TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

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MAR 10 1988

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

In the Matter of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

SEQUOYAH NUCLEAR PLANT (SQN) - DIESEL GENERATOR VOLTAGE AND MARGIN ANALYSIS (DGVMA) REVISIONS

Reference: TVA letter to NRC dated February 29, 1988, "Sequoyah Nuclear Plant (SQN) - Diesel Generators (DGs) - Operability and Analysis"

The purpose of this letter is to provide NRC with additional information they requested during a discussion held among NRC, TVA, and their respective consultants concerning the DGVMA on March 2, 1988. Enclosure 1 contains the revised sheets of the DGVMA (SQN-E3-015) regarding changes to the contactor pickup portion of the analysis. These changes to the DGVMA involve the use of the in-rush currents, verification of the affected circuits' fuse integrity, and evaluation of slave loads occurring concurrently at the load sequence pickup steps. Also included in enclosure 1 is a discussion of the Allis Chalmers contactors and their effect during the DG load sequence. Enclosure 2 contains a discussion of the motor-operated valves (including their function and identification) that were identified in the DGVMA as having greater than 5 percent but less than 10-percent margin in their respective stroke times. Furthermore, TVA has concluded that the contactor dropout and pickup test voltages, included in the DGVMA, bound the contactor analysis performed to support Branch Technical Position PSB-1.

TVA believes this information adequately addresses NRC's request. If there are any questions concerning the information provided, please telephone Barry A. Kimsey at (615) 870-6847.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

R. Gridley

R. Gridley, Director
Nuclear Licensing and
Regulatory Affairs

Enclosures
cc: See page 2

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U.S. Nuclear Regulatory Commission MAR 10 1988

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ENCLOSURE 1

Diesel Generator Voltage and Margin Analysis
(DGVMA)

TVA 10697 (DNE-6-86) **ORIGINAL** DNE CALCULATIONS

TITLE	PLANT/UNIT
DIESEL GENERATOR VOLTAGE & MARGIN ANALYSIS	SQN UNITS 1 & 2

PREPARING ORGANIZATION	KEY NOUNS (Consult RIMS DESCRIPTORS LIST)
DNE EEB	DIESEL GENERATOR, VOLTAGE, CALCULATIONS

BRANCH/PROJECT IDENTIFIERS: SQN-E3-015

Each time these calculations are issued, preparers must ensure that the original (RO) RIMS accession number is filled in.

Rev	(for RIMS' use)	RIMS accession number
R0	880224F0007 (277)	B25 '88 0223 305
R_		B25 '88 0308 303
R_		
R_		

APPLICABLE DESIGN DOCUMENT(S): RG-1.9

SAR SECTION(S): 8.3 | UNID SYSTEM(S):

	Revision 0	R1	R2	R3
ECN No. (or indicate Not Applicable)	N/A	N/A		
Prepared	A. N. PAL / apal	E. Sofaras		
Checked	S. MAZUMDAR / Smazumdar	apal		
Reviewed	GLNicely	GLNicely		
Approved	[signature]	WSRaughley		
Date	2/23/88	3/9/88		
List all pages added by this revision.		SEE REV. LOG		
List all pages deleted by this revision.		SEE REV. LOG		
List all pages changed by this revision.		SEE REV. LOG		

Use form 10534 if more space required

Safety-related? Yes ☒ No ☐

Statement of Problem

TO ESTABLISH THE LOAD MARGIN FOR THE DIESEL GENERATORS (DG) RESULTING FROM A BOUNDING CASE EVALUATION OF THE AUXILIARY POWER SYSTEM PERFORMANCE FOR DESIGN BASIS EVENT LOADING. ALSO CALCULATE MINIMUM VOLTAGE AT CONNECTED EQUIPMENT USING THIS BOUNDING CASE ANALYSIS TO SHOW THAT SAFETY-RELATED SYSTEMS/COMPONENTS WILL PERFORM THEIR INTENDED SAFETY FUNCTION WHEN POWERED BY THE DG, WITH ACCEPTABLE MARGIN.

Abstract

These calculations contain an unverified assumption(s) that must be verified later. Yes ☐ No ☒

FSAR COMPLIANCE REVIEW [signature] for LE

THIS CALCULATION ESTABLISHES 1) THE WORST CASE VOLTAGE PROFILE FOR THE 6.9 KV AND 480V CLASS 1E POWER SYSTEM BASED ON DIESEL GENERATOR TEST RESULTS, AND 2) THE MARGINS THAT EXIST IN THE CONNECTED EQUIPMENT DURING THE PREDICTED WORST-CASE VOLTAGE PROFILES.

IT HAS BEEN DETERMINED THAT THE DG WILL PERFORM ITS INTENDED SAFETY FUNCTION BY STARTING AND ACCELERATING ALL REQUIRED LOADS WITHIN THE REQUIRED LIMITS, WITH ACCEPTABLE MARGINS EVEN CONSIDERING WORST CASE VOLTAGE AND SEQUENCE TIMER INACCURACY AND MAXIMUM MOTOR STARTING TIME. FURTHERMORE, IT IS CONCLUDED THAT THE TEST RESULTS HAVE BEEN BOUNDED BY ANALYSIS.

FSAR COMPLIANCE REVIEW WSRaughley L.E | R1

CALC. CONSISTS OF TOTAL OF ~~277~~ ~~298~~ 304 PAGES.

☐ Microfilm and store calculations in RIMS Service Center. Microfilm and destroy. ☐

☐ Microfilm and return calculations to Return to G. Hunley Address: P-179 SB-K X-[illegible]

cc: RIMS, SL 26 C-K

TVA

Title: DG VOLTAGE AND MARGIN ANALYSIS	REVISION LOG SQN-EB-015

Revision No.	DESCRIPTION OF REVISION	Date Approved
1	REVISED APPENDIX H: STARTER PICKUP VOLTAGE WAS REANALYZED TO DETERMINE THE MINIMUM VOLTAGE AT THE MCC USING THE ACTUAL WORST CASE CONTROL CIRCUIT CONFIGURATION. ALSO, THE MAXIMUM CURRENT FOR THE CONTROL CIRCUIT WAS CALCULATED. REVISED PAGES: ii, 18, 28 COMPLETELY REVISED AND RENUMBERED APPENDIX H.	E. [illegible] 3/5/88 aPal 3/8/88

SUBJECT DG VOLTAGE & MARGIN ANALYSIS PROJECT

SQN - E3 - 015

COMPUTED BY DATE CHECKED BY DATE

FSAR SECTION 8.3 HAVE BEEN REVIEWED FOR COMPLIANCE BASED ON CALCULATION RESULTS. THE CALCULATION RESULTS SHOW THAT THE INTENT OF RG 1.9 IS SATISFIED. CAQR # SQP 871238 HAS BEEN ISSUED TO DOCUMENT AN OVERVOLTAGE CONDITION. THIS CAQR HAS BEEN CLOSED WITH NO CORRECTIVE ACTION NECESSARY, THE ANALYSIS BEING PROVIDED IN APPENDIX - J.

alal.
PREPARED BY

G L Nice
REVIEWED BY

CALCULATION DESIGN VERIFICATION (INDEPENDENT REVIEW) FORM

SQN-E3-015 — Calculation No.

1 — Revision

Method of design verification (independent review) used (check method used):

1. Design Review ✓
2. Alternate Calculation ______
3. Qualification Test ______

Justification (explain below):

Method 1: In the design review method, justify the technical adequacy of the calculation and explain how the adequacy was verified (calculation is similar to another, based on accepted handbook methods, appropriate sensitivity studies included for confidence, etc.).

Method 2: In the alternate calculation method, identify the pages where the alternate calculation has been included in the calculation package and explain why this method is adequate.

Method 3: In the qualification test method, identify the QA documented source(s) where testing adequately demonstrates the adequacy of this calculation and explain.

The calculation, revision 1, is technically adequate. The methods used are accepted industrial and handbook methods of individual impedance calculations, impedance reduction techniques, and resultant voltage divider networks. The input data is properly referenced and no assumptions were utilized. The output and conclusions are resonable.

R D Hall — Design Verifier (Independent Reviewer)

3/8/88 — Date

CALCULATION INDEPENDENT REVIEW VERIFICATION FORM

SQN-E3-015 — Calculation No.

0 — Revision

Method of independent review used (check one or more):

1. Alternate calculation method ____
2. Testing method ____
3. Other method ✓

Justification (explain below :

Method 1: Identify the pages where the alternate calculation has been included in the calculation package and explain why this method is adequate.

Method 2: Identify the QA documented source(s) where testing adequately demonstrates the adequacy of this calculation and explain.

Method 3: Justify the technical adequacy of the calculation and explain how the adequacy was verified (calculation is similar to another, based on accep'ed handbook methods, appropriate sensitivity studies included for confidence, etc.).

REVIEWED PURPOSE, RESULTS AND CONCLUSIONS FOR TECHNICAL ADEQUACY AND REASONABLENESS. REVIEWED USE OF DESIGN INPUT FOR ADEQUACY. SPOT CHECKED CALCULATIONAL METHODS FOR CORRECTNESS AND TECHNICAL ADEQUACY. REVIEWED CALCULATION PER NEP 3.1 REV 1 ATTACHMENT 10. THE CALCULATION METHOD IS BASED UPON ACCEPTED TEXTBOOK METHODS.

[signature] — Design Verifier (Independent Reviewer)

2-23-88 — Date

TVA 489H (EN DES-2-78) **TENNESSEE VALLEY AUTHORITY** SHEET i OF

SUBJECT DIESEL GENERATOR VOLTAGE & MARGIN ANALYSIS PROJECT SQN

SQN-E3-015

COMPUTED BY afal DATE 2/22/88 CHECKED BY &m DATE 2/23/88

TABLE OF CONTENTS

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN

SQN-E3-015

COMPUTED BY alal DATE 2/22/88 CHECKED BY Em DATE 2/22/88

R1 COMPUTED BY EH DATE 3/5/88 CHECKED BY alal DATE 3/5/88

TABLE OF CONTENTS (CONT'D)

1.0 PURPOSE

The purpose of this calculation is to establish the load margin for the diesel generators (DG) resulting from a bounding case evaluation of the auxiliary power system performance for design basis event loading. Calculate the minimum voltages at connected equipment using this bounding case analysis to show that safety-related systems/components will perform their intended safety function when powered by the DG, with acceptable margin..

1.1 PROCEDURE

The basis of this calculation are actual field test results of load sequence testing of all four diesel generators for SQN units 1 and 2.

The DG data obtained by testing was analyzed for each load sequence step. The minimum voltages at each step were compared and the lowest voltage for the step was selected to establish a worst case composite DG voltage profile for the 6.9KV and 480V shutdown boards.

During the diesel generator load sequence testing performance, it was not possible to fully load all the motors to their design basis load; therefore, the maximum voltage transients were not obtained for all the load sequence steps. In order to determine the maximum transient voltage, the composite worst case test voltage transients were adjusted ~~to~~ for the maximum loading that would occur for a loss of offsite power concurrent with a loss of coolant accident (LOOP/LOCA). This maximum loading is called schedule loading henceforth.

The calculation modified the composite test voltage profile to produce a conservative voltage profile which accounts for the most severe bounding case evaluation of factors not enveloped by actual testing. All of these bounding case factors do not occur simultaneously on any one diesel generator. By determining a bounding case value for each factor, and then combining their bounding case factors, this calculation provides a conservative estimate of some concerns. However, it ensures that the analysis has provided a bounding case evaluation of all concerns.

From these adjusted worst case voltages, the worst case voltages were calculated at the 480V Motor Control Center (MCC), 460V motors, and 460 MOVs. The cable drops used to calculate the above voltages were the worst cable impedance identified for each of the MCCs and loads to bound the analysis. The cable drop evaluation and field test results are document in Appendixes F and A respectively. The voltage analysis methodology and detailed calculations are documented in Appendix B.

Conservate factors used to bound the voltage analysis include the following:

A. The composite diesel generator voltage profile based on the worst case load sequence transient voltage dips for all four DGs.

B. The scheduled load profile based on the worst case loaded DG (DG 2B-B).

SQN-E3-015

Prepared aPat Date 2/23/88

Verified Sm Date 2/23/88

C. The contactor dropout,pickup analysis based on:

1) Maximum control circuit length of 5350 feet which is the maximum of all MCC control circuits. This results in a very conservative analysis since typical circuit length is 1500-2500 feet.

2) Smallest control transformer of 100VA.

3) Combined load of one size 1 contactor, one solenoid, and one timer.

D. Considers all running motors as constant MVA loads which results in a more severe voltage transient.

E. Does not consider the boosting effect of the running induction motors providing a generator effect during a sudden drop of bus voltage. This effect should reduce the voltage transient.

SGN-E3-015

Prepared [signature] Date 2/23/88
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SUBJECT DG VOLTAGE & MARGIN ANALYSIS PROJECT SQN

SQN-E3-015

COMPUTED BY aPal DATE 2/22/88 CHECKED BY [signature] DATE 2/22/88

R1 COMPUTED BY EH DATE 3/5/88 CHECKED BY aPal DATE 3/5/88

2.0 ASSUMPTIONS

2.1 PRE TRANSIENT RUNNING LOADS ARE TREATED AS CONSTANT MVA LOAD (CONSERVATIVE)

2.2 FOR THIS ASSUMPTION, SEE APPENDIX-E SH. E3

2.3 FOR THESE ASSUMPTIONS, SEE APPENDIX-G SH. G3

2.4 THE EFFECT OF STARTING THE LARGEST LOADS OF THE RANDOM LOAD BLOCK (60 HP A/C COMPRESSOR AND 25 HP AIR HANDLING UNIT) FOR EACH LOAD SEQUENCE STEP IS CONSIDERED. ALL OTHER RANDOM LOADS ARE ASSUMED TO BE RUNNING FOR ALL LOAD SEQUENCED STEPS (CONSERVATIVE)

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN

SQN-E3-015

COMPUTED BY afal DATE 2/22/88 CHECKED BY Sm DATE 2/22/88

3.0 SOURCES OF DESIGN INPUT INFORMATION (REFERENCES)

3.1 CALC. SQN-E3-002 REV. 7

3.2 ICF 37-999 - DG 1A FIELD TEST

3.3 STI 111 - DG 1B FIELD TEST

3.4 STI 77 - DG 2A FIELD TEST

3.5 STI 78 - DG 2B FIELD TEST

3.6 CALC. OE2-EEB CAL 001, REV. 9

3.7 CALC. SQN-APS-006, REV. 3

3.8 CALC. SQN-APS-010 REV. 2

3.9 CALC. DG TIMER RELAYS, REV 1 DATED 8/31/87
RIM NO 82588012245

3.10 MOTOR DATA SHEETS

A. SI PUMP, DATED 2/21/69
B. RHR PUMP, DATED 1/25/71
C. ERCW PUMP, DATED 6/1/76
D. AFW PUMP, DATED 4/19/72
E. CCWP, DATED 6/4/81
F. CSP, DATED 3/22/72
G. CENT. CHARG. PUMP, DATED 3/9/71

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN-E3-015

COMPUTED BY a Pat DATE 2/22/88 CHECKED BY SM DATE 2/22/88

3.11 DROP OUT VOLTAGE REPORT FOR SEQUOYAH NUCLEAR PLANT ON ARROW-HART CONTACTORS (ATTACHED IN APPENDIX-G)

3.12 PICK UP VOLTAGE REPORT FOR SEQUOYAH NUCLEAR PLANT ON ARROW-HART CONTACTORS (ATTACHED IN APPENDIX-H)

3.13 MOVATS TEST FOR MOV. ANALYSIS REPORT PREPARED FOR SQN NUCLEAR GENERATING STATION : THRUST SIGNATURE ANALYSIS. RIM # 870602T0001

3.14 QIR MEB SQN 87194 R0 RIM B44 871210 009

3.15 DG DATA SHEET (ATTACHED IN APPENDIX-H)

3.16 CAL. SQN-E3-011 REV. 2

3.17 DEMONSTRATED ACCURACY CALC. 2751A RIM # 825 88 0126456

3.18 REG GUIDE 1.9 R0

3.19 FSAR SECTION 8.3

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN-E3-015

COMPUTED BY aPat DATE 2/22/88 CHECKED BY Sm DATE 2/22/88

4.0 DESIGN INPUT DATA

4.1 FIELD TEST TRACE

ICF 37-999 - DG 1A FIELD TEST

STI - 111 - DG 1B FIELD TEST

STI - 77 - DG 2A FIELD TEST

STI - 78 - DG 2B FIELD TEST

5.0 DOCUMENTATION OF ASSUMPTIONS

5.1 ASSUMPTION 2.1

TREATING MOTORS AS CONSTANT MVA LOADS PROVIDES THE MAXIMUM VOLTAGE DROP

5.2 ASSUMPTION 2.2

FOR DOCUMENTATION OF THIS ASSUMPTION SEE APPENDIX E, SH.E3

5.3 ASSUMPTIONS 2.3

FOR DOCUMENTATION OF THESE ASSUMPTIONS SEE APPENDIX-G SH. G6

5.4 ASSUMPTION 2.4

THIS ASSUMPTION PROVIDES THE HEAVEST LOADING WHICH IS A WORST CASE ANALYSIS.

