SARGENT & LUNDY
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184669

S&L Letter No. Q1452E
April 16, 1992
Project No. 8913-67

Commonwealth Edison Company
Quad Cities Station - Units 1 and 2

Transmittal of "Evaluation of 460-V Diesel Generator Cooling Water Pump Minimum Starting Voltage" Calculation
W.O. No.: N/A
Mod. No.: N/A
System Codes: N/A

Mr. M. L. Reed
Electrical/I&C Design Superintendent
Commonwealth Edison Company
Nuclear Engineering Department
1400 Opus Place, Suite 400
Downers Grove, Illinois 60515

Dear Mr. Reed:

Enclosed is a copy of Design Input Transmittal (DIT) QC-EXT-0061 which transmits the following Sargent & Lundy calculation:

> Calculation 8913-67-19-2, Revision 0, dated April 15, 1992, "Evaluation of 460-V Diesel Generator Cooling Water Pump Minimum Starting Voltage."

The locations of the calculation purpose, methodology, assumptions, and any engineering judgements are referenced in the enclosed DIT.

Should you have any questions, please call me at (312) 269-6246.

Yours very truly,

R. M. Schiavoni
Senior Electrical
Project Engineer

RMS:mco
qdqc2689.ep
In duplicate
Enclosure - Addressee Only
Copies: See page two

SARGENT & LUNDY
ENGINEERS
CHICAGO

184669

Mr. M. L. Reed
Commonwealth Edison Company

S&L Letter No. Q1452E
April 16, 1992
Project No. 8913-67

Copies:

BWR Systems Design Superintendent (H. L. Massin)	(1/1/0)
CHRON Systems	(1/1/1)
Acting BWR Systems Design Supervisor (B. M. Wong)	(1/1/0)
Site Engineering Supervisor (C. A. Moerke)	(1/1/0)
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ENGINEERS

DESIGN INFORMATION TRANSMITTAL

X SAFETY-RELATED	NON-SAFETY-RELATED	DIT No. - QC-EXT-0061

Page 1 of 1

To M. L. Reed

CLIENT Commonwealth Edison Company

STATION Quad Cities UNIT(S) 1&2

PROJECT NO(S) 8913-67

SUBJECT Transmittal of Calculation 8913-67-19-2, Rev. 0, Dated 4/15/92 "Evaluation of 460-V Diesel Generator Cooling Water Pump Minimum Starting Voltage.

MODIFICATION OR DESIGN CHANGE NUMBER(S) N/A

R. M. Schiavoni	EPED	[signature]	4/16/92
PREPARER (PLEASE PRINT NAME)	DIVISION	PREPARER'S SIGNATURE	ISSUE DATE

STATUS OF INFORMATION (This information is approved for use. Design information, approved for use, that contains assumptions or is preliminary or requires further verification (review) shall be so identified.)

This information is approved for use.

IDENTIFICATION OF THE SPECIFIC DESIGN INFORMATION TRANSMITTED AND PURPOSE OF ISSUE (List any supporting documents attached to DIT by its title, revision and/or issue date, and total number of pages for each supporting document.)

Calculation 8913-67-19-2, Rev. 0, dated 4/15/92, "Evaluation of 460-V Diesel Generator Cooling Water Pump Minimum Starting Voltage."

The purpose, methodology, and assumptions can be found in the following calculation sections and pages:

Purpose: Section III, Page 4
Methodology: Section VII, Page 8
Assumptions and Engineering Judgements: Section V, Page 6
Comparison of Results with Acceptance Criteria: Section IX, Page 16

SOURCE OF INFORMATION

Calc. No. 8913-67-19-2 — 0 4-15-92 (Rev. and/or date) — Report No. N/A — (Rev. and/or date)

Other

DISTRIBUTION See Letter Q1452E, Dated April 16, 1992

Form GQ-3.17.1 Rev. 2

SARGENT & LUNDY ENGINEERS	Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage		Calc. No. 8913-67-19-2
	X Safety-Related	Non-Safety-Related	Rev. 0 Date 4-15-92
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Client	Commonwealth Edison Company
Project	Quad Cities Unit 1, Div.II; Units 1&2, Div.I
Proj. No.	8913-67 Equip. No.

Prepared by	Ping L. Lau	Date 4/15/92
Reviewed by	Zheng Ouyang	Date 4-15-92
Approved by	Jan B. Whisnant	Date 4-15-92

I. REVISION SUMMARY and REVIEW METHOD

A. Revision Summary

Revision 0, First Issue, Page 1 through 20, A1 through A5, B1 through B2, C1 through C3, D1 through D5, E1 through E5, F1 through F9, and G1 through G2

REVISION SUMMARY and REVIEW METHOD (continued)

B. METHOD OF REVIEW

QA CALCULATION REVIEW CHECKLIST
TYPE OF CALCULATION

☒ Hand-Prepared Design Calculation Only

☐ Computer-Aided Design Calculation Only

☐ Both hand-Prepared and Computer Aided Design Calculation

FOR HAND-PREPARED DESIGN CALC
(check the appropriate items)

☒ Detailed review of the original calculation.

☐ Review by an alternate, simplified or approximate method of calculation.

☐ Review of a representative sample of repetitive calculations.

☐ Review of the calculation against a similar calculation previously performed.

FOR COMPUTER-AIDED DESIGN CALC
(check the appropriate items)

☐ A review to determine if the engineering design and analysis computer program(s) used have been validated and documented and that the calculation, regardless of the program used, contains all the necessary documentation for reconstruction at a later date. (MUST BE PERFORMED)

☐ A review to verify that the computer program is suitable to the problem being analyzed. (MUST BE PERFORMED)

☐ A review to determine if the input data as specified for program execution is consistent with the design input, correctly defines the problem for the computer program algorithm and is sufficiently accurate to produce results within any numerical limitation of the program. (MUST BE PERFORMED)

☐ A review to verify that the results obtained from the program are correct and within stated assumptions and limitations of the program and are consistent with the input. (MUST BE PERFORMED)

☐ Validation documentation for temporary changes to listed programs or developmental programs or unique single application programs shall be reviewed to assure that methods used adequately validate the program for the intended application. (WHERE APPLICABLE)

REVIEWER: Zheng Ouyang DATE: 4-15-92

II. TABLE OF CONTENTS

Section — Contents — Page No.

III. PURPOSE/SCOPE

A. Purpose

The purpose of this calculation is to determine the minimum starting voltage requirement for the 460V diesel generator cooling water pump (DGCWP) motor for Quad Cities Unit 1, Division II; Units 1&2, Division I.

B. Scope

The scope of this calculation covers the steps necessary to determine the accelerating time of the subject motors, minimum voltage, and the possibility of nuisance tripping during starting for Quad Cities Unit 1, Division II; Units 1 and 2, Division I. The DGCWP motor for Unit 2, Division II will be addressed separately.

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IV. INPUT DATA

A. From Reference XII-1, the motors with frame size 365TS have the following characteristics:

1) an inertia of 14.76 lb-ft^2

2) a maximum motor accelerating time of 15 seconds.

3) available speed and torque data

Conditions	Torque (lb-ft)	Speed (rpm)
Locked rotor	212	0
Pull up	148	1270
Breakdown	367	3260
Full load	150	3525

B. From Reference XII-2:

Inertia of the DGCWP assembly is 3 lb-ft^2

C. From Reference XII-6:

The locked-rotor kVA per horsepower for the DGCWP motor is chosen to be 4.99. This value represents the upper range of the locked-rotor kVA per horsepower for NEMA Code-E AC motors.

V. ASSUMPTIONS

None

VI. ACCEPTANCE CRITERIA

A. The minimum starting voltage should be able to provide a motor torque that is 25% over the required load torque during acceleration. This 25% margin is a conservative recommendation obtained from Reference XII-5.

B. The accelerating time for the motor with frame size 365TS should be less than or equal to 15 seconds. (Reference XII-1)

C. The motor accelerating time should be less than the trip time set on the DGCWP motor protective device.

VII. METHODOLOGY

A. Given the locked rotor, pull up , breakdown and full load conditions from Reference XII-1, a speed versus torque curve similar to that of a NEMA Design-B Motor will be constructed.

B. Following the fact that the motor torque is proportional to the voltage squared, a starting voltage of 70% of the motor rated voltage is selected as a reasonable minimum motor starting voltage. The performance of the motor under this voltage will be evaluated.

C. To be conservative, the pump curve corresponds to the open discharge valve condition in Reference XII-3 will be selected to describe the speed versus torque characteristic of the centrifugal pump.

D. The motor starting time will be calculated for the minimum voltage established in step B above.

E. The criterion of 25% torque margin outlined in Acceptance Criteria VI-A will be verified.

F. Finally, the motor starting time found in step D will be compared to the characteristics of the DGCWP motor protective devices in order to ensure that nuisance trips will not occur during starting.

VIII. CALCULATIONS and RESULTS

A. MOTOR TORQUE VERSUS SPEED CURVE

Given the locked rotor, pull up, breakdown, and full load conditions from Reference XII-1, a torque versus speed curve similar to that of the NEMA Design-B Motor is constructed and shown in Figure 1. The following table is a summary of the given data:

Table 1 Motor's Torque Versus Speed Data

Conditions	Torque (lb-ft)	% of Full Load Torque	Speed (rpm)	% of Full Load Speed
Locked Rotor	212	141.3	0	0
Pull up	148	98.7	1270	36.0
Breakdown	367	244.7	3260	92.5
Full load	150	100.0	3525	100.0

Note that the curve in Figure 1 is plotted in % of full load torque versus % of rated speed at the rated voltage.

