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ACCESSION NBR:8202160541 DOC.DATE: 82/02/05 NOTARIZED: NO DOCKET #
FACIL:50-269 Oconee Nuclear Station, Unit 1, Duke Power Co. 05000269
50-270 Oconee Nuclear Station, Unit 2, Duke Power Co. 05000270
50-287 Oconee Nuclear Station, Unit 3, Duke Power Co. 05000287

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RECIP.NAME RECIPIENT AFFILIATION
DENTON,H.R. Office of Nuclear Reactor Regulation, Director
STOLZ,J.F. Operating Reactors Branch 4

SUBJECT: Forwards request for addl info re adequacy of station electric distribution sys volatges,in response to 811201 ltr.

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DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

February 5, 1982

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Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. J. F. Stolz, Chief
Operating Reactors Branch No. 4

Dear Sir:

resp

By letter dated December 1, 1981, the NRC Staff requested additional information regarding the adequacy of station electric distribution system voltages. Accordingly, please find attached the response to this request.

Based on the results of this study, certain actions are being considered. Confirming the telephone discussions held with the Staff on February 4, 1982, Duke will accomplish these actions following Staff review and acceptance of the attached study.

Very truly yours,

William O. Parker, Jr.

RLG/php
Attachment

A015
S.1/1

OCONEE NUCLEAR STATION

NRC REQUEST FOR INFORMATION

DEGRADED GRID VOLTAGE

References

1. Duke Power letter, William O. Parker, Jr. to Harold R. Denton, dated January 31, 1980.

2. Duke Power letter, William O. Parker, Jr. to Harold R. Denton, dated June 4, 1980.

1. The scenario at Oconee where an outage of one startup transformer can automatically cause a remaining transformer to overload by 167% and bus voltages to drop below 85% is alarmingly similar to the situation which occurred at Akransas Nuclear One. As ESG loads are added (Ref. 1, Fig. 4) motor voltages in some instances could be below 80%. At this voltage level, the staff is aware from reports at Millstone that some MCC contactors did not pick-up and this caused control transformers to overload and control fuses to blow. Also, if degraded voltages are sustained, motor heaters and possibly some motor circuit overcurrent protective devices will open and ESG loads will be dropped. Provide justification supported by analysis and data that substantiates your claim that there will not be spurious operation of controls, breakers or blow fuses (if used) during the postulated low voltage condition at the motors.

Response

As described in the Oconee FSAR, Section 8.2.2.13h, for ESG Motor loads at the 600 and 208 volt levels, one of the three overload heaters is sized to protect the motor and is wired to alarm only. The other two overload heaters are sized for circuit protection and are wired in the contactor trip circuit. In all cases, the ESG motor circuit breaker and overload heater circuit trip point is above the motor full load amperes expected at 80% voltage.

At the 4160V level, the relay set points for ESG and Hot Shutdown loads are above the currents calculated for degraded grid conditions. The currents and relay setpoints are shown on Attachment I.

Attachment II is a test report for starters of the type used at Oconee Nuclear Station. Note that the starter dropout voltage is below the minimum voltages calculated for degraded grid conditions. There were no failures of the control transformers primary or secondary fuses during the tests. The test did not include a continuous 4-hour running test. The worse condition in a continuous run is with overvoltage (not undervoltage). Overvoltages would cause the coil to draw higher currents which results in greater coil heating.

2. On page 4, paragraph 2 of Ref. 2, you indicate that the ESG motors can operate at 80% voltage for four hours with minimum loss of life. The staff is unable to corroborate this statement with published information. Provide you analysis, manufacturer's data and references to enable the staff to verify this statement. Data submitted should include manufacturer's curves of motor undervoltage versus temperature rise at rated loads, Arrhenius plots of expected life versus temperature, speed/torque curves, and results of tests performed by you or others.

Response

Attachment III is the Duke Power Company Calculation which establishes the loss of life resulting from operating ESG and hot shutdown motor loads at 80% voltage for 4 hours. The results of the calculation shows that the loss of life for the worse case motor is 324 hours.