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN-E3-015

COMPUTED BY aPal DATE 2/22/88 CHECKED BY Sm DATE 2/22/88

6.0 COMPUTATIONS / ANALYSIS

SEE APPENDICES.

7.0 SUPPORTING GRAPHICS

FIG.-1 REPRESENTS THE ONE-LINE DIAGRAM FOR A TYPICAL POWER TRAIN OF THE ONSITE POWER DISTRIBUTION SYSTEM.

FIG. 2 COMPARES THE TEST LOADING TO THE SCHEDULED (LOOP + LOCA) LOADING.

TVA 489H (EN DES-2-78) **TENNESSEE VALLEY AUTHORITY** SHEET 11 OF

SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN

SQN - E3 - 015

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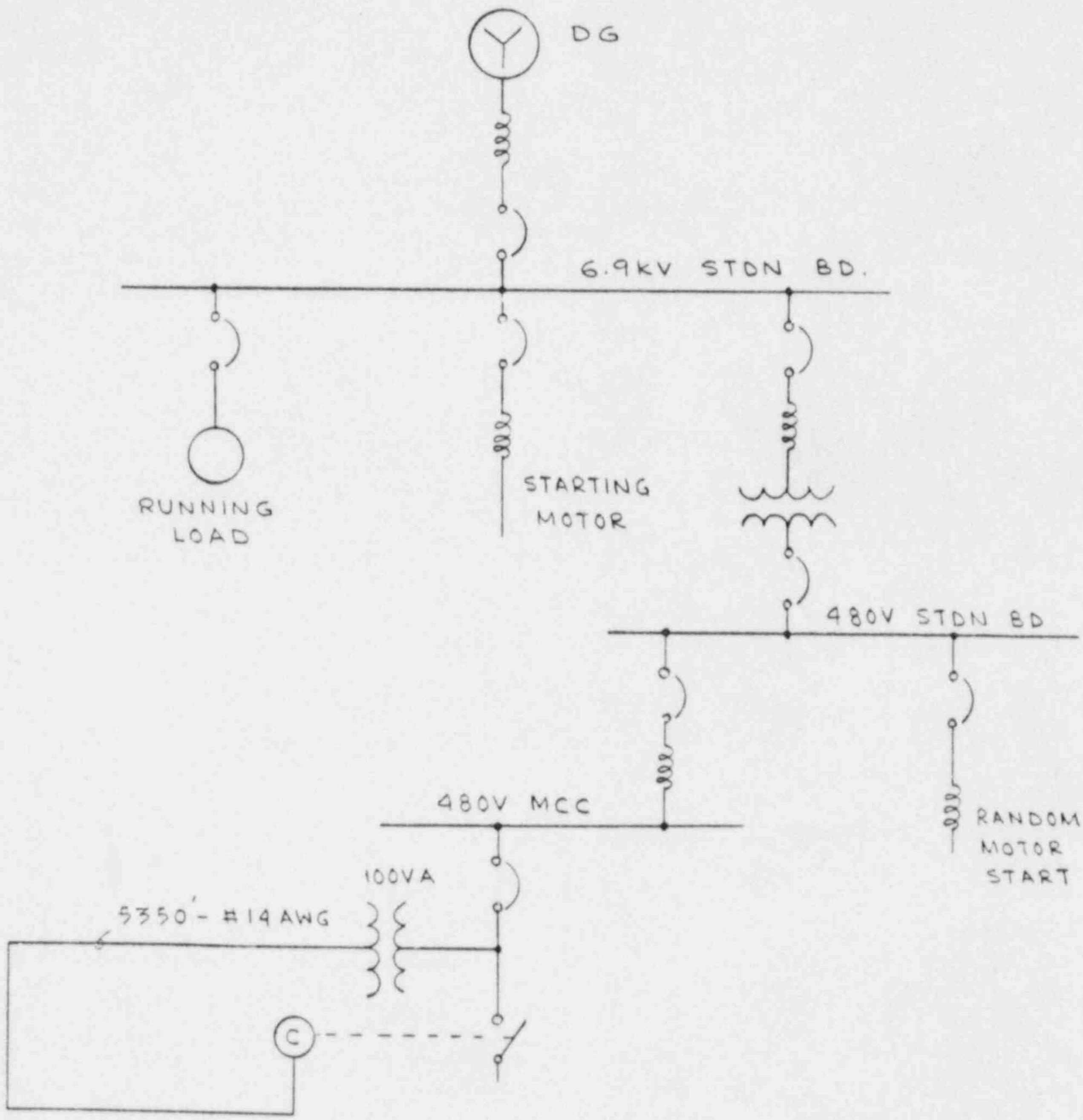
FIG. 1



ON LINE DIAGRAM

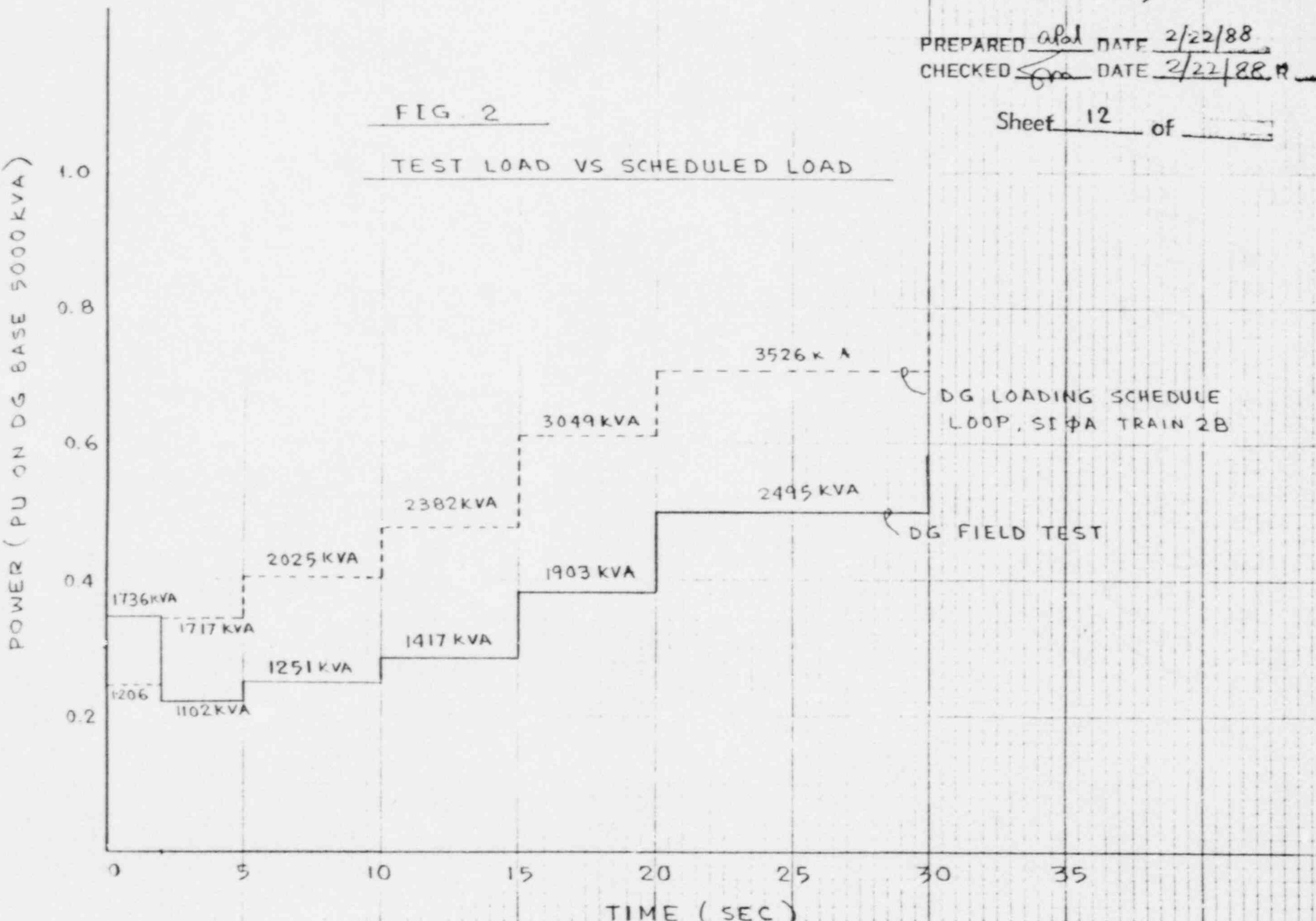
SQN-E3-015

PREPARED alol DATE 2/22/88
CHECKED Gm DATE 2/22/88 R

Sheet 12 of

FIG. 2

TEST LOAD VS SCHEDULED LOAD



8.0 Results of Voltage Analysis and Determination of Available Margins

The voltage transient can potentially effect the performance of the diesel generator systems and the components they power. The following sections discuss each of these items with regard to transient voltage effects on the components. The available margins between the anticipated transients and the components operation has been identified.

8.1. Diesel Generator Voltage Analysis

Tables 1 and 2, attached, summarizes the results of the DG voltage analysis. The minimum 6.9 KV shutdown board voltage was determined to be 76.5 percent and the minimum 480V shutdown board and motor control center (MCC) voltage was determined to be 77 percent and 75.6 percent respectively both for approximately 16 cycles.

The lowest motor terminal voltages are as follows:

6.6 KV motor	76.2 percent
460V Switchgear motor	74.3 percent
460V MCC Motor	74.5 percent
460V MCC MOV	74.6 percent

The calculations supporting these results are in Appendix B.

SQN - E3 - 015

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CHECKED Gm DATE 2/22/88 R ___

TABLE 1

Sheet 14 of ___

WORST CASE 6.9 KV BUS VOLTAGE CORRECTED FOR SCHEDULE LOAD

START MOTOR ①	SEQ. TIME SEC. ②	PRETRAN VOLTAGE PU ③	SOURCE DG ④	PRIOR TO START: DG LOAD FIELD TEST ⑤	PRIOR TO START: DG LOAD SCHEDULE [REF. 3.1] ⑥	PU DIP FIELD TEST ⑦	ADDITIONAL PU DIP DUE TO LOADING DIFFEREN ⑧	TOTAL PU DIP [⑦ + ⑧] ⑨	PU MINIMUM BUS VOLTAGE [③ - ⑨] ⑩
CCP	2	1.009	2A	1736 ∠54.5	1206 ∠42	0.174	0.0	0.174	0.835
SI	5	0.991	2B	1102 ∠21.8	1717 ∠34.7	0.162	0.010	0.172	0.819
RHR	10	0.969	2B	1251 ∠25.3	2025 ∠32.5	0.159	0.013	0.172	0.797
ERCW	15	1.001	1B	1417 ∠30.3	2382 ∠30.9	0.187	0.012	0.199	0.802
AFW	20	0.965	2A	1903 ∠29.5	3049 ∠31	0.183	0.017	0.200	0.765
CCWP	30	1.008	2B	2495 ∠31.1	3526 ∠29.9	0.110	0.013	0.123	0.885
CSP+FP *	180	1.0	2A	3083 ∠33.3	3837 ∠29.7	0.200 ▲	0.012	0.212	0.788

* 200HP FP WAS STARTED WITH CSP.

▲ ADJUSTED THE FIELD TEST DIP TO COMPENSATE THE EFFECT OF 200HP F.P (DIP = 0.039PU)

NOTE : FOR COLUMN ① THRU ⑤ AND ⑦ SEE TABLE - A1

TABLE 2

WORST, CASE 480V STND. BD. VOLTAGE

CORRECTED FOR SCHEDULE LOAD

SEQ TIME SEC. ①	PRE TRAN VOLTAGE PU ②	PU DIP FIELD TEST ③	④ ADDITIONAL PU DIP DUE TO LOADING DIFFERENCE	⑤ TOTAL PU DIP [③+④]	⑥ PU MIN. BUS VOLTAGE [②-⑤]
0	1.06	-	-	-	1.06
2	1.0	0.163	0.0	0.163	0.837
5	1.017	0.167	0.010	0.177	0.84
10	0.994	0.148	0.013	0.161	0.833
15	1.017	0.183	0.012	0.195	0.822
20	0.975	0.179	0.017	0.196	0.779
30	1.033	0.188	0.013	0.201	0.832
180 (CSP+FP*)	1.012	0.23▲	0.012	0.242	0.77

* 200HP FP WAS STARTED WITH CSP.

▲ ADJUSTED THE FIELD TEST DIP TO COMPENSATE THE EFFECT OF 200HP F.P (0.051PU DIP)

NOTE : COLUMN ① THRU ③ , SEE TABLE - A2

8.2 Effect of Random Loads

TVA has determined that the DG should be capable of accommodating the application of a random process load block (i.e., sixteen loads that are controlled by process parameters such as flow, pressure, etc.). We have assumed that 14 of these loads are running and that two of the largest loads are starting to calculate the additional voltage drop. The increase in the 6.9KV and 480V system transient voltage dip resulting from this random process load block is 1.9 percent, and 2.4 percent respectively. (See Appendix C)

~~This evaluation is documented in Appendix C.~~ alal.

8.3. Motor Starter Contactor Voltage Margin

In safety-related circuits at Sequoyah, size 1, 2, and 3 contactors are used. For Unit 2 operation, approximate number of each types of each contactor size are:

Size 1 Approximately 500 (27 ampere rating)
Size 2 Approximately 60 (45 ampere rating)
Size 3 Approximately 15 (90 ampere rating)

All of these are of the same manufacturer, Arrow-Hart Incorporated. Size 1 contactors are supplied from smaller control power transformers than larger contactors and experience lower per unit voltage. As such, the size 1 contactors are the limiting application; contactor dropout and pickup characteristics of Size 1 contactors were investigated. Tests were performed at TVA's Chicamauga Laboratory using new and used contactors from SQN. These tests yield a minimum drop out voltage of 54 percent and minimum pickup voltage of 73.6 percent on a 110V base. The corresponding required voltages on a 480-volt base are 49.5 percent and 67.5 percent respectively.

Conclusion:

1. Dropout

The limiting MCC contactor circuits are those with seal-in contact design that would require operator action should dropout of the contactor occur. These contactors are manufactured by Arrow-Hart. The ERCW MCCs, which use Allis-Chalmers contactors do not have seal-in contact design and the loads are either manually operated or have their power circuits deenergized. Therefore, the Allis-Chalmers contactors are not the limiting case. R1

Using the minimum adjusted test voltage from Appendix B the minimum adjusted voltage anticipated at 480V MCCs is 75.6 percent; therefore, the minimum margin is 26 percent above the required voltage of 49.5 percent (54 percent on contactor base of 110V).

2. Pickup

The pickup analysis has been revised to (1) evaluate the worst case actual MCC contactor circuit that would be required to pickup at t=0 seconds of the loading sequence or concurrent with the starting of a 6.6 KV motor during the loading sequence and (2) to evaluate the worst case MCC contactor circuit for maximum current to ensure that its control circuit fuse will not inadvertently interrupt.

For item 1, all slave loads were evaluated and the worst case circuit was determined to be a MOV that would start concurrent with the auxiliary feedwater pump motor at the 20-second load step. This circuit consists of six relays and two lights drawing holding current, and the inrush of the contactor coil. The minimum adjusted voltage anticipated at the 480V MCCs is conservatively calculated to be 84 percent when the MOV contactor closes concurrently with the 20-second load step. This voltage is above the required contactor voltage of 74.3 percent (73.6 percent on a contactor base of 110V). Therefore, the minimum voltage margin is 9.7 percent. This is conservative since the contactor voltage would be higher as the MOV contactor picks up at the same time as the 6.6 KV motor (i.e. before the voltage drop due to the locked rotor impedance of the motor). R1

For item 2, all circuits powered by the diesel were evaluated to determine the worst case circuit to be a room cooler fan that is energized at t=0 of the loading sequence. This circuit consists of a solenoid and a contactor coil both energizing at the same time. The resulting maximum current for this would be 3.23 amps. The control circuit fuse is a FRN 1 amp fuse which requires 8 amps for 1 second in order to interrupt. Therefore, the minimum margin is 59.6 percent at 1 second. Therefore, the fuse will not inadvertently interrupt. This analysis is conservative since the amperage at rated voltage was used as opposed to the reduced amperage at a lower voltage.

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R1 Verified aPal Date 3/8/88

8.4. Motor Operated Valve Torque and Time Margin

All MOVs that would be actuated during the loading sequence for a design basis event were evaluated for increased stroke times due to transient voltage dips. All MOVs under consideration are rated for a minimum start voltage of 77 percent* and can develop 100 percent torque at this voltage. Since there is more time above 77 percent than there is below 77 percent (more over-travel than under-travel) in the travel time, it is more appropriate to examine the average voltage. The average voltage experienced based on the adjusted load conditions for the loading sequence is approximately 95 percent; therefore, the voltage margin is 18 percent.

In addition, all MOVs required during this time have a minimum of 5.3 percent margin in their stroke times. This was determined by the design criteria safety limit minus the plant testing results which results in the following: of the 58 valves under consideration, 37 have greater than 100 percent margin, 18 have greater than 10 percent margin but less than 100 percent, and 3 greater than 5 percent but less than 10 percent margin.

