Nebraska Public Power District

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NLS2009110
December 21, 2009

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

Subject: Response to Nuclear Regulatory Commission Request for Additional Information Re: Non-Conservative Battery Resistance in Technical Specification Surveillance Requirements (TAC No. ME0848)
Cooper Nuclear Station, Docket No. 50-298, DPR-46

References:

1. Letter from Carl F. Lyon, U.S. Nuclear Regulatory Commission, to Stewart B. Minahan, Nebraska Public Power District, dated November 25, 2009, "Cooper Nuclear Station - Request for Additional Information Re: Battery Resistance Surveillance Requirements (TAC No. ME0848)"

2. Letter from Stewart B. Minahan, Nebraska Public Power District, to the U.S. Nuclear Regulatory Commission, dated March 11, 2009, "License Amendment Request to Revise Nonconservative Battery Resistance Technical Specification Surveillance Requirements"

Dear Sir or Madam:

The purpose of this letter is for Nebraska Public Power District to submit a response to a request for additional information (RAI) from the Nuclear Regulatory Commission (NRC) (Reference 1). The RAI requested information in support of the NRC's review of a license amendment request for the Cooper Nuclear Station (CNS) facility operating license and technical specifications to revise non-conservative battery resistance in the CNS Technical Specifications (TS) Surveillance Requirements (SRs) (Reference 2).

Responses to the specific RAI questions are provided in the Attachment. No regulatory commitments are made in this submittal.

The information submitted by this response to the RAI does not change the conclusions or the basis of the no significant hazards consideration evaluation provided with Reference 2.

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NRR

COOPER NUCLEAR STATION
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If you have any questions concerning this matter, please contact David Van Der Kamp, Licensing Manager, at (402) 825-2904.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 12/21/09
(date)

Sincerely,

Brian J. O'Grady
Site Vice President

/em

Attachment

Enclosure

cc: Regional Administrator w/ attachment & enclosure
USNRC - Region IV

Cooper Project Manager w/ attachment & enclosure
USNRC - NRR Project Directorate IV-1

Senior Resident Inspector w/ attachment & enclosure
USNRC - CNS

Nebraska Health and Human Services w/ attachment & enclosure
Department of Regulation and Licensure

NPG Distribution w/ attachment & enclosure

CNS Records w/ attachment & enclosure

Attachment

Response to Nuclear Regulatory Commission Request for Additional Information Re: Non-Conservative Battery Resistance in Surveillance Requirements (TAC No. ME0848)
Cooper Nuclear Station, Docket No. 50-298, DPR-46

NRC Question #1 (from Reactor Systems Branch)

1. *The following clarifying questions pertain to Calculation NEDC 87-131 C, "125 VDC Division I Load and Voltage Study," specifically page 15 of the calculation. These questions also apply to the other three calculations provided in the Nebraska Public Power District's letter dated August 12, 2009.*

   a. *Explain the origins and provide the technical justification for the formula listed on page 15. Please explain the term Aging Coefficient.*

   Response

   Calculations NEDCs 87-131A, 87-131B, 87-131C and 87-131D utilize the EDSA (trademark for EDSA Micro Corporation) software program to perform load flow analysis.

   The EDSA software for DC Load Flow considers the effects of battery aging and temperature in the DC Load Flow program. See enclosed EDSA User's Guide excerpts for load flow (vs. battery sizing) calculations.

   The formula is:
   $I_{corr} = I_{batt}$ x (Temp Factor/Aging Coef)

   Where:
   I_{corr} = Corrected battery amperes to account for aging, temperature and design margin
   I_{batt} = Nominal battery current (or duty cycle in amperes)
   Temp Factor = Temperature Correction Factor (from IEEE 485-1997, Table 1)
   Aging Coefficient = Fraction of manufacturer's rated battery capacity (e.g., if battery has lost 3% of rated capacity, the aging factor is 0.97)

   The EDSA formula used in CNS calculations is equivalent to the following IEEE 485-1997 formula:

   Corrected Amperes = Duty Cycle x Cumulative Correction Factor (CCF)

   Where: CCF = (Temp Factor x Aging Factor x Design Margin)

The EDSA software for DC Load Flow utilizes values for the Aging Factor and Design Margin of less than 1.0. Therefore an Aging Factor and/or Design Margin of 1.25 must be input as an Aging Coefficient of 0.8. Dividing by the Aging Coefficient is equivalent to multiplying the Aging Factor and/or Design Margin.

