

Station and Unit Number Oconee Nuclear Station, Units 1, 2, & 3

Title of Calculation Calculations of Qualified Motor Life Reduction of Large Electric Motors Running during 80% Voltage Drop on Motor Terminals

Calculation Number OSC-1033 Originally consisting of Pages 1 through 12.

These Engineering calculations cover QA CONDITION 1 items. In accordance with established procedures, the quality has been assured and I certify that the above calculation has been performed, checked or approved as noted below:

Performed by M. J. Wong 9/11/80 Date 12/22/80  
 Checked by J. L. Chisholm Date 01-06-81  
 Approved by B. J. F. [Signature] Date 1-6-81

Revision/Addenda Log:

No.	Pages Revised	Pages Deleted	Pages Added	Performed		Checked		Approved	
				By	Date	By	Date	By	Date

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A. PROBLEM: To calculate qualified life reduction of large motors running  
during 80% voltage on motor terminals.

D. RELATIONSHIP TO QA CONDITION: This calculation is related to QA Condition  
1, Nuclear Safety Related.

C. DESIGN METHODS: Calculations are based on equation of thermal endurance  
curve for Westinghouse.

D. APPLICABLE CODES AND STANDARDS (Name, Number, Date, Revision):

NEMA MG1-20.40, June 1978, Rev. 4

NEMA MG1-12.42, Nov. 1978, Rev. 4

E. OTHER DESIGN CRITERIA: N/A

F. RELATED SAR CRITERIA (PSAR or FSAR, Page, Amendment) N/A

G. CALCULATIONS: -----Page No. 1 - 9

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J. CONCLUSION: -----Page No. 12

OCONET NUCLEAR STATION

Calculations of qualified motor life reduction of large electric motors running during 80% voltage on motor terminals.

INTRODUCTION

Voltage decrease on motor terminals increases slip and, as a result, current through the motor windings and heat losses. It is conservatively assumed that heat losses and winding temperature rise is proportional to motor I<sup>2</sup>. The calculations below are based on the Westinghouse Thermalastic Epoxy Insulation Thermal Aging Curve having an equation of

$$\text{Log}_{10} (\text{hours}) = - 8.71 + \frac{5486}{(^{\circ}\text{C}) + 273}$$

as shown in the attachment to C. K. Moore - Westinghouse letter of September 26, 1978, in Files P81 1318.20 and MC 1318.00 and on Louis-Allis Thermal Endurance Curve shown in test report PR 359-279 in File MC 1318.20.

1. LOW PRESSURE INJECTION PUMP MOTOR FILE: OS-95C

Rated: 400 HP  
 FLA at 100% Voltage: 49.7 (tested) amps  
 Actual FLA at 80% Voltage: 60.6 amps

1.1 Based on complete engineering test report, the actual temperature rise by resistance is 77.5°C. Conservatively assuming that the temperature rise by embedded detector is 10°C higher in accordance with NEMA MG1-20.40 and is 87.5°C.

Based on data obtained from Steam Production, the maximum ambient temperature is 35°C. Conservatively assuming that the ambient temperature is 40°C and that operation of the motor at 80% voltage lasts for 4 hours during 40 years of the plant life.

1.2 Total winding temperature is:

$$T^{\circ} \text{ Ambient} + \text{Rise} + 10\% \text{ Rise} + 8^{\circ}\text{C Margin}$$

During normal operation at full rated load and 100% voltage

$$40 + 87.5 + 8.8 + 8 = \underline{144.3^{\circ}\text{C}}$$

Temperature rise at 80% voltage

$$87.5 \times \left(\frac{60.6}{49.7}\right)^2 = 130.1^{\circ}\text{C}$$

Total temperature at 80% voltage

$$40 + 130.1 + 13 + 8 = 191.1^{\circ}\text{C}$$

$$1.3 \quad \text{Log } t_{144.3} = -8.71 + \frac{5486}{144.3 + 273} = 4.44$$

$$\text{Log } t_{191} = -8.71 + \frac{5486}{191 + 273} = 3.11$$

$$\text{Log } \frac{t_{144.3}}{t_{191}} = \text{Log } t_{144.3} - \text{Log } t_{191} = 4.44 - 3.11 = 1.33$$

$$\frac{t_{144.3}}{t_{191}} = 21.3 \approx 22$$

- 1.4 The operation time at 80% voltage equivalent to operation under normal conditions is:

$$4 \times 22 = 88 \text{ hours}$$

It is the qualified life of the LP Injection Pump Motor operating at 80% voltage for 4 hours during the plant life is reduced by 88 hours.

2. HIGH PRESSURE INJECTION PUMP MOTOR: FILE OS-95B

Rated: 600 HP  
 FLA at 100% Voltage: 74 amps (data sheet)  
 Actual FLA at 80% Voltage: 95.6 amps

- 2.1 The complete engineering test results are not available. The motor specification calls for 60°C/60°C rise by thermometer. It is equivalent to 80°C rise by embedded detector in accordance with NEMA MG1-20.40. Based on data obtained from Steam Production, the maximum ambient temperature is 35°C. Conservatively assuming that maximum ambient temperature is 40°C and the motor operation at 80% voltage lasts for 4 hours during 40 years of the life of the plant.

