# Enclosure 3

# NEDC 87-131A, Revision 9, 250 VDC Division I Load and Voltage Study

Cooper Nuclear Station, Docket No. 50-298, DPR-46

# ATTACHMENT 1 DESIGN CALCULATION COVER SHEET

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| | |
|---|---|
| Title: 250 VDC Division I Load and Voltage Study | Calculation Number: 87-131A |
| | CED/EE Number: EE 02-038 |
| System/Structure: EE | Setpoint Change Number: N/A |
| Component: Various | Discipline: Electrical |
| Classification: [ X ] Essential; [ ] Non-Essential | SQAP Requirements Met? [X] Yes; [ ] N/A |

**Description:**

This NEDC documents the sequence of events on the Division I 250 Vdc system for the LOOP/LOCA and SBO scenarios at CNS. In addition, this NEDC determines the terminal voltage at the devices of the 250 Vdc Division I system and verifies that adequate voltage is available for components to perform their safety function.

**Revision Summary:**

Revised to use EDSA 2.95 as analysis software. Separated load profiles to show individual loading for SBO and LOCA scenarios. Added battery testing load profile. Performed minor correction of equipment load, cable data, thermal overload relay data, clarified requirements, assumptions, and methodology.

Raised Aging Coefficient from 0.80 (80%) to 0.90 (90%) consistent with Technical Specification Surveillance Requirement 3.8.4.8.

Incorporate changes from Revision 1 of NEDC 96-039, "DC Motor Operated Valve Stroke Time." The Design Calculation Cross-Reference Index sheet in NEDC 96-039 identifies NEDC 87-131A, B, C and D as affected documents and requiring change.

EJ 99-060 reviewed and determined to not require calculation incorporation as it was applicable for a temporary modification no longer installed.

Incorporated changes to address the following NAIT Items:
Other 4-03235 - Revise RPV level setpoint references to use generic levels (Level 1,2,3, etc.) rather than actual values in inches.
Other Calc 4-12992 - Incorporated revised NPBB load as documented in revised NEDC 90-395B.

CNS Personnel edited Appendix G of ERIN submittal to correct an editorial mistake. RR-MO-53A was described as being modeled with an inrush from 21 - 38 seconds. The valve was instead modeled as having an inrush time of only 3 seconds (21 - 24 seconds).
CNS Personnel also edited Appendix P of ERIN submittal to 're-run' the test profile to include the 0.90 aging factor. This change is consistent with the analyzed scenarios as well as conservative with respect to the calculations of record.

| | | | | |
|---|---|---|---|---|
| | | | | |
| 9 | 1 | ERIN Engineering & Research Company 5/29/02 | Ken Cohn<br>Ken Cohn 11/20/02 | Mike McCormack<br>M.R. McCormack 11/21/02 |
| Rev. Number | Status | Prepared By/Date | Reviewed By/Date | Approved By/Date |

**Status Codes**

| | |
|---|---|
| 1. Active | 4. Superseded or Deleted |
| 2. Information Only | 5. OD/OE Support Only |
| 3. Pending | 6. Maintenance Activity Support Only |

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Nebraska Public Power District

## DESIGN CALCULATION CROSS-REFERENCE INDEX

| ITEM NO. | DESIGN INPUTS | REV. NO. | PENDING CHANGES TO DESIGN INPUTS |
|---|---|---|---|
| 1 | NEDC 91-044 | 4 | None |
| 2 | NEDC 91-197 | 1 | None |
| 3 | NEDC 93-022 | 5 | EJ 96-144, EJ 97-87, EJ 97-101, EJ 97-72 REV.1, EJ 98-66, EJ 98-67, EJ 98-68, EJ 97-121 thru 124 |
| 4 | Procedure 5.3SBO | 2 | None |
| 5 | STP 87-013 | 0 | None |
| 6 | STP 92-034 | 0 | None |
| 7 | Procedure 14.10.11 | 4 | None |
| 8 | Tech Spec 3.8.4.8 | 178 | None |
| 9 | NEDC 90-395B | 3 | CCN 2C1 |
| 10 | Dwg 3058 | N41 | None |
| 11 | Dwg E507 Sht. 211 | N09 | None |
| 12 | Dwg E507 Sht. 212A | N07 | None |
| 13 | Dwg 3010 Sht 1 | N65 | None |
| 14 | CNS Procedure 6.EE.609 | 8 | None |
| 15 | CNS MOV Program Plan | 6 | None |
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## DESIGN CALCULATION CROSS-REFERENCE INDEX