The CNS Aging Coefficient is the product of 90% battery capacity (0.90) due to aging and a Design Margin of 0.95. (0.9 x 0.95 = 0.855)

b. *Provide the design bases temperature for each battery at Cooper Nuclear Station (CNS) and the temperature used in the cell sizing worksheet.*

<u>Response</u>

CNS TS specify minimum temperature limits, not upper limits. The minimum battery temperatures for the 125 VDC 1A, 125 VDC 1B, 250 VDC 1A and 250 VDC 1B are 70 deg F. This is the lowest ambient temperature expected in the CNS battery rooms. A lowest electrolyte temperature of 70 deg F was used as a design assumption in the battery sizing calculations for the CNS batteries. SR 3.8.6.3 requires average electrolyte temperature of representative cells to be $\geq$ 70°F. Institute of Electrical and Electronics Engineers (IEEE) 485-1997 provides guidance for cell size correction factors for temperatures. The correction factor for 70°F is 1.040 (IEEE 485-1997 Table 1), which is the lowest expected electrolyte temperature.

The temperature correction factor (K_T) functions for electrolyte temperature below 77°F (i.e. the factor is used to determine the cell rating at 77°F which will supply the required Ampere Hours (Ahs) at the lower temperature). The cell sizing worksheet in the IEEE Standard utilizes the lowest expected electrolyte temperature.

c. *The calculation lists a design margin factor of 0.95 and asserts that this gives a margin of 5 percent. The Nuclear Regulatory Commission (NRC) staff understands 1.05 as being a typical value representing a 5 percent margin. The staff's position is based on industry guidance documents (e.g., Institute of Electrical and Electronics Engineers (IEEE) Standard 485, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"). Provide the technical justification behind your rationale of having a 5 percent design margin.*

<u>Response</u>

IEEE Standard 485 uses a Design Margin value greater than 1.0 to multiply the amperes required from the battery when sizing the battery. Dividing by a Design Margin value less than 1.0 also increases the amps required and is equivalent.

Amperes x 1.05 = Amperes/0.95

These are equivalent methods and provide the equivalent results. See response to Question 1a for additional detail.

d. *In relation to the previous question, please explain how the 5 percent design margin that is being credited as part of the aging coefficient will be maintained in order to meet the minimum criteria specified in the Technical Specification (TS) and the calculation.*

Response

The 5 percent design margin is not required to meet the minimum criteria specified in the TS and the calculation. Thus, it does not need to be maintained. It is included as a capacity margin to account for load variations during subsequent calculation revisions and future load additions.

An Aging Coefficient of <= 0.9 (90% battery capacity remaining) assures the SR 3.8.4.8 requirement of >= 90% of the manufacturer's rating is correctly modeled.

The EDSA software for DC Load Flow does not accept separate input variables for battery capacity (due to aging) and battery capacity (design margin), therefore battery capacity and design margin must be input as one variable, the Aging Coefficient.

2. *In the Revision Summary Section of the calculations the NRC staff notes that the Aging Coefficient is raised from 0.80 (80 percent) to 0.90 (90 percent) consistent with TS Surveillance Requirement (SR) 3.8.4.8. Describe the impact of this change on the expected life of CNS batteries (e.g., conclusions drawn from the battery life versus performance curve for the batteries).*

Response

The expected life for the CNS batteries will be shorter. This will be managed as part of the CNS Battery Program.

3. *Provide the technical basis for the resistance values in the calculations (i.e., resistance values for inter-cell, inter-tie, inter-rack, terminal, and the total battery). The NRC staff understands that a 15-25 micro-ohm limit was included in the discharge curves, but this assumes that a clean, tight connection is established. The purpose of the SR is to verify adequate connections; therefore, it appears that this value should be included in the calculation and not subtracted. Please explain how subtracting 15 micro-ohms from the resistance values listed in the calculations is a conservative assumption and consistent with manufacturer's recommendations.*

<u>Response</u>

The 50 micro-ohm (μΩ) value for inter-cell resistance is the "ceiling value" recommended from the battery manufacturer for C&D Technologies LCR-25 cell to cell connections. This value is the Administrative Limit (AL) for the connection, which is less than the TS Limit.

The cable resistance values are also the ALs for the Inter-Rack and Inter-Tier connections, which are also less than the TS Limits.

The resistance values included in Section 4.2.2 of NEDC 87-131C are included in the DC one-line model as a Zero foot (0') cable between the battery and the associated DC switchgear. That is, NEDC 87-131C has a 2300 μΩ connection between the battery and the connection cable to the switchgear to account for the total of inter-cell connectors, inter-tier cables and connectors and inter-rack cables connectors. The battery is modeled in EDSA by the number of cells (58) and type of cells (C&D LCR-25). The battery discharge curves include an assumed 15-25 μΩ.