3. In your January 31, 1980, submittal, response #5 states the MCC fuses will not blow when motors are operated at 90% nominal voltages (worst case condition of the October 29, 1979, analysis). The worst case condition of the June 4, 1980 submittal produced voltage levels substantially lower than those produced by the October 29, 1979, analysis. Have the fuses, motor contactors, and control transformer been tested at these lower voltages to substantiate the statement in Ref. 2, page 5, paragraph III 4?

Response

Please refer to our response to question 1.

4. Justify that the motor-operated valves will perform satisfactorily at the lowest voltages experienced at the 208 volt MCC's noted in the Reference 2 tables.

Response

Motors applied to operate valves have a number of degrees of conservatism included in their design. The conservatisms are based on the variables of application such as valve friction, stem packing friction, pressure variance, flow variance, and voltage variance. These variables result in the motor operators being oversized by design. Therefore, based on design conservatisms and our own operating experience, we feel that the valve operators will perform their intended function at 80% of rated voltage. However, sufficient data is not available to analytically confirm the effects of low voltage on the operation of motor operated valves.

The mode of station operation dictating the requirement for a valve testing program as proposed on page 4, paragraph 3 of Reference 2 has been carefully reviewed. Based on the results of this review, we have evaluated the costs of such a test program and determined that the most economical plan of action is to eliminate this mode of operation and bring one of the three units to cold shutdown immediately upon the failure of one of the three startup transformers.

Only two units will be permitted to operate when one of the three startup transformers is failed. Three units will not be operated until three startup transformers are made available.

5. Provide your estimated date for submitting the results of your testing of valves and valve operators under degraded voltage (Ref. 2, page 4, paragraph 3).

Response

Please refer to our response to question 4.

6. Are there other 1E equipment such as battery chargers or electronic equipment which could impose a more severe voltage limitation on the 1E buses then the motors?

Response

Safety-related and non safety-related instrumentation which is used in plant protection and/or which is important in operating the plant and monitoring plant status is powered from battery-backed sources as shown in FSAR Figure 8-5. These battery-backed sources are not affected by degraded grid voltage.

The battery chargers are rated to maintain output voltage within ±1% between 0 and full load with ±10% input voltage variation. Operation at -20% would simply result in a wider output voltage regulation range from the charger. The wider regulation range would still maintain the battery and static inverter voltages at an acceptable level to maintain inverter output voltages within ±10% of rated voltage.

7. In Reference 2, Figures 1-4, 7, and 8, does the per unit voltage motor base take into account the feeder voltage drop from MCC to the motor? If not, then the per unit values in this column are overstated and should be recalculated considering feeder voltage drop.

Response

The per unit voltages in Figures 1-4, 7 and 8 are all bus voltages. Attachment IV provides voltages at the terminals of ESG Motors.

8. What is the minimum pick-up voltage and hold-in voltage of the MCC contactors as determined by the manufacturer's tests (Ref. 2, page 5, paragraph 4 and Ref. 1, item 3).

Response

Please refer to our response to question 1.

9. When the voltages of Ref. 2, tables 1 and 2 are recorded, what was the load on the distribution buses? (The load on the distribution buses should have been at least 30%.)

Response

The measured load on the distribution buses is given in tables 1 and 2 in Reference 2. The loads were recorded during normal power operation with the generator on-line and the unit auxiliary transformer (3T) supplying the distribution system. Therefore, the loads recorded are approximately 100% of normal operating loads.

10. What assurances can you give that there will be close correlation between calculated and actual voltages at Units 1 and 2, based on the results of the Unit 3 correlation tests?

Response

The comparison between the measured voltage conditions for Unit 3 and the calculated results of the test conditions demonstrate that the analytical methods are valid. Due to the similarity of systems and loads on Units 1 and 2 compared with loads and systems on Unit 3, it is reasonable that the correlation tests performed on Unit 3 can be extraplated to Units 1 and 2.

11. A voltage analysis using either CT4 or CT5 as the source of the 4160 volt ESG power for three units should be provided.

