



Commonwealth Edison
One First National Plaza, Chicago, Illinois
Address Reply to: Post Office Box 767
Chicago, Illinois 60690

October 27, 1988

Mr. Thomas E. Murley, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Undervoltage Effect on AC Motors
NRC Docket Nos. 50-237 and 50-249

References (a): Letter from J.A. Silady to T.E. Murley dated
July 19, 1988 responding to NRC Staff RAI
dated June 29, 1988.

(b): Letter from J.A. Silady to T.E. Murley dated
March 28, 1988 submitting proposed change to
the 4KV undervoltage relay setpoint.

Dear Mr. Murley:

As a result of conference call discussions on the Reference (a)
response to a NRC Staff Request for Additional Information on the Reference
(b) proposed amendment, Commonwealth Edison requested Sargent and Lundy to
evaluate the effects of bus undervoltage on 4KV and 480V AC motor qualified
life. The results of the study are enclosed and indicate that a setpoint of
67 percent of the rated 4KV bus voltage including negative tolerance has
negligible effect on motor thermal qualification.

Advance copies of this information were previously provided to Mr.
B.L. Siegel of your staff in preliminary form on September 12, 1988 and final
form on September 20, 1988.

Please direct any questions you may have regarding this transmittal
to this office.

Very truly yours,

J. A. Silady
Nuclear Licensing Administrator

lm

cc: A.B. Davis - Regional Administrator, RIII
B.L. Siegel - Project Manger, NRR

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September 20, 1988
Project No. 7927-44
S&L Letter No. D688E

Commonwealth Edison Company
Dresden Station - Units 2 & 3

4 kV Undervoltage Relay Setpoint

Mr. M. Kluge
BWR Engineering Department
Commonwealth Edison Company
Post Office Box 767, 35 FNW
Chicago, Illinois 60690

Dear Mr. Kluge:

This letter supplements my previous letter dated September 12, 1988. During the conference calls to the NRC, Commonwealth Edison Company (CECo) was asked to give justification for motor qualification when subjected to an undervoltage of 67 percent of rated 4 kV bus voltage (undervoltage relay setpoint with the negative tolerance included), which is less than motors one minute rating at 75 percent of rated voltage.

Sargent & Lundy (S&L), who also participated in the conference calls to the NRC, was asked by CECo to study and prepare technical documentation on the age degradation of the ac motor thermal qualification when subjected to 67 percent of rated bus voltage.

Sargent & Lundy prepared and reviewed "The Study and Technical Documentation on Effect of Undervoltage on AC Motors." The above document shows that undervoltage relay setpoint of 67 percent of the rated 4 kV bus voltage including negative tolerance has negligible effect on motor's thermal qualification.

SARGENT & LUNDY
ENGINEERS
CHICAGOMr. W. B. Fancher
Commonwealth Edison CompanySeptember 20, 1988
Page 2

We are forwarding you a copy of the above document. Should you have any questions or comments, please do not hesitate to contact me at 269-6987.

Yours very truly,

*Rajinder A. Yeldandi*R. Yeldandi
Electrical Engineer

RY:jjs

In duplicate

Enclosure

Copies:

M. J. Wallace

D. F. Wheeler

E. D. Eenigneburg

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T. J. Ryan/A. Walser

E. Schumacher/F. W. Fischer

Project No. 7927-44

Dresden Station - Units 2 & 3
STUDY AND TECHNICAL DOCUMENTATION ON EFFECT
OF UNDERVOLTAGE ON AC MOTORS

PURPOSE:

The purpose of this study is to assess the impact of bus undervoltage (to the lower tolerance limit of undervoltage relay set point) on 4 kV and 480 Vac motor qualified life.

REFERENCE:

1. Publication "Effect of Power Supply Variations on AC Motor Characteristics" by J. R. Linder IEEE Transactions on Industrial Applications Vol. IA-8, No. 4 July/August 1972.
2. S&L Electrical Engineering Standard ESC 193.
3. S&L Calculation No. 7317-33-19-1 Rev. 0.
4. CQD-016764, Rev. 5 Environmental Qualification of GE Motors.
5. Westinghouse Qualification document MM-9112.

BACKGROUND:

The loss of offsite power undervoltage relay on the 4 kV essential bus at Dresden Station with its negative tolerance has a setpoint of 67% of rated voltage. Undervoltage protection logic on the 4 kV buses would permit an undervoltage above the relay setpoint for five minutes before a bus is transferred to onsite power.