- 2.2 Total winding temperature at full rated load and 100% voltage.

$$40 + 80 + 8 + 8 = 136^\circ\text{C}$$

Temperature rise at 80% voltage

$$80 \times \left(\frac{95.6}{74}\right)^2 = 133.5^\circ\text{C}$$

Total temperature at 80% voltage

$$40 + 133.5 + 13.5 + 8 = 195^\circ\text{C}$$

- 2.3  $\text{Log } t_{136} = -8.71 + \frac{5486}{136 + 273} = 4.70$

$$\log t_{195} = -8.71 + \frac{5486}{195 + 273} = 3.01$$

$$\log \frac{t_{136}}{t_{195}} = 4.70 - 3.01 = 1.69$$

$$\frac{t_{136}}{t_{195}} = 48.9 \approx 50$$

- 2.4 The operation time at 80% voltage equivalent to operation under normal condition is:

$$4 \times 50 = 200 \text{ hours}$$

It is, the qualified life of the HP Injection Pump Motor operating at 80% voltage for 4 hours during the plant life is reduced by 200 hours.

3. LOW PRESSURE SERVICE WATER PUMP MOTOR: FILE OS-95K

Rated: 600 HP

FLA at 100% Voltage: 75 (tested) amps

Actual FLA at 80% Voltage: 69.8 amps

- 3.1 Assuming that 80% voltage condition lasts for 4 hours during 40 years of plant life and that 66°C rise measured by resistance is equivalent to 76°C rise by embedded detector. Based on Steam Production information, the ambient temperature is 35°C. Conservatively assume 40°C ambient temperature.

- 3.2 Total winding temperature during normal operation at rated load and 100% voltage.

$$40 + 76 + 7.6 + 8 = 131.6^\circ\text{C}$$

Based on T.P. Harrall's report the actual full load amps at 100% voltage is 55.3 amps. Therefore the temperature rise of this load is:

$$76 \times \left(\frac{55.3}{75}\right)^2 = 41.3^\circ\text{C}$$

Total temperature during operation at 100% voltage and 55.3 amps

$$40 + 41.3 + 4.1 + 8 = 93.4^\circ\text{C}$$

Temperature rise at 69.8 amps and 80% voltage

$$76 \times \left(\frac{69.8}{75}\right)^2 = 65.8^\circ\text{C}$$

Total temperature during operation at 80% voltage

$$T_{\text{Tot 80\%}} = 40 + 65.8 + 6.6 + 8 = 120.4^\circ\text{C}$$

- 3.3  $\log t_{93.4} = -8.71 + \frac{5486}{93.4 + 273} = 6.26$

$$\text{Log } t_{120.4} = -8.71 + \frac{5486}{120.4 + 273} = 5.23$$

$$\text{Log } \frac{t_{93.4}}{t_{120.4}} = 6.26 - 5.23 = 1.03$$

$$\frac{t_{93.4}}{t_{120.4}} = 10.7 \cong 11$$

- 3.4 The operation time at 80% voltage equivalent to operation at 100% voltage is:

$$4 \times 11 = 44 \text{ hours (prolonged)}$$

It is the qualified life of the Low Pressure Service Water Pump Motor operating at 80% voltage for 4 hours during the plant life is prolonged by 44 hours.

4. REACTOR BUILDING SPRAY PUMP MOTOR: FILE OS-950

Rated: 250 HP  
 FLA at 100% Voltage: 32.3 (tested) amps  
 Actual FLA at 80% Voltage: 39.3 amps

- 4.1 Assuming that 80% voltage lasts for 4 hours during plant life and that ambient temperature is 40°C.

- 4.2 Complete engineering test report performed on original motor gives 49°C rise. This correlates with temperature rise of 43°C obtained during test on spare RB Spray Pump Motor.

Total temperature at 100% voltage

$$40 + 49 + 4.9 + 8 = 101.9 \cong 102^\circ\text{C}$$

Temperature rise at 80% voltage

$$49 \times \left(\frac{39.3}{32.3}\right)^2 = 72.5^\circ\text{C}$$

Total temperature at 80% voltage

$$40 + 72.5 + 7.3 + 8 = 127.8^\circ\text{C}$$

- 4.3  $\text{Log } t_{102} = -8.71 + \frac{5486}{102 + 273} = 5.91$

$$\text{Log } t_{127.8} = -8.71 + \frac{5486}{127.8 + 273} = 4.97$$

$$\text{Log } \frac{t_{102}}{t_{127.8}} = 5.91 - 4.97 = 0.94$$

$$\frac{t_{102}}{t_{127.8}} = 8.7 \approx 9$$

- 4.4 The operation time at 80% voltage equivalent to operation at 100% voltage is:

$$4 \times 9 = 36 \text{ hours}$$

It is the qualified life of Reactor Building Spray Pump Motor operating at 80% voltage for 4 hours during the plant life is reduced by 36 hours.