Response

The CT4 power source is an on-site power supply. Thus, degraded voltage considerations are not applicable.

Transformer CT5 is supplied by a gas turbine located at Lee Steam Station via a 100KV transmission circuit. The Lee gas turbine and 100KV transmission circuit is electrically separated from the system grid and offsite non safety-related loads when supplying emergency power via CT5. Thus, degraded grid considerations also do not apply to CT5.

12. The proposed reduction in second-level undervoltage protection setpoints from 88% to 77% (80%-3% relay tolerance) is unacceptable unless manufacturers documentation or testing results by Duke Power Company can be provided for NRC review that clearly demonstrate that all Class 1E equipment can operate continuously at this degraded voltage level without damage or a significant reduction in equipment life.

Response

The undervoltage protection setpoint value will be 88%, since the mode of operation requiring the lower settings will be avoided as discussed in our response to question 4.

OCONEE NUCLEAR STATION
4160 VOLT SAFETY RELATED AND HOT SHUTDOWN MOTOR LOADS
MINIMUM OPERATING VOLTAGE FULL LOAD AMPERES vs PROTECTIVE RELAY TRIP POINTS

Load	Full Load Amps At 80% of Motor Rated Voltage (i.e. 3200V)	Relay Trip Point (Primary Amps)
Switchgear Incoming Feeder Breaker	2646	3000
High Pressure Injection Pump	95.6	120
Low Pressure Injection Pump	60.6	90
Low Pressure Service Pump	69.8	120
Reactor Building Spray Pump	39.3	60
Emergency Feed-Water Pump (500HP)	81.1	100
Emergency Feed-Water Pump (600HP)	75.8	100
Condenser Circulating Pump	344.4	480
Air Conditioning System Chiller Compressor	35.1	75
High Pressure Service Water Pump	84	100

CONCLUSION: These motors will not be tripped by protective relays at or above the designated minimum operating voltage.

WHJ 9/18/80

Electrical Equipment Group
GTE Sylvania Incorporated
9161 [illegible]
PO Box [illegible]
Charlotte NC 28203
704 372-4161
Telex 572-429

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. Suk

William J. Suk

cc: [redacted]
Mr. Dick Schneider - GTE-Cleveland

GTE SYLVANIA INCORPORATED
ELECTRICAL EQUIPMENT GROUP
ELECTRICAL CONTROL DIVISION
CLEVELAND, OH 44110

ENGINEERING DEPARTMENT

Determination of Device Operating Voltages For Duke Power

The following tests were run in 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.

GTE SYLVANIA INCORPORATED
ELECTRICAL EQUIPMENT GROUP
ELECTRICAL CONTROL DIVISION
CLEVELAND, OH 44110

ENGINEERING DEPARTMENT

(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

CERTIFICATION OF ENGINEERING CALCULATION

ATTACHMENT III

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-1088 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. Wang [signature] 9PV 12/22/80 Date: 12/22/80

Checked by: [signature] Date: 01-06-81

Approved by: [signature] Date: 1-6-81

Revision/Addenda Log:

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

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

B. 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

OCONEE 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^2. The calculations below are based on the Westinghouse Thermalastic Epoxy Insulation Thermal Aging Curve having an equation of

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

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° Ambient + Rise + 10% Rise + 8°C Margin

During normal operation at full rated load and 100% voltage

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

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

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

1.3 $$\text{Log } t_{144.3} = -8.\text{[illegible]} + \frac{5486}{144.3 + 273} = 4.44$$

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

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

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

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.

$$40 + 80 + 8 + 8 = 136°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 133.5 + 13.5 + 8 = 195°C$$

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

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

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

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

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

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

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.

$$40 + 76 + 7.6 + 8 = 131.6°C$$

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:

$$76 \text{ X } \left(\frac{55.3}{75}\right)^2 = 41.3°C.$$

Total temperature during operation at 100% voltage and 55.3 amps

$$40 + 41.3 + 4.1 + 8 = 93.4°C$$

Temperature rise at 69.8 amps and 80% voltage

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

Total temperature during operation at 80% voltage

$$T_{ToT\ 80\%} = 40 + 65.8 + 6.6 + 8 = 120.4°C$$

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

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

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

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

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-95D

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

$$40 + 49 + 4.9 + 8 = 101.9 \cong 102°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 72.5 + 7.3 + 8 = 127.8°C$$