There is no record at the Dresden Station that a five minute undervoltage condition of 67 percent of rated voltage has ever occurred. For the purpose of this study, the emergency bus voltage is assumed to drop to 67 percent of rated bus voltage (4160 V essential bus) and to remain at that value for approximately five minutes before load shedding occurs (motors are de-energized) and the bus is transferred to onsite power.

STUDY

METHODOLOGY:

The effect of reduced motor terminal voltage on motor temperature rise is determined. The aging effect of this temperature for the expected five minute period is determined and compared with the motor qualified life to show the effect is negligible.

IMPACT OF MOTOR UNDERVOLTAGE ON TEMPERATURE:

Reference 1 identifies the effects of motor terminal voltage on various motor parameters. From the values taken from the referenced publication the variation of temperature rise is plotted against voltage at the motor terminal (Attachment 1).

Reference 2, Section 4.1 states that there should be a negligible drop in voltage in 4 kV motor feeder cable. Reference 3 indicates the voltage drop in 4 kV essential service motor cables to range from 0.44 percent to 0.7 percent of rated voltage. Reference 2, Section 4.6 states that for 480 V motors, the voltage drop on motor cables can be approximately 2 percent.

In this evaluation the conservative value of two percent is used for the voltage drop in 480 V and 4 kV motor cables.

This voltage drop results in a motor terminal voltage of 65 percent of rated bus voltage. This corresponds to 67.6% of motor rated voltage, from the plotted curve the value of a temperature rise at 67.6% percent of motor rated voltage will be 1.9 times the rated temperature rise. For the purpose of this study we will conservatively, utilize a temperature rise 2.0 times the rated temperature rise.

MOTOR QUALIFICATION:

The Class 1E motors in the Environmental Qualification Program of Dresden Units 2 & 3 are:

1. GE 4 kV ECCS Pump Motors (Model #5K6337XC71A and 5K6338XC23A)
2. Westinghouse 480 Vac Room Cooler and Exhaust Fan Motors
3. Limitorque 480 Vac valve actuators.

4 kV MOTORS:

The GE 4 kV motors are located in a zone where the maximum normal ambient temperature is 40°C. The worst case temperature rise for any ECCS pump motor under normal load and rated voltage is 60°C (See Table 2 of GE document NEDC-30066 in Reference 4). Adding a 10°C hot spot temperature to the motor coil temperature, the ECCS pump motors are subjected to a maximum of 110°C (40°C + 60°C + 10°C) coil temperature during normal plant operation. The test-motor was aged to an equivalent of 69,000 hours at 140°C (See Page 7 of

GE document NEDC-30066, Reference 4). The 69,000 hours of aging at 140°C is equivalent to 7×10^5 hours at 110°C (See Figure 2 of GE document NEDC-30066, Reference 4). During accident conditions, the ambient temperature can reach as high as 114°F (45.5°C). So the coil temperature during the accident can reach up to a maximum temperature of 115°C (45.5°C + 60°C + 10°C). The post DBE duration of one year at 115.5°C is thermally equivalent to $\frac{7}{4}$ years at 110°C (See Figure 2 of GE document NEDC-30066, Reference 4). The expected maximum operating time during 40 years (3.5×10^5 hours) for these motors is 69,000 hours (See Page 3 of GE document NEDC-30066, Reference 4). During the period when the motors are not running there is negligible thermal degradation to the motors as the motors do not see any heat rise. So the total thermal degradation during 40 years service life and one year post DBE is 69,000 + $\frac{7}{4} \times 365.25 \times 24 = 84341$ hours at 110°C. Hence, the motor insulation life is $(\frac{7 \times 10^5}{84341} - 1) \times 100 = 730\%$ in excess of the thermal stress induced over 40 years of normal service + one year PDBE.

As stated earlier, due to an undervoltage of 65 percent of rated voltage, the temperature rise can become 2.0 times the rated temperature rise under rated voltage conditions. Hence the temperature rise at 65 percent of rated voltage will be $60^\circ\text{C} \times 2 = 120^\circ\text{C}$. In reality this additional 60°C rise is the long term steady state effect. The five minute occurrence is expected to cause a rise of only a few degrees. However, the long-term value will be used for conservatism.