*This value has been adjusted from 80 percent on a motor base of 460V to 77 percent on a system base of 480V.

8.5 Overcurrent Protection Margin

Due to transients during the loading sequence, all switchgear motors have their overcurrent protective devices set at a minimum of 200 percent of locked rotor current to ensure that tripping will not occur. Additionally, the load will not trip inadvertently since the transients under consideration are less than one second in duration and actuation is at least 10 seconds.

8.6 Diesel Generator Load Sequence Timer Margin

In order to determine the load sequence timer margin calculations "27S1A" and "DG TIMER RELAYS" were reviewed. "DG TIMER RELAYS" (Reference 3.9) addresses the effects of sequence timer inaccuracies upon DG loading by calculating the minimum time between load steps. Calculation "27S1A" (Reference 3.17) calculates the maximum time it takes to make electric power available to the sequenced loads. Both calculations are based on the methodology presented ISA 67.04, "SETPOINTS FOR NUCLEAR SAFETY-RELATED INSTRUMENTATION USED IN NUCLEAR POWER PLANTS" and Reg Guide 1.105, "INSTRUMENT SETPOINTS FOR SAFETY-RELATED SYSTEMS."

"DG TIMER RELAYS" calculates the minimum time interval between loadings by calculating the root-sum-square of (square root of the sum of the squares) the random errors associated with two adjacent relays. The root-sum-square technique is addressed in ISA 67.04. Also note that there is one systematic error associated with these relays, a bias error due to ambient temperature changes. Since all relays are located in the same cabinet, all relays will experience the same ambient temperature changes; therefore, this effect cancels out for adjacent sequence timers. The results of this calculation are summarized in Figure 2.

"27S1A" calculates errors associated with each timer in turn (errors calculated for only one relay rather than adjacent relays) since the parameter of concern is maximum time required to make electric power available to a particular load. This means the bias error associated with temperature must also be included in the accuracy. The results are for a concurrent loss of offsite power and safety injection initiation, and are summarizied in Figure 3.

These calculations previously resulted in a change for the auxiliary feedwater and component cooling system timers and these figures reflect this change.

DIESEL LOAD SEQUENCING

SQN-E3-015

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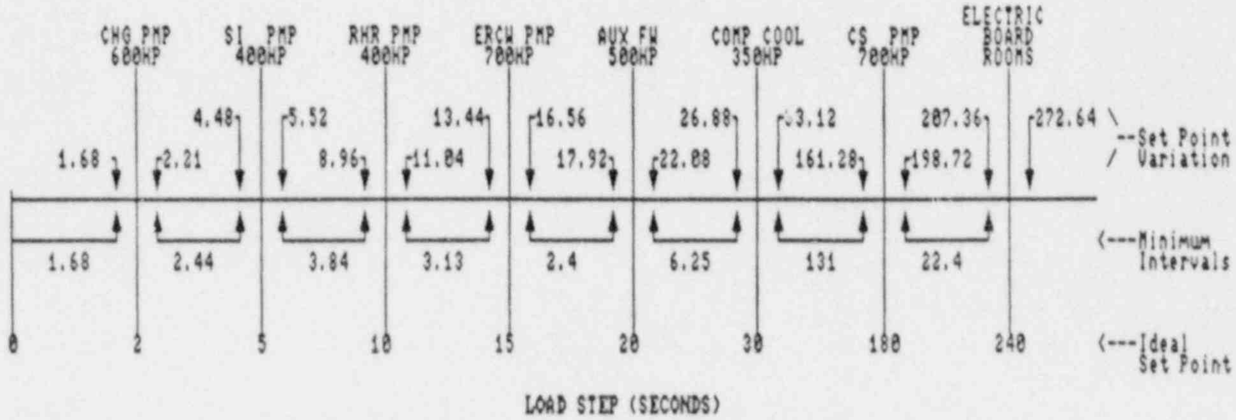
Sheet 22 of ______

Figure 2

SUMMARY OF "DG TIMER RELAYS"

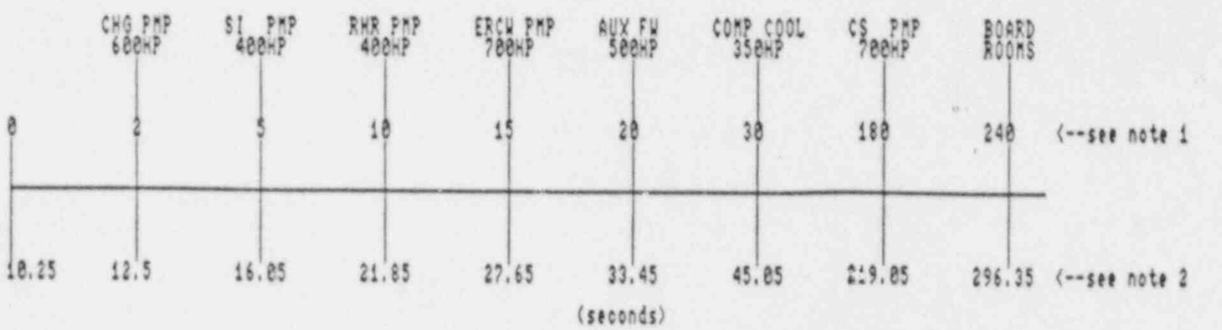


Variations about ideal setpoint are shown for algebraic error combinations.

Minimum interval times shown are for Square Root of the Sum of the Squares (SRSS) combinations of errors(pg 42DG timers)

Figure 3

SUMMARY OF "27S1A"



note 1 - Sequence timer setpoints (provided for comparison purposes).

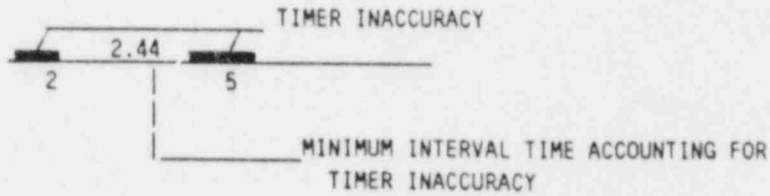
note 2 - Time from initial loss of offsite power until load breaker closure. Includes sequence timer timeout, diesel generator runup time (10 sec), and load breaker closure time for two breakers at 0.125 sec per breaker.

Table 3 summarizes the voltage transient effect on motor starting time and its effect on load sequence time interval including timer accuracy and repeatability. The analysis in Appendix D accounts for the overlap of acceleration between the SI and CCP for the worst case.

TABLE 3

6.6 KV MOTOR ACCELERATION TIME

MOTOR	WORST CASE MOTOR TERM VOLTAGE PU 6.6KV BASE	MIN. TIME INTERVAL SEC (C)	ACCELERATION TIME			
			MEASURED FROM TEST IN SECS	MIN. VOLT FOR FIRST ONE SEC & 100% AVERAGE THE REST, SEC	100% RATED VOLTAGE FOR THE ENTIRE PERIOD SEC	MARGIN BETWEEN 3 & 5 SEC
(1)	(2)	(3)	(4)	(5)	(6)	
CCP	0.867	2.44	2.15	3.33	2.99	*
SI	0.833	3.84	2.80	3.39	3.01	0.45
RHR	0.811	3.13	1.83	1.85	1.39	1.28
ERCW	0.782	2.4	1.56	1.67	1.20	0.73
AFW	0.778	6.25	3.46	3.77	3.22	2.48
CSP	0.798	---	2.56	2.79	2.35	---



* Margin is not applicable since CCP and SI pump motor starts could overlap; however, this condition has been considered in the Appendix D and it has been established that this overlap will not cause any additional drop over what has been observed during testing.

8.7 Diesel Generator Capacity

Chart 1 shows a comparison of the ratings for the diesel generators to the maximum anticipated scheduled load for the heaviest loaded diesel generator (2B-B). In summary, it shows that there is at least 8 percent margin between the manufacturer's rating and the maximum scheduled loads for the first 2 hours and at least 2.3 percent margin for greater than 2 hours. This is acceptable margin since the maximum load must be less than or equal to rated capacity.

8.8 Motor Voltage Margin

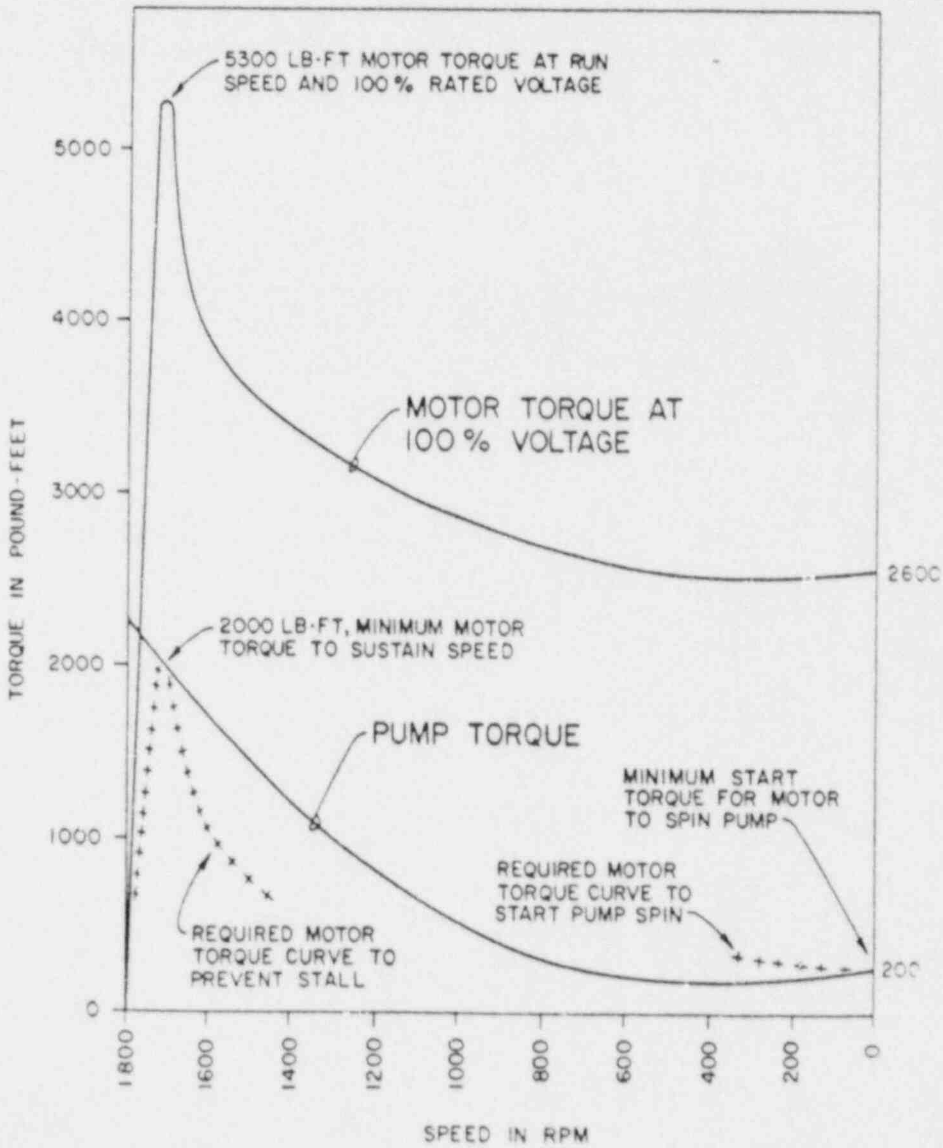
In order to ensure that the motors powered by the DG during the worst case design basis event have adequate voltage for starting and/or running, a review of the 6.9KV and 480V motors speed-torque characteristics was performed. This review evaluated the unique types of 6.6KV and 460V motors (e.g., safety injection pump, centrifugal charging pump, motor operated valves, etc.).

Using the basic relationship that torque for a motor is proportional to the square of the voltage (See ANSI C50.41, Paragraph 11), we can determine the minimum voltage required to sustain pump motor speed and the minimum voltage required to sustain breakaway.

Below is a pump/motor speed-torque curve for the SQN containment spray pump that displays these pertinent characteristics. This curve is typical for NEMA Class B motors which are used at SQN.

TYPICAL PUMP/MOTOR SPEED-TORQUE CURVES

FIGURE I



For 6.9KV motors and a very large 460-volt motor, the analytical technique resulted in the following:

MOTOR	MINIMUM SUSTAINING MOTOR VOLTAGE TO SUSTAIN ROTATION (Percent V at Bus)	MINIMUM BREAKAWAY MOTOR VOLTAGE TO SUSTAIN ROTATION (Percent V at Bus (Locked Rotor)
CCP	64	33
SI	54	32
RHR	56	37
ERCW	63	36
AFW	55	35
CCS (480 Volt)*	44	29
CSP	59	27

*At motor terminal

The small 460-volt motors are standard NEMA designs; therefore, the minimum start and sustaining voltages are evaluated utilizing the standards from which they are designed. NEMA MG1-12.37 and 12.38 were used to obtain the locked-rotor and breakdown torque values for design types A and B motors for various horsepowers. "Motor Application and Maintenance Handbook" edited by R. M. Smeaton was used to obtain typical data for the pump, fan, and compressor loads. This data corresponds to the points of interest for the motor/load speed torque curve.

SQN - E3 - 015

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In conclusion, motor loads have been evaluated to determine the maximum voltage dip which still allows adequate torque to sustain the load rotation. For the 6.6KV motor, the limiting voltage for running motors was determined to be 64 percent, and the limiting breakaway voltage was 37 percent. For 460-volt motors the limiting voltage for running motors is 68 percent and limiting breakaway voltage is 59 percent. In addition, for a 460-volt motor/pump load, calculations predict additional margin in the rotating inertia of the load with the occurrence of short-term voltage dips (e.g., for 65 percent percent for 1/2 second, speed drop of the low inertia pump would be less than 6.18 percent). TVA sees no adverse effect on the mechanical system performance since the thermal and mechanical inertia is such that a 1/2-second decrease in flow of air or water would have effects that would be within the normal operating fluctuations of these types systems. This assumes the associated motors and controls do not trip as a result of this voltage decrease. Therefore, the minimum 6.9KV margin for the maximum expected voltage dip is 12.5 percent of 6.9KV and minimum 480V margin is 6.3 percent of 480V.

9.0 Conclusions

TABLE 4

SUMMARY OF MARGINS

COMPONENT	PERCENT MINIMUM MARGIN
6.6 KV MOTORS - SUSTAIN/BREAKAWAY	12.5/39.5
460V MOTORS - SUSTAINING	6.3
CONTACTORS - DROPOUT	26.0
CONTACTORS - PICKUP	9.7
FUSES - CONTACTOR PICKUP INRUSH	59.6
MOV PERFORMANCE AND STROKE TIMES	18 (Voltage)/5.3 (Time)/56 (Torque)
DIESEL GENERATOR LOADING	2.3

R1

Based on the summary of margins listed above in Table 4, we have determined that the diesel generator will perform its intended safety function by starting and accelerating all required loads within the required limits, with acceptable margins. The margins are not only sufficient to allow for test inaccuracies, but provide the capability for the DG to start and accelerate all required loads concurrent with the random process load block. Furthermore, it is concluded that the test results have been bounded by analysis and the DG meet the intent of Regulatory Guide 1.9.

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SUBJECT DG VOLTAGE AND MARGIN ANALYSIS PROJECT SQN
SQN-E3-015

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APPENDIX - H

CONTACTOR PICKUP VOLTAGE

SUBJECT STARTER COIL PICKUP VOLTAGE PROJECT SQN

SQN-E3-015

COMPUTED BY E.J.J. DATE 3/8/88 CHECKED BY [illegible] DATE 3/8/88

1.0 PURPOSE

THE PURPOSE OF THIS ANALYSIS IS AS FOLLOWS:

1. TO EVALUATE THE WORST CASE ACTUAL MCC CONTACTOR CIRCUIT, (IN TERMS OF LOAD AND CIRCUIT LENGTH), THAT WOULD BE REQUIRED TO PICKUP AT T=0 SECOND OF THE LOADING SEQUENCE OR CONCURRENT WITH THE STARTING OF A 6.6KV MOTOR DURING THE LOADING SEQUENCE, AND
2. TO EVALUATE THE WORST CASE MCC CIRCUIT FOR MAXIMUM CURRENT TO ENSURE THAT ITS CONTROL CIRCUIT FUSE IS ADEQUATELY SELECTED.