| ITEM NO. | AFFECTED DOCUMENTS | REV. NUMBER |
|---|---|---|
| 1 | NEDC 91-094 | 4 |
| 2 | NEDC 93-022 | 5 |
| 3 | NEDC 88-298 | 4 |
| 4 | SBO Coping Analysis for CNS | 2 |
| 5 | DCD-35 | 2 |
| 6 | Technical Specification Bases, Section 3.8.4 | 0 |
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## ATTACHMENT 3 AFFECTED DOCUMENT SCREENING

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The purpose of this form is to assist the Preparer in screening new and revised design calculations to determine potential impacts to procedures and plant operations.©

| | SCREENING QUESTIONS | YES | NO | UNCERTAIN |
|---|---|---|---|---|
| 1. | Does it involve the addition, deletion, or manipulation of a component or components which could impact a system lineup and/or checklist for valves, power supplies (breakers), process control switches, HVAC dampers, or instruments? | [ ] | [X] | [ ] |
| 2. | Could it impact system operating parameters (e.g., temperatures, flow rates, pressures, voltage, or fluid chemistry)? | [ ] | [X] | [ ] |
| 3. | Does it impact equipment operation or response such as valve closure time? | [ ] | [X] | [ ] |
| 4. | Does it involve assumptions or necessitate changes to the sequencing of operational steps? | [ ] | [X] | [ ] |
| 5. | Does it transfer an electrical load to a different circuit, or impact when electrical loads are added to or removed from the system during an event? | [ ] | [X] | [ ] |
| 6. | Does it influence fuse, breaker, or relay coordination? | [ ] | [X] | [ ] |
| 7. | Does it have the potential to affect the analyzed conditions of the environment for any part of the Reactor Building, Containment, or Control Room? | [ ] | [X] | [ ] |
| 8. | Does it affect TS/TS Bases, USAR, or other Licensing Basis documents? | [X] | [ ] | [ ] |
| 9. | Does it affect DCDs? | [X] | [ ] | [ ] |
| 10. | Does it have the potential to affect procedures in any way not already mentioned (see review checklists in Procedure EDP-06)? If so, identify: | [ ] | [X] | [ ] |

The Station Blackout Coping Assessment, Rev. 2 (Ret# 09666 0008) states that an aging factor of 1.20 (0.80%) is applied in the battery capacity calculations to account for battery degradation and is conservative with respect to Technical Specification, which allows no more than a 15% reduction in rated capacity. This same discussion is also included in DCD-35. CNS Technical Specifications now, however, allow no more than a 10% reduction in rated capacity. This revision utilizes an aging coefficient of 0.90 (equates to aging factor of 1.11) which is consistent with a 10% reduction is capacity. This revision remains consistent with Technical Specifications. The Coping Assessment and DCD-35 should be revised to clarify the treatment of "battery aging" in the new revision of NEDC 87-131A.

If all answers are NO, then additional review or assistance is not required.

If any answers are YES or UNCERTAIN, then the Preparer shall obtain assistance from the System Engineer and other departments, as appropriate, to determine impacts to procedures and plant operations. Affected documents shall be listed on Attachment 2.

[illegible]

ERIN® ENGINEERING AND RESEARCH, INC.

# CALCULATION COVER SHEET

Project No: 0122-01-0044 Project Name: Update DC Calculations

ERIN Calc No.: C0122010044.004 Client Calc No. NEDC 87-131A, Revision 9

Client Name: Nebraska Public Power District

Subject: Revision 9 of 250 VDC Division I Load and Voltage Study

Total Sheets (including cover) 86

| | | | |
|---|---|---|---|
| Computer Program: EDSA | Standard Computer Program<br>☒ YES ☐ NO | Program No(s). | Version/Release No.<br>Client's Version 2.95 |

## REVISION RECORDS

| Rev. | Description | Orig. | Ckd. | App. | Date |
|---|---|---|---|---|---|
| 0 | Initial Issue | See Previous Cover Sheet for Signatures and Dates | | | |
| 1 | Revised to Incorporate NPPD Comments | Thomas L. Sarver<br>2002/05/29 | Roger W. Moberly<br>5/29/02<br>Roger Moberly | C. KEN CAPLES | 5/29/02 |
| | | | | | |

REMARKS

This calculation was performed under the ERIN QA Program consistent with NPPD-CNS Procedures and Practices. This calculation is a revision of an existing District Calculation. Refer to the District Calculation Cover Sheet (next page) for details of the revision. Complete rewrite of text and appendices.