The maximum coil temperature under the undervoltage conditions will be 170°C (40°C + 120°C + 10°C). The qualified life of the motor is 8000 hours at 170°C (See Figure 2 of GE document NEDC-30066, Reference 4). Considering one

undervoltage occurrence (i.e., a condition where an undervoltage of 67 percent of of a bus rated voltage lasts for five minutes) the resulting loss in motor thermal life is only .001 percent ($\frac{5}{60 \times 8000} \times 100$). This allows for 1,000 such occurrences before one percent of motor life is utilized. Considering the significant existing margin in motor life such occurrence has no impact on motor qualified life of the GE 4 kV ECCS Pump Motors.

480 VAC MOTORS

The 480 VAC Westinghouse motors are used on the room cooler fans and the exhaust fans. These motors are rated for continuous duty. However, their function is not continuous. They are used only during testing or whenever the RHR system is in use. During the period when the motors are not running, (i.e., 40 years - 69,000 hours) there is negligible thermal degradation to the motors as the motors do not see any heat rise.

The maximum ambient temperature where these motors are located is 120°F (48.9°C). The heat rise of the subject motors is 55°C at the rated voltage (See CQD-002651, Rev. 04). Adding 10°C hot spot temperature to the motor coil temperature, the service temperature experienced by the motor is 113.9°C, (48.9°C + 55°C + 10°C). These motors are qualified for 40 years of operation at 130°C (Reference 5, Page 11). The 40 years at 130°C equates to 160 years at service temperature of 113.9°C (See Page 11, Reference 5).

The motors are required to be operational for 69,000 hours of normal service at 48.9°C + one year POBE at 48.9°C. This equates to thermal degradation at 113.9°C for 8.88 years ($\frac{69,000}{24 \times 365.25} + 1$) years. Hence, the qualified thermal life is 1700% ($\frac{160}{8.88} - 1 \times 100$) in excess of the thermal stress induced over

the 40 years of normal service + one year of PDBE. An undervoltage of about 67 percent of the motor rated voltage can double the heat rise. The temperature with heat rise due to undervoltage conditions can reach $48.9^{\circ}\text{C} + 10^{\circ}\text{C} + 2 \times 55^{\circ}\text{C} = 168.9^{\circ}\text{C}$. The qualified life of the motor is 19,000 hours at 168.9°C (See Page 11, Reference 5). One occurrence of the subject undervoltage will utilize only 0.00044% ($\frac{5}{60 \times 19,000} \times 100$) of the total thermal life of the motor.

This allows for about 2,240 such occurrences before 1 percent of motor life is utilized. Considering the significant existing margin in motor life such occurrences will have no impact on motor qualified life.

LIMITORQUE 480 Vac MOTORS

The Limitorque 480 Vac valve actuators are not continuous running motors. The stroking time for these actuators is less than 30 seconds and hence, the undervoltage phenomena for five minutes will have negligible impact on the qualification for Limitorque 480 Vac actuators.

CONCLUSION:

The undervoltage relay set point of 67 percent of rated voltage with negative tolerance included will not degrade the motor thermal qualification for 4 kV and 480 V essential service motors.

Prepared: Rajendra A. Yeldandi
Date: September 20, 1988
Department: Electrical Project Engineering Div.

Reviewed: J. K. Mathews for AMVP SENRA
Date: 9/20/88
Department: MECHANICAL / C&D

Reviewed: S. H. Patel
Date: 9/20/88
Department: Electrical Analytical Div.

Approved: E. Schumacher
Date: 9/20/88
Department: Electrical Project Engineering Division

