to ascertain the equipment availability.

1. **Component cooling water pump aux lube oil pump motors**
   - 49-1F-44 "1-20-E-MTR-CCWAP1"
   - 49-1H-36 "1-20-E-MTR-CCWAP3"
   - 49-2F-44 "2-20-E-MTR-CCWAP1"
   - 49-2G-41 "2-20-E-MTR-CCWAP2"
   - 49-2H-36 "1-20-E-MTR-CCWAP3"

Review of attachment A indicates that TOL relay heaters for these pumps will not trip prior to FLUR trip for up to 70% of 480V (73% of 460V)and meet the acceptance criteria. Per attachment A, at voltages higher than 73% the TOL relay heater may trip prior to FLUR trip due to high Locked Rotor Amps. However, these pump motors will not be in LRA condition even at 73% voltage as explained below:

The pump motor is rated at 0.5HP with an 1800 RPM synchronous speed. NEMA standard MG-1 does not list a minimum locked rotor torque value for this type of motor. Extrapolating the torque values in NEMA MG-1 Table 12-2, Locked rotor torque for this size of motor can be conservatively assumed to be 225% of running torque. At 73% voltage Locked rotor torque will be $(.73)^2 X225 = 120\%$. Which is more than running torque and fan motor will accelerate at this speed. Motor running current at 73% voltage will be 1.37 Amps (normal current 1.0/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20s. Therefore, degraded voltage will not result in loss of CCW aux lube oil motors and is acceptable. R1

2. **Supply Fans Vital 4KV Swgr Bus F & G**
   - 49-1G-63 "1-23-E-MTR-S-68"
   - 49-2F-36 "2-23-E-MTR-2S-69"

Review of attachment A indicates that TOL relay heaters for these fans will not trip prior to FLUR trip for up to 70% of 480V (73% of 460V) and meet the acceptance criteria. Per attachment A, at voltages higher than 73% the TOL relay heater may trip prior to FLUR trip due to high Locked Rotor Amps. This fan motor will not be in LRA condition even at 73% voltage as explained below:

The fan motor is rated at 1.5HP with an 1800 RPM synchronous speed, design class B. Per NEMA standard MG-1, Locked rotor torque for this size of motor is 250% of running torque. At 73% voltage Locked rotor torque will be $(.73)^2 X250 = 133\%$. Which is more than running torque and fan motor will accelerate at this speed. Motor current at 73% voltage will be 3.01 Amps (normal current 2.2/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20 seconds. Therefore, degraded voltage will not result in loss of 4KV swgr room fans and is acceptable. R1

3. **Spent Fuel Pit Pumps**
   - 49-1G-66 "1-13-E-MTR-SFPP1"
   - 49-1H-47 "1-13-E-MTR-SFPP2"

- 49-2G-66 "2-13-E-MTR-SFPP1"
- 49-2H-79 "2-13-E-MTR-SFPP2"

Spent Fuel Pit Pumps are continuously running and are started manually. Hence these motors would be at running current during a degraded voltage event. Motor current at 73% voltage will be 156 Amps (normal current 114/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20 seconds. Therefore, degraded voltage will not result in loss of Spent Fuel Pit Pumps.

4. Main Feedwater Pump TurbineTurning Gear Motors

- 49-1H-10 "1-03-E-MTR-TG2"
- 49-2F-14 " 2-03-E-MTR-TG1"

These main feedwater pump turbine turning gear motors are Non Class 1E. These motors are not required to start on MFW Pump trip and are required to run before starting MFW pump. These motors are not required to start during Design basis event scenarios.

5. Control Room Compressor Units

- 49-A-4 "1-23-E-MTR-CP-35",
- 49-B-4 "1-23-E-MTR-CP-36",
- 49-D-4 "2-23-E-MTR-CP-37"
- 49-E-4 "2-23-E-MTR-CP-38".

These are control room air conditioning system compressor units. The compressor motors are rated at 50HP with an 1800 RPM synchronous speed. Per attachment F of this calculation, these compressors start 33% loaded and increase load after motor has started. For conservatism these motors are modeled in Attachment A as 25HP motors starting in locked rotor condition. Attachment A shows that for voltages between 70% nominal bus voltage and 76.5% nominal bus voltage, the thermal overload relays do not coordinate with the FLUR undervoltage protection relays if the motor is assumed to be in locked rotor condition during the entire duration. R1

Per NEMA standard MG-1, Locked rotor torque for this size of motor is 150% of running torque. At 73% voltage Locked rotor torque will be $(.73)^2$X150 = 79.9%. This value is less than full load running torque, however the compressors do not start fully loaded as described above and in Attachment F. The compressors start only with 33% of running load. Assuming an additional 17% torque requirement for motor losses, the compressor will still have enough torque to accelerate to rated speed with 29.9% margin. Motor running current at 73% voltage will be 66 Amps (normal current 48/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20 seconds. Therefore, degraded voltage will not result in loss of 4KV swgr room fans and is acceptable.

6. Control Room Ventilation Motor Operated Dampers

- 49-A2-3 "1-23-E-MTR-VAC-1-MOD-1B"
- 49-A2-4 "1-23-E-MTR-VAC-1-MOD-1C"
- 49-B2-3 "1-23-E-MTR-VAC-1-MOD-1"

- 49-B2-4 "1-23-E-MTR-VAC-1-MOD-1A"
- 49-D2-3 "2-23-E-MTR-VAC-2-MOD-1B"
- 49-D2-4 "2-23-E-MTR-VAC-2-MOD-1C"
- 49-E2-3 "2-23-E-MTR-VAC-21-MOD-1"
- 49-E2-4 "2-23-E-MTR-VAC-2-MOD-1A"

These are control room ventilation motor operated dampers each rated at 0.13HP. Review of attachment A indicates that TOL relay heaters for these dampers will not trip prior to FLUR trip for up to 68% of 460V (65% of 460V)and meet the acceptance criteria. Per attachment A, at 73% of 460V (70% of 480V), the TOL relay heater may trip in 8 seconds against FLUR trip of 8.48 seconds due to high Locked Rotor Amps. Per attachment C, these damper motors will not be in Locked Rotor condition at 73% voltage and this voltage is adequate to produce the required torque in closing & opening cycle of these dampers with 74.6% margin. Therefore, degraded voltage will not result in loss of MODs.

7. Control Room Ventilation Motor Operated Dampers

- 49-A1-1 "1-23-E-MTR-VAC-1-MOD-2A"
- 49-A1-2 "1-23-E-MTR-VAC-1-MOD-3A"
- 49-A1-3 "1-23-E-MTR-VAC-1-MOD-7A"
- 49-A1-4 "1-23-E-MTR-VAC-1-MOD-8A"
- 49-B1-1 "1-23-E-MTR-VAC-1-MOD-2"
- 49-B1-2 "1-23-E-MTR-VAC-1-MOD-3"
- 49-B1-3 "1-23-E-MTR-VAC-1-MOD-7"
- 49-B1-4 "1-23-E-MTR-VAC-1-MOD-8"
- 49-E1-1 "2-23-E-MTR-VAC-2-MOD-2"
- 49-E1-2 "2-23-E-MTR-VAC-2-MOD-3"
- 49-E1-3 "2-23-E-MTR-VAC-2-MOD-7"
- 49-E1-4 "2-23-E-MTR-VAC-2-MOD-8"
- 49-D1-1 "2-23-E-MTR-VAC-2-MOD-2A"
- 49-D1-2 "2-23-E-MTR-VAC-2-MOD-3A"
- 49-D1-3 "2-23-E-MTR-VAC-2-MOD-7A"
- 49-D1-4 "2-23-E-MTR-VAC-2-MOD-8A"

These are control room ventilation motor operated dampers each rated at 1.3HP. Review of attachment A indicates that TOL relay heaters for these dampers will not trip prior to FLUR trip for up to 73% of 460V (70% of 480V)and meet the acceptance criteria. Per attachment A, at voltages higher than 73% of 460V (70% of 480V), the TOL relay heater may trip prior to FLUR trip due to high Locked Rotor Amps. Per attachment C, these damper motors will not be in Locked Rotor condition at 73% voltage and this voltage is adequate to produce the required torque in closing &

opening cycle of these dampers with 0.7% margin. Therefore, degraded voltage will not result in loss of MODs.

DDP 1000000429 Changes Evaluation (pending):

Review of the attachment B indicates that margin between TOL relay heater trip and FLUR trip time increases as voltage decreases. Review of attachment B indicates that TOL relay heater trip time is greater than FLUR trip time at voltages up to 70% of 480V and meets the acceptance criteria. At 76.5% of 480V, TOL relay heater trip time is greater than FLUR trip time except the following:

1. Component cooling water pump aux lube oil pump motors

- 49-2F-44 "2-20-E-MTR-CCWAP1"

Review of attachment B indicates that TOL relay heaters for this pump will not trip prior to FLUR trip for up to 70% of 480V (73% of 460V)and meet the acceptance criteria. Per attachment B, at voltages higher than 73% the TOL relay heater may trip prior to FLUR trip due to high Locked Rotor Amps. However, this pump motor will not be in LRA condition even at 73% voltage as explained below:

The pump motor is rated at 0.5HP with an 1800 RPM synchronous speed. NEMA standard MG-1 does not list a minimum locked rotor torque value for this type of motor. Extrapolating the torque values in NEMA MG-1 Table 12-2, Locked rotor torque for this size of motor can be conservatively assumed to be 225% of running torque. At 73% voltage Locked rotor torque will be $(.73)^2$X225 = 120%. Which is more than running torque and fan motor will accelerate at this speed. Motor running current at 73% voltage will be 1.37 Amps (normal current 1.0/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20s. Therefore, degraded voltage will not result in loss of CCW aux lube oil motor and is acceptable. R1

2. Supply Fans Vital 4KV Swgr Bus F & G

- 49-1G-63 "1-23-E-MTR-S-68"

Review of attachment B indicates that TOL relay heaters for these fans will not trip prior to FLUR trip for up to 70% of 480V (73% of 460V) and meet the acceptance criteria. Per attachment A, at voltages higher than 73% the TOL relay heater may trip prior to FLUR trip due to high Locked Rotor Amps. This fan motor will not be in LRA condition even at 73% voltage as explained below:

The fan motor is rated at 1.5HP with an 1800 RPM synchronous speed, design class B. Per NEMA standard MG-1, Locked rotor torque for this size of motor is 250% of running torque. At 73% voltage Locked rotor torque will be $(.73)^2$X250 = 133%. Which is more than running torque and fan motor will accelerate at this speed. Motor current at 73% voltage will be 3.01 Amps (normal current 2.2/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20 seconds. Therefore, degraded voltage will not result in loss of 4KV swgr room fans and is acceptable. R1

3. Spent Fuel Pit Pumps

- 49-1G-66 "1-13-E-MTR-SFPP1"
- 49-1H-47 "1-13-E-MTR-SFPP2"
- 49-2G-66 "2-13-E-MTR-SFPP1"

- 49-2H-79 "2-13-E-MTR-SFPP2"

Spent Fuel Pit Pumps are started manually. Hence any running motors would be at running current during a degraded voltage event. Motor current at 73% voltage will be 156 Amps (normal current 114/0.73). Review of the TOL relay heater curve indicates that TOL relay will not trip in 20 seconds. Therefore, degraded voltage will not result in loss of Spent Fuel Pit Pumps. R1

4. Main Feedwater Pump TurbineTurning Gear Motors

- 49-1H-10 "1-03-E-MTR-TG2"
- 49-2F-14 " 2-03-E-MTR-TG1"

These are main feedwater pump turbine turning gear motors. These motors are not required to start on MFW trip and are required to run before starting MFW pump. These motors are not required to start during Design basis event scenarios.

5. Control Room Ventilation Motor Operated Dampers

- 49-A2-3 "1-23-E-MTR-VAC-1-MOD-1B"
- 49-A2-4 "1-23-E-MTR-VAC-1-MOD-1C"
- 49-B2-3 "1-23-E-MTR-VAC-1-MOD-1"
- 49-B2-4 "1-23-E-MTR-VAC-1-MOD-1A"
- 49-D2-3 "2-23-E-MTR-VAC-2-MOD-1B"
- 49-D2-4 "2-23-E-MTR-VAC-2-MOD-1C"
- 49-E2-3 "2-23-E-MTR-VAC-21-MOD-1"
- 49-E2-4 "2-23-E-MTR-VAC-2-MOD-1A"

These are control room ventilation motor operated dampers each rated at 0.13HP. Review of attachment A indicates that TOL relay heaters for these dampers will not trip prior to FLUR trip for up to 73% of 460V (70% of 480V)and meet the acceptance criteria. Per attachment B, at 79.9% of 460V (76.5% of 480V), the TOL relay heater may trip in 7.5 seconds against FLUR trip of 10 seconds due to high Locked Rotor Amps. Per attachment C, these damper motors will not be in Locked Rotor condition at 79.9% voltage and this voltage is adequate to produce the required torque in closing & opening cycle of these dampers with 109% margin. Therefore, degraded voltage will not result in loss of MODs.

Margin Assessment:

Instrument uncertainty has been conservatively added to FLUR trip time listed in attachments A & B. Margin between TOL relay heater and FLUR trip time for each device is listed in attachments A & B.

Conclusion:
FLUR will trip before TOL relay heaters for Motors & MOVs and will not impact the equipment availability for both TMOD and pending design change.

Impact on other documents:
Per notification 50039118, calculation 366A-DC (9*33785) will be revised to state that TOL relay heater for 480V Motors shall be sized so that it does not trip before FLUR trips under degraded voltage conditions.

Per notification 50467362, DCM T-23 will be revised to incorporate design requirements for ensuring future design of 480VAC thermal overload devices are such that they coordinate with the FLUR undervoltage protection relays. R1

References:

Input References:

i. DCM S-64, Revision 11E, "480V System"

ii. Calculation 9*9021(195A-DC), Revision 18, "460V Class 1E Motor Thermal Overload Heater Sizing Calculation"

iii. Calculation 9*9093(195B-DC), Revision 20, "Molded Case Circuit Breaker Settings for 460V Class 1E Motors"

iv. Calculation 9*33785(366A-DC), Revision 2, "Guidelines for Selecting/Sizing of MCCBs and TOL Relay Heaters"

v. Drawing 437916 Rev. 45 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 1F"

vi. Drawing 437542 Rev. 52 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 1G"

vii. Drawing 437543 Rev. 49 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 1H"

viii. Drawing 441237 Rev. 34 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 2F"

ix. Drawing 441238 Rev. 47 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 2G"

x. Drawing 441239 Rev. 43 "Single Line Meter and Relay Diagram 480 Volt System Bus Section 2H"

Output References:

i. DDP 1*429.

ii. DDP 1*803.

iii. Calc 366A-DC (9*33785).

Other:
None

Attachments:

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SEP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	T T @ V
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19		L	2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	1063			169 AMPS	665.5	721.0	776.5	848.6	28	25	21	18	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	70		H	9.8 AMPS	43.8	47.5	51.1	55.9	24	21	19	16	5.76	6.83	8.48	12.79	YES	Y
		460 VOLT	10.8	**		2.2 AMPS	6.8	7.3	7.9	8.6	63	49	42	35	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	12.6	*	M	2.1 AMPS	7.9	8.5	9.2	10.1	30	27	25	21	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	145		G	18.5 AMPS	90.8	98.3	105.9	115.7	21	19	16	15	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	12.4			2.2 AMPS	7.8	8.4	9.1	9.9	30	26	23	20	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	7		H	0.97 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	1410		F	220 AMPS	882.8	956.3	1029.9	1125.5	77	62	52	47	5.76	6.83	8.48	12.79	YES	Y
P	7.5 HP	460 VOLT	106		F	17.6 AMPS	66.4	71.9	77.4	84.6	36	32	28	26	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	69	*		11.5 AMP	43.2	46.8	50.4	55.1	39	36	29	27	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	23			3.1 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	528			88 AMPS	330.6	358.1	385.7	421.5	31	27	24	21	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	. 2113		F	330 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
P	7.5 HP	460 VOLT	106		F	17.7 AMPS	66.4	71.9	77.4	84.6	32	27	24	22	5.76	6.83	8.48	12.79	YES	Y
IP		460 VOLT	75	*		12.5 AMPS	47.0	50.9	54.8	59.9	37	32	28	25	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	423		F	72 AMPS	264.8	286.9	309.0	337.7	37	32	28	24	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	177		F	32.0 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	16.5	*		2.75 AMPS	10.3	11.2	12.1	13.2	51	43	39	32	5.76	6.83	8.48	12.79	YES	Y
		460 VOLT	43			6.8 AMPS	26.9	29.2	31.4	34.3	27	23	21	17	5.76	6.83	8.48	12.79	YES	Y
	.5 HP	460 VOLT	5.82	*		.97 AMPS	3.6	3.9	4.3	4.6	26	22	19	16	5.76	6.83	8.48	12.79	YES	Y
	15 HP	460 VOLT	109.8	*	G	18.3 AMPS	68.7	74.5	80.2	87.6	35	31	27	25	5.76	6.83	8.48	12.79	YES	Y
	7.5 HP	460 VOLT	66			9.8 AMPS	41.3	44.8	48.2	52.7	29	22	20	18	5.76	6.83	8.48	12.79	YES	Y
	30 HP	VOLT	218		F	36.5 AMPS	136.5	147.9	159.2	174.0	27	24	20	17	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	20	19	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	20		M	2.2 AMPS	12.5	13.6	14.6	16.0	16	14	11	9	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	19.5			3.1 AMPS	12.2	13.2	14.2	15.6	30	28	26	23	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	423			72 AMPS	264.8	286.9	309.0	337.7	33	28	24	20	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	725		F	114 AMPS	453.9	491.7	529.6	578.7	13	11	10	8.5	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	2113		F	335 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	1410	A*	F	221 AMPS	882.8	956.3	1029.9	1125.5	77	62	52	47	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	211		F	36 AMPS	132.1	143.1	154.1	168.4	32	24	22	18	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	177			32 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19			1.9 AMPS	11.9	12.9	13.9	15.2	11	9.5	8	7	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	23	20	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	7		H	0.97 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	12.6	*	M	2.1 AMPS	7.9	8.5	9.2	10.1	27	25	23	21	5.76	6.83	8.48	12.79	YES	Y
	75 HP	VAC VOLT	526		G	91 AMPS	329.3	356.8	384.2	419.9	15	13	11.5	10	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	1063			169 AMPS	665.5	721.0	776.5	848.6	28	25	21	18	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	58.8	*	H	9.8 AMPS	36.8	39.9	42.9	46.9	38	35	29	27	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	40			6.4 AMPS	25.0	27.1	29.2	31.9	30	27	23	21	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	528		F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	5.76	6.83	8.48	12.79	YES	Y
HP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	5.76	6.83	8.48	12.79	YES	Y

SEP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	T T @ V
IP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	528	*	F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	5.76	6.83	8.48	12.79	YES	Y
IP	HP	460 VOLT	1057			169 AMPS	661.8	716.9	772.1	843.8	27	25	21	18	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	19			1.9 AMPS	11.9	12.9	13.9	15.2	11	9	7	6	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	62			9.8 AMPS	38.8	42.1	45.3	49.5	32	26	22	21	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	19			2.4 AMPS	11.9	12.9	13.9	15.2	17	16	14	12	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	100.8	*	G	16.8 AMPS	63.1	68.4	73.6	80.5	33	30	26	22	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	20	19	5.76	6.83	8.48	12.79	YES	Y
P	HP	460 VOLT	7		H	1 AMPS	4.4	4.7	5.1	5.6	14	13	10.5	9.5	5.76	6.83	8.48	12.79	YES	Y
P	7.5 HP	460 VOLT	105.6	*	F	17.6 AMPS	66.1	71.6	77.1	84.3	36	32	28	26	5.76	6.83	8.48	12.79	YES	Y
IP		460 VOLT	69	*		11.5AMPS	43.2	46.8	50.4	55.1	37	32	26	23	5.76	6.83	8.48	12.79	YES	Y
	HP	460 VOLT	23			3.1 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	Y
HP	100 HP	460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	Y
P	7.5 HP	460 VOLT	106		F	18 AMPS	66.4	71.9	77.4	84.6	36	32	28	26	5.76	6.83	8.48	12.79	YES	Y
IP		460 VOLT	78	*		13 AMPS	48.8	52.9	57.0	62.3	32	28	25	23	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	5.76	6.83	8.48	12.79	YES	
P	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	22	20	5.76	6.83	8.48	12.79	YES	
P	HP	460 VOLT	177		F	32.5 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	17.22	*		5.74 AMPS	10.8	11.7	12.6	13.7	48	41	37	30	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	18.78	*		5.74 AMPS	11.8	12.7	13.7	15.0	42	37	32	29	5.76	6.83	8.48	12.79	YES	
		460 VOLT	43			6.8 AMPS	26.9	29.2	31.4	34.3	27	23	21	17	5.76	6.83	8.48	12.79	YES	
	.5 HP	460 VOLT	7			1.94 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	5.76	6.83	8.48	12.79	YES	
P	HP	460 VOLT	108.6	*	G	18.1 AMPS	68.0	73.7	79.3	86.7	36	31	27	25	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	70			9.8 AMPS	43.8	47.5	51.1	55.9	24	21	19	16	5.76	6.83	8.48	12.79	YES	
	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	21	17	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	14.4	*	K	2.4 AMPS	9.0	9.8	10.5	11.5	31	27	25	22	5.76	6.83	8.48	12.79	YES	
	HP	460 VOLT	23		L	3.2 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	423			72 AMPS	264.8	286.9	309.0	337.7	33	28	24	20	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	725			114 AMPS	453.9	491.7	529.6	578.7	13	11	10	8.8	5.76	6.83	8.48	12.79	YES	
HP	100 HP	460 VOLT	2113		F	330 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	177			32.5 AMPS	110.8	120.1	129.3	141.3	34	27	23	21	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	13			1.9 AMPS	8.1	8.8	9.5	10.4	22	19	17	15	5.76	6.83	8.48	12.79	YES	
IP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	22	20	5.76	6.83	8.48	12.79	YES	
	.5 HP	460 VOLT	7			1.94 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	12.6	*	K	2.1 AMPS	7.9	8.5	9.2	10.1	30	27	25	21	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	5.76	6.83	8.48	12.79	YES	
	150 HP	460 VOLT	1038	*	F	173 AMPS	649.9	704.0	758.2	828.6	29	27	23	20	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	64			9.8 AMPS	40.1	43.4	46.7	51.1	28	25	22	20	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	528		F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	5.76	6.83	8.48	12.79	YES	
HP	HP	460 VOLT	526		G	91 AMPS	329.3	356.8	384.2	419.9	15	13	11.5	10	5.76	6.83	8.48	12.79	YES	
P		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	31	27	22	19	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	34	31	27	23	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	9	7	6	5	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	
HP		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	37	31	27	22	5.76	6.83	8.48	12.79	YES	
							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7.5	5.76	6.83	8.48	12.79	YES	

SEP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	TI T @ V
P		460 VOLT	60	*		10 AMPS	37.6	40.7	43.8	47.9	34	31	27	23	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	9	7	6	5	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	32	26	22	20	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y
		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	32	27	22	19	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	33	28	24	21	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	70.2	*	A**	11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	9	7	6	5	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	35	29	25	20	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y
		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	31	27	22	19	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	34	32	27	23	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	5.76	6.83	8.48	12.79	YES	Y
P		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	17	15	12	11	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	37	31	27	22	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	5.76	6.83	8.48	12.79	YES	Y

Notes: 1 - Motor/TOL heater data is taken from SAP, Calc. 195A-DC & 195B-DC.
2. * - Indicates that Motor Locked Rotor Current is assumed as 6XNormal Current.
3. ** - Indicates that Motor Locked Rotor Current in ETAP is used.
4. A*- Indicates that Locked Rotor Amps are assumed to be same as other similar unit o
5. A**- Indicates that data is not available and is assumed to be same as other similar co
6. *** - Control room compressors are listed as 50 HP. Per Attachment F these compressors start at less than 50% loading. Hence for starting conditions the compressor motor will be modelled as 25HP motor and associated locked rotor current will be that of a similar 25HP motor.

EP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	T T @ V
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19		L	2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	1063			169 AMPS	665.5	721.0	776.5	848.6	28	25	21	18	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	70		H	9.8 AMPS	43.8	47.5	51.1	55.9	24	21	19	16	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	10.8	**		2.2 AMPS	6.8	7.3	7.9	8.6	63	49	42	35	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	12.6	*	M	2.1 AMPS	7.9	8.5	9.2	10.1	30	27	25	21	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	145		G	18.5 AMPS	90.8	98.3	105.9	115.7	21	19	16	15	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	12.4			2.2 AMPS	7.8	8.4	9.1	9.9	30	26	23	20	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	7		H	0.97 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	1410		F	220 AMPS	882.8	956.3	1029.9	1125.5	77	62	52	47	4.00	4.00	6.00	10.00	YES	Y
P	7.5 HP	460 VOLT	106		F	17.6 AMPS	66.4	71.9	77.4	84.6	36	32	28	26	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	69	*		11.5 AMP	43.2	46.8	50.4	55.1	39	36	29	27	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	23			3.1 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	528			88 AMPS	330.6	358.1	385.7	421.5	31	27	24	21	4.00	4.00	6.00	10.00	YES	Y
IP	100 HP	460 VOLT	2113		F	330 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
IP	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	7.5 HP	460 VOLT	106		F	17.7 AMPS	66.4	71.9	77.4	84.6	32	27	24	22	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	75	*		12.5 AMPS	47.0	50.9	54.8	59.9	37	32	28	25	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	423		F	72 AMPS	264.8	286.9	309.0	337.7	37	32	28	24	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	177		F	32.0 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	18	15	14	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	16.5	*		2.75 AMPS	10.3	11.2	12.1	13.2	51	43	39	32	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	43			6.8 AMPS	26.9	29.2	31.4	34.3	27	23	21	17	4.00	4.00	6.00	10.00	YES	Y
	.5 HP	460 VOLT	5.82	*		.97 AMPS	3.6	3.9	4.3	4.6	26	22	19	16	4.00	4.00	6.00	10.00	YES	Y
	15 HP	460 VOLT	109.8	*	G	18.3 AMPS	68.7	74.5	80.2	87.6	35	31	27	25	4.00	4.00	6.00	10.00	YES	Y
	7.5 HP	460 VOLT	66			9.8 AMPS	41.3	44.8	48.2	52.7	29	22	20	18	4.00	4.00	6.00	10.00	YES	Y
	30 HP	VOLT	218		F	36.5 AMPS	136.5	147.9	159.2	174.0	27	24	20	17	4.00	4.00	6.00	10.00	YES	Y
'	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	20	19	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	20		M	2.2 AMPS	12.5	13.6	14.6	16.0	16	14	11	9	4.00	4.00	6.00	10.00	YES	Y
'	HP	460 VOLT	19.5			3.1 AMPS	12.2	13.2	14.2	15.6	30	28	26	23	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	423			72 AMPS	264.8	286.9	309.0	337.7	33	28	24	20	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	725		F	114 AMPS	453.9	491.7	529.6	578.7	13	11	10	8.5	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	4.00	4.00	6.00	10.00	YES	Y
HP	100 HP	460 VOLT	2113		F	335 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	1410	A*	F	221 AMPS	882.8	956.3	1029.9	1125.5	77	62	52	47	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	211		F	36 AMPS	132.1	143.1	154.1	168.4	32	24	22	18	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	177			32 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			1.9 AMPS	11.9	12.9	13.9	15.2	11	9.5	8	7	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	23	20	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	7		H	0.97 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	12.6	*	M	2.1 AMPS	7.9	8.5	9.2	10.1	27	25	23	21	4.00	4.00	6.00	10.00	YES	Y
	75 HP	VAC VOLT	526		G	91 AMPS	329.3	356.8	384.2	419.9	15	13	11.5	10	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	1063			169 AMPS	665.5	721.0	776.5	848.6	28	25	21	18	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	58.8	*	H	9.8 AMPS	36.8	39.9	42.9	46.9	38	35	29	27	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	40			6.4 AMPS	25.0	27.1	29.2	31.9	30	27	23	21	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	528		F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	4.00	4.00	6.00	10.00	YES	Y
							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.00	YES	

EP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	TI TF @ VO
P		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	528	*	F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	1057			169 AMPS	661.8	716.9	772.1	843.8	27	25	21	18	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	19			1.9 AMPS	11.9	12.9	13.9	15.2	11	9	7	6	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	62			9.8 AMPS	38.8	42.1	45.3	49.5	32	26	22	21	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.4 AMPS	11.9	12.9	13.9	15.2	17	16	14	12	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	100.8	*	G	16.8 AMPS	63.1	68.4	73.6	80.5	33	30	26	22	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	20	19	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	7		H	1 AMPS	4.4	4.7	5.1	5.6	14	13	10.5	9.5	4.00	4.00	6.00	10.00	YES	Y
	7.5 HP	460 VOLT	105.6	*	F	17.6 AMPS	66.1	71.6	77.1	84.3	36	32	28	26	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	69	*		11.5AMPS	43.2	46.8	50.4	55.1	37	32	26	23	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	23			3.1 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	4.00	4.00	6.00	10.00	YES	Y
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	100 HP	460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	100 HP	460 VOLT	2113		F	333 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	100 HP	460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	7.5 HP	460 VOLT	106		F	18 AMPS	66.4	71.9	77.4	84.6	36	32	28	26	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	78	*		13 AMPS	48.8	52.9	57.0	62.3	32	28	25	23	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	22	20	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	177		F	32.5 AMPS	110.8	120.1	129.3	141.3	37	30	27	24	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	19			2.8 AMPS	11.9	12.9	13.9	15.2	22	19	17	14	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	17.22	*		5.74 AMPS	10.8	11.7	12.6	13.7	48	41	37	30	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	18.78	*		5.74 AMPS	11.8	12.7	13.7	15.0	42	37	32	29	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	43			6.8 AMPS	26.9	29.2	31.4	34.3	27	23	21	17	4.00	4.00	6.00	10.00	YES	Y
	.5 HP	460 VOLT	7			1.94 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	108.6	*	G	18.1 AMPS	68.0	73.7	79.3	86.7	36	31	27	25	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	70			9.8 AMPS	43.8	47.5	51.1	55.9	24	21	19	16	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	12			1.8	7.5	8.1	8.8	9.6	26	24	21	17	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	14.4	*	K	2.4 AMPS	9.0	9.8	10.5	11.5	31	27	25	22	4.00	4.00	6.00	10.00	YES	Y
	HP	460 VOLT	23		L	3.2 AMPS	14.4	15.6	16.8	18.4	25	22	20	17	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	423			72 AMPS	264.8	286.9	309.0	337.7	33	28	24	20	4.00	4.00	6.00	10.00	YES	Y
HP	HP	460 VOLT	725			114 AMPS	453.9	491.7	529.6	578.7	13	11	10	8.8	4.00	4.00	6.00	10.00	YES	Y
HP	100 HP	460 VOLT	2113		F	330 AMPS	1322.9	1433.2	1543.4	1686.7	27	25	23	19	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	1138			208 AMPS	712.5	771.9	831.2	908.4	32	29	26	23	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	177			32.5 AMPS	110.8	120.1	129.3	141.3	34	27	23	21	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	13			1.9 AMPS	8.1	8.8	9.5	10.4	22	19	17	15	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	444	*	F	74 AMPS	278.0	301.1	324.3	354.4	32	26	22	20	4.00	4.00	6.00	10.00	YES	Y
	.5 HP	460 VOLT	7			1.94 AMPS	4.4	4.7	5.1	5.6	17	15	13	11	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	12.6	*	K	2.1 AMPS	7.9	8.5	9.2	10.1	30	27	25	21	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	340		G	60 AMPS	212.9	230.6	248.3	271.4	28	25	23	19	4.00	4.00	6.00	10.00	YES	Y
	150 HP	460 VOLT	1038	*	F	173 AMPS	649.9	704.0	758.2	828.6	29	27	23	20	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	64			9.8 AMPS	40.1	43.4	46.7	51.1	28	25	22	20	4.00	4.00	6.00	10.00	YES	Y
IP	HP	460 VOLT	6.6	*	M	1.1 AMPS	4.1	4.5	4.8	5.3	27	21	15	13	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	528		F	88 AMPS	330.6	358.1	385.7	421.5	34	28	23	21	4.00	4.00	6.00	10.00	YES	Y
P	HP	460 VOLT	526		G	91 AMPS	329.3	356.8	384.2	419.9	15	13	11.5	10	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	31	27	22	19	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	34	31	27	23	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	17	15	12	11	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	37	31	27	22	4.00	4.00	6.00	10.00	YES	Y
						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y

;EP R	HORSE POWER LOW	VOLTAGE	AMPS LOCKED ROTOR		KVA CODE	AMPS HIGH	LRA @60%OF 480V	LRA @65%OF 480V	LRA @70%OF 480V	LRA @76.5%OF 480V	TOL TRIP TIME IN SEC @60% OF 480V	TOL TRIP TIME IN SEC @65% OF 480V	TOL TRIP TIME IN SEC @70% OF 480V	TOL TRIP TIME IN SEC @76.5% OF 480V	FLUR TRIP TIME IN SEC @60% OF 480V	FLUR TRIP TIME IN SEC @65% OF 480V	FLUR TRIP TIME IN SEC @70% OF 480V	FLUR TRIP TIME IN SEC @76.5% OF 480V	TIME >FLUR TRIP TIME @60% VOLTAGE	T T @ V
P		460 VOLT	60	*		10 AMPS	37.6	40.7	43.8	47.9	34	31	27	23	4.00	4.00	6.00	10.00	YES	Y
ɔ		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	4.00	4.00	6.00	10.00	YES	Y
ɔ		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	17	15	12	11	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	32	26	22	20	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	32	27	22	19	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	33	28	24	21	4.00	4.00	6.00	10.00	YES	Y
ɔ		460 VOLT	70.2	*	A**	11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	4.00	4.00	6.00	10.00	YES	Y
ɔ		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	17	15	12	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	35	29	25	20	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y
		460 VOLT	29.7	*		4.95 AMP	18.6	20.1	21.7	23.7	31	27	22	19	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	59.4	*		9.9 AMPS	37.2	40.3	43.4	47.4	34	32	27	23	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	70.2	*		11.7 AMPS	44.0	47.6	51.3	56.0	32	27	24	21	4.00	4.00	6.00	10.00	YES	Y
P		460 VOLT	177	***		48 AMPS	110.8	120.1	129.3	141.3	17	15	12	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	16			2.4 AMPS	10.0	10.9	11.7	12.8	19	16	13	11	4.00	4.00	6.00	10.00	YES	Y
IP		460 VOLT	63	*		10.5 AMPS	39.4	42.7	46.0	50.3	37	31	27	22	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y
HP		460 VOLT	3.5			0.6 AMPS	2.2	2.4	2.6	2.8	11	9.5	8	7.5	4.00	4.00	6.00	10.00	YES	Y

Notes: 1 - Motor/TOL heater data is taken from SAP, Calc. 195A-DC & 195B-DC.

2. * - Indicates that Motor Locked Rotor Current is assumed as 6XNormal Current.

3. ** - Indicates that Motor Locked Rotor Current in ETAP is used.

4. A*- Indicates that Locked Rotor Amps are assumed to be same as other similar unit o

5. A**- Indicates that data is not available and is assumed to be same as other similar co

6. *** - Control room compressors are listed as 50 HP. Per Attachment F these compressors start at less than 50% loading. Hence for starting conditions the compressor motor will be modelled as 25HP motor and associated locked rotor current will be that of a similar 25HP motor.

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CALCULATIONS FOR FISHER BUTTERFLY VALVES
WITH LIMITORQUE OR ROTORK ACTUATOI (VER 5/28/98)

INPUT INFORMATION

==

PG & E VALVE NO.	VAC-1-MOD-1			
VALVE MODEL NO.				
OPERATOR SERIAL NO.				
OPERATOR ORDER NO.				
VALVE MANUFACTURER	PACIFIC AIR			
VALVE NOMINAL SIZE	14		IN	
VALVE TYPE	BUTTERFLY			
VALVE STEM DIAMETER	1		IN	
ACTUATOR MANUFACTURER	LIMITORQUE			
ACTUATOR SIZE	SMB-000			
NOMINAL MOTOR SIZE/High Tem	2		0	FT LBS
MOTOR RPM	1700			
MOTOR TYPE (AC=1, DC=2)		1		
GEAR OPERATOR SIZE	0			
ACTUATOR OVERALL RATIO	23.3		(SMB RATIO)	
APPLICATION FACTOR (Cl/Op)		0.9	0.9	
UNIT PULLOUT EFFICIENCY	0.55		(decimal)	
RUNNING EFFICIENCY	0.6		(decimal)	
STALL EFFICIENCY	0.7		(decimal)	
GEAR OPERATOR RATIO	71		(HBC RATIO)	
HBC EFFICIENCY		0.3	(decimal)	
HANDWHEEL RATIO	1			
HANDWHEEL EFFICIENCY	1		(decimal)	
UNDERVOLTAGE (close/open)		73	73	%
DYNAMIC TORQUE REQD	1		FT LBS	
STATIC TORQUE REQD	150		FT LBS	
VALVE ALLOWABLE TORQUE	400		FT LBS	
SMB TORQUE RATING	90		FT LBS	
HBC OUTPUT TORQUE RATING	445		FT LBS	
DIFFERENTIAL PRESSURE (OP)	1		PSI	
DIFFERENTIAL PRESSURE (CL)	1		PSI	
LINE PRESSURE	1		PSI	
VALVE Cv(100% open)				
SYSTEM FLOW			GPM	
SPRING PACK NUMBER	0101-99			
SPRING PACK TORQUE: @	1.5		LIMIT PLATE	
MAX / MIN	16		12	FT-LBS
OPERATING TIME (DES/ACT)	15		15	SEC
OPENING ANGLE:		90	DEGREES	
VALVE IS SAFETY RELATED (YES=1,NO=2)		1		
DIAGNOSTIC SYSTEM ERROR		10	%	

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VALVE NO VAC-1-MOD-1 CALCULATION RESULTS

	VALVE TORQUE (FT LBS)	SMB TORQUE (FT LBS)	MOTOR TORQUE (FT LBS)	HANDWHEEL TORQUE (FT LBS)
OPERATING TORQUE:				
STATIC GOVERNS	150	7	0.6	7
ALLOWABLE TORQUE:				
LIMITING COMPONENT				
VALVE ASSEMBLY	400	19	1.6	19
SPRING PAK MAX TORQUE	341	16	1.4	16
SPRING PAK MIN TORQUE	256	12	1.0	12
STALL TORQUE	655	31	2.4	31
MAX MOTOR CAPACITY:				
FULL VOLTAGE	491	23	2.0	23
73 % CLOSING	262	12	1.1	12
73 % OPENING	262	12	1.1	12

CALCULATED SMB GEAR RATIO 23.9
MANUFACTURER'S SMB GEAR RATIO 23.3
CALCULATED OPERATING TIME 14.6 SEC
ACTUAL OPERATING TIME 15.0 SEC

HANDWHEEL TURNS FOR DESIGN ROTATI(17.8

STALL REVIEW: STALL PROBLEM W/ VALVE
MARGIN AVAIL (CLOSE/OPEN): 74.6 74.6 %

MIN TORQUE REQD	MAX TST	MAX COAST	
165	360	360	(FT-LBS)

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CALCULATIONS FOR FISHER BUTTERFLY VALVES
WITH LIMITORQUE OR ROTORK ACTUATORS (VER 5/28/98)

INPUT INFORMATION

==

PG & E VALVE NO.	VAC-2-MOD-2A			
VALVE MODEL NO.				
OPERATOR SERIAL NO.				
OPERATOR ORDER NO.				
VALVE MANUFACTURER	PACIFIC AIR			
VALVE NOMINAL SIZE	24	IN		
VALVE TYPE	BUTTERFLY			
VALVE STEM DIAMETER	1.5	IN		
ACTUATOR MANUFACTURER	LIMITORQUE			
ACTUATOR SIZE	SMB-00			
NOMINAL MOTOR SIZE/High Tem	10		0	FT LBS
MOTOR RPM	3400			
MOTOR TYPE (AC=1, DC=2)	1			
GEAR OPERATOR SIZE	1			
ACTUATOR OVERALL RATIO	32	(SMB RATIO)		
APPLICATION FACTOR (Cl/Op)	0.9		0.9	
UNIT PULLOUT EFFICIENCY	0.4	(decimal)		
RUNNING EFFICIENCY	0.6	(decimal)		
STALL EFFICIENCY	0.6	(decimal)		
GEAR OPERATOR RATIO	35	(HBC RATIO)		
HBC EFFICIENCY	0.3	(decimal)		
HANDWHEEL RATIO	4.38			
HANDWHEEL EFFICIENCY	0.95	(decimal)		
UNDERVOLTAGE (close/open)	73		73	%
DYNAMIC TORQUE REQD	1	FT LBS		
STATIC TORQUE REQD	640	FT LBS		
VALVE ALLOWABLE TORQUE	1301	FT LBS		
SMB TORQUE RATING	250	FT LBS		
HBC OUTPUT TORQUE RATING	1300	FT LBS		
DIFFERENTIAL PRESSURE (OP)	1	PSI		
DIFFERENTIAL PRESSURE (CL)	1	PSI		
LINE PRESSURE	1	PSI		
VALVE Cv(100% open)				
SYSTEM FLOW				
SPRING PACK NUMBER	0301-111			
SPRING PACK TORQUE: @	2.5	LIMIT PLATE		
MAX / MIN	123		55	FT-LBS
OPERATING TIME (DES/ACT)	15		5	SEC
OPENING ANGLE:	90	DEGREES		
VALVE IS SAFETY RELATED (YES=1,NO=2)	1			
DIAGNOSTIC SYSTEM ERROR	10	%		

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VALVE NO VAC-2-MOD-2A

CALCULATION RESULTS

	VALVE TORQUE (FT LBS)	SMB TORQUE (FT LBS)	MOTOR TORQUE (FT LBS)	HANDWHEEL TORQUE (FT LBS)
OPERATING TORQUE:				
STATIC GOVERNS	640	61	5.3	15
ALLOWABLE TORQUE:				
LIMITING COMPONENT				
90deg GEARBOX	1300	124	10.7	30
SPRING PAK MAX TORQUE	1292	123	10.7	30
SPRING PAK MIN TORQUE	578	55	4.8	13
STALL TORQUE	1613	154	12.0	37
MAX MOTOR CAPACITY:				
FULL VOLTAGE	1210	115	10.0	28
73 % CLOSING	645	61	5.3	15
73 % OPENING	645	61	5.3	15

CALCULATED SMB GEAR RATIO	32.4	
MANUFACTURER'S SMB GEAR RATIO	32.0	
CALCULATED OPERATING TIME	4.9	SEC
ACTUAL OPERATING TIME	5.0	SEC

HANDWHEEL TURNS FOR DESIGN ROTATIO 38.3

STALL REVIEW: STALL PROBLEM W/ VALVE
MARGIN AVAIL (CLOSE/OPEN): 0.7 0.7 %

MIN TORQUE REQD	MAX TST	MAX COAST	
704	1170	1170	(FT-LBS)

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CALCULATIONS FOR FISHER BUTTERFLY VALVES
WITH LIMITORQUE OR ROTORK ACTUATOI (VER 5/28/98)

INPUT INFORMATION

==

PG & E VALVE NO.	VAC-1-MOD-1			
VALVE MODEL NO.				
OPERATOR SERIAL NO.				
OPERATOR ORDER NO.				
VALVE MANUFACTURER	PACIFIC AIR			
VALVE NOMINAL SIZE	14	IN		
VALVE TYPE	BUTTERFLY			
VALVE STEM DIAMETER	1	IN		
ACTUATOR MANUFACTURER	LIMITORQUE			
ACTUATOR SIZE	SMB-000			
NOMINAL MOTOR SIZE/High Tem	2		0	FT LBS
MOTOR RPM	1700			
MOTOR TYPE (AC=1, DC=2)	1			
GEAR OPERATOR SIZE	0			
ACTUATOR OVERALL RATIO	23.3	(SMB RATIO)		
APPLICATION FACTOR (Cl/Op)	0.9	0.9		
UNIT PULLOUT EFFICIENCY	0.55	(decimal)		
RUNNING EFFICIENCY	0.6	(decimal)		
STALL EFFICIENCY	0.7	(decimal)		
GEAR OPERATOR RATIO	71	(HBC RATIO)		
HBC EFFICIENCY	0.3	(decimal)		
HANDWHEEL RATIO	1			
HANDWHEEL EFFICIENCY	1	(decimal)		
UNDERVOLTAGE (close/open)	79.9	79.9	%	
DYNAMIC TORQUE REQD	1	FT LBS		
STATIC TORQUE REQD	150	FT LBS		
VALVE ALLOWABLE TORQUE	400	FT LBS		
SMB TORQUE RATING	90	FT LBS		
HBC OUTPUT TORQUE RATING	445	FT LBS		
DIFFERENTIAL PRESSURE (OP)	1	PSI		
DIFFERENTIAL PRESSURE (CL)	1	PSI		
LINE PRESSURE	1	PSI		
VALVE Cv(100% open)				
SYSTEM FLOW		GPM		
SPRING PACK NUMBER	0101-99			
SPRING PACK TORQUE: @	1.5	LIMIT PLATE		
MAX / MIN	16	12	FT-LBS	
OPERATING TIME (DES/ACT)	15	15	SEC	
OPENING ANGLE:	90	DEGREES		
VALVE IS SAFETY RELATED (YES=1,NO=2)	1			
DIAGNOSTIC SYSTEM ERROR	10	%		

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VALVE NO VAC-1-MOD-1

CALCULATION RESULTS

	VALVE TORQUE (FT LBS)	SMB TORQUE (FT LBS)	MOTOR TORQUE (FT LBS)	HANDWHEEL TORQUE (FT LBS)
OPERATING TORQUE:				
STATIC GOVERNS	150	7	0.6	7
ALLOWABLE TORQUE:				
LIMITING COMPONENT				
VALVE ASSEMBLY	400	19	1.6	19
SPRING PAK MAX TORQUE	341	16	1.4	16
SPRING PAK MIN TORQUE	256	12	1.0	12
STALL TORQUE	655	31	2.4	31
MAX MOTOR CAPACITY:				
FULL VOLTAGE	491	23	2.0	23
79.9 % CLOSING	314	15	1.3	15
79.9 % OPENING	314	15	1.3	15

CALCULATED SMB GEAR RATIO	23.9	
MANUFACTURER'S SMB GEAR RATIO	23.3	
CALCULATED OPERATING TIME	14.6	SEC
ACTUAL OPERATING TIME	15.0	SEC

HANDWHEEL TURNS FOR DESIGN ROTATI(17.8

STALL REVIEW: STALL PROBLEM W/ VALVE
MARGIN AVAIL (CLOSE/OPEN): 109.1 109.1 %

MIN TORQUE REQD	MAX TST	MAX COAST	
165	360	360	(FT-LBS)

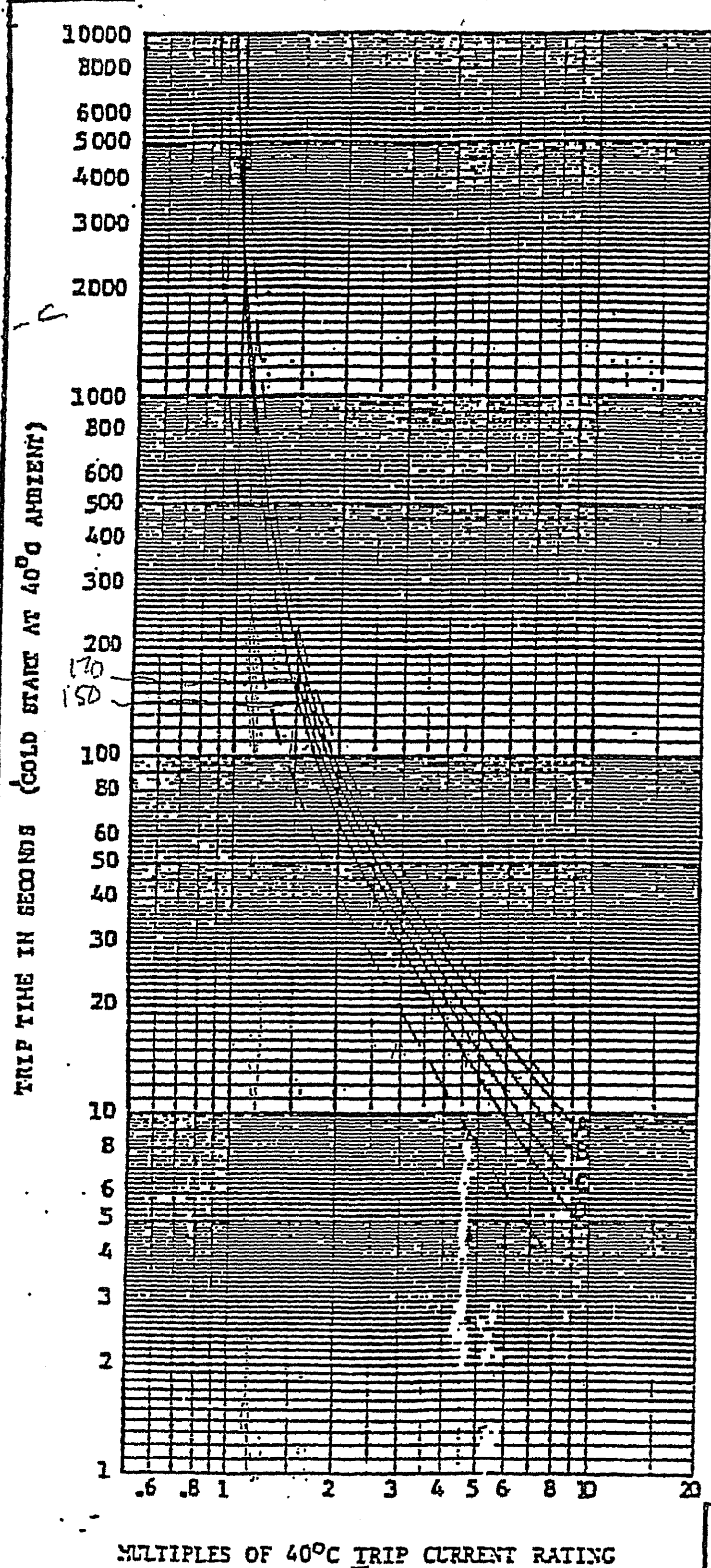
Time Current Characteristics of TOL Relay Heaters

FH29 - 3.62 - C

FH42 - 12 - A

FH43 - 13.2 A

FH49 23 - A



TYPE A OR B, SIZE 1 OR 2, 3 POLE THERMAL OLR WITH THREE FH SERIES HEATERS ONLY

FOR NON-COMPENSATED OLR's IN ANY SIZE ENCLOSURES LESS THAN 5300 CU.IN.