2.0 ASSUMPTIONS

NONE

3.0 SOURCE OF DESIGN INPUT INFORMATION

3.1 SQN-APS-010 REV. 2

3.2 PICKUP VOLTAGE REPORT FOR SEQUOYAH NUCLEAR PLANT ON ARROW-HART CONTACTOR (ATTACHED)

3.3 CALC. SQN-E3-002 REV. 7

3.4 DRAWINGS:

35W726-2 R8
45N771-3 R20
45N779-9 R22
45N779-19 R18
45N779-20 R19
45N779-24 R24
45N779-31 R18
45N779-38 R12

SUBJECT STARTER COIL PICKUP VOLTAGE PROJECT SQN

SQN-E3-015

COMPUTED BY EJJ DATE 3/5/88 CHECKED BY afal DATE 3/5/88

4.0 DESIGN INPUT DATA [REF. 3.1]

4.1 14AWG COPPER CONDUCTOR

RESISTANCE 0.3413 Ω/100'

REACTANCE 0.00825 Ω/100'

4.2 100VA CONTROL TRANSFORMER

RESISTANCE 8.44 Ω

REACTANCE 1.15 Ω

TURNS RATIO $\left(\frac{N_P}{N_S}\right) = 3.7$

4.3 SIZE 1 STARTER INRUSH

VA 175

WATTS 80

RATED VOLTAGE 110V

PICKUP VOLTAGE 0.736 × 110V = 81V (PAGE H36)

4.4 AGASTAT 7000 SERIES TIMER

VA (HOLDING) 18

WATTS 7

RATED VOLTAGE 120V

4.0 DESIGN INPUT DATA (CONT.)

4.5 POTTER BRUMFIELD RELAY

TYPE - MDR 131-1

VOLTAGE - 115 VAC

COIL CURRENT - 0.215A

WATTS - 6.5

4.6 ASCO SOLENOID INRUSH

VA INRUSH 195

RATED VOLTAGE 120

4.7 INDICATING LIGHT

TRANSFORMER = 120-6V

VA = 6.1

4.8 ALARM RELAY

CRYDON SERIES 1

INPUT INPEDANCE = 60kΩ

5.0 PROCEDURE

1. Pickup analysis

Evaluation of the mcc contactor circuits were peformed in two parts. Part 1 was to evaluate the circuits that would be auto initiated at t=0 of the loading sequence. These circuits are identified in calculation SQN-E3-002. The evaluation of these circuits determined that these circuits were not limiting because 1) at t=0 there are no 6.6 KV motors starting, therefore the 6.9 KV voltage is approximately at nominal, 2) the DG tested load at t=0 was greater than the schedulad load and no problem occured due to contactor pickup, and 3) because the 480 V board voltage takes approximately 30 cycles to ramp up to approximately 80 percent of nominal, due to the energization of the 6900/480 V transformers, all required mcc contactors would pickup at this time.

Part 2 was to evaluate the circuits that receive the same start signals and permissives as the 6.6 KV sequenced loads. The schematic/elementary diagrams were reviewed to identify all loads started simultaneously with the 6.6 KV motors. Devices slaved from these major loads that have time delays associated with their start were not included as the DG will have time to recover prior to their start. Also loads that receive the same start but not the permissives were not included because they would be loaded prior to these load sequences (ie, valves open on the SI signal at t=0 but the pumps wait for their load sequence timer to start them). These concurrent started loads are listed on page H27. These circuits were evaluated for number of components in parallel with the starter ,operation of the components (ie, inrush or holding current), total circuit length. This information was contained in calculation SQN-AFS-010 and the 480V schematics. The worst case circuit was determined to be MOV FCV-3-116 that would start concurrent with the auxiliary feedwater pump motor at the 20 second load step and consists of 6 relays and two indicating lights drawing holding current and the inrush of the contactor coil with a total circuit lenght of 2224 feet.

2. Control Circuit Fuse Evaulation

Evaulation of the mcc control circuits to determine the worst case in terms of maximum current only was performed in a similar manner as described in item 1 above with the exception that cable lenght was not a consideration. The worst case circuit was determined to be Penetration room el

669 room cooler fan that is energized at t=0 of the loading sequence and consists of a solenoid and a contactor coil both energizing at the same time.

6.0 COMPUTATION/ANALYSIS

6.1 PICK UP

THE REVIEW OF CONTROL CIRCUITS WHICH ARE REQUIRED DURING DG LOADING REVEALED THE ERCW HDR ISOL VALVE (FCV-3-116A) AS THE WORST CASE CONTROL CIRCUIT. THIS CIRCUIT CONSISTS OF THE FOLLOWING:

1) INRUSH OF STARTER

2) ONE TIMER AND 5 RELAYS HOLDING. THESE DEVICES ARE PICKED UP PRIOR TO THE ENERGIZATION OF STARTER

3) TWO INDICATING LIGHTS

IMPEDANCE CALCULATION

Z_1 - CABLE TO STARTER

$R_1 = 2224\ ft \times 0.3413\ \Omega/100ft = 7.59\ \Omega$

$X_1 = 2224\ ft \times 0.00825\ \Omega/100ft = 0.18\ \Omega$

$Z_1 = 7.59 + j0.18 = 7.59\ \angle 1.36°$

Z_2 - STARTER

$$Z_2 = \frac{V^2}{VA} = \frac{(110)^2}{175} = 69\ \Omega$$

$$PF = \cos\theta = \frac{W}{VA} = \frac{80}{175} = 0.457$$

$R_2 = Z_2 \cos\theta = 69 \times 0.457 = 31.54\ \Omega$

$X_2 = \sqrt{(Z_2)^2 - (R_2)^2} = \sqrt{(69)^2 - (31.54)^2} = 61.4\ \Omega$

$Z_2 = 31.54 + j61.4 = 69\ \angle 62.8°$

NOTE - CABLE LENGTHS ARE OBTAINED FROM SEC. 3.1

STARTER COIL PICK UP

SHEET H10 OF

SQN-E3-015

COMPUTED EY DATE 3/5/88

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IMPEDANCE CALCULATION

Z_3 - CABLE TO RELAYS

$R_3 = 1280\ ft \times 0.3413\ \Omega/100ft = 4.37\ \Omega$

$X_3 = 1280\ ft \times 0.00825\ \Omega/100ft = 0.11\ \Omega$

$Z_3 = 4.37 + j0.11 = 4.37\angle 1.44°$

Z_4 - AGASTAT RELAY

$$Z_4 = \frac{V^2}{VA} = \frac{(120)^2}{18} = 800\ \Omega$$

$$PF = \frac{W}{VA} = \frac{7}{18} = 0.389$$

$R_4 = Z \cos\theta = 800 \times 0.389 = 311\ \Omega$

$X_4 = \sqrt{Z_4^2 - R_4^2} = \sqrt{(800)^2 - (311)^2} = 737\ \Omega$

$Z_4 = 311 + j737 = 800\angle 67.12°$

IMPEDANCE CALCULATION

$Z_5 = Z_6 = Z_7 = Z_8$ – POTTER BLUMFIELD RELAY

$Z_5 = \frac{V}{I} = \frac{115}{0.215} = 535\ \Omega$

$PF = \frac{W}{VA} = \frac{6.5}{(115)(0.215)} = 0.263$

$R_5 = Z\cos\theta = 535\,(0.263) = 140.6\ \Omega$

$X_5 = \sqrt{Z_\Delta^2 - R_\Delta^2} = \sqrt{(535)^2 - (140.6)^2} = 516.2$

$Z_5 = 140.6 + j\,516.2 = 535\angle 74.8°$

INDICATING LIGHTS

$Z = \frac{V^2}{VA} \times \left(\frac{120}{6}\right)^2 = \frac{6^2}{6.1} \times \left(\frac{120}{6}\right)^2 = 2360\ \Omega$

$R = 2360\ \Omega \qquad X = 0$

CRYDON RELAY

$Z = 60{,}000 + j0$

STARTER COIL PICKUP VOLTAGE

SHEET H12 OF

SQN-E3-015

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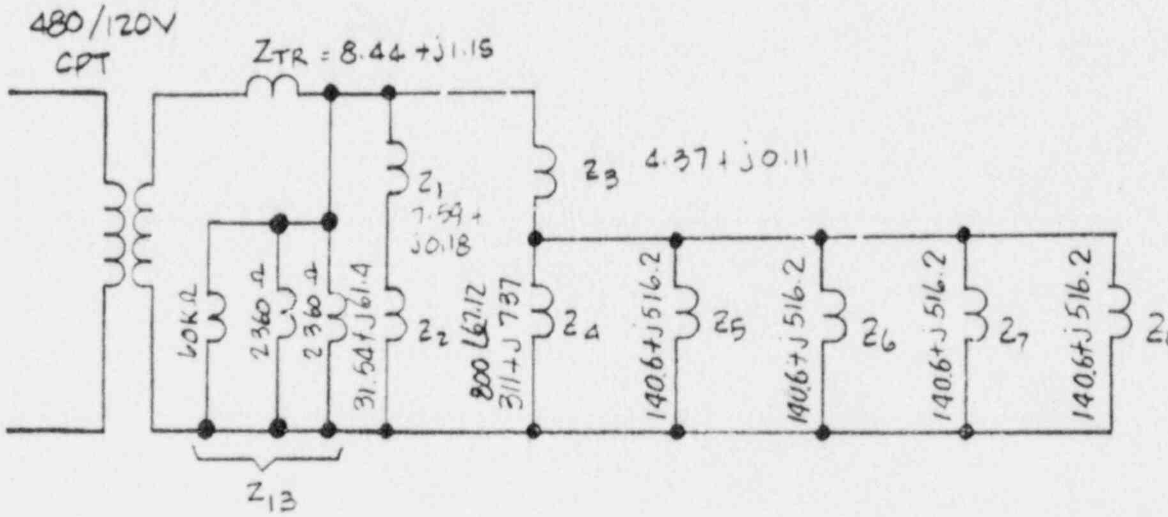


$$Z_9 = Z_5 \,//\, Z_6 \,//\, Z_7 \,//\, Z_8 = \frac{140.6 + j\,516.2}{4} = 35.2 + j\,129$$

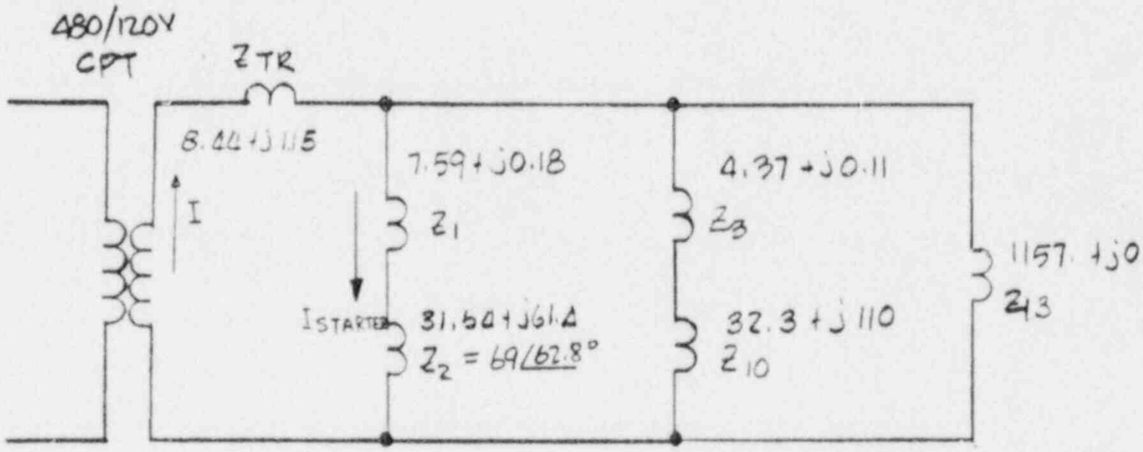
$$= 133.7 \angle 74.7$$

$$Z_{10} = Z_4 \,//\, Z_9 = \frac{800 \angle 67.12 \times 133.7 \angle 74.7}{800 \angle 62.12 + 133.7 \angle 74.7} = \frac{800 \angle 67.12 \times 133.7 \angle 74.7}{932.6 \angle 68.2}$$

$$Z_{10} = 114.7 \angle 73.62 = 32.3 + j110$$

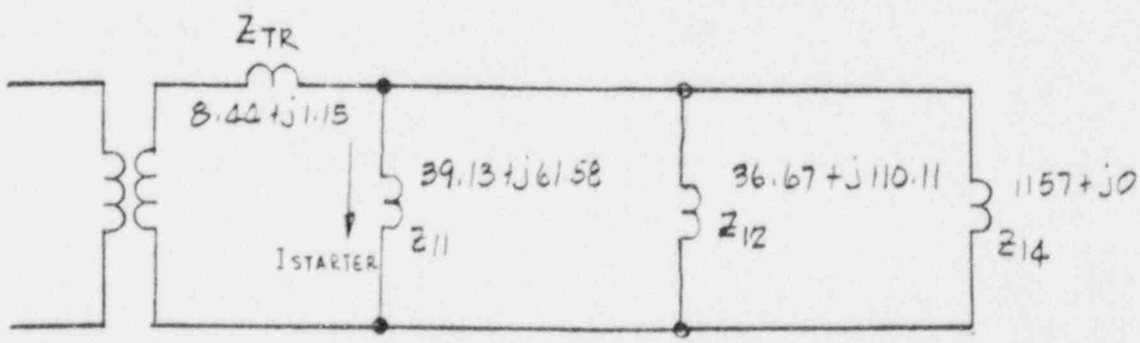
$$Z_{13} = (2360 + j0) \,//\, (2360 + j0) \,//\, (60{,}000 + j0)$$

$$Z_{13} = 1157 + j0$$



$$Z_{11} = Z_1 + Z_2 = 39.13 + j\,61.58 = 73\angle 57.6°$$

$$Z_{12} = Z_3 + Z_{10} = 36.67 + j\,110.11 = 116.1\angle 71.6°$$



$$Z_{14} = Z_{13} \| Z_{12} = \frac{1157\angle 0° \times 116.1\angle 71.6°}{1157\angle 0° + 116.1\angle 71.6°} = \frac{1157\angle 0° \times 116.1\angle 71.6°}{1198.7\angle 5.3°}$$

$$Z_{14} = 112.1\angle 66.3° = 45.1 + j\,102.6$$

STARTER COIL PICK UP VOLTAGE

SHEET H14 OF

SQN-E3-015

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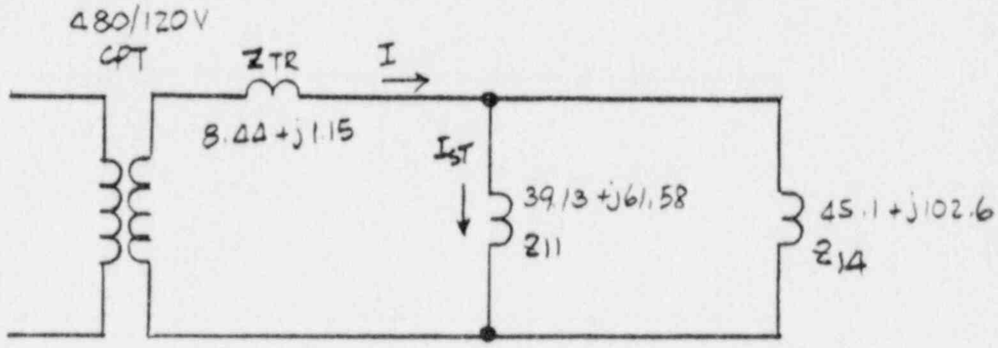
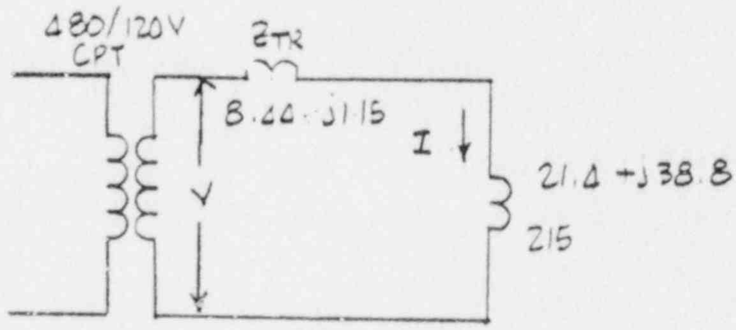


$$Z_{15} = Z_{11} // Z_{14} = \frac{73\angle 57.6^\circ \times 112.1\angle 66.3^\circ}{73\angle 57.6^\circ + 112.1\angle 66.3^\circ} = \frac{73\angle 57.6^\circ \times 112.1\angle 66.3^\circ}{184.5\angle 62.8^\circ}$$

$$Z_{15} = 44.3\angle 61.1^\circ = 21.4 + j38.8$$



$$Z_{EQ} = Z_{TR} + Z_{15} = (8.44 + j1.15) + (21.4 + j38.8)$$

$$Z_{EQ} = 29.84 + j39.95 = 49.86\angle 53.2^\circ$$

$$I = \frac{V}{Z_{EQ}} = \frac{V}{49.86}$$

STARTER COIL PICK UP VOLTAGE

SHEET H 15 OF

SQN - E3 - 015

COMPUTED EJJ DATE 3/5/88

CHECKED afal DATE 3/5/88

$$I_{ST} = \frac{I \times Z_{14}}{Z_{11} + Z_{14}} = \frac{V}{49.86} \times \frac{112.1 \angle 66.3^\circ}{73.\angle 57.6^\circ + 112.1 \angle 66.3^\circ}$$

$$= \frac{V}{49.86} \times \frac{112.1}{184.5}$$

$$= 0.01218V$$

$$V_{ST} = I_S \; Z_2 = 0.01218V \times 69 = 0.84 \; V$$

$$V = \frac{V_{ST}}{0.84} = \frac{81}{0.84} = 96.4 \text{ volts}$$

$$V_{mcc} = 3.7 \times 96.4 = 356.7 \text{ volts}$$

$$\% V_{mcc} = \frac{356.7}{480} \times 100 = 74.3 \%$$

SUBJECT ______ PROJECT SQN-E3-015

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R1 COMPUTED BY EJJ DATE 3/5/88 CHECKED BY afal DATE 3/5/88

PICKUP MARGIN

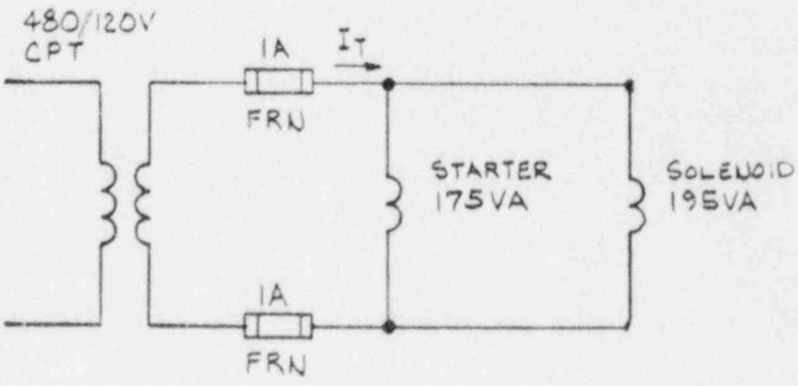
MINIMUM VOLTAGE REQUIRED AT THE 480V MCC'S TO ENSURE THAT THE CONTACTOR COIL VOLTAGE IS AT LEAST 0.736 PU AT 110V FOR CONTACTOR PICKUP IS 0.739 PU AT 480V R1

THE MINIMUM ADJUSTED VOLTAGE AT THE 480V MCC WHEN A 480V CONTACTOR CLOSES CONCURRENTLY WITH THE STARTING OF A 6.6 KV MOTOR IS 0.84 PU (SH.H23) R1
THE MINIMUM MARGIN IS 0.84 - 0.743 = 0.097 PU OR 9.7 PERCENT AT 480V.