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

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

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

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

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

$$40 + 73 + 7.3 + 8 = 128.3°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 119 + 12 + 8 = 179°C$$

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

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

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

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

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

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

It is the 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. <u>CONDENSER CIRCULATING WATER PUMP MOTOR: FILE OS-95H</u>

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

$$40 + 80 + 8 + 8 = 136°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 97.5 + 9.8 + 8 = 155.3°C$$

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 (UNLOADED)

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

$$40 + 100 + 10 + 8 = 158°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 140 + 14 + 8 = 202°C$$

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

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

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

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

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

$$40 + 80 + 8 + 8 = 136^\circ C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

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

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:

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

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

$$40 + 75 + 7.5 + 8 = 130.5°C$$

Temperature rise at 80% voltage

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

Total temperature at 80% voltage

$$40 + 116.5 + 12 + 8 = 176.5°C$$

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. <u>ASSUMPTIONS</u>

12.1 Heat losses are proportional to motor's I^2.

12.2 Temperature rise by embedded detector is 10°C higher than by resistance in accordance with MG1-20.40.

12.3 That the ambient temperature is 40°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 P81M 1318.20 and MC 1318.00.

13.2 Louis-Allis Thermal Endurance Curve shown in Test Report PR 359-279 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. <u>CONCLUSIONS</u>

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
EL4016E

Westinghouse
Electric Corporation

XXXXX Box 32817
2001 W Morehead Street
Charlotte North Carolina 28232

September 26, 1978

FILE P81/318

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

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

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

D. E. Plumb
AC Utility Sales
Engineer

DEP/1

Discard Date:

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 assu 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
TOTAL EQ. HRS =	199430.76

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

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

$$\text{Log 10 (hours)} = -8.71 + \frac{5486}{(104.3) + 273}$$

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

Therefore the margin of thermal endurance over the total equilavalent 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:

40 -

ATTACHMENT

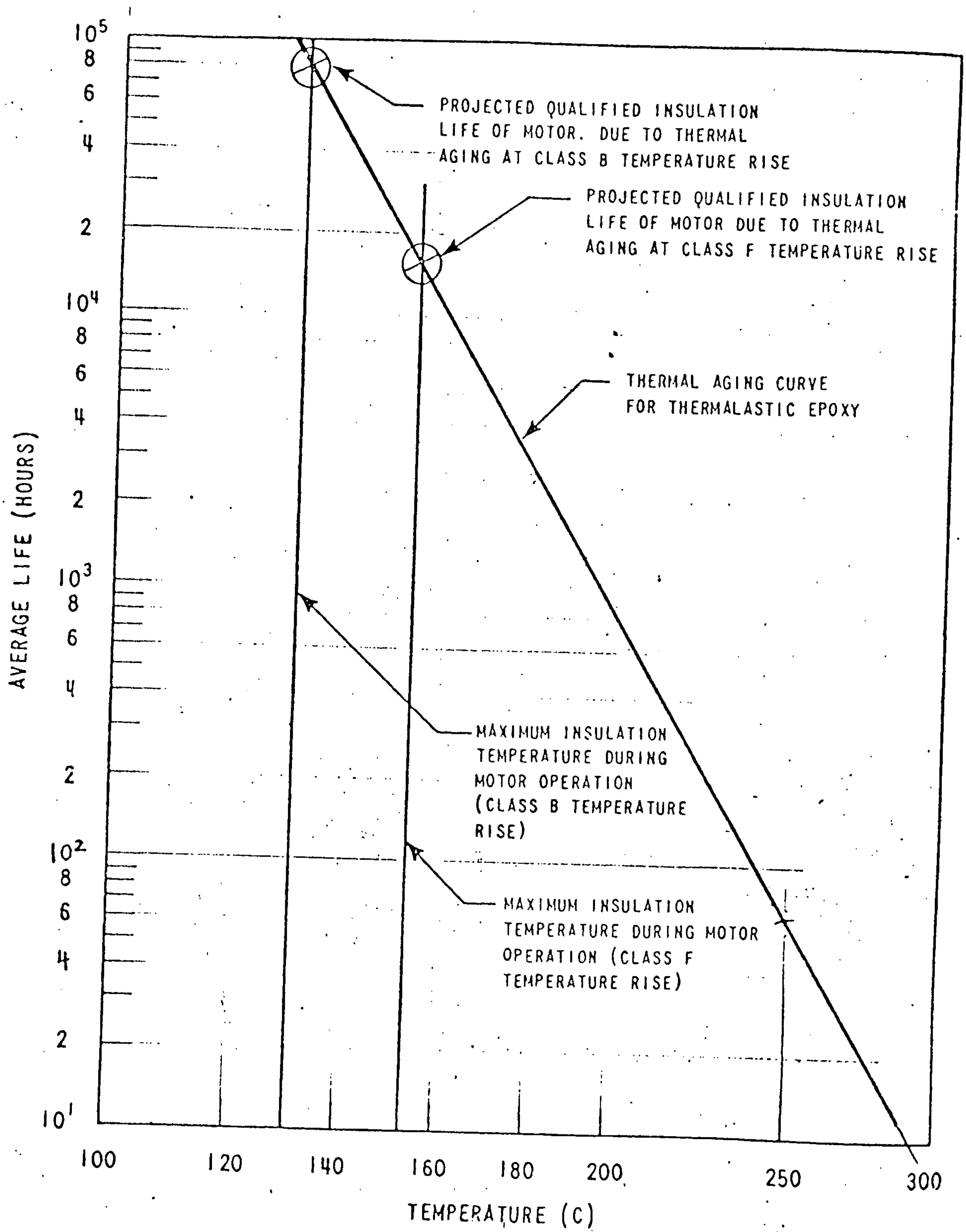

Figure 4-1. Thermal Endurance of Thermalastic Epoxy per IEEE 275-1966

APPROX. EQUATION FOR ABOVE:

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

ADDITIONAL STUDIES OF TERMINAL VOLTAGES UPON TWO UNIT TRANSFER *

* 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	0.854
	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 SWGR	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	0.711
	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	0.8063	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
		EFWP	0.8065	3355V	0.839
	3TE	HP Injection	0.8057	3352V	0.838
		EFWP	0.8064	3355V	0.839
600V MCC	3XS1	P. R. Vent Fan	0.7963	478V	0.831
	3XS2	P. R. Vent Fan	0.7940	476V	0.829
	3XS3	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 SWGR	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	0.838
		EFWP	0.8069	3357V	0.839
600V MCC	3XS1	P. R. Vent Fan	0.7996	480V	0.834
	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
600V MCC	3XS1	P. R. Vent Fan	.7488	449V	.781
	3XS2	P. R. Vent Fan	.7462	448V	.779
	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)

LOCATION		MOTOR	Per Unit Voltage Nominal Base	VOLTAGE	Per Unit Voltage Motor Base
4.16 KV SWGR	3TC	LP Injection	.7992	3325V	.831
		RB Spray	.7996	3326V	.832
		LP Service	.7992	3325V	.831
	3TD	HP Injection	.7987	3323V	.831
		LP Injection	.7990	3324V	.831
		RB Spray	.7999	3328V	.832
		EFWP	.7994	3326V	.831
	3TE	HP Injection	.7985	3322V	.830
		EFWP	.7992	3325V	.831
600V MCC	3XS1	P.R. Vent Fan	.7915	475V	.826
	3XS2	P.R. Vent Fan	.7892	474V	.824
	3XS3	RBCU Fan	.7667	460V	.800
208V MCC	3XS3				
		Valve Motor (1HP)	.7715	160V	.802

FIGURE 8A
FINAL STEADY-STATE VOLTAGES WITH COND BOOSTER RUNNING
(MOTOR TERMINAL VOLTAGE)