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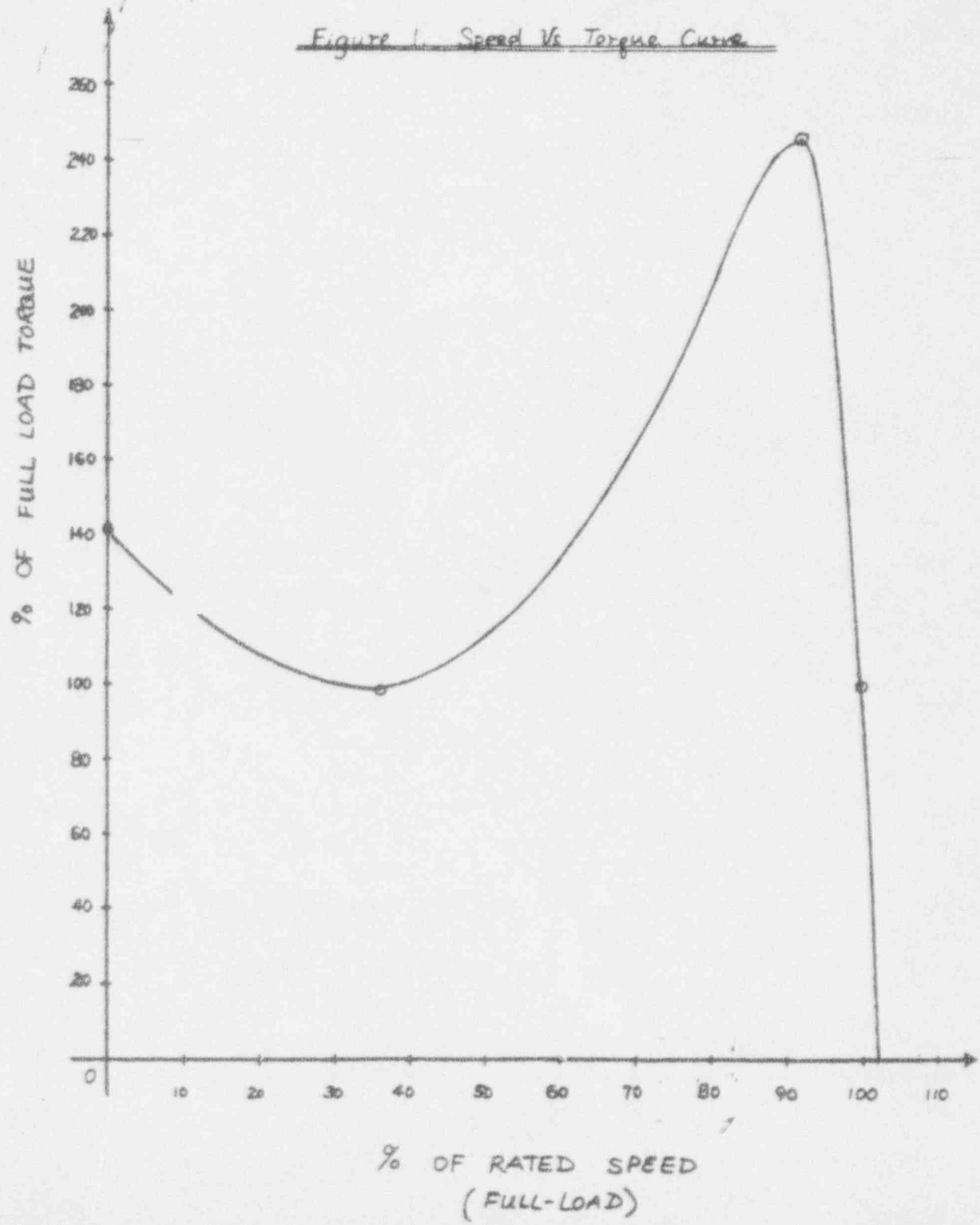
Figure 1. Speed Vs Torque Curve



CALCULATIONS and RESULTS (continued)

B. ACCELERATING TIME REQUIRED TO START THE MOTOR

Using a starting voltage of 70% of 460 Volts, the accelerating time required to start the motor is 3.775 seconds and the minimum accelerating torque is 43.005 lb-ft. These values are calculated using a spreadsheet given in Table 2.

The followings identify the columns in Table 2:

Column No.1 - speed interval in percent of full load rpm

Column No.2 - beginning of speed interval in rpm. (Column No.1 times full load speed - 3525 rpm)

Column No.3 - end of speed interval in percent of full load rpm

Column No.4 - the magnitude of speed interval in rpm

Column No.5 - motor torque output in lb-ft at rated voltage obtained from Figure 1.

Column No.6 - motor torque output in lb-ft at the motor minimum starting voltage (Column No.5 multiplies the squared ratio of the minimum starting voltage to the rated voltage)

Column No.7 - load torque (open discharge valve) in percent of full load torque read from Reference XII-3

Column No.8 - load torque in lb-ft (Column No.7 times full load torque of the motor)

Column No.9 - net accelerating torque in lb-ft (Column No.6 minus Column No. 8)

Column No.10 - time to accelerate through speed interval using the formula given in Reference XII-4

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CALCULATIONS and RESULTS (continued)

$$t = \frac{(\Delta RPM)*(WK^2)}{(308)*T_N}$$

where t = accelerating time in seconds
ΔRPM = change in rpm (Column No.4)
T_N = net accelerating torque in lb-ft (Column No.9)
WK^2 = total inertia of motor and pump in lb-ft^2

In this calculation,

ΔRPM = 176.25 rpm (Table 2, Column No.4)
WK^2 = 14.76 + 3.0 = 17.76 lb-ft^2 (Reference XII-1,2)

Column No.11 - the cumulative time for the motor to accelerate at 70% rated voltage

Table 2 Cumulative Time to Accelerate at 70% Rated Voltage

% OF FULL LOAD SPEED (1)	INITIAL SPEED (RPM) (2)	SPEED @ THE END OF INCREMENT (3)	SPEED INTERVAL (RPM) (4)	MOTOR TORQUE IN lb-ft @ 100% (5)	MOTOR TORUQE IN lb-ft @ 70% (6)	% OF LOAD TORQUE (7)	LOAD TORQUE IN lb-ft (8)	NET ACC. TORQUE IN lb-ft (9)	TIME TO ACC. THROUGH SPEED INTERVAL IN SEC. (10)	CUMULATIVE TIME IN SEC. (11)
0.000	0.000	176.250	176.250	212.000	103.880	15.000	22.500	81.380	0.125	0.125
5.000	176.250	352.500	176.250	195.000	95.550	9.500	14.250	81.300	0.125	0.250
10.000	352.500	528.750	176.250	183.000	89.670	6.700	10.050	79.620	0.128	0.378
15.000	528.750	705.000	176.250	172.500	84.525	5.000	7.500	77.025	0.132	0.509
20.000	705.000	881.250	176.250	163.500	80.115	5.500	8.250	71.865	0.141	0.651
25.000	881.250	1057.500	176.250	155.250	76.073	7.000	10.500	65.573	0.155	0.806
30.000	1057.500	1233.750	176.250	150.000	73.500	9.500	14.250	59.250	0.172	0.977
35.000	1233.750	1410.000	176.250	148.500	72.765	12.500	18.750	54.015	0.188	1.166
40.000	1410.000	1586.250	176.250	151.500	74.235	16.000	24.000	50.235	0.202	1.368
45.000	1586.250	1762.500	176.250	159.000	77.910	20.500	30.750	47.160	0.216	1.583
50.000	1762.500	1938.750	176.250	169.500	83.055	25.500	38.250	44.805	0.227	1.810
55.000	1938.750	2115.000	176.250	183.000	89.670	30.500	45.750	43.920	0.231	2.042
60.000	2115.000	2291.250	176.250	199.500	97.755	36.500	54.750	43.005	0.236	2.278
65.000	2291.250	2467.500	176.250	220.500	108.045	42.500	63.750	44.295	0.229	2.507
70.000	2467.500	2643.750	176.250	244.500	119.805	49.500	74.250	45.555	0.223	2.730
75.000	2643.750	2820.000	176.250	271.500	133.035	56.500	84.750	48.285	0.210	2.941
80.000	2820.000	2996.250	176.250	304.500	149.205	64.500	96.750	52.455	0.194	3.135
85.000	2996.250	3172.500	176.250	340.500	166.845	73.000	109.500	57.345	0.177	3.312
90.000	3172.500	3348.750	176.250	363.000	177.870	81.500	122.250	55.620	0.183	3.495
95.000	3348.750	3525.000	176.250	351.000	171.990	90.500	135.750	36.240	0.280	3.775
100.000	3525.000					100.000	150.000			

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CALCULATIONS and RESULTS (continued)

Table 3 demonstrates that a torque margin of at least 25% over the load torque is maintained with 70% motor rated voltage (460 V) during starting.

Columns in Table 3 are identified as follows:

Column 1 through 9 - same as in Table 2

Column 10 - load torque in lb-ft with 25% margin (Column No. 8 * 1.25)

Column 11 - net accelerating torque in lb-ft with 25% margin (Column No. 6 minus Column No. 10)

Note that the point on the spreadsheet at 95% speed represents a point at which the motor is entering into steady-state operation after the accelerating period has been completed.

C. NUISANCE TRIPPING DURING STARTING

Reference XII-8 indicates that the DGCWP motors are protected by a 200 ampere General Electric type RMS-9 trip device with a long time tap of 0.8 times trip unit rating (160 A) or higher ,and a time band setting of 2. At 70% rated voltage, the corresponding maximum locked rotor current will be

$$0.7 * \frac{100 * 4.99^{\dagger}}{\sqrt{3} * 0.46} = 438.4 \text{ A}$$

or 2.74 times the circuit breaker trip device setting. This corresponds to a tripping time of about 23 seconds. Since the motor starts in less than 4 seconds, nuisance tripping is not a concern.

Note that † denotes the allowable locked-rotor kVA per horsepower value for the 100 horsepower NEMA Code-E DGCWP motors (Reference XII-6,7).

Table 3 Net Accelerating Torque With 25% Margin

% OF FULL LOAD SPEED (1)	INITIAL SPEED (RPM) (2)	SPEED @ THE END OF INCREMENT (3)	SPEED INTERVAL (RPM) (4)	MOTOR TORQUE IN lb-ft @ 100% (5)	MOTOR TORUQE IN lb-ft @ 70% (6)	% OF LOAD TORQUE (7)	LOAD TORQUE IN lb-ft (8)	NET ACC. TORQUE IN lb-ft (9)	LOAD TORQUE WITH 25% MARGIN IN lb-ft (10)	NET ACC. TORQUE WITH 25% MARGIN IN lb-ft (11)
0.000	0.000	176.250	176.250	212.000	103.880	15.000	22.500	81.380	28.1250	75.755
5.000	176.250	352.500	176.250	195.000	95.550	9.500	14.250	81.30[illegible]	17.8125	77.738
10.000	352.500	528.750	176.250	183.000	89.670	6.700	10.050	79.62[illegible]	12.5625	77.108
15.000	528.750	705.000	176.250	172.500	84.525	5.000	7.500	77.025	9.3750	75.150
20.000	705.000	881.250	176.250	163.500	80.115	5.500	8.250	71.865	10.3125	69.803
25.000	881.250	1057.500	176.250	155.250	76.073	7.000	10.500	65.573	13.1250	62.948
30.000	1057.500	1233.750	176.250	150.000	73.500	9.50[illegible]	14.250	59.250	17.8125	55.688
35.000	1233.750	1410.000	176.250	148.5[illegible]	72.765	12.500	1[illegible].750	54.015	23.4375	49.328
40.000	1410.000	1586.250	176.250	151.500	74.235	16.000	[illegible]00	50.235	30.0000	44.235
45.000	1586.250	1762.500	176.250	159.000	77.910	20.500	30.750	47.160	38.4375	39.473
50.000	1762.500	1938.750	176.250	169.500	83.055	25.500	38.250	44.805	47.8125	35.243
55.000	1938.750	2115.000	176.250	183.000	89.670	30.500	45.750	43.920	57.1875	32.483
60.000	2115.000	2291.250	176.250	199.500	97.755	36.500	54.750	43.005	68.4375	29.318
65.000	2291.250	2467.500	176.250	220.500	108.045	42.500	63.750	44.295	79.6875	28.358
70.000	2467.500	2643.750	176.250	244.500	119.805	49.500	74.250	45.555	92.8125	26.993
75.000	2643.750	2820.000	176.250	271.500	133.035	56.500	84.750	48.285	105.9375	27.098
80.000	2820.000	2996.250	176.250	304.500	149.205	64.500	96.750	52.455	120.9375	28.268
85.000	2996.250	3172.500	176.250	340.500	166.845	73.000	109.500	57.345	136.8750	29.970
90.000	3172.500	33[illegible].750	176.250	363.000	177.870	81.500	122.250	55.620	152.8125	25.058
95.000	3348.750	3525.000	176.250	351.000	171.990	90.500	135.750	36.240	169.6875	2.302
100.000	3525.000					100.000	150.000		187.5000	

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IX. COMPARISON of RESULTS with ACCEPTANCE CRITERIA

The net accelerating torque in Table 3 shows that with 70% of rated motor terminal voltage, the 25% torque margin as outlined in Acceptance Criteria VI-A is satisfied during the acceleration.