TYPE A - AN13 AND AN23
TYPE B - BN13 AND BN23

HEATER CODE MARKING	40°C TRIP CURRENT RATING	CABLE SIZE (COPPER ONLY)		CURVE
		60°C	75°C	
FH03	.300	14	14	C
FH04	.325	14	14	C
FH05	.362	14	14	C
FH06	.400	14	14	C
FH07	.450	14	14	C
FH08	.500	14	14	C
FH09	.550	14	14	C
FH10	.60	14	14	D
FH11	.65	14	14	C
FH12	.72	14	14	C
FH13	.80	14	14	B
FH14	.88	14	14	C
FH15	.97	14	14	B
FH16	1.07	14	14	B
FH17	1.17	14	14	C
FH18	1.30	14	14	D
FH19	1.42	14	14	C
FH20	1.57	14	14	B
FH21	1.72	14	14	C
FH22	1.90	14	14	B
FH23	2.07	14	14	B
FH24	2.27	14	14	B
FH25	2.50	14	14	C
FH26	2.75	14	14	C
FH27	3.00	14	14	B
FH28	3.30	14	14	C
FH29	3.62	14	14	C
FH30	3.97	14	14	A
FH31	4.35	14	14	A
FH32	4.75	14	14	B
FH33	5.15	14	14	C
FH34	5.7	14	14	B
FH35	6.3	14	14	B
FH36	7.0	14	14	B
FH37	7.5	14	14	A
FH38	8.3	14	14	B
FH39	9.1	14	14	B
FH40	10.0	14	14	C
FH41	11.0	14	14	C
FH42	12.0	14	14	A
FH43	13.2	14	14	A
FH44	14.5	12	12	A
FH45	15.8	12	12	A
FH46	17.3	12	12	A
FH47	19.0	10	10	C
FH48	21.0	10	10	A
FH49	23.0	10	10	A
FH50	25.3	10	10	A
FH51	27.8	8	8	B
FH52	30.5	8	8	B
FH53	33.3	8	8	C
FH54	36.5	8	8	B
FH55	40.1	6	8	B
FH56	44.1	6	8	B
FH57	48.2	6	6	B
FH58	53.0	4	4	B

OVERLOAD RELAY
TIME - CURRENT
CHARACTERISTICS

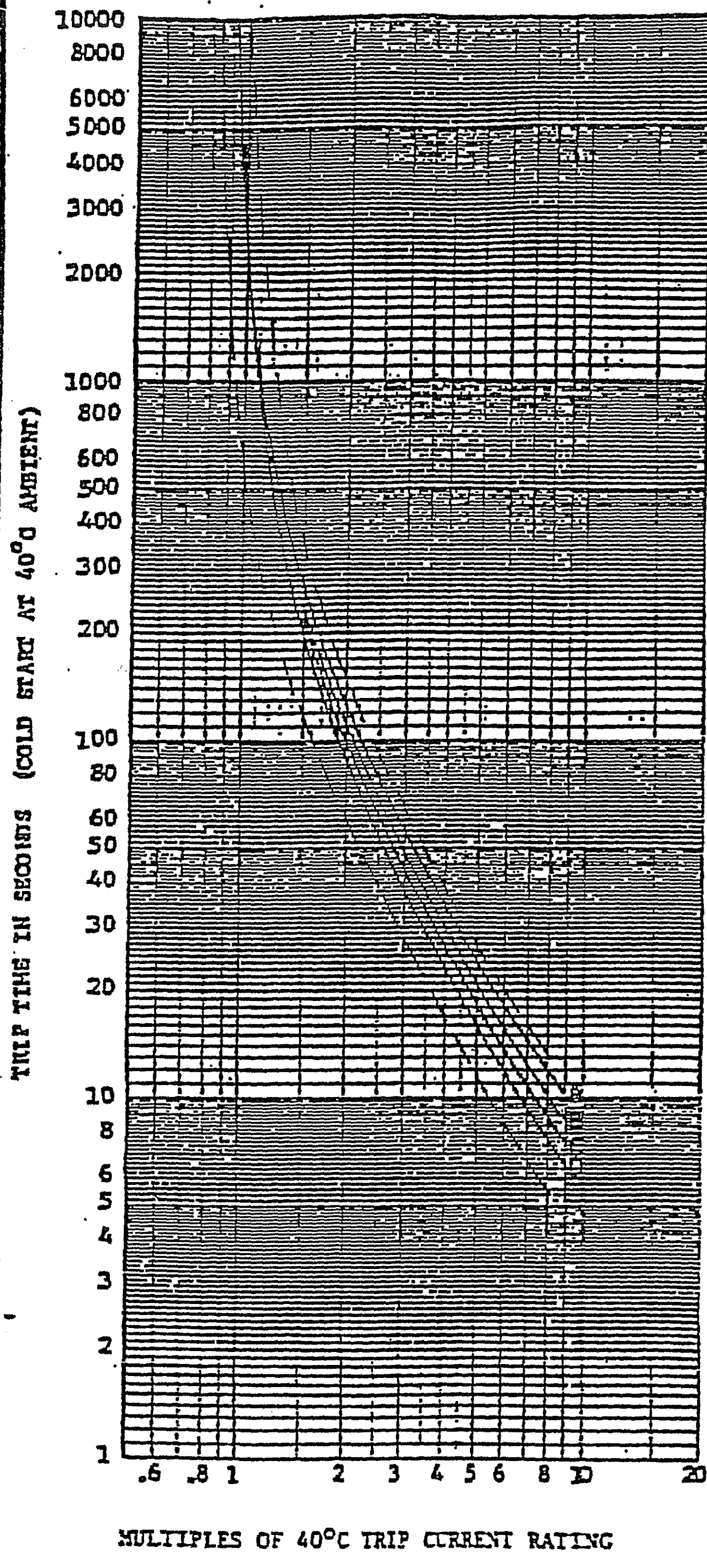
WESTINGHOUSE ELECTRIC CORP.
ASHEVILLE, N.C. 28813

REV. 1 - 1/11/85

CURVE SHEET NO. PTA 032880 REV. 1

6B012041

CALCULATION 366A-DC
APPENDIX 6A
Sheet 5 of 7



TYPE A OR B, SIZE 3 OR 4, 3 POLE THERMAL OLR WITH THREE FH SERIES HEATERS ONLY AND TYPE A, 1 POLE WITH ONE HEATER

FOR NON-COMPENSATED OLR's IN ENCLOSURES LESS THAN 3500 CU.IN.

TYPE A - AN31, AN41, AN33 AND AA43
TYPE B - BN33, AND BN43

HEATER CODE MARKING	40°C TRIP CURRENT RATING	CABLE SIZE (COPPER ONLY) 60°C	75°C	CURVE
FH68	14.8	12	12	[illegible]
FH69	16.3	12	12	[illegible]
FH70	18.0	12	12	[illegible]
FH71	20.0	10	10	[illegible]
FH72	21.8	10	10	D
FH73	24.0	10	10	C
FH74	26.5	10	10	B
FH75	29.1	8	8	D
FH76	32.1	8	8	[illegible]
FH77	35.2	8	8	B
FH78	38.6	6	8	D
FH79	43.2	6	8	D
FH80	47.8	6	6	C
FH81	53.3	4	6	C
FH82	58.7	4	6	C
FH83	65.0	4	4	C
FH84	71.2	3	4	D
FH85	77.5	3	4	D
FH86	85.0	2	3	D
FH87	91.2	1	3	C
FH88	97.5	1	2	C
FH89	106	0	2	C
FH90	115	0	1	B
FH91	125	-	0	B
FH92	138.5	-	00	A
FH93	153.5	-	00	A
FH94	161	-	00	A

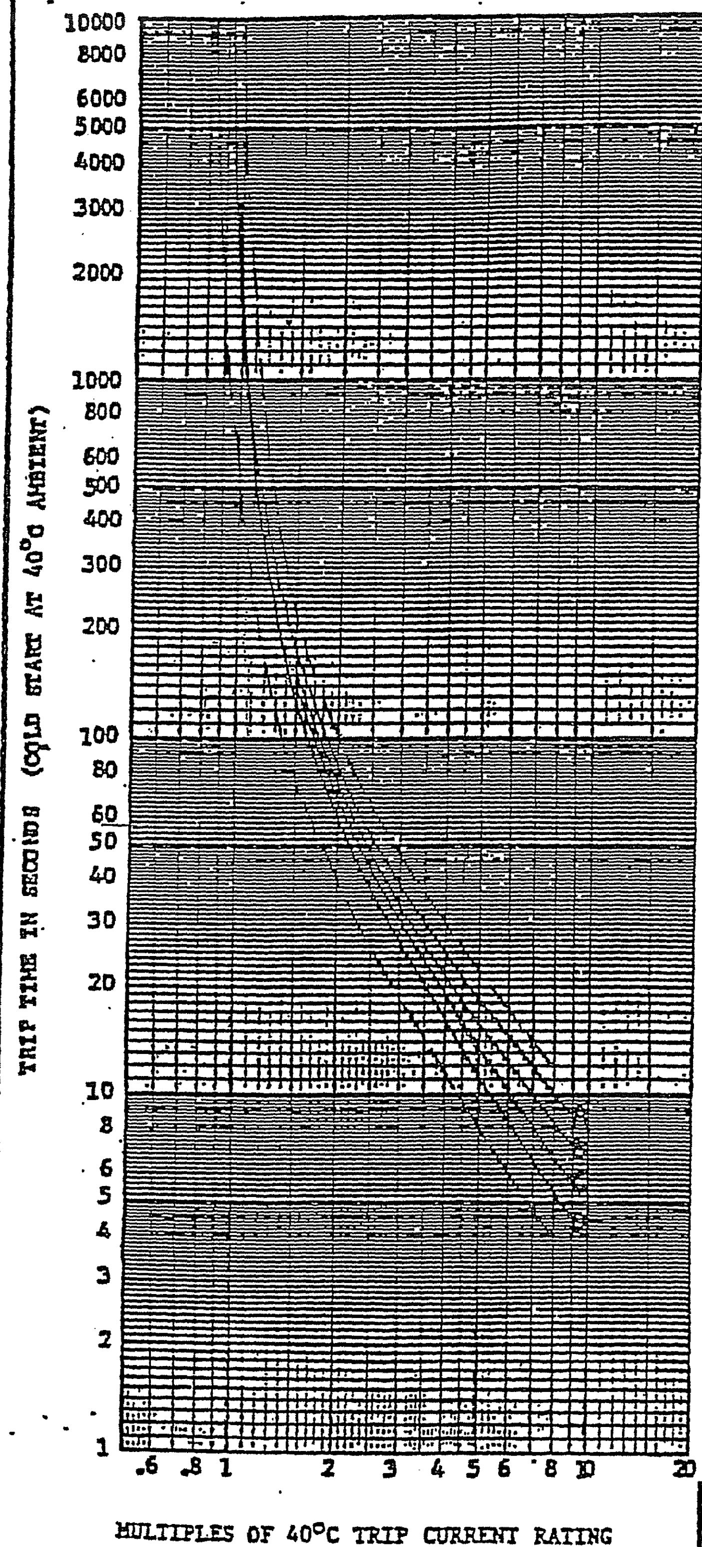
OVERLOAD RELAY
TIME - CURRENT
CHARACTERISTICS

WESTINGHOUSE ELECTRIC CORP.
ASHEVILLE, N.C. 28813

CURVE SHEET NO. PTA 012525

-- Time Current Characteristics of TOL Relay Heaters 2.7

2.16
Min Heater Value X 1.25 = Trip current



TYPE A OR B. SIZE 1 OR 2. 3 POLE THERMAL OLR WITH THREE FH SERIES HEATERS ONLY

FOR COMPENSATED OLR's IN ANY SIZE ENCLOSURE AND NON-COMPENSATED OLR's IN ENCLOSURES GREATER THAN 5500 CU.IN.

TYPE A - AA13, AA23, AN13 AND AN23
TYPE B - BA13, BA23, BN13 AND BN23

HEATER CODE MARKING	40°C TRIP CURRENT RATING	CABLE SIZE (COPPER ONLY) 60°C	75°C	CURVE
FH03	.312	14	14	C
FH04	.350	14	14	C
FH05	.400	14	14	C
FH06	.437	14	14	C
FH07	.487	14	14	C
FH08	.537	14	14	C
FH09	.58	14	14	C
FH10	.63	14	14	D
FH11	.70	14	14	C
FH12	.78	14	14	C
FH13	.86	14	14	B
FH14	.95	14	14	C
FH15	1.05	14	14	B
FH16	1.15	14	14	B
FH17	1.26	14	14	C
FH18	1.40	14	14	D
FH19	1.53	14	14	C
FH20	1.68	14	14	B
FH21	1.85	14	14	C
FH22	2.03	14	14	B
FH23	2.23	14	14	B
FH24	2.45	14	14	B
FH25	2.70	14	14	C
FH26	2.95	14	14	C
FH27	3.23	14	14	B
FH28	3.55	14	14	C
FH29	3.90	14	14	C
FH30	4.28	14	14	A
FH31	4.67	14	14	A
FH32	5.10	14	14	B
FH33	5.50	14	14	C
FH34	6.1	14	14	B
FH35	6.7	14	14	B
FH36	7.5	14	14	B
FH37	8.1	14	14	A
FH38	9.0	14	14	B
FH39	9.8	14	14	B
FH40	10.7	14	14	C
FH41	11.8	14	14	C
FH42	13.0	14	14	A
FH43	14.2	12	12	A
FH44	15.6	12	12	A
FH45	17.0	12	12	A
FH46	18.7	10	10	A
FH47	20.5	10	10	C
FH48	22.6	10	10	A
FH49	24.8	10	10	A
FH50	27.2	10	10	A
FH51	30.0	8	8	B
FH52	32.8	8	8	B
FH53	36.0	8	8	C
FH54	39.3	6	8	B
FH55	43.2	6	8	B
FH56	47.5	6	6	B
FH57	52.0	4	6	B

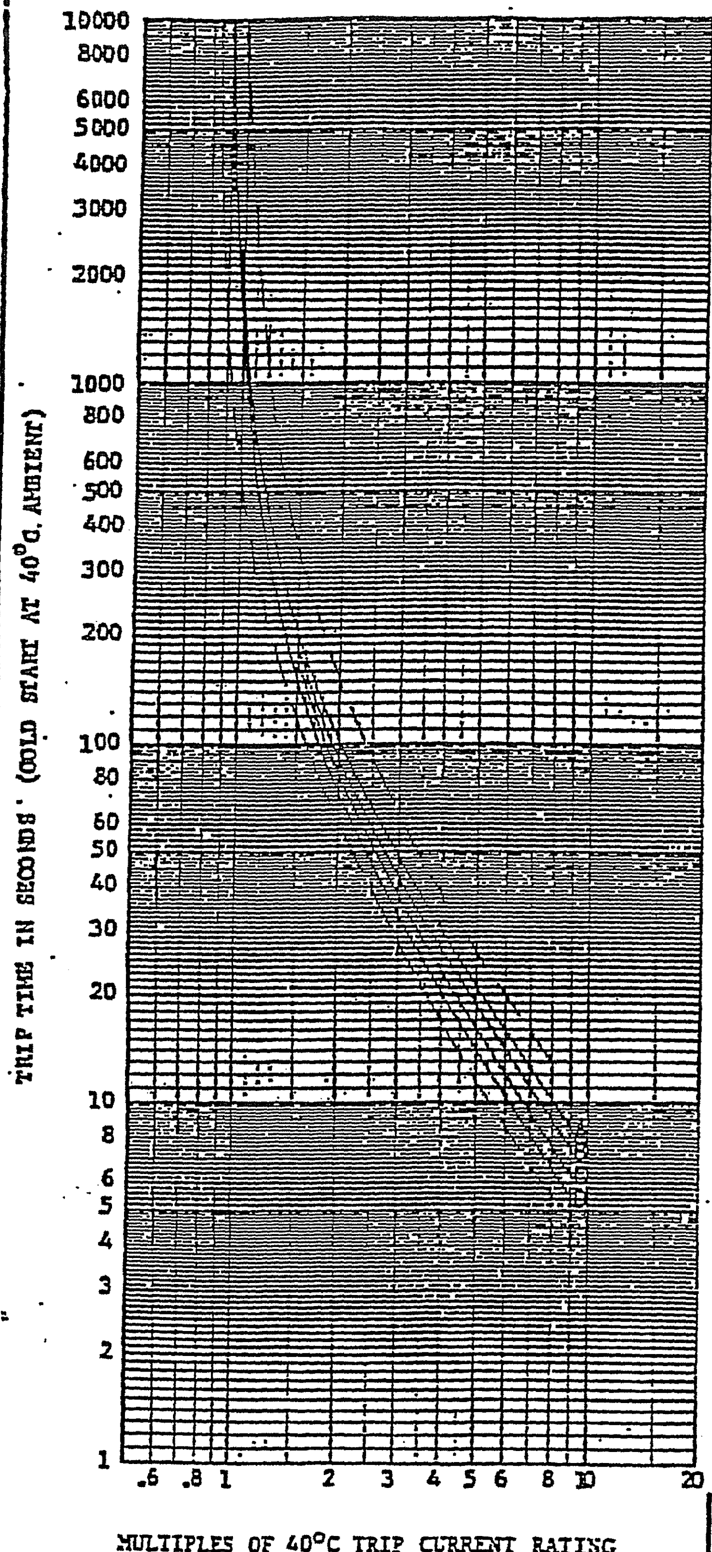
OVERLOAD RELAY
TIME - CURRENT
CHARACTERISTICS

WESTINGHOUSE ELECTRIC CORP.

REV. 1 - 1/11/85

PTA 032480 REV. 1

1.4



TYPE A OR B, SIZE 3 OR 4, 3 POLE THERMAL OLR WITH THREE FH SERIES HEATERS ONLY AND TYPE A, 1 POLE WITH ONE HEATER

FOR COMPENSATED OLR's IN ANY SIZE ENCLOSURE AND NON-COMPENSATED OLR's IN ENCLOSURES GREATER THAN 5500 CU. IN.

TYPES - AA31, AA41, AA33, AA43, AN31, AN41, AN33, AN43, BA33, BA43, BN33, AND BN43

HEATER CODE MARKING	40°C TRIP CURRENT RATING	CABLE SIZE (COPPER ONLY)		CURVE
		60°C	75°C	
FH68	16.0	12	12	D
FH69	17.7	12	12	D
FH70	19.5	10	10	C
FH71	21.5	10	10	D
FH72	23.7	10	10	D
FH73	26.1	10	10	C
FH74	28.7	8	8	B
FH75	31.6	8	8	D
FH76	34.8	8	8	C
FH77	38.4	6	8	B
FH78	42.0	6	8	D
FH79	47.0	6	6	B
FH80	52.0	4	6	C
FH81	58.0	4	6	C
FH82	63.7	4	4	C
FH83	70.0	3	4	C
FH84	77.5	3	4	D
FH85	83.7	2	3	D
FH86	92.5	1	3	D
FH87	98.7	1	2	C
FH88	106	0	2	C
FH89	116	-	1	C
FH90	127	-	0	B
FH91	138	-	00	B
FH92	153	-	00	A
FH93	162	-	00	A

WESTINGHOUSE ELECTRIC CORP.

OVERLOAD RELAY
TIME - CURRENT
CHARACTERISTICS

CURVE SHEET NO. PTA 012485

Tables 13 Thru 18

Table 13

Motor Full-Load Current (Amp.)			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
0.29-0.31	0.29-0.31	0.28-0.30	B 0.44
0.32-0.34	0.32-0.34	0.31-0.34	B 0.51
0.35-0.38	0.35-0.38	0.35-0.37	B 0.57
0.39-0.45	0.39-0.45	0.38-0.44	B 0.63
0.46-0.54	0.46-0.54	0.45-0.53	B 0.71
0.55-0.61	0.55-0.61	0.54-0.59	B 0.81
0.62-0.66	0.62-0.66	0.60-0.64	B 0.92
0.67-0.73	0.67-0.73	0.65-0.72	B 1.03
0.74-0.81	0.74-0.81	0.73-0.80	B 1.16
0.82-0.94	0.82-0.94	0.81-0.90	B 1.30
0.95-1.05	0.95-1.05	0.91-1.03	B 1.45
1.06-1.22	1.06-1.22	1.04-1.14	B 1.67
1.23-1.34	1.23-1.34	1.15-1.27	B 1.88
1.35-1.51	1.35-1.51	1.28-1.43	B 2.10
1.52-1.71	1.52-1.71	1.44-1.62	B 2.40
1.72-1.93	1.72-1.93	1.63-1.77	B 2.65
1.94-2.14	1.94-2.14	1.78-1.97	B 3.00
2.15-2.40	2.15-2.40	1.98-2.32	B 3.30
2.41-2.72	2.41-2.72	2.33-2.51	B 3.70
2.73-3.15	2.73-3.15	2.52-2.99	B 4.15
3.16-3.55	3.16-3.55	3.00-3.42	B 4.85
3.56-4.00	3.56-4.00	3.43-3.75	B 5.50
4.01-4.40	4.01-4.40	3.76-3.98	B 6.25
4.41-4.88	4.41-4.88	3.99-4.48	B 6.90
4.89-5.19	4.89-5.19	4.49-4.93	B 7.70
5.20-5.73	5.20-5.73	4.94-5.21	B 8.20
5.74-6.39	5.74-6.39	5.22-5.84	B 9.10
6.40-7.13	6.40-7.13	5.85-6.67	B 10.2
7.14-7.90	7.14-7.90	6.68-7.54	B 11.5
7.91-8.55	7.91-8.55	7.55-8.14	B 12.8
8.56-9.53	8.56-9.53	8.15-8.72	B 14
9.54-10.6	9.54-10.6	8.73-9.66	B 15.5
10.7-11.8	10.7-11.8	9.67-10.5	B 17.5
11.9-13.2	11.9-12.0	10.6-11.3	B 19.5
13.3-14.9	....	11.4-12.0	B 22
15.0-16.6	....	....	B 25
16.7-18.0	....	....	B 28.0
Following Selections for Size 1 Only			
....	11.9-13.2	....	B 19.5
....	13.3-14.9	11.4-12.7	B 22
....	15.0-16.6	12.8-14.1	B 25
16.7-18.9	16.7-18.9	14.2-15.9	B 28.0
19.0-21.2	19.0-21.2	16.0-17.5	B 32
21.3-23.0	21.3-23.0	17.6-19.7	B 36
23.1-25.5	23.1-25.5	19.8-21.9	B 40
25.6-26.0	25.6-26.0	22.0-24.4	B 45
....	....	24.5-26.0	B 50

Table 14

Motor Full Load Current Amps.			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
0.43-0.47	0.41-0.45	0.40-0.41	A .49
0.48-0.51	0.46-0.50	0.42-0.46	A .54
0.52-0.56	0.51-0.55	0.47-0.51	A .59
0.57-0.64	0.56-0.62	0.52-0.57	A .65
0.65-0.69	0.63-0.67	0.58-0.62	A .71
0.70-0.76	0.68-0.72	0.63-0.67	A .79
0.77-0.84	0.73-0.81	0.68-0.75	A .86
0.85-0.91	0.82-0.88	0.76-0.80	A .95
0.92-1.01	0.89-0.97	0.81-0.89	A 1.02
1.02-1.15	0.98-1.08	0.90-1.02	A 1.16
1.16-1.23	1.09-1.18	1.03-1.09	A 1.25
1.24-1.37	1.19-1.32	1.10-1.21	A 1.39
1.38-1.45	1.33-1.40	1.22-1.29	A 1.54
1.46-1.56	1.41-1.48	1.30-1.37	A 1.63
1.57-1.67	1.49-1.60	1.38-1.48	A 1.75
1.68-1.77	1.61-1.72	1.49-1.58	A 1.86
1.78-1.92	1.73-1.84	1.59-1.72	A 1.99
1.93-2.09	1.85-2.00	1.73-1.85	A 2.15
2.10-2.31	2.01-2.22	1.86-2.05	A 2.31
2.32-2.56	2.23-2.45	2.06-2.29	A 2.57
2.57-2.92	2.46-2.82	2.30-2.62	A 2.81
2.93-3.16	2.83-3.08	2.63-2.84	A 3.61
3.17-3.48	3.09-3.39	2.85-3.10	A 3.95
3.49-3.83	3.40-3.75	3.11-3.46	A 4.32
3.84-4.24	3.76-4.16	3.47-3.85	A 4.79
4.25-4.62	4.17-4.51	3.86-4.16	A 5.30
4.63-4.92	4.52-4.83	4.17-4.46	A 5.78
4.93-5.61	4.84-5.49	4.47-5.08	A 6.30
5.62-5.85	5.50-5.67	5.09-5.35	A 6.99
5.86-6.36	5.68-6.16	5.36-5.82	A 7.65
6.37-6.99	6.17-6.75	5.83-6.34	A 8.39
7.00-7.67	6.76-7.00	6.35-6.95	A 9.25
7.68-8.15	....	6.96-7.00	A 9.85
8.16-9.00	....	....	A 11.0

Table 15

Motor Full Load Current (Amp.)			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
0.31-0.33	0.31-0.33	0.29-0.31	B 0.44
0.34-0.36	0.34-0.36	0.32-0.36	B 0.51
0.37-0.40	0.37-0.40	0.37-0.38	B 0.57
0.41-0.48	0.41-0.48	0.39-0.46	B 0.63
0.49-0.57	0.49-0.57	0.47-0.55	B 0.71
0.58-0.64	0.58-0.64	0.56-0.61	B 0.81
0.65-0.70	0.65-0.70	0.62-0.66	B 0.92
0.71-0.77	0.71-0.77	0.67-0.75	B 1.03
0.78-0.85	0.78-0.85	0.76-0.83	B 1.16
0.86-0.99	0.86-0.99	0.84-0.93	B 1.30
1.00-1.10	1.00-1.10	0.94-1.06	B 1.45
1.11-1.28	1.11-1.28	1.07-1.18	B 1.67
1.29-1.41	1.29-1.41	1.19-1.31	B 1.88
1.42-1.58	1.42-1.58	1.32-1.47	B 2.10
1.59-1.80	1.59-1.80	1.48-1.67	B 2.40
1.81-2.03	1.81-2.03	1.68-1.83	B 2.65
2.04-2.25	2.04-2.25	1.84-2.04	B 3.00
2.26-2.51	2.26-2.51	2.05-2.38	B 3.30
2.52-2.83	2.52-2.83	2.39-2.60	B 3.70
2.84-3.29	2.84-3.29	2.61-3.13	B 4.15
3.30-3.75	3.30-3.75	3.14-3.59	B 4.85
3.76-4.22	3.76-4.22	3.60-3.94	B 5.50
4.23-4.65	4.23-4.65	3.95-4.19	B 6.25
4.66-5.16	4.66-5.16	4.20-4.72	B 6.90
5.17-5.53	5.17-5.53	4.73-5.21	B 7.70
5.54-6.09	5.54-6.09	5.22-5.51	B 8.20
6.10-6.80	6.10-6.80	5.52-6.17	B 9.10
6.81-7.60	6.81-7.60	6.18-7.07	B 10.2
7.61-8.35	7.61-8.35	7.08-8.05	B 11.5
8.36-9.04	8.36-9.04	8.06-8.69	B 12.8
9.05-9.99	9.05-9.99	8.70-9.32	B 14
10.0-11.1	10.0-11.1	9.33-10.2	B 15.5
11.2-12.3	11.2-12.0	10.3-11.3	B 17.5
12.4-13.7	....	11.4-12.0	B 19.5
13.8-15.4	....	....	B 22
15.5-18.0	....	....	B 25
Following Selections for Size 1 Only			
....	11.2-12.3	....	B 17.5
....	12.4-13.7	11.4-12.1	B 19.5
....	13.8-15.4	12.2-13.7	B 22
15.5-17.2	15.5-17.2	13.8-15.2	B 25
17.3-19.4	17.3-19.4	15.3-17.2	B 28.0
19.5-21.7	19.5-21.7	17.3-18.9	B 32
21.8-23.9	21.8-23.9	19.0-21.4	B 36
24.0-26.0	24.0-26.0	21.5-23.7	B 40
....	....	23.8-26.0	B 45

Table 16

Motor Full-Load Current (Amp.)			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
16.2-17.5	15.1-16.2	14.3-15.4	CC 20.9
17.6-18.8	16.3-17.3	15.5-16.4	CC 22.8
18.9-20.5	17.4-19.5	16.5-18.5	CC 24.6
20.6-22.2	19.6-20.7	18.6-19.6	CC 26.3
22.3-23.7	20.8-22.3	19.7-21.1	CC 28.8
23.8-25.4	22.4-24.0	21.2-22.7	CC 31.0
25.5-27.3	24.1-25.7	22.8-24.4	CC 33.3
27.4-29.3	25.8-27.5	24.5-26.1	CC 36.4
29.4-31.5	27.6-29.6	26.2-28.1	CC 39.6
31.6-33.9	29.7-31.7	28.2-30.0	CC 42.7
34.0-36.2	31.8-33.9	30.1-32.1	CC 46.6
36.3-39.3	34.0-36.6	32.2-34.7	CC 50.1
39.4-42.3	36.7-39.3	34.8-37.3	CC 54.5
42.4-45.3	39.4-42.3	37.4-40.1	CC 59.4
45.4-48.3	42.4-44.9	40.2-42.6	CC 64.3
48.4-52.0	45.0-48.3	42.7-45.8	CC 69.5
52.1-54.9	48.4-50.9	45.9-48.3	CC 74.6
55.0-59.7	51.0-55.5	48.4-52.6	CC 81.5
59.8-65.4	55.6-59.9	52.7-56.0	CC 87.7
65.5-69.6	60.0-64.2	56.1-60.9	CC 94.0
69.7-74.8	64.3-68.7	61.0-65.1	CC 103
74.9-79.7	68.8-71.4	65.2-67.7	CC 112
79.8-83.1	71.5-74.8	67.8-70.9	CC 121
83.2-86.0	74.9-78.0	71.0-73.9	CC 132
....	78.1-80.7	74.0-76.5	CC 143
....	80.8-86.0	76.6-80.2	CC 156
....	....	80.3-83.1	CC 167
....	....	83.2-86.0	CC 180

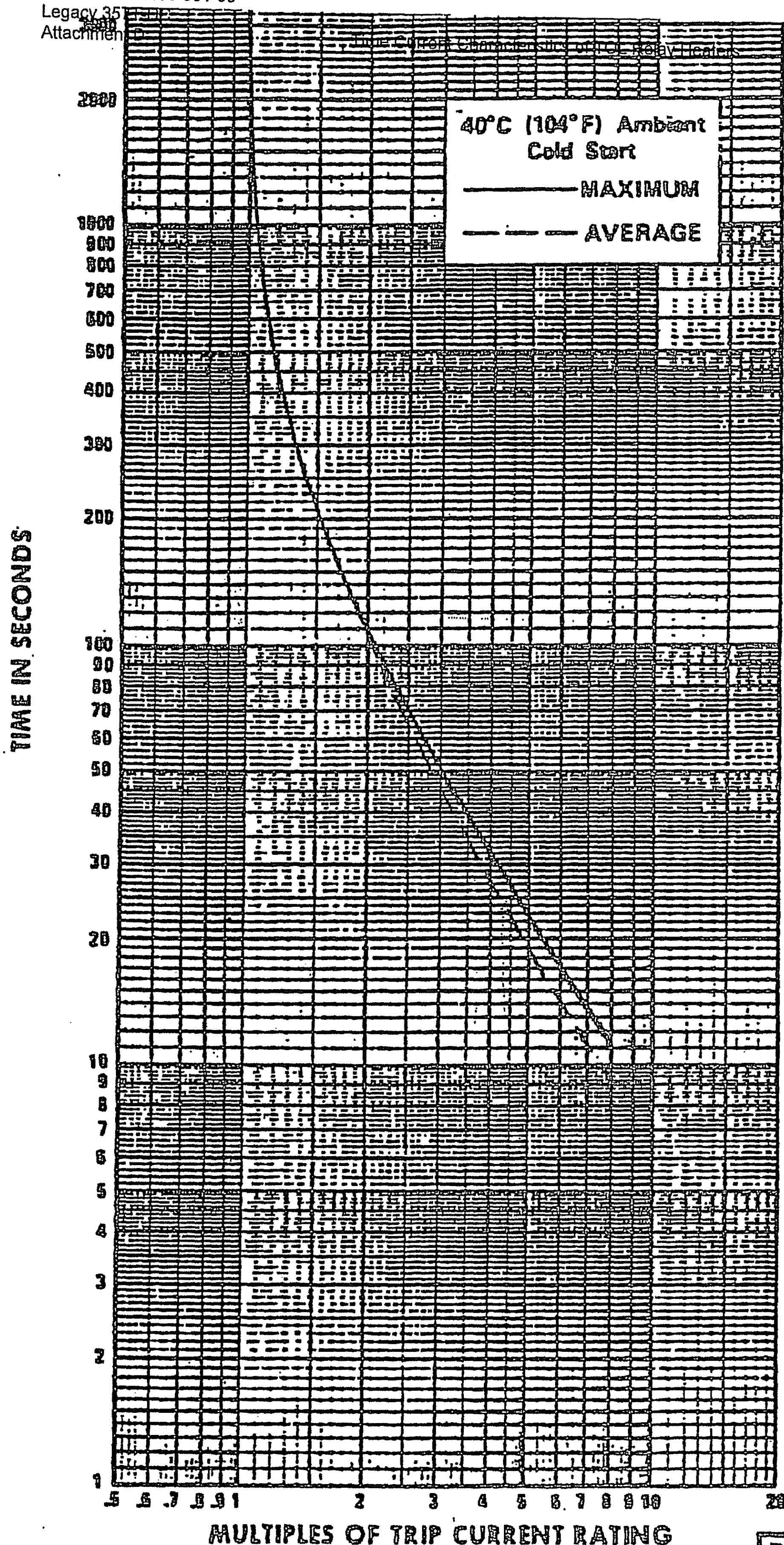
Table 17

Motor Full Load Current (Amp.)			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
0.42-0.46	0.39-0.43	0.38-0.40	A .49
0.47-0.50	0.44-0.47	0.41-0.44	A .54
0.51-0.55	0.48-0.52	0.45-0.49	A .59
0.56-0.62	0.53-0.58	0.50-0.55	A .65
0.63-0.67	0.59-0.64	0.56-0.60	A .71
0.68-0.73	0.65-0.68	0.61-0.65	A .78
0.74-0.81	0.69-0.77	0.66-0.72	A .86
0.82-0.89	0.78-0.84	0.73-0.79	A .95
0.90-0.98	0.85-0.93	0.80-0.88	A 1.02
0.99-1.12	0.94-1.05	0.89-0.98	A 1.16
1.13-1.20	1.06-1.13	0.99-1.07	A 1.25
1.21-1.34	1.14-1.25	1.08-1.17	A 1.39
1.35-1.41	1.26-1.33	1.18-1.25	A 1.54
1.42-1.51	1.34-1.42	1.26-1.33	A 1.63
1.52-1.62	1.43-1.52	1.34-1.44	A 1.75
1.63-1.73	1.53-1.63	1.45-1.53	A 1.86
1.74-1.86	1.64-1.75	1.54-1.65	A 1.99
1.87-2.02	1.76-1.90	1.66-1.79	A 2.15
2.03-2.25	1.91-2.13	1.80-1.99	A 2.31
2.26-2.46	2.14-2.33	2.00-2.18	A 2.57
2.47-2.77	2.34-2.73	2.19-2.45	A 2.81
2.78-2.99	2.74-2.86	2.46-2.65	A 3.61
3.00-3.26	2.87-3.14	2.66-2.90	A 3.95
3.27-3.59	3.15-3.47	2.91-3.19	A 4.32
3.60-3.99	3.48-3.83	3.20-3.56	A 4.79
4.00-4.42	3.84-4.16	3.57-3.83	A 5.30
4.43-4.61	4.17-4.43	3.84-4.08	A 5.78
4.62-5.23	4.44-5.00	4.09-4.64	A 6.30
5.24-5.39	5.01-5.16	4.65-5.00	A 6.99
5.40-5.88	5.17-5.56	5.01-5.36	A 7.65
5.89-6.56	5.57-6.22	5.37-5.87	A 8.39
6.57-7.18	6.23-6.89	5.88-6.43	A 9.25
7.19-7.80	6.90-7.00	6.44-6.79	A 9.85
7.81-9.00	....	6.80-7.00	A 11.0

Table 18

Motor Full-Load Current (Amp.)			Thermal Unit Number
1 T. U.	2 T. U.	3 T. U.	
15.5-16.4	14.4-15.3	13.6-14.5	CC 20.9
16.5-17.6	15.4-16.4	14.6-15.5	CC 22.8
17.7-19.1	16.5-18.4	15.6-17.4	CC 24.6
19.2-20.4	18.5-19.6	17.5-18.5	CC 26.3
20.5-22.1	19.7-21.0	18.6-19.9	CC 28.8
22.2-23.4	21.1-22.7	20.0-21.5	CC 31.0
23.5-25.6	22.8-24.2	21.6-22.9	CC 33.3
25.7-27.3	24.3-25.9	23.0-24.5	CC 36.4
27.4-29.4	26.0-27.8	24.6-26.3	CC 39.6
29.5-31.5	27.9-29.8	26.4-28.2	CC 42.7
31.6-33.7	29.9-31.7	28.3-30.0	CC 46.6
33.8-34.5	31.8-34.2	30.1-32.3	CC 50.1
34.6-39.1	34.3-36.9	32.4-34.9	CC 54.5
39.2-41.7	37.0-39.8	35.0-37.6	CC 59.4
41.8-44.8	39.9-42.3	37.7-40.0	CC 64.3
44.9-48.0	42.4-45.3	40.1-42.8	CC 69.5
48.1-50.7	45.4-47.9	42.9-45.3	CC 74.6
50.8-54.9	48.0-51.9	45.4-49.1	CC 81.5
55.0-59.9	52.0-56.5	49.2-53.4	CC 87.7
60.0-63.3	56.6-60.7	53.5-57.4	CC 94.0
63.4-67.2	60.8-64.8	57.5-61.3	CC 103
67.3-72.4	64.9-67.1	61.4-63.5	CC 112
72.5-74.9	67.2-70.1	63.6-66.3	CC 121
75.0-77.4	70.2-72.9	66.4-69.0	CC 132
77.5-80.7	73.0-74.9	69.1-70.9	CC 143
80.8-83.1	75.0-77.9	71.0-73.7	CC 156
83.2-86.0	78.0-80.9	73.8-76.5	CC 167
....	81.0-82.9	76.6-78.4	CC 180
....	83.0-86.0	78.5-86.0	CC 198

Index And Instructions — Pages 16-16 – 16-30



[X] M

RELAY DESIGN: [ ] B

[ ] T

THERMAL UNIT TYPE(S): B0.4

Curves apply only for e indicated below:

[X] AC Magnetic Start

[ ] AC Manual Starte

[ ] Separate Overload

[ ] ____________

Size 0&1 Typ

Form ____________ Seri

With (qty.) 3 Ther

When installed in:

[X] Small Enclosure (C Only)

[ ] Motor Control Cen 8998, 8999, QMB,

[ ] All Other (Larger)

[X] QMB, I-LINE

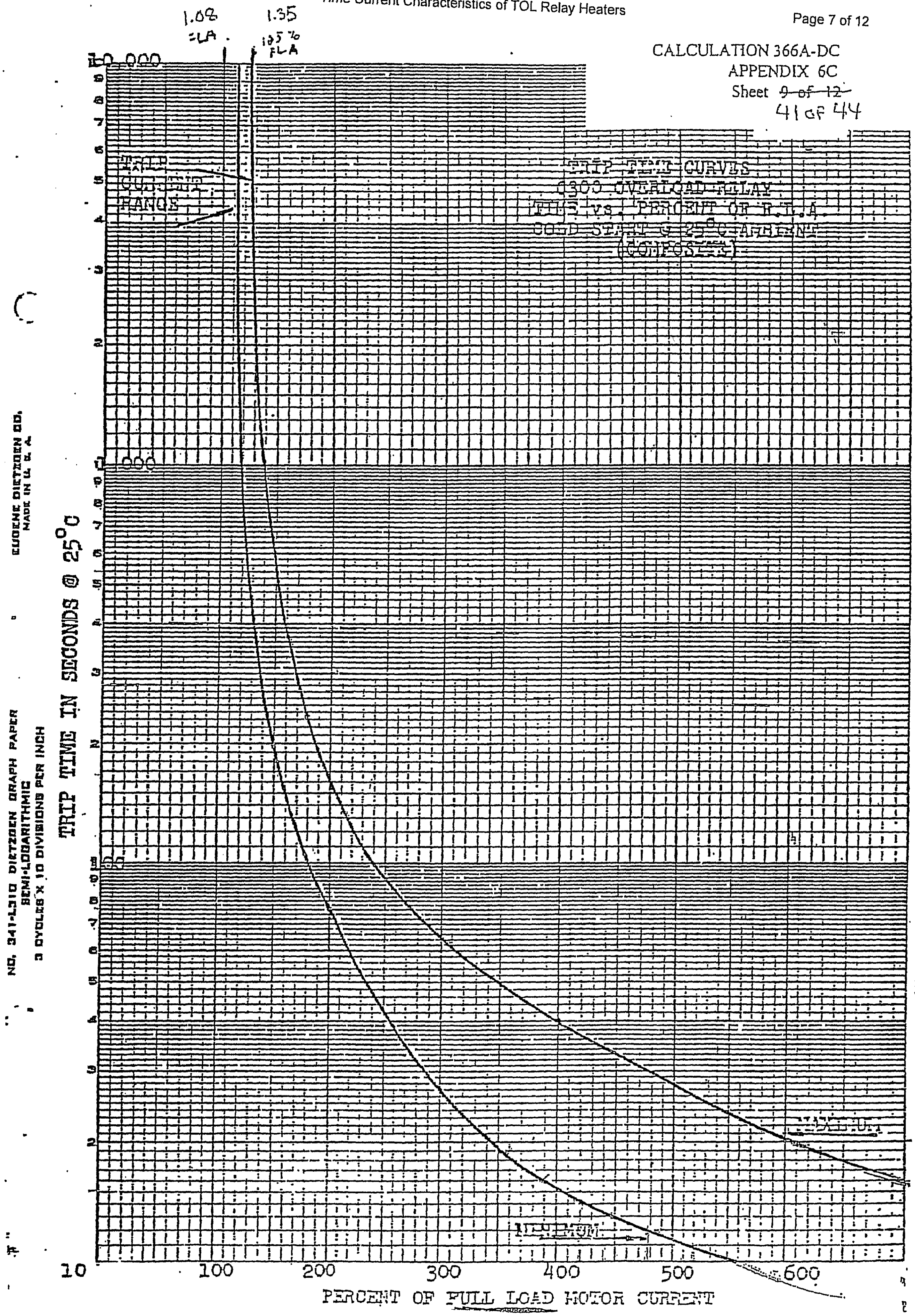
(Based on table B30(

rev.______, and test !

Trip current rating can be determined from instructions given with appropriate thermal unit selection table. Characteristics shown do not necessarily apply to equipment manufactured before date of this drawing.

REV.	DATE	DRN. BY	CHKD. BY
	11-28-73	FWP	FWP
		SQUARE	
		MILWAUKEE 12	

Time Current Characteristics of TOL Relay Heaters



Bulletin C303 — Size "1"
Slow Trip Eutectic Overload Relay

HEATER COIL SELECTION

This overload relay has two steps of adjustment (low or high) obtained by positioning the heater coils as shown in the Heater Coil Selection Table. Note the location of the pointed terminal on the heater coil.

Select heater coils according to the motor ampere rating. Note both the catalog number and the position in which the coils must be mounted.