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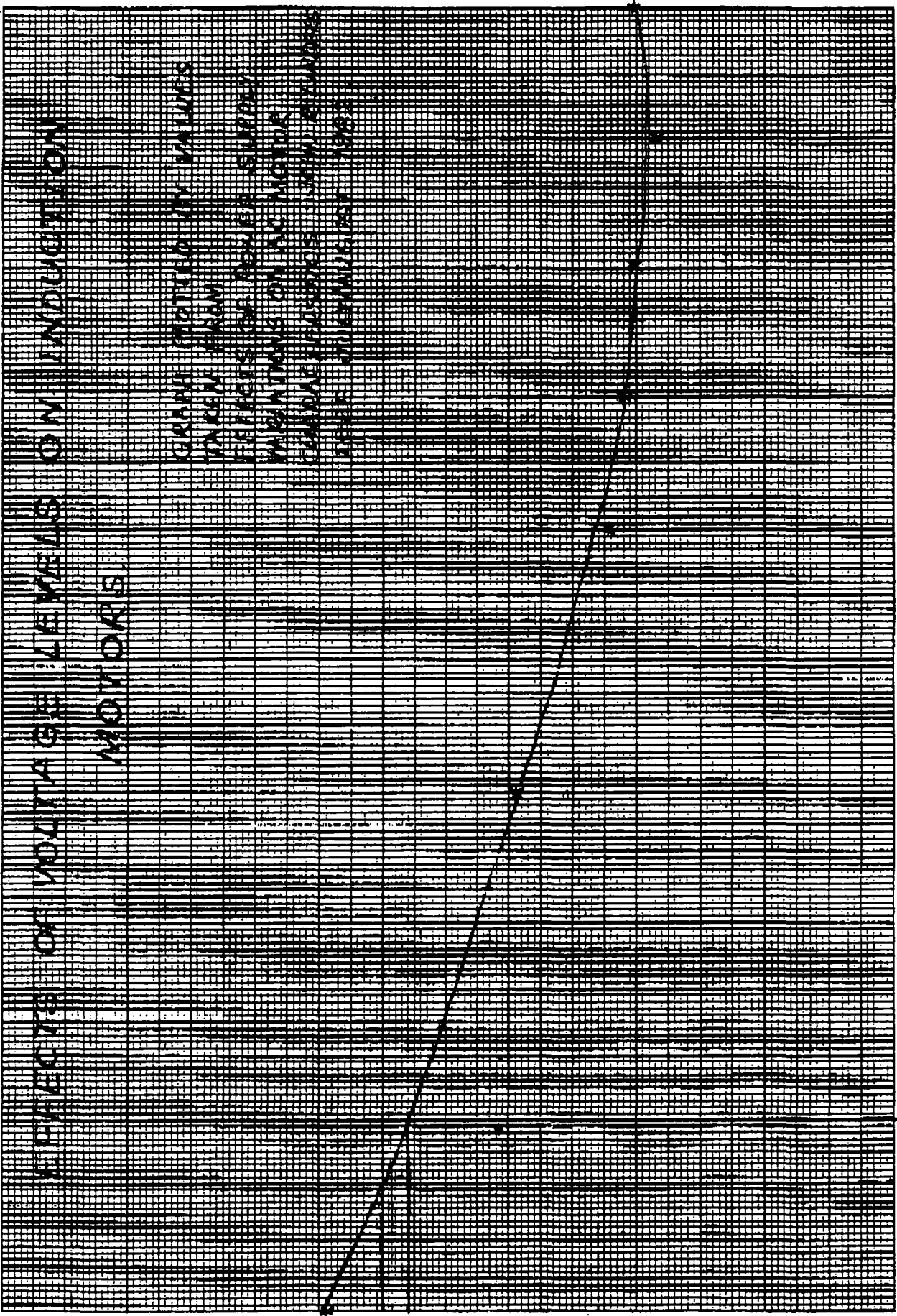
K-E 20 X 20 TO THE INCH 7 X 30 INCHES
MONTVAL & LESSEN CO. MADE IN U.S.A.

EFFECTS OF VOLTAGE LEVELS ON INDUCTION MOTOR

GRAND TOTAL OF 11 VALUES
TAKEN FROM THE
EFFECTS OF VOLTAGE LEVELS
ON INDUCTION MOTOR
EXPERIMENTAL REPORT
DATE: JULY 1987

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001 % OF NORMAL TEMP.
002



110
100
90
80
70
65
60
% OF NORMAL VOLTAGE

TRANSMITTAL SHEET

NUCLEAR LICENSING DEPARTMENT

DATE: 9-20-86

Transmittal Sheet Plus 10 Pages

TO: Byron Siegel

STATION/DEPARTMENT: NRC Project Manager

FROM: J. Silady

STATION/DEPARTMENT: Nuclear Licensing/Safety - 34 FNE

TELEPHONE NUMBER: _____

IF YOU HAVE ANY PROBLEMS RECEIVING YOUR TELECOPY, PLEASE CALL x-3906

NOTES