From Table 2, the calculated accelerating time is 3.775 seconds which is less than the maximum allowable accelerating time of 15 seconds.

Nuisance tripping shall not occur since the 3.775 seconds accelerating time of the motor is less than the anticipated 23 seconds trip time set on the DGCWP protective device.

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X. CONCLUSIONS

A minimum starting voltage of 70% of 460 Volts has been established for the subject diesel generator cooling water pump (DGCWP). At this voltage, the DGCWP motor is capable of maintaining a torque at 25% over the required load torque during acceleration without nuisance tripping of the protective device.

XI. RECOMMENDATIONS

Not applicable since it is not required for the scope of this calculation.

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XII. REFERENCES

1. Memo transmitted by Mr. D. Barton of Lincoln Electric Co. to J. Wisniewski of S&L, dated March 20,1992. (Attachment A)
   - This reference provides the locked rotor, pull up, breakdown and full load conditions for the torque versus speed curve, inertia and maximum accelerating time.

2. Memorandum of telephone conversation between Mr. S. Kiefer of Ingersoll-Rand and J. Wisniewski of S&L, dated March 20, 1992. (Attachment B)
   - This reference provides the data for the total inertia of the diesel generator cooling water pump.

3. Louis-Allis Curve No. 18296, dated November 6,1975. (Attachment C)
   - This reference provides a typical torque versus speed curve for a centrifugal pump.

4. Sargent & Lundy Standard ESC-307, Section 11, "Accelerating time and losses."
   - This reference provides the method and formula to calculate the motor acceleration time.

5. Moore, R.C. "An Analytical Look at Squirrel Cage Induction Motor Startup," Power Engineering, November, 1964 p.48-51. (Attachment D)
   - This paper recommends that the motor torque should be about 25% over the required load torque during accelerating period.

6. NEMA Publication No. MG 1-1987, Part 10.37.
   - This material provides the range of locked-rotor kVA per horsepower for motor having NEMA code letter designation.

7. Fax transmittal from Mr. J. Cruz to Mr. R. Schiavoni of S&L, dated March 17, 1992.(Attachment E)
   - This transmittal provides the walkdown DGCWP motor data for Quad Cities Station.

8. Telecopy Transmittal from Mr. L. Cabrera of CECo. to Mr. A. G. Ashrafi, dated April 14, 1992.(Attachment F)
   - This material provides the NED record of existing settings for the breaker that feeds DGCWP at Quad Cities Station.

9. GE Type-AKR circuit breaker RMS-9 trip device time-current curve GES-6227, dated November, 1986.(Attachment G)

ATTACHMENTS

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SARGENT & LUNDY ENGINEERS	Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage				Calc. No. 8913-67-19-2	
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ATTACHMENT A

DGCWP MOTOR CHARACTERISTICS

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TO: Jon Wisniewski
Sargent & Lundy

From: Dave Barton
Date: 3-20-92
Subject: 2 - 100 Hp, 3600 R
Multigard, 365TS, 230/460
3/60.

Persuant to your request the following information represents performance specifications of the motors described above having the following serial & Code numbers.

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CODE TM2907 Serial # 1288784
CODE TM2907 Serial # 1298469

SPEED TORQUE CHARACTERISTICS

Locked Rotor Torque [redacted]		Pull up Torque [redacted]		Breakdown Torque [redacted]		Full Load Torque [redacted]	
RPM	ft-lbs	RPM	ft-lbs	RPM	ft-lbs	RPM	ft-lbs
0	212	1270	148	3260	367	3525	150

→ Curve TYPE - Design B Torque Characteristic.

POWER FACTOR - Efficiency - Input Amp.

% Nominal Eff

% of Rated Load			
100%	75%	50%	25%
88.5%	89%	86%	79%

% Nominal Power Factor

% of Rated Load					
100%	75%	50%	25%	IDLE	Locked Rotor
91.2	90.7	89.2	72.2	12	34

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Pg 2

Input Amp Draw
on 460 V/3/60

% of Rated Load				
100%	75%	50%	25%	IDLE
116 A	87A	61A	41A	27A

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Rotor & Shaft Assy. WK^2 = 14.76 lb-ft^2

The Maximum Allowable time in seconds for a Lincoln Electric motor to come up to speed is as follows.

10 Seconds max. for frame sizes 143T-286T

12 Seconds max for frame sizes 324T-326T

15 Seconds max for frame Sizes 364T-445

Reference additional information in our bulletin D6T which is enclosed. D7T also is helpful in determining acceptable composite loading cycles.

184669

Pg 3

If you need additional information please feel free to contact me at the Moline District office.

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Proj. No. 8913-67	

Sincerely,

Dave Bartz

SARGENT & LUNDY ENGINEERS	Calcs. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage	Calc. No. 8913-67-19-2
	Safety-Related / Non-Safety-Related	Rev. 184669 Date
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Client	Commonwealth Edison Company	Prepared by	Date
Project	Quad Cities Unit 1, Div. II; Unit 1 & 2, Div. I	Reviewed by	Date
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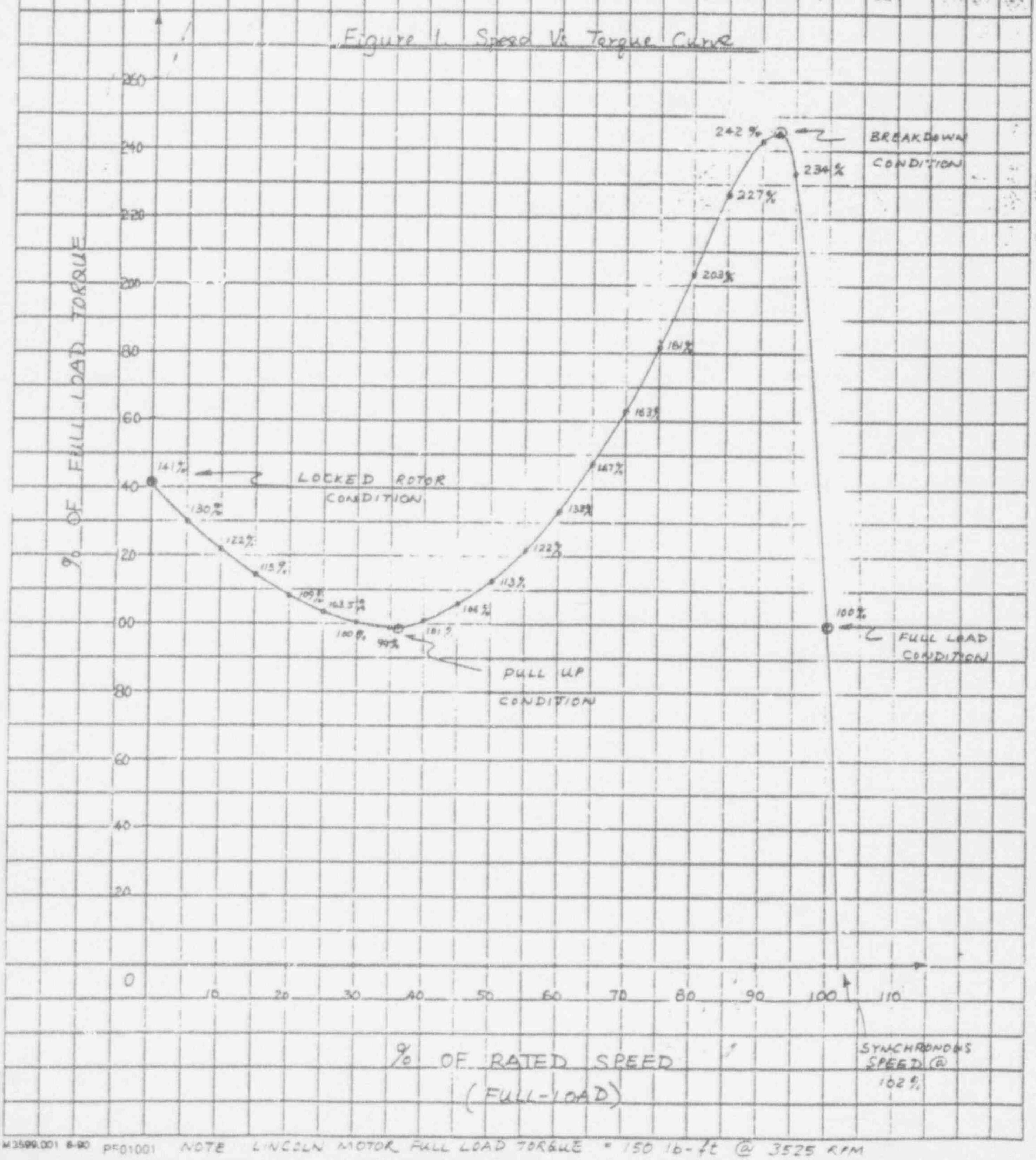
Figure 1. Speed Vs Torque Curve



NOTE LINCOLN MOTOR FULL LOAD TORQUE = 150 lb-ft @ 3525 RPM

184669

SARGENT & LUNDY
ENGINEERS

Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage			
X	Safety-Related		Non-Safety-Related

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Client Commonwealth Edison Company	
Project Quad Cities Unit 1, Div.II; Units 1&2, Div.I	
Proj. No. 8913-67	Equip. No.

Prepared by	Date
Reviewed by	Date
Approved by	Date

ATTACHMENT B

INERTIA OF DGCWP

SARGENT & LUNDY
ENGINEERS
CHICAGO

March 20, 1992

SARGENT & LUNDY

Memorandum of Telephone Conversation

	Date 03/20/92 Time 10:45 a.m.
Person Called: Steven Kiefer	Company: 708-668-3707 Ingersoll-Rand
Person Calling: Jan B. Wisniewski	Company: Sargent & Lundy (S&L)
Project: Quad Cities	Project No. 8913-94

Subject Discussed: Pump Diesel Cooling Water

Summary of Discussion, Decisions, and Commitments:

This is to confirm our conversation this morning that the 5SB (5x9 SB) pump, shaft, and coupling have a total inertia of approximately 3 lb • ft^2.

Please note the information supplied was basis price book pumps as they would be sold today. The number given was for reference only. Exact numbers would have to be derived and approved by Ingersoll-Rand Engineering.

SRK

Calc. No. 8913-67-19-2	
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Note: PLEASE CONFIRM THAT WE HAVE ACCURATELY RECORDED THE CONVERSATION BY SIGNING BELOW AND RETURNING TO MR. J. B. WISNIEWSKI VIA FAX AT 312-269-3757.