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## APPENDICES

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| Appendix A | Load Flow/Voltage Drop Results Summary - LOOP/LOCA |
| Appendix B | Load Flow/Voltage Drop Results Summary - SBO |
| Appendix C | Not Used |
| Appendix D | One-Line Cable Information |
| Appendix E | Not Used |
| Appendix F | Scenario Profile Data - LOOP/LOCA |
| Appendix G | Scenario Loading Descriptions - LOOP/LOCA |
| Appendix H | Scenario Profile Data - SBO |
| Appendix I | Scenario Loading Descriptions - SBO |

NEDC: 87-131A Preparer: Reviewer:

Rev. No: 9 Date: 2002/05/22 Date: 5/29/02

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|---|---|
| Appendix J | Not Used |
| Appendix K | Not Used |
| Appendix L | Not Used |
| Appendix M | EDSA Output - LOOP/LOCA |
| Appendix N | EDSA Output - SBO |
| Appendix O | Not Used |
| Appendix P | EDSA Output – Service Test Profile |
| Appendix Q | Letter from G. Walker (C&D) to A. Bitar (DE&S) |
| Appendix R | Not Used |
| Appendix S | Inverter 1A Efficiency and Load Determination |
| Appendix T | EDSA Battery Loading Summary |
| Appendix U | Record of Walkdown |
| Appendix V | EDSA Model ECAD One Line Diagram |

## 1.0 PURPOSE

The purpose of this NEDC is to demonstrate, by analysis, the adequacy of voltage to Division I 250VDC components to perform their required function for all design basis events. This includes the following:

1) Determine the 250 VDC Division I equipment start, stop, and run times for the following scenarios:

   a) LOCA event with concurrent loss of 250 VDC battery chargers and loss of off-site power occurring at time t = 0 seconds and ending at t = 4 hours.

   b) Station Blackout (SBO) occurring at time t = 0 seconds and ending at t = 4 hours. (Ref. 6.23)

   Note: Based on the Appendix R Post-Fire Safe Shutdown Topical Design Criteria Document (Ref. 6.30-4), the 250 VDC Division I system is not required for the Appendix R Fire Alternate Shutdown scenario. Therefore, no Appendix R scenario or loading analysis is developed or performed.

2) Determine the loads on each of the main buses in the 250 VDC Division I system for the LOCA and SBO scenarios.

3) Determine the terminal voltages at the devices in the 250 VDC Division I System and verify adequate voltage to perform their safety function for the LOCA and SBO scenarios.

4) Verify adequate voltage exists at the DC Starter Buses for the Motor-Operated Valves (MOVs) in the "CNS MOV Program Plan" (Ref. 6.12).

## 2.0 REQUIREMENTS

All safety related components in the 250 VDC system must have adequate voltage to perform their safety function for the 4 hours LOOP/LOCA and SBO scenarios as defined by specific load types below:

1) All 250 VDC starter rack bus voltages must be greater than the required 125 VDC required to maintain operability of the Siemens 3TH8 undervoltage relays.

2) The terminal voltage to the inverter must be greater than 210 VDC throughout the scenario (Ref. 6.18).

3) The 250 VDC Reactor Building Starter Rack bus voltage must be greater than 184 VDC (80% of rated 230V) for proper operation of the Siemens contactors per VM 1026 (Ref. 6.16).

4) The 250 VDC Division I Starter Racks powering DC MOVs in the CNS MOV Program Plan must have a minimum calculated bus voltage greater than the minimum allowable voltage defined in NEDC 93-022 (Ref. 6.8).