6.0 COMPUTATION/ANALYSIS (CONT.)

6.2 MAXIMUM CONTROL CURRENT

A REVIEW OF 480V LOADS IDENTIFIED IN CALCULATION SQN-E3-002 AND SQN-APS-010 INDICATES THAT THE WORST CASE 120V CONTROL CIRCUITS CONSIST OF SIMULTANEOUS ENERGIZATION OF STARTER AND SOLENOID, FOR SIZE 1 AND 2 STARTERS. THE TOTAL INRUSH CURRENT EQUALS THE INRUSH OF THE STARTER AND SOLENOID. NO INDICATING LIGHT IN THIS CIRCUIT.

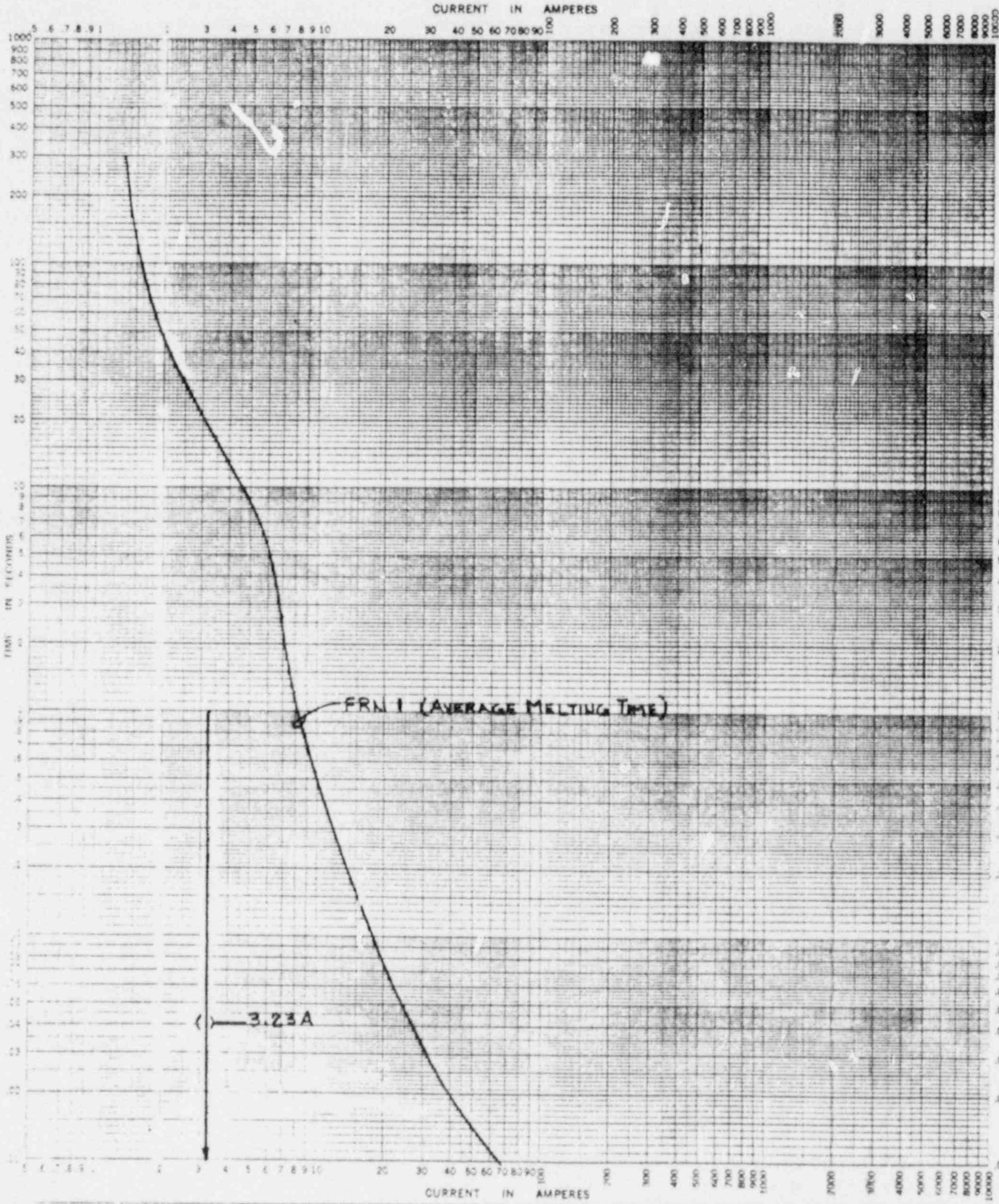


$$I_T = \frac{175}{110} + \frac{195}{120}$$

$$I_T = 1.6 + 1.63 = 3.23 \text{ Amps.}$$

SQN - E3 - 015

Sheet H18 of ______



TIME-CURRENT CHARACTERISTIC CURVES

Fuse Links. In ______

Dated ______

Tests made at ______ Volts a.c. at ______ p.f., starting at 25C with no initial load ______

Curves are plotted to ______ Test points so variations should be ______

No. ______

Date ______

Prepared R.P. Ernst Date 3-5-88

Verified E. Tafavas Date 3/5/88

SUBJECT ____ PROJECT SQN

SQN-E3-015

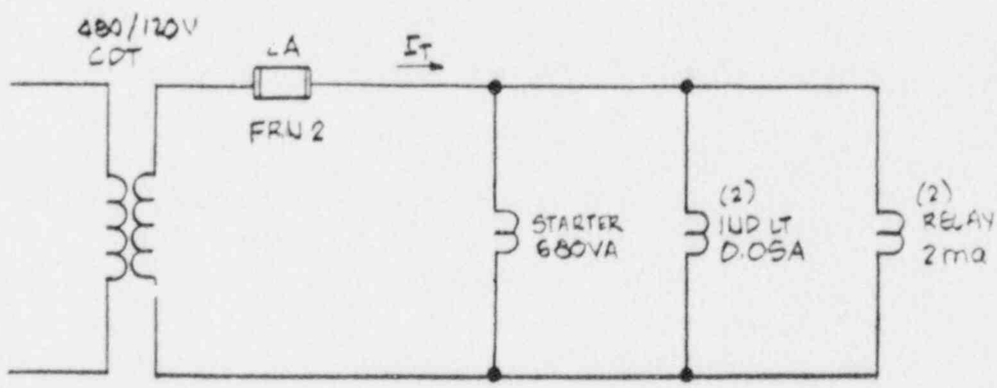
COMPUTED BY E.S.J. DATE 3/8/88 CHECKED BY afal DATE 3/8/88

MARGIN

THE 1 AMP FUSE WILL REQUIRE 8 AMPS FOR 1 SEC. TO BLOW.

THE MARGIN IS $(8 - 3.23) \times \frac{100}{8} = 59.61\%$ BASED ON FUSE RATING AT 1 SEC.

FOR SIZE 3 STARTER



$I_T = \frac{680}{110} + 2 \times 0.05 + 2 \times 2 \times 10^{-3}$

$I_T = 6.3$ A

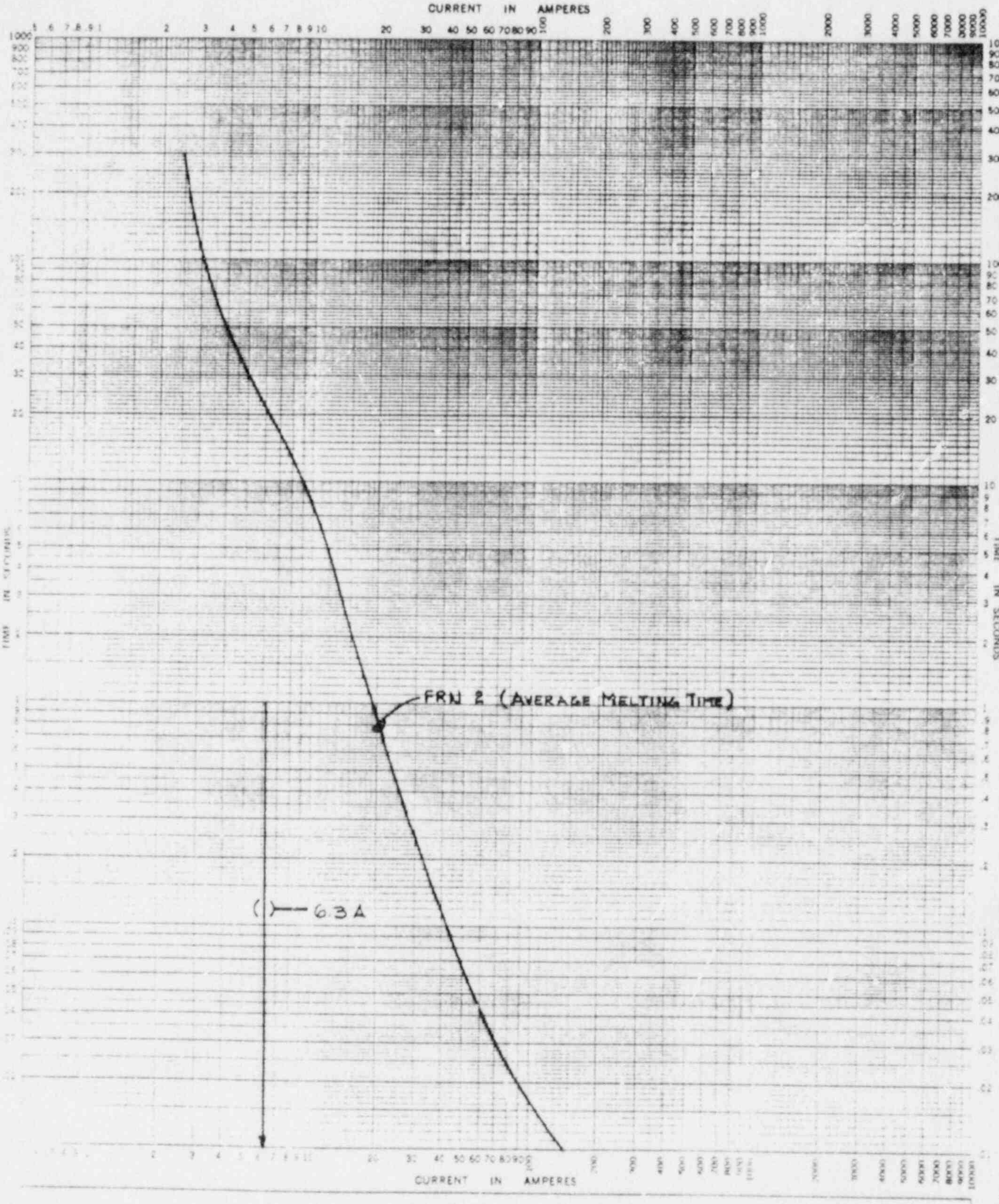
MARGIN

THE 2A FUSE WILL REQUIRE 19A FOR 1 SEC TO BLOW.

THE MARGIN IS $(19 - 6.3) \times \frac{100}{19} = 66.8\%$ BASED ON FUSE RATING AT 1 SEC.

SQN-E3-015

Sheet H20 of ______



TIME-CURRENT CHARACTERISTIC CURVES

Fuse Links

BASIS FOR DATA Standards ...... Dated

Tests made at ...... Volts a.c. at ...... p.f. starting at 25C with no initial load

Curves are plotted to ...... Test points so variations should be ......

No.

Date

R1

Prepared R.P. Ernst Date 3-8-88

Verified E Iglesias Date 3-8-88

SUBJECT STARTER PICKUP VOLTAGE PROJECT SQN

SQN-E3-015

COMPUTED BY EJJ DATE 3/5/88 CHECKED BY afal DATE 3/8/88

6.0 RESULTS AND CONCLUSIONS

FOR PICKUP, THE WORST CASE CIRCUIT WAS DETERMINED TO BE AN MOV THAT WOULD START CONCURRENT WITH THE AUXILIARY FEEDWATER PUMP MOTOR AT THE 20 SECOND LOAD STEP AND CONSISTS OF 6 RELAYS AND TWO LIGHTS DRAWING HOLDING CURRENT, AND THE INRUSH OF THE CONTACTOR COIL. THE MINIMUM ADJUSTED VOLTAGE ANTICIPATED AT THE 480V MCC IS CONSERVATIVELY CALCULATED TO BE 84 PERCENT WHEN THE MOV CONTACTOR CLOSES CONCURRENTLY WITH THE 20 SECOND LOAD STEP. THIS VOLTAGE IS ABOVE THE REQUIRED CONTACTOR VOLTAGE OF 74.3 PERCENT (73.6 PERCENT ON A CONTACTOR BASE OF 110V). THEREFORE, THE MINIMUM VOLTAGE MARGIN IS 9.7 PERCENT, REALIZING THAT THE CONTACTOR VOLTAGE ACTUALLY WOULD BE HIGHER BECAUSE THE MOV CONTACTOR WOULD PICKUP AT THE SAME TIME AS THE 6.6 KV MOTOR AND BEFORE THE VOLTAGE DROPS DUE TO THE LOCKED ROTOR IMPEDANCE OF THE MOTOR.

SUBJECT STARTER PICKUP VOLTAGE PROJECT SQN

SQN - E3 - 015

COMPUTED BY EH DATE 3/5/88 CHECKED BY [illegible] DATE 3/8/88

FOR MAXIMUM CURRENT, THE WORST CASE CIRCUIT WAS DETERMINED THE PEN RM ELEV. 669 COOLER FAN 2B-B THAT WOULD BE ENERGIZED AT = 0 SECOND OF THE LOADING SEQUENCE AND CONSISTS OF A SOLENOID AND A CONTACTOR COIL BOTH ENERGIZING AT THE SAME TIME. THE RESULTING MAXIMUM CURRENT WOULD BE 3.23 AMPERES. THE CONTROL CIRCUIT FUSE IS A FRN 1 AMP FUSE WHICH WOULD REQUIRE 8 AMPERES FOR 1 SECOND IN ORDER TO INTERRUPT. THEREFORE, THE MINIMUM MARGIN IS 59.6 PERCENT AT 1 SECOND.

Correction Of Contactor Pickup Voltage

Due to Variation of Generator Impedance

The profiles of various voltage and current characteristics of DG1B at the start of ERCW is shown on attached Figure 5 reproduced from field test traces.

The voltage profile V_T indicates that at start there is an initial sharp drop followed by a slow drop over about the next 15 cycles. The initial drop is basically limited by the generator direct axis subtransient reactance X''_d and the slowly dropping part by the generator direct axis transient reactance X'_d.

Our voltage dip calculations are based on worst case drop which corresponds to the drop at the end of the slowly decaying period.

At the start of a 6.9kV motor, the associated 480V motor contactor will pick up by the end of the initial sharp drop and much before the bus voltage reaches the bottom. For example under scheduled load condition, while the worst case maximum voltage drop on the start of the AFW pump is 0.196 pu at the 480V Bd, the associated 480V contactors will pick up before this drop.