CONFIRMATION: [signature] 3-20-92

CC:

File: QA Calculation

Jan B. Wisniewski
J. B. Wisniewski

ATTACHMENT C

TYPICAL CENTRIFUGAL PUMP TORQUE VERSUS SPEED CURVE

184667

LOUIS ALLIS
Litton Milwaukee, Wisconsin 53201

DATE November 6, 1975

FROM R. L. Nailen

TO M. J. Buckna
R. O. Brotherhood
J. L. Breitbach
R. Halfpap

SUBJECT Load characteristics for design

cc. C. C. Cummins
E. J. Michaels
J. F. Billings
R. R. Smick

Here is the third curve, No. 18296, for centrifugal pumps. It should be used to inform customers of our assumptions in the same way as previous curves.

All MD-70 standard motors have been designed to accelerate NEMA inertia (with load torque per NEMA MG1-20.42). This has not necessarily been true of the 440 frame, however. Also, in cost reduction or in evaluating "tight" designs, we have recognized that 2 pole pump motors almost never see load inertia anywhere near the NEMA level.

So to bring 2 pole motor application closer to reality, and yet keep the assumptions simple, I have used 25% of NEMA as the maximum inertia assumed for 2 pole motors.

Please do not expect that a motor redesign for lower cost will automatically be possible if actual load inertia on any job turns out to be less than the attached assumptions. The assumptions were chosen to eliminate any need for oversized motors in the first place. However, if the application does require a special design, because of the need to start at 50% voltage, for example, then it is possible that actual inertia less than these assumed values would permit a cheaper design. Again I must point out that for us to assume any load conditions is always a poor substitute for finding out what they really are.

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R. L. Nailen
Chief Electrical Engineer,
Large Motor Engineering

RLN;fb

Atchm.

3M MICROFILM

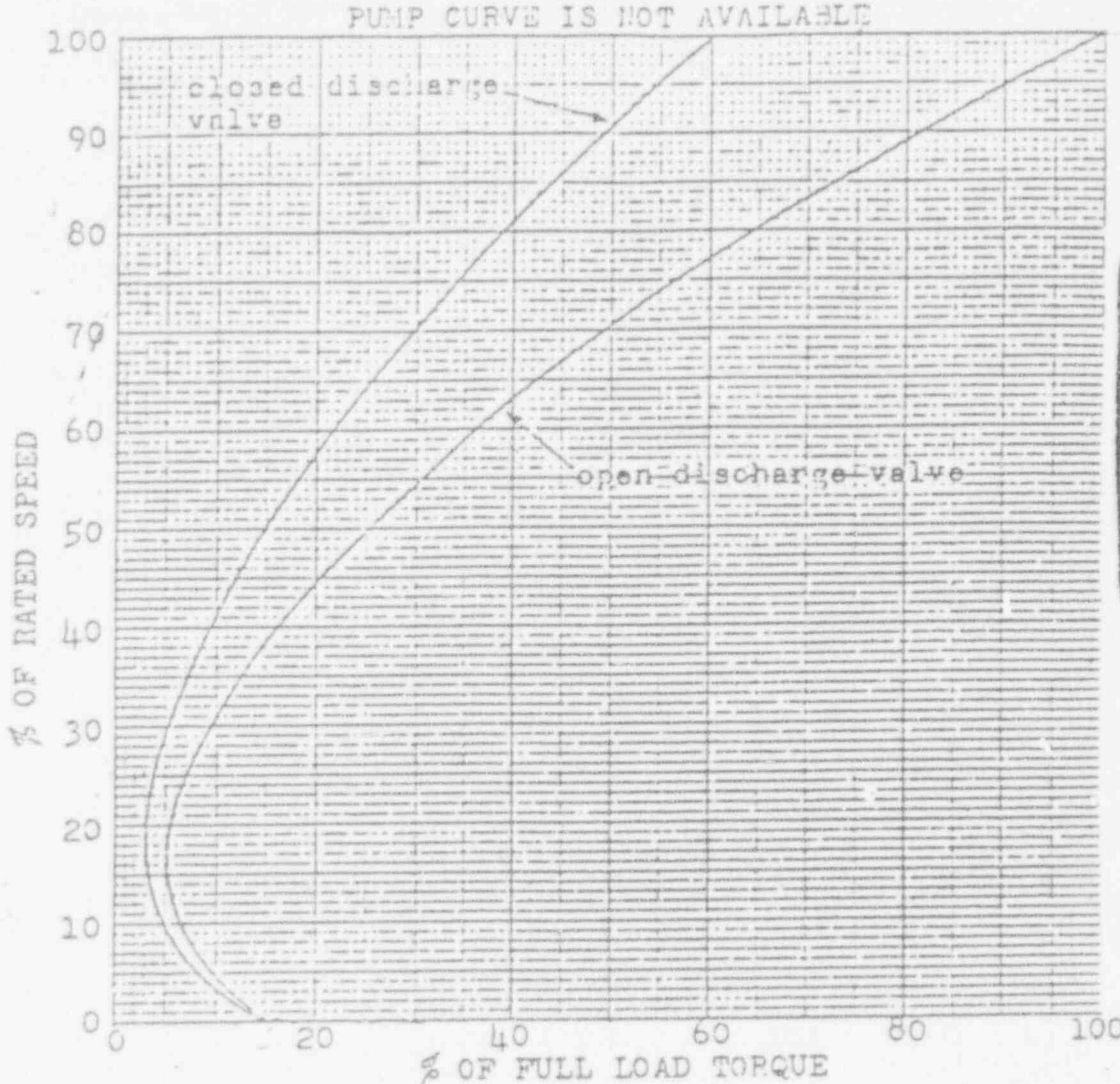
DISREGARD
PREVIOUS
DOCUMENT

ROLL NO.
0263-0033

LOUIS ALLIS
Litton

104009

SPEED-TORQUE CURVE FOR CENTRIFUGAL PUMPS USED FOR MOTOR DESIGN WHEN ACTUAL PUMP CURVE IS NOT AVAILABLE



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Basis for motor design using this curve:

1. Total load inertia (including any couplings or gearing) not to exceed:
   a. The NEMA value for the motor rated horsepower, for 1800 rpm & slower motors.
   b. 25% of the NEMA value, for 3600 rpm motors.

2. The 100% torque point on the curve corresponds to motor nameplate horsepower, and is therefore equal to motor rated torque.

3. Curves shown are not applicable to axial-flow, mixed-flow, piston, or screw pumps of any kind.

Note: A motor designed to safely accelerate the above load will not necessarily be able to start a load having a different speed-torque curve, even though the difference may appear slight.

Apprvd. by R. White 11/6/75

Curve # 18296

184669

SARGENT & LUNDY ENGINEERS	Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage			Calc. No. 8913-67-19-2	
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				Page D1 of D5	

Client Commonwealth Edison Company	
Project Quad Cities Unit 1, Div.II; Units 1&2, Div.I	
Proj. No. 8913-67	Equip. No.

Prepared by	Date
Reviewed by	Date
Approved by	Date

ATTACHMENT D

PAPER ON INDUCTION MOTOR STARTING

AN ANALYTICAL LOOK AT SQUIRREL-CAGE INDUCTION MOTOR STARTING

By R. C. MOORE, Allis-Chalmers Mfg. Co.

PRACTICAL METHODS of starting squirrel cage induction motors are full voltage, reduced voltage and part winding. Of the three, full voltage starting is the simplest and least expensive.

Starting at full voltage, squirrel cage motors draw from four to eight or more times full-load current or kva. Penalties for large starting currents are kva demand costs and possible momentary feeder voltage drops. Others include light flicker and abnormal operation of protective devices to interrupt other feeder-connected motors or services. Undesirable starting disturbances may be corrected in certain applications to tolerable values by reducing motor starting currents. How to do this depends on the characteristics of the motor, the load it drives, and the motor starting used.

FULL-VOLTAGE STARTING from a large capacity bus may result in the motor drawing full locked-rotor current. The motor must be designed to withstand this. Couplings and driven machines also must be able to withstand the resulting high motor starting torque, acceleration, etc. In general, consider full-voltage starting where high

Table I — Calculations for Reactor Starting

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Fig. 3 values divided by 100				$^*Z_m$	Z_r	$Z_t = Z_m + Z_r$	I_L	T	V_m
Speed	I_m Full Voltage	T_m Full Voltage	Power Factor	$Z_m = R_m + jX_m$	$= jX_r$ Reactor	$Z_t = (5) + (6)$	$\frac{(5) \times (2)}{(7)}$	$\frac{(8)^2 \times (3)}{(2)^2}$	$\frac{(5) \times 100}{(7)}$
0	6.35	1.20	.23	1.55 = .36 + j 1.51	j 1.60	3.12 = .36 + j 3.11	3.17	.30	[illegible]
.50	5.75	1.54	.28	1.72 = .49 + j 1.65	j 1.60	3.29 = .49 + j 3.25	3.05	.42	[illegible]
.70	5.23	1.75	.34	1.88 = .65 + j 1.77	j 1.60	3.43 = .65 + j 3.37	2.88	.53	[illegible]
.80	4.75	1.90	.39	2.08 = .81 + j 1.91	j 1.60	3.60 = .81 + j 3.51	2.75	.64	[illegible]
.85	4.40	2.01	.44	2.44 = 1.00 + j 2.01	j 1.60	3.75 = 1.00 + j 3.61	2.63	.72	[illegible]
.90	4.00	2.34	.54	2.47 = 1.33 + j 2.08	j 1.60	3.91 = 1.33 + j 3.68	2.53	.94	[illegible]
.95	3.08	2.55	.77	3.21 = 2.47 + j 2.04	j 1.60	4.40 = 2.47 + j 3.64	2.26	1.36	[illegible]
.97	1.90	2.10	.85	5.20 = 4.42 + j 2.74	j 1.60	6.21 = 4.42 + j 4.34	1.59	1.47	[illegible]

*Motor base ohms $= 2300/\sqrt{3} \times 135 = 9.85$ (3-phase motor—Fig. 3)

Computations—parenthetical numbers refer to columns in the table.

(5) Z_m = Motor base ohms divided by (2) $= R_m + jX_m$ = (scalar value of Z_m) × $((4) + j\sqrt{1-(4)^2})$

(6) Assume $jX_r = Z_r$ (reactor resistance neglected)

At "0" speed, estimate Z_r, and if necessary recalculate to get desired I_L, remembering that $I_L = I_m Z_m / Z_t$. Z_r, once determined, is unchanged for all speeds.

(8) (9) These columns multiplied by 100, give per cent current and torque values using reactor. Data in Fig. 4.

(10) Percent of supply line voltage at motor terminals

torque is required.

A motor switched directly on a low capacity bus may draw enough current to cause appreciable voltage drop through a supply transformer (Fig. 1). To analyze standstill conditions, consider motor and transformer as pure reactances.

At standstill (locked rotor), motor line amps vary with motor terminal voltage. Such a variation for a particular squirrel cage motor is shown in Fig. 2. It may be used to predict the effect of voltage drop through a supply transformer.

ANALYTICAL SOLUTION. Assume transformer primary voltage is constant. Because the transformer kva rating is twice the motor full-load kva, a locked-rotor current of 200% at low power factor corresponds to 100% transformer current and causes an 8% voltage drop through the transformer. This is point A in Fig. 2. The reasoning may be extended for larger motor currents and results in the dashed line for transformer secondary voltage. At the intersection of the dashed and solid line curves, motor and tranformer secondary voltages are equal. The resultant voltage is 80% of full voltage. This is the transformer voltage at the motor terminals if voltage drops in the lines, etc., are neglected.