Mount the coils in the position corresponding to the column that includes the motor ampere rating. All coils must be mounted in the same position for a given overload relay.

The Heater Coil Selection Table is for use with motors having a 1.15 service factor. The selected heater coils will allow a maximum of 125% of rated motor current. For motors with a 1.0 service factor use one size smaller heater coil mounted in the same position as the regular larger coil.

The approximate ultimate tripping current, in a 40°C ambient, can be determined by multiplying the minimum currents by 1.25.

RENEWAL PARTS

For complete Renewal Parts information, see Publication No. C303C-1 which may be obtained from a local Cutler-Hammer Representative.

△Each of these numbers prefixed by "H" is the catalog number of a package containing one coil. Order as many packages as the number of coils needed.

*Circuit Breakers may be used for branch circuit protection.

WARNING — To provide continued protection against fire or shock hazard, the complete overload relay must be replaced if burnout of the heater coil occurs.

Cutler-Hammer

Pub. 14161 Made in U. S. A. 1276

HEATER COIL SELECTION TABLE

MOTOR AMPERE RATING — Heater Coil Position: Low (Min–Max)	High (Min–Max)	Class 30: Max. Fuse Size Amps. *	No. on Coil △
.167-.176	.176-.186	2	1001
.187-.197	.198-.209	2	1002
.210-.221	.222-.233	2	1003
.234-.247	.248-.260	2	1004
.261-.275	.276-.293	2	1005
.294-.310	.311-.329	2	1006
.330-.349	.350-.373	2	1007
.374-.395	.396-.417	2	1008
.418-.442	.443-.471	3	1009
.472-.499	.500-.531	3	1010
.532-.563	.564-.591	3	1011
.592-.626	.627-.660	3	1012
.661-.700	.701-.739	4	1013
.740-.783	.784-.823	4	1014
.824-.873	.874-.919	5	1015
.920-.974	.975-1.01	5	1016
1.02-1.07	1.08-1.14	5	1017
1.15-1.21	1.22-1.27	6	1018
1.28-1.35	1.36-1.41	7	1019
1.42-1.50	1.51-1.61	7	1020
1.62-1.70	1.71-1.86	10	1071
1.07-1.98	1.99-2.01	10	1022
2.02-2.13	2.14-2.27	10	1023
2.28-2.41	2.42-2.51	12	1024
2.52-2.66	2.67-2.80	..	1025
2.81-2.97	2.98-3.21	..	1026
3.22-3.40	3.41-3.61	..	1066
3.62-3.72	3.73-3.86	..	1027
3.87-4.09	4.10-4.36	..	1028
4.37-4.63	4.64-4.83	..	1029
4.84-5.12	5.13-6.41	..	1030
5.42-5.73	5.74-6.07	..	1031
6.08-6.43	6.44-6.66	..	1032
6.67-7.06	7.07-7.51	..	1033
7.52-7.96	7.97-8.31	..	1034
8.32-8.81	8.82-9.27	..	1035
9.28-9.84	9.85-10.3	..	1036
10.4-10.9	11.0-11.7	..	1037
11.8-12.4	12.5-13.0	..	1038
13.1-13.8	13.9-14.5	..	1039
14.6-15.3	15.4-16.3	..	1040
16.4-17.3	17.4-18.1	..	1041
18.2-19.2	19.3-20.3	..	1042
20.4-21.5	21.6-23.0	..	1043
23.1-24.4	24.5-26.9	..	1044
26.0-27.0	....	..	1045

Bulletin C303 — Size "2"
Slow Trip Eutectic Overload Relay

HEATER COIL SELECTION

This overload relay has two steps of adjustment (low or high) obtained by positioning the heater coils as shown in the Heater Coil Selection Table. Note the location of the pointed terminal on the heater coil.

Select heater coils according to the motor ampere rating. Note both the catalog number and the position in which the coils must be mounted.

Mount the coils in the position corresponding to the column that includes the motor ampere rating. All coils must be mounted in the same position for a given overload relay.

The Heater Coil Selection Table is for use with motors having a 1.15 service factor. The selected heater coils will allow a maximum of 125% of rated motor current. For motors with a 1.0 service factor use one size smaller heater coil mounted in the same position as the regular larger coil.

The approximate ultimate tripping current, in a 40°C ambient, can be determined by multiplying the minimum currents by 1.25.

RENEWAL PARTS

For complete Renewal Parts information, see Publication No. C303D-1 which may be obtained from a local Cutler-Hammer Representative.

CUTLER-HAMMER ®

Pub. 14194 Made in U.S.A. 1276

HEATER COIL SELECTION TABLE

MOTOR AMPERE RATING — Heater Coil Position: Low (Min–Max)	High (Min–Max)	Class 30: No. on Coil △
3.67-3.87	3.88-3.99	1027
4.00-4.23	4.24-4.61	1028
4.62-4.78	4.79-5.03	1029
5.04-5.33	5.34-5.59	1030
5.60-5.93	5.94-6.20	1031
6.21-6.57	6.58-6.88	1032
6.89-7.30	7.31-7.80	1033
7.81-8.27	8.28-8.71	1034
8.72-9.24	9.25-9.59	1035
9.60-10.1	10.2-10.7	1036
10.8-11.4	11.5-12.0	1037
12.1-12.7	12.8-13.4	1038
13.5-14.2	14.3-14.9	1039
15.0-15.8	15.9-16.8	1040
16.9-17.8	17.9-18.8	1041
18.9-19.9	20.0-21.1	1042
21.2-22.4	22.5-24.1	1043
24.2-25.5	25.6-27.3	1044
27.4-29.0	29.1-31.3	1045
31.4-33.2	33.3-35.5	1046
35.6-37.6	37.7-40.3	1047
40.4-42.7	42.8-45.0	1048

△Each of these numbers prefixed by "H" is the catalog number of a package containing one coil. Order as many packages as the number of coils needed.

WARNING — To provide continued protection against fire or shock hazard, the complete overload relay must be replaced if burnout of the heater coil occurs.

ATTACHMENT #10, SH. 1 OF 1
CALC. No 195A-DC

CALCULATION 366A-DC
APPENDIX 6C
Sheet ~~10 of 12~~ 42 of 44

AC RELAYS

...e ST Standard Trip and C303-Type ...ow Trip Eutectic Overload Relay

(Supersedes I: dated 6/...

121

U2 - 1022/Low 1.87A (500/5) = 224.4

Post-it® Fax Note 7671	Date 12/3/97	# of pages 1
To Frank Haynes	From Ann	
Co./Dept. PG+E San Fran	Co. Cutler-Hammer	
Phone # 415-973-6393	Phone #	
Fax # 415-973-9971	Fax #	

U1

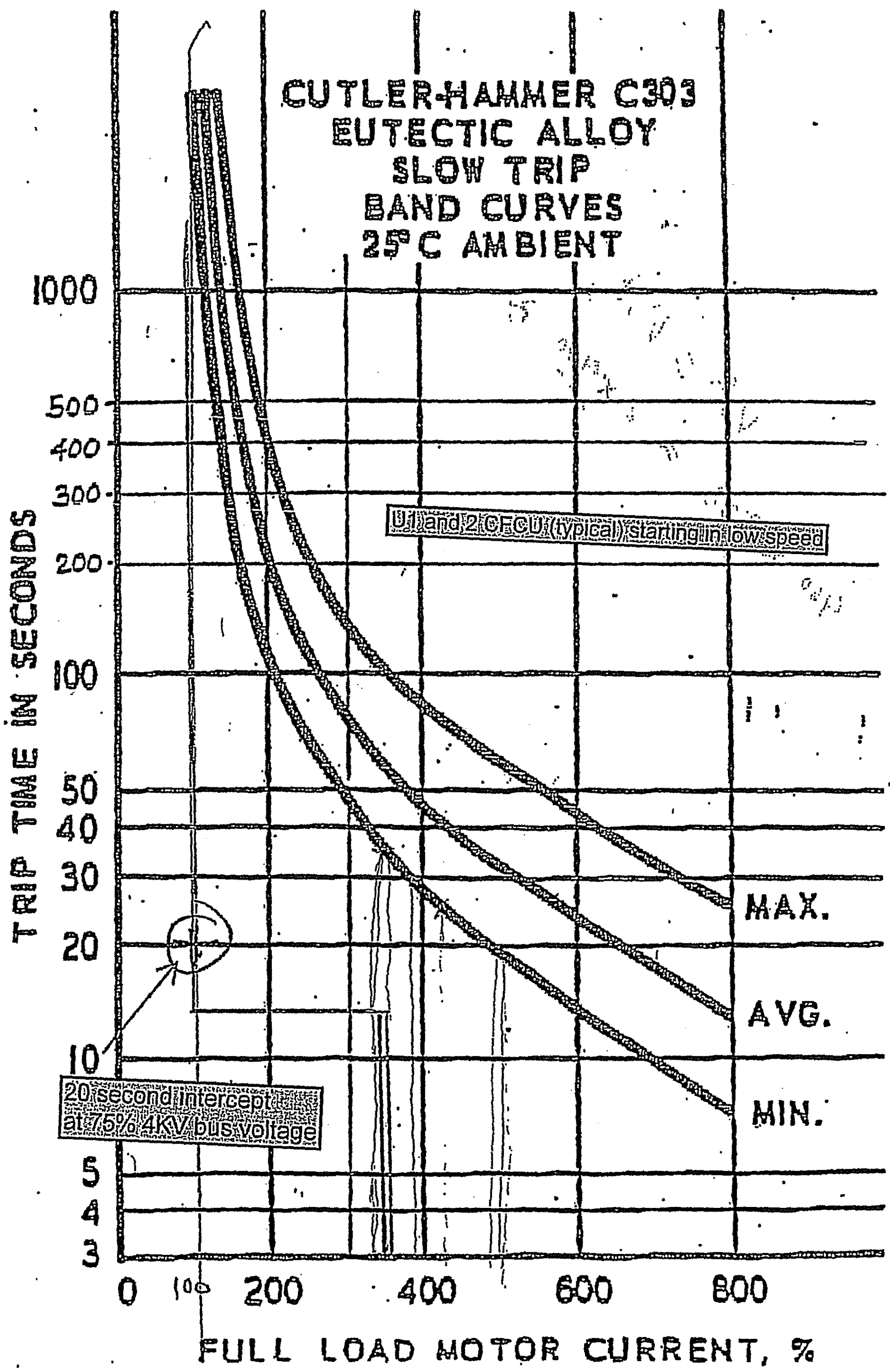
1023/HI

2.14 (500/5) = 214A

100% <=> 214A

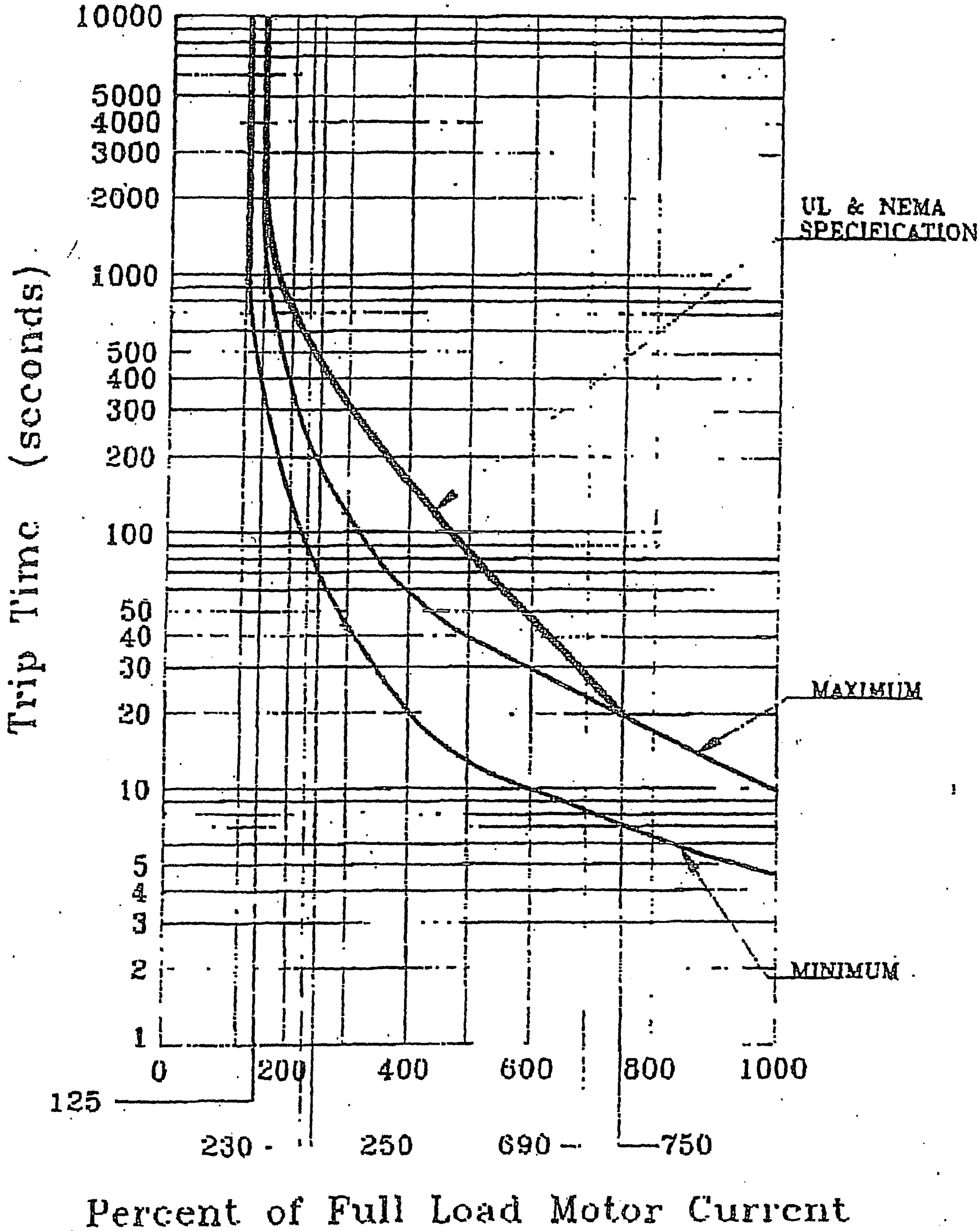
Running at 208

CRA = 369% FOR 13 SEC.



CALCULATION 366A-DC
APPENDIX 6C
Sheet ~~11 of 12~~ 43 of 44

C306 Overload Relays
1.15 S.F.
Class 20, 3 Phase Trip Curve



Min Heater

CUTLER-HAMMER CONTROL COMPONENTS

Thermal Overload Relays

FILE
C303

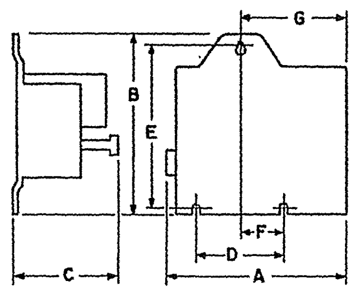
R1

APPROXIMATE DIMENSIONS — Cat. Nos. C300, C301, C303 (continued)

OPEN TYPE — Mounting Screws #10-32

Size	Dimensions in Inches							Ship. Wt. Lbs.
	Wide A	High B	Deep C	❶ Mounting				
				D	E	F	G	
1	3-3/8	3-13/16	3-7/8	2	3-1/4	1	1-11/16	1-1/2
2	3-3/8	4-5/16	3-7/8	2-1/2	3-3/4	1-1/4	1-11/16	2
3	5-3/16	5-13/16	3-7/8	1-3/4	3-3/4	1-3/4	3-5/16	3
4	5-3/16	6-1/16	3-7/8	1-3/4	3-3/4	1-3/4	3-5/16	4

❶ Top mounting hole centered on Size 1-2 and off center on Sizes 3-4.



FILE
C300 10176

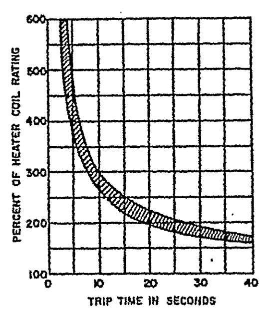
Fast Trip Overload Relay
Manual Reset

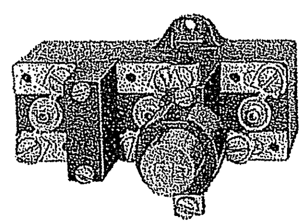
WHEN ORDERING SPECIFY

- Catalog number of relay
- Catalog number of heater coils or full load current

Fast Trip Overload Relays — Used primarily with hermetic motors and submersible pumps — Overcurrent protection up to 50 amperes — One or three coil — Reset button only — Trip in approximately 3-5 seconds at 6 times full load current — See composite trip curve at right.

NOTE: 40°C open coil rating is approximately 1.25 times the minimum current listed for that heater coil.





RELAYS

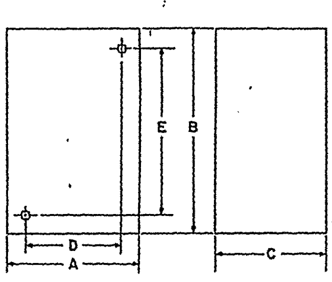
No. of Thermal Elements	Maximum Amperes	Size	Open Type N.C. Contacts	
			Cat. No.	Price
1	30 50	1 2	10176 H135 H138	$33. 48.
3	30 50	1 2	H137 H140	63. 90.

Prices of relays do not include heater coils. Select coils as required at **$9.00** per coil. See listing of heater selection tables.

HEATER COIL SELECTION

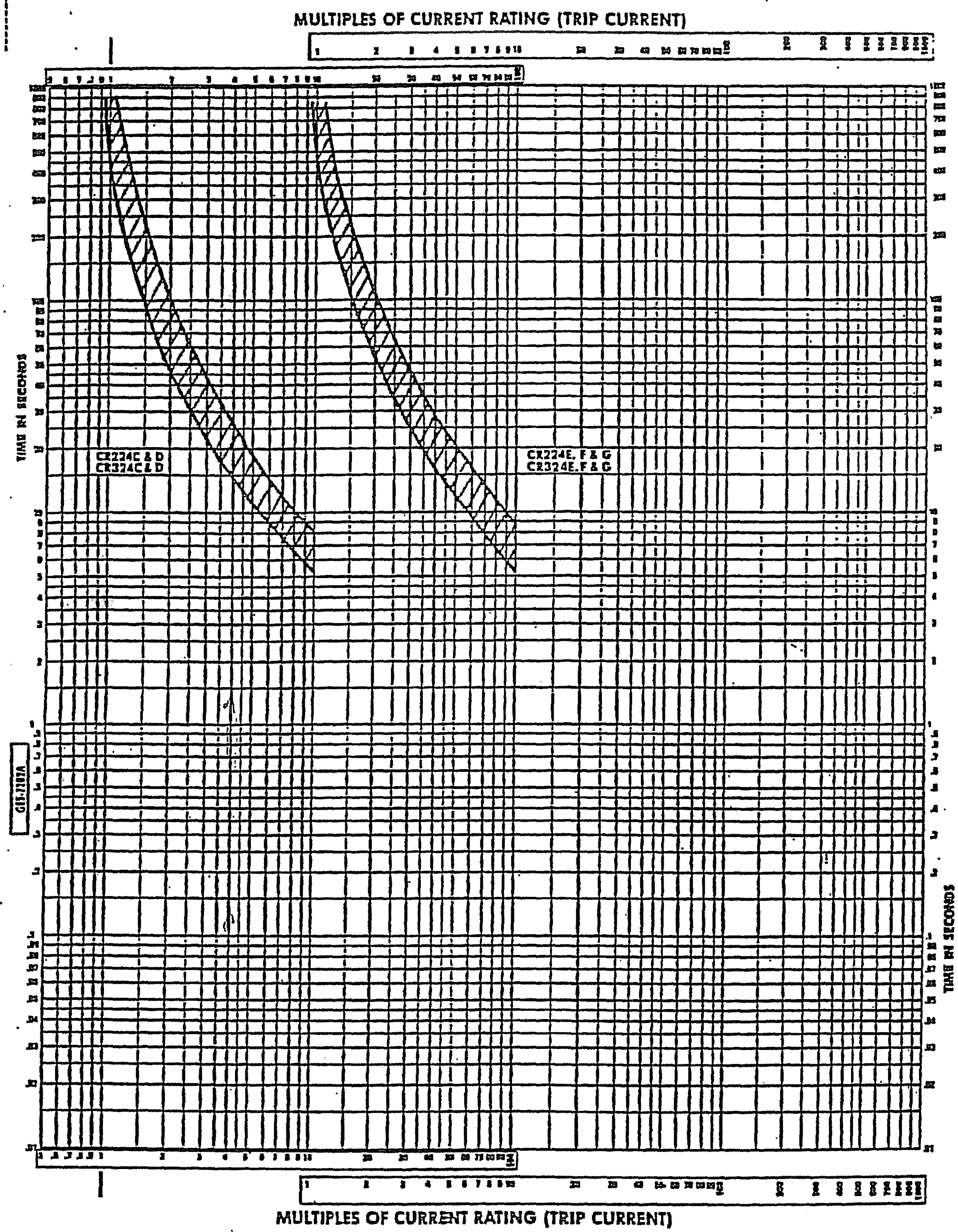
Size	Table Nos. (See **Page 509**)
1	49A
2	51A

APPROXIMATE DIMENSIONS AND SHIPPING WEIGHTS



Size	No. of Heater Coils	Dimensions in Inches				Ship. Wt. Lbs.
		Wide A	High B	Deep C	❷ Mtg. E	
1	1	2-5/8	2-3/8	4-1/8	2	1
1	2 or 3	4-1/8	2-3/8	4-1/8	2	1-1/2
2	1	2-5/8	2-5/8	4-1/8	2	1-1/4
2	2 or 3	4-1/8	2-5/8	4-1/8	2	1-3/4

❷ Mounting holes 3/16″ Dia.



GENERAL ELECTRIC	THERMAL OVERLOAD RELAYS **TYPE CR224, CR324**	GES-7202A
Current Ratings 0.41 to 270 amperes Frequency Rating 25 to 60 Hertz	CR224C, D, E, F and G CR324C, D, E, F and G Time-current Curves (Curves show relay in 40 C ambient)	Adjustments Current setting: 90 to 110% of heater current rating. Curves shown at 100%.

1.19 POLYPHASE MOTORS ▲

Alternating-current polyphase motors are of the squirrel-cage induction, wound-rotor induction, or synchronous types.

1.19.1 Design Letters of Polyphase Squirrel-Cage Medium Motors ▲

Polyphase squirrel-cage medium induction motors may be one of the following:

1.19.1.1 Design A ▲

A Design A motor is a squirrel-cage motor designed to withstand full-voltage starting and developing locked-rotor torque as shown in 12.38, pull-up torque as shown in 12.40, breakdown torque as shown in 12.39, with locked-rotor current higher than the values shown in 12.35.1 for 60 hertz and 12.35.2 for 50 hertz and having a slip at rated load of less than 5 percent.[1] ▲

1.19.1.2 Design B ▲

A Design B motor is a squirrel-cage motor designed to withstand full-voltage starting, developing locked-rotor, breakdown, and pull-up torques adequate for general application as specified in 12.38, 12.39, and 12.40, drawing locked-rotor current not to exceed the values shown in 12.35.3 for 60 hertz and 12.35.3 for 50 hertz, and having a slip at rated load of less than 5 percent.[1] ▲

1.19.1.3 Design C ▲

A Design C motor is a squirrel-cage motor designed to withstand full-voltage starting, developing locked-rotor torque for special high-torque application up to the values shown in 12.38, pull-up torque as shown in 12.40, breakdown torque up to the values shown in 12.39, with locked-rotor current not to exceed the values shown in 12.34.1 for 60 hertz and 12.35.2 for 50 hertz, and having a slip at rated load of less than 5 percent. ▲

1.19.1.4 Design D ▲

A Design D motor is a squirrel-cage motor designed to withstand full-voltage starting, developing high locked rotor torque as shown in 12.38, with locked rotor current not greater than shown in 12.35.1 for 60 hertz and 12.35.2 for 50 hertz, and having a slip at rated load of 5 percent or more. ▲

1.20 SINGLE-PHASE MOTORS ▲

Alternating-Current single-phase motors are usually induction or series-wound although single-phase synchronous motors are available in the smaller ratings.

1.20.1 Design Letters of Single-Phase Small Motors ▲

1.20.1.1 Design N ▲

A Design N motor is a single-phase small motor designed to withstand full-voltage starting and with a locked-rotor current not to exceed the values shown in 12.33.

1.20.1.2 Design O ▲

A Design O motor is a single-phase small motor designed to withstand full-voltage starting and with a locked-rotor current not to exceed the values shown in 12.33.

1.20.2 Design Letters of Single-Phase Medium Motors ▲

Single-phase medium motors include the following:

[1] Motors with 10 or more poles shall be permitted to have slip slightly greater than 5 percent.

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12.35.2 50-Hertz Design B, C, and D Motors at 380 Volts ▲

The locked-rotor current of single-speed, 3-phase, constant-speed induction motors rated at 380 volts, when measured with rated voltage and frequency impressed and with rotor locked, shall not exceed the values shown in Table 12-1.

Table 12-1
MAXIMUM LOCKED-ROTOR CURRENT FOR 50-Hz DESIGN B, C, AND D MOTORS AT 380 VOLTS

Hp	Locked-Rotor Current, Amperes*	Design Letters	Hp	Locked-Rotor Current, Amperes*	Design Letters
3/4 or less	20	B, D	25	243	B, C, D
1	20	B,C, D	30	289	B, C, D
1-1/2	27	B, C, D	40	387	B, C, D
2	34	B, C, D	50	482	B, C, D
3	43	B, C, D	60	578	B, C, D
5	61	B, C, D	75	722	B, C, D
7-1/2	84	B, C, D	100	965	B, C, D
10	107	B, C, D	125	1207	B, C, D
15	154	B, C, D	150	1441	B, C, D
20	194	B, C, D	200	1927	B, C

**The locked-rotor current of motors designed for voltages other than 380 volts shall be inversely proportional to the voltages.

12.36 INSTANTANEOUS PEAK VALUE OF INRUSH CURRENT

The values in the previous tables are rms symmetrical values, i.e. average of the three phases. There will be a one-half cycle instantaneous peak value which may range from 1.8 to 2.8 times the above values as a function of the motor design and switching angle. This is based upon an ambient temperature of 25°C.

12.37 TORQUE CHARACTERISTICS OF POLYPHASE SMALL MOTORS

The breakdown torque of a general-purpose polyphase squirrel-cage small motor, with rated voltage and frequency applied, shall be not less than 140 percent of the breakdown torque of a single-phase general-purpose small motor of the same horsepower and speed rating given in 12.32.

NOTE—The speed at breakdown torque is ordinarily much lower in small polyphase motors than in small single-phase motors. Higher breakdown torques are required for polyphase motors so that polyphase and single-phase motors will have interchangeable running characteristics, rating for rating, when applied to normal single-phase motor loads.

12.38 LOCKED-ROTOR TORQUE OF SINGLE-SPEED POLYPHASE SQUIRREL-CAGE MEDIUM MOTORS WITH CONTINUOUS RATINGS

12.38.1 Design A and B Motors

The locked-rotor torque of Design A and B, 60- and 50-hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the values shown in Table 12-2 which are expressed in percent of full-load torque. For applications involving higher torque requirements, see 12.38.2 and 12.38.3 for locked-rotor torque values for Design C and D motors.

ADJUST LOCKED ROTOR (T_A) TORQUE BY $(V_{PU})^2$ IF T'_{AC} IS

Table 12-2
LOCKED-ROTOR TORQUE OF DESIGN A AND B, 60- AND 50-HERTZ SINGLE-SPEED POLYPHASE SQUIRREL-CAGE MEDIUM MOTORS

	Synchronous Speed, Rpm							
	60 Hertz	3600	1800	1200	900	720	600	514
Hp	50 Hertz	3000	1500	1000	750	...	...	...
1/2		...	...	...	140	140	115	110
3/4		...	...	175	135	135	115	110
1		...	275	170	135	135	115	110
1-1/2		175	250	165	130	130	115	110
2		170	235	160	130	125	115	110
3		160	215	155	130	125	115	110
5		150	185	150	130	125	115	110
7-1/2		140	175	150	125	120	115	110
10		135	165	150	125	120	115	110
15		130	160	140	125	120	115	110
20		130	150	135	125	120	115	110
25		130	150	135	125	120	115	110
30		130	150	135	125	120	115	110
40		125	140	135	125	120	115	110
50		120	140	135	125	120	115	110
60		120	140	135	125	120	115	110
75		105	140	135	125	120	115	110
100		105	125	125	125	120	115	110
125		100	110	125	120	115	115	110
150		100	110	120	120	115	115	...
200		100	100	120	120	115	...	...
250		70	80	100	100	...	...	...
300		70	80	100	...	...	...	...
350		70	80	100	...	...	...	...
400		70	80	...	...	...	...	...
450		70	80	...	...	...	...	...
500		70	80	...	...	...	...	...

12.38.2 Design C Motors

The locked-rotor torque of Design C, 60- and 50-hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the values shown in Table 12-3 which are expressed in percent of full-load torque.

Table 12-3
LOCKED-ROTOR TORQUE OF DESIGN C MOTORS

	Synchronous Speed, Rpm			
	60 Hz	1800	1200	900
Hp	50 Hz	1500	1000	750
1		285	255	225
1.5		285	250	225
2		285	250	225
3		270	250	225
5		255	250	225
7.5		250	225	200
10		250	225	200
15		225	210	200
20-200 Inclusive		200	200	200

TYPICAL: WHY, SLIP ... ?

12.38.3 Design D Motors

The locked-rotor torque of Design D, 60- and 50-hertz, 4-, 6-, and 8-pole, single-speed polyphase squirrel-cage medium motors rated 150 horsepower and smaller, with rated voltage and frequency applied, shall be not less than 275 percent, expressed in percent of full-load torque.

12.39 BREAKDOWN TORQUE OF SINGLE-SPEED POLYPHASE SQUIRREL-CAGE MEDIUM MOTORS WITH CONTINUOUS RATINGS

12.39.1 Design A and B Motors

The breakdown torque of Design A and B, 60- and 50-hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

	Synchronous Speed, Rpm							
	60 Hertz	3600	1800	1200	900	720	600	514
Hp	50 Hertz	3000	1500	1000	750	...	...	...
1/2		...	...	...	225	200	200	200
3/4		...	...	275	220	200	200	200
1		...	300	265	215	200	200	200
1-1/2		250	280	250	210	200	200	200
2		240	270	240	210	200	200	200
3		230	250	230	205	200	200	200
5		215	225	215	205	200	200	200
7-1/2		200	215	205	200	200	200	200
10-125, inclusive		200	200	200	200	200	200	200
150		200	200	200	200	200	200	...
200		200	200	200	200	200	...	...
250		175	175	175	175	...	...	...
300-350		175	175	175	...	...	...	...
400-500, inclusive		175	175	...	...	...	...	...

12.39.2 Design C Motors

The breakdown torque of Design C, 60- and 50-hertz, single-speed polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

	Synchronous Speed, Rpm			
	60 Hz	1800	1200	900
Hp	50 Hz	1500	1000	750
1		200	225	200
1-1/2		200	225	200
2		200	225	200
3		200	225	200
5		200	200	200
7-1/2-20		200	190	190
25-200 Inclusive		190	190	190

FANS SIMILAR BUT SCALE BY THE CUBE

MOTOR AND LOAD TORQUE SCALE TOGETHER

12.40 PULL-UP TORQUE OF SINGLE-SPEED POLYPHASE SQUIRREL-CAGE MEDIUM MOTORS WITH CONTINUOUS RATINGS

12.40.1 Design A and B Motors

The pull-up torque of Design A and B, single-speed, polyphase squirrel-cage medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

	Synchronous Speed, Rpm							
	60 Hertz	3600	1800	1200	900	720	600	514
Hp	50 Hertz	3000	1500	1000	750	...	...	...
1/2		...	...	...	100	100	100	100
3/4		...	...	120	100	100	100	100
1		...	190	120	100	100	100	100
1-1/2		120	175	115	100	100	100	100
2		120	165	110	100	100	100	100
3		110	150	110	100	100	100	100
5		105	130	105	100	100	100	100
7-1/2		100	120	105	100	100	100	100
10		100	115	105	100	100	100	100
15		100	110	100	100	100	100	100
20		100	105	100	100	100	100	100
25		100	105	100	100	100	100	100
30		100	105	100	100	100	100	100
40		100	100	100	100	100	100	100
50		100	100	100	100	100	100	100
60		100	100	100	100	100	100	100
75		95	100	100	100	100	100	100
100		95	100	100	100	100	100	100
125		90	100	100	100	100	100	100
150		90	100	100	100	100	100	...
200		90	90	100	100	100	...	...
250		65	75	90	90	...	...	...
300		65	75	90	...	...	...	...
350		65	75	90	...	...	...	...
400		65	75	...	...	...	...	...
450		65	75	...	...	...	...	...
500		65	75	...	...	...	...	...

12.40.2 Design C Motors

The pull-up torque of Design C motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

	Synchronous Speed, Rpm			
	60 Hz	1800	1200	900
Hp	50 Hz	1500	1000	750
1		195	180	165
1-1/2		195	175	160
2		195	175	160
3		180	175	160
5		180	175	160
7-1/2		175	165	150
10		175	165	150
15		165	150	140
20		165	150	140
25		150	150	140
30		150	150	140
40		150	150	140
50		150	150	140
60		140	140	140
75		140	140	140
100		140	140	140
125		140	140	140
150		140	140	140
200		140	140	140

12.41 BREAKDOWN TORQUE OF POLYPHASE WOUND-ROTOR MEDIUM MOTORS WITH CONTINUOUS RATINGS

The breakdown torques of 60- and 50-hertz, polyphase wound-rotor medium motors, with rated voltage and frequency applied, shall be not less than the following values which are expressed in percent of full-load torque:

	Breakdown Torque, Percent of Full-Load Torque			
	Synchronous Speed, Rpm			
	60 Hz	1800	1200	900
Hp	50 Hz	1500	100	750
1		...	...	250
1½		...	...	250
2		275	275	250
3		275	275	250
5		275	275	250
7½		275	275	225
10		275	250	225
15		250	225	225
20-200 Inclusive		225	225	225

20.9.4 Motors with 60- and 50-hertz ratings shall be marked with a code letter designating the locked-rotor kVA per horsepower on 60 Hertz.

20.9.5 Part-winding-start motors shall be marked with a code letter designating the locked-rotor kVA per horsepower that is based upon the locked-rotor current for the full winding of the motor.

20.10 TORQUE

20.10.1 Standard Torque

The torques, with rated voltage and frequency applied, shall be not less than the following:

Torques	Percent of Rated Full-Load Torque
Locked-rotor*	60
Pull-up*	60
Breakdown*	175
Pushover**	175

*Applies to squirrel-cage induction motors or induction generators when specified for self-starting

**Applies to squirrel-cage induction generators

In addition, the developed torque at any speed up to that at which breakdown occurs, with starting conditions as specified in 20.14.2, shall be higher than the torque obtained from a curve that varies as the square of the speed and is equal to 100 percent of rated full-load torque at rated speed by at least 10 percent of the rated full-load torque.

20.10.2 High Torque

When specified, the torques with rated voltage and frequency applied, shall not be less than the following:

Torques	Percent of Rated Full-load Torque
Locked-rotor	200
Pull-up	150
Breakdown	190

In addition, the developed torque at any speed up to that at which breakdown occurs, with starting conditions as specified in 20.14.2, shall be higher than the torque obtained from a curve that has a constant 100 percent of rated full-load torque from zero speed to rated speed, by at least 10 percent of the rated full-load torque.

20.11 LOAD WK^2 FOR POLYPHASE SQUIRREL-CAGE INDUCTION MOTORS

Table 20-1 lists load Wk^2 which polyphase squirrel-cage motors having performance characteristics in accordance with this Part 20 can accelerate without injurious temperature rise provided that the connected load has a speed characteristic torque according to 20.10.1. For torque-speed characteristics according to 20.10.2 maximum load Wk^2 shall be 50 percent of the values listed in Table 20-1.

The values of Wk^2 of connected load given in Table 20-1 were calculated from the following formula:

$$\text{Load } Wk^2 = A\left[\frac{Hp^{0.95}}{\left(\frac{RPM}{1000}\right)^{2.4}}\right] - 0.0685\left[\frac{Hp^{1.5}}{\left(\frac{RPM}{1000}\right)^{1.8}}\right]$$

Calc 9000041185-000-00
Legacy 357T-DC
Attachment F

Montoya, Ariel

From: Farmer, Ronnie [RFARMER@TRANE.COM]
Sent: Thursday, February 09, 2012 6:14 AM
To: Hantman, David E
Cc: Moore, Bobby
Subject: RE: Trane Web Site Feedback

David,
Suggest you contact Bobby with our QC group.

From: Hantman, David E [mailto:DEHf@pge.com]
Sent: Wednesday, February 08, 2012 5:00 PM
To: Farmer, Ronnie
Cc: Montoya, Ariel; Singh, Harinder
Subject: RE: Trane Web Site Feedback R1

Ronnie,
Thank you for your information. Can you provide me with a contact at the Charlotte location?
David

From: Farmer, Ronnie [mailto:RFARMER@TRANE.COM]
Sent: Wednesday, February 08, 2012 1:35 PM
To: Hantman, David E
Cc: Auby, Dick; Foster, Anna; Kotike, Murthy; Moore, Bobby
Subject: RE: Trane Web Site Feedback

David,
Model and serial numbers are Charlotte remanufactured model F compressors. 13th digit indicates you have standard compressors and they start with 2 cylinders loaded then other 4 load as needed. For your other questions you will need to work with Charlottes QC group.

From: support@trane.com [mailto:support@trane.com]
Sent: Wednesday, February 08, 2012 12:42 PM
To: Trane TCS Customer Service
Subject: Trane Web Site Feedback

Name: David Hantman. P.E.
Address:
Address:
City: Avila Beach,
State: CA
Zip: 93424
County/Parish:
Country: USA
Daytime Phone: 805 545 6129
Fax:
E-mail: dehf@pge.com
Model 1: CRHF300B4B0P0R2G1B0
Serial 1: N00G05309

Model 2: CRHF300B4B0P0R2G1B0
Serial 2: N06J15106
Model 3: CRHF300B4B0P0R2G1B0 R1
Serial 1: N05115586
Comments:
We are doing a study for operation at degraded voltage for a time limited period to determine the performance (margin to trip) of the thermal overload protection for our HVAC compressors. For the hermetic compressors listed above, (please include additional serial number N02F09244, model number CRHF300B4B0P0R2G1B0), please provide the mass moment of inertia for the rotating element. We David Hantmanalso are interested to know whether these compressors start unloaded, and what the expected full voltage starting transient time is. The compressors are designated to have HF & HFC Suction unloading, and are not part winding start, (e.g. full winding is energized at t= 0). Please call with comments or questions. Thank you,

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Attachment 3
Calculation 9000032529-0-0, Fuse Adequacy Analysis Methodology

PACIFIC GAS AND ELECTRIC COMPANY
DESIGN CALCULATION COVER SHEET

File No. :
Calculation No.: 333-DC, SECTION "D"

/_/ Preliminary   /X/ Final

Project: DIABLO CANYON UNIT 1 AND 2   Date :
Engineering Discipline:

Structure, System or Component:

Type or Purpose of Calculation: Fuse Selection Criteria

No. of Sheets: 113 (calc) + one cover sheet (page i) = 114

Computer Program Name :	N/A	Version :	
PC Model :	↓	Serial No. :	
Hard Disk File Name (If Applicable) :	↓	Date of Last File Change :	
Floppy Diskette Control No. (If Applicable) :	N/A	Date of Last Validation :	

	Signature	Discipline/Dept.	Date
PREPARER	Sunil Roy	NES-EE	6/15/93
CHECKER	Gira Bhatt *Check Method: B	NES-EE	6/16/93
APPROVAL	M.K. Hentschel Discipline Engineer (If required)		
GROUP SUPERVISOR	[signature] for	NES-EE	6/21/93

For civil calculation, enter the registered engineer's stamp or seal and expiration date of certificate or authority in this space.

For other calculation, enter the registered engineer's full name and registration number, or stamp, or seal in this space.

REGISTERED PROFESSIONAL ENGINEER
MRINMOY BASU
No. E12314
ELECTRICAL
STATE OF CALIFORNIA

REV	REGISTERED ENGINEER	SIGNATURE	CA REG NO	EXP DATE
0	MRINMOY BASU	[signature]	E12314	12/31/94

RECORDS OF REVISIONS

Revision Number	Date	Reasons for Revision	Rev. By	Checked By	*Check Method	Approval Engr.	Approval Grp Supvr.
0	6/21/93	ISSUED FOR USE	S. ROY	G. BHATT	B	[initials]	[signature]

*A - Alternate Calculation (Note added pages)
B - Detailed Check
C - Critical Point Check

CALCULATION NO. 333-DC

SECTION	DESCRIPTION	REMARKS/REV
SECTION 0	FUSE SELECTION CRITERIA	ISSUED/0
SECTION I	ADEQUACY ANALYSIS FOR CLASS -1E FUSES FOR UNIT 1	LATER
SECTOIN II	ADEQUACY ANALYSIS FOR CLASS -1E FUSES FOR UNIT 2	LATER
Section III	COORDINATION STUDY (FUSE/BREAKER TCC CURVES) FOR UNIT 1	LATER
Section IV	COORDINATION STUDY (FUSE/BREAKER TCC CURVES) FOR UNIT 2	LATER

NOTE: EACH SECTION OF THIS CALCULATION IS ISSUED AND MAINTAINED SEPARATELY

FUSE SELECTION CRITERIA

TABLE OF CONTENTS

FUSE SELECTION CRITERIA

1.0 PURPOSE:

(B) Based on the existing fuse selection procedures, develop formalized fuse selection criteria for Class 1E fuses per item (B) applications. Selection criteria will be documented under Section "0" (zero) of the calculation.

Update drawing numbers in this section →

The DCPP Class 1E systems, as presently configured, contain approximately 5500 fuses. These fuses are listed on a dedicated drawing no. 064740 for Unit # 1 and 064741 for Unit # 2. Based on the formalized criteria, evaluate adequacy of the existing Class 1E fuses under worst case loads, and voltage (high, and degraded voltage) conditions for the following applications:

(1) Control circuits
(2) Instrument circuits
(3) Cable protection - main, feeder, and branch circuit protection
(4) Equipment protection - transformers, motors, breakers, and electrical devices
(5) Isolation circuits
(6) Containment penetration protection
(7) Appendix "R" circuits
(8) Battery and battery charger (UPS system)

(C) Per above analysis (item B), where required, recommend replacement fuses.

(d) Adequacy analysis for Unit 1 and Unit 2 will be documented under Section I and Section II, respectively. Section III and Section IV will be used to document Coordination Study (fuse/breaker TCC curves) for Unit 1 and Unit 2, respectively. Summary of adequacy analysis for Unit 1 and Unit 2 will be reflected on the updated Fuse List drawings #064740 (Unit 1) and #064741 (Unit 2).

2.0 SCOPE:

2.1 All Class 1E fuses shown on fuse list drawings # 064740 and # 064741 (Unit 1, and 2, respectively) will be considered for the adequacy analysis except the following:

(1) Fuses, which were sized by the vendor for his equipment. These fuses will be categorized as "V". If required, coordination studies will be performed for such fuses.

(2) Fuses, which are used for maintenance purpose and do not perform any overcurrent protection function, will be categorized as "M".

3.0 FUSE CATEGORIES:

The following are the categories and description of the fuse applications which are listed under Section 1.0 (B).

(A) CONTROL CIRCUITS:

These circuits are used for the control of devices or equipment such as breakers or motors. 120 volt AC control circuits could be with or without transformers. Fuses used for the above circuits including transformer will be categorized as "CC" fuses.

(B) INSTRUMENT CIRCUITS:

These circuits are used for connecting instruments, computer interface circuits, transducer (I & C) loops, alarms, and electronic/electrical devices for measurement purposes. Fuses used for the above circuits including transformer will be categorized as "I" fuses.

(C) CABLE PROTECTION:

Fuses used for protection of main, feeder, and branch circuits (cable) will be categorized as "CAP" fuses.

(D) EQUIPMENT PROTECTION:

Fuses used for the protection of the electrical equipment e.g. motors, transformers, generators, will be categorized as "EQP" fuses.

(E) ISOLATION CIRCUITS:

These Non-Class 1E circuits are connected to Class 1E circuits through isolation fuses. Fuses are used to isolate Class 1E circuits from the Non-Class 1E circuits. Fuses used for the isolation circuits with or without interfacing electrical devices will be categorized as "ISO" fuses.

(F) CONTAINMENT PENETRATION CIRCUITS:

Fuses used for the protection of the containment penetration and cable will be categorized as "CPC" fuses.

(G) APPENDIX "R" CIRCUITS:

Circuits which are essential for the operation of a safe shutdown components are identified as Appendix "R" circuits. Since all safe shutdown circuit fuses will be covered for coordination under categories "A" through "F" Appendix "R" circuit fuses will not be categorized.

4.0 FUSE TERMS AND DEFINITIONS:

Arcing Time:

The arcing time of a fuse is the time elapsing from the melting of the current-responsive element to the final interruption of the circuit.

Clearing I^2t:

Clearing I^2t is a measure of the let-through energy in terms of current and time. I^2t is calculated in ampere-squared- seconds. "I" stands for effective let-through current (RMS), and "t" stands for the time of opening in seconds.

Clearing Time:

The total time between the beginning of the specified overcurrent and the final interruption of the circuit at rated voltage. It is the sum of the minimum melting time plus the tolerance and arcing time. For clearing times in excess of half cycle, the clearing time is substantially the maximum melting time for low voltage fuses.

Current-Limiting Fuses:

- Peak let-through current

It is the maximum instantaneous current through a current limiting fuse during the total clearing time. This peak let-through current will be less than the peak current available without a fuse in the circuit if the fault level is high enough for it to operate in its current limiting mode.

- Threshold current

The magnitude of current at which a fuse becomes current-limiting, specifically the symmetrical RMS available current at the threshold of the current limiting range where the fuse total clearing time is less than half cycle at rated voltage and rated frequency. The threshold ratio is the relationship of the threshold current to the fuse's continuous current rating.

Fuse Classes G, J, L, R, CC, and T are labeled by UL as current limiting fuses, although Class K fuses are, in fact, current limiting.

Dual-Element Fuses:

A dual-element fuse is a fuse having a current-responsive of two different fusing characteristics in series in a single cartridge. These fuses can carry five times rated current for a minimum of ten seconds for Class H, K, J, and R fuses. The other element of these fuses is designed to carry larger current without intentional time delay.

Interrupting Rating:

A rating based upon the highest RMS alternating current that the fuse is required to interrupt under the conditions specified.

Melting Time:

Melting time of a fuse is time required for the current to melt the current-responsive element.

Opening time:

Opening time is the total clearing time at reduced voltage.

Voltage Rating:

The RMS alternating current (or the direct current) voltage for which the fuse is designed to operate. All low voltage fuses will function on any lower voltage but use on higher voltages than rated is hazardous. For high short circuit currents the magnitude of applied voltage will affect the arcing and clearing times and increase the clearing I^2t values.