From Reference 3.15, the generator $X''_d = .242$ and $X'_d = .148$.

The initial drop = $\frac{0.148}{0.242} \times 0.196 = 0.12$ pu.

Thus, the voltage available for contactor pickup is 0.975 - 0.12 = 0.855 pu at 480V.

From Appendix F, the worst case drop between the 480V board and 480V MCC = 0.014 pu.

So the worst case minimum voltage available at 480V MCC

= 0.855 - .014 = 0.84 pu on 480V base.

R1 Prepared Sm Date 3/8/88
Verified ala Date 3/8/88

SQN-E3-015
H24

INFO ONLY

D/G 1B-B ERCW - START AT 16.11 SEC.

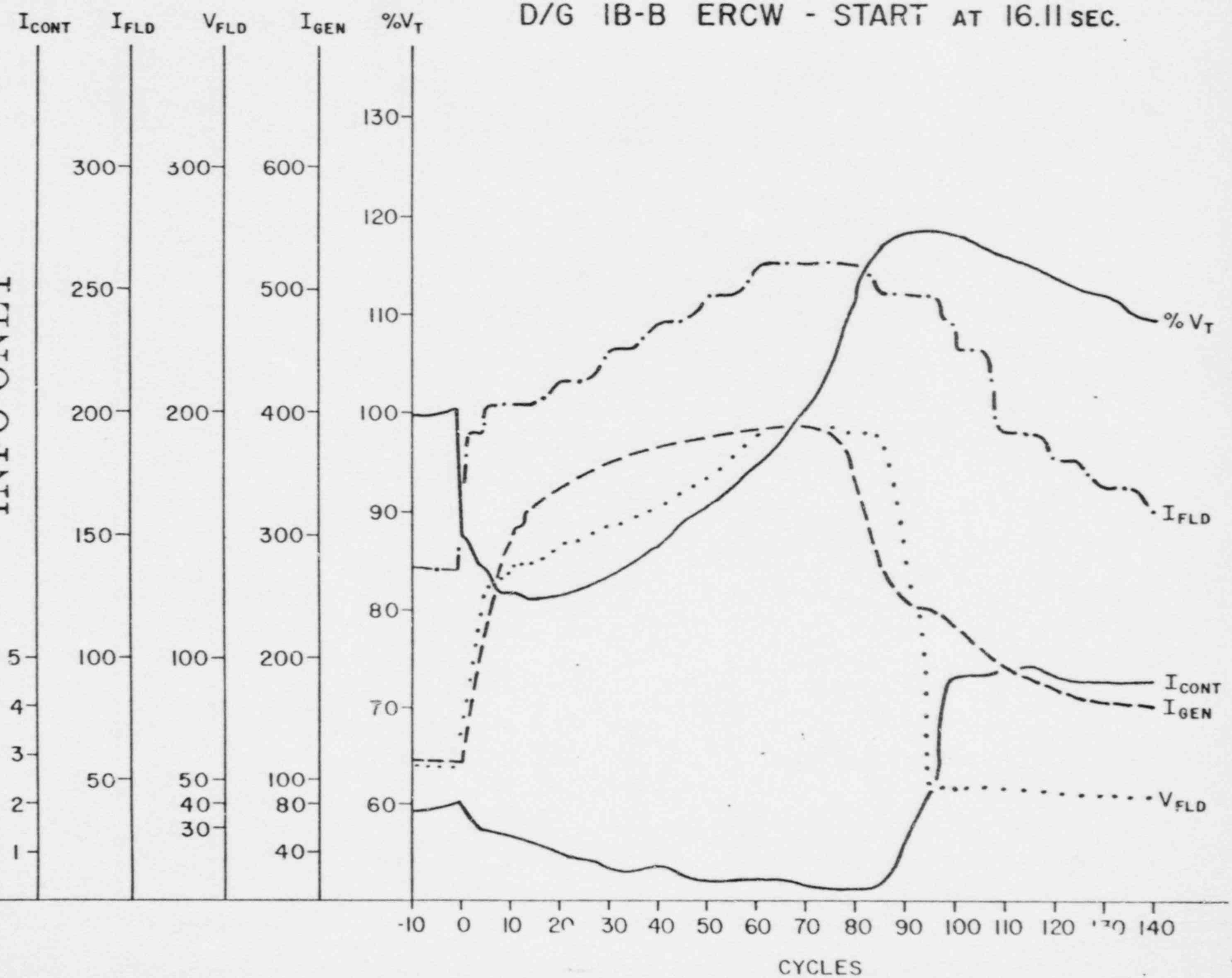


FIGURE 5

REF. 3.15 SQN-E3-015 H25

SERIAL NO.		A. C. SYNCHRONOUS GENERATOR DATA	SALES ORDER NO.	DATE
17103018/21	200		17103018/21	6/7/71

F	KVA	VOLTS	AMPS	PHASE	HERTZ
.0803	5000	6900	418	3 (6 wire)	60
FRAME	**INSUL. CLASS**	**P.F.**	**POLES**	**DUTY**	**RPM**
140	B	.8	8	Cont.	900

GENERATOR:

1	Direct Axis Synchronous Reactance (Unsaturated)	Xd	1.57	P.U.
2	Quadrature Axis Synchronous Reactance (")	Xq	.776	P.U.
3	Direct Axis Transient Reactance (Rated Voltage)	X'd	.242	P.U.
4	Direct Axis Subtransient Reactance (" ")	X"d	.148	P.U.
5	Quadrature Axis Subtransient Reactance (" ")	X"q	.165	P.U.
6	Zero Sequence Reactance (" ")	Xo	.114	P.U.
7	Negative Sequence Reactance (" ")	X2	.156	P.U.
8	Direct Axis Transient Open Circuit Time Constant	T'do	4.08	Sec.
9	Short Circuit Transient Time Constant	T'd	.77	Sec.
10	Short Circuit Subtransient Time Constant	T"d	.045	Sec.
11	Synchronous Impedance Unit on Rated KVA Base		9.54	Ohms
12	Short Circuit Ratio	SCR	.71	
13	Field Resistance at 25 Deg. C		.485	Ohms
14	Field Current at Full Load, Rated Voltage and Power Factor		148 *	Amps
15	Field Current at No Load, Rated Voltage		68.2	Amps
16	Field Current at No Load 605 Volts		37.3	Amps
17	Continuous Duty Field Voltage		111.5	Volts
18	Inherent Regulation		40%	%
19	Recommended Field Discharge Resistor 1.0	Ohms	50	Amps
20	Synchronizing Power Coefficient at No Load	PrNL	6480	KW/El. Rad
21	Synchronizing Power Coefficient at Full Load	PrFL	9050	KW/El. Rad
22	Unbalance Magnetic Pull at .031" Displacement	Pd (1/32)	9000	Lbs.
23	Magnetization Characteristics		Curve No. 2310	

STATIC EXCITATION

SERIAL NO.	600	D.C. EXCITER DATA	TYPE L-

KW	VOLTS	AMP	RPM	INSUL. CLASS

2	Field Resistance at 25 Deg. C		Ohms
3	Recommended Discharge: Plate(s)	Ohms	Amps
4	Saturation Curve	Curve No.	

*Rev. was 146 6/14/71

For the devices automaticly loaded onto the Diesel Generators identified in the two I&C calculations (27SIA and DG TIMERS) the schematic/elementary diagrams were reviewed to identify all loads started simultaneously with this equipment. Devices slaved from these major loads that have time delays associated with their start were not included as the DG will have time to recover prior to their start. Also loads that recieve the same start but n[illegible] the permissives were not included because they would be loaded prior to these load sequences (ie valves open on SI signal at time 0 but pumps wait for load sequencer at 20 seconds).

SQN-E3-015

DESIGNED	SJB 3-8-88	0
CHECKED	ZBG 3-8-88	

H 26

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THE FOLLOWING MAJOR EQUIPMENT HAS THE NOTED SLAVE LOADS START SIMULTANEOUSLY WITH OR AS A RESULT OF THEIR BREAKER CLOSURE.

CHARGING PUMP	45N765-16, R13
ROOM COOLER	45N779-19, R19
AUX LUBE OIL PUMP	45N779-25, R22
SAFETY INJECTION PUMP	45N765-14, R13
ROOM COOLER	45N779-19, R19
RHR PUMP	45N765-13, R13
ROOM COOLER	45N779-19, R19
MINIFLOW RECIRC	45N779-9, R21
ERCW PUMP	45N765-15, R16
NONE	
AUX FW MOTER DRIVEN PUMPS	45N765-6, R15
FCV-3-116A,B,126A,B	45N779-23, R24
COMPONENT COOLING PUMPS	45N779-2, R22
NONE	
C[illegible]PONENT COOLING BOOSTER PUMPS	45N779-31, R18
NONE	
CONTAINMENT SPRAY	45N765-7, R16
ROOM COOLER	45N779-19, R19
IF HI CONT PRES OPEN FCV-72-2,39	45N779-10, R17
ELECTRIC BOARD ROOM AHU	45N779-46, R1
ELECT BD ROOM AC COMPRESSOR OIL PUMP	45N779-7, R14

SQN-E3-015

DESIGNED	SJB 3-8-88	0
CHECKED	YBY 3-8-88	

TVA 64 (OS-9-65) (OP-WP-5-85)

E13 880216 002

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : W. S. Raughley, Chief, Electrical Engineering Branch, DNE, W8 C126 C-K

FROM : R. L. Morley, Chief, Central Laboratories Services Branch, LA PSC 1-C

DATE : February 16, 1988

SUBJECT: VOLTAGE PICKUP TESTS FOR ARROW-HART CONTACTORS

The attached report is a summary of data gathered at the Central Laboratories Services Branch (CLSB) for Ken Greene, Division of Nuclear Engineering (DNE). This data is needed for evaluation of contactors at Sequoyah Nuclear Plant.

If you need any additional information, please contact me at extension 4317 or Jerry Wormsley at extension 4337.

RLM

SQN-E3-015

H28

RLM:JAW:SWH
Attachments
cc: RIMS, MR 4N 72A-C
J. K. Greene, W8 C144 C-K

SQN-E3-015
H 29

PICKUP VOLTAGE REPORT
FOR
SEQUOYAH NUCLEAR PLANT
ON
ARROW-HART CONTACTORS

Jerry A. Wormsley
J. A. Wormsley, Engineer

J. B. Ragsdale, Jr., QA/QC

R. L. Morley
R. L. Morley, Chief, CLSB

SQN-E3-015
H30

INVESTIGATION OF CONTACTOR PICKUP VOLTAGE
FOR
ARROW-HART CONTACTOR

The Central Laboratories Services Branch performed tests for the determination of dropout voltages for certain Arrow-Hart contactors for Sequoyah Nuclear Plant. These tests were requested by Ken Greene of the Division of Nuclear Engineering on February 12, 1988 and were performed on February 13 and 14, 1988.

All work performed in conjunction with this test was accomplished with the CLSB Quality Assurance Program which complies with all applicable requirements of 10 CFR 50/Appendix B and ANSI N45.2. Defects are reported in accordance with the requirements of 10 CFR 21.

Tests were performed on seven samples. Five were contactors that had been removed from the plant and two were from the plant storeroom. The storeroom's contactors were returned to the plant; one contactor was held at CLSB for other investigations, and the others were returned to Ken Greene.

The contactor under test was mounted in an approximate vertical position and the voltage, coil current, and contactor conditions monitored. The data for each contactor tested is provided in table form in TABLE I through TABLE VII.

The instrumentation used for this test were:

DESCRIPTION	MANUFACTURER	MODEL	USTVA#	CAL. DATE	DUE DATE
Digital Multimeter	Keithley	197	548489	1-16-88	3-16-88
Digital Multimeter	Keithley	197	548501	11-25-87	2-25-88
Digital Stopwatch	Micronta	63-5009A	902653	10-1-87	10-1-88
Glass Thermometer	ERTCO	ASTM-17F	S/N83388	2-12-88	2-12-89

SQN-E3-015
H31

TABLE I

SAMPLE 1 (Removed from plant service).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	558.5 ma	No pickup
50	10 "	619.5 "	" "
55	10 "	679.2 "	" "
60	10 "	743.3 "	" "
65	10 "	803.6 "	" " , hum
70	10 "	865.1 "	" " "
75	10 "	930.1 "	" " "
80	---	76.8 "	Pickup, buzz, latched
75	10 "	930.0 "	No pickup, hum
76	10 "	940.8 "	" " "
77	---	72.3 ma	Pickup, buzz, latched
77	10 "	954.9 ma	No pickup, hum
78	10 "	965.1 "	" " "
79	0.5 sec.	75.0 ma	Pickup, buzz, latched
79	10 sec.	973.4 "	No pickup, hum
80	---	76.4 ma	Pickup, buzz, latched
80	---	76.5 "	" " "
80	---	76.6 "	" " "
80	---	76.4 "	" " "
79	10 sec.	973.8 ma	No pickup, hum

Average temperature during test: 71 degrees F.

SQN-E3-015
H32

TABLE II

SAMPLE 2 (Removed from plant service).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	558.7 ma	No pickup
50	10 "	623.3 "	" "
55	10 "	686.1 "	" "
60	10 "	749.0 "	" "
65	10 "	811.3 "	" " , hum
70	10 "	871.8 "	" " "
75	---	82.1 "	Pickup
70	10 "	874.8 "	No pickup, hum
71	10 "	883.9 "	" " "
72	---	77.5 ma	Pickup
72	10 "	896.8 ma	No pickup, hum
72	---	77.2 "	Pickup
73	---	78.9 ma	"
73	---	78.6 "	"
73	---	78.8 ma	Pickup

Average temperature during test: 71 degrees F.

SQN-E3-015
H33

TABLE III

SAMPLE 3 (Overlabeled Arrow-Hart, from plant storeroom).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	564.6 ma	No pickup
50	10 "	626.7 "	" "
55	10 "	690.2 "	" "
60	10 "	753.6 "	" "
65	---	63.0 ma	Pickup, loud buzz
65	---	[illegible].3 ma	" " "
60	10 sec.	[illegible].2 "	No pickup, hum
61	10 "	765.7 "	" " "
62	10 "	776.2 "	" " "
63	---	59.8 "	Pickup, loud buzz
63	---	60.0 ma	" " "
63	---	59.6 "	" " "
63	10 sec.	787.[illegible] "	No pickup, hum
64	---	61.2 "	Pickup, loud buzz
64	10 sec.	798.4 "	No pickup, hum
65	---	62.8 "	Pickup, loud buzz
65	---	62.3 "	" " "
65	---	62.2 "	" " "
65	---	62.3 "	" " "

Average temperature during test: 72 degrees F.

SQN-E3-015
H34

TABLE IV

SAMPLE 4 (Overlabeled Arrow-Hart, from plant storeroom).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	571.2 ma	No pickup
50	10 "	636.5 "	" "
55	10 "	698.5 "	" "
60	10 "	760.9 "	" "
65	---	60.4 ma	Pickup, buzz
60	10 sec.	760.1 "	No pickup, hum
61	10 "	772.7 "	" " , loud hum
62	10 "	783.5 "	" " " "
63	10 "	794.7 "	" " " "
64	---	58.0 "	Pickup, buzz
64	10 sec.	805.4 "	No pickup, hum
64	---	58.6 ma	Pickup, buzz
64	10 sec.	805.1 "	No pickup, hum
65	---	60.2 "	Pickup, buzz
65	10 sec.	816.4 "	No pickup, hum
65	10 "	816.2 "	" " "
66	10 "	828.3 "	" " "
66	10 "	829.3 "	" " "
66	---	60.7 "	Pickup, buzz
66	---	61.7 "	" "
66	---	60.3 "	" "
66	10 sec.	828.1 ma	No pickup, hum
67	---	63.0 "	Pickup, hum
67	---	62.9 "	" "
67	---	63.1 "	" "
67	---	62.9 "	Pickup, no hum
67	---	62.8 "	" " "
67	---	62.9 "	Pickup, buzz
67	---	62.9 "	Pickup, hum
67	---	62.8 "	Pickup, no hum

Average temperature during test: 72 degrees F.

SQN-E3-015
H35

TABLE V

SAMPLE 5 (Labeled Federal Pacific Electric; removed from plant.)

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	567.5 ma	No pickup, hum
50	10 "	630.5 "	" " "
55	10 "	694.4 "	" " "
60	10 "	756.5 "	" " "
65	10 "	820.3 "	" " "
70	---	76.2 "	Pickup, buzz
70	---	76.2 "	" "
65	---	68.2 "	" "
65	---	68.3 "	" "
65	10 sec.	821.6 ma	No pickup, hum
66	---	70.1 "	Pickup, buzz
66	---	69.9 "	" "
66	---	69.8 "	" "
66	---	69.9 "	" "
66	---	69.9 "	Pickup, buzz

Average temperature during test: 72 degrees F.