MATHEMATICAL SOLUTION. Again, assume motor reactance equals motor impedance because of low locked-rotor power factor.

An induction motor of 2500 kva input at full load having a locked-rotor current of 6.35 times full-load current has a locked impedance of 100%/6.35, or 15.8%. Bring both motor and transformer impedances (Z) to the same kva base (the 5000-kva transformer base):

Motor Z, 2500-kva base = 15.8%
Motor Z, 500-kva base = 15.8% x kva ratio = 31.6%
Transformer Z, 5000-kva base = 8%
Motor terminal voltage =

$$\frac{\text{motor Z}}{\text{motor Z} + \text{transformer Z}} = \frac{31.6}{31.6 + 8} \times 100 = 79.8\%$$

The analytical solution used the actual motor locked-rotor curve, which deviates slightly from a linear voltage-current relationship, due to motor magnetic saturation. In the mathematical solution, the motor is assumed to have a linear locked-voltage-current relationship. The difference in the results of the two methods is small. For motors having a higher degree of saturation, the analytical solution may be preferred.

As the motor accelerates from standstill, motor current, and, therefore, voltage drop through the transformer decreases. Thus, the voltage across the motor steadily increases as the speed increases. Having transformer data available, the motor design engineer can predict motor terminal voltage and, hence, the motor speed-torque curve.

For loads not requiring large torques during the starting period, reduced voltage starting methods may be used for squirrel cage motors. Practical and widely-used methods are reactor and autotransformer starting.

REACTORS are voltage reducing devices placed in series with the stator winding of a squirrel cage motor. They may be shorted out at a previously chosen speed, time, or current value, and the motor then operates at its normal full-voltage characteristics. It is possible to use two or even more shorting steps during reactor starting.

A disadvantage of the reactor method of starting is the kva consumed in the reactor itself. Thus, where minimum starting kva may

Table III — Computations to Determine Accelerating Time of Motor Plus Series Reactor. Use Fig. 4 and Follow Computation Instructions Below

1	2	3	4	5
Δ(% Speed)	ΔRpm	Δ(% T_{acc})	ΔT_{acc} = lbs ft	Δt = Sec
0-10%	90	A = 29%	1030	0.56
10-20	90	B = 30	1065	0.55
20-40	180	C = 30	1055	1.10
40-60	180	D = 28	975	1.17
60-75	135	E = 27	[illegible]	0.91
75-85	90	F = 26	923	0.63
8[illegible]-90	45	G = 35	1230	0.24
90-95	45	H = 60	2130	0.14
95-97	27	J = 88	3120	0.05
		Time to Speed Sum Items in Col. 5		5.36 Sec.

Computation instructions.
Column 1 = Assumed % speed interval, Fig. 4.
Column 2 = Column 1 x synchronous speed
Column 3 = Average % torque for speed range column 1, see Fig. 4
*Column 4 = Column 3 x full load torque (equation 1)
Column 5 = Use equation 2. (Wk² for problem = 2000 lbs ft²)

$$\text{*F.L.T.} = \frac{600 \text{ hp} \times 5252}{890} = 3550 \text{ hp}$$

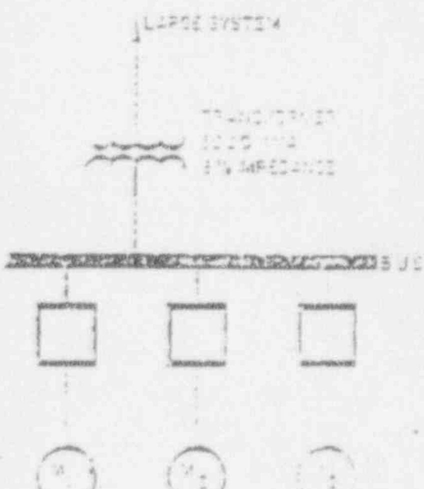

Fig. 1. Motors M_1 and M_2 not running. Motor M_3 is 3000 hp, 2500 kva full load, switched directly on bus (see Fig. 2.).

be desired, other methods of reduced voltage starting may be more favorable.

Reactor application can be shown by the following example. Data from Fig. 3 will be used. Objective: reduce motor locked-rotor current I_L to half the full-voltage locked-rotor current I_M with a series reactor.

Calculations in Table I provide a method of predicting the reactor's effect in reducing motor current and torque. In the table, obtain current in amps for I_M (column 2), or for I_L (column 8), by multiplying the values shown by motor full-load current. Obtain torque in lbs-ft (columns 3 or 9), by multiplying the values shown by motor full-load torque in lbs-ft. Calculate full-load motor torque from the well-known equation:

$$\text{Torque} = \frac{\text{Full load HP} \times 5252}{\text{Full load rpm}} = \text{lbs-ft} \qquad (1)$$

During acceleration of motor and connected load, the voltage across the reactor decreases and across the motor V_M increases. This tends to maintain motor current more nearly constant for a large part of the accelerating period. Current and torque of the motor taken from columns 8 and 9 of Table I are shown in Fig. 4.

The torque curve of the driven load depends on the load characteristics. For example, the torque curve of an unloaded blower or pump may have the shape shown in Fig. 4. Other types of driven loads may have different characteristics. At any speed, the difference between the motor-developed torque and the load-required torque represents torque available to accelerate the inertia of all the rotating parts. Acceleration time may then be calculated from the formula:

$$\Delta t = \frac{Wk^2 \times \Delta \text{ rpm}}{308 \times T_{ave}} \text{ seconds} \qquad (2)$$

where:

Δt = time interval in seconds

Wk^2 = lbs-ft² of all rotating parts

rpm = speed interval in revolutions per minute

T_{ave} = average torque, lbs-ft, for rpm

From Equation (2), Table II may be constructed to show sequence of calculations to determine time for the motor to accelerate load, coupling, etc., Wk^2 from standstill to full speed.

DISCUSSION OF RESULTS. A single-step reactor is preferable for motor starting. However, the reactor must be chosen so that the resulting motor torque exceeds the load torque through the entire speed range from standstill to full speed (Fig. 4). If an excess of motor torque over load torque is not obtained with the chosen reactor ohmic value, the motor will not accelerate the load to full speed. A reactor must then be chosen to allow more motor current. Greater motor current permits more motor torque to be developed. **During the accelerating period, motor torque at any speed should be about 25% over required load torque.** This percentage is debatable; some engineers may allow a smaller value.

Certain applications may require more than one step of starting reactor. Such a situation may occur when one step of reactor will provide required current limit and torque at standstill, but will not provide adequate torque at some value of speed during acceleration.

Should the motor get hung-up at some speed point and refuse to accelerate further, it may be possible at that point to reduce reactor ohms in a second step to increase motor current and torque to accelerate to full speed. With suitable step removal of reactor ohms, the additional motor current may not cause total resultant current to exceed standstill, or locked rotor current, which is assumed to be the maximum permissible value.

The method of calculation for more than one reactor step is the same as outlined for the single step.

AUTOTRANSFORMER STARTING has kva and current reduction advantages over the reactor method. A motor supplied at full voltage is shown in Fig. 5. The same motor supplied through an autotransformer to provide, say 50% of full voltage, is shown in Fig. 5b. At the reduced voltage, motor kva is the product of the reduced voltage and current, that is, kva is reduced to $(0.50)^2$ or 25% of the full-voltage value. Thus, load kva in Fig. 5b varies as $(V_M/V_L)^2$. Neglecting autotransformer magnetizing kva, supply line kva in Fig. 5b equals motor kva and is, therefore, reduced as $(V_M/V_L)^2$. With a reactor to provide the same voltage V_M at the load, the supply line kva would be reduced only as V_M/V_L.

Although the discussion and the elementary circuits in Fig. 5 are single-phase analyses, these circuits may be extended to three phase. For three-phase motors, the circuits of Fig. 5 may be considered the customary single-phase equivalent circuits commonly used in three-phase calculations. Thus, for three-phase applications, voltages in Fig. 5 are terminal-to-neutral values. Multiplying any of the voltages by $\sqrt{3}$ gives line-to-line three-phase voltage. For three-phase motor problems, line supply kva is then $\sqrt{3}\, V_L I_L$.

Torque developed by a squirrel cage motor varies approximately as the square of its terminal voltage. Thus, 50% voltage applied to the motor of Fig. 3 gives the torque curve of Fig. 6.

A comparison of autotransformer and reactor application to the example motor of Fig. 3 is shown in Fig. 7. An assumed required load torque curve, such as for a fan or pump, is also shown. Line kva demand for either type of starting may be obtained from Fig. 7 by multiplying the currents in the figure by $\sqrt{3}$ times line-to-line supply voltage.

PART-WINDING STARTING is little used for large motors. A specially designed motor may be started by connecting only a portion of the stator winding to the full-voltage power supply. A common arrangement is to wind the motor with two parallel circuits.

At start, full voltage is impressed across one parallel only. Motor impedance is greater than for the entire winding and both motor starting current and torque are reduced. Motor current may be from 60 to 70% or normal locked rotor full winding value. The motor torque curve may have pronounced cusps. Thus the motor may accelerate its connected load only up to the speed at which the cusp occurs. To reach full speed use the full stator winding. END

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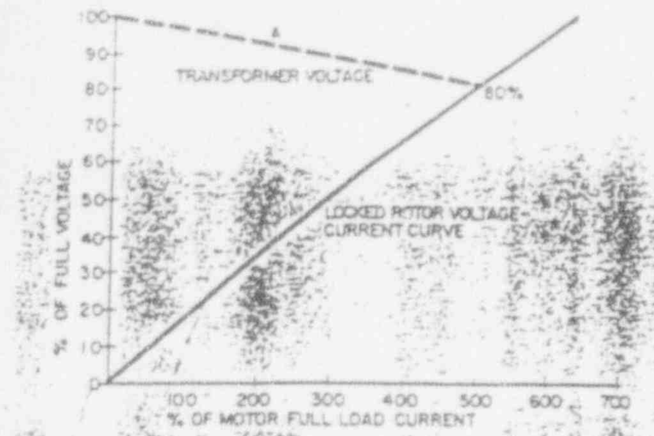

Fig. 2. Variation of locked-rotor current with voltage for a 3000-hp (2500 kva full load) squirrel cage motor.

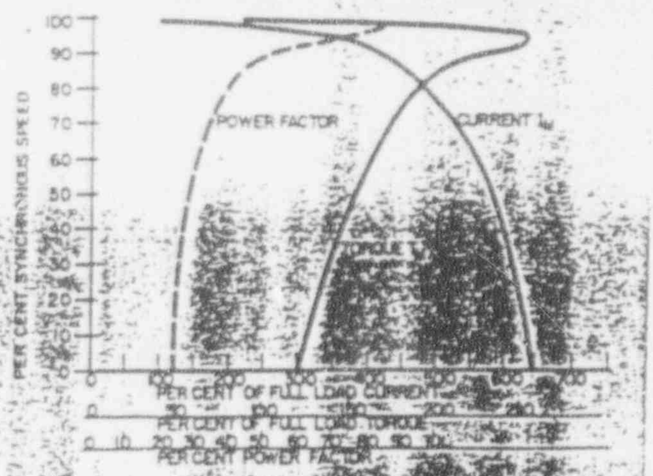

Fig. 3. Full-voltage current, torque and power factor of a squirrel cage induction motor. Motor rated 600 hp, 2300 v, 135 amps F.L., 890 rpm, 3 phase, 60 cycle.