5) The sustained terminal voltage at motors must be equal to or greater than 90% of motor's rating. (Ref. 6.29)

## 3.0 DESIGN INPUTS / ASSUMPTIONS

### 3.1 DESIGN INPUTS

1) For motor loads other than MOVs, the circuit resistance is based on two times the power cable length between the starter and the DC motor. The cable Size and length is taken from NEDC 91-044 (Ref 6.2).

2) For motor-operated valves, the thermal overload (TOL) resistance is taken from NEDC 93-022 (Ref. 6.8).

3) The battery duty cycle is 4 hours for a LOOP/LOCA, and for the SBO scenario

4) The 250 Vdc battery is a C&D LCR-25. This is a lead calcium battery with 25 plates/cell, 120 cells/bank, and four square posts/cell.

5) The battery discharge characteristics are taken from the C&D Battery Discharge Characteristic Curve, D841, as captured and verified in the EDSA software. (EDSA battery profile C&D LCR-25 D841).

6) A worst case ground fault, defined in NEDC 91-197 (Ref. 6.9), of 2.11 amps at 270 VDC is added to the 250 VDC switchgear bus to conservatively account for ground faults in any non-essential circuits in the 250 VDC Division I distribution system.

7) Inverter 1A efficiency is taken from the original purchase documentation testing included in P.O. 332834 (Ref. 6.18)

## 3.2 ASSUMPTIONS

1) The individual load start and stop times are given in Appendices F and H of this calculation, which list the main events of the scenarios, and the individual assumptions for each load.

2) Conductor temperatures are conservatively assumed to be 75 °C. Most of these loads are intermittent, and the continuous loads are well below the ampacity of the cables. Therefore, a conductor temperature of 75 °C is considered adequate for these loads.

3) The TOL resistance tends to reduce the amount of current flowing during the critical starting period of operation because the starting load is a constant impedance. During the running period, the motor is modeled as a constant current device so the TOL resistance reduces available voltage to the motor. For conservatism, the TOL is input at rated (25 °C) temperature. This assures starting load current is not underestimated. During the running period, the conservatism of modeling the motor as a constant current load will compensate for any increased resistance of the TOL due to increased temperature.

4) Based on STP 92-034 (Ref. 6.5), a DC motor powering a pump type load will operate properly during low voltage conditions; however, the power output of the motor will be significantly reduced, which could affect the function of the pump type load. The results of STP 92-034 indicate that for a compound motor, the input current will vary as the input voltage to the 1.01 power and for a shunt motor, the input current will be directly proportional to the input voltage. Although the relationship closely resembles constant resistance, a constant resistance model is not always conservative. Therefore, a constant current model at rated voltage is used.

5) For opening MOVs, sufficient torque must be produced to operate the MOV during the unseating period. The required torque is directly related to a minimum required starter rack bus voltage, which must be available in order for the MOV to operate. The minimum calculated starter rack bus voltage will be compared to the minimum required starter rack bus voltage defined in NEDC 93-022 (Ref. 6.8) to verify adequate voltage is available for the MOVs to perform their safety function.

6) The Bus 1F First Level Undervoltage relays have a one second time delay after sensing a loss of voltage condition to the time when an automatic action is initiated.

7) The inverter efficiency can be approximated by a linear relationship from zero to full load current. The effect of input voltage variation can be accounted for by the linear interpolation of the low and high volt test performance.

8) Motors with a terminal voltage of at least 90% of rated (0.90 x 240V = 216V or 0.9 x 250V = 225V) are assumed to produce required horsepower since motors are designed and sized to produce required power with +/-10% of rated voltage.

9) Impedance of internal control wiring and power fuses, transfer/disconnect switches and power contacts of contactors are insignificant as compared to the cable and device impedances and are not included.

10) The DC motors supplied from this system have an efficiency of 85% or greater.

11) The RCIC condensate pump is assumed to operate periodically during a small break LOCA/LOOP event. However, is not assumed to operate during the first minute. This is because it is not considered credible that the condenser would fill to a sufficient level within this time period

## 4.0 METHODOLOGY

The following sections describe the loading scenarios and model details used to perform the system load and voltage study.