SQN-E3-015
H 36

TABLE VI

SAMPLE 6 (Mechanical lockout device tied to Sample 7 and reset to rest against Sample 6).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	561.9 ma	No pickup, hum
50	10 "	625.7 "	" " "
55	10 "	688.6 "	" " "
60	10 "	748.4 "	" " "
65	10 "	812.8 "	" " "
70	10 "	875.9 "	" " "
75	10 "	704.7 "	Pickup, no latch, loud buzz
80*	---	88.2 "	Pickup, latch, buzz
80	10 sec.	741.8 "	Pickup, no latch, loud buzz
80	10 "	743.4 "	" " " " "
81	---	89.8 "	Pickup, latch, buzz
81	10 sec.	749.8 "	Pickup, no latch, loud buzz
81	10 "	749.4 "	" " " " "
82	---	91.4 "	Pickup, latch, buzz
82	---	91.4 "	" " "
82	---	91.2 "	" " "
82	---	91.2 "	" " "
82	---	91.2 "	" " "
83	---	93.4 "	" " "
81	---	89.6 "	" " "
81	---	89.4 "	" " "
81	10 sec.	748.1 "	Pickup, no latch, loud buzz
81	---	89.1 "	Pickup, latch, buzz

*NOTE: Delete-not mechanically reset to rest on Sample 6.

Average temperature during test: 72 degrees F.

SQN-E3-015
H 37

TABLE VII

SAMPLE 7 (Mechanical lockout device tied to Sample 6 and reset to rest against Sample 7).

VOLTS APPLIED	DWELL TIME	COIL CURRENT	COMMENTS
45	10 sec.	566.6 ma	No pickup, hum
50	10 "	629.7 "	" " "
55	10 "	692.3 "	" " "
60	10 "	756.3 "	" " "
65	10 "	818.4 "	" " "
70	10 "	881.7 "	" " "
75	10 "	689.2 "	Pickup, no latch, loud buzz
80	10 sec.	726.9 "	" " " "
85	---	100.8 "	Pickup, latch, quiet
81	---	93.7 "	" " "
81	---	93.8 "	" " "
81	---	93.9 "	" " "
81	---	93.7 "	" " "
81	---	94.6 "	" " "
80	---	92.8 "	" " "
80	---	92.8 "	" " "
79	10 sec.	718.9 "	Pickup, no latch, loud buzz

Average temperature during test: 72 degrees F.

Data Received from Arrow Hart Inc.
Crouse Hinds Co.

UV

I Arrow Hart Starter Coils

Prepared HWH Date 6/8/87
Verified RSE Date 6-8-87

Size Starter	Rated Voltage	VA inrush*	Watts inrush*	VA sealed*	Watts sealed
1	110/120	175	90	21	6
2		175	80	21	6
3		680	160	45	20
4		680	160	45	20

Size Starter	Pickup Percent of Rated Voltage	Rated Voltage Pickup Time milliseconds*-1
1	85%	26
2	75%	26
3	85%	50
4	85%	55

* Values given are for cold coils, for hot coils reduce values by 5 percent.

*-1 Pickups for all starter coils, hot or cold, is 85 percent of rated voltage. For pickup time at minimum voltage increase each starter size time by 20 percent.
Maximum coil voltage is 10 percent above rated for all starters.

Minimum coil voltage for all starters to prevent dropout is 65 percent of rated.

VA amps at maximum voltage, increase volt amps by 25 percent.

PUSHBUTTONS AND MASTER SWITCHES

ype T — Heavy Duty Oiltight Control Units and Master Stations

OPERATORS (Continued)

LAMPS FOR INDICATING LIGHTS — STANDARD AND PRESTEST

Indicating Light Voltage	Transformer Type			Full Voltage Type			Neon Type	
	Lamp Rating		Lamp Number	Watts		Lamp Number	Rated Watts	Lamp Number
	Volts	VA						
4-6	—	—	—	—	6	6S6-6V.	—	—
14-17	—	—	—	—	6	6S6-18V.	—	—
18-23	—	—	—	—	6	6S6-24V.	—	—
24-30	—	—	—	—	6	6S6-30V.	—	—
31-40	—	—	—	—	6	6S6-40V.	—	—
40-48	—	—	—	—	6	6S6-60V.	—	—
120	6	6.1	255	—	*4.4	6S6-120V.	0.25	B7A
240	6	6.7	255	—	*6.7	10S6-250V.	0.25	B7A
380	6	7.6	255	—	—	—	0.25	B7A
480	6	6.7	255	—	—	—	0.25	B7A
600	6	6.6	255	—	—	—	0.25	B7A
Dc Only								
440	—	—	—	—	—	—	0.25	B7A
500	—	—	—	—	—	—	0.25	B7A

* These devices employ a series resistor.

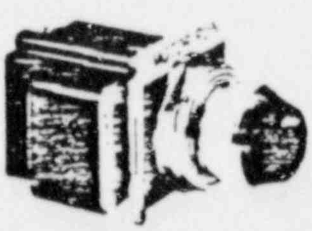
Neon type indicating lights have the advantage of exceptionally long life regardless of the severity of operating conditions. The level of illumination, however, is much less than the transformer or resistor types. The lamp used in neon units emits a low intensity light which is strong in the red spectrum. Because of this, they should be used with clear or amber plastic or glass lenses only. An internal leak resistor connected across the lamp prevents nuisance lighting by the capacitive effect of long lines.

The above table lists the voltages available for each of the three types along with the power rating and the lamp number used in each.

Indicating lights can be supplied with either a plastic or a glass lens. The glass lens holder is copper-nickel-chrome plated brass. Both types of lenses are available in red, green, amber, blue, clear and white.

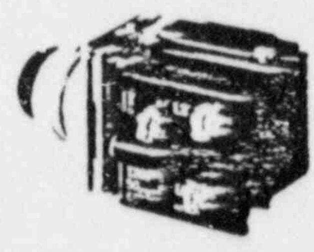
All three types of indicating lights are available for either one-hole or base mounting. Terminals are serrated pressure type with screw and captive saddle clamp.

A Buna N synthetic rubber lens gasket prevents oil and other contaminants from entering the lamp unit. This gasket is in addition to the standard gasket between operator and panel.



TRANSFORMER TYPE PRETEST INDICATING LIGHT WITH GLASS LENS

FULL VOLTAGE OR RESISTOR TYPE PRETEST WITH PLASTIC LENS



Prestest Indicating Lights — NEMA 13

Prestest indicating lights take the guesswork out of indicating lamp operation. They provide a positive, quick means of checking the lamp without removing the lens. Depressing the lens disconnects the lamp from the control circuit and reconnects it to a continuously energized testing circuit for immediate indication of a faulty lamp. A single pole, double throw, momentary contact switch within the lamp disconnects the light from the control circuit to prevent feedback during the test operation. The prestest testing circuit is NC and the indicating light circuit is NC.

Two types of prestest indicating lights are available:

- a transformer type for ac operation only
- a resistor type for ac/dc operation

Both types can be supplied with either a plastic or a glass lens in six colors: red, green, amber, blue, clear or white. The lens holder is corrosion resistant nickel-chrome plated brass.

The transformer type is equipped with a #755 6 volt, vibration resistant bayonet base lamp and is available for 120, 240, 380, 480 or 600 volt, 50/60 hertz operation (a #44 lamp can be used as an alternate). The transformer which supplies reduced voltage to the lamp is designed to protect the lamp from burnout by transients and short duration overvoltage. Low heat radiation increases the number that can be mounted in a small space. They are available for one-hole or base mounting and occupy a space equivalent to one contact block pushbutton depth.

See note on installation and use of this product at bottom of page 1.

SQN-E3-015 Sheet ___ of ___

Moderate Flow

3 WAY SOLENOID VALVES

For (oil free) Instrument Air
1/8", 1/4", 3/8" and 1/2" N.P.T.

ASCO Red-Hat

BULLETINS
206-380 208-448
206-381 208-266
206-832 210-036

General Description

These rugged forged brass, steel and stainless steel body valves are especially suited for heavy duty industrial applications.

Important: No minimum operating pressure is required.

Applications

They are primarily used as pilot operators on larger control valves in nuclear power plants.

These valves also may be used on:
- air vises
- machine tools
- compressors
- turbines

Specifications

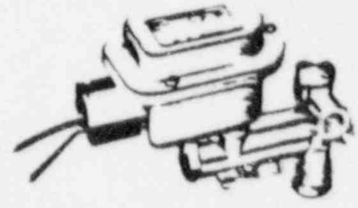
Operation: Three types are available:
(a) Normally Closed
(b) Normally Open
(c) Universal

Pipe Sizes: 1/8", 1/4", 3/8" and 1/2" N.P.T.

Valve Parts in Contact with Media:
Body — Brass, Steel or 304 s.s., as listed.
Disc — 303 s.s.
Core Tube — 305 s.s.
Core and Plugnut — 430F s.s.
Springs — 302 s.s. and 17-7 PH s.s.
Shading Coil — Copper for brass and steel valves; Silver for stainless steel valves.
Seats — Ethylene propylene or 303 s.s.
Gaskets — Ethylene Propylene
No aluminum parts.

Solenoid Enclosures: Two types are available:
(a) Watertight (NEMA 4 and 6).
(b) Explosion-Proof and Watertight (NEMA 7C, 7D and 4).

Electrical: Standard Voltages:
24, 120, 240, 480 volts, A-C, 60 Hz (or 50 Hz in 110 volt multiples).
6, 12, 24, 125, 250 volts, D-C (battery voltages).
Other voltages available when required.



Coils: Continuous Duty Class H.

Temperature: Fluid: To 180°F.

Ambient: Nominal Range, 32°F. to 140°F.

Installation: Valves must be mounted with solenoid vertical and upright.

Coarse Filter: Integral in valve inlet.

Optional Features:

- Junction box enclosure (AC watertight solenoid only)
- Manual operator
- 1/2" threaded conduit hub
- Screw terminal coils (AC watertight solenoid only)
- Viton elastomers

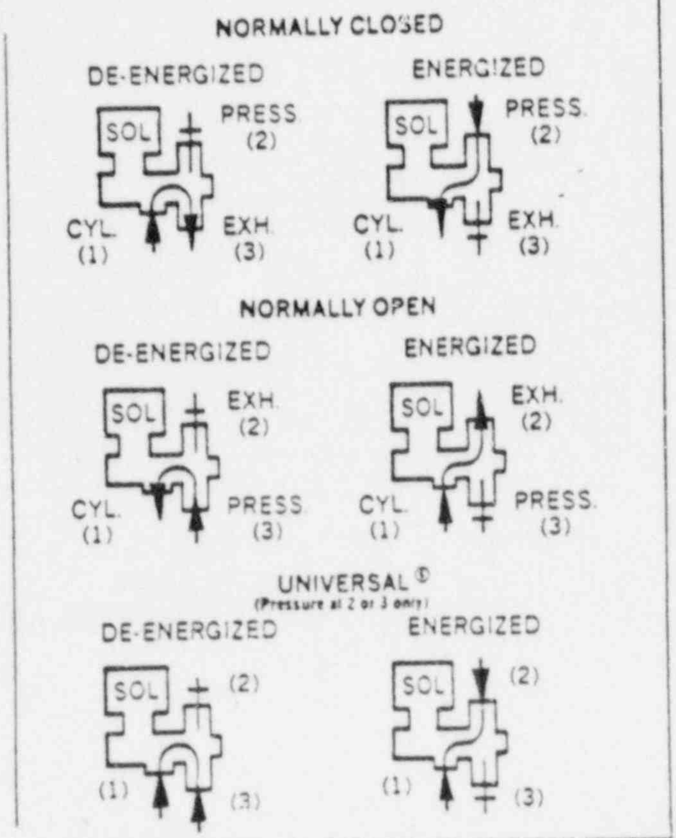
Specifications

Normally Closed / Normally Open / Universal

Pipe Size (Ins.)	Orifice Size (Ins.)	Max. Operating Pressure Differential P.S.I.: Normally Closed ① or Normally Open ②	Universal ③	Safe Working Pressure (P.S.I.)	Max. ④ Fluid Temp. °F	Cv ⑤ Flow Factor	Watertight Solenoid Enclosure Catalog Number	Explosion Proof — Watertight Solenoid Enclosure Catalog Number	Body Material	Watt Rating AC	Watt Rating DC	Approx. Shipping Weight (Lbs.)
AC Construction												
⑥ 1/4	3/32	200	100	600	180	.35	206-380-1	206-832-1	Brass	20	–	4
⑥ 1/4	3/32	200	100	600	180	.35	206-380-2	206-832-2	Brass	20	–	4
⑥ 1/4	1/8	150	75	600	180	.45	206-380-3	206-832-3	Brass	20	–	4
⑥ 1/4	3/32	200	100	600	180	.35	206-380-4	206-832-4	Brass	20	–	4
⑥ 1/4	1/8	150	75	600	180	.45	206-380-5	206-832-5	Brass	20	–	4
⑥ 1/4	3/16	100	50	600	180	.75	206-380-6	206-832-6	Brass	20	–	4
⑥ 1/4	3/16	100	50	600	180	.75	206-380-7	206-832-7	Brass	20	–	4
1/4	3/32	200	100	1500	180	.35	208-266-1	210-036-1	Steel	20	–	6
1/4	1/8	150	75	1500	180	.45	208-266-2	210-036-2	Steel	20	–	6
1/4	3/16	100	50	1500	180	.75	208-266-3	210-036-3	Steel	20	–	6
1/2	3/16	100	50	1500	180	.75	208-266-4	210-036-4	Steel	20	–	6
1/2	3/16	100	50	1500	180	.75	208-266-5	210-036-5	Stainless Steel	20	–	7
DC Construction												
⑥ 1/4	3/32	200	100	600	180	.35	–	206-381-1	Brass	–	35.1	7
⑥ 1/4	3/32	200	100	600	180	.35	–	206-381-2	Brass	–	35.1	7
⑥ 1/4	1/8	150	75	600	180	.45	–	206-381-3	Brass	–	35.1	7
⑥ 1/4	3/32	200	100	600	180	.35	–	206-381-4	Brass	–	35.1	7
⑥ 1/4	1/8	150	75	600	180	.45	–	206-381-5	Brass	–	35.1	7
⑥ 1/4	3/16	125	60	600	180	.75	–	206-381-6	Brass	–	35.1	7
⑥ 1/4	3/16	125	60	600	180	.75	–	206-381-7	Brass	–	35.1	7
1/4	3/32	200	100	1500	180	.35	–	208-448-1	Steel	–	35.1	10
1/4	1/8	150	75	1500	180	.45	–	208-448-2	Steel	–	35.1	10
1/4	3/16	125	60	1500	180	.75	–	208-448-3	Steel	–	35.1	10
1/2	3/16	125	60	1500	180	.75	–	208-448-4	Steel	–	35.1	10
1/2	3/16	125	60	1500	180	.75	–	208-448-5	Stainless Steel	–	35.1	10

Notes:
① For normally closed operation use catalog number Suffix "F".
② For normally open operation use catalog number Suffix "G".
③ For universal operation use catalog number Suffix "U".
④ Maximum AC/DC continuous ambient 140°F.
⑤ Resilient seats (Suffix "R") available — 3/32" orifice Cv = .25, 1/8" orifice Cv = .39, 3/16" orifice Cv = .53.
⑥ Coarse filter supplied at pressure connection 2 and 3 only.

Flow Diagrams

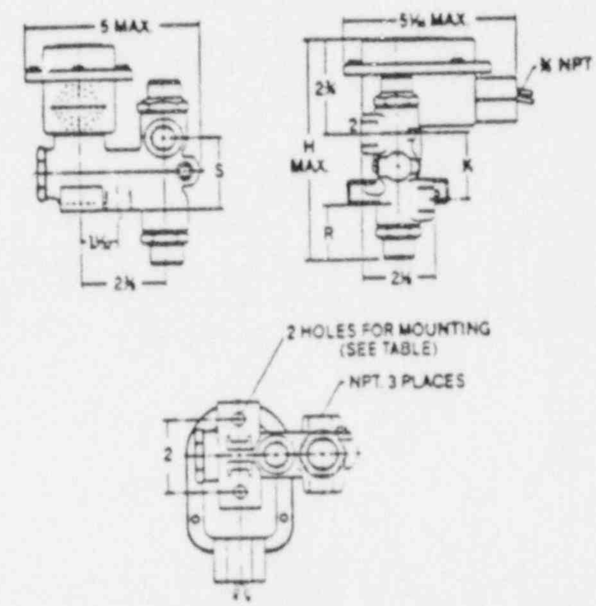


Electrical Information

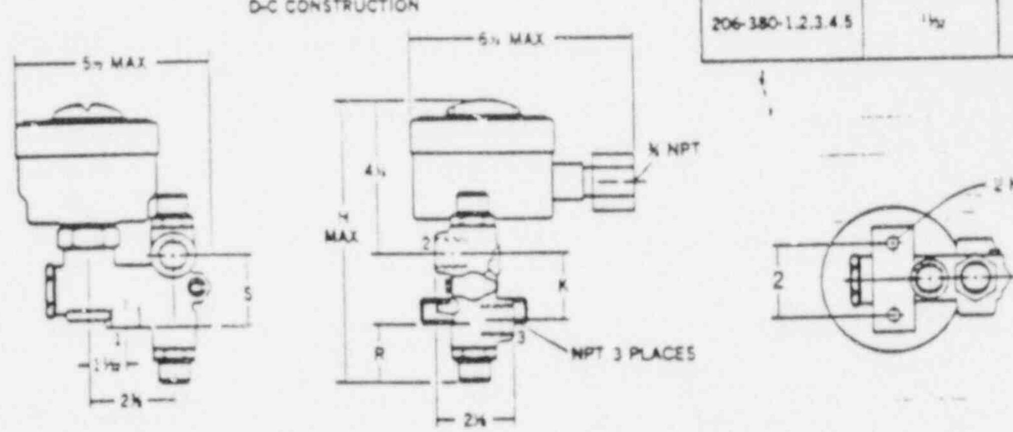
Standard Coil and Class of Insulation	Watt Rating and Power Consumption				Spare Coil Part No.	
	D-C	A-C				
	D-C Watts	Watts	VA Holding	VA Inrush	A-C	D-C
H	35.1	20	41.5	195	102-005	208-49.