## 5. EMERGENCY FEEDWATER PUMP MOTORS

### 5.1 Motors transferred from McGuire

Rated: 500 HP  
 FLA at 100% Voltage: 63.5 amps (tested)  
 Actual FLA at 80% Voltage: 81.1 amps

- 5.1.1 Use the same assumptions as in 4.1

- 5.1.2 Complete engineering test report gives 73°C rise at full load.

Total temperature at 100% voltage

$$40 + 73 + 7.3 + 8 = 128.3^\circ\text{C}$$

Temperature rise at 80% voltage

$$73 \times \left(\frac{81.1}{63.5}\right)^2 = 119^\circ\text{C}$$

Total temperature at 80% voltage

$$40 + 119 + 12 + 8 = 179^\circ\text{C}$$

- 5.1.3  $\text{Log } t_{128.3} = -8.71 + \frac{5486}{128.3 + 273} = 4.96$

$$\text{Log } t_{179} = -8.71 + \frac{5486}{179 + 273} = 3.42$$

$$\text{Log } \frac{t_{128.3}}{t_{179}} = 4.96 - 3.42 = 1.54$$

$$\frac{t_{128.3}}{t_{179}} = 34.6 \approx 35$$

- 5.1.4 The operation time at 80% voltage equivalent to operation at 100% voltage is:

$$4 \times 35 = 140 \text{ hours}$$



It is qualified life of Emergency Feedwater Pump Motor transferred from McGuire operating at 80% voltage for 4 hours during the plant life is reduced by 140 hours.

5.2 Motors transferred from Catawba

Rated: 600 HP  
FLA at 100% Voltage: 76.7 amps (tested)  
Actual FLA at 80% Voltage: 75.8 amps

As it can be seen, the actual FLA current at 80% voltage is lower than tested at rated horsepower due to the fact that pumps were modified at Oconee and motor is running at lower than rated load. As a result, qualified life of Emergency Feedwater Pump Motors transferred from Oconee is not reduced.

6. CONDENSER CIRCULATING WATER PUMP MOTOR: FILE OS-95H

Rated: 1750 HP  
FLA at 100% Voltage: 312 amps (From data sheet. The motor could not be tested at full load because of its size).  
Actual FLA at 80% Voltage: 344.4

6.1 Temperature rise at full load is 60°C measured by thermometer or 80°C by embedded detector.

6.2 Total temperature at 100% voltage

$$40 + 80 + 8 + 8 = 136^{\circ}\text{C}$$

Temperature rise at 80% voltage

$$80 \times \left(\frac{344.4}{312}\right)^2 = 97.5^{\circ}\text{C}$$

Total temperature at 80% voltage

$$40 + 97.5 + 9.8 + 8 = 155.3^{\circ}\text{C}$$

6.3  $\text{Log } t_{136} = -8.71 + \frac{5486}{136 + 273} = 4.70$

$$\text{Log } t_{155.3} = -8.71 + \frac{5486}{155.3 + 273} = 4.09$$

$$\text{Log } \frac{t_{136}}{t_{155.3}} = 4.70 - 4.09 = 0.69$$

$$\frac{t_{136}}{t_{155.3}} = 4.89 \cong 5$$

6.4 The operation time at 80% voltage equivalent to operation at 100% voltage is:

$$4 \times 5 = 20 \text{ hours}$$

It is the qualified life of Condenser Circulating Water Pump Motor operating at 80% voltage for 4 hours during the plant life is reduced by 20 hours.

7. AIR COMPRESSOR (UNLOADLD)

Rated: 125 HP

FLA at 100% Voltage: 116 amps (from data sheet)

Actual current (no load) at 80% Voltage: 21 amps

It can be seen that unloaded compressor motor can be run at 80% voltage without reduction of qualified life.

8. RECIRCULATING COOLING WATER PUMP MOTOR

Rated: 150 HP

FLA at 100% Voltage: 135 amps

Actual FLA at 80% Voltage: 159.8 amps

8.1 Motor specification calls for Class F insulation rise per NEMA. In turn, NEMA MG1-12.42 gives 110°C/40°C rise by resistance. The data sheet shows 90°C/40°C rise and does not specify the measurement method.

Assume 100°C rise over 40°C as measured by embedded detector.

8.2 Total temperature at 100% voltage

$$40 + 100 + 10 + 8 = 158^\circ\text{C}$$

Temperature rise at 80% voltage

$$100 \times \left(\frac{159.8}{135}\right)^2 = 140^\circ\text{C}$$

Total temperature at 80% voltage

$$40 + 140 + 14 + 8 = 202^\circ\text{C}$$

8.3  $\text{Log } t_{158} = 4.02$

$\text{Log } t_{202} = 2.83$

$$\text{Log } \frac{t_{158}}{t_{202}} = 4.02 - 2.83 = 1.19$$

$$\frac{t_{158}}{t_{202}} = 15.5 \approx 16$$

8.4 The operation time at 80% voltage equivalent to operation at 100% voltage is:

$$4 \times 16 = 64 \text{ hours}$$

It is the qualified life of Recirculating Cooling Water Pump Motor operating at 80% voltage for 4 hours during the plant life is reduced by 64 hours.