5.0 LV FUSE (0-600V) CLASSES:

The various UL clarifications for low-voltage fuses (600V or less) are listed below.

Class CC Fuses:

A very small, high performance, 600 V, 200,000 Ampere interrupting rating, branch circuit fuses with overall dimensions of 13/32" x 1-1/2". Their design incorporates rejection feature that allow them to be inserted into rejection fuse holders and fuse blocks that reject all lower voltage, lower interrupting rating 13/32" x 1-1/2" fuses.

Class G Fuses:

300 V, 100,000 ampere interrupting rating branch circuit fuses that are designed with rejecting feature to eliminate overfusing.

Class H Fuses:

Cartridge fuses were formerly known as "NEC-dimensioned fuses". Class H fuses are tested and listed by UL under their Standard ANSI/UL 198B-1982 in 250 and 600 V ratings with interrupting capabilities of 10,000 A. Class H fuses are not marked as current-limiting. UL standards for Class H fuses have a time-delay requirement of at least 10 s opening time at five times rating in order to have the words "time delay" on the label.

Class J Fuses:

These fuses are rated to interrupt 200,000 A ac and meet the standards of UL for Class J fuses. They are UL-labeled as "current limiting," are rated only for 600 volt (or less) ac, and of dimensions not interchangeable with other classes. Class J fuses that have a time delay of at least 10 s opening time at five times the rated current may have the words "time delay" on the label.

Class K Fuses:

These fuses meet ANSI/UL 198D-1982 of Underwriters Laboratories, Inc, Class K as either K-1, K-5, or K-9. These standards have prescribed values for maximum peak let-through current and I^2t for each subclass, with K-1 having the lowest (most restrictive) values and Class K-9 having the highest (least restrictive) values. Dimensionally the same as Class H fuses, these fuses have no UL-recognized "rejection feature." Their ac interrupting rating appears on the labels as 50 000, 100,000 or 200,000 A. They are not labeled as "current limiting." The words "time delay," "dual element," letter "D," or phrase of similar significance on the label will indicate the manufacturer has met UL's optional testing for this feature. The use of Class K fuses permits equipment and circuits to be applied on systems having potential fault currents in excess of 10,000 A. Some hazards may exist in that they can be replaced by Class H fuses by uninformed personnel under present standards.

Class L Fuses:

These fuses meet ANSI/UL 198C-1981 of Underwriters Laboratories, Inc, Class L fuses, have ratings in the range of 601-6000 A, are rated to interrupt 200,000 A ac, are rated only for 600 volt or less, and are of specified dimensions larger than those of other fuses rated 600 V (or less). They are intended to be bolted to bus bars and are not used in clips. UL has no definition of time delay for Class L fuses; however, many Class L fuses have substantial overload time-current carrying capability. Class L fuses do not include 250 V ratings, dc testing, or dc ratings.

Class R Fuses:

These fuses meet ANSI/UL 198E-1981 of Underwriters Laboratories, Inc, for Class R as either RK-1 or RK-5. Their interrupting ratings are 200,000 A ac. The standard prescribed values for maximum peak let-through currents, I^2t and threshold current, with subclass RK-1 having the lowest (most restrictive) values as compared to subclass RK_5. These fuses have dimensions that provide a one-way physical rejection feature, that is, no other class of fuse will fit into equipment designed to employ Class R fuses; however, Class R fuses can be installed in older Class H or Class K equipment as replacement to upgrade these systems to the maximum allowed by other devices in the system. Class R fuses are available with or without time delay. If marked "time delay" or similar phrase, they are required to have a minimum opening time of 10 when subjected to a load of five times rated current.

6.0 MEDIUM VOLTAGE (2.4 KV - 34.5 KV) FUSES:

As per present design approach, medium voltage fuses are used only in the primary circuits of the voltage transformers. Current limiting power fuses, Types EJ-1 and EJO-1 of General Electric are used for the protection of the voltage transformers. These E-rated fuses are classified as general purpose fuses. Fuses rated 100E or less open in 300 seconds at current between 200% and 240% of their E ratings. Fuses rated more than 100E open in 600 seconds at currents between 220% and 264% of their E ratings.

7.0 TIME-CURRENT CHARACTERISTIC (TCC) CURVES:

Time-Current Characteristic Curves are intended to show the relationship between various overcurrent values and some opening function of the fuse. Average melting time is assumed to be represented unless otherwise stated. Average current is defined as being subject to a maximum tolerance of plus or minus 10% in current for any given time. Thus, minimum melting current is approximately 10% less than average. In times of approximately 0.1 s or more, maximum melting time is virtually the same as total clearing time. For times between 0.1 s and 0.01 s total clearing time is relatively greater than melting time due to greater percentage of arcing time. For period of less than 0.01 s, the melting time may be as little as half the clearing time. In these short time periods, I^2t becomes of increasing importance. (Ref. 2)

8.0 ASSUMPTIONS:

8.1 Control circuit conductors are generally lightly loaded (less than 50%). It is assumed, therefore, that conductor temperature inside switchgear/MCC should be 10°C above an ambient of 40°C.

8.2 Based on the Table 4.3-14, DCM T-22(Ref.10), a correction factor of 0.80 is assumed for cable ampacity in trays going through fire stop.

8.3 As per ANSI C57-12-00, 1973, dry type transformer shall be capable of withstanding short circuit without any mechanical or thermal stress provided the magnitude and the duration of the short-circuit current are limited as shown below:

A. The magnitude of the RMS symmetrical current in any winding of the transformer does not exceed 25 times the base current of the winding.

B. The duration and magnitude of the short circuit is limited to the time periods shown below. Intermediate value may be determined by interpolation.

RMS SYM. CURRENT IN ANY WINDING	TIME PERIOD IN SECONDS
25 TIMES BASE CURRENT	2
20 TIMES BASE CURRENT	3
16.6 TIMES BASE CURRENT	4
14.3 TIMES OR LESS TIMES BASE CURRENT	5

Above criteria is true for power transformer. However this criteria will be used as an assumption for other transformers. (Note: ANSI point as specified in Table 10.4 may be used in lieu of this assumption).

8.4 Existing control transformer loads are within the VA rating of the control transformer.

8.5 For control transformer secondary circuit, as a minimum, consider inrush current of one starter coil along with one auxiliary relay provided no other loads (ie motors, heaters) are part of the circuit.

8.6 Cable

8.6.1 Cable impedance will be assumed per attachment No. 15.

8.6.2 Since DCPP uses minimum cable size of #16 AWG, it is assumed per attachment No. 13, that fuse size equal to or less than 6 Amp will provide adequate cable protection to the minimum cable size used in the circuit.

8.7 The fuse-time characteristics shown on the coordination curves are either melting or clearing time curves depending on the availability of the vendor information. Since sufficient margin exists between the fuse and the upstream device curves, the use of fuse melting TCC curve will not jeopardize coordination.

8.8 For inductive load, in lieu of actual data, assume inrush current equal to 10 times full load current at 0.1 second. This assumption is based on the setting of the thermal-magnetic breaker.

8.9 For calculation purpose, where equipment rating can not be obtained either by walkdown or from the drawings, data available for similar equipment manufactured by the same vendor may be assumed. Calculation will be revised later per actual data.

9.0 BASIC FUSE SELECTION CRITERIA:

Fuse selection for the given application shall fulfill the following requirements.

9.1 Quality Class

Fuses shall be of quality Class 1E for all Class 1E applications or where required by other regulatory requirements. Fuses shall be installed in seismically qualified structures. Commercial grade fuses shall be dedicated for Class 1E application.

9.2 Protection

A good axiom in selecting a fuse fit into an overcurrent protective scheme is to select smallest fuse size that will provide the followings. (Ref. 2)

9.2.1 Under worst possible scenario, fuse shall carry the maximum continuous current and inrush or accelerating current of the connected loads without fuse melting.

9.2.2 Open the circuit on an abnormal load or fault in a time less than the average time of the wire, cable, or equipment protected. For cable protection criteria see section 9.8 of this document.

9.2.3 Coordination with the upstream fuses or circuit breakers, when required. For coordination criteria, refer to section 9.9 of this document.

9.3 Minimum Protection

As a minimum, fuse shall be sized properly to provide 100% short circuit protection to the equipment and cable. This minimum requirement is applicable only when higher size fuse selection is necessary to avoid nuisance fuse blow in favor of completing safety function.

9.4 Fuse Interrupting Rating

Fuse interrupting rating shall be greater than maximum fault current available as indicated in Attachment No. 1.

9.5 Fuse Voltage Rating

Fuse voltage rating shall be greater than the maximum operating voltage that fuse will experience. 125 v dc system shall use fuse voltage rating of 250 v dc.

9.6 Ambient Temperature

Ambient Temperature can greatly affect the current rating of the fuse. Hence, a temperature correction factor shall be used per vendor's instructions for the correct fuse size, at the given location. For Bussmann fuse, use a correction factor of 1.1 at 50 C for dual element (time delay) fuse and 1.04 for all other types of fuses. See Attachment No. 10.

9.7 Fault Current

The following fault current locations shall be considered for coordination with the upstream overcurrent protective devices. See attachment No.1 to determine available fault current.

(A) For selective coordination between feeder fuse and upstream overcurrent device, consider fault current at the fuse terminals or the bus.

(B) For selective coordination between molded case breaker and branch fuse, consider fault current at the load end.

(C) For coordination requirement of Appendix 'R' circuits, consider fault current at the Appendix 'R' fire location.

9.8 Cable Protection

(1) Ampacity of cable outside containment shall be based upon 40 °C ambient temperature. (Ref. 10)

(2) Ampacity of cables inside containment shall be based upon 50 °C ambient temperature. (Ref. 10)

(3) Ampacity of cables in underground cable duct shall be based upon 20 °C ambient temperature. (Ref. 10)

(4) The following cable temperature shall be used for the determination of cable ampacity. (Ref. 10)

(1) continuous loading 90 °C
(2) emergency loading 130 °C
(3) short-circuit loading 250 °C

(5) In lieu of actual cable impedance data, use cable impedance data from Attachment No.15.

(6) Overload Protection

Fuse rating shall be based on the derated cable ampacity in the raceway times 0.80 fire stop derating factor Table 4.3-14, Reference 10. Without fire stop, the base ampacity and derating of the cable under different application shall be determined per Attachment No. 2.

Where the fuse size is required to be higher than the derated ampacity of the cable, as noted above, adequacy shall be evaluated such that fuse will blow at or below cable ampacity @ 120 °C per the following formula (Ref. 2).

$$\frac{I_E}{I_N}\% = \sqrt{\frac{\frac{T_E - T_O}{T_N - T_O} - \left(\frac{I_O}{I_N}\right)^2 \cdot e^{-\frac{t}{K}}}{1 - e^{-\frac{t}{K}}} \cdot \frac{230 + T_N}{230 + T_E}} \cdot 100 \qquad (1)$$

where,

I_E	=	emergency operating current
I_N	=	normal current rating
I_O	=	operating current prior to emergency
T_E	=	conductor emergency operating temperature of 120 °C
T_N	=	conductor normal operating temperature of 90 °C

T_o = ambient temperature
t = emergency loading in hours in the given formula

K = a constant, determine constant K from the attachment No. 16.
230 = zero resistance temperature value (234 for copper, 238 for aluminum).
e = 2.7183 (base for natural logarithm)

For the existing installed cable with fire stop, use 80% of the derated ampacity values shown under 43+ cables: See attachment no.2, Tables 2.1 through 2.5.

(7) Short-Circuit Protection

For adequate short-circuit protection, Time-Current characteristic curve of the selected fuse shall be below and to the left of the cable thermal damage curve by the margin of at least 20%. Thermal damage curves for cables shall be plotted per Attachment No. 3.

9.9 Selective Coordination

Selective coordination means that the nearest overcurrent protective device to a fault will clear the overcurrent before any of the larger upstream overcurrent protective device begin to open or unlatch. Only the faulted circuit is isolated from the system by the nearest protective device, and the other parts of the system are not affected.

Current-limiting fuses can be selectively coordinated by maintaining at least a minimum ampere rating ratio between the line side fuse and load side fuse. These ampere rating ratios that should be maintained are shown in the "Selectivity Guide" as an Attachment No. 4 and 5 of this calculation.

Fuses are apparently much faster than the circuit breakers, especially when the fuses are smaller in continuous current rating than the circuit breaker. But in actual practice the system might prove to be non-selective, because the breaker functions on the magnetic effect of the short-circuit current such that the unlatching time of the circuit breaker is faster than the clearing time of the fast acting current limit. Thus it is probable the circuit breaker will unlatch while the fuse is clearing the fault and the system will not be selective.

Since total clearing time curves for fuses below 0.01 second and unlatching time for the molded case breaker are not commonly available, it will be difficult to ensure the load side fuse will open without unlatching the circuit breaker in the instantaneous region.

Based on the Attachment No. 6, the minimum unlatching time for the molded case breakers Frames "E" and "F" is as follows.

Average unlatching times for
Breaker tripping magnetically

Current RMS Amps	Time Seconds
1000	0.0080
3000	0.0042
5000	0.0032
10000	0.0023

The above data along with the fuse I^2t data will be used for the coordination study. In case where the value of the fault current is not above the current limiting mode of the selected fuses, for selectivity, there should be as much rating difference between the fuse (load) and breaker (line) as possible. In no case should the fuse be more than one-fourth the rating of the circuit breaker. The following criteria is based on the above discussion.

(1) Selectivity Between Line Side Fuse and Load Side Fuse

(a) For overload and short-circuit at the load end, selective coordination between fuses shall be selected such that the downstream (load) fuse's total clearing I^2t (melt and clear) shall be less than the upstream (line) fuse's minimum I^2t. All data used for I^2t must be supplied by the manufacturer and will apply only to his fuse types.

(b) In lieu of I^2t data, vendor's selectivity ratio guide may be used for his fuse types to obtain selective coordination. (See Attachment No. 4)

(c) Where fuses I^2t data is not available and line-load fuses are from different manufacturer, a typical selectivity ratio guide shown is Attachment No. 5 may be used as a last resort for selective coordination between fuses.

(2) Selectivity Between Molded Case Breaker (Line)/Fuse (Load)

(a) For short-circuit current (fault @ load end) in the current-limiting mode of the current limiting fuse and the instantaneous region of the breaker, current limiting fuse shall be sized such that the breaker unlatching time is greater than the fuse clearing time. The following breaker unlatching time shall be used. Following data has been taken from Attachment No. 6

Average unlatching times for
Breaker tripping magnetically

Current RMS Amps	Time Seconds
1000	0.0080
3000	0.0042
5000	0.0032
10000	0.0023

(b) For short-circuit current (fault at load end) not in the current-limiting mode of the current limiting fuses, for selective coordination below 0.01 second, select very fast acting current limiting fuse with breaker to fuse size ratio as large as possible, preferably above 8 and not less than 4. See Attachment No.9 .

(c) For "Non-Current Limiting" type fuse, use fuse I^2t data for selective coordination below 0.01 second, per item (a) above.

10.0 SPECIFIC FUSE SELECTION CRITERIA:

The following criteria shall be used for the selection of fuse size and type. Where coordination is required, fuse shall provide selective coordination per Section 9.9 of this calculation.

10.1 Non-motor Loads

(A) The minimum fuse size shall be calculated per the following formula.

$$\text{Fuse Size* (Minimum)} = 1.25 \times I_{load} \times T_{AC}$$

Where,

125% factor is used to account for the following:

- Voltage variation - 10%
- Tolerances - 10% (Ref. 2)
- Safety margin - 5%

I_{load} - Maximum Continuous Current under worst scenario.

T_{AC} - Temperature Correction factor per Vendor's instructions. For mild environment, use fuse ambient temperature of 50°C.

* Minimum fuse size: If calculated value is less than 1 amp, use 1 amp fuse as minimum fuse size, unless it is specified otherwise by the vendor.

(B) For high inrush current, time delay or dual element type fuse is preferred.

(C) For Non-chattering inductive load (for example, transformers, induction type relays, etc.), fuse shall be sized to carry at least 1.8 times inrush current at rated voltage for devices energizing at the same time, for time greater than 0.1 second.

(D) For chattering load (starter coils, solenoids, or hinged type electron mechanical devices) fuse shall be sized to carry inrush current for devices energizing at the same time for at least 15 seconds. The time delay of 15 seconds is based on the 12 kV motor acceleration time under degraded voltage condition. (See attachment No. 8 INPO SEN 80 and reference 7).

(E) Fuse shall clear minimum fault current of the circuit per the requirement of the Section 9.7.

(F) In lieu of inrush current data, fuse shall be sized as follows:

(1) Fast acting fuse shall be sized equal to or greater than 300% of the rated load.

(2) Dual element fuse shall be sized equal to or greater than 125% of the rated load.

10.2 <u>Motor Loads</u>

(A) Dual element fuse shall be selected for the motor overload protection. Minimum fuse size shall be determined as follows.

(1) Continuous duty with service factor 1.15 and temperature rise not over 40 °C, fuse shall be sized at 125% of full load current or next higher standard size.

(2) Continuous duty motor with service factor less than 1.15 and temperature rise not over 40 °C fuse shall be sized at 115% of full loads current or next larger standard size.

(B) Temperature Correction Factor shall be used per vendor's instructions. For mild environment use ambient temperature at fuse location as 50°C.

(C) Fuse shall be sized to carry current equal to or greater than 175% of motor locked rotor current at rated voltage for greater than 1.0 second.

(D) Fuse shall be sized to carry motor locked rotor current at least 1.50 times greater than motor acceleration time. If acceleration time is not given, assume following data.

- General purpose motor - less than 15 seconds (assume 10 seconds)
- High inertia motor - between 15 to 30 seconds (Assume 20 seconds)

(E) Where the rating specified is not sufficient for the starting current of the motor:

(1) The rating of non-time-delay fuses not exceeding 600 amperes, may be increased but shall, in no case, exceed 400 percent of the full load current.

(2) The rating of a dual element fuses, may be increased but shall, in no case, exceed 225 percent of the full load current.

10.3 <u>Main Service, Feeder and Branch Circuit Protection</u>

At DCPP, main service and feeder circuits are protected by the circuit breakers except for DC Battery circuits. The main service fuse protection for the battery is discussed under section 10.11 "Battery Fuses". At present fuses are used for branch circuit protection only. Fuse size determined by the following criteria shall be further modified by a factor of 1.15 to account for the safety margin and the temperature correction factor. (Ref. 4).

*(A) **Dual-Element Time-Delay Fuses**

1. <u>Feeder Circuits With No Motor Loads</u>

The fuse size must be at least 125% of the continuous load plus 100% of the non-continuous load. Fuse must not be sized larger than conductor ampacity.

2. Feeder Circuit With All Motor Loads

Fuse must be sized at 150% of the full load current of the largest motor plus the full load current of all motors.

3. Feeder Circuit With Mixed Loads

a. 150% of the full load current of the largest motor +
b. 100% of the full load current of all other motors +
c. 125% of the continuous non-motor load +
d. 100% of the non-continuous, non-motor load.

4. Branch Circuit With No Motor Load

The fuse size must be at least 125% of the continuous load plus 100% of the non-continuous load. Fuse must not be sized larger than conductor ampacity.

6. Motor Branch Circuit with Overload Relays

Where overload relays are sized for motor running overload protection, the following provide backup, ground fault, and short circuit protection:

a. Motor 1.15 service factor or 40°C rise:

Size the fuse at 125% of motor full-load current or the next higher standard size.

b. Motor less than 1.15 service factor or over 40°C rise:

Size the fuse at 115% of the full-load current or the next higher standard size.

7. Motor Branch Circuit With Fuse Protection Only

Where the fuse is the only protection, the following criteria provides motor running overload protection and short circuit protection.

a. Motor 1.15 service factor or 40°C rise:

Size the fuse at 110% to 125% of motor full-load current.

b. Motor less than 1.15 service factor or over 40°C rise:

Size the fuse at 100% to 115% of the motor full-load current.

8. Large Motor Branch Circuit - Fuse larger than 600 amps.

For large motors, size the time-delay fuse at 150% to 225% of the motor full-load current, depending on the starting method; i.e. part winding starting, reduced voltage starting, etc.

*(B) **Non-Time-Delay Fuses**

1. Feeder Circuit With No Motor Loads

The fuse size must be at least 125% of the continuous load plus 100% of the non-continuous load. Fuse must not be sized larger than conductor ampacity.

2. Feeder Circuit With All Motor Loads
Fuse must be sized at 300% of the full load current of the largest motor plus the full load current of all other motors. Fuse must not be sized larger than conductor ampacity.

3. Feeder Circuit With Mixed Loads

a. 300% of the full load current of the largest motor +
b. 100% of the full load current of all other motors +
c. 125% of the continuous non-motor load +
d. 100% of the non-continuous, non-motor load.

4. Branch Circuit With No Motor Load

The fuse size must be at least 125% of the continuous load plus 100% of the non-continuous load. Fuse must not be sized larger than conductor ampacity.

5. <u>Motor Branch Circuit with Overload Relays</u>

The fuse must be sized as close to but not exceeding 300% of the motor running full load current. Provides ground fault and short circuit protection only.

6. <u>Motor Branch Circuit With Fuse Protection Only</u>

Non-time delay fuses cannot be sized close enough to provide motor running overload protection. If sized for motor overload protection, non-time-delay fuse would open due to motor starting current. Use dual-element fuses.

The following Table 10.1 shows the summary of the above criteria.

Table 10.1

Circuit Type	Load Description	Fuse Size (% of FLA **)	
		Time Delay	Non-Time Delay
A.*Feeder	1. Non-Motor Loads Notes 1 & 2	125% Cont. + 100% Non-Continuous.	125% Cont. + 100% Non-continuous.
	2. Motor Loads Notes 1 $ 2	150% of largest + all other motor FLA	300% of largest + all other motor FLA
	3. Motor & Non-motor Loads Notes 1 & 2	Sum of Items 1 & 2 above	Sum of Items 1 & 2 above
B.*Branch Circuit	1. Non-motor load Notes 1 & 2	125% of continuous + 100% Non-continuous	125% of Continuous + 100% Non-continuous

* Add 15% extra margin for safety and temperature correction factor to the fuse rating to avoid fuse

blowing.

** FLA = Full Load Amperes

NOTES:

1. Given values are minimum. The upper limit is the conductor ampacity.
2. If the required fuse size does not match a standard fuse size, use the next higher standard size.
3. Provides backup overload protection.
4. Does not provide backup overload protection.

5. All motors are assumed continuously running. For duty-cycle service motors use the FLA corresponding to its duty-cycle. Demand factors are excluded from the above table.

10.4 <u>Power Transformer</u>

Power transformer may have the fuses on the primary side or both primary and secondary sides. The selection of the fuses depends on transformer full load current, inrush current, and impedance. The fuses shall be sized in accordance with the following Table (Ref. 6)

Table 10.2

POWER TRANSFORMER FUSE PROTECTION TABLE
(VOLTAGE 600V)

<table>
<tr><th>IMPEDANCE</th><th>PRIMARY (600V)
FLA*</th><th>SECONDARY (600V)
FLA*</th></tr>
<tr><td>Any</td><td>125%
250%</td><td>None
125%</td></tr>
<tr><td>≤ 6%</td><td>600%</td><td rowspan="2">Integral Thermal Protector Provided By Manufacturer</td></tr>
<tr><td>> 6% ≤ 10%</td><td>400%</td></tr>
</table>

Also, the transformer full load current depends on the operating temperature. This effect should be taken into account in determining the transformer full load current.

Table 10.3

TRANSFORMER COOLING AND TEMPERATURE RISE FACTORS

Type	KVA Rating	Cooling		Temperature	
		Type	Factor	Ave. Rise	Factor
Dry	≤2500	AA	1.0	150°C	1.0
		AFA	1.3		

Table 10.4

TRANSFORMER SHORT-CIRCUIT POINT (ANSI POINT)
(≤500 KVA UNITS)

KVA	% TRANS. Z	MULTIPLES OF FLA IN ANY WINDING		TIME PERIOD IN SECONDS
		ΔΔ or YY CONNECT	ΔY CONNECT	
≤25 (1 ϕ) ≤75 (3 ϕ)	2.5 or less	40	23.2	0.78
≥37.5-100 (1 ϕ) ≥112.5-300 (3 ϕ)	2.8 or less 3	35 35.3	20.3 19.3	1.02 1.13
≤500 (1 ϕ) * ≤500 (3 ϕ) *	4 5 5.25 5.50 5.75 6.00	25 20 19 18.2 17.4 16.6	14.5 11.6 11.0 10.5 10.1 9.6	2.0 3.12 3.46 3.77 4.13 4.54

* For transformers 500 KVA and below, use the equation $I^2t=1250$, where I is the through fault current (in per unit) and t is the withstand time in sec. For ΔY connected transformers the withstand current is I x 0.58.

10.5 Control Circuits

Control circuit is a circuit of electrical control devices that carries a low energy signal for the operation of the connected devices.

For class-1 system, it is necessary that under all plant operating condition particularly under accident condition (LOCA), control circuit fuse should not blow due to high increase current, overload or elevated ambient temperature.

In addition to "Basic Selection Criteria," the following criteria shall be used.

(A) <u>Control circuit without control transformer</u>

(1) Determine fuse size per criteria given in sections 10.1 and 10.2.

(2) Fuse shall be sized to assure protection to the smallest size control cable per either Section 9.8 of this document or table shown below: Fuse size shall be lower than the size shown in the Table 10.5 for cable routed in a conduit without fire stops. (Ref. NEC 430-72(b), 1993).

Table 10.5

Control circuit conductor size AWG	Column A Amb. 40°C	Column B Amb. 50°C	Column C Amb. 40°C
	Acceptable Maximum Current in Amp	Acceptable Maximum Current in Amp	Cable and fuse inside the same enclosure and with ground fault protection Acceptable Current in Amp
16	10.0	9.0	40
14	11.3	10.0	100
12	13.5	12.0	120
10	18.0	16.0	160

(3) Fuse shall be sized to protect penetration cables per section 10.10 of this calculation.

(4) Fuse TCC curves shall be coordinated with the upstream protection device per section 9.9 of this document.

(B) <u>Control circuits with control transformer:</u>

Select fuse size per the following criteria. In some cases, higher size may be required than fuse size shown in the selection Table 10.6 below.

(1) Determine control transformer primary side fuse size per Table No. 10.6 and criteria given in section 10.1.

(2) Determine control transformer secondary side fuse size per Table No. 10.6 and criteria given in section 10.1.

(3) Fuse size selected based on the criteria (1) and (2) above shall clear minimum short circuit current fault at the load end within actual or assumed ANSI point. See section 8.3(B).

The above criteria is based on the following discussion:

For 100 VA control transformers, present fuse size of 6 amps is oversized to the extent that in some cases transformers will burn out before the fuse can blow under low secondary fault current. Attachment No. 7 shows the minimum fault current of 7.88 amps for 100 VA control transformer. 6 amp BAF fuse under such condition may take between 20 to 100 seconds to blow and will not protect the transformer against assumed ANSI point. To ensure that fuse on the secondary blow before transformer burns out under minimum short-circuit fault current, fuse shall be sized per actual or assumed ANSI point ($I^2t=1250$). See section 8.3 (B).

(4) Control circuit fuse shall be sized to assure the protection to the smallest size control and penetration cable. See sections 10.5(A)(2), 10.10 and 9.8.

(5) Wherever it is applicable, fuse TCC curves shall be coordinated with the upstream protection device per section 9.9 of this document.

The fuse selection table 10.6 for control or potential transformer is based on the reference 3. In the table, fuse size is given in percent (%) of the full load amps of the transformer where the calculated size is not a standard fuse size, use the next higher standard size.

Table 10.6

CONTROL TRANSFORMER FUSE PROTECTION TABLE

Voltage (Volts)	Primary		Secondary	
	FLA	Fuse Rating (%FLA)	FLA	Fuse Rating (%FLA) (600V or less)
	≥9	125		
	≥2, <9	167		No Fuse
< 600	<2	300		
		250	> 9	125
		250	< 9	167
> 600		250		No Fuse
		300		250 (% Z < 6%)
		300		225 (% Z > 6%, <10%)

Exception 1. Control transformer rated 50 VA or less, which is an integral part of a motor

controller and located within the controller enclosure, overcurrent protection is not required.

Exception 2. For motor control transformers, if the primary current is rated less than 2 amperes, a primary fuse rated at no higher than 500% is acceptable.

Exception 3. In applications such as in fire pump control circuits, where opening the circuit is hazardous, overcurrent protection may be omitted.

Exception 4. In most applications the Control Circuit Transformer (CCT) had no primary protection (with the exception of the motor branch circuit protection), but the secondary did utilize a small or "midget" fuse that provided protection of the secondary wiring and the possible overloading of the CCT. The system is safe and reliable as the transformer is not vulnerable to burn out as it is mounted inside the controller package. Hence, this approach was used to avoid nuisance primary circuit fuse blow in favor of completing class 1E safety function. This exception is acceptable for past applications.

Exception 5. When higher size fuse selection is necessary to avoid nuisance fuse blow under all plant operating modes, overload protection is sacrificed to some extent during fuse sizing. In such cases, fuse shall be sized per 80 % of actual or assumed transformer ANSI point to avoid control transformer burnout.

(C) <u>DC Control Circuit:</u>

(1) The preceding selection criteria is applicable to DC fuse selection except for inductive load inrush current.

(2) The DC voltage rating for fuse shall be 250V DC for 125V DC. System with maximum system operating voltage of 140V DC.

(3) For the control circuits of the medium voltage circuit breakers, fuse shall be sized to clear 1.50 times starting current of the spring charged motor + 100 percent of other connected loads for greater than 10 seconds.

10.6 Circuit Breaker protection

Circuit breakers protected by current limiting fuses may be applied in circuits where the available short circuit current exceeds the interrupting rating of the circuit breakers alone. The short circuit withstand data for circuit breakers can be compared to fuse let-through current values to determine the degree of protection provided. The circuit breaker and the fuse manufacturers should be contacted for proper application.

10.7 Instrument Circuit Protection

Fuse for Instrument Circuit shall be sized per the following criteria:

(1) Based on the load data, determine minimum fuse size requirements per Section 10.1.

(2) Based on the cable protection and coordination requirements, determine maximum allowable fuse size. See Section 9.8, 9.9, and 10.5 (B)(3).

(3) In order to avoid nuisance fuse blow and fuse wear and tear, it is common industry practice to use oversize fuses for the applications where overload is not present other than under fault conditions. Hence select fuse size requirement per criteria 10.7(1) and below maximum allowable fuse size requirements per criteria (2) above.

(4) For electronics and other vendor instruments, fuse size shall be sized per the vendor's instructions.

(5) When load data is not available, fuse shall be sized per assumed load data, criteria (2), and (3) above.

(6) Overcurrent protection shall not exceed 7 amperes for No. 18 conductors and 10 amperes for No. 16 (Ref. 5).

10.8 Appendix 'R' Circuits

Attachment 'B' to DCPP Calculation M-680 (Ref. 9) lists the components required for safe shutdown (SSD). The components are categorized as Hot Shutdown (HSD), Cold Shutdown (CSD), or Spurious Operating Equipment (SOE). The HSD and CSD are active components required to operate for bringing the plant to hot shutdown and cold shutdown respectively. An SOE is a passive component and is not required to operate for SSD of the plant. However, it must maintain its normal status for the SSD system to perform its intended function.

Each Appendix 'R' SSD circuit has two paths routed under two separate independent fire areas. Hence, in case of a given fire area, these two paths will function as an alternate to each other.

Under fire induced hot shorts, open circuits or short to ground, fuse shall be coordinated per the following criteria. Refer to Attachment No.1 of Electrical Procedure EE-2, Revision No.1.

(1) Multiple Branch Circuits

Safe shutdown and non-safe shutdown multiple branch circuits fed from the same upstream protective device, load side fuse shall open prior to the initiation of opening of any upstream device. In most cases, this will require selective coordination below 0.01 second in the instantaneous region due to breaker unlatching time below 0.01 second.

Criteria:

(A) For the short circuit current in the current limiting mode of the current limiting fuse, load side fuse shall be sized such that the breaker unlatching time is greater than the fuse opening time.

(B) For short circuit current not in the current limiting mode of the current limiting fuses, select fuse with ratio of breaker size to fuse size as large as possible but not less than four (4).

(2) Single Branch Circuit

For a single branch circuit, circuit will be damaged by a fire in the given area and will not be functional. For the same function, alternate shutdown path will be used. Hence, from Appendix 'R' view point, selective coordination between load side fuse and upstream protective device is not required for single branch circuit. However, standard coordination shall be provided at 0.01 second.

Criteria

For a single branch circuit, fuse shall be sized to be coordinated with the upstream protective device at and above 0.01 second.

10.9 Isolation Circuits

The original design of DCPP was based on a single failure criteria. To meet single failure criteria, safety related functions were designed with redundancy and electrical isolation such that no single credible failure could prevent completion of safety function during and following a design base accident.

DCPP is not committed to R.G. 1.75, separation and isolation requirements. However, R.G. 1.75 is used for design guidance where feasible on new designs (Reference 8). Hence, for adequacy analysis, following criteria will be used.

(A) Criteria for Existing Design:

(1) Isolation fuse shall have selective coordination between fuse and upstream overcurrent protective device for fault currents (short-circuit and shorts to ground at the load terminal per the requirements of Section 9.9.

(2) Fuse shall be selected such that fault on the non-class 1E side will clear quickly and will not degrade the operation of the Class 1E devices below an acceptable level.

(3) Fuse shall be sized to protect cable per the requirements of either Section 9.7, Cable protection, or Section 10.5, (A), (2).

(4) Fuse shall be sized to Protect load per the requirements of either Section 9.0, or 10.0 of this document.

(B) Criteria for New Design:

In addition to above criteria, the following criteria shall be used where feasible on new design.

(1) For AC circuits, provide two isolation fuses in series to provide redundancy.

(2) For DC circuits, provide one isolation fuse in positive leg and one in negative leg.

10.10 Containment Penetration

Regulatory guide 1.63 and IEEE-279 require that the overcurrent protection system automatically disconnect circuits passing through containment when currents exceed preset limits. These preset limits must not exceed the limit for which the penetration has been designed and qualified.

Each circuit, in every penetration, was analyzed to ensure its conformance with application procedures outlined in P.G.&E Rec. No. DC-663081-92-1, Appendix A (Attachment No.11), for both total penetration heating load and conductor continuous current carrying capacities: For Conax penetrations refer to Vendor Print V/P 663081-219, "Design Qualification Report for Electric Penetration Assemblies" Table 5.9.5. (See Att. No.12).

The penetration steady state heating load (Watts/Foot) and determination of allowable ampacity are shown in Attachment No.11. All electrical penetrations, 600 volt and below, at DCPP are 12 inches (nominal) in diameters for which the maximum permissible heat load is 25 Watts /foot at an ambient temperature of 50 °C. The maximum continuous ampacity of conductor was determined from Attachment No.11.

As per Qualification Test Documentation No. DC-663081-19-1, the current per conductor is less than 5% of that allowed by the National Electrical Code, Table 310-12, and there is no effective heating due to that conductor.

Hence, in such case, ambient temperature will be the temperature of the conductor under the normal condition.

The primary protection curves include penetration conductor time-current curves for an initial conductor temperature T_1 of at least 132 °C (270 °F) and a final conductor temperature T_2 of 171 °C (340 °F). The initial temperature T_1 is assumed to be at least equal to the LOCA peak containment temperature shown in Figure 6.2-6 of the FSAR. Where required, because of continuous operation of equipment, the initial penetration conductor temperature T_1 was increased to give a conservative allowance for normal current heat rise in the penetration conductors. The temperature rise due to continuous load current shall be determined per DCM No. T-22. The final temperature T_2 is the penetration qualification test temperature of 171 °C (340 °F) (See Reference 10).

The equation to calculate the conductor time-current curve under fault current is (Ref. 2).

$$t = \frac{0.0297 \times A^2}{I^2} \log \frac{T_2 + 234}{T_1 + 234} \qquad \textbf{(2)}$$

Where,

t = Time - Seconds
I = Current in Amperes
A = Conductor Area - Circular Mils
T_1 = Assumed initial conductor temperature
T_2 = Maximum allowable conductor temperature (171 °C)

The calculations are based upon the assumption that all heat generated by the current flowing through the conductor remains in the conductor. The maximum prefault penetration conductor temperature is equal to the peak LOCA temperature of 132 °C plus any temperature rise due continuous load current. For conductor current less than 5% of that allowed by the National Electric Code, it is assumed that initial temperature for the conductor will be same as the ambient temperature. The time-current curves for cables # 12 AWG through # 18 AWG under fault current and initial ambient temperature is shown in Attachment No. 13.

The document "Diablo Canyon Time-Current Values of Conductors in Containment Penetration" prepared by Julius Herbst, dated August 16, 1979, shows the penetration thermal limitations for the circuits which were determined by qualification tests. These results were used in the calculations 117-DC and 119-DC.

(A) Criteria for Existing Design

(1) The minimum current requirement to blow the fuse shall not exceed the derated continuous current capacity of the conductor. Determine conductor's derated ampacity per above guidelines.

(2) The maximum short circuit current available at the fuse shall not be greater than the conductor's short time current carrying capacity. Determine maximum prefault penetration conductor temperature and thermal damage curve per above guidelines.

(3) Based on the existing penetration thermal limits, for the given circuits, fuse shall be sized such that the Time-Current characteristic curve of the selected fuse shall be below and to the left of the penetration thermal limits by the margin of at least 25%.

(B) Criteria for New Design

Primary and backup protection shall reliably protect the containment electrical penetration for overload and short circuit conditions. Fuse shall be sized such that it satisfies the following conditions per guideline given in DCM No. T-22(Ref.10).

(1) The minimum current requirement to blow the fuse shall not exceed the derated continuous current capacity of the conductor. Determine conductor's derated ampacity per above guidelines.

(2) The maximum short circuit current available at the fuse shall not be greater than the conductor's short time current carrying capacity. Determine maximum prefault penetration conductor temperature and thermal damage curve per above guidelines.

(3) Calculated penetration short circuit conductor temperature shall be less than the rated penetration short circuit temperature for which the penetration is qualified.

(4) Overload protection shall not exceed the maximum penetration ampacity for which the penetration is qualified.

(5) Selected fuse shall be below and to the left of the penetration thermal limit by the margin of at least 25%.

10.11 <u>BATTERY & CHARGER CIRCUIT MAIN FUSES</u>

(1) <u>Vital Battery & Charger Configuration</u>

The vital 125 VDC system is distributed from three separate distribution buses 11, 12 & 13 for Unit 1 (21,22 & 23 for Unit 2). See Attachment No. 1 for the system configuration.

Each battery is connected to the respective bus through a set of main fuses. Each Charger is connected through a main circuit breaker. According to the applicable standard (IEEE Std 946-1985, Ref. 11), the battery connection can be through a breaker, fuses, or even a disconnect switch (without any protective devices).

For Bus 13(23), the main fuses are applied to both poles P & N of the battery. However, for buses 11 & 12 (21 & 22), only one pole is fused - P for 11 (21) and N for 12 (22). This is because, previously, the two buses were used together to provide a 3-wire, 250/125 VDC system which served to supply, through a set of downstream 1600A fuses, the non-vital 250 VDC MCC. The existing 3000A battery main fuses were selected to coordinate with the downstream 1600A fuses. Later, the 250 VDC MCC was separated out. However, the fuse arrangement was left unchanged on these buses as this was found to be still acceptable. See DCM S-67, Ref. 15.

(2) <u>Battery Main Fuse Selection Criteria</u>

If fuses are provided at the battery connection to the bus, their selection shall be based on the following criteria which are compatible with the principles stated in the applicable Standard (Ref. 11):

2.1 <u>Fuse Voltage Rating</u>

<u>(a) Criteria:</u>

Voltage Rating shall be minimum 250 VDC.

<u>(b) Basis:</u>

Fuse Voltage Rating shall be sufficient to cover the maximum voltage excursion of the system, considering equalizing charging. This is 140 VDC in this case, per Calculation 230-DC (Ref. 12). Therefore, the next higher standard rating of 250 VDC shall be used as a minimum. A fuse with only an AC voltage rating can be accepted in exceptional circumstances, if the rating is 600V or if certified by the manufacturer for 250 VDC.

2.2 <u>Fuse Interrupting Rating</u>

<u>(a) Criteria:</u>

Interrupting Rating shall be equal or greater than 50 kA at 250 VDC.

(b) Basis:

Fuse Interrupting Rating shall be sufficiently (about 25%) higher than the maximum fault current available under worst case conditions including:

- o Battery fully charged
- o Electrolyte temperature at the higher limit
- o Charger connected at the equalizing charge position

Availability of adequate interrupting capacity is usually not a concern for main fuses which are in larger current ratings and are normally available in interrupting ratings of 200 Ka.

In this case, per Calculation No. 233A-DC (Ref. 13) for Battery 11 short circuit currents (typical for all class 1E batteries):

Battery S.C. Current = 12.80 Ka at standard temperature 25C
= 14.38 Ka at 40 C

Hence the Interrupting Rating should be at least 25% higher or 18 Ka. The next higher size commercially available at 250 VDC is recommended. Normally, this would be 50 Ka or more.

2.3 Fuse Type

(a) Criteria:

Fuse shall be of UL Class L and with a small time delay characteristic.

(b) Basis:

For the current ranges required, Class L fuses with 601 to 6000A current rating and 200 kA interrupting rating are the usually available choice. These come with the current limiting

K Facor for Eqs in Section 9.8(6)

Cable Size	Air: No Cond	Air: In Cond	UG Duct	Direct Buried
<#2	0.33	0.67	1.00	1.25
#2-#4	1.00	1.50	2.50	3.00
≥250 MCM	1.50	2.50	4.00	6.00

Source:

ANSI/IEEE
Std 242-1986

feature, and different time delay and non-time delay characteristics. A small time delay is desirable to ensure the ride-through of harmless current surges due to motor or relay starts. For example, Buss type KRP-C and Shawmut types A4BY or A4BQ (preferred due to its having a published DC rating) all provide a minimum 4 second delay at 500% current, and are suitable for this application.

2.4 Fuse Current Rating

(a) Criteria:

Fuse shall be sized as low as possible to satisfy the following conditions:

1) No damage to fuse while sustaining the one-minute rated current of the battery

2) Operate positively at minimum fault current

3) Maintain proper coordination with the downstream over current devices

(b) Basis:

Fuse Current Rating shall be sufficiently high to prevent damage to the fuse element while sustaining current at the one-minute rating of the battery. This will be assured if the minimum melt current of the fuse at one minute is sufficiently (recommended 25%) higher than the one-minute rating of the battery which, in this case, is 1799A per Single Line Diagram (Ref. 14). Therefore, a rating of 1.25 times 1799A or 2250A can be selected.

Fuse current rating shall be high enough also to carry the inrush currents of the connected loads (motors, contactors, relays, etc.). Generally, this is not a concern for the main fuse, since it is relatively much larger. However, considering all possibilities, a low time delay characteristic has already been selected under item 3) above.

Fuse Current Rating shall also be sufficiently low so as to ensure positive opening of the fuse at minimum available fault current. In this case, Ref. 13 shows 12.80 kA available fault current at 25 C. However, this is at 125 VDC. The minimum available current will be at the end-of-discharge voltage at 1.75V per cell or 105 VDC (see Ref. 11). Hence this is 105/125 of 12.80 or 10.75 Ka.

Fuse Time Current Characteristic as well as the current rating shall be so selected as to coordinate with the downstream breakers and fuses. This may require a higher current rating than is necessary just to satisfy the one-minute rating of the battery.

The final selection of the current rating shall be made after due consideration of all the above factors.

11.0 METHODOLOGY:

The fuse adequacy analysis will be performed per the criteria provided in Sections 9.0 and 10.0. The Fuse Control Program activities are outlined in Electrical Engineering Procedures EE-5 and EE-7. These activities include verification of fuse data, fuse adequacy analysis, and procedure for fuse maintenance and fuse changes. Sectuon 11.2 lists the steps followed to perform adequacy analysis, and the detail explanation is provided in Section 11.1.

11.1 Adequacy Analysis procedure:

(1) Obtain and verify fuse data from the fuse list, vendor drawings, connection diagrams, schematics and walkdowns. Document the data under Item A, Section 11.2.

(2) Obtain all other necessary information for fuse sizing from the PG&E/vendor documents, PIMS Data Base and if necessary, by walkdowns. List all reference drawings and later revision No.(PIMS Data Base) under Item B, Section 11.2. Revision number is documented for the adequacy analysis, Calc.333-DC, Rev. 0 only. For all other revisions, Fuse Change Request Form and DCN will be used as

a base document. See Electrical Procedure EE-7, Rev. 0, Reference No.17.

(3) Determine if class for the existing fuse is properly classified per system DCMs, Seismic Qualification List (NED-001), Reg Guide 1.97 (DCMs T-24 & T-34) and reference 8.0.

(4) Record fuse size, voltage rating, and model number as obtained from the field. Document above data under Item D, Section 11.2.

(5) Determine fuse category, and application (AC or DC). Verify if existing voltage rating is adequate for AC or DC application. Document above data under Item E, Section 11.2.

(6) Determine minimum cable size for the circuit or circuits.

Determine cable ampacity per Attachment No. 2. Derate cable ampacity for fire stops and fire wrapping as applicable. Use average fuse derating factor of 0.80 for tray fire stop (See Ref.10). For wrapped trays and conduits, see reference No.10.

Document minimum cable size and derated ampacity under Item No. F, Section 11.2. If fuse size is 6 Amp or less, it will be assumed that the minimum cable size is adequately protected. See Assumption 8.6.2.

(7) Provide load data, e.g. connected load, maximum energized load at rated voltage under worst conditions, inrush current, nameplate data of transformer, motor, or equipment as applicable under Item (G) of Section 11.2. Based on this data, fuse will be sized.

(8) Provide circuit configuration indicating branch and upstream overcurrent device under Item (H) of Section 11.2.

(9) Review fuse circuit protection scheme in term of safety requirements (nuisance fuse blow), Appendix " R " requirements (Ref.16), cable isolation

requirements (Ref.8), protection, and equipment protection. Based on the above review and single failure criteria, determine if selective coordination for the fuse below 0.01 second is essential or not. Document results of the circuit review under Item (I) of Section 11.2.

(10) If fuse needs to be sized per load, calculate the worst load per Section 10.0 as shown below.

(a) Continuous or connected load

(b) Inrush current of chattering devices under degraded voltage conditions.

(c) Preload and inrush current of electrical devices.

(d) VA/Watts, Volts, Impedance, and Nameplate data.

(11) Perform fuse size selection and adequacy analysis per Sections 8.0, 9.0, 10.0, under Item (J) of Section 11.2.

(12) Determine short-circuit current at the required location, at the fuse terminals and at the load end either by performing a calculation or by using appropriate valid system calculations (see Section 9.7). Further determine under what fault condition selective coordination is essential. Fuse shall also protect equipment or device under minimum short circuit condition. Document analysis under Item (J) of Section 11.2.

(13) Fuse shall protect the minimum cable size per Section 9.8 and Item (6) above. Document analysis under Item (J).

(14) If required, perform coordination study per the requirements of item (9) above and Section 9.8 "Selective Coordination". For 100% selective coordination between fuse (load side) and molded case breaker (line), use criteria Section 9.8 (2)(a) first. Criteria 9.8 (2)(b) shall be applied only in cases where criteria 9.8 (2)(a) cannot be successfully applied.