NEDC 87-131C sums resistances as follows subtracting 15 μΩ for the resistance included in the discharge curves:

Intercell connectors	54 x (50-15) = 1890 μΩ
Inter- tier cables and connectors	2 x (95-15) = 160 μΩ
Inter-rack cables and connectors	(265-15) = 250 μΩ
Total Resistance	2300 μΩ

Adding the additional resistance (2300 μΩ) to the model increases the voltage drop to the supplied loads. This conservatively assumes that each connection is at the allowable AL (50 μΩ, 95 μΩ or 265 μΩ).

If a portion of the assumed resistance from the discharge curves was not subtracted, the 15-25 μΩ value (20 μΩ +/- 5 μΩ) would be modeled twice when calculating voltage at the supplied loads, once in the curve and once in the Total Resistance. Not subtracting for the resistance included in the discharge curves and including the maximum allowed connection resistance is unnecessarily conservative and not warranted. Using the lower value of 15 μΩ (versus median value of 20 μΩ) per connection provides the highest total resistance and thus the highest voltage drop due to connection resistances and is therefore conservative.

Enclosure

USER'S GUIDE EXCERPTS

EDSA
Electrical Distribution and Transmission
Systems Analyses and Design Programs

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USER'S GUIDE

EDSA*

ELECTRICAL DISTRIBUTION AND TRANSMISSION
SYSTEMS ANALYSES AND DESIGN PROGRAMS

OBJECT-ORIENTED DC LOAD FLOW

WINDOWS

EDSA MICRO CORPORATION
11440 W. Bernardo Court, Suite 370
San Diego, CA 92127
U.S.A.

Version 2.90.00

April 1999

EDSA
OBJECT-ORIENTED DC LOAD FLOW PROGRAM

I. FOREWORD

It is assumed that the user is a Professional Engineer familiar with the concepts of DC distribution systems, DC loads, DC generators, AC/DC rectifiers, rechargeable storage batteries and load flow calculation. Determination of validity of the results, and whether the DC Load Flow program is applicable to a system, is the user's sole responsibility.

EDSA DC Load Flow program is continuously improved in the attempt to make it as comprehensive and easy to use as possible. Additional analysis capabilities will be made available as they are developed. Any comments, suggestions or errors encountered in either the results or documentation should be immediately brought to EDSA's attention.

II. INTRODUCTION

Load flow study of a power system involves the study of the flow of power from one or more power sources through the distribution network to energy consuming loads. Electric power flow in a power network, like water flow in a complex water supply system, divides the flow among branches according to their respective resistances (impedances) until a pressure or voltage balance is reached according to Kirchhoff's laws.

Direct current (DC) power distribution systems have been extensively used in nuclear power plants and transit systems. The major concern in DC system load flow studies is the Voltage and Voltage drop at load buses. In many cases the load in a DC system varies with time. In such cases the total period of interest can be divided into small study periods. In each study period, bus load is assumed to be constant and the load flow is performed to show Voltage profile (Voltage plotted versus time period).

The commonly used DC power sources are DC generators, AC/DC rectifier converters, where AC power is converted into DC power, and rechargeable storage batteries. In the case of AC/DC rectifiers, the interaction between the AC and DC systems, the reactive power consumption and the harmonics generated by a rectifier are of concern. In the case of battery application, the discharge of the stored electric energy, and the battery Voltage profile are of interest. EDSA DC Load Flow program has been designed to study the load flow of DC distribution systems to assist the user in understanding the associated problems.

The DC load flow problem is nonlinear. The Newton-Raphson algorithm has been proved to be the most reliable method for nonlinear load flow problems. The Jacobian matrix is a sparse matrix. For a large network most of its elements are zeroes. The sparse matrix technique is used to speed up load flow solution and to save computer memory requirements.

III. CAPABILITIES

The program can handle DC systems with unlimited buses, branches, batteries and other devices. It can simulate up to 24 periods. Load can be modeled as constant power, constant current or constant impedance (resistance) load, or a combination of different types (functional load). Available DC power source models are : **constant-E (DC generator), rectifier and battery.** If the simulation periods are more than one, bus load and constant-E bus voltages can be differently specified for each period. **A rectifier may be modeled in DC Voltage control mode, DC current control mode or firing angle control mode.** Text output and graphics output are both available.