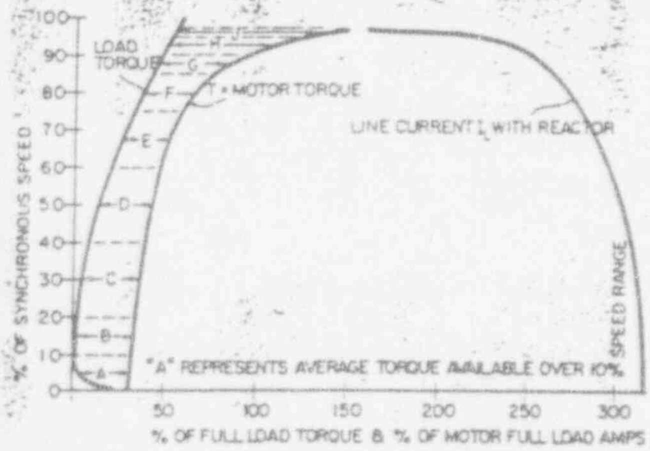

Fig. 4. Motor torque and current curves with series reactor to provide a locked-rotor current of 50% of full-voltage locked rotor current without reactors. Load-torque current is assumed.

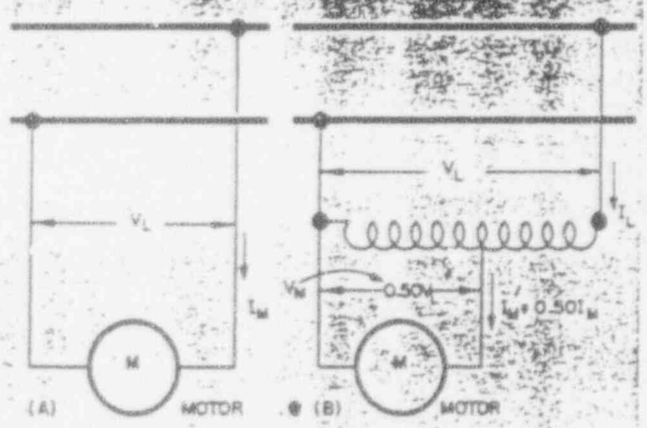

Fig. 5. (A) Motor connected directly to power supply. (B) Motor supplied through autotransformer.

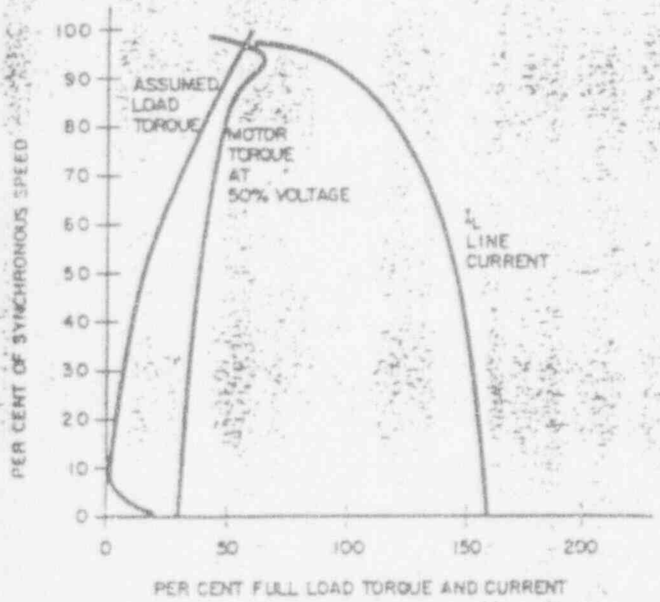

Fig. 6. Motor-torque and line-current curves with autotransformer of Fig. 5B to provide 50% of full voltage. Multiply I_L x 2 to obtain motor current (autotransformer magnetizing-current neglected).

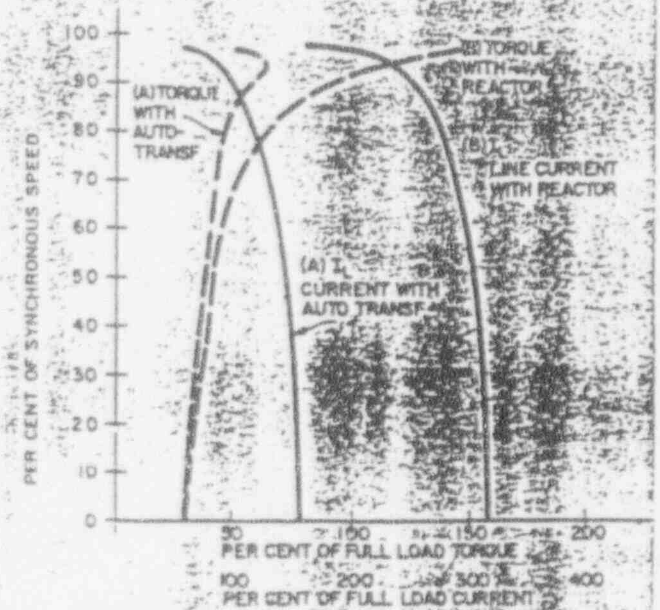

Fig. 7. Torque and current for motor of Fig. 3. (A) Autotransformer on 50% voltage tap (magnetizing current of autotransformer neglected). (B) Reactor provides 50% rated voltage at locked rotor.

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Project Quad Cities Unit 1, Div.II; Units 1&2, Div.I	Reviewed by	Date
Proj. No. 8913-67 Equip. No.	Approved by	Date

ATTACHMENT E

WALKDOWN DGCWP MOTOR DATA

184669

SARGENT & LUNDY
ENGINEERS

Quad Cities Nuclear Power Station
22710 206 Avenue North
Cordova, Illinois 61242

Fax: (309) 654-2650

Calc. No. 8913-67-19-2	
Rev. 0	Date
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Proj. No. 8913-67	

Date: 3-17-92

Time: 1434

To: ROGER SCHIAVONI

Location: 21

Extension: 6246

From: J. CRUZ X-2844

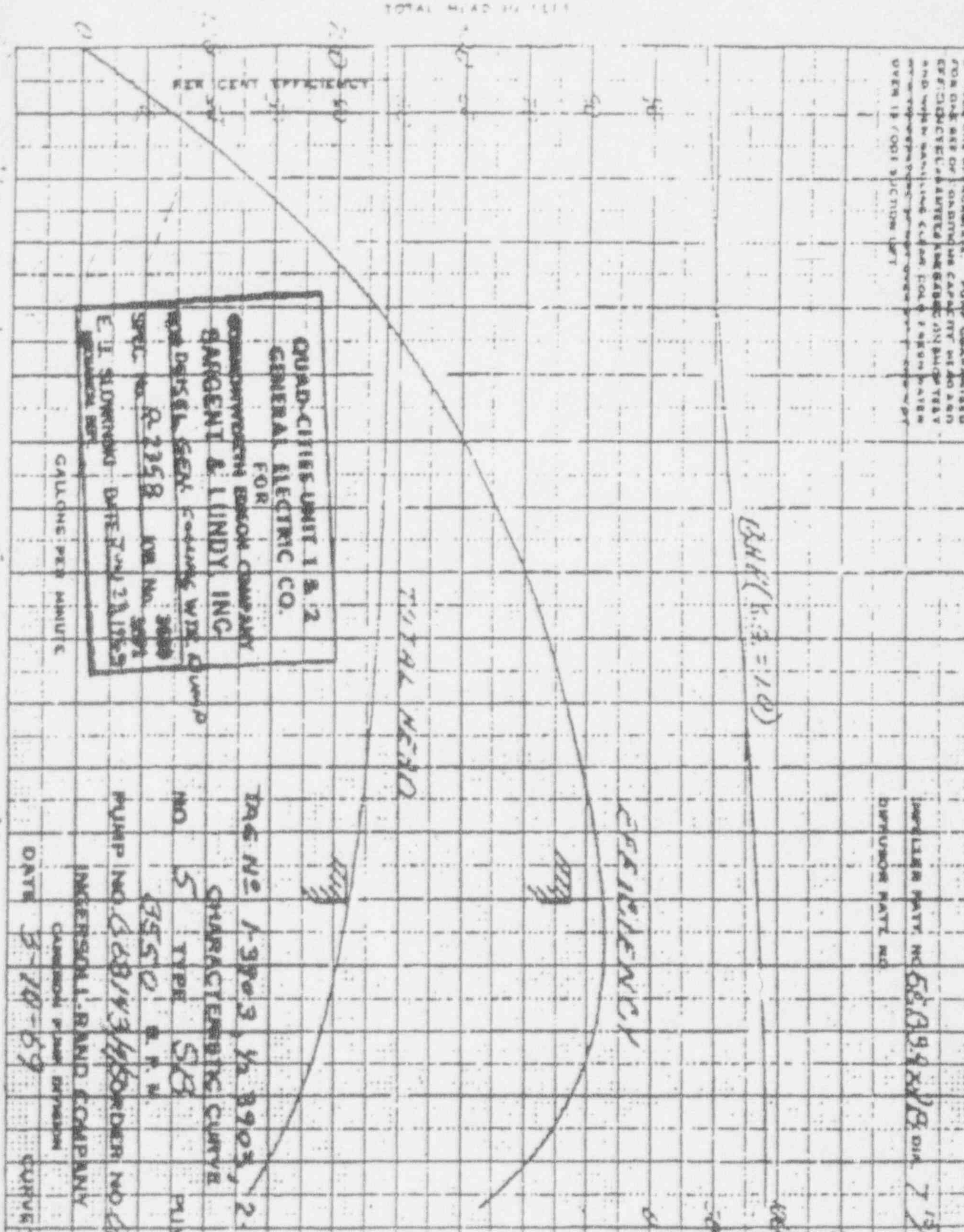
Comments:

Cover sheet plus: 3 pages

Call upon receipt: ✓ yes ____ no

For verification or trouble call: (309) 654-2241 extension 2842
(309) 654-2241 extension 2598

184669



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	0013-67

Calc. No.	8913-67-19-2
Rev. 0	Date

SARGENT & LUNDY ENGINEERS

MOTOR DATA WALKDOWN

Safety-Related | Non-Safety-Related

Rev. | Date

Page | of

Client CECO

Project

Proj. No. 8913-74 Equip. No.