Dimensions (in inches)

Watertight Solenoid Shown. WP-EP Details On Request.



CATALOG NUMBER	MOUNTING HOLE DIA	H	K	R	S
208-266-1.2.3.4.5	[illegible]	6[illegible]	1[illegible]	1[illegible]	2
206-380-6.7	[illegible]				
206-380-1.2.3.4.5	[illegible]	5[illegible]	1[illegible]	[illegible]	1[illegible]



CATALOG NUMBER	MOUNTING HOLE DIA	H	K	R	S
206-381-6.7	[illegible]	7[illegible]	1[illegible]	1[illegible]	2
208-448-1.2.3.4.5					
206-381-1.2.3.4.5	[illegible]	6[illegible]	1[illegible]	1[illegible]	1[illegible]

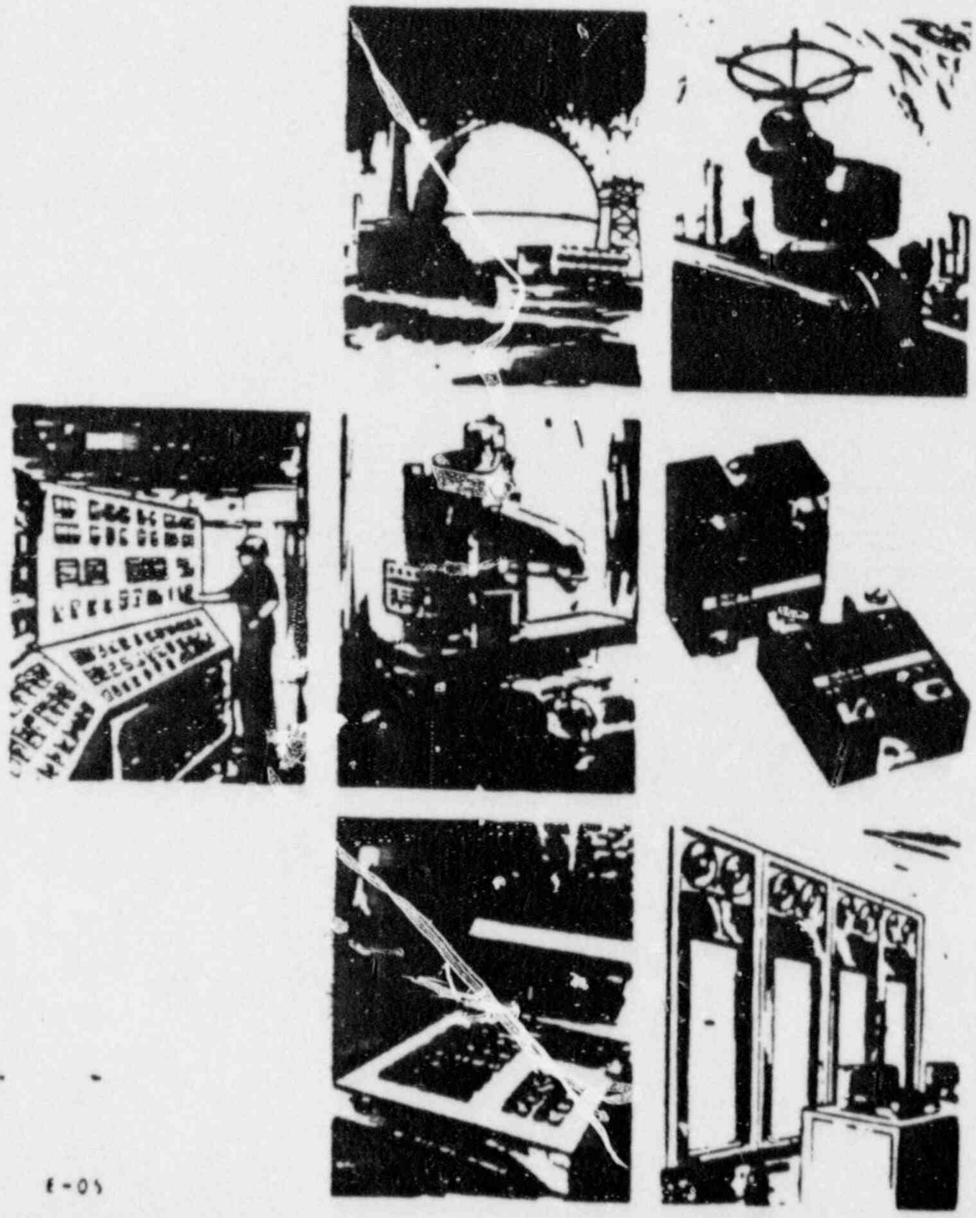
4855463 INTERNATIONAL RECTIFIER 40C 00418 D A-27-11

BULLETIN 604D

INTERNATIONAL RECTIFIER IOR CRYDOM

SERIES 1
SCR Output Solid-State Relay

2.5 Thru 75 Amp AC Output



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4855463 INTERNATIONAL RECTIFIER

40C 00420 0A-04-11

SQN-VD-VAC-2

Electrical Specifications (25 C unless otherwise specified)

All models are UL recognized and CSA certified [illegible]

OUTPUT CHARACTERISTICS		120 VAC				240 VAC					480 VAC					
MODEL NUMBERS	AC Control	A1202	A1210	A1225	A1240	A2402	A2410	A2425	A2440	A2475	A4808	A4812	A4825	A4840	A4875	Units
	DC Control	D1202	D1210	D1225	D1240	D2402	D2410	D2425	D2440	D2475	D4808	D4812	D4825	D4840	D4875	
Operating Voltage Range 47-63 Hz ①		24-140				48-280					80-530					Vrms
Max. Load Current (See derating curves) ②		2.5	10	25	40	2.5	10	25	40	75	8	12	25	40	75	Arms
Min. Load Current		80				50					50					mArms
Transient Overvoltage ③		300				600					800					Vpeak
Max. Surge Current (Non-Repetitive 16.6 ms) (See surge curves)		22.5	120	250	625	22.5	120	250	625	1000	72	140	250	400	1000	Apeak
Max. Over Current (Non-Repetitive) 1 sec.		5	22	40	80	5	22	40	80	150	17	24	40	64	180	Arms
Max. On-State Voltage Drop @ Rated Current		3.5	1.6	1.6	1.6	3.5	1.9	1.3	1.6	1.6	1.6	1.6	2.0	2.1	2.1	Vpeak
Max. I^2t for Fusing (8.3 ms)		21	80	260	1620	21	80	260	1620	4150	22	81	260	660	4150	A^2sec
Thermal Resistance, Junction-to-Case, $R_{\theta JC}$ (T_J Max. = 115 C)		8.5	1.48	1.02	0.63	8.5	1.48	1.02	0.63	0.3	1.48	1.48	1.02	0.63	0.3	C/W
Power Dissipation @ Max. Current (See dissipation curves)		8.3	12	29	48	8.3	12	29	48	90	9.3	14	34	60	90	Watts
Max. Zero Voltage Turn-on ④		15				30					75					Vpeak
Max. Peak Repetitive Turn-on Voltage		10				12					35					Vpeak
Max. Off-State Leakage Current @ Rated Voltage (-30 C ≤ TA ≤ 80 C)		8				10					10					mArms
Min. Off-State dv/dt (Static) @ Max. Rated Voltage ⑤		200				200					200					V/µs

INPUT CHARACTERISTICS — ALL MODELS	DC INPUT MODELS (with "D" Prefix)	AC INPUT MODELS (with "A" Prefix)
Control Voltage Range	3 to 32 VDC	90 to 280 Vrms (60Hz) X
Max. Reverse Voltage	32 VDC	—
Max. Turn-On Voltage (-30°C ≤ TA ≤ 80°C)	3.0 VDC	90 Vrms
Min. Turn-Off Voltage (-30°C ≤ TA ≤ 80°C)	1.0 VDC	10 Vrms
Min. Input Impedance	1500 Ohms	60K Ohms ¥
Max. Input Current	4mA (@5 VDC)	2mA (@ 120 VAC) ¥
	20mA (@28 VDC)	4ma (@ 240 VAC)
Max. Turn-On Time (60 Hz)	8.3 msec	10 msec
Max. Turn-Off Time (60 Hz)	8.3 msec	40 msec

GENERAL CHARACTERISTICS — ALL MODELS

Dielectric Strength ⑥ ⑦ 50/60 Hz		2500 Vrms
Insulation Resistance @ 500 VDC ⑦		10^{10} Ohms
Max. Capacitance Input/Output		8 pf
Ambient Temperature Range	Operating	-30°C to 80°C
	Storage	-40°C to 120°C

SPECIAL NOTE: The -10 version of DC input Series 1 relays are "non-zero voltage turn-on" types, and are optimized for operation from a phase-controlled signal applied at each half of the line cycle. All Series 1 data applies except as noted on the right. (Caution: Without zero crossing, inductive loads may give rise to "ringing" and voltage "overshoot" that could exceed the relay's peak transient rating. If this occurs, consideration might be given to the use of an MOV transient suppressor to protect the relay.)

Control Voltage Range	3.5 to 28Vdc
Max. Turn-On Voltage	3.5Vdc
Min. Input Impedance	1K Ohms
Max. Input Current	5mA (at 5Vdc), 28mA (at 28Vdc)
Max. Turn-On Time	30µsec
Min. Pulse Width	0.5msec

3

1204 8-07

SQU - E3 - 015

Sheet H 44 of

TYPICAL OPERATE AND RELEASE TIMES
AT NOMINAL COIL VOLTAGE AT +25°C

TYPE	OPERATE TIME IN MILLISECONDS	RELEASE TIME IN MILLISECONDS
SMALL AC NON-LATCHING	5 to 12	5 to 18
SMALL DC NON-LATCHING	15 to 30	5 to 15
SMALL AC LATCHING	6 to 12	N/A
SMALL DC LATCHING	10 to 16	N/A
MEDIUM AC NON-LATCHING	6 to 12	6 to 20
MEDIUM DC NON-LATCHING	65 to 90	10 to 30
MEDIUM AC LATCHING	8 to 14	N/A
MEDIUM DC LATCHING	30 to 80	N/A

48VDC ± 10%.. 230Ω coil resis.

Sherly Colbert SELES

COIL CHARACTERISTICS OF SMALL NON-LATCHING MDR ROTARY RELAYS

SMALL NON-LATCHING

(100-140VDC) MDR 5059

SERIES	CONTACTS	COIL VOLTAGE 60 Hz for AC	COIL CURRENT AMPERES	DC COIL RESISTANCE OHMS	COIL POWER WATTS*	BREAKDOWN VOLTS RMS
MDR131-1	4PDT	115VAC	0.215	66	6.5	1230
MDR131-2	4PDT	440 VAC	0.045	1256	5.1	1880
MDR135-1	4PDT	28 VDC	0.362	76	10.0	1308
MDR137-8	4PDT	125VDC	0.082	1520	10.3	2375
MDR134-1	8PDT	115 VAC	0.215	66	6.5	1230
MDR134-2	8PDT	440 VAC	0.045	1256	5.1	1880
MDR136-1	8PDT	28 VDC	0.362	76	10.0	1308
MDR138-8	8PDT	125 VDC	0.082	1520	10.3	2375
MDR163-1	12PDT	115 VAC	0.230	62	6.9	1230
MDR163-2	12PDT	440 VAC	0.055	940	6.3	1880

$242.32

MDR 5059 (100-140 VDC) ±10%

*Actual Wattmeter readings

COIL CHARACTARISTICS OF MEDIUM NON-LATCHING MDR ROTARY RELAYS

MEDIUM NON-LATCHING

SERIES	CONTACTS	COIL VOLTAGE 60 Hz for AC	COIL CURRENT AMPERES	DC COIL RESISTANCE OHMS	COIL POWER WATTS*	BREAKDOWN VOLTS RMS
MDR170-1	16PDT	115 VAC	0.620	8.4	17.0	1230
MDR170-2	16PDT	440 VAC	0.160	107	17.0	1880
MDR172-1	16PDT	28 VDC	0.667	42	18.7	1308
MDR173-1	16PDT	125 VDC	0.125	1024	16.0	2375
MDR141-1	24PDT	115 VAC	0.620	8.4	17.0	1230
MDR141-2	24PDT	440 VAC	0.160	107	17.0	1880
MDR167-1	24PDT	28 VDC	0.667	42	18.7	1308
MDR142-1	24PDT	125 VDC	0.125	1024	16.0	2375

*Actual Wattmeter readings

COIL CHARACTERISTICS OF SMALL LATCHING MDR ROTARY RELAYS

SMALL LATCHING

SERIES	CONTACTS	COIL VOLTAGE 60 Hz for AC	COIL CURRENT AMPERES	DC COIL RESISTANCE OHMS	COIL POWER WATTS	BREAKDOWN VOLTS RMS
MDR67-2	4PDT	115 VAC	0.150	210	5.5	1230
MDR4091	4PDT	440 VAC	0.020	4500	3.0	1880
MDR67-3	4PDT	28 VDC	0.308	91	8.6	1308
MDR5060	4PDT	125 VDC	0.104	1200	13.0	2375
MDR4076	8PDT	115 VAC	0.150	210	5.5	1230
MDR4092	8PDT	440 VAC	0.020	4500	3.0	1880
MDR5035	8PDT	28 VDC	0.308	91	8.6	1308
MDR5061	8PDT	125 VDC	0.104	1200	13.0	2375

COIL CHARACTERISTICS OF MEDIUM LATCHING MDR ROTARY RELAYS

MEDIUM LATCHING

SERIES	CONTACTS	COIL VOLTAGE 60 Hz for AC	COIL CURRENT AMPERES	DC COIL RESISTANCE OHMS	COIL POWER WATTS	BREAKDOWN VOLTS RMS
MDR6064	12PDT	115 VAC	0.380	24	12.0	1230
MDR6065	12PDT	440 VAC	0.055	540	5.7	1880
MDR7020	12PDT	28 VDC	0.316	88.6	8.8	1308
MDR7035	12PDT	125 VDC	0.083	1500	10.4	2375
MDR66-4	16PDT	115 VAC	0.380	24	12.0	1230
MDR6066	16PDT	440 VAC	0.055	540	5.7	1880
MDR7025	16PDT	28 VDC	0.316	88.6	8.8	1308
MDR7036	16PDT	125 VDC	0.083	1500	10.4	2375

Per phone conv w/ Ron Foust by PB 2/19/85
MDR [illegible]

ENCLOSURE 2

Motor-Operated Valves (MOV Margin Discussion)

Enclosure 2

The purpose of this enclosure is to supplement our response on MOV stroke-time margin.

The following three valves identified in Table K of calculation SQN-E3-015 have a valve stroke-time margin of greater than 5 percent but less than 10 percent. We have performed an evaluation to determine if these margins are conservative. In all cases, they are conservative because the technical specification limits are nominal numbers and conservatism was already built into the analysis.

1. Valve FCV-67-111 is an essential raw cooling water (ERCW) lower containment ventilation cooler containment isolation valve. Valve FCV-70-89 is a component cooling system (CCS) isclation valve for the reactor coolant pump oil coolers. These valves are in nonessential process lines and receive phase B containment isolation signals, indicative of a large break; therefore, these valves are required to prevent a release of radioactivity. However, no radioactivity would be released to the atmosphere unless the following conditions have occurred:

   A. Fuel damage and fission products release to the containment.

   B. The ERCW and CCS components inside containment are closed systems that normally have a water head supplied by the pumps. A release path will not exist unless a cooling water line has broken and drained.

   C. Radioactivity migration into and through the water system.

   Because it would take at least several minutes for this to occur, a few seconds' delay in the closure of this valve will not cause a release of radioactivity to the atmosphere.

2. Valve FCV-63-25 is a safety injection system (SIS) boron injection tank isolation valve.

   No specific time limits are established for this valve alone. Instead, overall SIS performance response times have been established by the accident analysis for the different design basis accidents.

   The increase in valve stroke time for FCV-63-25 has been evaluated, and the overall system response time is still found to be within the analysis assumptions.

   This valve is one of the early valves to actuate. It also has a faster design stroke time (10 seconds versus 15 seconds) than the limiting valves in the system. The calculated increase in stroke time for FCV-63-25 is less than one second.