### 4.1 SCENARIO DEVELOPMENT

Appendices G and I list the main events of the postulated event sequences that address the two design basis events. These events are LOOP/LOCA and SBO. As described in section 1.0, an event specific Appendix R load profile is not required for the Division I 250 Vdc system. The following sections describe the operation of equipment based on these scenarios. References to starting time are intended to apply to the time interval that begins at that value unless specifically stated otherwise.

### 4.1.1 LOOP/LOCA Scenario

For the LOOP-LOCA scenario, the large break LOCA represents the most limiting case for the DC system even though the RCIC system would operate longer during a small break LOCA. During the first minute of operation, the RCIC system vacuum pump is started and is postulated to operate until secured by operator action. The RCIC system condensate pump is assumed to operate periodically during the event. However, it is not assumed to operate during the first minute. This is because it is not considered credible that the condenser would fill to a sufficient level within this time period

A large break, loss of coolant accident (LOCA) is assumed to occur at T=0 seconds. At the same time, a loss of offsite power (LOOP) occurs. The 0-1 second time interval represents the instrument response delay. As such, the application of the system loads in response to the postulated event occurs at T=1 second.

The large break will cause the High Pressure Coolant Injection (HPCI) system to be initiated by high containment pressure or low reactor water level and the Reactor Core Isolation Cooling (RCIC) system to be initiated by low reactor water level. The HPCI system is assumed to initiate first at T=1 seconds on high drywell pressure with RCIC system initiation on low reactor water level (Level 2, Ref. 6.30-21) occurring immediately thereafter at T=2 seconds (Ref. 6.30-20). Because of the relatively rapid depressurization of the reactor due to the LOCA, the HPCI and RCIC systems will isolate due to low steam pressure. This results in a start and isolate cycle for both the HPCI and RCIC systems. Reactor pressure will be down to 100 psig at approximately 40 to 45 seconds and 50 psig at T=60 seconds (Ref. 6.30.6, Fig. 4-7.1), which will initiate isolation of HPCI and RCIC, respectively, on low reactor pressure.

The LPCI injection valves and the associated recirculation pump discharge valve are initiated based on an appropriate reactor pressure permissive signal. Other DC system loads are started because of falling lube oil pressure caused by loss of AC power, e.g., main turbine and generator lube oil and seal oil pumps, and reactor feed pump oil pumps. In addition, the NBPP inverter load is supported by the Div. I battery.

Finally there is a random load associated with the potential cycling of the HPCI system and/or RCIC system for a postulated small break LOCA. This is discussed further in the random loads section below.

Appendix G contains the bases for the treatment of the load timing for the LOOP/LOCA scenario. Appendix F tabulates the load sequencing and magnitudes for the LOOP/LOCA scenario.

### 4.1.2 SBO Scenario

A loss of offsite power (LOOP) is assumed to occur at T=0 seconds which initiates a scram. The emergency diesel generators are assumed not to be available for the duration of the event. Since no AC power is available, the batteries supply the necessary DC loads to maintain the plant is a safe condition.

The scram and loss of condensate and condensate booster pumps causes reactor water level to drop which causes the High Pressure Coolant Injection (HPCI) and Reactor Core Isolation Cooling (RCIC) systems to start. The RCIC and HPCI are conservatively assumed to initiate at the low reactor water level (Level 2 – Ref. 6.30-21) after a 2 second delay (Ref. 6.30-20) consistent with the LOOP/LOCA event timing. The initiation signals will cause

RCIC and HPCI valves and pump motors to operate to correctly line up the systems. These systems help bring the reactor water level and pressure under control. No independent failures, other than those causing the station blackout event, are assumed to occur in the course of the event. Since there is no significant reactor water loss, the ECST inventory is adequate for this scenario and no transfer to the suppression chamber (torus) will be required (Ref. 6.30-3).

The SBO coping analysis (Ref. 6.30-3) states that the HPCI system cycles once and that the RCIC system cycles six times per hour. These additional cycles do not have definite time periods of operation; therefore, the cycling of the RCIC system will be treated as a random load, which is discussed below. At the end of the 4 hour coping duration, a successful EDG start and breaker closure occurs to terminate the SBO event.

Appendix I contains the bases for the treatment of the load timing for the SBO scenario. Appendix H tabulates the load sequencing and magnitudes for the SBO scenario.