A battery can be simulated by using its discharge curves, supplied by the battery manufacturer. A library of commonly used battery discharge curves is available, ready to be used by the user. One can also easily add a new battery to the library and/or edit the existing battery curves in the library. The effect of operating temperature and aging factor on the performance of a battery can be simulated. A battery minimum Voltage, for example 1.75/Cell, can be specified by the user. The program can estimate the battery margin (in percent) against the minimum Voltage. The margin information can be used for battery sizing. Batteries with split bus can be simulated. The voltage profile of both the main bus and the split bus can be obtained.

V. MINIMUM SYSTEM VOLTAGE AS LIMITING FACTOR

For a minimum battery voltage, determined by the minimum system voltage, the use of the largest possible number of cells allows the lowest end-of-discharge cell voltage and, therefore, the smallest size cell for the duty cycle. For example,

$$\text{No. of cells} = \frac{\text{Min. allowable battery voltage}}{\textit{End - of - discharge cell voltage}} \qquad (2)$$

EXAMPLE: Assume that the minimum allowable battery voltage is 105 V and that the desired end-of-discharge cell voltage is 1.75 V.

No. of cells = 105 V/1.75 VPC
= 60

Calculations resulting in a fractional cell should be rounded off to the nearest whole number of cells.

VI. ADDITIONAL CONSIDERATIONS

TEMPERATURE CORRECTION FACTOR (K_T)

The available capacity of a cell is affected by its operating temperature. The standard temperature for stating cell capacity is 25°C (77°F). The temperature correction factor (K_T) functions for electrolyte temperature below 25°C (77°F) (i.e. the factor is used to determine the cell rating at 25°C (77°F) which will supply the required Ampere Hours (Ahs) at the lower temperature). The program maintains a table of suggested factors that can be changed to account for new or unusual conditions.

DESIGN MARGIN (Kd)

The design margin factor (**Kd**) compensates for unforeseen additions to the DC system. In addition, the factor (**Kd**) includes less-than-optimum operating conditions of the battery due to improper maintenance, recent discharge, or ambient temperature lower than anticipated, or both. Generally, a factor of 1.10 - 1.15 (i.e. 10% - 15% higher) is used.

AGING FACTOR (Ka)

The aging factor (**Ka**) allows the battery to meet its duty cycle as it reaches the end of its service life. A factor of **1.25** is normally used. ANSI/IEEE Std. 450-1980 [2] recommends that a battery be replaced when its actual capacity drops to 80% of its rated capacity; therefore, the battery's rated capacity should be at least 125% of the load expected at the end of its service life.

NOTE: Aging (Correction) factors are also used in EDSA Load Flow Program with a different meaning. The aging correction factor is used there to represent battery capacity degradation from aging after it is used for a period of time. It is always less than 1.0 (100%).

5.2 Temperature and Aging Correction

The effects of temperature and aging on battery capacity can be considered in the simulation. According to the new IEEE Std-P485-1994, the battery load current is adjusted by a temperature factor and an aging coefficient for a particular application, as follows:

$$\text{Amps(adjusted)} = \text{Amps(load)} \times \text{TempFactor} / \text{AgingCoef} \qquad (11)$$

For example, the battery discharge curves entered into the library are measured at a temperature of 25°C(77°F) and a particular time, but simulation may be desired at a condition of 60°F and at 5 years in use after the measurement. The temperature correction factor according to IEEE Standard (ANSI/IEEEStd 450-1987) is 1.110. It is believed that the battery has lost, for example, 3% of its capacity due to aging. The aging coefficient for this case is 0.97. The battery capacity (AmpHrs) is adjusted in the program according to eqn (11).