9. AC SYSTEM CHILLER COMPRESSOR: FILE OS-95S

Rated: 350 HP  
FLA at 100% Voltage: 45 amps (data sheet)  
Actual FLA at 80% Voltage: 35.1 amps

It can be seen that the Chiller Compressor Motor can be run at 80% voltage without reduction in qualified life.

10. HIGH PRESSURE SERVICE WATER PUMP MOTOR: FILE OS-95K

Rated: 500 HP  
FLA at 100% Voltage: 63 amps (data sheet)  
Actual FLA at 80% Voltage: 84 amps

10.1 Same assumptions as in 4.1 and temperature rise is 80°C/40°C by embedded detector.

10.2 Total temperature at 100% voltage

$$40 + 80 + 8 + 8 = 136^\circ\text{C}$$

Temperature rise at 80% voltage

$$80 \times \left(\frac{84}{63}\right)^2 = 142^\circ\text{C}$$

Total temperature at 80% voltage

$$40 + 142 + 14 + 8 = 204^\circ\text{C}$$

10.3  $\text{Log } t_{136} = 4.70$

$$\text{Log } t_{204} = 2.79$$

$$\text{Log } \frac{t_{136}}{t_{204}} = 4.70 - 2.79 = 1.91$$

$$\frac{t_{136}}{t_{204}} = 81$$

10.4 The operation time at 80% voltage equivalent to operation time at 100% voltage is:

$$4 \times 81 = 324 \text{ hours}$$

It is the qualified life of High Pressure Service Water Pump Motor operating at 80% voltage for 4 hours during plant life is reduced by 324 hours.

11. PENETRATION ROOM VENTILATION FAN MOTOR: FILE OS-95P

Rated: 5 HP  
FLA at 100% Voltage: 5.28 amps  
Actual FLA at 80% Voltage: 6.58 amps

- 11.1 This motor is Louis-Allis built. Test data are not available. The motor data sheet gives 75°C/40°C rise at rated HP and 100% voltage. The calculations are based on Louis-Allis Standard Insulation System Motorette Testing Data Report PR 359-279 available in File MC 1318.20. This report gives the equation of Class F insulation system as follows:

$$\text{Log } t = - 10.07 + \frac{6212.64}{C^{\circ} + 273}$$

- 11.2 Total temperature at 100% voltage and 40°C ambient

$$40 + 75 + 7.5 + 8 = 130.5^{\circ}\text{C}$$

Temperature rise at 80% voltage

$$75 \times \left(\frac{6.58}{5.28}\right)^2 = 116.5^{\circ}\text{C}$$

Total temperature at 80% voltage

$$40 + 116.5 + 12 + 8 = 176.5^{\circ}\text{C}$$

- 11.3  $\text{Log } t_{130.5} = - 10.07 + \frac{6212.64}{130.5 + 273} = 5.33$

$$\text{Log } t_{176.5} = - 10.07 + \frac{6212.64}{176.5 + 273} = 3.75$$

$$\text{Log } \frac{t_{130.5}}{t_{176.5}} = 5.33 - 3.75 = 1.58$$

$$\frac{t_{136}}{t_{195}} = 38$$

- 11.4 The operation time at 80% voltage equivalent to operation under normal conditions is:

$$4 \times 38 = 152 \text{ hours}$$

It is the qualified life of the Penetration Room Ventilation Fan Motor operating at 80% voltage for 4 hours during the plant life is reduced by 152 hours.

12. ASSUMPTIONS

- 12.1 Heat losses are proportional to motor's  $I^2$ .
- 12.2 Temperature rise by embedded detector is  $10^{\circ}\text{C}$  higher than by resistance in accordance with MG1-20.40.
- 12.3 That the ambient temperature is  $40^{\circ}\text{C}$ .
- 12.4 That operation of motors at 80% voltage lasts 4 hours during the 40 years of plant life.

13. REFERENCES

- 13.1 C. K. Moore of Westinghouse letter of 9/26/78 in Files PR1A 1318.20 and MC 1318.00.
- 13.2 Louis-Allis Thermal Endurance Curve shown in Test Report PR 359-2/9 in File MC 1318.20.
- 13.3 NEMA MG1-20.40, June 1978, Rev. 4.
- 13.4 NEMA MG1-12.42, Nov. 1978, Rev. 4.
- 13.5 Files OS-95B, OS-95C, OS-95D, OS-95H, OS-95K, OS-95P, OS-95S.
- 13.6 T. P. Harrall's June 4, 1980 letter to K. S. Canady

14. CONCLUSIONS

- 14.1 Based on previous experience with life calculations for similar motors, we feel that the 80% voltage drop on motor terminals for 4 hours during plant life will not cause substantial decrease in motor qualified life.