(15) If required, recommend proper fuse size for the given application.

(16) Plot coordination curves with existing and new recommended class 1E fuses. Computer program will generate coordination curves. Coordination curves shall be checked for the validity by the Engineer. Document results under coordination Item (J) of Section 11.2.

(17) Document results showing acceptability with the existing or new recommended fuse under Item K, Section 11.2.

(18) In case of discrepancy, provide further corrective actions on case by case basis per Electrical Procedure EE-5 (Ref.1). Document discrepancy under Item L, Section 11.2.

(19) Provide final conclusion on the fuse adequacy analysis under Item (M) of Section 11.2.

11.2 FUSE ADEQUACY ANALYSIS

(A) Fuse Data:

(1) Computer ID:

(2) Current Rating:

(3) Voltage Rating:

(4) Manufacturer:

(5) Model / Catalog Number:

(6) Class / Interrupting Rating:

(7) Fuse Ambient Temperature:

(8) Temperature Correction Factor:

(B) Reference Drawings:

(C) Fuse QA Class:

(D) Fuse Field Data:

(1) Fuse Current Rating:
(2) Fuse voltage rating:
(3) Fuse Manufacturer/Model:

(E) Fuse Category/Application:

(F) Wire Size / Ampacity Rating:

(G) Load Data:

(H) Circuit Configuration:

(I) Circuit Review:

(J) Adequacy Analysis:

(1) Fuse Size:

(2) Short circuit Current:

(3) Cable Protection:

(4) Coordination:

(K) Acceptibility and Recommendation:

(L) Discrepancy:

(1) As Found:

(2) As Required:

(M) Conclusion:

12.0 REFERENCES:

1. Electrical Procedure EE-5, Rev.0. "Electrical Procedure for Fuse Control Program".

2. Protection and Coordination of Industrial and Commercial Power Systems ANSI/IEEE Standard 242-1986.

3. National Electric Code - 1993.

4. Electrical Protection Handbook - SPD Bussmann, Cooper Industries

5. National Electric Code - 1993, Section 725-12.

6. ANSI/IEEE C57.12.00-1980

7. Calc. No. 161-DC, Rev 2, 12 kV and 4kV motor acceleration time.

8. DCPP FSAR, Section 8.3.1.4.1, Rev. 7; DCM No.T-19, Rev.0, "Electrical Separation and Isolation"; DCM No.T-24, Rev.1, "Design Criteria for DCPP Instrumentation and Control"; DCM No.T-34, Rev.0, "Post Accident Monitoring Instrumentation".

9. Calculation M-680, Appendix 'R' Safe Shutdown Equipment, Rev. 6, "Fire Protection".

10. DCM No. T-22 Rev 0, "Electrical Cable Termination and Raceway"

11. IEEE Std 946-1985, "Recommended Practice for the Design of Safety Related DC Auxiliary Power Systems for Nuclear Power Generating Stations"

12 Calc. 230-DC, Rev. 0, "Under & Over Voltage Relays for Class 1E 125VDC systems"

13. Calc. 233A-DC, Rev.1, "125VDC System Short Circuit Currents - Battery # 11"

14. Single Line Diagrams, Vital 125VDC Systems:
    Dwg. No. 445075, 445076 (Unit-1)
    441240 (Unit-2)

15. DCM No. S-67, Rev 0, "125V and 250V DC System".

16. EE-2, Rev.1, "Electrical Engineering Procedure for the Review of Electrical DCN for Impact on 10 CFR50 Appendix 'R' Electrical Analysis".

17. EE-7, Rev. 0, "Electrical Engineering Procedure for the Processing and Control of Fuse Change Requests".

13.0 ATTACHMENTS:

1. S/L Diagram showing Short Circuit Currents (9 pages)

2. Cable Ampacity Tables (5 pages)

3. Short Time Current - Temperature Characteristics (18 pages)

4. Selectivity ratio Guide per vendor's instruction (Source:- Bussmann, Shawmut) (2 pages)

5. Typical Selectivity ratio guide (Source:- ANSI/IEEE Std. 242) (1 page)

6. Molded case circuit breakers' unlatching time (2 pages)

7. 100 VA Control Transformer circuit minimum fault current (3 pages)

8. INPO SEN 80 - "Motor Control Circuit Fuses undersized for degraded voltage conditions" (7 pages)

9. Bussmann Document on "Selective System for Overcurrent Protection". (6 pages)

10. Bussmann EDPH, "Selective Protective Devices for Electronics Equipment" (1 pages)

11. General Electric, Electrical Penetration, Appendix "A" "Calculation of maximum rating for low voltage power penetration." DC663081-92-33, Page 137, GEK-32434. (4 pages)

12. Conax Electrical Penetration, Current Rating, Section 1-8 Specification No. 5560, Revision 0. (4 pages)

13. Time-Current Curves for Penetration Control Cables # 12 AWG through # 16 AWG. (1 page)

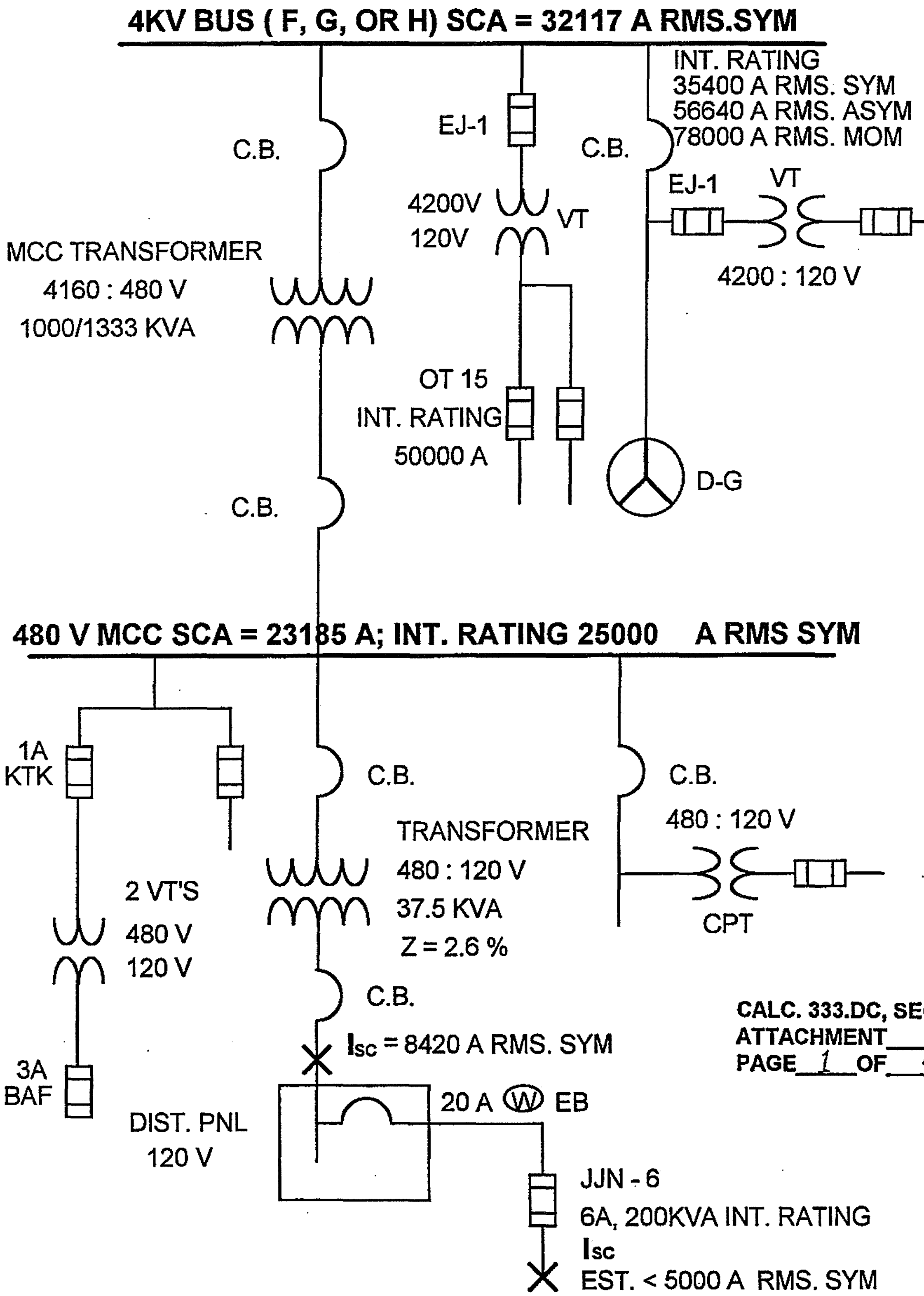
14. Control Ttansformer Date from Westinghouse. (1 page)

15. Cable Impedance Data. (1 page)

16. "K" Factor for Cable Ampacity. (1 page)

CLASS 1E SHORT CIRCUIT CURRENTS

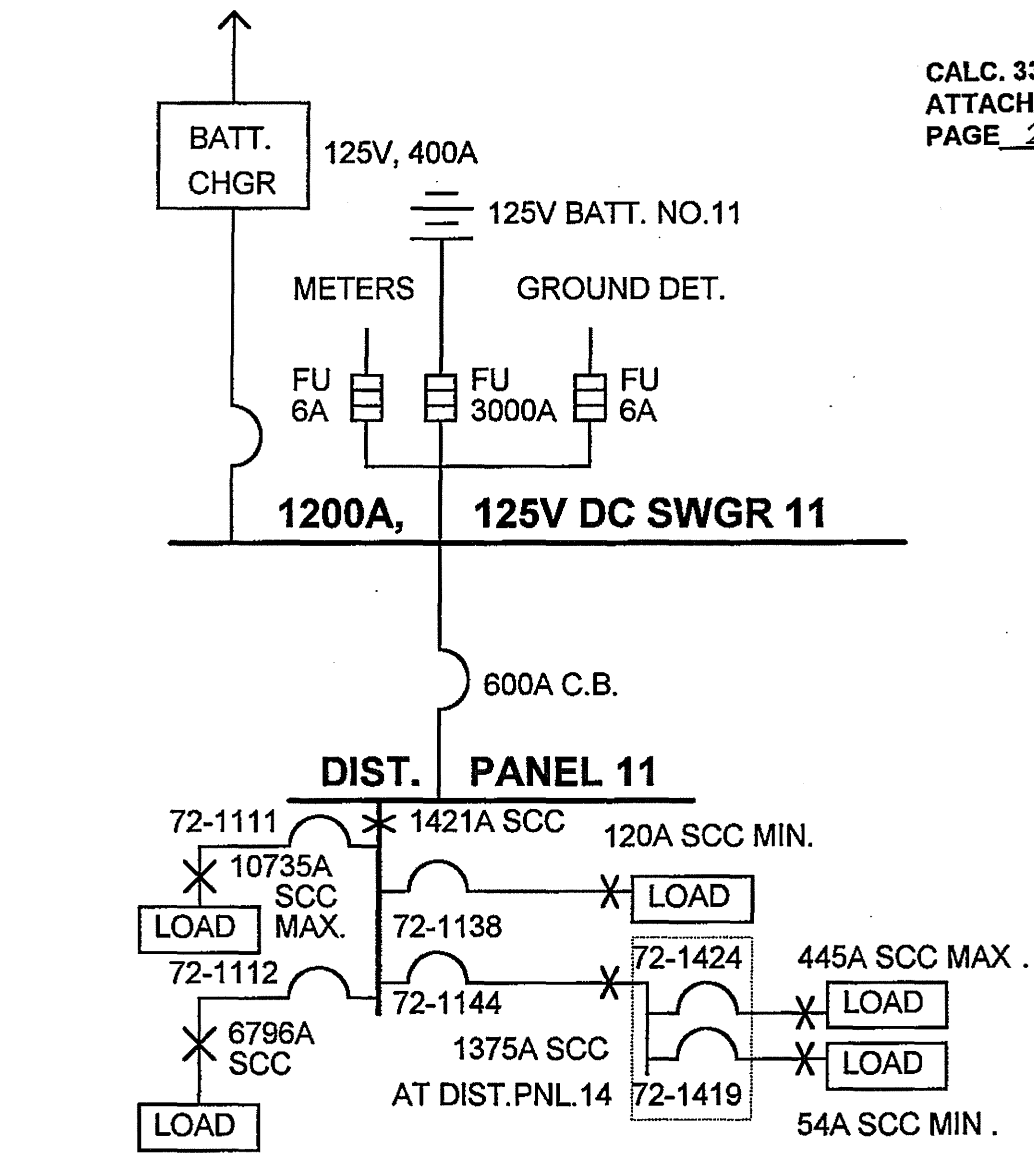
Ref. Calc. 96A-DC Rev 3



CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 1
PAGE 1 OF 9

125V DC SYSTEM SHORT CIRCUIT CURRENTS

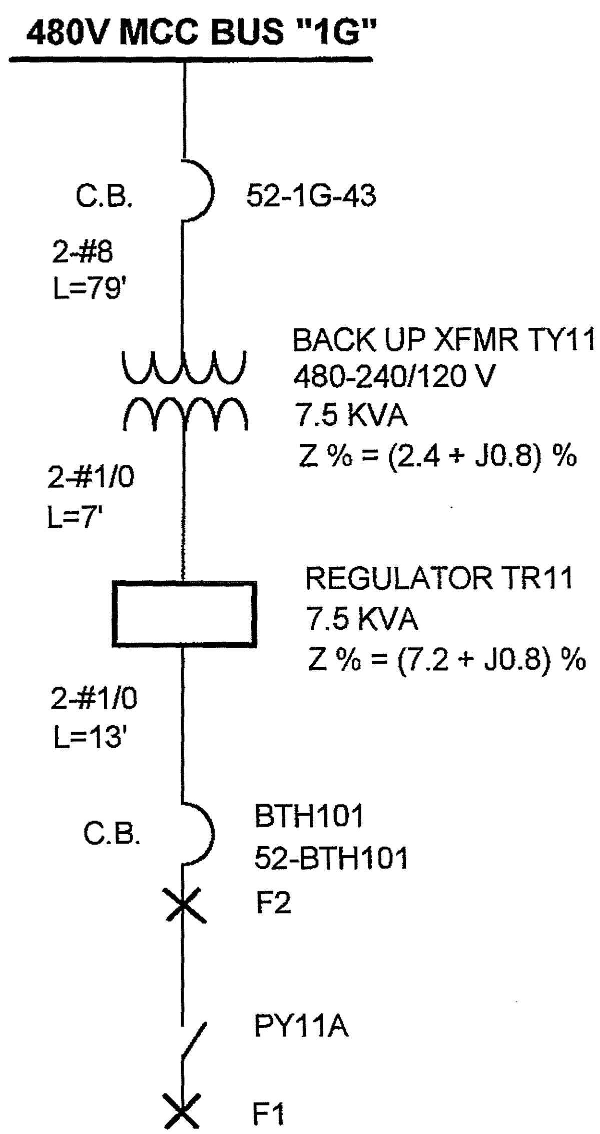
Ref. Calc. 233-DC Rev 1



SCC AT OTHER FEEDER ENDS
< 4000A SCC

NOTE: CIRCUIT BREAKER INTERRUPTING CAPACITY > 20000A
FUSE INTERRUPTING CAPACITY > 50000A
BUSSMANN TYPE KTN OR KRP-C
FOR OTHER 125C DC SYSTEM SEE TABLE

Short Circuit Calculation for 120V Vital Instrument AC Panel PY 11A



Cable Impedances: (Attachment No. 15)

#8:	$Z = (0.81734 + J0.04501)\Omega/1000'$
#1/0:	$Z = (0.13006 + J0.03727)\Omega/1000'$
#2:	$Z = (0.20480 + J0.03948)\Omega/1000'$

Impedances:

Choose 7.5 KVA Base

1. Source Impedance ---------------- 480V Bus "1G"

Isc = 20168.2 A (Per Calc. 96A - DC)

X/R = 4.0

3 Phase Impedance:

$$Z_{3\Phi} = \frac{\text{KVA Base}}{\sqrt{3} * \text{KV} * I_{SC}}$$

$$= \frac{7.5}{\sqrt{3} * 0.48 * 20168.2}$$

$$= 0.0004473 \text{ PU}$$

1 Phase Impedance:

$$Z_{1\Phi} = 2 * Z_{3\Phi}$$
$$= 2 * 0.0004473$$
$$= 0.0008946 \text{ PU}$$

$$Z_{1\Phi} = \sqrt{R_{1\Phi} + X_{1\Phi}}$$

$$\frac{X_{1\Phi}}{R_{1\Phi}} = 4$$

$$R_{1\Phi} = \frac{Z_{1\Phi}}{\sqrt{1 + 4^2}} = \frac{0.0008946}{\sqrt{17}} = 0.000217 \text{ PU}$$

$$X_{1\Phi} = 0.0008679 \text{ PU}$$

2. Cable Impedance:

$$\text{Per Unit Impedance} = \frac{(\text{Ohms Impedance}) * (\text{KVA Base})}{KV^2 * 1000}$$

2-#8 L = 79'

$$R = \frac{(0.81734 * 79/1000)(7.5)}{0.48^2 * 1000} = 0.002102 \text{ PU}$$

$$X = \frac{(0.04501 * 79/1000)(7.5)}{0.48^2 * 1000} = 0.000116 \text{ PU}$$

2-#1/0 L = 20'

$$R = \frac{(0.13006 * 20/1000)(7.5)}{0.12^2 * 1000} = 0.001355 \text{ PU}$$

$$X = \frac{(0.03727 * 20/1000)(7.5)}{0.12^2 * 1000} = 0.000388 \text{ PU}$$

2-#2 L = 47'

$$R = \frac{(0.2048 * 47/1000)(7.5)}{0.12^2 * 1000} = 0.005013 \text{ PU}$$

$$X = \frac{(0.03948 * 47/10000)(7.5)}{0.12^2 * 1000} = 0.000966 \text{ PU}$$

3. Transformer Impedance:

Z % = (2.4 + J1.8) %
Converting % impedance to per unit:
Z = 0.024 + J0.018 PU

4. Voltage Regulator Impedance:

Z % =(7.2 +J0.8) %
Converting % impedance to per unit:
Z = 0.072 +J0.008 PU

Total Impedance:

$$Z_{TOTAL} = \sqrt{R_{TOTAL}^2 + X_{TOTAL}^2}$$

$$R_{TOTAL} = 0.000217 + 0.002102 + 0.024 + 0.001355 + 0.72 + 0.005013$$
$$= 0.1047 \text{ PU}$$

$$X_{TOTAL} = J0.0008679 + J0.000116 + J0.018 + J0.000388 + J0.008 + J.000966$$
$$= J0.02834 \text{ PU}$$

$$Z_{TOTAL} = \sqrt{0.1047^2 + 0.02834^2} = 0.1085 \text{ PU}$$

Fault Current:

@ F1:

$$I_{SC} = \frac{\text{KVA Base}}{\text{KV} * Z_{PU}}$$

$$= \frac{7.5}{0.12 * 0.1085} = 576.21 \text{ A}$$

@ F2:

$$Z_{PU} = \sqrt{(0.1047 - 0.005013)^2 + (0.02834 - 0.000966)^2}$$

$$= \sqrt{0.09969^2 + 0.02737^2}$$

$$= 0.1034 \text{ PU}$$

$$I_{SC} = \frac{\text{KVA Base}}{\text{KV} * Z_{PU}}$$

$$= \frac{7.5}{0.12 * 0.1034} = 604.57 \text{ A}$$

Summary of Results

UNIT 1			UNIT 2	
Fault @ Panel	Short Circuit Current		Fault @ Panel	Short Circuit Current
PY11A	576.21A		PY21A	579.68A
PY13A	583.31A		PY23A	585.54A
PY11	593.75A		PY21	597.82A
PY12	593.67A		PY22	600.24A
PY13	594.05A		PY23	598.10A
PY14	592.88A		PY24	595.83A
PY15	460.06A		PY25	502.85A
Fault @ BTH101	604.57A		Fault @ BTH101	603.93A

For unit 1, the short circuit current at down stream of the terminal box BTH101 can be calculated as following:

$$Z_{PU} = \sqrt{(0.09969 + R_{CABLE\ RESISTANCE,\ PU})^2 + (0.02737 + X_{CABLE\ REACTANCE,\ PU})^2}$$

$$I_{SC} = \frac{\text{KVA Base}}{KV * Z_{PU}}$$

For unit 2, the short circuit current at down stream of the terminal box BTH101 can be calculated as following:

$$Z_{PU} = \sqrt{(0.09983 + R_{CABLE\ RESISTANCE,\ PU})^2 + (0.02728 + X_{CABLE\ REACTANCE,\ PU})^2}$$

$$I_{SC} = \frac{\text{KVA Base}}{KV * Z_{PU}}$$

The sample calculation of short circuit current at 120V AC panels is selected for panel PY11A. The similar calculations for other panels were performed and the results were checked and tabulated as above.

DC SYSTEM SHORT CIRCUIT CURRENTS

UNIT 1		UNIT 2	
Fault @ Battery	Short Circuit Current	Fault @ Battery	Short Circuit Current
BATTERY 11	14382	BATTERY 21	14382
BATTERY 12	14382	BATTERY 22	14382
BATTERY 13	14382	BATTERY 23	14382
Fault @ PNL Bus	Short Ckt Current	Fault @ PNL Bus	Short Ckt Current
SD11	14121	SD21	14082
SD12	14074	SD22	14034
SD13	14074	SD23	14034
SD14	1375	SD24	1221

To determine the short circuit current at the end of the feeder

Determine Rpanel , Rcable , and Isc at the panel as follows :

$$Rpanel = \frac{125}{Isc\ panel}$$

$$Rcable = \frac{Cable\ Length}{1000} \times Resistance\ per\ 1000\ Ft.$$

$$Isc = \frac{125}{Rpanel + Rcable}$$

Example: Panel : SD12 , Isc at SD12 = 14074

$$Rpanel = \frac{125}{14074} = 0.008881779$$

Rcable = 0.0024534 (for cable from 72 - 1211)

$$Isc = \frac{125}{0.008881779 + 0.0024534} = 11028\ Amps$$

References:

1. Calc. 233A-DC, Rev. 1, Pages 11 thru 14
2. Calc. 233B-DC, Rev. 2, Pages 11, 12
3. Calc. 233C-DC, Rev. 2, Pages 11, 12
4. Calc. 233D-DC, Rev. 2, Pages 11 thru 14
5. Calc. 233E-DC, Rev. 1, Pages 11, 12
6. Calc. 233F-DC, Rev. 2, Pages 11, 12

TABLE 2.1

Current Carrying Amperes of Low Voltage Copper Power Conductors in a Common Raceway with a Maximum Conductor Temperature of 90°C

AWG MCM	40°C Ambient (Outside Containment) No. of Conductors in Raceway 1-3	4-6	7-24	25-42	43+	50°C Ambient (Inside Containment) No. of Conductors in Raceway 1-3	4-6	7-24	25-42	43+
14	22.5	18.0	15.75	13.5	11.2	20	16.0	14.0	12.0	10
12	27.0	21.6	18.9	16.2	13.5	24	19.2	16.8	14.4	12
10	36.0	28.8	25.2	21.6	18.0	32	25.6	22.4	19.2	16
8	45.0	36.0	31.5	27.0	22.5	40	32.0	28.0	24.0	20
6	63.0	50.4	44.1	37.8	31.5	56	44.8	39.2	33.6	28
4	81.0	64.8	56.7	48.6	40.5	72	57.6	50.4	43.2	36
3	94.5	75.6	66.1	56.7	47.2	84	67.2	58.8	50.4	42
2	108.0	86.4	75.6	64.8	54.0	96	76.8	67.2	57.6	48
1	126.0	100.6	88.2	75.6	63.0	112	89.6	78.4	67.2	56
1/0	139.5	111.6	97.6	83.7	69.7	124	99.2	86.8	74.4	62
2/0	166.5	133.2	116.5	99.9	83.2	148	118.4	103.6	88.8	74
3/0	189.0	151.2	132.3	113.4	94.5	168	134.4	117.6	100.8	84
4/0	211.5	169.2	148.0	126.9	105.7	188	150.4	131.6	112.8	94
250	243.0	194.4	170.1	145.8	121.5	216	172.8	151.2	129.6	108
300	270.0	216.0	189.0	162.0	135.0	240	192.0	168.0	144.0	120
350	292.5	234.0	204.7	175.5	146.2	260	208.0	182.0	156.0	130
400	324.0	259.2	226.8	194.4	162.0	288	230.4	201.6	172.8	144
500	364.5	291.6	255.1	218.7	182.2	324	259.2	226.8	194.4	162
600	409.5	327.6	286.6	245.7	204.7	364	291.2	254.8	218.4	182
700	441.0	352.8	308.7	264.6	220.5	392	313.6	274.4	235.2	196
750	450.0	360.0	315.0	270.0	225.0	400	320.0	280.0	240.0	200
800	463.5	370.8	324.4	278.1	231.7	412	329.6	288.4	247.2	206
900	499.5	399.6	349.6	299.7	249.7	444	355.2	310.8	266.4	222
1000	526.5	421.2	368.5	315.9	263.2	468	374.4	327.6	280.8	234
1250	580.5	464.4	406.3	348.3	290.2	516	412.8	361.2	309.6	258
1500	630.0	504.0	441.0	378.0	315.0	560	448.0	392.0	336.0	280
1750	661.5	529.2	463.0	396.9	330.7	588	470.4	411.6	352.8	294
2000	697.5	558.0	488.2	418.5	348.7	620	496.0	434.0	372.0	310

TABLE 2.2

AMPACITY OF LOW VOLTAGE CONDUCTORS IN DUCTBANK - 90°C CABLE

Current Carrying Capacity of Low Voltage Copper Power Conductors in a Ductbank with a Maximum Conductor Temperature of 90°C, 20°C Ambient Earth, RHO=90, 100% Load Factor [1962 AIEE S-135-1 Page 180 and 240]

600V and LESS

	Three 1/C cables per duct No. of Conductors in Ductbank				One 1/C cable per duct No. of Conductors in Ductbank			
AWG or MCM	1-3	4-9	10-18	19-27	1-3	4-9	10-18	
8	64	56	48	45		80	71	68
6	85	73	62	58		104	93	87
4	111	95	80	74		135	120	112
2	146	123	103	95		176	155	145
1/0193	161	133	122		231	201	188	
2/0220	183	150	137		264	228	213	
3/0252	208	170	155		301	260	242	
4/0290	237	193	176		345	296	275	
250319	260	211	192		379	325	301	
350387	313	252	229		461	391	362	
500471	376	301	273		564	475	438	
750585	461	365	330		706	589	541	
1000670	523	412	372		823	682	625	

TABLE 2.3

AMPACITY OF MEDIUM VOLTAGE CONDUCTORS IN COMMON RACEWAY - 90°C CABLE

Current Carrying Capacity of Medium Voltage Copper Power Conductors in a Common Raceway with a Maximum Conductor Temperature of 90°C [1962 AIEE S-135-1 Page 264 & Table VIII]

5KV Cables

	40°C Ambient (Outside Containment)					50°C Ambient (Inside Containment)				
AWG/MCM	1-3	4-6	7-24	25-42	43+	1-3	4-6	7-24	25-42	43+
6	83	66.4	58.1	49.8	41.5	74.1	59.3	51.9	44.5	37.0
4	108	86.4	75.6	64.8	54.0	96.5	77.2	67.5	57.9	48.2
2	144	115.2	100.8	86.4	72.0	128.7	102.9	90.0	77.2	64.3
1	165	132.0	115.5	99.0	82.5	147.4	117.9	103.2	88.4	73.7
1/0	188	150.4	131.6	112.8	94.0	168.0	134.4	117.6	100.8	84.0
2/0	221	176.8	154.7	132.6	110.5	197.5	158.0	138.2	118.5	98.7
3/0	252	201.6	176.4	151.2	126.0	225.2	180.1	157.6	135.1	112.6
4/0	287	229.6	200.9	172.2	143.5	256.4	205.1	179.5	153.8	128.2
250	314	251.2	219.8	188.4	157.0	280.6	224.4	196.4	168.3	140.3
350	387	309.6	270.9	232.2	193.5	345.8	276.6	242.0	207.5	172.9
500	473	378.4	331.1	283.8	236.5	422.6	338.1	295.8	253.6	211.3
750	579	463.2	405.3	347.4	289.5	517.3	413.9	362.1	310.4	258.6
1000	657	525.6	459.9	394.2	328.5	587.0	469.6	410.9	352.2	293.5

15KV Cables

AWG	40°C Ambient (Outside Containment) No. of Conductors in Raceway					50°C Ambient (Inside Containment) No. of Conductors in Raceway				
MCM	1-3	4-6	7-24	25-42	43+	1-3	4-6	7-24	25-42	43+
2	150	120.0	105.0	90.0	75.0	133.9	107.1	93.7	80.3	66.9
1	171	136.8	119.7	102.6	85.5	152.6	122.1	106.8	91.6	76.3
1/0	195	156.0	136.5	117.0	97.5	174.1	139.2	121.8	104.4	87.0
2/0	227	181.6	158.9	136.2	113.5	202.6	162.1	141.8	121.6	101.3
3/0	259	207.2	181.3	155.4	129.5	231.2	184.9	161.8	138.7	115.6
4/0	295	236.0	206.5	177.0	147.5	263.3	210.6	184.3	158.0	131.6
250	329	263.2	230.3	197.4	164.5	293.7	234.9	205.6	176.2	146.8
350	394	315.2	275.8	236.4	197.0	351.7	281.3	246.1	211.0	175.8
500	481	384.8	336.7	288.6	240.5	429.3	343.4	300.5	257.5	214.6
750	588	470.4	411.6	352.8	294.0	524.7	419.8	367.3	314.8	262.3
1000	677	541.6	473.9	406.2	338.5	604.2	483.3	422.9	362.5	302.1
1500	825.9	660.7	578.1	495.5	412.9	737.1	589.6	515.9	442.2	368.5

TABLE 2.4

AMPACITY OF MEDIUM VOLTAGE CONDUCTORS IN VENTILATED TRAY - 90°C CABLE

Current Carrying Capacity of Medium Voltage Copper Power Conductors in a Ventilated Tray with a Maximum Conductor Temperature of 90°C [1962 AIEE S-135-1 Page 309 & Table VIII, Equation 5a

5KV Cables

	40°C Ambient (Outside Containment)					50°C Ambient (Inside Containment)				
MCM	1-3	4-6	7-24	25-42	43+	1-3	4-6	7-24	25-42	43+
6	93	74.4	65.1	55.8	46.5	83.1	66.5	58.2	49.8	41.5
4	122	97.6	85.4	73.2	61.0	109.0	87.2	76.3	65.4	54.5
2	159	127.2	111.3	95.4	79.5	142.1	113.7	99.4	85.2	71.0
1	184	147.4	128.8	110.4	92.0	164.4	131.5	115.1	98.6	82.2
1/0	211	168.8	147.7	126.6	105.5	188.6	150.8	132.0	113.1	94.3
2/0	243	194.4	170.1	145.8	121.5	217.2	173.7	152.0	130.3	108.6
3/0	279	223.2	195.3	167.4	139.5	249.3	199.5	174.5	149.6	124.6
4/0	321	256.8	224.7	192.6	160.5	286.9	229.5	200.8	172.1	143.4
250	355	284.0	248.5	213.0	177.5	317.3	253.8	222.1	190.3	158.6
350	435	348.0	304.5	261.0	217.5	388.8	311.0	272.1	233.2	194.4
500	536	428.8	375.2	321.6	268.0	479.0	383.2	335.3	287.4	239.5
750	668	534.4	467.6	400.8	334.0	597.0	477.6	417.9	358.2	298.5
1000	768	614.4	537.6	460.8	384.0	686.3	549.0	480.4	411.8	343.1

15KV Cables

	40°C Ambient (Outside Containment) No. of Conductors in Raceway					50°C Ambient (Inside Containment) No. of Conductors in Raceway				
AWG MCM	1-3	4-6	7-24	25-42	43+	1-3	4-6	7-24	25-42	43+
2	164	131.2	114.8	98.4	82.0	146.5	117.2	102.5	87.9	73.2
1	187	149.6	130.9	112.2	93.5	167.0	133.6	116.9	100.2	83.5
1/0	215	172.0	150.5	129.0	107.5	192.0	153.6	134.4	115.2	96.0
2/0	246	196.8	172.2	147.6	123.0	219.7	175.7	153.8	131.8	109.8
3/0	283	226.4	198.1	169.8	141.5	252.7	202.2	176.9	151.6	126.3
4/0	325	260.0	227.5	195.0	162.5	290.2	232.2	203.1	174.1	145.1
250	359	287.2	251.3	215.4	179.5	320.6	256.4	224.4	192.3	160.3
350	438	350.4	306.6	262.8	219.0	391.1	312.8	273.7	234.6	195.5
500	536	428.8	375.2	321.6	268.0	478.5	382.8	335.0	287.1	239.2
750	669	535.2	468.3	401.4	334.5	597.2	477.8	418.1	358.3	298.6
1000	770	616.0	539.0	462.0	385.0	687.4	549.9	481.1	412.4	343.7
1500										

TABLE 2.5

AMPACITY OF MEDIUM VOLTAGE CONDUCTORS IN DUCTBANK - 90°C CABLE

Current Carrying Capacity of Medium Voltage Copper Power Conductors in a Ductbank with a Maximum Conductor Temperature of 90°C, 20°C Ambient Earth, RHO=90, 100% Load Factor [AIEE 135-1 Pages 181, 182, 241, & 242]

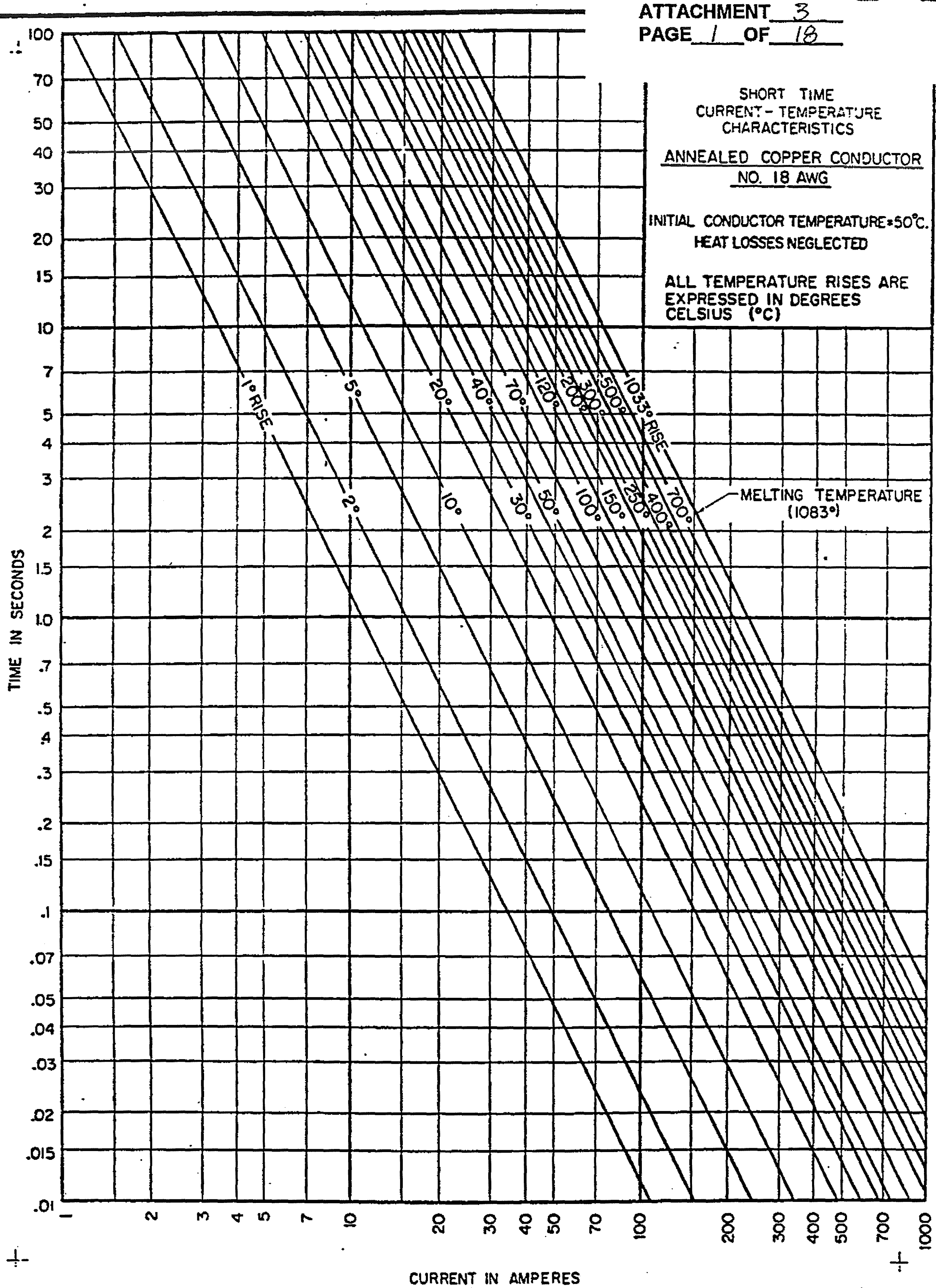
5kV Cables

AWG MCM	Three 1/C cables per duct – No. of Cables in Ductbank 1-3	4-9	10-18	19-27	One 1/C cable per duct – No. of Cables in Ductbank 1-3	4-6	7-9
6	90	77	64	59	106	94	88
4	117	99	82	75	137	121	114
2	151	127	104	95	178	156	146
1/0	198	164	134	122	233	202	188
2/0	225	185	151	137	265	229	213
3/0	256	210	170	155	302	260	242
4/0	292	237	192	174	345	296	274
250	320	259	209	189	379	324	300
350	386	309	247	224	460	390	360
500	465	368	292	264	561	472	435
750	565	442	348	313	702	585	537
1000	639	495	387	348	816	676	619

15kV Cables

AWG MCM	Three 1/C cables per duct – No. of Cables in Ductbank 1-3	4-9	10-18	19-27	One 1/C cable per duct – No. of Cables in Ductbank 1-3	4-6	7-9
2	155	128	105	95	179	156	146
1/0	201	165	133	121	232	201	188
2/0	228	186	150	136	265	228	212
3/0	260	210	169	153	302	259	241
4/0	295	238	190	172	344	294	273
250	323	259	207	187	378	322	298
350	387	308	244	220	457	387	357
500	465	366	288	259	557	468	431
750	565	439	343	307	695	579	531
1000	637	490	380	340	807	668	611
1500					981	804	733

NOTE: Derate 30% for cables not in outside duct bank position [TEDS 050167]



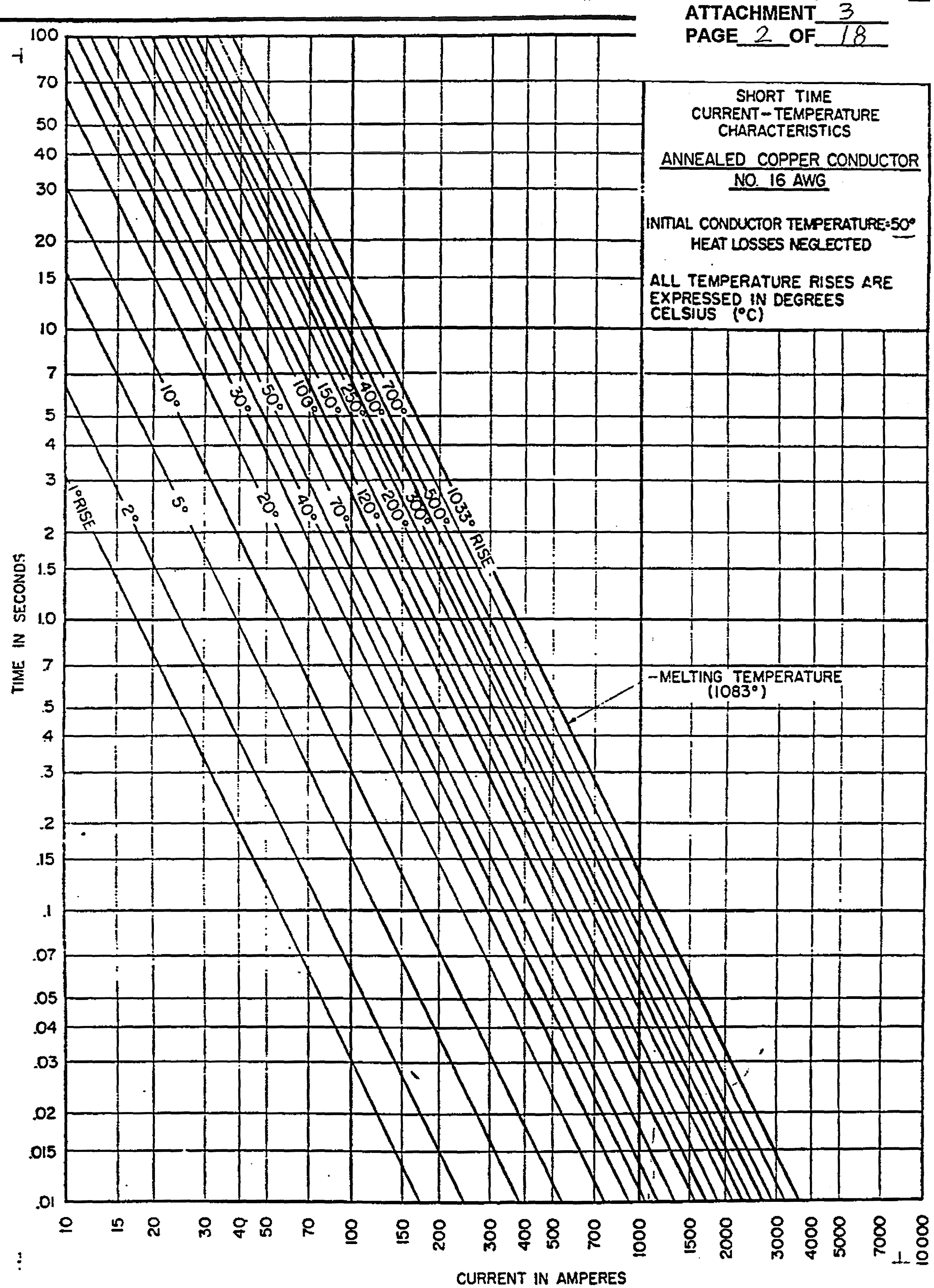
THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT - TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

SHEET 5 OF SHEETS

DRAWING NUMBER 055076

CHANGE



THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT–TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