### 4.1.3 Random Load

The random load on the 250 Vdc division I system is the RCIC system. As indicated above the RCIC is assumed to operate six times per hour during the SBO event. The exact time of operation is unknown and therefore, this load is random.

Further, the RCIC condensate pump, which cycles as needed, is also considered a random load. As described in Appendices F and H, this load has starting resistors to limit inrush current. It is conservatively modeled in both scenarios as starting at T= 42 seconds and running continuously for the remainder of the event.

## 4.2 SPECIFIC LOADING DETAILS

Appendices F and G list the individual loads at their rated voltage. The following provides the basis of the developed loads.

1) MOV Locked Rotor Amps (LRA) - This value is the locked (0 speed) motor current, in amps, at motor rated temperature obtained from NEDC 93-022 (Ref. 6.8). For MOVs that stroke from closed to open, the LRA is only listed at the beginning of the stroke. For MOVs that stroke from open to closed, the LRA will be listed at the beginning of the stroke for initial starting considerations and also at the end of the stroke for seating considerations for valves that have a close function and close on differential pressure (dP). This starting and closing load is treated as a constant impedance load based on the LRA and motor rated voltage.

2) MOV Running Amps - The MOV motor nameplate current will be used as the running current after the 3 seconds locked rotor period. This will be conservative because the unseating and initial high differential pressure period is complete. This value is approximately the 20% motor torque value on the motor speed-torque curve and is typical for an MOV in the middle of the stroke. MOV running load is treated as a constant during the valve stroke (after the initial 3 seconds) because the current controls the torque, not the terminal voltage. Therefore, MOVs will be modeled as constant current loads. The MOV motor rated resistance is used in EDSA by dividing the motor rated voltage by the motor rated current.

3) Non-MOV LRA - The value used for non-MOV motor LRA loads is ten times the nameplate FLA unless starting resistors are installed. If starting resistors are installed, then two times the nameplate FLA is used, which is conservative because the reduced voltage starter will limit the starting inrush to 1.5 to 2.0 times FLA. This value is also treated as an ohmic load.

4) Non-MOV Running Amps - The value used for non-MOV motor running amps is nameplate FLA. From Assumption 3.2(4), these motors behave very similar to a constant impedance load and since the motor terminal voltage is less than the motor rated voltage, the motor current is equal or less than the rated current. However, for conservatism, motors are modeled as constant current loads.

5) Inverter 1A Load – The inverter load is based on the supplied load as detailed in the NBPP load calculation (Ref. 6.11) and the efficiency of the inverter as developed in Appendix S. The efficiency is based on vendor test data corrected for input voltage and percentage of rated load supplied by the inverter. Performance testing of the inverter was conducted for no load and full rated load at 210V and 280V. The efficiency of these two test series is combined by linear interpolation to achieve 230V efficiency, which is approximately the input voltage during the battery loading sequence. The final input load is determined by use of the combined efficiency and the load current is determined using rated inverter input voltage of 230V. This load current and nominal voltage is input to EDSA as a constant power load.

## 4.3 POWER CABLE IMPEDANCE

Appendix D lists the cable number and circuit length from 91-044 (Ref. 6.2). For MOVs with TOLs, the TOL resistance, obtained from NEDC 93-022 (Ref. 6.8) is included in the cable resistance. The total cable resistance is equal to: $R_{VD} = R_{cable} + R_{TOL}$.

The total circuit length is input into the EDSA program. For MOV feeders, this is equal to four times the one-way cable length. For non-MOV loads, this is equal to two times the one-way length. EDSA performs the circuit resistance calculation based on the input parameters and the analysis temperature (75°C).

## 4.4 CONTROL CIRCUIT IMPEDANCE

The controls for the DIV I starters for EE-STR-250 (MO25A) and EE-STR-250 (MO53A) are powered from the 250 VDC motive power supply for the starters. The control circuits that automatically operate these MOVs during a LOCA are defined below with their respective cables:

RR-MO-53A

| Cable ID | Size | Length (Ft) | From | To |
|---|---|---|---|---|
| DC514 | 12 AWG | 260 | EE-STR-250(53A) | RR-MO-53A |
| DC514 | 12 AWG | 260 | RR-MO-53A | EE-STR-250(53A) |
| DC515 | 12 AWG | 400 | EE-STR-250(53A) | BD 9-4 |
| H623 | 12 AWG | 200 | BD 9-4 | BD 9-32 |
| H694 | 12 AWG | 21 | BD 9-32 | BD 9-33 |
| H694 | 12 AWG | 21 | BD 9-33 | BD 9-32 |
| H623 | 12 AWG | 200 | BD 9-32 | BD 9-4 |
| DC515 | 12 AWG | 400 | BD 9-4 | EE-STR-250(53A) |
| Total | | 1762 | (2-way cable length) | |

RHR-MO-25A

| Cable ID | Size | Length (Ft) | From | To |
|---|---|---|---|---|
| DC498 | 12 AWG | 260 | EE-STR-250(25A) | RR-MO-25A |
| DC498 | 12 AWG | 260 | RR-MO-25A | EE-STR-250(25A) |
| DC511 | 12 AWG | 400 | EE-STR-250(25A) | BD 9-3 |
| RH20 | 12 AWG | 156 | BD 9-3 | BD 9-32 |
| H694 | 12 AWG | 21 | BD 9-32 | BD 9-33 |
| H694 | 12 AWG | 21 | BD 9-33 | BD 9-32 |
| RH20 | 12 AWG | 156 | BD 9-32 | BD 9-3 |
| DC511 | 12 AWG | 400 | BD 9-3 | EE-STR-250(25A) |
| Total | | 1674 | (2-way cable length) | |

## 4.5 BATTERY CONNECTION IMPEDANCE

The resistance between the battery and the switchgear consists of three components: the inter-cell connections, the inter-rack/level connections, and the cable connections. The cable connections consist of DC6A and DC6B (DC6C is included in the inter-rack connection resistance). The resistance of these cables is determined in NEDC 91-044 (Ref. 6.2). In addition to the cable resistance, connection resistance of 50 micro-ohms is added for each battery termination (total is for all 3 conductors in each cable).

The resistance of the inter-cell connections is based on allowable limits for these connections. CNS Procedure 6.EE.609 (Ref. 6.25) establishes the "ACCEPTABLE VALUE" for inter-cell connection resistance. The measured resistances vary due to changes in connection tightness and surface corrosion. The use of the maximum "ACCEPTABLE VALUE" resistance for all battery connections provides a margin that will envelop actual measured connection resistances. This is conservative since it is improbable that all connections will be at their administrative limit simultaneously, therefore, on average the intercell connection resistances would be below this limit.

Per reference 6.21 (Appendix Q) the published "as built" ratings and discharge characteristics for the LCR-25 include the voltage drop across standard connectors torqued to specification and having a nominal resistance of 15 to 25 micro-ohms. Since this resistance value is "embedded" in the discharge characteristic curves, they are already accounted for, and need not be included in the cable resistance. Therefore, a value of 15 micro-ohms is used as a conservative value for the intercell connector resistance included in the published ratings and discharge characteristics. In turn, 15 micro-ohms are subtracted from the assumed maximum connection resistance taken from CNS Procedure 6.EE.609 (the ACCEPTABLE VALUE, or administrative limit). The exception to this is the cable connection resistance at the battery terminals, where 15 micro-ohms are not subtracted since these are considered external connections.

The following tabulation documents the battery to switchgear connection impedance. This value is used as the Battery to Switchgear impedance in EDSA.

Battery Connection Impedance

| | | |
|---|---|---|
| Inter-cell resistance | 112 x (50-15) = | 3920 μΩ |
| Inter-tier cable resistance (29-30, 89-90) | 2 x (95-15) = | 160 μΩ |
| Inter-rack cable resistance (15-16, 43-44, 73-74, & 105-106) | 4 x (85-15) = | 280 μΩ |
| Inter-rack cable resistance (58-59)* | 1 x (265-15) = | 250 μΩ |
| Cables terminals | 2 x (50) = | 100 μΩ |
| Cable DC6A | | 260 μΩ |
| Cable DC6B | | 390 μΩ |
| Total resistance | | 0.005360 Ω |

* Includes Cable DC6C

## 4.6 EDSA INPUT

The following sections provide details of the model and data entry into the EDSA program including cable and thermal overload resistance, loading and battery characteristics.