Prepared by J. CRUZ 184669 Date 3-17-9[illegible]

Reviewed by [signature] Date 3-17-9[illegible]

Approved by Date

UNIT 2 DG COOLING WATER PUMP

GENERAL ELECT CO TRICLAD INDUCTION MOTOR

MODEL - 5K365AK169

SERIAL - HE375058

100 HP SERV FACTOR - 1.15 CONT.

F.L. RPM 3550 230/460V 60HZ 3Ø

F.L AMPS - 226/113

TYPE - K FRAME 365TS

NEMA CLASS DES - B CODE G

INS CLASS - B MAX AMB - 40°C

Calc. No. 8913-67-19-2

Rev. 0 Date

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Proj. No. 8913-67

Form GQ-3.08.1 Rev. 2 SL-F847 10-83 KPE

SARGENT & LUNDY ENGINEERS	Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage			Calc. No. 184669
	X	Safety-Related	Non-Safety-Related	Rev. 0 Date
				Page F1 of F9

Client Commonwealth Edison Company	Prepared by	Date
Project Quad Cities Unit 1, Div.II; Units 1&2, Div.I	Reviewed by	Date
Proj. No. 8913-67 Equip. No.	Approved by	Date

ATTACHMENT F

EXISTING SETTINGS FOR DGCWP

Commonwealth Edison
1400 Opus Place
Downers Grove, Illinois 60515

Engineering & Construction
Nuclear Operations

Calc. No	8913-67-19-2
Rev.	0
Page	F2 of F9
Proj. No.	8913-67

184669

TELECOPY TRANSMITTAL

DATE: 4/14/92

DOCUMENT: NED RECORD OF EXISTING SETTINGS FOR D/G COOLING WATER PUMPS AS REQUESTED

TO: Name A G ASHRAFI Phone 2041

Department SARGENT & LUNDY

Location CHICAGO

Telecopy Phone 8-72' 3757

FROM: Name L. R. Cabrera Phone X7654

Department Nuclear Engineering

Location Downers Grove

Telecopy Phone X7199/X7299

← HAND DELIVERED FROM 3RD FLOOR

← ADVISE IF SENT HERE

TOTAL NUMBER OF PAGES: 8 (Including this Form)

REMARKS:

02/20/91

QUAD CITIES STATION UNIT 1
480V SWITCHGEAR RELAY SETTINGS
BUS 18

* = estimated value

SERVICE	CIRCUIT CUB NO.	CIRCUIT LOAD	AMPS FLI	AMPS LRI	BREAKER MFG TYPE	BREAKER RATING AMPS	BREAKER EL ME	TRIP TYPE RANGE TAP	LONG RANGE SETTING AMPS	(PU) RANGE SETTING AMPS	TIME DELAY BAND	SHORT TIME RANGE SETTING AMPS	SHORT TIME DELAY BAND	INSTANT RANGE SETTING AMPS	RSO STATUS ISSUED DATE	RSO STATUS FOLLOW UP DATE	RSO STATUS COMPL. DATE	COMMENT
OMPARTMENT	2A					0		E 0	0.0-0.00 0.00X 0						/ /	/ /	/ /	
EED	2B				GE AK-2A-75	3000	E	RMS-9 1200-3000 3000	0.5-1.10 0.80X 2400		2	1.5- 9.00 3.000C MAX 7200		R	/ /	/ /	/ /	
E TO BUS 19	2C				GE AK-2A-50	1600	E	RMS-9 600-1600 1600	0.5-1.10 1.00X 1600		2	1.5- 9.00 3.000C INT 4800			/ /	/ /	/ /	
G 480V MCC	3A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
G SUPPLY FAN	3B	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/ /	
OL COOLING	3C	075	95		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.60X 120		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
INE BLDG FAN 1A	3D	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/ /	
BLDG 480V 2	4A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700		R	/ /	/ /	/ /	
SUPPLY FAN	4B	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/ /	
GEN. COOLING 1/2	4C	100	113		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/ /	

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No. 8913-67

184669

12/20/91

QUAD CITIES STATION UNIT 1
480V SWITCHGEAR RELAY SETTINGS
BUS 19

* = estimated value

SERVICE	CUB NO.	LOAD	AMPS FLI	AMPS LRI	BREAKER MFG TYPE	BREAKER RATING AMPS	EL NE	TRIP TYPE RANGE TAP	LONG RANGE SETTING AMPS	(PU) RANGE SETTING AMPS	TIME DELAY BAND	SHORT TIME RANGE SETTING AMPS	SHORT TIME DELAY BAND	INSTANT RANGE SETTING AMPS	RSO STATUS ISSUED DATE	FOLLOW-UP DATE	COMPL. DATE	COMMENT
COMPARTMENT	2A					0		E 0	0.0-0.00 0.00X 0						7 / /	/ /	/ /	
EED	2B				GE AK-2A-75	3000	E	RMS-9 1200-3000 3000	0.5-1.10 0.80X 2400		2	1.5- 9.00 3.000C 7200	MAX	R	/ /	/ /	/ /	
IE TO BUS 1B	2C				GE AK-2A-50	16[illegible]	E	RMS-9 600-1600 1600	0.5-1.10 1.00X 1600		2	1.5- 9.00 3.000C 4800	INT	R	/ /	/ /	/ /	
HE BLD[illegible]	3A				GE AK-2A-25	[illegible]00	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C 2700	MIN		/ /	/ /	/ /	
HE BLDG EXHAUST	3B	150/	171		GE AK-2A-25	600	E	RMS-9 200- 600 300	0.5-1.10 0.80X 240		2			1.5-10.00 7.00X 2100	/ /	/ /	/ /	
G SUPPLY FAN	3C	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/ /	
BINE BLDG FAN 1B	3D	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 9.00X 1800	/ /	/ /	/	
E BLDG 480V -2	4A				GE AK-2A-25	600	M	RMS-9 200- 600 400	0.5-1.10 0.90X 360		4	1.5- 9.00 9.000C 3240	MIN.		/ /	/ /	/	
R BLDG EXHAUST	4B	100/	118		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
G COOLING PUMP 1/2C	4C	125	151		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 1.00X 200		2			1.5-10.00 9.00X 1800	/ /	/ /		

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:2/20/91

QUAD CITIES STATION UNIT 1
480V SWITCHGEAR RELAY SETTINGS
BUS 19

* = estimated value

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SERVICE	CUB NO.	LOAD	AMPS FLI	AMPS LRI	BREAKER M/G TYPE	RATING AMPS	EL ME	TRIP TYPE RANGE TAP	LONG RANGE SETTING AMPS	(PU) RANGE SETTING AMPS	TIME DELAY BAND	SHORT TIME RANGE SETTING AMPS	TIME DELAY BAND	INSTANT RANGE SETTING AMPS	RSO STATUS ISSUED DATE	FOLLOW UP DATE	COMPL. DATE	COMMENT
:G LIGHTING 1	4D	108KW	133		GE AK-2A-25	600	M	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 5.00X 1000	/ /	/ /	/ /	
:B 480V MCC	5A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN 2700			/ /	/ /	/ /	
:G SUPPLY FAN	5B	100/	118		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.00 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
:G COOLING PUMP 1B	5C	125	151		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 1.00X 200		2			1.5-10.00 10.00X 2000	/ /	/ /	/ /	
:OOL COOLING PUMP 1B	5D	75	87		GE AK-2A-25	600	E	RMS-9 200- 600 200	C.5-1.10 0.60X 120		2			1.5-10.00 5.00X 1000	/ /	/ /	/ /	
. GEN. COOLING MP 1	6A	100	160		GE AK-2A-25	600	E	RMS-9 200- 600 300	0.5-1.10 0.70X 210		2			1.5-10.00 7.00X 2100	/ /	/ /	/ /	
:G 480V MCC 5	6B				GE AK-2A-25	600	E	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/	
:G 480V MCC	6C				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/	
:G 480V MCC	6D				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN 2700			/ /	/ /	/ /	

02/20/91

QUAD CITIES STATION UNIT 2
480V SWITCHGEAR RELAY SETTINGS
BUS 28

* = estimated value

SERVICE	CUB NO.	LOAD	AMPS FLI	AMPS LRI	BREAKER MFG TYPE	BREAKER RATING AMPS	EL ME	TRIP TYPE RANGE TAP	LONG RANGE SETTING AMPS	(PU) RANGE SETTING AMPS	TIME DELAY BAND	SHORT TIME RANGE SETTING AMPS	SHORT TIME DELAY BAND	INSTANT RANGE SETTING AMPS	RSO STATUS ISSUED DATE	FOLLOW UP DATE	COMPL. DATE	COMMENT
COMPARTMENT	2A					0		E 0	0.0-0.00 0.00X 0						/ /	/ /	/ /	
FEED	2B				GE AK-2A-75	3000	E	MVT RMS-9 1200-3000 3000	0.5-1.00 0.80X 2400	0.8-1.1 1.0C 2400	2	1.5- 9.00 3.000C MAX. 7200			04/05/88	10/05/88	2/2/92	RMS-9 INSTALLED COPY OF RSO ATTACHED
IE TO BUS 29	2C				GE AK-2A-50	1600	E	MVT RMS-9 600-1600 1600	0.5-1.10 1.00X 1600	0.8-1.1 1.0C 1600	2	1.5- 9.00 3.000C INT. 4803		R	04/05/88	10/05/88	1/22/92	SEE RSO ATTACHED
G 480V MCC	3A				GE AK-2A-25	600	M	MVT RMS-9 200- 600 300	0.5-1.00 1.00X 300	0.8-1.1 1.0C 300	4	1.5-9C 9C (2700 A) min		1.5-10.00 10.00X 3000	04/05/88	10/05/88	1/31/92	RMS-9 INSTD SEE COPY OF RSO ATTACH
G SUPPLY FAN	3B	100	123		GE AK-2A-25	600	E	MVT 200- 600 200	0.5-1.00 0.80X 160	0.8-1.1 1.0C 160	2			1.5-10.00 8.00X 1600	04/05/88	10/05/88	/ /	
OOL COOLING A	3C	75	87		GE AK-2A-25	600	E	MVT RMS-9 200- 600 200	0.5-1.00 0.60X 120	0.8-1.1 1.0C 120	2			1.5-10.00 ~~6.00X~~ 5X ~~1200~~/1000	04/05/88	10/05/88	1/22/92	SEE RSO COPY ATTAC
BINE BLDG FAN 2A	3D	100	123		GE AK-2A-25	600	E	MVT RMS-9 200- 600 200	0.5-1.00 0.80X 160	0.8-1.1 1.0C 160	2			1.5-10.00 ~~8.00X~~ 7X 1600/(1400 A)	04/05/88	10/05/88	1/22/92	SEE RSO COPY ATTACH
E BLDG 480V -2	4A				GE AK-2A-25	600	M	MVT RMS-9 200- 600 300	0.5-1.00 1.00X 300	0.8-1.1 1.0C 300	4	1.5-9C min 9C 2700		~~1.5-10.00~~ ~~10.00X~~ ~~3000~~	04/05/88	10/05/88	2/1/92	RSO COPY ATTACHED
G SUPPLY FAN	4B	100	123		GE AK-2A-25	600	E	MVT 200- 600 200	0.5-1.00 0.80X 160	0.8-1.1 1.0C 160	2			1.5-10.00 8.00X 1600	04/05/88	10/05/88	2/29/92	RSO COPY ATTACHED
GEN. COOLING /2	4C	100	113		GE AK-2A-25	600	E	MVT RMS-9 200- 600 200	0.5-1.00 0.80X 160	0.8-1.1 1.0C 160	2			1.5-10.00 ~~8.00X~~ 7X ~~1600~~ 1400	04/05/88	10/05/88	2/2/92	RMS-9 INSTALLED SEE RSO ATTACH