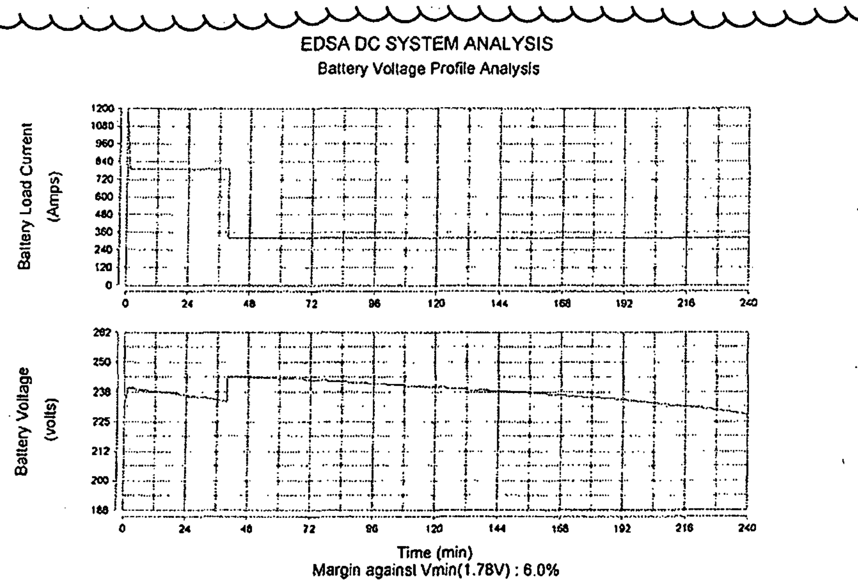

Fig.15 Battery Voltage Profile, Base Case

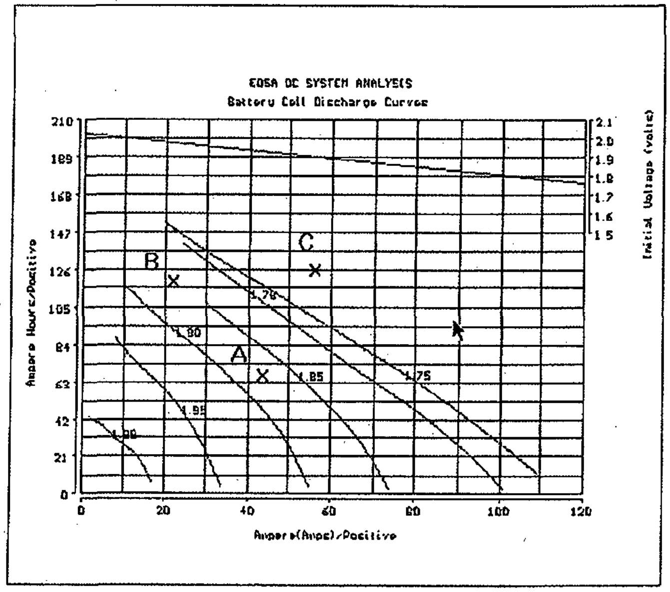

Fig.18 Battery Voltage Interpolation

Note: The aging correction coefficient used in the load flow study is different from the aging factor used in battery sizing. In battery sizing, a battery is sized for use, for example, for ten years. It must be "over-sized", say 20%, for the aging. Therefore, an aging factor of 1.20 has to be used. In the load flow study, a battery already in use, for example, for five years is simulated. The battery capacity may be less than the one described by the discharge curves. Therefore an aging correction coefficient, say 0.95, to count 5% capacity loss due to aging has to be used.

5.3 Battery Margin Estimation

On the battery Voltage profile graphic output there is a statement: Margin Against Vmin(1.78V) 6% (for example), which means the battery has a 6% margin (reserve) before its Voltage reaches the minimum Voltage. This is an approximate estimation method. It may be necessary to repeat the process to obtain an accurate battery margin estimation. The following is an example to show how to use the method to estimate the margin:

Base Case : A battery of 125 cells and 13 positive plates is simulated. The minimum cell Voltage is 1.78 Volts. The cell Voltage profile is shown in Fig.15. The battery has 6.0% margin against the min. Voltage.

Case-1: Decrease the battery capacity by 6.0%:

$$\text{Positive plates} = 13 \times 0.94 = 12.22. \qquad (12)$$

and use 12.22 positive plates. The Voltage profile simulation results are shown in Fig.16.

As can be seen from Fig.16, the lowest cell Voltage is nearly equal to 1.78V/Cell or 222.5V/Battery. The result says that the battery has a margin of -0.4%.

Case-2 : Continuing the estimation process, increase the battery positive plates by 0.4%, because of -0.4% margin in Case-1:

$$\text{Positive plates} = 12.22 \times 1.004 = 12.27 \qquad (13)$$

ATTACHMENT 3 LIST OF REGULATORY COMMITMENTS©4

Correspondence Number: **NLS2009110**

The following table identifies those actions committed to by Nebraska Public Power District (NPPD) in this document. Any other actions discussed in the submittal represent intended or planned actions by NPPD. They are described for information only and are not regulatory commitments. Please notify the Licensing Manager at Cooper Nuclear Station of any questions regarding this document or any associated regulatory commitments.

COMMITMENT	COMMITMENT NUMBER	COMMITTED DATE OR OUTAGE
None		