AE/cmm  
EL1016E

Westinghouse  
Electric Corporation

ROOM Box 32817  
2001 W Morehead Street  
Charlotte North Carolina 28232

September 26, 1978

Mr. C. J. Wylie  
Chief Engineer  
Electrical Division  
Duke Power Company  
P. O. Box 33189  
Charlotte, N. C. 28242

FILE P811318

Attention: Mr. Alex Ehrenburg

Subject: Project 81 Nuclear Station  
Nuclear Service Water Pump Motors  
Mill-Power Orders C-79227 and C-79226  
Our CH-19499-L7 and CH-19500-L7  
IEEE-323-1974 Qualifications of Motor Life

Dear Mr. Ehrenburg:

In reply to Duke Power's August 8, 1978 letter concerning the motor life, I am attaching a copy of our Mr. D. E. Plumb's letter of September 14, 1978. In his letter, Mr. Plumb provides a step-by-step calculation as was requested.

If there are further questions concerning this subject, please let me know.

Very truly yours,

*Chester Moore*  
Chester Moore

CM/mr

CENTRAL RECORDS/DIVIS



From : Buffalo AC Utility Sales  
WIN : 245-2792  
Date : September 14, 1978  
Subject:

# ATTACHMENT

To :  
Chester Moore  
Charlotte Office

SUBJECT: Protect 81 Nuclear Stations  
Nuclear Service Water Pump Motor (81-1318.20)  
M.P.S. Co. Order Nos. C79227 and C79226  
Westinghouse G.O. CH-19499-L7  
CH-19500-L7  
S.O. 77F14430-1-2-3-4-5  
IEE-323-1974 Qualifications of motor life

In reply to Alex Ehrenburg's letter to you of August 8, 1978, the following step by step calculations have been made and are being summarized in answer to his questions.



D. E. Plumb  
AC Utility Sales  
Engineer

DEP/1

STATED OPERATING CONDITIONS:

ATTACHMENT

1. NORMAL OPERATION: 20 years of continuous duty at 1064 BHP.

NOTE: Only one train runs during normal operation and if equipment time is balanced each motor should see 50% of the total plant life (40 YEARS).

2. Unit Shutdown: 2 years of continuous duty at 1064 BHP.

NOTE: Both trains are required to run until the unit is shutdown for refueling or cold shutdown. A conservative estimate of 18 days per year in the shutdown process yields 2 years.

3. Accident (Post LOCA) - 30 days of continuous duty at 1175 BHP.

The environmental conditions for the mentioned above modes of operation, are:

NORMAL: 40° to 100°F or 4.44° to 37.78°C - pessimistically assume 38°C

ACCIDENT: 125°F or 51.67°C - pessimistically assume 52°C

Each motor will operate as follows over a span of 40 years:

(on basis of total temperature at each operating condition of ambient + rise + \*10% of rise + 8° margin)

Idle Motor 20 yrs = 175320 hrs @ total temp of 46°C  
 Normal Operation 20 yrs = 175320 hrs. @ total temp of 104.3°C  
 Shutdown 2 years = 17532 hrs @ total temp of 104.3°C  
 Accident (one) 0.08 yrs = 720 hrs @ total temp. of 127.1°C

Converting all to 104.3°C

Idle	3081.96
Normal Operation	175320.
Shut Down	17532.
Accident (one)	3496.80
<b>TOTAL EQ. HRS =</b>	<b><u>199430.76</u></b>

Using approximate equation for curve figure 4.1 thermal endurance of thermalastic epoxy per IEEE 275 - 1966

$$\begin{aligned} \text{Log 10 (hours)} &= -8.71 \\ &+ \frac{5486}{(\text{°C})+273} \\ \text{Log 10 (hours)} &= -8.71 \\ &+ \frac{5486}{(104.3) + 273} \end{aligned}$$

Log 10 (hours) = 5.83  
 hours = 676322. (thermal endurance)

Therefore the margin of thermal endurance over the total  
equivalent hours for 40 years operation is

$$\frac{676322}{199430.76} = 3.39 \text{ times}$$

Since the revised expected life of the motors is greater than  
the requested life of 40 years no extension of life is required.

*D. E. Plumb*

D. E. Plumb  
LAC Utility Sales

DEP/1  
attach:

# ATTACHMENT

9751-5

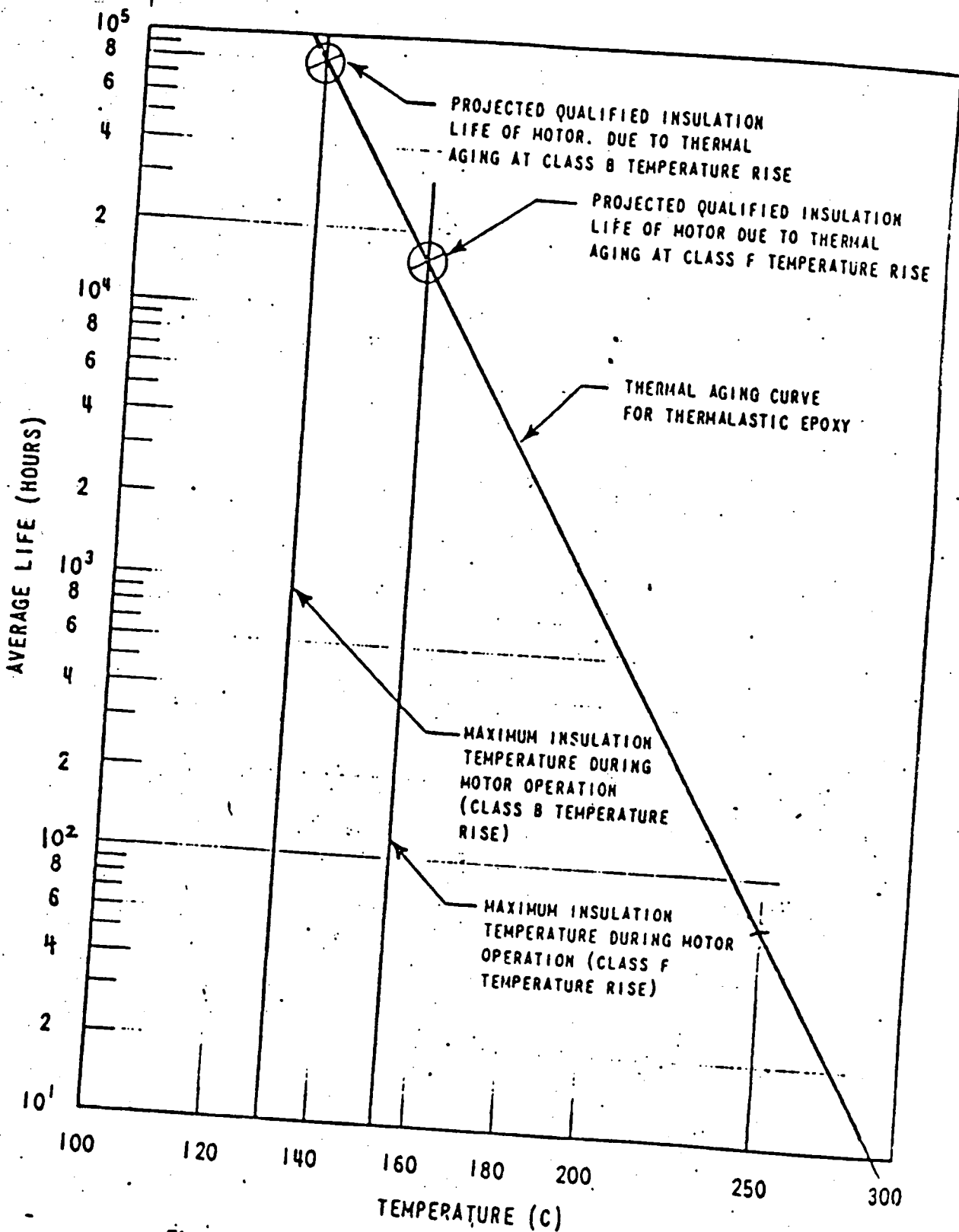


Figure 4-1. Thermal Endurance of Thermalastic Epoxy per IEEE 275-1966

APPROX. EQUATION FOR ABOVE:

$$\log_{10}(\text{hours}) = -8.71 + \frac{5486}{(C) + 273}$$

ADDITIONAL STUDIES OF  
TERMINAL VOLTAGES UPON  
TWO UNIT TRANSFER \*

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\* FIGURE NUMBERS CORRESPOND TO FIGURE NUMBERS  
(1-4) IN JUNE 4 SUBMITTAL

LOCATION		MOTOR	Per Unit Voltage Nominal Base	Voltage	Per Unit Voltage Motor Base
4.16 KV SWGR	3TC	LP Injection	0.8249	3432V	0.858
		RB Spray	0.8249	3432V	0.858
		LP Service	0.8249	3432V	0.858
	3TD	HP Injection	0.8247	3431V	0.858
		LP Injection	0.8247	3431V	0.858
		RB Spray	0.8247	3431V	0.858
		EFWP	0.8247	3431V	0.858
	3TE	HP Injection	0.8246	3430V	0.858
		EFWP	0.8246	3430V	0.858
	600V MCC	3XS1	P. R. Vent Fan	0.8186	491V
3XS2		P. R. Vent Fan	0.8170	490V	0.853
3XS3		RBCU Fan	0.8217	493V	0.858
208V MCC	3XS3*	Valve Motor (1HP)	0.8217	171V	0.855

\* The load on 208V MCCs is made of several small misc. motors (mostly valve motors). To model these motors, the total HP was lumped at the 208V MCC. To exemplify the typical voltage drop over the cable, the results for the worst case motor on MCC 3XS3 are given.