SHEET 6 OF SHEETS

DRAWING NUMBER 055076

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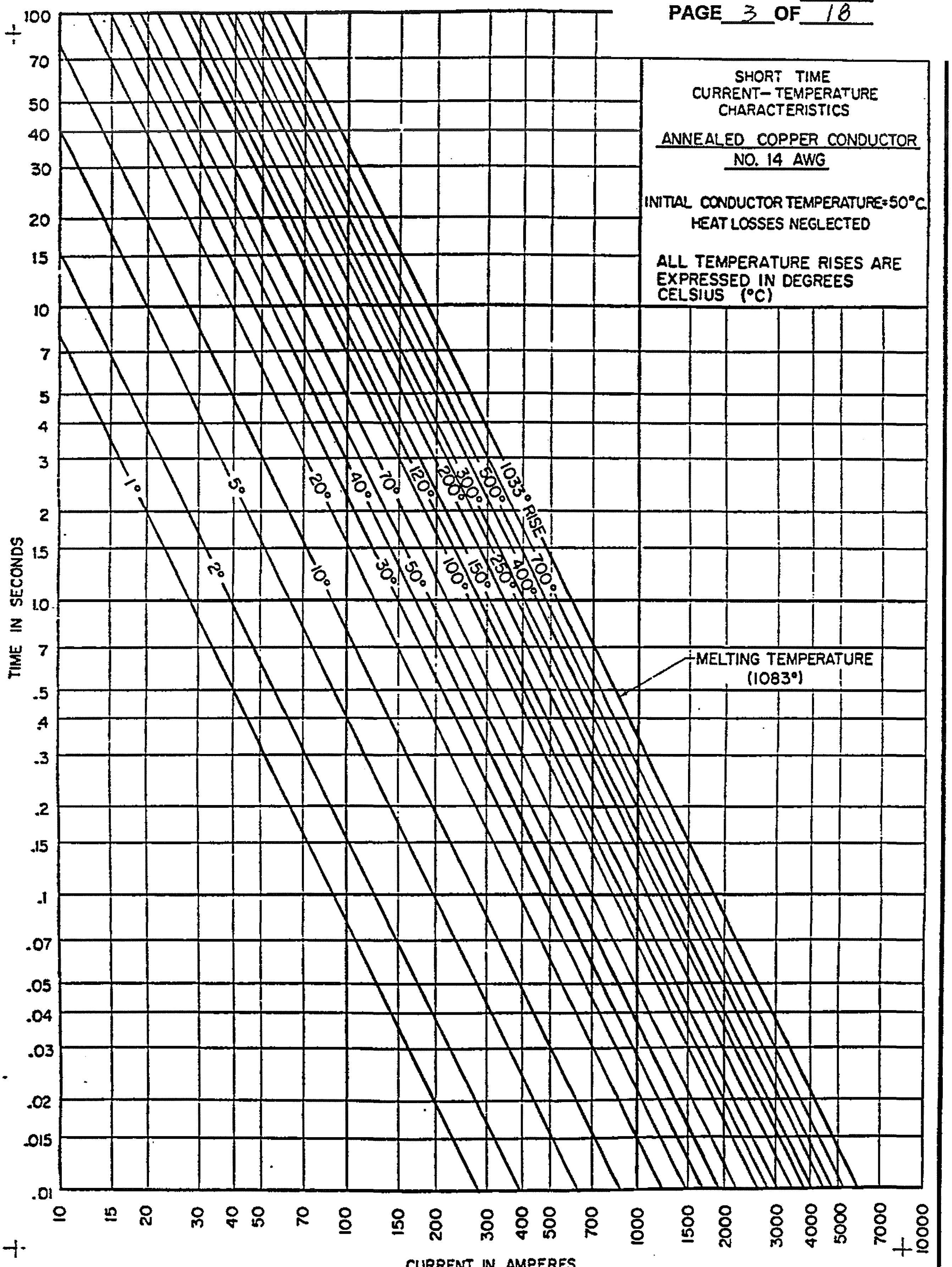
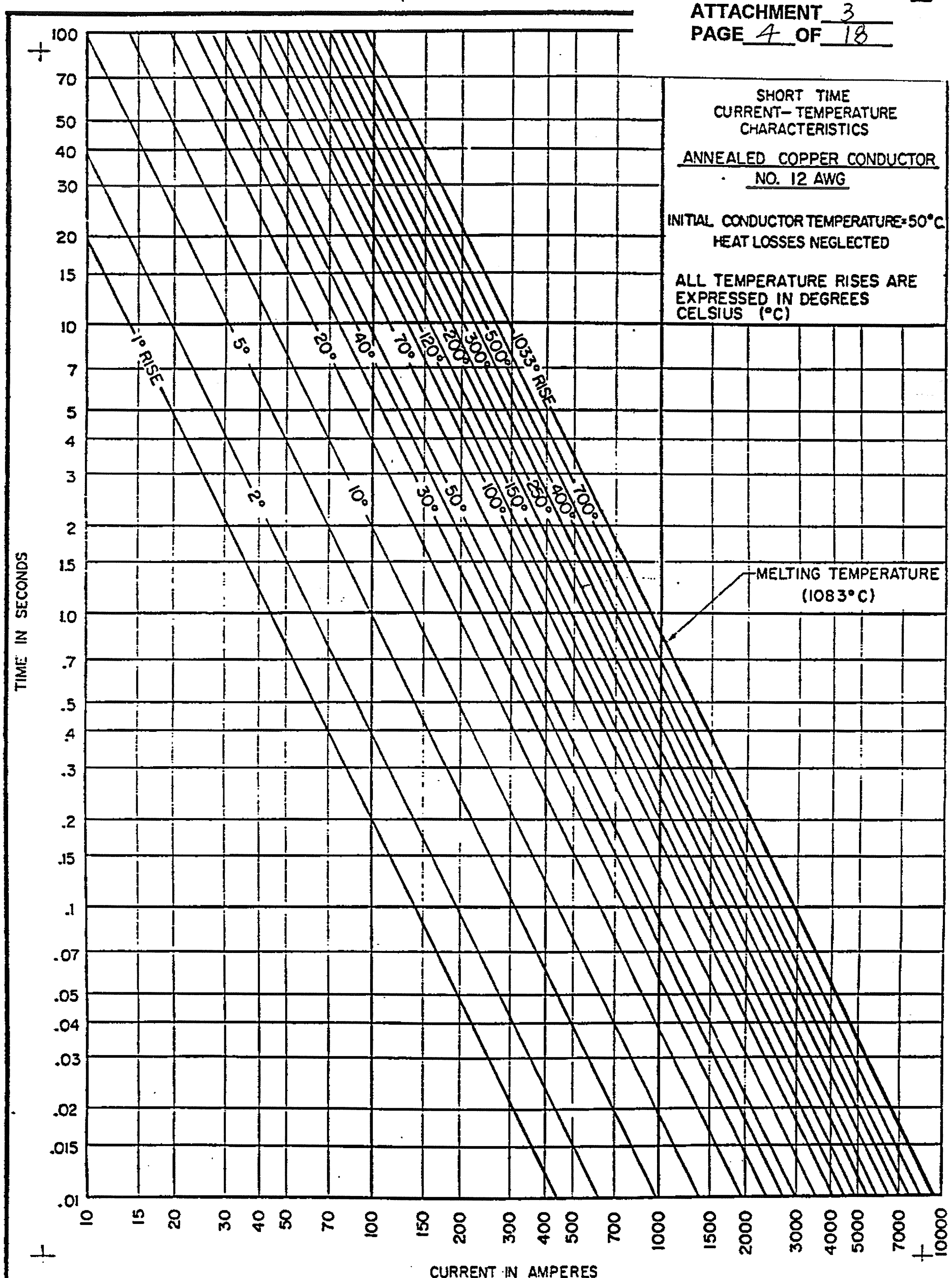
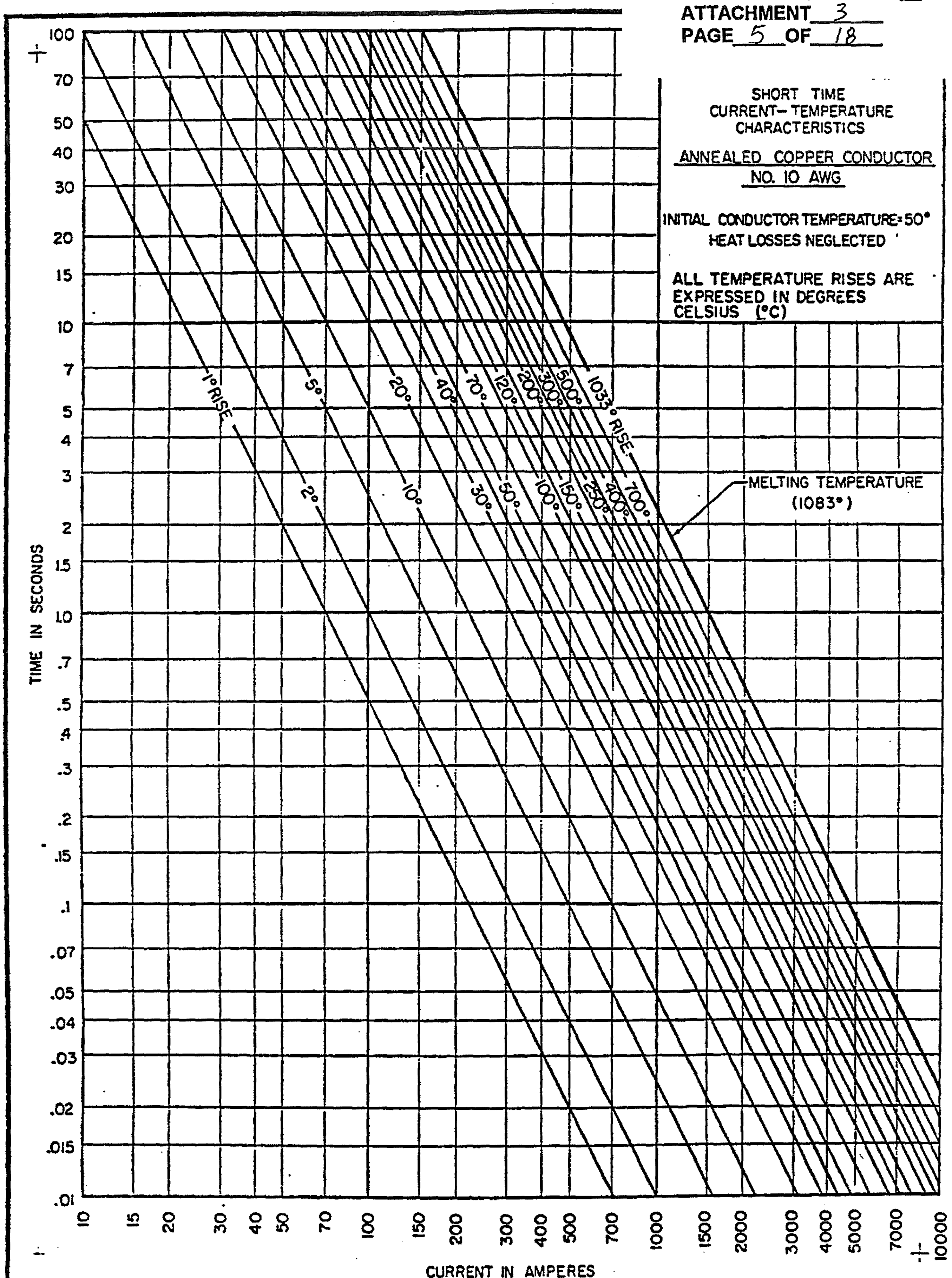


THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT—TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 7 OF SHEETS	DRAWING NUMBER 055076	CHANGE



THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.	DRAWING NUMBER	CHANGE
SHEET 8 OF SHEETS	055076	


SHORT TIME
CURRENT– TEMPERATURE
CHARACTERISTICS
ANNEALED COPPER CONDUCTOR
NO. 10 AWG
INITIAL CONDUCTOR TEMPERATURE=50°
HEAT LOSSES NEGLECTED
ALL TEMPERATURE RISES ARE EXPRESSED IN DEGREES CELSIUS (°C)
MELTING TEMPERATURE
(1083°)
1°RISE
2°
5°
10°
20°
30°
40°
50°
70°
100°
120°
150°
200°
250°
300°
400°
500°
700°
1033° RISE
TIME IN SECONDS
100
70
50
40
30
20
15
10
7
5
4
3
2
1.5
1.0
.7
.5
.4
.3
.2
.15
.1
.07
.05
.04
.03
.02
.015
.01
CURRENT IN AMPERES
10
15
20
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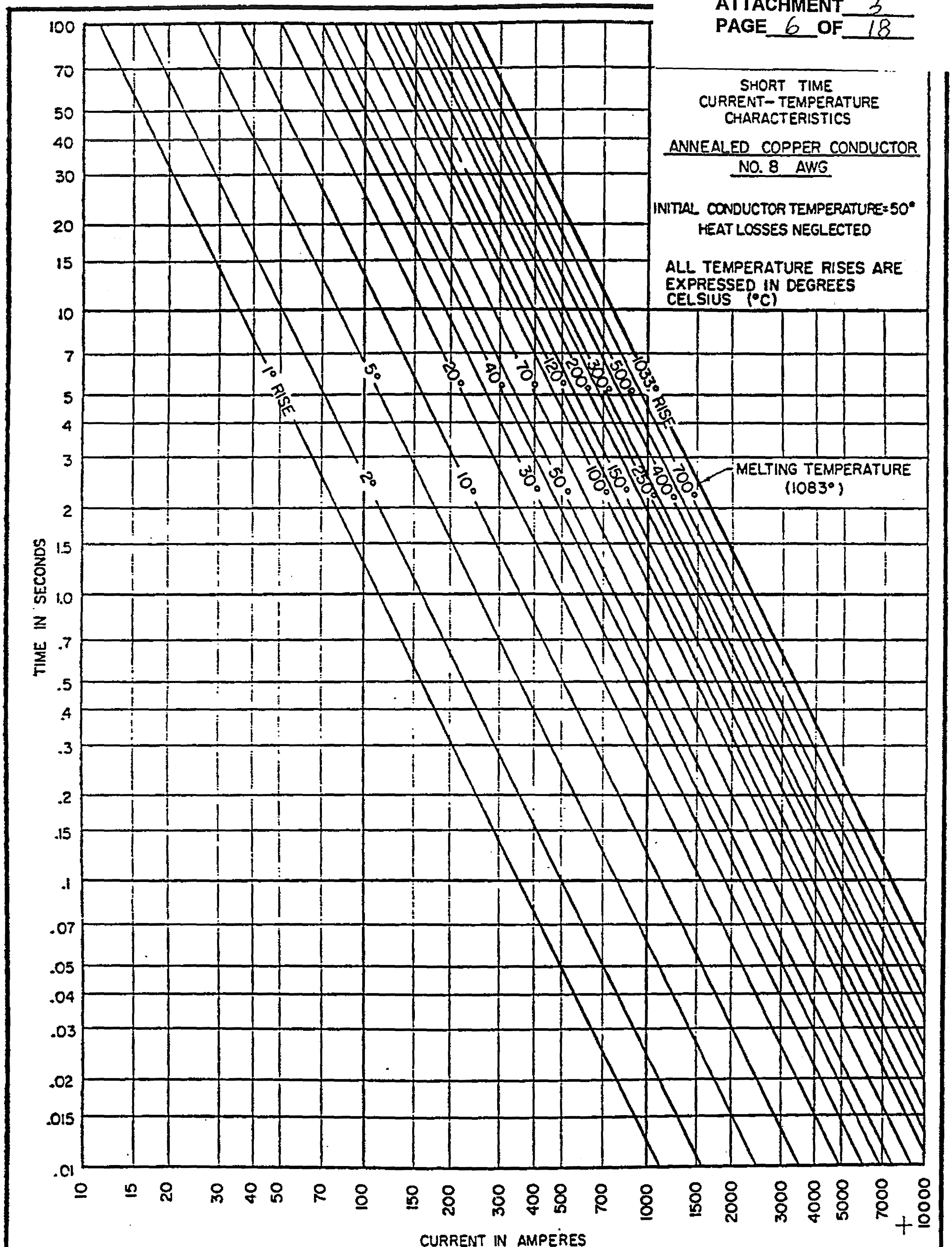
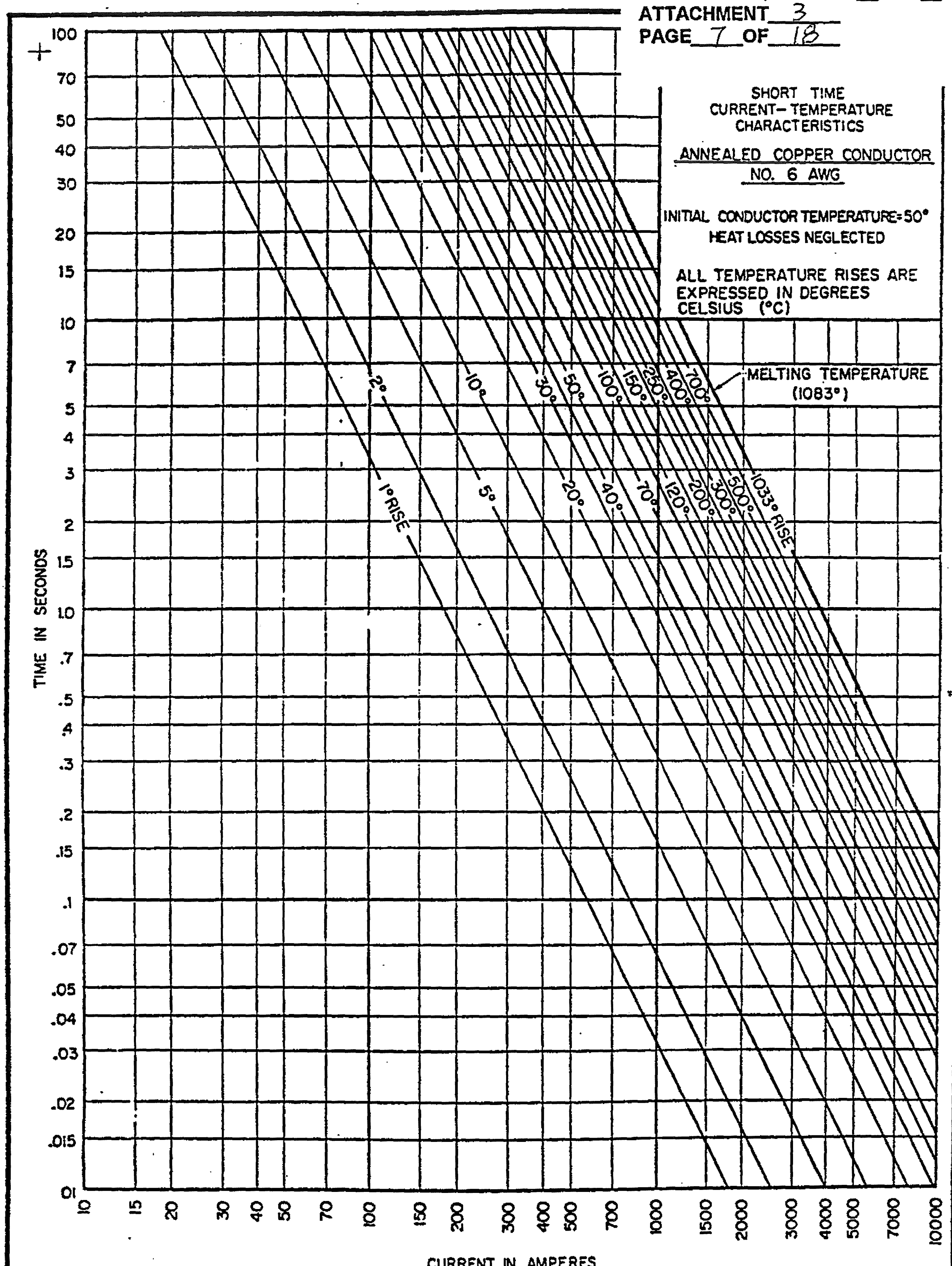
400
500
700
1000
1500
2000
3000
4000
5000
7000
10000



THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 10 OF SHEETS	DRAWING NUMBER 055076	CHANGE



THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT-TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

SHEET 11 OF SHEETS

DRAWING NUMBER 055076

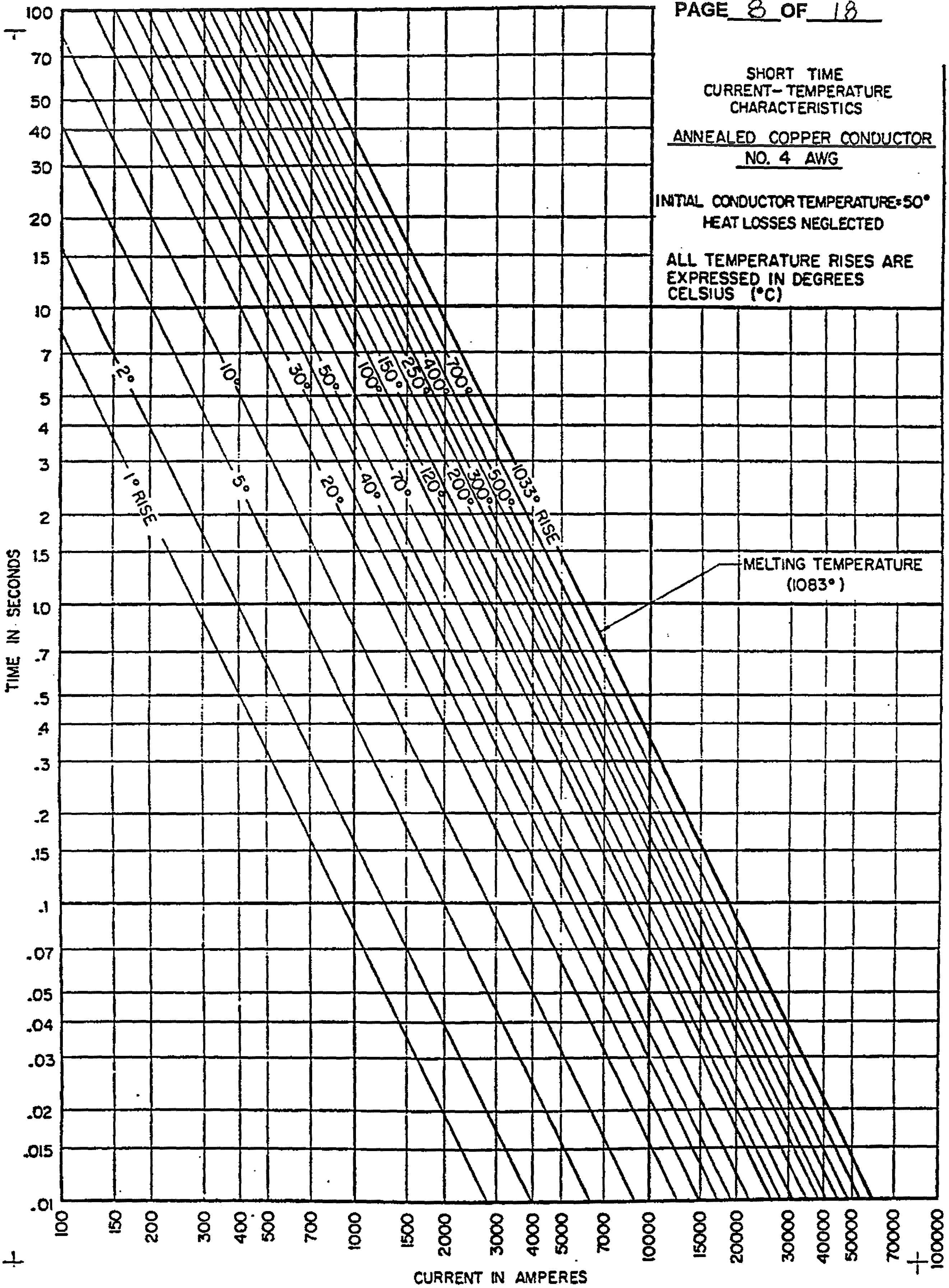
CHANGE

SHORT TIME
CURRENT-TEMPERATURE
CHARACTERISTICS

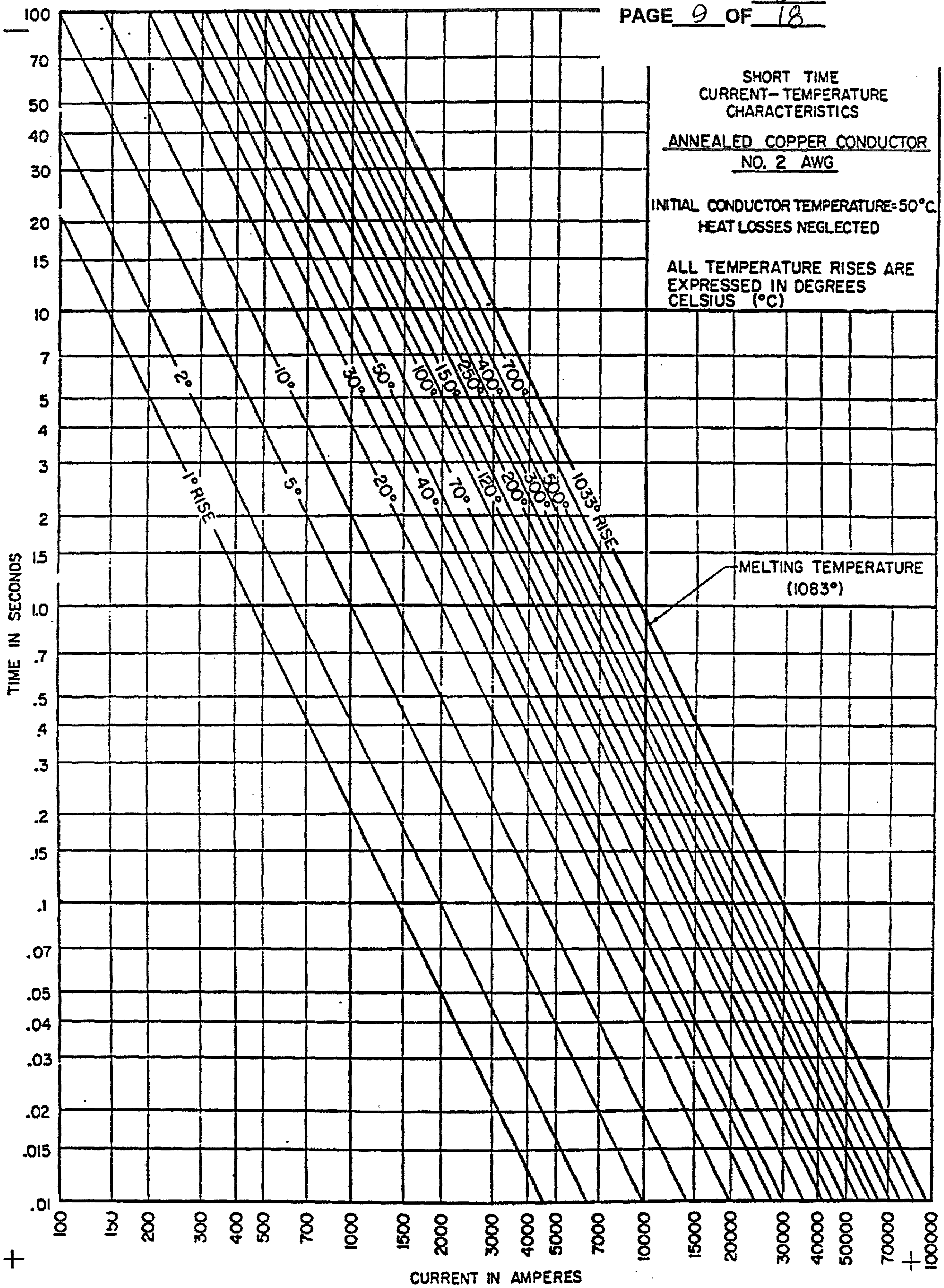
ANNEALED COPPER CONDUCTOR
NO. 4 AWG

INITIAL CONDUCTOR TEMPERATURE=50°
HEAT LOSSES NEGLECTED

ALL TEMPERATURE RISES ARE EXPRESSED IN DEGREES CELSIUS (°C)



CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 3
PAGE 9 OF 18



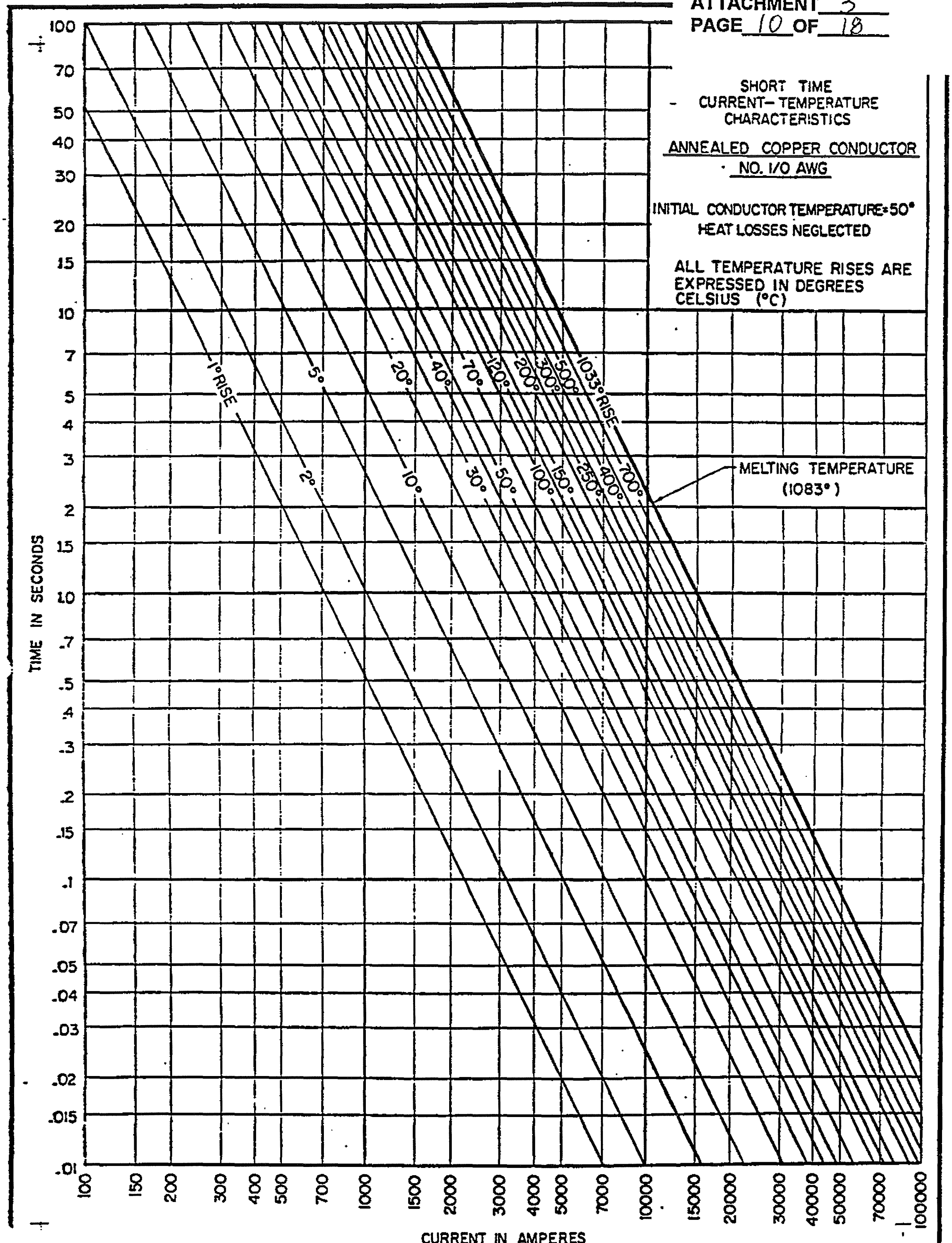
THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

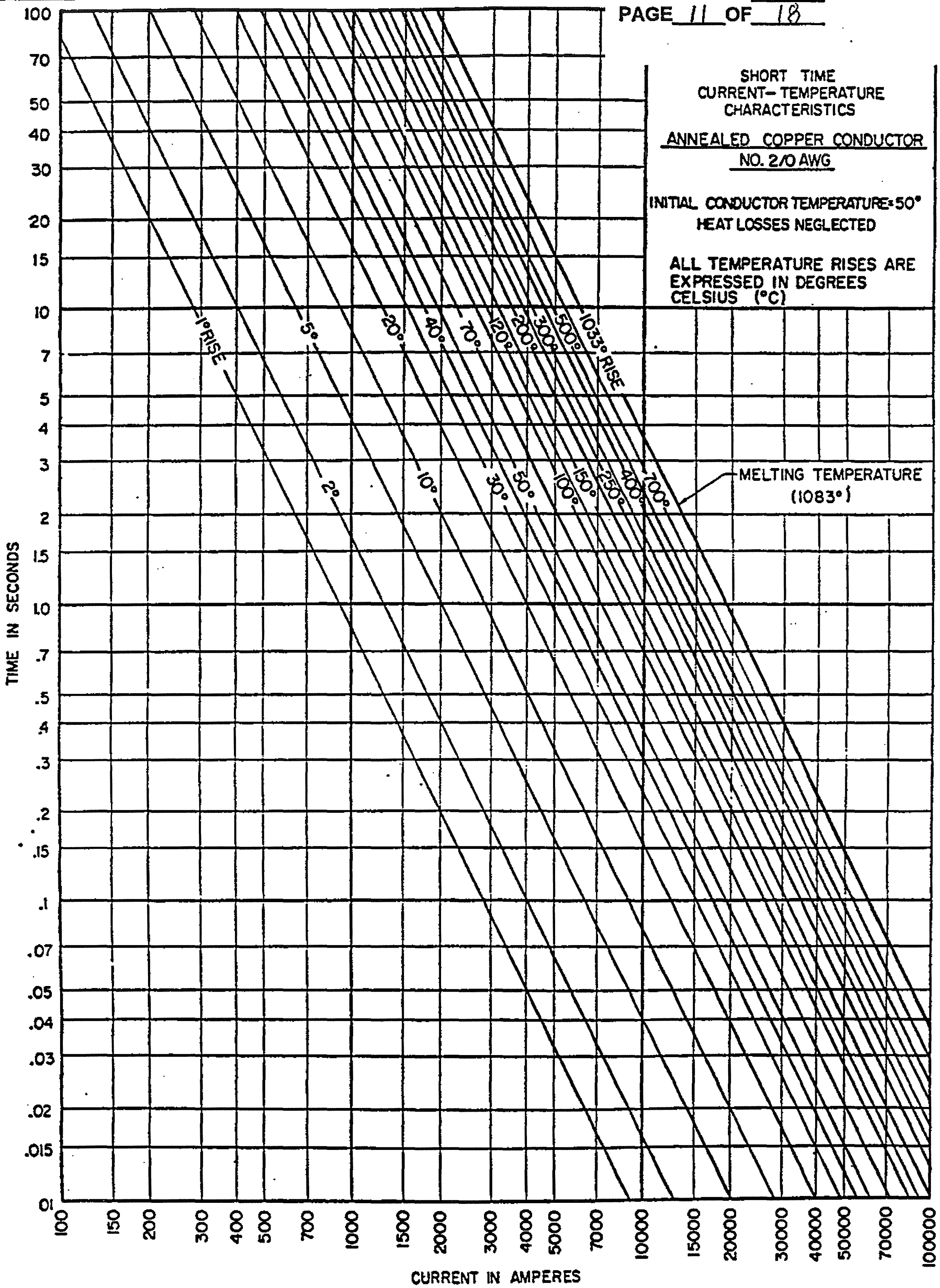
SHEET 13 OF SHEETS

DRAWING NUMBER 055076

CHANGE



THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 14 OF SHEETS	DRAWING NUMBER 055076	CHANGE



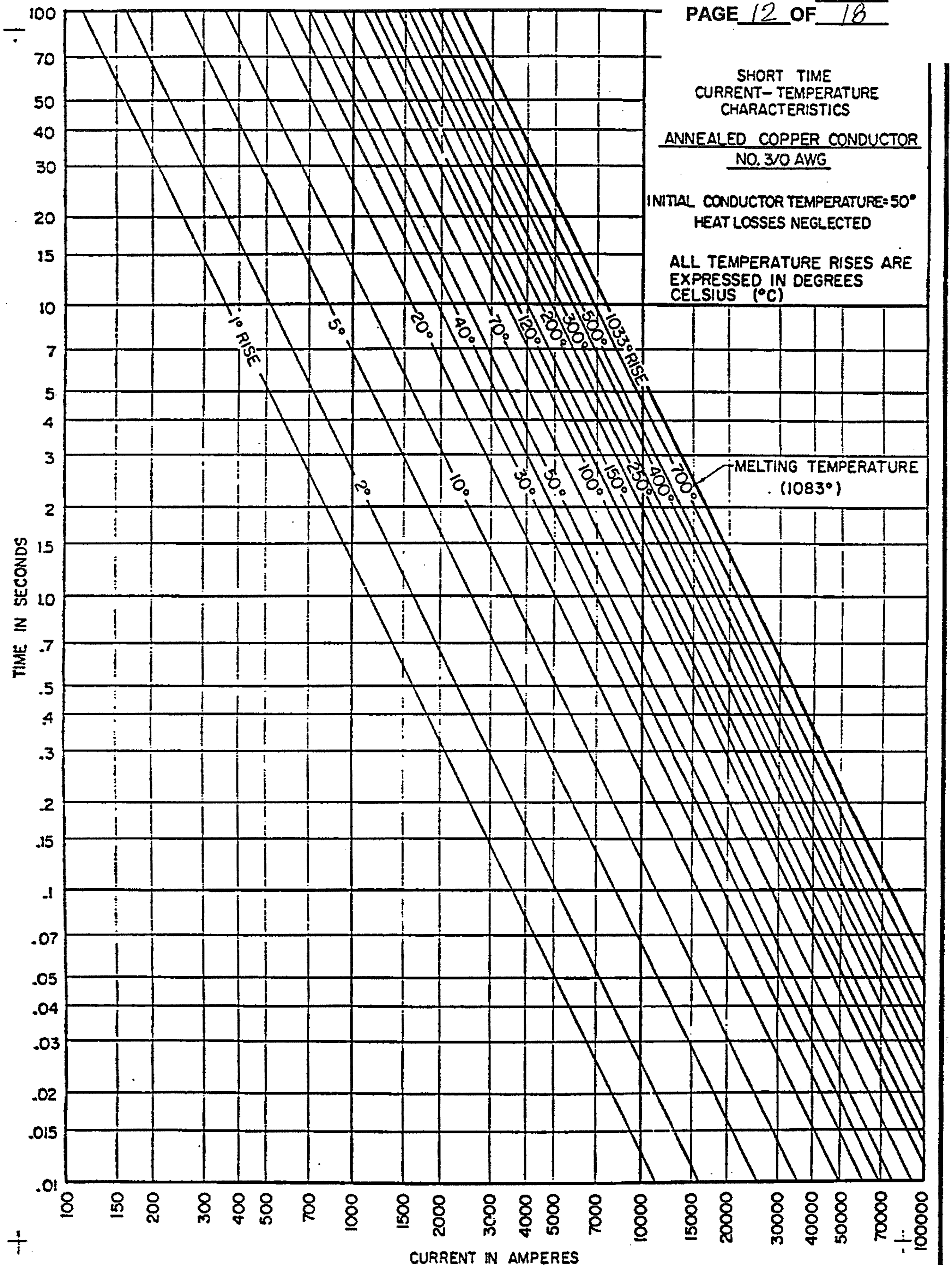
THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

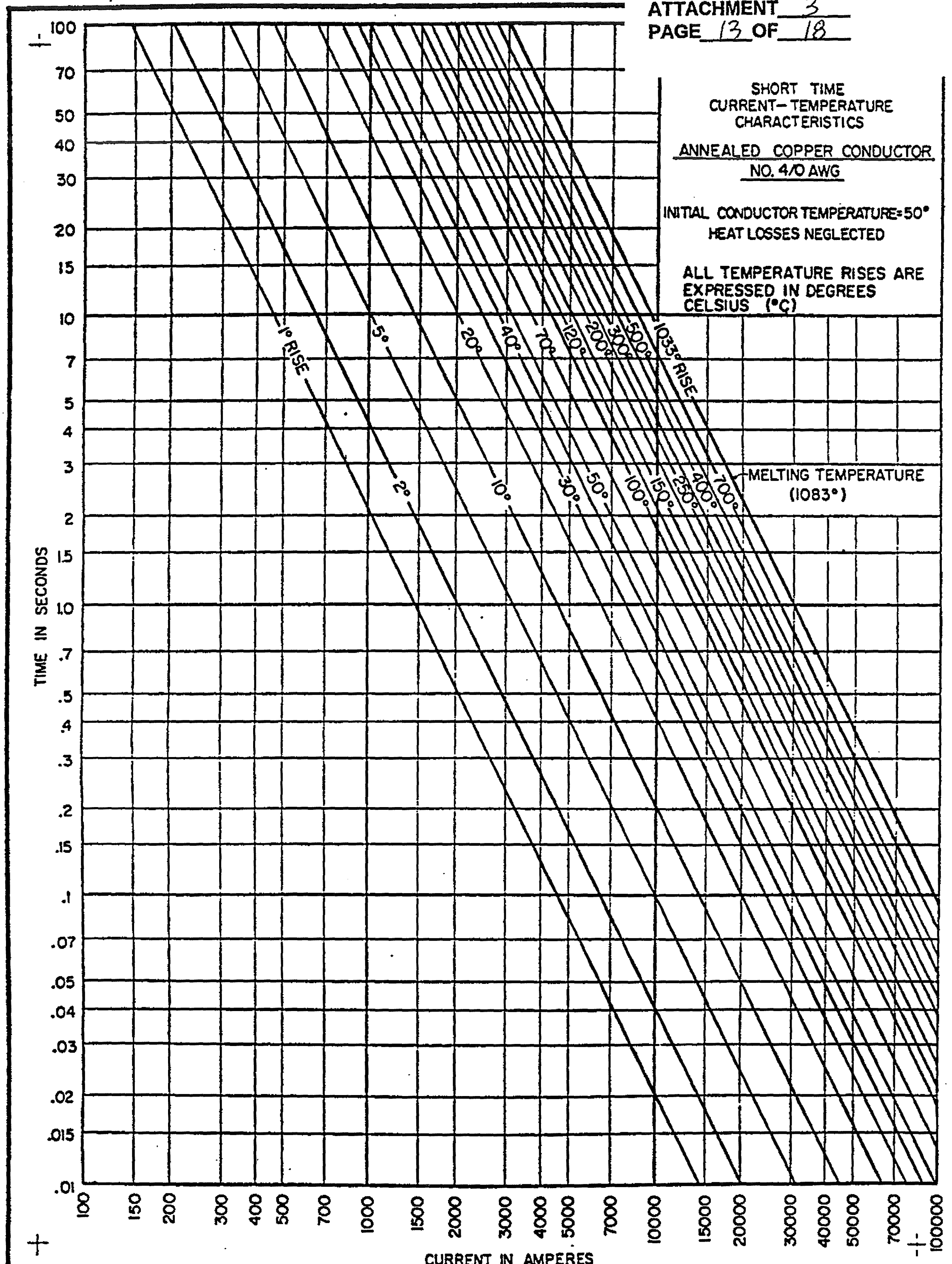
SHEET 15 OF SHEETS

DRAWING NUMBER 055076

CHANGE



THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT – TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 16 OF SHEETS	DRAWING NUMBER 055076	CHANGE



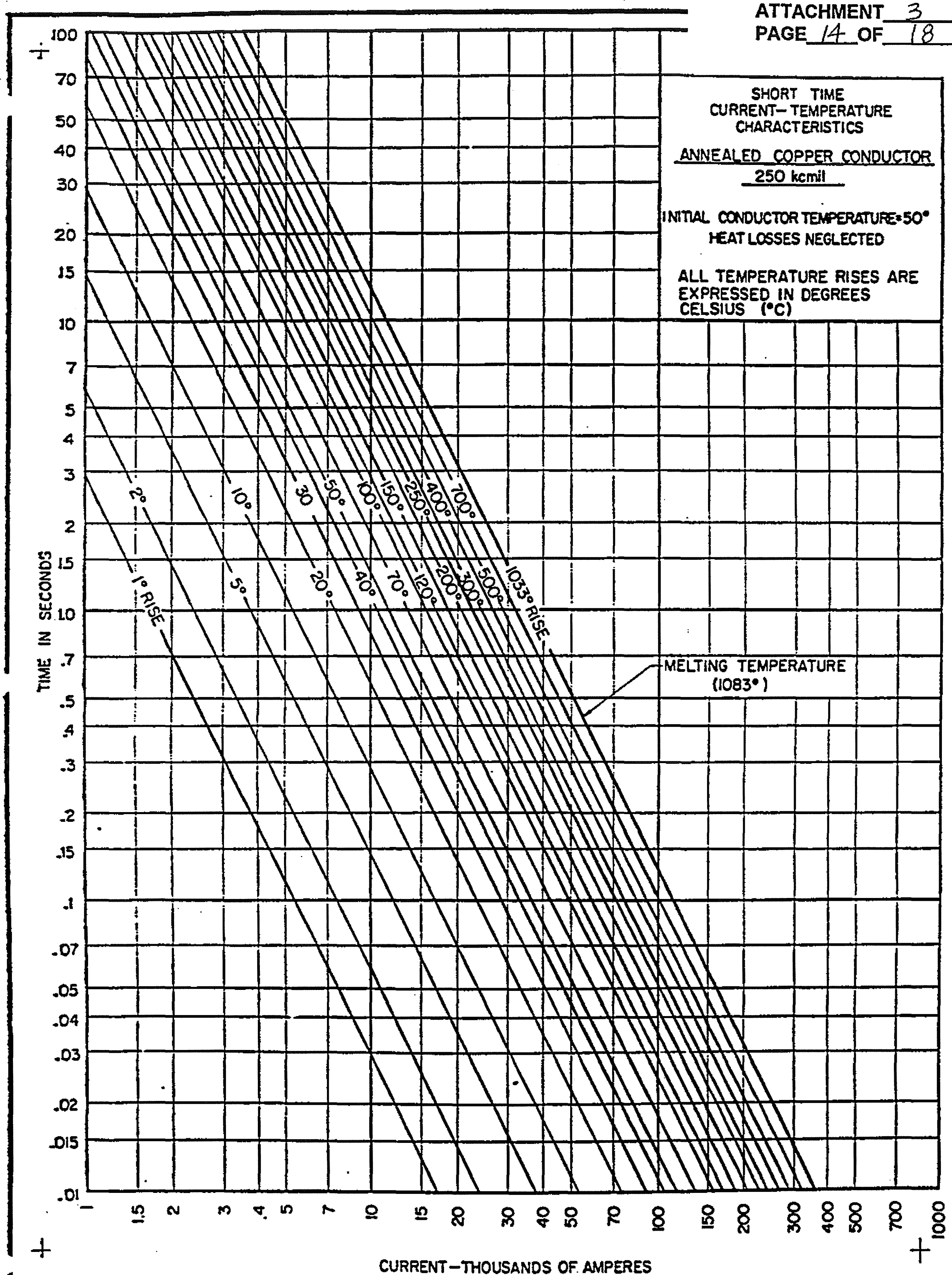
THERMAL ELECTRIC DESIGN STANDARD
SHORT TIME CURRENT–TEMPERATURE CHARACTERISTICS
FOR COPPER AND ALUMINUM CONDUCTORS

P. G. & E. CO.

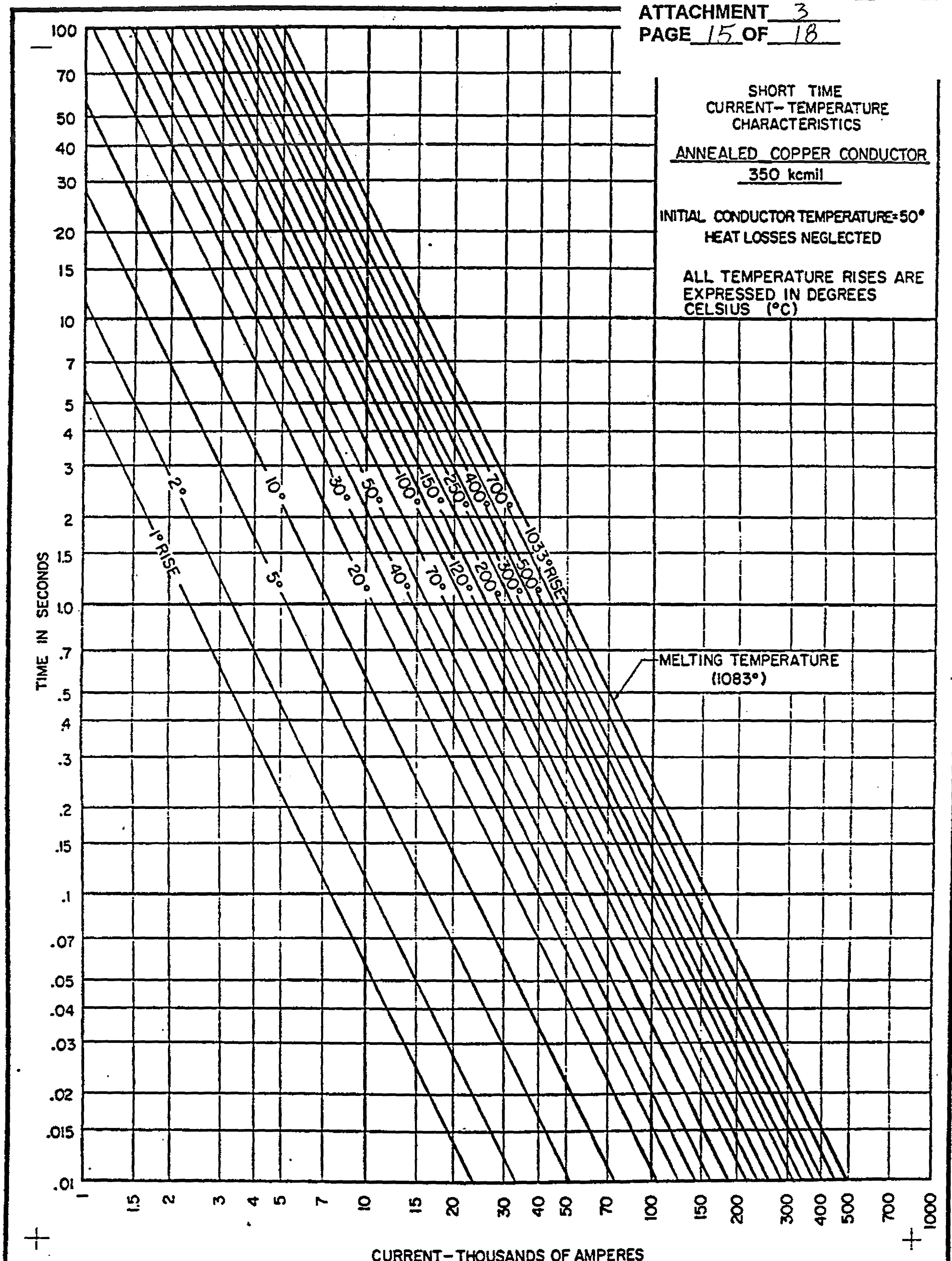
SHEET 17 OF SHEETS

DRAWING NUMBER 055076

CHANGE



THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT - TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 18 OF SHEETS	DRAWING NUMBER 055076	CHANGE