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QUAD CITIES STATION UNIT 2
480V SWITCHGEAR RELAY SETTINGS
BUS 29

* = estimated value

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184669

CIRCUIT: SERVICE	CUB NO.	LOAD	AMPS FLI	AMPS LRI	BREAKER: MFG TYPE	RATING AMPS	EL ME	TRIP: TYPE RANGE TAP	LONG: RANGE SETTING AMPS	(PU): RANGE SETTING AMPS	TIME: TIME DELAY BAND	SHORT TIME: RANGE SETTING AMPS	TIME DELAY BAND	INSTANT: RANGE SETTING AMPS	RSO STATUS: ISSUED DATE	FOLLOW UP DATE	COMPL. DATE	COMMENT
COMPARTMENT	2A					0		E 0	0.0-0.00 0.00X 0						/ /	/ /	/ /	
FEED	2B				GE AK-2A-75	3000	E	RMS-9 1200-3000 3000	0.5-1.10 0.80X 2400		2	1.5- 9.00 3.000C MAX. 7200			/ /	/ /	/ /	
IE TO BUS 28	2C				GE AK-2A-50	1600	E	RMS-9 600-1600 1600	0.5-1.10 1.00X 1600		2	1.5- 9.00 3.000C INT. 4800			/ /	/ /	/ /	
IE BLDG 480V ?-3	3A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
IE BLDG EXHAUST	3B	150	171		GE AK-2A-25	600	E	RMS-9 200- 600 300	0.5-1.10 0.80X 240		2			1.5-10.00 7.00X 2100	/ /	/ /	/ /	
ILDG SUPPLY	3C	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 * 7.00X 1400	/ /	/ /	/ /	
BINE BLDG FAN 2B	3D	100	123		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
E BLDG 480V -2	4A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
G EXHAUST FAN	4B	100/	118		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
3 COOLING UMP 1/2C	4C	125	151		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 1.00X 200		2			1.5-16.00 9.00X 1800	/ /	/ /	/ /	

02/20/91

QUAD CITIES STATION UNIT 2
480V SWITCHGEAR RELAY SETTINGS
BUS 29

* = estimated value

SERVICE	CUB NO.	LOAD	AMPS FLI	AMPS LRI	BREAKER MFG TYPE	BREAKER RATING AMPS	BREAKER EL ME	TRIP TYPE RANGE TAP	LONG RANGE SETTING AMPS	(PU) RANGE SETTING AMPS	TIME DELAY BAND	SHORT TIME RANGE SETTING AMPS	SHORT TIME DELAY BAND	INSTANT RANGE SETTING AMPS	RSO STATUS ISSUED DATE	RSO STATUS FOLLOW UP DATE	RSO STATUS COMPL. DATE	COMMENT
G LIGHTING 2	4D	108 KW	130		GE AK-2A-25	600	M	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 5.00X 1000	/ /	/ /	/ /	
G 480V MCC	5A				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
G EXHAUST FAN	5B	100/	118		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
G COOLING PUMP 2B	5C	125	151		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 1.00X 200		2			1.5-10.00 9.00X 1800	/ /	/	/ /	
OOL COOLING B	5D	75	87		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.60X 120		2			1.5-10.00 5.00X 1000	/ /	/ /	/ /	
GEN. COOLING	6A	100	113		GE AK-2A-25	600	E	RMS-9 200- 600 200	0.5-1.10 0.80X 160		2			1.5-10.00 7.00X 1400	/ /	/ /	/ /	
G 480V MCC 5	6B				GE AK-2A-25	600	E	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
G 480V MCC	6C				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	
G 480V MCC	6D				GE AK-2A-25	600	M	RMS-9 200- 600 300	0.5-1.10 1.00X 300		4	1.5- 9.00 9.000C MIN. 2700			/ /	/ /	/ /	

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3M MICROFILM

DISREGARD
PREVIOUS
DOCUMENT

ROLL NO.

0263-0053

RELAY SETTING ORDER

C.E.CO. 08-4604 5-83

FROM ☐ STA. ELEC. ☐ SYST. PLAN. ☒ OR PSD ~~DIV. ENG.~~

STATION QUAD-CITIES UNIT 2 480V RELAY TYPE MICRO-VERSA RMS-9 184669

A ☒ B ☒ C ☒ RES. ☐ ± ☐ BL. ☐ INSTALL ☐ REPL. ☒ CHG. ☐ DEACTIVATE ☐

* BUS 2B - CUB. 4C

ZONE OR EL. (CHAR.)	LONG T.D.		INSTANT.		
P.T. (P.D.) RATIO	UNIT		UNIT		
C.T. TURN RATIOS					
RANGE (RATING) C.T.	.5-1.1X				
PRIMARY SETTING	.8X(160A)				
SEC. SET'G (OP. VALUE) P.U.	FIXED @		1.5-10X		
COMPUTED TAPS	1C(160A)		7X(1400A)		
TEST A-V CUE TAG DEG	480V(20-33 SEC.)		3500A(.05 SEC. MAX.)		
TIMING	2				

D/G COOLING 1/2 — 200-600A SENSOR

200A TAP

ISSUE DATE 4/5/88 BY RMM COMPLETED 2/2/92 BY JM

*DESIGNATIONS NOT COVERED ABOVE OR BELOW, SUCH AS LINE NO., NEW OR OLD SETTING, ETC.

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SARGENT & LUNDY ENGINEERS	Calc. For Evaluation of 460V Diesel Generator Cooling Water Pump Minimum Starting Voltage				Calc. No. 8913-67-19-2	
	X	Safety-Related		Non-Safety-Related	Rev. 0	Date
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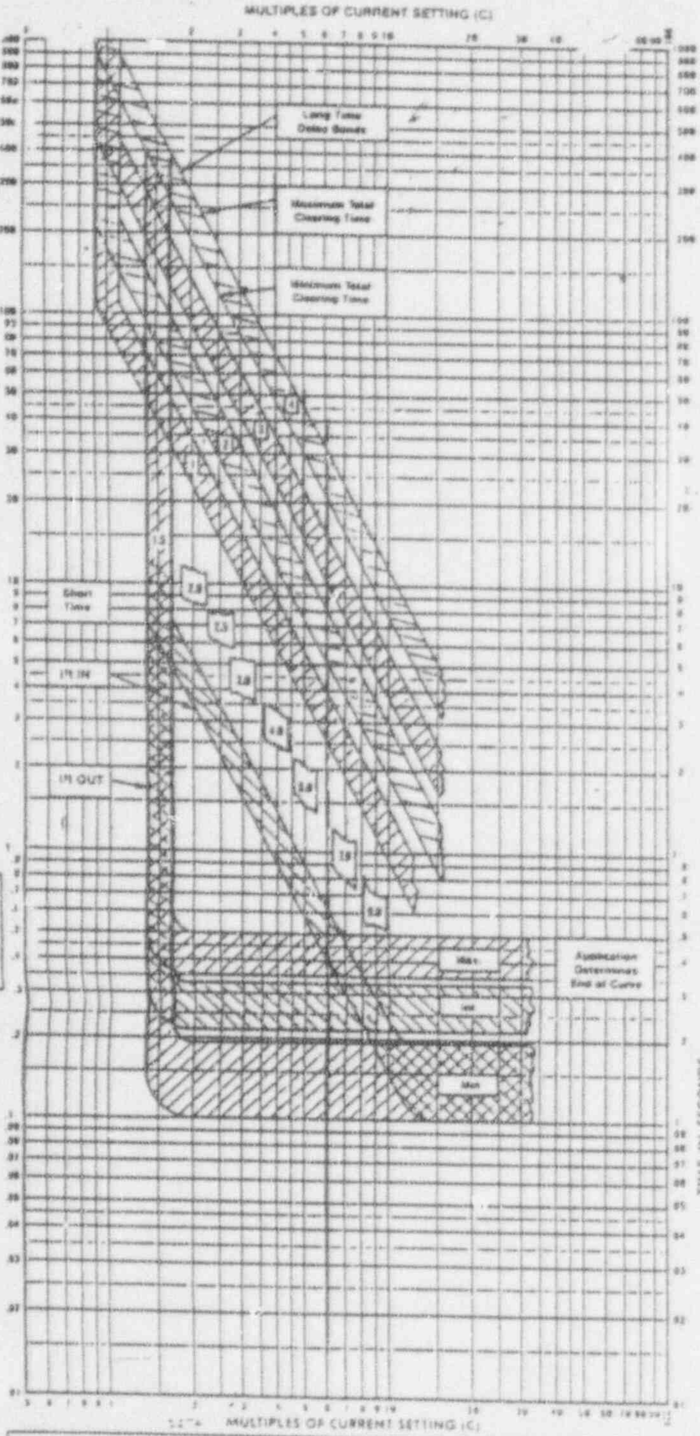
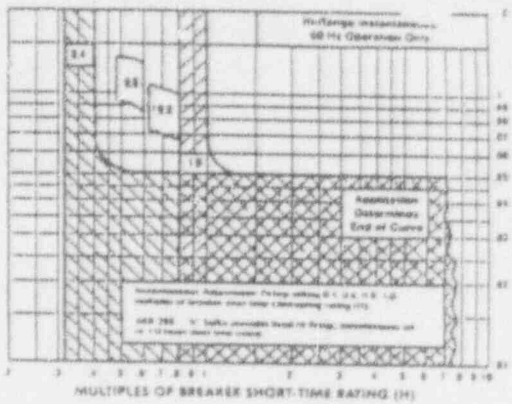
Client Commonwealth Edison Company	Prepared by / Date
Project Quad Cities Unit 1, Div.II; Units 1&2, Div.I	Reviewed by / Date
Proj. No. 8913-67 Equip. No.	Approved by / Date

ATTACHMENT G

TIME-CURRENT CURVE FOR GE AKR BREAKER





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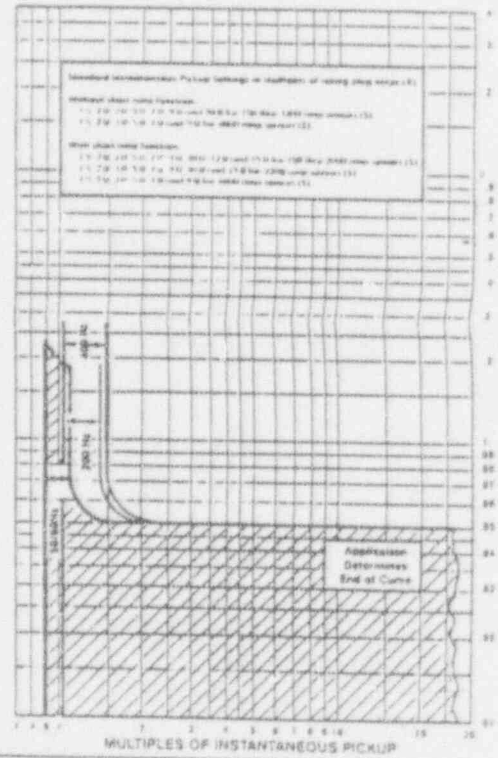

GENERAL ELECTRIC

LOW-VOLTAGE POWER CIRCUIT BREAKERS
TYPE AKR
with MicroVersaTrip™ RMS-9
or
Epic MicroVersaTrip™
Long-time delay, Short-time delay, and instantaneous Time-current Curves

GES-6227

Available Ratings (Amperes)

Programmer Adjustments

S = Current Sensor Amps
X = Rating Plug Amps
C = Current Setting Amps
H = Breaker Short-time Rating Amps

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