FIGURE 1A  
 VOLTAGE EXISTING BEFORE ESG SIGNAL WITH NORMAL LOAD OF TWO UNITS  
 (MOTOR TERMINAL VOLTAGE)

LOCATION		MOTOR	Per Unit Voltage Nominal Base	Voltage	Per Unit Voltage Motor Base
4.16 KV SMGR	3TC	LP Injection	0.7093	2951V	0.738
		RB Spray	0.7100	2954V	0.738
		LP Service	0.7090	2949V	0.737
	3TD	HP Injection	0.7079	2945V	0.736
		LP Injection	0.7090	2949V	0.737
		RB Spray	0.7105	2956V	0.739
		EFWP	0.7097	2952V	0.738
	3TE	HP Injection	0.7075	2943V	0.736
		EFWP	0.7094	2951V	0.738
	600V MCC	3XS1	P. R. Vent Fan	0.6809	409V
3XS2		P. R. Vent Fan	0.6767	406V	0.706
3XS3		RBCU Fan	0.6216	373V	0.649
208V MCC	3XS3	Valve Motor (1HP)	0.6156	128V	0.640

FIGURE 2A

STARTING ESG LOADS WITH CT3 CARRYING THE NORMAL LOAD OF TWO UNITS

(MOTOR TERMINAL VOLTAGE)

LOCATION		MOTOR	Per Unit Voltage Nominal Base	Voltage	Per Unit Voltage Motor Base
4.16 KV SWGR	3TC	LP Injection	0.3063	3354V	0.839
		RB Spray	0.8068	3356V	0.839
		LP Service	0.8063	3354V	0.839
	3TD	HP Injection	0.8059	3353V	0.838
		LP Injection	0.8062	3354V	0.838
		RB Spray	0.8071	3358V	0.839
		EFP	0.8065	3355V	0.839
	3TE	HP Injection	0.8057	3352V	0.838
		EFP	0.8064	3355V	0.839
	600V MCC	3XS1 3XS2 3XS3	P. R. Vent Fan	0.7963	478V
P. R. Vent Fan			0.7940	476V	0.829
RBCU Fan			0.7737	464V	0.807
208V MCC	3XS3	Valve Motor (1HP)	0.7715	160V	0.802

FIGURE 3A

VOLTAGES WITH NORMAL LOAD OF TWO UNITS + ESG LOADS + ALL VALVES RUNNING  
(MOTOR TERMINAL VOLTAGE)



LOCATION		MOTOR	Per Unit Voltage Nominal Base	Voltage	Per Unit Voltage Motor Base
4.16 KV SMGR	3TC	LP Injection	0.8069	3357V	0.839
		RB Spray	0.8073	3358V	0.840
		LP Service	0.8068	3356V	0.839
	3TD	HP Injection	0.8064	3355V	0.839
		LP Injection	0.8068	3356V	0.839
		RB Spray	0.8076	3360V	0.840
		EFWP	0.8071	3358V	0.839
	3TE	HP Injection	0.8062	3354V	0.836
		EFWP	0.8069	3357V	0.839
	600V MCC	3XS1	P. R. Vent Fan	0.7996	480V
3XS2		P. R. Vent Fan	0.7974	478V	0.832
3XS3		RBCU Fan	0.7748	465V	0.808
208V MCC	3XS3	Valve Motor (1HP)	0.7795	162V	0.811

FIGURE 4A

VOLTAGES WITH NORMAL LOAD OF TWO UNITS + ESG LOADS - VALVES OFF

(MOTOR TERMINAL VOLTAGE)

LOCATION		MOTOR	Per Unit Voltage Nominal Base	Voltage	Per Unit Voltage Motor Base
4.16 KV SWGR	3TC	LP Injection	.7569	3149V	.787
		RB Spray	.7574	3151V	.788
		LP Service	.7869	3149V	.787
	3TD	HP Injection	.7562	3146V	.786
		LP Injection	.7566	3147V	.787
		RB Spray	.7576	3152V	.788
		EFWP	.7569	3149V	.787
	3TE	HP Injection	.7559	3145V	.786
		EFWP	.7566	3147V	.787
		P. R. Vent Fan	.7488	449V	.781
	600V MCC	3XS1			
		3XS2	P. R. Vent Fan	.7462	448V
3XS3		RBCU Fan	.7221	433V	.754
208V MCC	3XS3				
		Valve Motor (1HP)	.7273	151V	.756

FIGURE 7A  
STARTING COND BOOSTER AFTER STEADY-STATE  
VOLTAGES RE-ESTABLISHED  
(MOTOR TERMINAL VOLTAGE)

Sheet 1 of 3  
SL 3/4/86  
DXP 3/4/86

Electric Equipment Corp.  
GTE Sylvania Corporation  
9101 Fair Road, East  
P.O. Box 3541  
Charlotte, N.C. 28226  
704-372-4161  
Telex 572429

ATTC-  
3

**SYLVANIA**

Electrical  
Equipment

September 15, 1980

Duke Power Company  
P.O. Box 33189  
Charlotte, North Carolina 28242

Attention: Mr. Luis A. Lecaros,  
Elect. Engr.

SUBJECT: Test Report

Dear Mr. Lecaros:

I am attaching, hereto, a copy of tests made on starters at our Lancaster, South Carolina plant on January 10, 1980.

The purpose of these tests was to get the pick-up and drop-out values of our starters.