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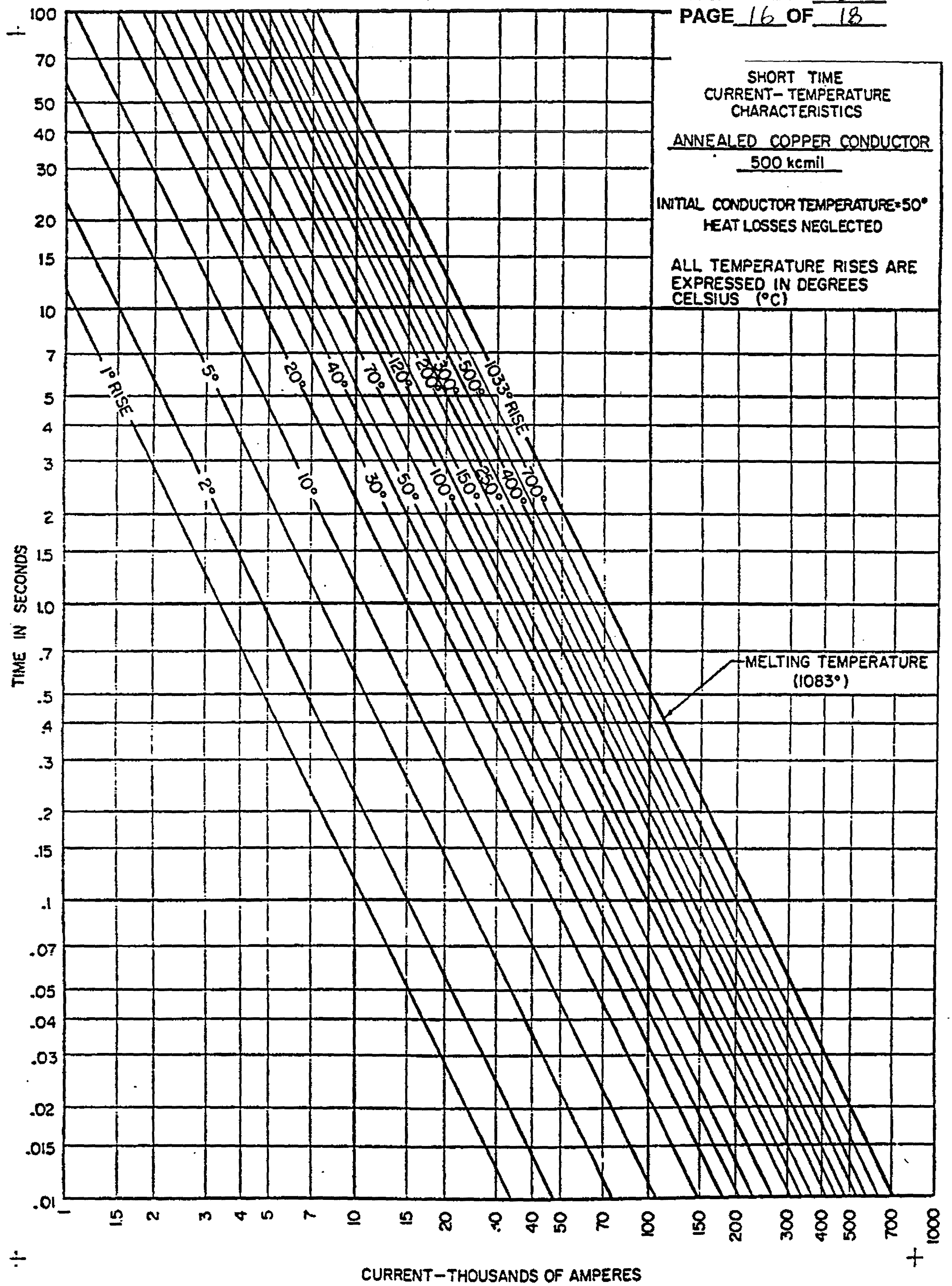
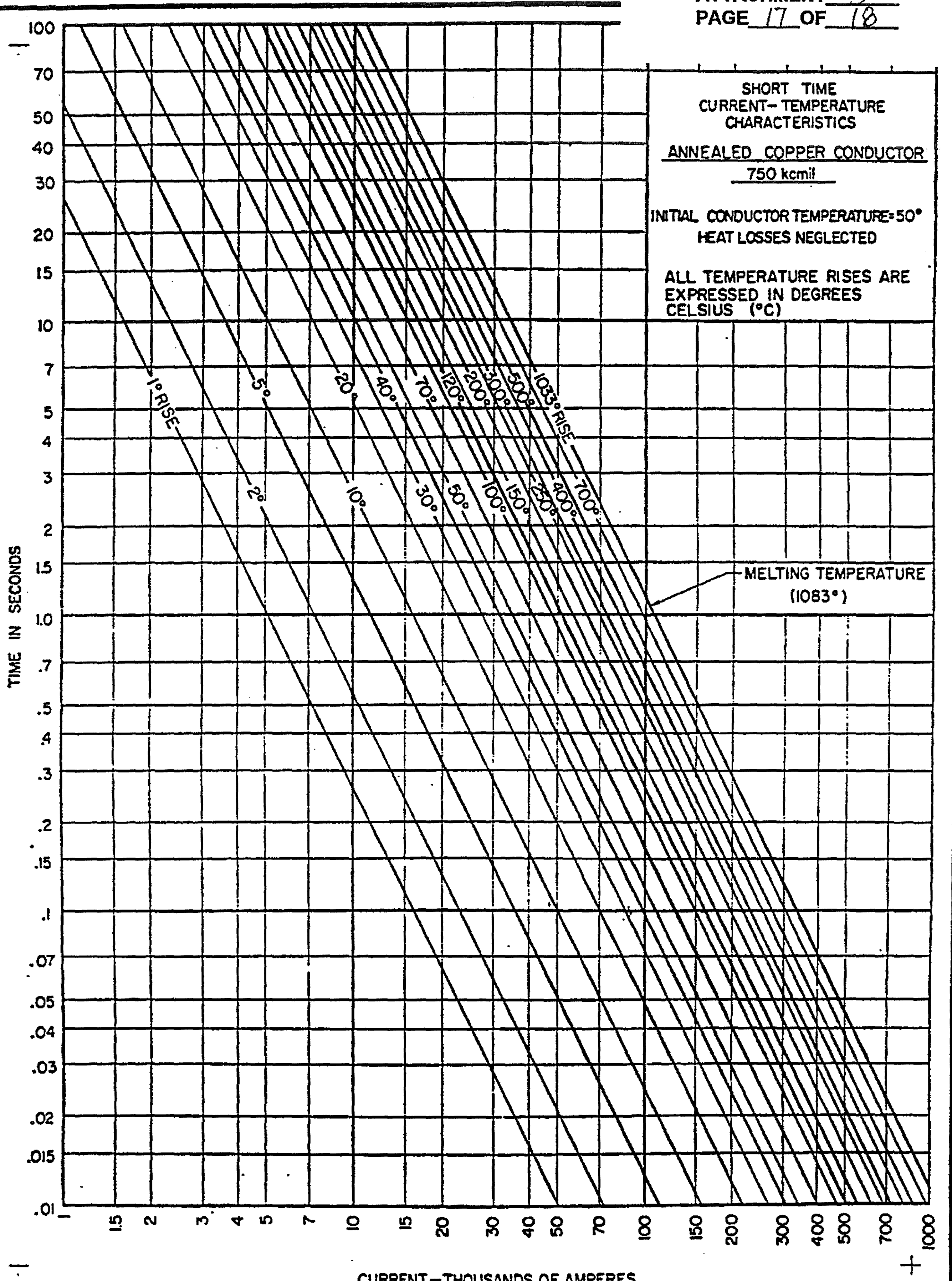


THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT-TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 20 OF SHEETS	DRAWING NUMBER 055076	CHANGE



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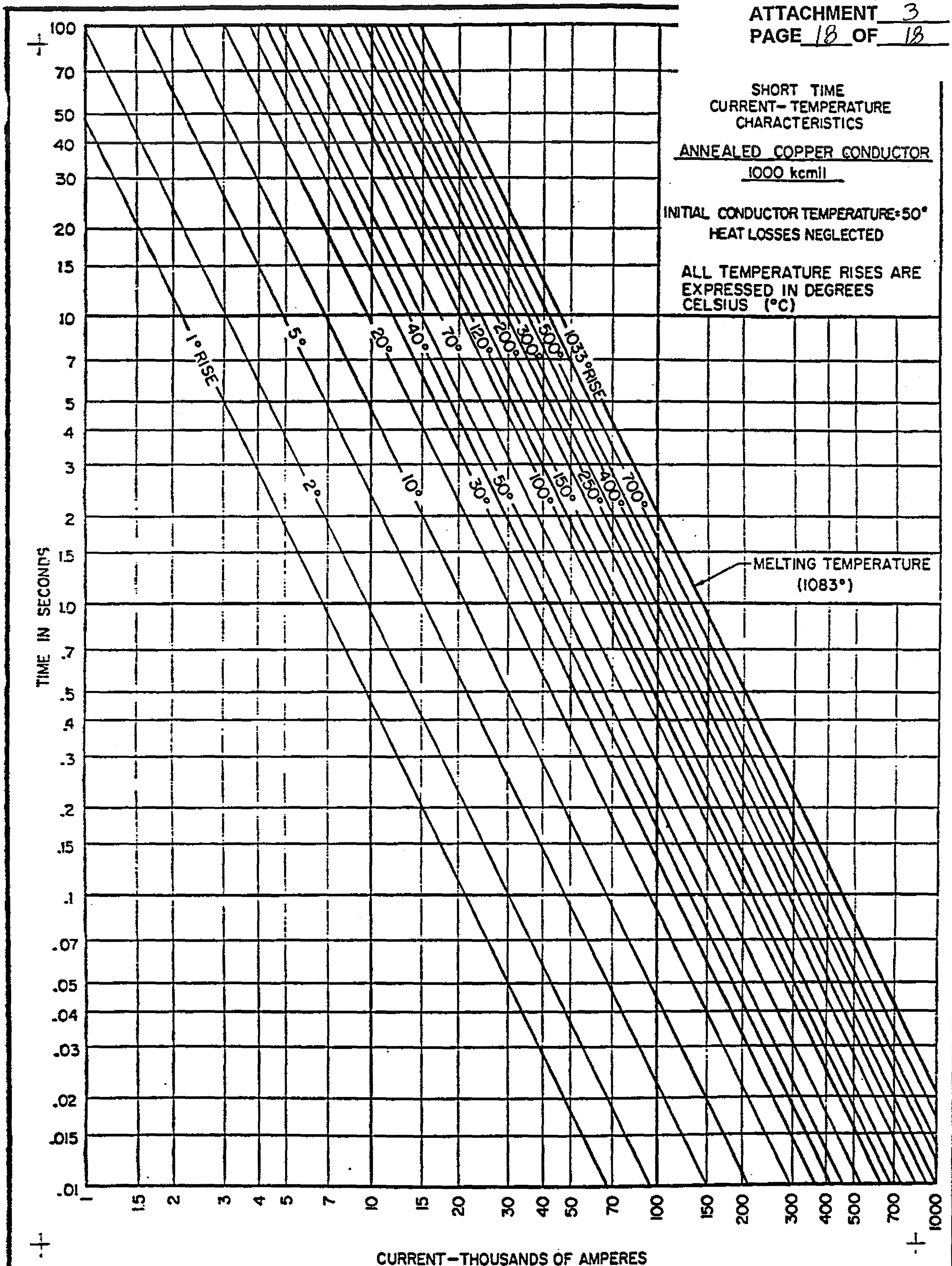


THERMAL ELECTRIC DESIGN STANDARD SHORT TIME CURRENT-TEMPERATURE CHARACTERISTICS FOR COPPER AND ALUMINUM CONDUCTORS	P. G. & E. CO. SHEET 22 OF SHEETS	DRAWING NUMBER 055076	CHANGE

REFERENCE DATA

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 4
PAGE 1 OF 2

The Unique Performance Characteristics of Fuses

The fuse is a reliable overcurrent protective device. A "fusible" link or links encapsulated in a tube and connected to contact terminals comprise the fundamental elements of the basic fuse. Electrical resistance of the link is so low that it simply acts as a conductor. However, when destructive currents occur, the link very quickly melts and opens the circuit to protect conductors and other circuit components and loads. Fuse characteristics are stable. Fuses do not require periodic maintenance or testing. Fuses have three unique performance characteristics.

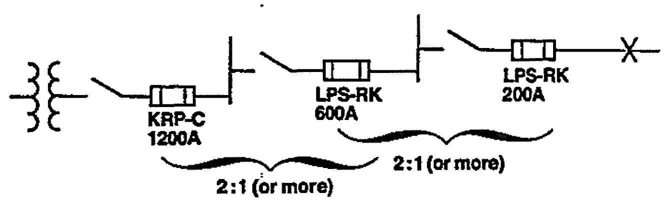
1) **They are safe. Modern fuses have an extremely "high interrupting" rating—can withstand very high fault currents without rupturing.**
2) **Properly applied, fuses prevent "blackouts." Only a fuse nearest a fault opens without upstream fuses (feeders or mains) being affected—fuses thus provide "selective coordination." (These terms are precisely defined in subsequent pages.)**
3) **Fuses provide optimum component protection by keeping fault currents to a low value . . . They are said to be "current limiting."**

Interrupting Rating-Safe Operation

A protective device must be able to withstand the destructive energy of short-circuit currents. If a fault current exceeds a level beyond the capability of the protective device, the device may actually rupture, causing additional damage. Thus it is important in applying a fuse or circuit breaker to use one which can sustain the largest potential short-circuit currents. The rating which defines the capacity of a protective device to maintain its integrity when reacting to fault currents is termed its "interrupting rating." The interrupting rating of most branch-circuit, molded case, circuit breakers typically used in residential service entrance panels is 10,000 amperes. The rating is usually expressed as "10,000 AIC" (AIC being the abbreviation of "amperes interrupting capacity.") Larger, more expensive circuit breakers may have AIC's of 14,000 amperes or higher. In contrast, most modern, current-limiting fuses have an interrupting capacity of 200,000 amperes and are commonly used to protect the lower rated circuit breakers. The National Electrical Code, Section 110-9, requires equipment intended to break current at fault levels to have an interrupting rating sufficient for the current that must be interrupted.

Selective Coordination-Prevention of Blackouts

The coordination of protective devices prevents system power outages or blackouts caused by overcurrent conditions. When only the protective device nearest a faulted circuit opens and larger upstream fuses remain closed, the protective devices are "selectively" coordinated (they discriminate). The word "selective" is used to denote total coordination . . . isolation of a faulted circuit by the opening of only the localized protective device.



This diagram shows the minimum ratios of ampere ratings of HI-CAP and LOW-PEAK fuses that are required to provide "selective coordination" (discrimination) of upstream and downstream fuses.

***Selectivity Ratio Guide (Line-Side to Load-Side) for Blackout Prevention**

Circuit				**Load-Side Fuse**									
Current Rating				601-6000A	601-2000A	0-600A		601-6000A	0-600A	0-1200A	0-600A	15-600A	0-6
Type				Time-Delay	Time-Delay	Dual-Element Time-Delay		Fast-Acting	Fast-Acting			Time-Delay	
Trade Name & U.L. Inc. Class				HI-CAP (L)	LIMITRON (L)	LOW-PEAK (RK1)**	FUSETRON (K5/RK5)	LIMITRON (L)	LIMITRON (K1/RK1)	T-TRON (T)	LIMITRON (J)	HI-CAP (J Dim.)	S (G
Buss Symbol				**KRP-C**	**KLU**	**LPN-RK LPS-RK**	**FRN-R FRS-R**	**KTU**	**KTN-R KTS-R**	**JJN JJS**	**JKS**	**JHC**	**SC**
LINE-SIDE FUSE: 601 to 6000A	Time-Delay	HI-CAP (L)	**KRP-C**	**2:1**	**2.5:1**	**2:1**	**4:1**	**2:1**	**2:1**	**2:1**	**2:1**	**3:1**	**N/A**
601 to 2000A	Time-Delay	LIMITRON (L)	**KLU**	**2:1**	**2:1**	**2:1**	**4:1**	**2:1**	**2:1**	**2:1**	**2:1**	**3:1**	**N/A**
0 to 600A	Dual-Element	LOW-PEAK (RK1)**	**LPN-RK LPS-RK**	—	—	**2:1**	**8:1**	—	**3:1**	**3:1**	**3:1**	**4:1**	**4:1**
0 to 600A	Dual-Element	FUSETRON (K5/RK5)	**FRN-R FRS-R**	—	—	**1.5:1**	**2:1**	—	**1.5:1**	**1.5:1**	**1.5:1**	**1.5:1**	**1.5:**
601 to 6000A	Fast-Acting	LIMITRON (L)	**KTU**	**2:1**	**2.5:1**	**2:1**	**6:1**	**2:1**	**2:1**	**2:1**	**2:1**	**5:1**	**N/A**
0 to 600A	Fast-Acting	LIMITRON (K1/RK1)	**KTN-R KTS-R**	—	—	**3:1**	**8:1**	—	**3:1**	**3:1**	**3:1**	**4:1**	**4:1**
0 to 1200	Fast-Acting	T-TRON (T)	**JJN JJS**	—	—	**3:1**	**8:1**	—	**3:1**	**3:1**	**3:1**	**4:1**	**4:1**
0 to 600	Fast-Acting	LIMITRON (J)	**JKS**	—	—	**3:1**	**8:1**	—	**3:1**	**3:1**	**3:1**	**4:1**	**4:1**
15 to 600A	Time-Delay	HI-CAP (J Dim.)	**JHC**	—	—	**1.5:1**	**4:1**	—	**1.5:1**	**1.5:1**	**1.5:1**	**2:1**	**2:**
0 to 60A	Time-Delay	SC (G)	**SC**	—	—	**3:1**	**4:1**	—	**2:1**	**2:1**	**2:1**	**3:1**	**2:1**

**U. L. Class K5/RK5 Low-Peak fuses (no longer produced) have the same ratios as Hi-Cap (JHC) fuses.
*Note: At some values of fault current, specified ratios may be lowered to permit closer fuse sizing. Plot fuse curves or consult with Bussmann.
General Notes: Ratios given in this Table apply only to Buss fuses. When fuses are within the same case size, consult Bussmann.

Application

Information

SELECTIVITY BETWEEN 240, 480 OR 600 VOLT MAIN AND BRANCH FUSES

DEFINITION: "Coordination is defined as properly localizing a fault condition to restrict outages to the equipment affected, accomplished by choice of selective fault protecting devices."[1]

Coordination is generally desirable and often times mandatory. A lack of coordination can represent a hazard to people and equipment. When designing for coordination, fuses provide distinct advantages over other types of overcurrent protective devices.

To coordinate a circuit breaker protected system, it is generally necessary intentionally to delay the short circuit response of upstream breakers. Though coordination may be achieved, short circuit protection is compromised. The speed and consistency of response of fuses allows coordination without compromising component protection.

The terms coordination and selectivity are often used interchangeably. The term coordination should be used to describe a system as defined above, while two fuses are said to be selective if the branch fuse opens while the main fuse remains operable under **all** conditions of overcurrent.

The word **all** is key. Fuse selectivity cannot be assured by comparing fuse time current curves alone. These curves stop at .01 seconds. Fuse performance under high level fault conditions must also be evaluated. Fuse I^2t is the best tool for assuring coordination under high fault current conditions. If the total clearing I^2t of the branch fuse is less than the melting I^2t of the main fuse, the fuses will be selective under high level fault conditions.

The ratios found in the following tables are conservative and are appropriate for all overcurrents up to 200,000 amperes RMS. In some cases smaller ratios than shown may be used. Consult your Gould Shawmut representative for specific recommendations.

[1]Article 240-12, 1984 National Electrical Code.

Fuse Selectivity Ratios—600 and 480 Volt Applications Up To 200,000 RMS Symmetrical Amperes

BRANCH FUSE	RATIO*								
	MAIN FUSE								
	A4BY	A4BQ	A4BT	FTS	TRS	A6K	A6D	A4J	AJT
A4BY	2.5:1	2:1	2:1	—	—	—	—	—	—
A4BQ	2.5:1	2:1	2:1	—	—	—	—	—	—
A4BT	2.5:1	2.5:1	2:1	—	—	—	—	—	—
FTS	4:1	4:1	3:1	2:1	2:1	4:1	4:1	4:1	4:1
TRS	4:1	4:1	3:1	2:1	2:1	4:1	4:1	4:1	3:1
A6K	2:1	2:1	1.5:1	1.5:1	1.5:1	2:1	2:1	3:1	2:1
A6D	2:1	2:1	1.5:1	1.5:1	1.5:1	2:1	2:1	3:1	2:1
A4J	2:1	2:1	1.5:1	1.5:1	1.5:1	2:1	2:1	2:1	2:1
AJT	2:1**	2:1**	2:1	1.5:1	1.5:1	2:1	2:1	2.5:1	2:1

Fuse Selectivity Ratios—240 Volt Applications Up To 200,000 RMS Symmetrical Amperes

BRANCH FUSE	RATIO*									
	MAIN FUSE									
	A4BY	A4BQ	A4BT	FT	TR	A2K	A2D	A4J	AJT	A3T
A4BY	2.5:1	2:1	2:1	—	—	—	—	—	—	—
A4BQ	2.5:1	2:1	2:1	—	—	—	—	—	—	—
A4BT	2.5:1	2.5:1	2:1	—	—	—	—	—	—	—
FT	5:1	5:1	4:1	2:1	1.5:1	4:1	3:1	4:1	3:1	5:1
TR	4:1	4:1	4:1	2:1	1.5:1	4:1	3:1	4:1	3:1	5:1
A2K	2:1	2:1	1.5:1	1.5:1	1.5:1	2:1	1.5:1	2:1	1.5:1	3:1
A2D	2.5:1	2.5:1	2:1	1.5:1	1.5:1	2:1	1.5:1	2:1	2:1	3:1
A4J	2:1	2:1	1.5:1	1.5:1	1.5:1	2:1	1.5:1	2:1	2:1	3:1
AJT	2:1	2:1	2:1	1.5:1	1.5:1	2.5:1	2:1	2.5:1	2:1	3:1
A3T	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	2:1

*These ratios apply to fuses rated 61-6000A. **Exception: For AJT450-600, use 2:1 on 480V only, 2.25:1 on 600V.

Table 27
Typical Selectivity Schedule* for UL Listed Fuses

	Load Side					
Line Side	Class L Fuse 601-6000 A	Class K1 Fuse 0–600 A	Class J Fuse 0–600 A	Class K5 Time-Delay Fuse 0–600 A	Class J Time-Delay Fuse 0–600 A	Class G Fuse 0–60 A
Class L Fuse 601–6000 A	2:1	2:1	2:1	6:1	5:1	—
Class K1 Fuse 0–600 A		3:1	3:1	8:1	4:1	4:1
Class J Fuse 0–600 A		3:1	3:1	8:1	4:1	4:1
Class K5 Time-Delay Fuse 0–600 A		1.5:1	1.5:1	2:1	1.5:1	1.3:1
Class K5 Time-Delay Current-Limiting Fuse 0–600 A		1.5:1	1.5:1	4:1	2:1	2:1
Class J Time-Delay Fuse 0–600 A		1.5:1	1.5:1	4:1	2:1	2:1

* Exact ratios vary with ampere ratings, system voltage, and short-circuit current.
NOTE: For illustration purposes only. Refer to fuse manufacturer for specific and up-to-date data.

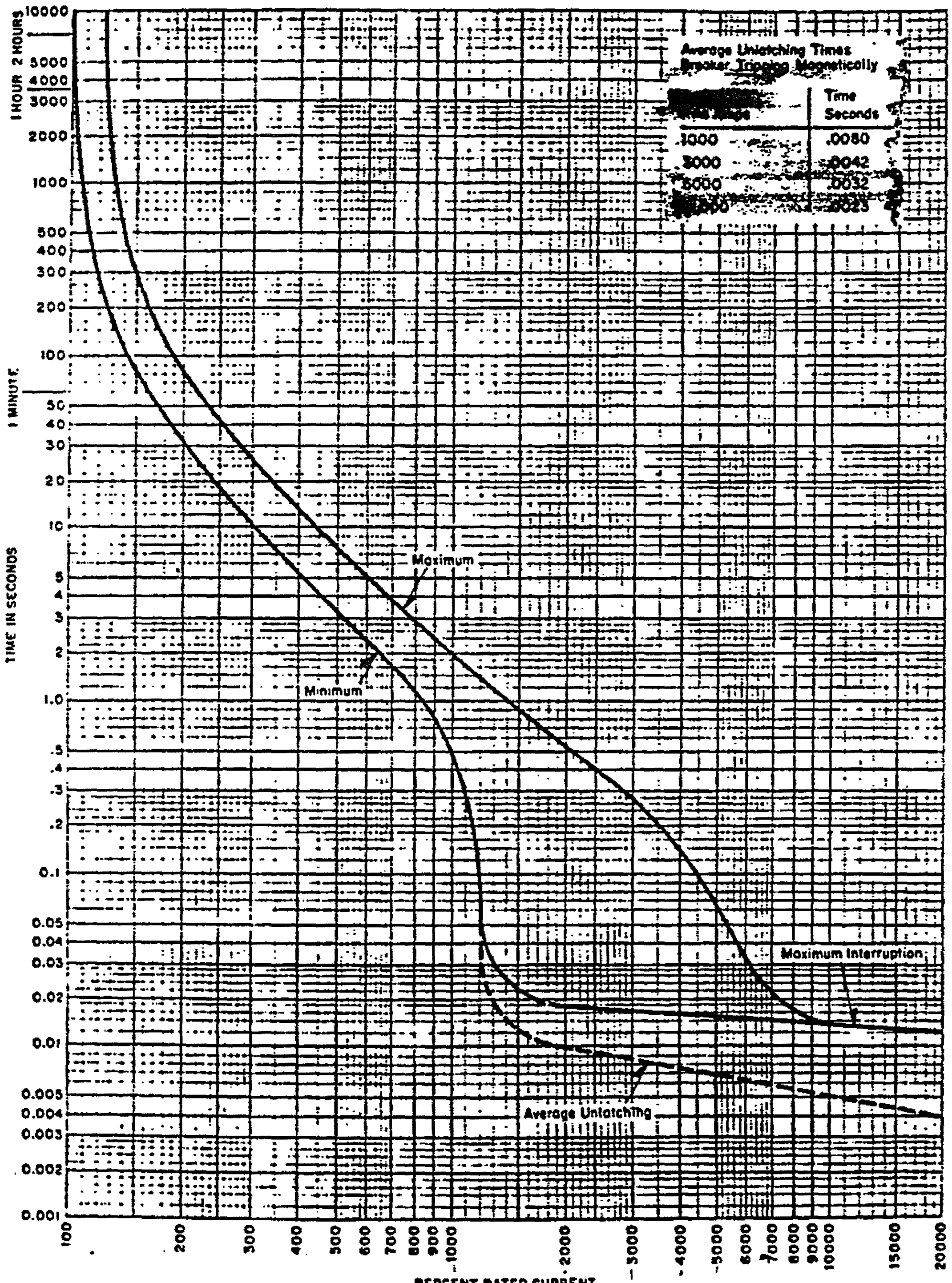
Westinghouse

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 6
PAGE 1 OF 2

Type EB 100 Ampere
Type EHB 100 Ampere
Type FB 150 Ampere
AB De-ion® Circuit Breakers

Thermal Magnetic, Saf-T-Vue
600 Volts Ac, 250 Volts Dc Max.

Maximum and Minimum Characteristics Curves, 40°C Ambient, Cold Start
Type EB, 15 through 40 Amperes. 2 and 3 Poles. 240 Volts Ac, 125/250 Volts Dc



SAME EB, EHB 1 POLE 120VAC, 125VDC

40A EB → 400

October, 1968
New Information
E. D. C/1901, 1903 1928/DB

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 6
PAGE 2 OF 2

Type EB 100 Ampere
Type EHB 100 Ampere
Type FB 150 Ampere
AB De-ion® Circuit Breakers

Thermal Magnetic, Saf-T-Vue
600 Volts Ac, 250 Volts Dc Max.

Maximum and Minimum Characteristics Curves, 40°C Ambient, Cold Start
Type EB, EHB, 15 through 40 Amperes, 1 Pole, 120 Volts Ac, 125 Volts Dc

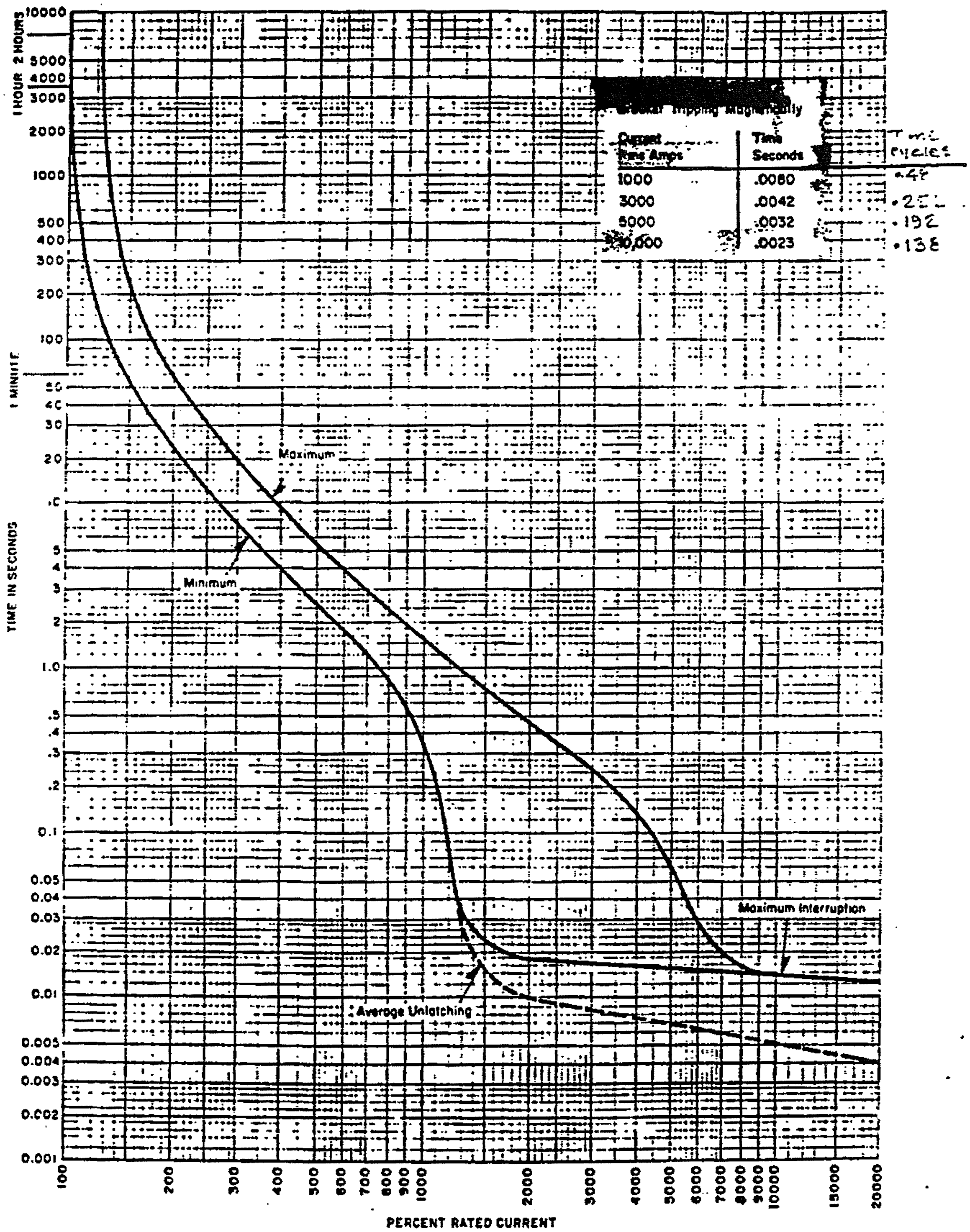


TABLE OF CONTENTS

FUSE COORDINATION STUDY

1. CRITERIA FOR FUSE SELECTION

   1. Fuse must allow full load capacity of control power transformer (CPT).
   2. Fuse must clear short circuit fault anywhere on the secondary - even for fault at load terminals.
   3. Fuse must allow inrush current of the load.
   4. Fuse must protect the control wires.
   5. Short circuit currents should be calculated for ± 10% of CPT secondary voltage.

2. SHORT CIRCUIT CALCULATION

V_{min}	= 0.9 P.U.
Control Power Transformer	= 100 VA
Resistance	= 5.5% (Typical Assumed)
Reactance	= 0.37%
Control Wire	# 12 AWG
Resistance	1.81 Ohms/ 1000 Ft.

With 100 VA CPT, and # 12 AWG control wire, maximum length of 3200 Feet is permitted (per Calc 192A-DC).

Z_B = V^2/VA
= $120^2/100$
= 144 Ohms

R_{CPT} = 0.055 x 144
= 7.92 Ohms

R_W for 3200 Ft.
= (3200/1000)1.81

$= 5.792$ Ohms

X_T = Neglect, It is very small

$I_{SC} = V/(R_W + R_{CPT}) = 120/(5.792 + 7.92)$
$= 8.75$ Amps.

I_{SC} at the load terminals, (i.e. at the end of 3200 Feet) and at the CPT secondary terminals are given below for various voltage conditions.

Voltage P.U.	Fault at load Terminals Amps	Fault at CPT Secondary
0.9	7.88	13.64
1.0	8.75	15.15
1.1	9.63	16.67

3. CONCLUSION :

The existing Westinghouse MCC 100 VA control transformer has 6.8% impedance (See Att. 14). This calculation has assumed average impedance for 100 VA control transformer as 5.5%. Hence fault current calculated with 5.5% impedance will be higher than the fault current calculation with 6.8%. This is acceptable because calculated fault current values are conservative.

03/12/91
10:47:47

PACIFIC GAS AND ELECTRIC COMPANY
OPERATING EXPERIENCE
SCREENING PROGRAM

SREF #: 91-037 | Source: SEN 80 | Source Date: 02/27/91

MOTOR CONTROL CIRCUIT FUSES UNDERSIZED FOR DEGRADED VOLTAGE CONDITIONS

Event Applicability: APPLICABLE

Explanation : DCPP HAS 480V MOTOR CONTROL CENTER. THE EFFECTS OF DEGRADED VOLTAGE ON DCPP IS BEING REVIEWED.

Event Significance : NORMAL

Explanation : DEGRADED VOLTAGE ON THE 480V BUS COULD AFFECT PLANT RELIABILITY.

Event Probability : NORMAL

Explanation : THE 480V SYSTEM IS PROTECTED BY TRANSIENT SUPPRESSORS.

Resulting Priority : NORMAL ACTION   Initial Action Due Date : 04/11/91

KW Search Results (attach printout) : SREF 90-048 (IEN 89-83) ADDRESSES DEGRADED VOLTAGE ON THE GRID. NECS-EE IS REVIEWING. SREF 90-112 AND 84-120 ADDRESSED UNDERRATED FUSES IN DC SYSTEMS. THE SREFS DEAL WITH SPECIFIC TYPES OF FUSES THAT WERE NOT USED AT DCPP.

Resolution Strategy: REQUEST NECS-EE TO REVIEW SEN AND DETERMINE THE EFFECT OF DEGRADED VOLTAGE ON THE 480V SYSTEM. THE REVIEW MAY BE COMBINED WITH THE STUDY BEING PERFORMED BY NECS-EE AND TRANSMISSION PLANNING.

IMMEDIATE DISTRIBUTION

___	JD Townsend	104 5/502		___	RC Anderson	333/A1411
___	BW Giffin	104 5/505		___	KL Herman	333/A1103
___	WG Crockett	104 5/523		___	TP Lee	333/A7073
___	MJ Angus	104 5/504		✓	T Fetterman	333/A9042
___	DE Miklush	104 5/503		___	S Bhattacharya	333/A1414
✓	TJ Martin	109 2/222		✓	WT Rapp	104 3/23C
___	SR Fridley	104 5/519		___	JM Gisclon	77/1459
___	DA Vosberg	104 5/286		___	DH Oatley	77/1409
___	TL Grebel	104 5/536		___	JE Tomkins	333/A6013
___	SG Banton	104 4/401		___	H Thailer	333/A1205

SYSTEM ENGINEER

✓	S BEDNARZ	104/4/20A		✓	RB GOEL	77/1469
✓	BH SUPREMO	333/A9088B		✓	BM GROSSE	333/A9073
___				✓	KC KOZMINSKI	333/A9080

[signature] 3/12/91
Screening Engineer, Date

[signature] 3/12/91
Senior Engineer, Date

IS 1010 I COWAN (INPO) 15-FEB-91 11:30 EST
Subject: SEN 80, Motor Control Circuit Fuses Undersized For Degraded Voltage Conditions

UNIT:	Calvert Cliffs Units 1 & 2 (Baltimore Gas and Electric)
YEAR COMMERCIAL:	1975/1977
REACTOR TYPE (SIZE):	PWR (845 MWe/845 MWe)
REACTOR MANUFACTURER:	Combustion Engineering
PLANT DESIGNER:	Bechtel
EVENT DATE:	December 6, 1990

REFERENCES:

1. NUCLEAR NETWORK Operating Experience Entry OE-4335, "Undersize Fuses Could Have Prevented Safety Related Equipment From Operating," dated January 15, 1991

2. NRC Information Notice 89-83, "Sustained Degraded Voltage on the Offsite Electrical Grid and Loss of Other Generating Stations as a Result of a Plant Trip," dated December 11, 1989

DESCRIPTION:

An electrical design deficiency affecting multiple safety-related systems was discovered during an engineering review of the site electrical distribution system. Fuses installed in approximately 75 safety-related 120 Volt AC motor control circuits were determined to be undersized. Fuses in the motor control circuits were not adequately sized to withstand a sustained degraded voltage condition on the electrical distribution system with a concurrent safety injection actuation signal (SIAS).

The control circuitry of each motor is powered from one phase of the 480 Volt AC power supply to that motor via a 480 to 120 Volt AC step-down transformer. A degraded voltage on the electrical distribution system reduces the 480 Volt AC motor control bus voltage and the 120 Volt AC motor control circuit voltage. If the degraded voltage condition exists for greater than six seconds, the on-site electrical distribution system separates from the offsite power supply, electrical loads are shed, and the emergency diesel generators are started and loaded.

If a safety injection actuation signal is received while the electrical distribution system voltage is degraded, the motor control circuits (see figure 1) will energize the motor starting contactors, but the degraded voltage will be below that required for contactor armature pick-up. Because the armature does not pick-up, the contactor initial high in-rush current continues until the contactor is deenergized when the electrical distribution system separates from the offsite power supply.

The engineering review determined that the motor control circuit fuses would not carry the high in-rush current for the time required to allow the degraded voltage relays to time out. As a result, the fuses for the 480 Volt AC motor control circuits would open, disabling the automatic and remote-manual operation of the motors. Reference 2 describes a 1976 occurrence in which control circuit fuses opened during a degraded voltage event.

This undersized fuse design deficiency resulted from an incomplete analysis of the motor control circuit during off-normal electrical distribution system conditions. Two problems identified as contributing to the incomplete analysis include:

- o In previous circuit analysis, small parallel motor control circuit loads, such as auxiliary relays, were assumed to have negligible effect on the circuit. During re-analysis of the motor control circuit it was realized that these parallel loads reduced the circuit impedance sufficiently to increase the current through the fuse.

- o The original circuit analysis was not revised to incorporate changes to the motor starting contactor operating characteristics (increase in the minimum armature pick-up voltage) that were provided by the manufacturer after the original circuit analysis was performed.

CORRECTIVE ACTIONS:

The undersized fuses were replaced with higher rated fuses and all drawings and engineering calculations were revised to reflect this fuse sizing.

EVENT CRITERIA: Design Deficiency (Undersized fuses)

CAUSE CATEGORIES: Analysis (Incomplete electrical circuit analysis)

MALFUNCTIONING SYSTEMS: Various

ATTACHMENTS: Figure 1, Simplified Schematic Diagram of Typical Valve Motor Control Circuit

The figure that accompanies this SEN is transmitted by telecopy to utility and participant SEE-IN contacts. Copies of this figure can be obtained from your company's SEE-IN contact. Assistance with telecopy reception problems can be obtained by contacting Tony Talton at INPO, (404) 951-4732.

It is recommended that the operations, maintenance, and engineering support managers be included in the distribution of this Significant Event Notification.

Utilities and participants are requested to provide feedback on similar occurrences and solutions at their plants or on their equipment to the information contact listed below.

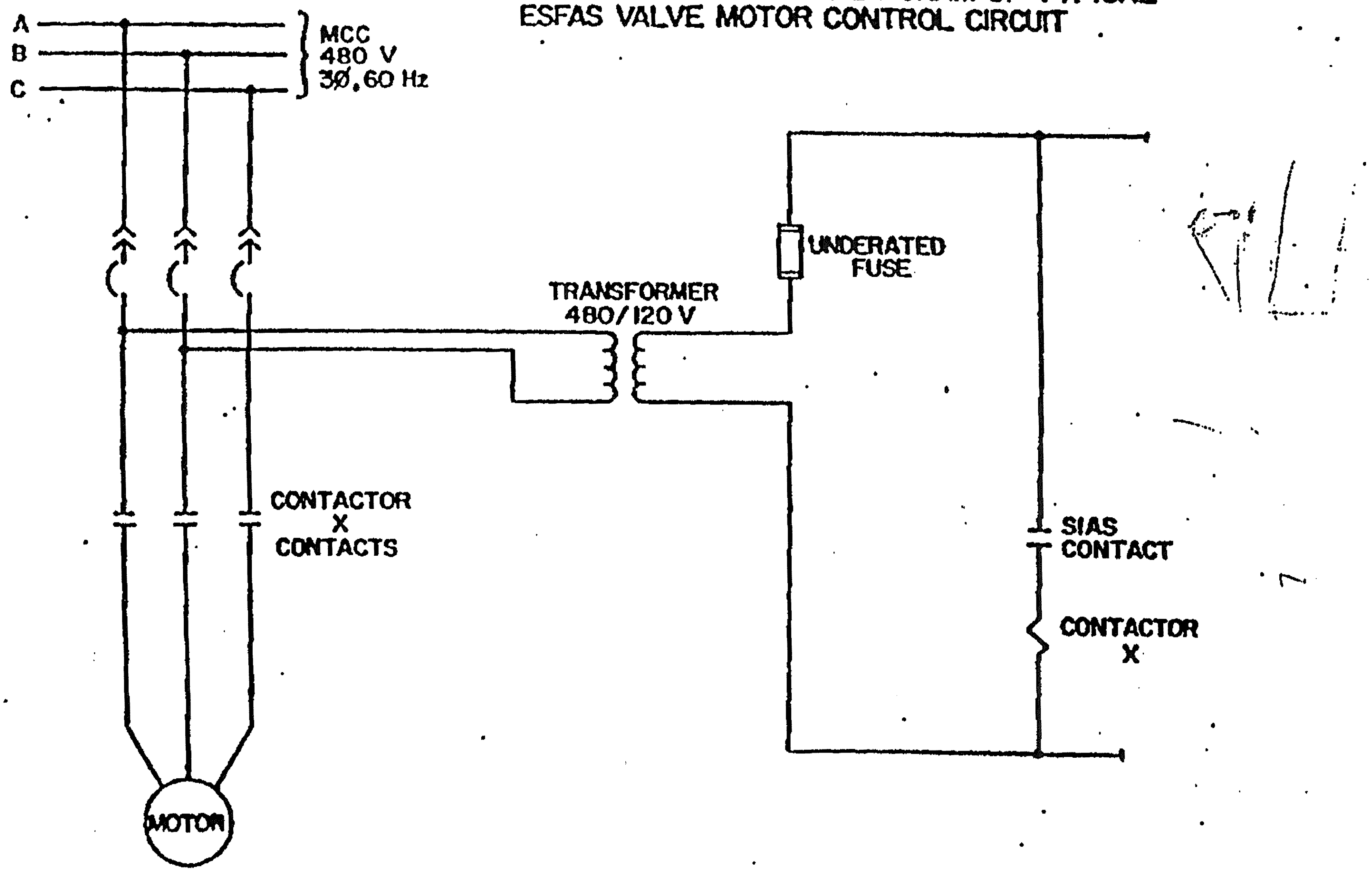
LIMITED DISTRIBUTION

KEYWORDS: Fuse, Degraded Voltage, Contactor

INFORMATION CONTACT: Brian O'Donnell, INPO, (404) 953-7628

FIGURE 1

SIMPLIFIED SCHEMATIC DIAGRAM OF TYPICAL ESFAS VALVE MOTOR CONTROL CIRCUIT



SEN 80, MOTOR CONTROL CIRCUIT FUSES UNDERSIZED FOR DEGARDED VOLTAGE CONDITIONS

03/11/91 Nuclear Operations Support
13:43:23 SEARCH SREFs FOR KEYWORDS
Matching SREFs Found

UNION - Start OR Search

** Search Criteria **
FUSE

83-012
84-053
84-100
84-120 ✓
85-038
85-026
85-121
86-153
86-145
86-102
86-081
87-083
88-039
83-045
83-083 ✓
83-096 ←
82-032

Choose the SREF you would like to Display
<Esc> to Exit

03/11/91 Nuclear Operations Support User: DPY
13:43:23 SEARCH SREFs FOR KEYWORDS
Matching SREFs Found

UNION - tart OR Search

** Search Criteria **
FUSE

82-100 ✓
82-113
82-116
81-005
81-031
81-036
81-062
87-132
88-182
89-079
81-001
90-010
83-317
84-292
87-181
87-188
87-190

Choose the SREF you would like to Display
<Esc> to Exit

03/11/91 Nuclear Operations Support User: DPY
13:43:23 SEARCH SREFs FOR KEYWORDS
.atching SREFs Found

UNION - Start OR Search

87-191
87-195

89-312
85-350
85-355
86-251
86-258
88-285
89-321
90-112 ✓
82-195

** Search Criteria **
FUSE

82-207
84-237
88-228
80-108
82-178
84-222

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<Esc> to Exit

03/11/91 Nuclear Operations Support User: DPY
13:43:23 SEARCH SREFs FOR KEYWORDS

Matching SREFs Found

UNION - Start OR Search

86-258
88-285
89-321
90-112
82-195
82-207
84-237
88-228
80-108
82-178
84-222

** Search Criteria **
FUSE

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90-186
84-323
90-180
90-309

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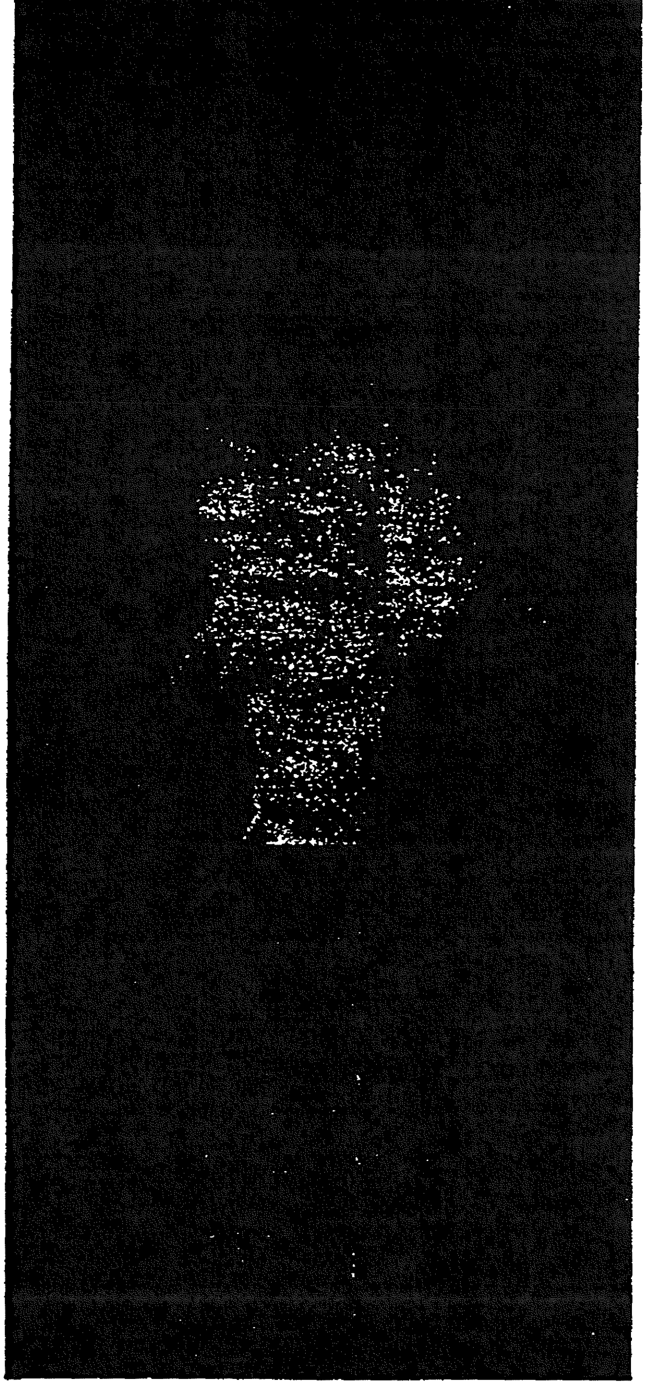
SELECTIVE SYSTEMS FOR OVERCURRENT PROTECTION



This twelfth article in the continuing series on overcurrent protection continues the discussion of selective systems and selectivity of current breakers, fuses and combinations of fuses and circuit breakers. Instructions are given how to coordinate these devices.