The worst operating conditions a starter is subjected to is pick-up where the VA inrush is high and the energy required to pick-up the magnet and starter is high. As you can see from the attached results on the Size 1, the pick-up voltage was 65% and drop-out was 50.2%. For the size 5 TM, the pick-up was 70.2% and drop-out 40.2%.

Although this test did not include a continuous 4-hour running test, we operated the starters long enough to have hot coils.

The worst condition in a continuous run is with overvoltage. This causes the coil to draw higher currents which causes overheating. We are required by NEMA to run satisfactorily continuously at 110% voltage.

With undervoltage such as 80% as long as the starter picks-up and seals in the coil heating will be less than 100%.

Very truly yours,

GTE SYLVANIA

*William J. Zuk*  
William J. Zuk

cc: ~~Mr. Jim Stone - Duke Power~~  
Mr. Dick Schneider - GTE-Cleveland

Determination of Device Operating Voltages  
For Duke Power

The following tests were run at the Lancaster plant of GTE Products Corporation on 1/10/80 with the following parties present:

M. Susinno - Duke Power  
T. J. Al-Hussani - Duke Power  
J. D. Heffner - Duke Power  
E. H. Walters - Polytech Inc.  
W. J. Suk - Polytech Inc.  
D. P. Phillips - GTE Products Corp.

- (1) A type CY, Size 1 Motor Control Center compartment with a 600 volt control transformer, (2) 2 amp. primary fuses, (1) 3 amp. secondary fuse, and main circuit breaker was supplied by Duke Power personnel.

The following tests were run on this unit.

- A) 600 volts was applied to the L1 and L2 bus clips on the back of the compartment, energizing the starter. The voltage to the bus clips was decreased slowly by means of a variac until the starter dropped out.

Using this procedure 5 times, the starter was found to drop out at an average of 310 volts being applied to the bus clips.

Using the same voltage source, the minimum operating voltage required to energize the starter was found to be 390 volts. This value was determined by energizing the starter 10 consecutive times at 390 volts suddenly applied.

There were no failures of the transformer primary or secondary fuses during the above tests.

- B) The control transformer was disconnected from the compartment noted in (A) above and 120 volts was connected through the single control transformer secondary fuse to energize the starter.

Using the same procedure as outlined in (A) above, the minimum operating voltage was found to be 78 volts, and the dropout voltage was found to be 65 volts.

There was no failure of the secondary fuse as a result of these tests.

- (2) A Size 5 TM Starter, Bulletin 6013, equipped with a 120 volt coil and taken directly from production was tested per the procedure outlined in (1A) above, with the 120 volt source wired directly to the coil terminals.

Under these conditions, the minimum operating voltage for the device was found to be 87 volts and the dropout voltage was found to be 49 volts.

General: All of the above tests were performed in an ambient of approximately 25°C, and the main and auxiliary contacts on the starters tested did not carry current.

The source of supply for these tests was a 3 KVA control transformer controlled on the primary by a 4.2 KVA variac. All voltages were 60 Hertz and were measured by a Fluke Type 8040A Digital Meter which had been calibrated on 12/5/79.

*Don P. Phillips*

Don P. Phillips  
Product Engineer  
1/10/80

Battery Charger Specification Data Sheet

1. Electrical Data

Nominal Input Voltage 575, 3 phase, 60 cycle  
Input Voltage: -15%, Min Input Volts +10%, Max Input Volts  
Input Current and Power Factor for the following loads (rated load-  
130 volts, 150 amps)

DATA FOR SINGLE 600 AMP CHARGER

	Input Current	Power Factor
100% rated load	<u>93 amps</u>	<u>0.9 lag</u>
75% rated load	<u>71 amps</u>	<u>" "</u>
50% rated load	<u>49 amps</u>	<u>" "</u>

Input Voltage taps available  $\rightarrow$  % above line 606  
 $\rightarrow$  % below line 460, 480, 498, & 525

System Efficiency

For the following condition: Float Voltage 130 VDC at rated output current

<u>Input Voltage</u>	<u>Input Current</u>	<u>Input KVA</u>	<u>Power Factor</u>	<u>Efficiency</u>
Nominal line	<u>93 amps</u>	<u>93</u>	<u>0.9 lag</u>	<u>94 %</u>
-10% below line	<u>103 amps</u>	<u>"</u>	<u>"</u>	<u>"</u>
10% above line	<u>84 amps</u>	<u>"</u>	<u>"</u>	<u>"</u>

Output Voltage

Adjustable Float Voltage from 125 VDC min. to 140 VDC Max.  
Adjustable Equalize Voltage from 135 VDC min. to 150 VDC Max.

Output Current

Rated output current 600 amps  
Current limit adjustable from 630 min. to 660 max.  
Momentary short circuit current 660 amps for 1 seconds.  
Maximum time charger can operate in current limit with no derating of components indefinitely

Typical Average Direct Current Static Load Voltage Regulation +0.5 %

Typical Alternating Current Static Input Line Voltage Regulation +10 %  
-15%