Previous articles in the series on overcurrent prot tion have dealt with the safety of the electrical s tem, with the calculation of short circuits and u the effects of overcurrents on various components the electrical system.

Edited by Frank R. Valvoda, P.E., *Frank Valvoda & A ciates, Oak Park, Ill.*

■ Selectivity is the ability of overcurrent protect devices to coordinate with one another under sh circuit conditions, so that only the protective dev immediately on the line side of the source of overc rent will open. A selective system is desirable beca it insures that there will be minimum disturbance the system when an overcurrent occurs. No one wa to open a main service or an important feeder fo short circuit on a small branch circuit, yet this is w can and does happen far too frequently. (See Fig.

Obviously, the design of selective systems w circuit breakers can be extremely difficult and, in so cases, even impossible. This is due to the minim irreducible opening time of a circuit breaker coup with the very fast unlatching action of the break instantaneous trip elements.

These instantaneous trip elements are operated the magnetic effects of the short circuit, which is function of the total magnetic energy in the syst under short circuit conditions. The unlatching ti under severe short circuits will be dependent on the rate of rise and the peak values rather than the r values of the short circuit current. These times may less than one-half cycle.

Selective Action of Fuses

The action of fuses is quite different. The fuse ope due to the heating effect of the current, and the ra of rise or peak current affect the fuse only as th affect the total equivalent rms current. The te "equivalent rms current" is used because the curve usually of a distorted, rather than of a true sine wa shape, and the total time of opening can be less th one-half cycle. The current which actually pas through a fuse while it is clearing a short circuit c be assigned an rms value based on the equivale heating effect of that current.

The opening of a fuse can be divided into two par the melting time and the arcing time. (See Fig. The sum of the melting time and the arcing time is t total clearing time. The equivalent heating ener which is required to melt the fuse link during t melting time is represented by the area A under t curve in Fig. 3a, while the equivalent heating ener which passes through the fuse while it is clearing

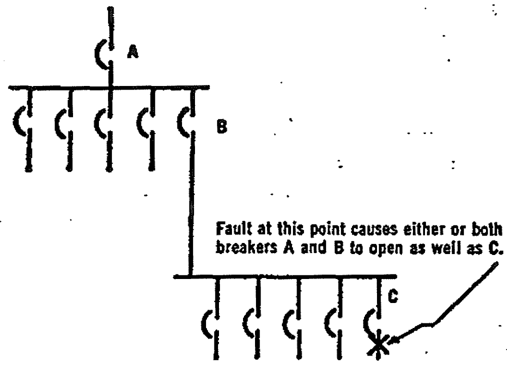


Fig. 1—Example of non-selective system.

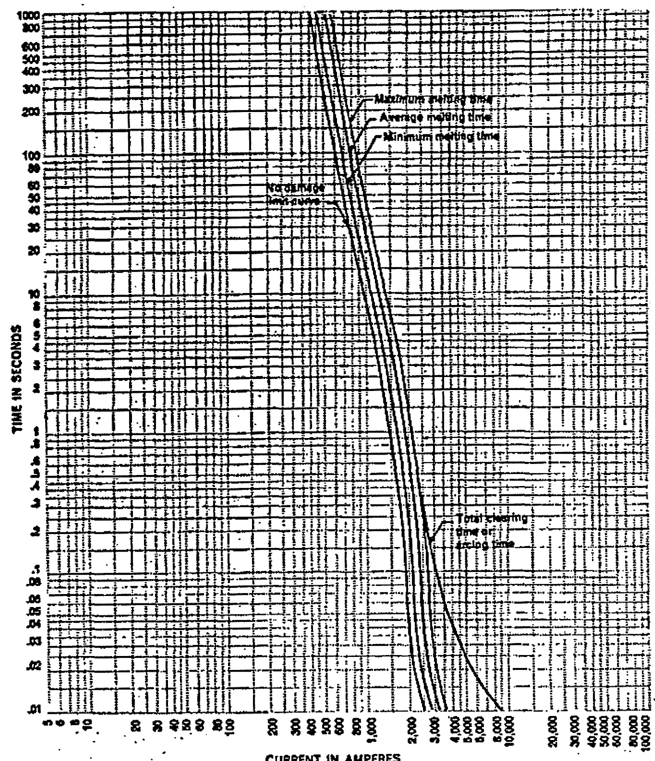


Fig. 4—Development of fuse time-current band for coordination studies.

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 9
PAGE 2 OF 6

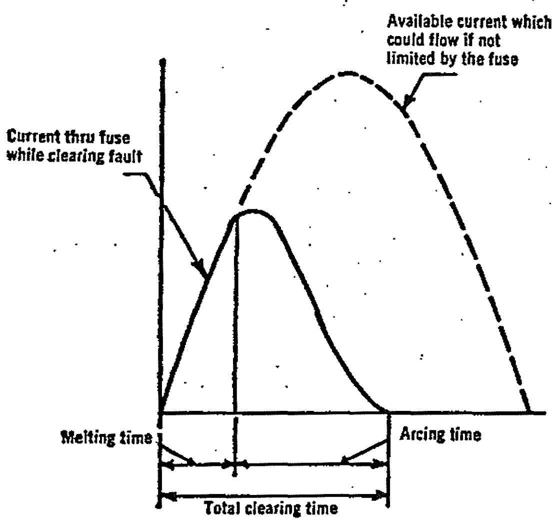


Fig. 2—Action of current-limiting fuse in clearing fault.

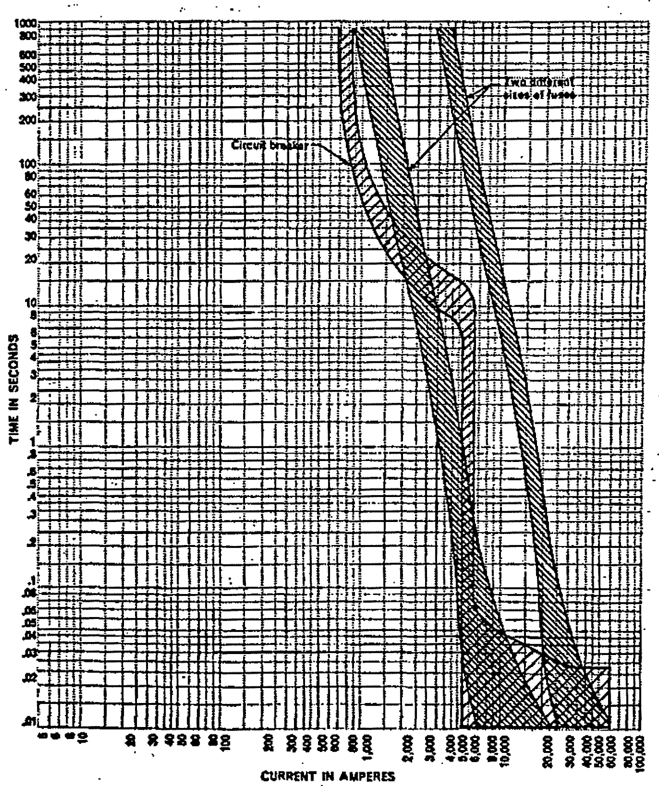


Fig. 5—Time-current curves of fuses serving circuit breakers, illustrating lack of selectivity.

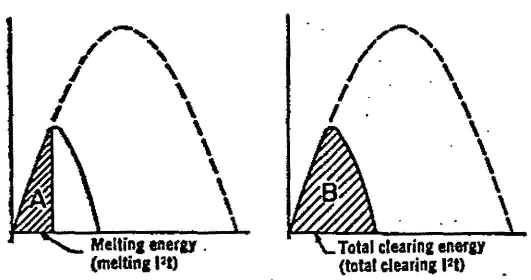


Fig. 3—Heating energy through fuse while melting fuse link and clearing short circuit.

short circuit is represented by area B in Fig. 3b.

The value of these areas can be converted to and expressed in ampere-squared-seconds (I^2t); the melting energy is termed the melting I^2t and the total energy is termed either the total clearing I^2t or, more simply, clearing I^2t. The clearing I^2t for any given size and type of fuse increases as the available short circuit current increases.

However, when the available short circuit currents reach very high levels in relation to the fuse size, the clearing I^2t approaches a constant, and may be treated as such for each size and type fuse. The melting I^2t under short circuit conditions of any given fuse is very close to a constant for all values of current which are high enough to cause melting of the fuse link in less than one second, because the rapidly melting link does not have time to be cooled by the effects of radiation or convection.

It should be apparent that only the branch fuse will open if the total clearing ampere-squared-seconds that can pass through the branch fuse while it is clearing a fault on its load side is less than the melting ampere-squared-seconds of the feeder fuse. The feeder fuse will be unaffected.

It is important to note that the actual melting of the fuse link takes place over a very short period of time. Although some measurable time occurs while the fuse is being heated toward its melting point, the actual melting takes place almost instantaneously. With a properly designed fuse, if the link is heated to just below its melting point and the flow of current is interrupted, the fuse will cool off and the link will be undamaged.

With the older type fuses, especially those with zinc links, it was possible for the fuse's continuous current carrying capacity to be reduced due to crystalization of the metal in the link. However, with today's high interrupting capacity fuses of quality manufacture, the action of the fuse is so carefully controlled that almost any value of current that will begin the melting of the fuse link will cause the fuse to completely open. This is true in most cases even if the flow of current should be interrupted from another source.

Due to the positive-acting nature of the fuse, selectivity can be achieved relatively easily. It is merely necessary to be able to determine that the clearing I^2t of the branch fuse is less than the melting I^2t of the fuse feeding it. The most satisfactory way of determining this is through the use of selectivity tables furnished by the fuse manufacturer.

These tables indicate the size ratios that need to be maintained between various types of fuses. For example, when fuses are of the same type the general requirement is a ratio of two to one with the feeder fuse being twice the size of the branch fuse. While these tables are available for the fuses of the major low-voltage fuse manufacturers, they have never been developed for medium and high-voltage fuses. In addition, the tables apply only to the fuses of one manufacturer and are not suitable for application when selectivity is desired between two or more different makes of fuses or between fuses and circuit breakers.

Under the above conditions, it is necessary to resort to the time-current curves of the fuse manufacturers. The first step is to obtain from the manufacturer both the melting and total clearing time-current curves of the fuses in question. When these curves are obtained, it is very important to note whether these curves are based on minimum, average, or maximum values. Melting-time curves are usually expressed as either minimum or average melting times. The difference between the minimum and average values may be approximated for coordination purposes at 10%.

To convert the average melting time curves to minimum melting time curves, plot a line that is 10% below the average values of the current. An additional curve should be plotted 10% below the minimum melting curve. This is the no-damage limit curve, a safety factor to insure that there will be no damage to the fuse link of the feeder fuse caused by the clearing of the branch protective device. The entire procedure of developing the coordination curve of a particular fuse is shown in Fig. 4. This coordination curve, or band, needs to be developed for each of the fuses in a mixed system and plotted on the coordination sheet described later.

When low-voltage fuses are being coordinated with other low-voltage fuses by the same manufacturer, the tables in Data Book Section VII-E should be followed. These data give the correct ratios for high interrupting capacity and current-limiting fuses of all American manufacturers.

Relays

The time-current characteristics of relays make them just about the most accurate of all devices. Thus the curve for a given relay plots on log-log paper as a single line rather than as a band. A detailed investigation of such relay curves is presently beyond the scope of this study, but specific information may be obtained from the manufacturer of the relays under consideration.

Some problems can occur in the application of relays due to the errors in operation introduced by improper current transformer selection or application. In addition, the effect of the DC component must be taken into consideration with the operation of some relays, but not in the operation of others. The decay of the short circuit current due to changing circuit reactances can also affect the operation.

It is obvious that no engineer commonly doing industrial or commercial specifying is able to spend sufficient time to become a relay application expert due to infrequent application in his work.

Ordinarily the engineer will encounter primary relays only in those relay settings used on the utility company service feeding the facility. The vast majority of all transformers serving installations of the type in question are protected on their primary side by current-limiting fuses. This is especially true of the transformer owned by the light industrial or commercial installation. However, the utility will usually have relays at its substation which must be considered as part of the overall picture of selectivity.

Curves furnished by the utility company for the relays being applied will have allowances made for any decrement of short circuit current due to generator decay, and the utility will furnish the necessary information as to the effect of the DC component on the relay. Adjustment of their time-current curves may be required to compensate for any change in X/R ratio between utility relaying point and facility service entrance. This change in X/R ratio would result in a corresponding change in the DC component.

Coordination of Different Devices in Series

To this point consideration has been given to the coordination of essentially the same devices with one another. This type of coordination is simple compared to the problems encountered with the coordination of dissimilar devices. In particular, the coordination of fuses with circuit breakers or circuit breakers with fuses presents some real problems.

These problems arise from the different ways in which short circuit currents affect these devices. The action of the circuit breaker, as has been pointed out, is a function of the magnetic field, while the action of the fuse is a function of the heating effects of the short circuit current. Thus, when these devices are in series and their time-current curves are compared they may appear to be selective; in actual practice they will not coordinate.

If the fuse is on the line side of the circuit breaker, the problem is readily apparent. The circuit breaker cannot clear the higher value short circuits prior to the operation of the fuse, and there will be a crossing of the time-current curves as shown in Fig. 5. This relationship holds true whether primary or secondary fuses are ahead of the circuit breakers.

In systems with available short circuit currents which are large in comparison to the continuous ratings of the protective devices, coordination is virtually impossible regardless of the difference in the continuous ratings. The only time that there can be coordination of fuses ahead of circuit breakers is when the available short circuit current is not sufficient to cause the fuse to open in times less than the circuit breaker's maximum interrupting time. Such a relationship is indicated in Fig. 6.

Another problem that may be encountered is when the fuse is so fast that the circuit breakers do not unlatch. This appears to depend upon the actual amount of short circuit current trying to flow in the system, upon the condition of the breakers, upon the type of fuses, and even upon the loading of the breakers at the time of short circuit.

A common example of this may be found when current-limiting fuses are used to increase the interrupting capacity of lighting panel circuit breakers. A fault on the load side of one of the small size branch circuit breakers can cause the fuse protecting that phase to open without tripping the circuit breaker.

Then one-third of the circuits in a three-phase, four-wire panel are shut off and the maintenance man has no indication of the location of the trouble. Because he sees no branch breaker open, he frequently assumes that the fault is in the wiring to the panel or within the panel itself. After spending some time looking for a fault, he replaces the fuse and closes the circuit only to immediately blow another fuse.

He finally realizes that the fault is on one of the branch circuits. Rather than look through 10 to 20 circuits, he opens all of the breakers on that phase and replaces the fuse. When another fuse blows as he closes the breakers one at a time, he has isolated the fault.

Circuit Breakers Ahead of Fuses

It would seem to be a simple procedure to coordinate fuses with circuit breakers when the circuit breakers are feeding the fuses. Fuses are apparently much faster than the circuit breakers, especially when the fuses are smaller in continuous current rating than the circuit breakers, and coordination curves plotted on a common graph might indicate complete selectivity. (Fig. 7.)

But in actual practice the system might prove to be non-selective, because the breaker functions on the magnetic effect of the short circuit current while the fuse functions on the equivalent rms value. The log-log graph paper usually used is based on true rms current, and the shortest time shown on the standard paper is 0.01 sec.

On higher values of short circuit current it was seen that the unlatching of the circuit breakers took place

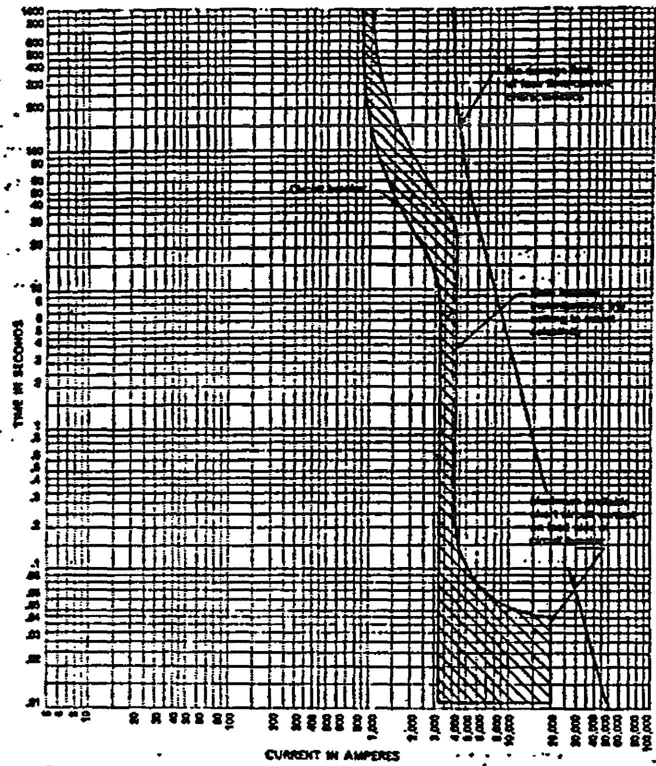


Fig. 6—Time-current curves of fuse serving circuit breaker showing how limited available short circuit current can permit selective operation.

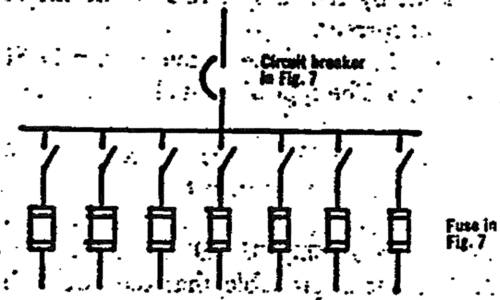


Fig. 8—One-line diagram of system plotted in Fig. 7.

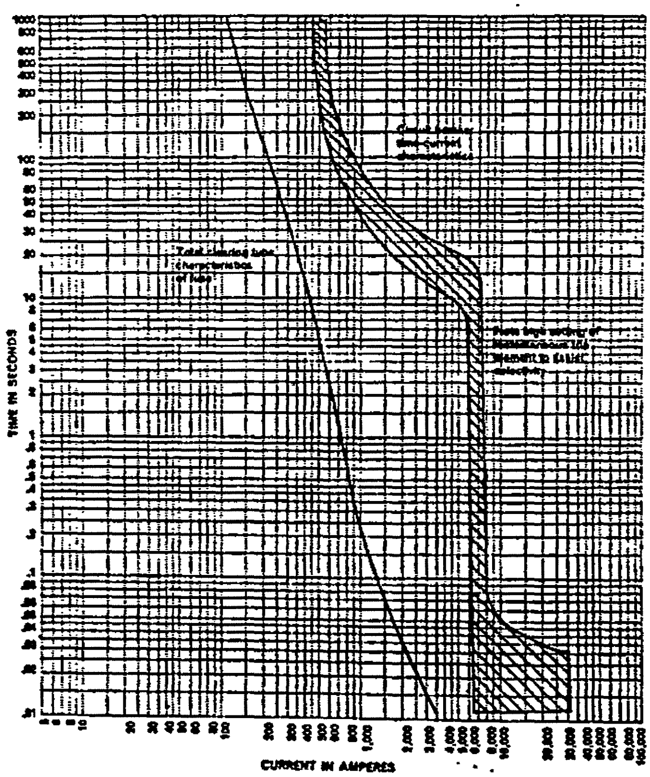


Fig. 7—Time-current characteristic of circuit breaker serving fuse, indicating selectivity. But system may not actually be selective (see text).

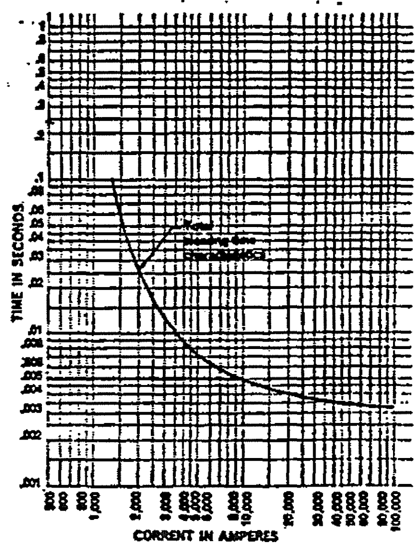


Fig. 9—Total clearing time characteristics for a typical high interrupting capacity fuse at times less than 0.01 sec. (see text for explanation).

in a very short time. (Westinghouse JA frame and larger molded case circuit breakers actually unlatch in much less than one half of a cycle.) The unlatching is brought about by the rate of rise of current coupled with the peak current.

A one-line diagram of the system shown in Fig. 7 is shown in Fig. 8. The typical total clearing time for one of the fuses is indicated in Fig. 9, and it can be seen that a fault of 10,000 amp is cleared in 0.005 sec. While this is much faster than the total clearing time of the circuit breaker, it is not faster than the breaker's unlatching time of only 0.0029 sec for this available current. Thus, it is probable that the circuit breaker will unlatch while the fuse is clearing the fault, and the system will not be selective.

Because total clearing time curves for fuses showing times below 0.01 sec are not commonly available, and unlatching times are not available for all the different makes of circuit breakers, it is almost impossible to insure that branch fuses will open without unlatching the circuit breakers. This lack of selectivity has been noted even when there has been a size difference between the fuses and circuit breakers of over eight to one.

As a practical matter, if circuit breakers must serve fuses, there should be as much rating difference between the largest fuse and the circuit breaker as possible. In no case should the fuse be more than one-fourth the rating of the circuit breaker. $\frac{\text{Rating of Breaker}}{\text{Rating of Fuse}} \geq 4$

In addition, the circuit breaker itself should be kept as far from the fuses as possible so that there will be impedance between the breaker and the fuses to cause a short circuit on the load side of the fuses to be quite different in value than a short circuit on the load side of the circuit breaker.

In some applications of large air breakers, the use of short time delay trip elements in conjunction with long time-delay and instantaneous trip elements will be justified and will assist in insuring selectivity. (See Fig. 10.)

In this system observe that the continuous rating of the circuit breaker is 1,000 amp, the available short circuit current on the load side of the circuit breaker is 10,000 amp, the available short circuit current at the motor control center is 5,000 amp, and the available short circuit current on the load terminals of the MCC is 4,000 amp. By setting the short time delay trip element of the circuit breaker at the minimum value that will permit starting the largest motor while all other motors are running (in this instance, 2,500 amp), and setting the instantaneous trip element at 4,500 amp, we achieve instantaneous tripping of faults greater than 4,500 amp for the entire system.

The short time delay trip elements will not allow the breaker to trip for 6 cy for a fault on the load terminals of the motor control center, so that coordination with the fuses is more certain. In some makes of breakers, 3 cy short delay trips are available which will insure better protection when there are arcing faults. Remember, that when time-delay is introduced into this portion of the circuit, coordination with devices to the line side of the circuit breaker needs to be checked carefully.

Plotting the Coordination Curves

A finished coordination chart for a system employing fuse protection for motor control center combination starters, feeder breakers without a main breaker, primary fuse protection for the transformer, and relay protection at the power company substation is shown in Fig. 11.

This system is apparently selective except for higher values of short circuit current which might cause the primary fuses to open before the feeder breakers can clear a fault. The large difference in continuous ratings between the motor control center's largest fuse and the breaker serving the motor control center is being depended on to provide selectivity between these devices. Short time-delay trip elements have not been introduced into the feeder breaker because it was desired to keep the instantaneous trip settings of the breaker as low as possible to insure the maximum degree of selectivity between the feeder breakers and the primary fuses.

Information Required to Prepare Coordination Chart For a System

Prior to starting the preparation of a coordination chart the necessary information and data should be assembled as is tabulated in Data Book Section VII-D. After this information and material is assembled, it is possible to begin with the plotting of the chart. It is usually wise to begin the study at the point farthest removed from the source and to progress towards the source, analyzing each pair of protective devices for selectivity and making adjustments as necessary. If the study is started at the source and worked toward the branch circuits, it is possible that all of the work will have to be repeated several times as conflicts in selectivity are revealed.

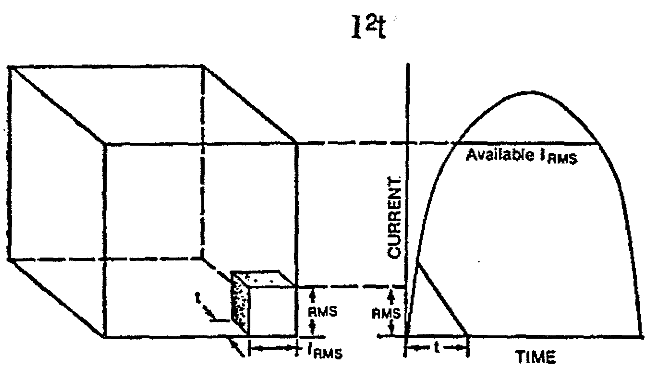
Actual Plotting of the Charts

The most convenient way of plotting the charts is by tracing the time-current curves of the various protective devices on a blank sheet of the standard 4½ by 5 in. log-log paper, (K & E No. 48-5257 or equal). The curves need to be properly indexed to one another based on the current which each device will see. Par-

5B. Current Limitation

Current limitation is the ability of a fuse when interrupting currents in its current-limiting range, to reduce the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the fuse were replaced with a solid conductor having comparable impedance.

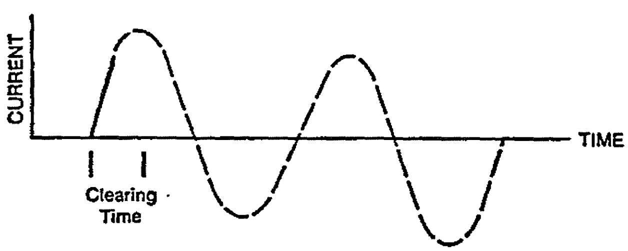
Current limitation is required in order to protect sensitive electronic components. When a short-circuit occurs, damaging magnetic forces and thermal energy result. These magnetic forces, along with the damaging thermal energy, are responsible for blowing tracings off PC boards. The magnetic forces are proportional to the peak of the current squared. If a current limiting device is able to reduce the peak let-thru current to ¼ of the peak available current, the magnetic forces are reduced to 1/16, or less, of that available. Excessive thermal energy, proportional to the RMS current squared, will melt the delicate junctions of semiconductors. If the RMS let-thru current is reduced to ¼ of that available, the damaging thermal energy is reduced to 1/16, or less, of that available, further reducing the damage due to the short circuit.



Volume of small cube = let-through $I_{RMS}{}^2t$ in Ampere² Seconds

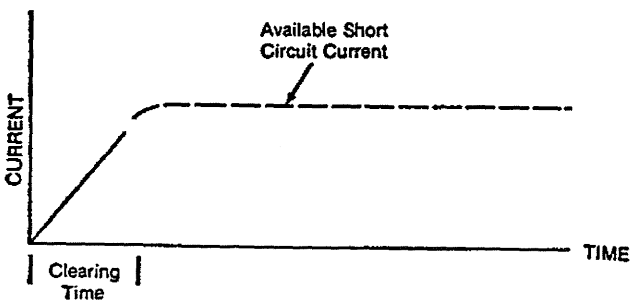
A.

In an AC system, the current limiting fuse must drive the current to zero before normal current zero.



B.

In DC systems, the current limiting fuse must begin driving the current to zero before the full available DC current is reached.



C.

6. Ambient Temperature

Ambient temperature can greatly affect the fuse's current rating. Therefore, it is important to test a system at the highest and lowest anticipated ambient temperature as part of the new product design process. Figure 6-1 is the Ambient Effect Chart for FUSETRON, Dual Element Time-Delay fuses. The percent of rating or opening time is depicted on the vertical axis. Across the bottom are ambient temperatures in both degrees Fahrenheit and degrees Centigrade. For example, a FUSETRON, Dual Element fuse (such as the MDL series) applied at 140F would operate in approximately 70% of its standard opening time, and its current carrying capacity would be approximately 87% of its normal current rating. The nominal fuse ratings are based on ambient temperatures in the range of 70F (21.0C) thru 80F (26.7C). Change in opening time occurs with loads of 500% (or less) of the nominal current rating of the fuse.

Figure 6-2 shows the Ambient Effects for Non-Dual-Element fuses. This chart is generally used for all but dual-element fuses. Applying a non-dual-element fuse at 140 F., one can see that the fuse would open in about 90-95% of its normal opening time and it would have a current rating of between 90 and 95% of its normal rating. The single curve reflects the effects of ambient temperature on both the current carrying capacity and opening time relative to ratings based on a nominal 75.2F (24C) ambient.

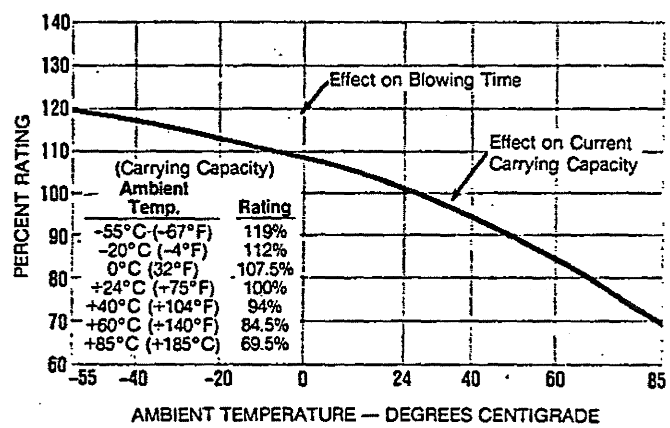


Figure 6–1. Derating curve of time delay fuse.

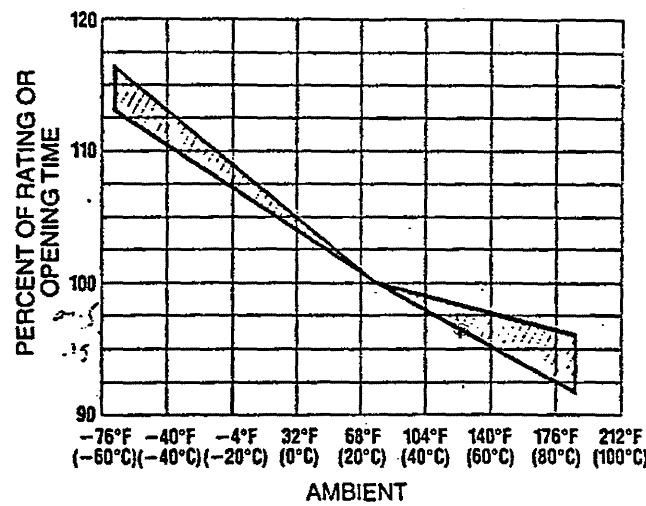


Figure 6–2. Derating curve of normal blow fuse.

PENETRATION CONDUCTOR

ENGINEERING DATA SHEET

Penetration Number______________

Containment Ambient______________°C

Outer End Ambient______________°C

Length of Nozzle ______________"

Nom. Pipe Size______________"

Schedule______________

Inside Dia. of Liner Pipe in Shield
______________"

Is annulus open to air circulation___

1. To select a conductor size use ampacity from Table I derated for containment ambient temperature (Table II) and derated for diversity (Table III).

   IE: Allowable ampacity = Ampacity from Table I x temperature derating from Table II x diversity derating from Table III.

   No conductor may carry more than the above current.

2. Determine total penetration heating load on a per foot basis by calculating the heating affect of a one foot length of each active conductor as in Table IV. For wires which have a low duty cycle see Note 3. Determine if heating load is within the per foot allowable shown in Table V. If not, wires may be paralleled or a larger conductor size may be selected.

TABLE I.

MAXIMUM WIRE AMPACITY

30°C - No Derating, 3 Conductors in a conduit

Wire Size	Maximum Current	Resistance/foot @ 90°C
No. 18 AWG	14 Amperes	.00815 ohms
No. 16	18	.00513
No. 14	25	.00321
No. 12	30	.00203
No. 10	40	.00127
No. 8	50	.000801
No. 6	70	.000513
No. 4	90	.000324
No. 2	120	.000203
No. 1	140	.000161
No. 0	155	.000128
No. 2/0	220	.000102

TABLE II

DERATING FACTORS FOR CONTAINMENT

AMBIENT TEMPERATURE

Containment Ambient Temperature	Derating Factor
30°C	1.00
40°C	.90
50°C	.80
60°C	.67
65°C	.60
70°C	.52

TABLE III

DIVERSITY DERATING FACTORS

% Wires in Use	Derating Factor
100%	0.33
90%	0.35
80%	0.38
70%	0.41
60%	0.45
50%	0.51
40%	0.57
30% to 0%	0.66

Diversity is defined as the percentof wires which are in use at the same time. Wires which have low duty cycles may be ignored or weighted as in Note 3 below. Wires which carry 5% or less of the current listed in Table I may be ignored in calculating percent wires in use. Table III above applies to conduits with 84 or more wires.

AMBIENT. DIVERSITY

#16 AWG - 18A x 0.8 x 0.66 = 9.5 A

#10 AWG 40A x 0.8 x 0.66 = 21.12 A

TABLE IV

CALCULATION OF PER FOOT HEAT LOADS

Wire Size AWG or MCM	No. of Wires (N)	Amps per Wire (1)	Resistance of Wire 90°C /ft.(R)	Duty (D) Cycle 0, 0.5, 1	Effective Watts/ft. (NxI^2xRxD)

Total Effective Heat Load Watts/Ft.______

TABLE V

MAXIMUM ALLOWABLE

EFFECTIVE HEAT LOAD

Nominal Size of Penetration	Containment Temperature 70°C	60°C	50°C	40°C
	Maximum Allowable Watts/Foot			
12"	12	18	25	32
10"	10	15	21	27
8"	8	12	17	21

1. Summation of watts per foot of Table IV must not exceed maximum permissible watts per foot of Table V. Interpolation is permissible in using Table II, III and IV.

2. Resistance to be based on 90°C conductor temperature. See Table I for values. For other wire sizes use DC resistance at 25°C x 1.25.

3. Duty Cycle

Time on in 8 hours	Effective Duty Cycle (D of Table IV)
0 - 1/2 hour	0
1/2 - 2 hours	0.5
2 - 8 hours	1

4. The wattage rating of the penetration is based on the assumption that a 3" minimum annulus surroundsit and this annulus is open to free air circulation for cooling. Consult factory for other configurations.

5. Tables I and II are based on Table 310-12 and Table 8, Chapter 9 of the 1965 National Electric Code. Wire has 90°C insulation.

PACIFIC GAS AND ELECTRIC COMPANY

SAN FRANCISCO, CALIFORNIA

Department of Engineering

ACCOUNTING DATA

GM 167027
Loc. Div. 18
Account 64
Activity Item 23
Location and/or Item 40

Project File No. 122.60

SPECIFICATION NO. 5560
REVISION NO. 0

Nuclear Safety Related: Yes X No ___

(a) 10CFR21 Applies: Yes X No ___

(a) Part 21 of Title 10 of the Code of Federal Regulations

Refer also to REVISION No. 1, 2

SPECIFICATION FOR FURNISHING AND DELIVERING OF ELECTRICAL PENETRATION ASSEMBLIES FOR UNIT 1 - DIABLO CANYON SITE

Comprising

Specific Conditions
Design Specification

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 12
PAGE 1 OF 4

APPROVED BY

J. J. McCann (ATL) (EDC/AAC)

R. V. Bettinger/EPW/OWS

D. V. Kelly (AGW)

J. R. Herrera (JWC) (FJD) JEH

J. V. Rocca/CER

ACCEPTED BY: J. B. Hoch

DATE August 5, 1980

Values of R to be used in the above are:

Cond. Size	R
No. 18 AWG	$7.14\ (10^{-3})$
No. 16 AWG	$4.49\ (10^{-3})$
No. 14 AWG	$2.83\ (10^{-3})$
No. 12 AWG	$1.78\ (10^{-3})$
No. 10 AWG	$1.12\ (10^{-3})$
No. 8 AWG	$7.02\ (10^{-4})$
No. 6 AWG	$4.42\ (10^{-4})$
No. 4 AWG	$2.78\ (10^{-4})$
No. 2 AWG	$1.75\ (10^{-4})$
No. 2/0 AWG	$8.46\ (10^{-5})$
250 MCM	$4.77\ (10^{-5})$
350 MCM	$3.06\ (10^{-5})$
500 MCM	$2.16\ (10^{-5})$

FAULT CURRENT RATINGS
FOR
LOW VOLTAGE POWER & CONTROL
CONTAINMENT ELECTRIC PENETRATION ASSEMBLIES
(FOR 12" SCH 80 NOZZLE)

Conductor Size	Max. Magnitude for t = .033 sec. (AMPS-RMS Sym)	Max. Thermal Capacity for t = 1.67 sec. max. (AMP^2 - Sec.)
No. 14 AWG	1,550	$8.74\ (10^{4})$
No. 12 AWG	2,460	$2.21\ (10^{5})$
No. 10 AWG	3,900	$5.55\ (10^{5})$
No. 8 AWG	6,225	$1.41\ (10^{6})$
No. 6 AWG	9,900	$3.56\ (10^{6})$
No. 4 AWG	15,700	$9.02\ (10^{6})$
No. 2 AWG	21,800	$2.28\ (10^{7})$
No. 2/0 AWG	28,500	$1.02\ (10^{8})$
250 MCM	32,850	$3.24\ (10^{8})$
350 MCM	32,850	$7.89\ (10^{8})$
500 MCM	32,850	$1.64\ (10^{9})$

NOTES:

1 Column D is the maximum continuous rated current per conductor when only one 3-conductor circuit is energized at an ambient temperature of 50°C (112°F).

2 The rated continuous current values shown in Column F is based on 100% duty cycle, that is, all conductors energized at an ambient temperature of 50°C (122°F). The maximum nozzle/concrete interface temperature is 66°C (150°F).

3 For ambient temperature other than 50°C (122°F), multiply the reference column values by:

Temperature	(D) &(E)	(F)
40°C (104°F)	1.109	1.26
57°C (135°F)	.90	.69

4 The rated continuous current shown in Column F is derived from the relationship:

$$I^2RN = 30 \text{ or } I = \left(\frac{30}{RN}\right)^{0.5}$$

where

I = rated continuous current

R = conductor resistance

N = number of conductors

From the values shown in Column F, rated continuous current may be determined for other densities from

$$I_2 = I_1 \left(\frac{N_1}{N_2}\right)^{0.5}$$

where I_2 equals rated continuous current for conductor density N_2 and N_1 is the number of conductors from Column C, and I_1 is the current related to N_1.

5 For a mixture of conductor sizes within a single penetration or for unequal loading of conductors of the same size within a penetration, the rated continuous currents may be determined from

$$\Sigma I^2RN = 30$$

DENSITY/AMPACITY LEGI [illegible]OR ELECTRIC PENETRATION ASSEMBLIES FOR LOW VOLTAGE SERVICE CLASSIFICATIONS

A Conductor Size	B Conductors Per 1" Ø Feed thru	C Conductors Per 12" Sch 80 Nozzle 4	D Max. Current -One Circuit- 1 3	E Max. Current Conductor Density Per Column "B" 1 3	F Max. Current Conductor Density Per Column "C" 2 3 4
No. 18 AWG	42	1008	17a	10.0a	2.0a
No. 16 AWG	36	864	18a	10.5a	2.5a
No. 14 AWG	30	720	21a	12.5a	3.5a
No. 12 AWG	24	576	25a	17.5a	5.0a
No. 10 AWG	19	456	33a	23.0a	7.5a
No. 8 AWG	12	288	41a	28.5a	12.0a
No. 6 AWG	9	216	57a	39.5a	17.5a
No. 4 AWG	6	144	74a	59.0a	27.0a
No. 2 AWG	3	72	98a	98.0a	48.0a
No. 2/0 AWG	1	24	152a	152.0a	121.0a
250 MCM	1	24	221a	221.0a	161.0a
350 MCM	1	24	267a	267.0a	202.0a
500 MCM	1	24	332a	332.0a	240.0a

FUSES CB-AA-01, CB-AA-02 TIME-CURRENT CHARACTERISTIC CURVES

I-T-E HE2A, BUSSMANN ABC-5 Fuse Links. In

G. BHATT 9/2/92

BASIS FOR DATA Standards. Dated

1. Tests made at ______ Volts a-c at ______ p-f., starting at 25C with no initial load ______

2. Curves are plotted to ______ Test points so variations should be ______

No. CALC 333-DC REV. 0 SEPT 2 1992

TIME-CURRENT CHARACTERISTIC 46 5255
KEUFFEL & ESSER CO.

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 13
PAGE 1 OF 1

Westinghouse
Electric Corporation

Lafayette Terrace
3697 Mt Diablo Boulevard
Lafayette California 94549

CALC. 333.DC, SECTION 0 REV 0
ATTACHMENT 14
PAGE 1 OF 1

APRIL 26, 1988

VIA TELEFAX

RANCHO SECO POWER PLANT - SHERRY JACOBS
IMPELL CORPORATION - FUNIL ROY

RE: IMPEDANCE FIGURES
100 VOLT AMP CONTROL TRANSFORMER
USED IN 5 STAR MCC S2A3

PER GARY KLANN, THE SHORT CIRCUIT REACTANCE ON THE SECONDARY IS AS FOLLOWS:

100VA CPT MTC TYPE	6.8%
200VA CPT MTC TYPE	4.15%

PER BILL HAAS, THE OPEN CIRCUIT SECONDARY IMPEDANCE (R+jX) OR Z IS APPROXIMATELY 1330 OHMS.

REGARDS,

Pam Cahill

PAMELA CAHILL
SALES/SERVICE REP.

RESISTANCE AND REACTANCE
OF TWO OR MORE CONCENTRIC STRANDED
NON-SHIELDED SINGLE CONDUCTOR COPPER CABLES IN SAME MAGNETIC RACEWAY
IN OHMS PER 1000 FEET, P.F. = 0.8

WIRE SIZE AWG OR kcmil	RESISTANCE DC R AT 20°C	RESISTANCE DC R CORR. TO 90°C	AC/DC RATIO AT 60 Hz	AC R_2 AT 90°C 60 Hz	X REAC. AT (2) 60 Hz	(R_2 cosθ + X sin θ) CONDUCTORS/PHASE 1	(R_2 cosθ + X sin θ) CONDUCTORS/PHASE 2 (3)
12	1.62 (1)	2.065662	1 (1)	2.065662	.04688	1.680658	0.840329
10	1.02	1.300602	1	1.300602	.04473	1.067320	0.533660
8	.641	0.817339	1	0.817339	.04501	0.680877	0.3404385
6	.403	0.513865	1	0.513865	.04480	0.437972	0.218986
4	.253	0.332600	1	0.332600	.04232	0.291472	0.145736
3	.201	0.256295	1	0.256295	.04066	0.229432	0.114716
2	.159	0.202741	1.01	0.204768	.03948	0.187502	0.093751
1	.126	0.160663	1.01	0.162270	.03730	0.152196	0.076098
1/0	.100	0.127510	1.02	0.130060	.03727	0.126410	0.063205
2/0	.0795	0.101370	1.03	0.104411	.03659	0.105483	0.052741
3/0	.0630	0.080331	1.04	0.083544	.03565	0.088225	0.044112
4/0	.0500	0.063755	1.05	0.066943	.03633	0.075352	0.037676
250	.0423	0.053937	1.06	0.057173	.03701	0.067944	0.033972
300	.0353	0.045011	1.07	0.048162	.03614	0.060214	0.030107
350	.0302	0.038508	1.08	0.041589	.03554	0.054595	0.027297
400	.0264	0.033663	1.10	0.037029	.03515	0.050713	0.025356
500	.0212	0.027032	1.13	0.030546	.03477	0.045300	0.022650
600	.0176	0.022442	1.16	0.026033	.03404	0.041250	0.020625
700	.0152	0.019254	1.19	0.022912	.03376	0.038586	0.019293
750	.0141	0.017979	1.21	0.021754	.03368	0.037611	0.018805
800	.0132	0.016831	1.22	0.020534	.03362	0.036599	0.018299
900	.0118	0.015046	1.25	0.018808	.03359	0.035200	0.017600
1000	.0106	0.013516	1.30	0.017571	.03367	0.034259	0.017129
1250	.00846	0.010787	1.41	0.015210	.03422	0.032700	0.016350
1500	.00705	0.008989	1.53	0.013753	.03376	0.031258	0.015629
1750	.00605	0.007714	1.67	0.012882	.03319	0.030220	0.015110
2000	.00529	0.006745	1.82	0.012276	.03287	0.029543	0.014771

(1) BASED ON N.E.C. CHAPTER 9 TABLE 8 & 9

(2) BASED ON FORMULA $0.05292 \log_{10} \frac{GMD}{GMR}$ + 10% (FOR MAGNETIC RACEWAY INFLUENCE)

WHERE:

GMD = GEOMETRIC MEAN DISTANCE BETWEEN CONDUCTORS CENTER TO CENTER OR: 1.123D
D = OUTSIDE DIAMETER OF CONDUCTOR.
GMR = GEOMETRIC MEAN RADIUS OF CONDUCTOR CORE WITH CORRECTION FACTOR FOR STRANDING

7 STR.	0.726 R	61 STR.	0.772 R
19 STR.	0.758 R	91 STR.	0.774 R
37 STR.	0.768 R	127 STR.	0.776 R

(3) BASED ON "INDUSTRIAL POWER SYSTEM HANDBOOK," PAGE 81, MODIFICATION OF SPECIAL CONDITIONS.