### 4.6.1 Circuit Impedance

Cable data from NEDC 91-044 are input into EDSA. The cable resistance values are based on Okonite cable. These values are Okonite annealed copper cable values per NEDC 91-044. These values are entered into the EDSA file "feeder.dt2" at 25°C and only include the resistance. The cable coding includes "0K DC" followed by the wire size, e.g., a number 12 AWG cable is "0K DC #12." The EDSA program corrects the resistance for the analysis temperature set in the "Master" file. For this analysis, the temperature is set at 75°C.

The cable length in EDSA is input as the total circuit length for each path. For example, MOV cables are entered as four time the one-way cable length and dc motors are entered as two times the one-way cable lengths. The one-way length is from Appendix D (source NEDC 91-044) and is corrected for circuit length prior to entry. EDSA uses this number directly as the "Feeder R Option" is set to "Rx1" in the Master file. This data is in the EDSA Job file (250D1L.EDS and 250D1S.EDS).

The MOV thermal overload relays (TORs) are included as protective devices on the bus side of the feeder cable to the MOV. The corrected values from Appendix D have been input to the EDSA database. These values have been added to the "bkrdata.dat" file and are coded "TOR" followed with the valve number, e.g., for MOV HPCI M19, the TOR is "TOR HP MO19." The resulting circuit impedance reported by EDSA in the input data print is the combination of the cable and TOR resistance.

See Appendix D for additional circuit impedance coding information.

### 4.6.2 Loads

The load magnitude, type and sequencing are input into EDSA as identified in Appendices f and H. Loads that do not operate are shown as "non-load" in the data file. Control loads are input as constant impedances, and MOV and motors are input as starting motors. The system ground detection is included as a load on the switchgear bus. Control loads are modeled with the total circuit length and operating loads to simulate the voltage drop. See Appendix A for additional load coding information. This information is in the EDSA Job file.

### 4.6.3 Battery

EDSA corrects for temperature and aging by correcting battery current based on the following formula (Ref. 6.27, See EDSA Help files):

$$I_{corr} = I_{batt} \times \left( \frac{\text{Temp. Factor}}{\text{Aging Coef.}} \right)$$

Where:

$I_{corr}$ = Corrected battery current

$I_{batt}$ = Nominal battery current

Temp. Factor = Temperature correction factor (from IEEE std 450-1987, per Ref. 6.27)

Aging Coefficient = Fraction of manufacturer's rated battery capacity (e.g. if battery has lost 3% of its rated capacity, the aging coefficient is 0.97)

The battery terminal voltage is calculated using the following correction factors:

a) Temperature Correction factor of 1.04 to allow for a battery room temperature of 70 °F.

b) Aging Coefficient of 0.90 which will allow 10% degradation (90% capacity) of the battery to account for aging effects. Per CNS Technical Specification Surveillance Requirement 3.8.4.8, battery capacity is required to be 90% of rated or greater.

c) Design Margin Factor of 0.95 which gives a margin of 5% to account for any load variations found during subsequent calculation revisions prior to approval and is acceptable because a revision to this NEDC will be performed prior to adding new loads. Since EDSA does not include the design margin in calculating terminal voltage, the 5% design margin is combined with the aging coefficient. This results in a coefficient of (0.90 x 0.95) = 0.855 (Conservatively rounded to 0.85).

The analysis uses a verified battery curve contained in the QA approved EDSA for a C&D type LCR-25 D841.

### 4.6.4 Data Files

Three EDSA data files were updated placed in the EDSA295:\DATA subdirectory. Those files include: Z1QE13K4.BVL, MANUFACT.MAN, and C&D.BTB. Revision of these files was necessary to reflect cables with overload heater resistances included with the cable (See Protective Dev tab in EDSA Branch editor for the individual cables or Appendix D of this calculation) and also to include a modified battery performance curve that includes lower discharge rates than is shown on C&D drawing D-841. The modified battery is denoted as LCR-25 NPPD. This calculation does not use the modified battery information; rather the standard LCR-25 D-841 battery is used. This information is included for completeness since the LCR-25 NPPD battery is used for other 87-131 series calculations.

## 4.7 BATTERY SERVICE TEST PROFILE

IEEE 450-1995 (ref. 6.26) describes a service test as a special battery capacity test that may be required to determine if the battery will meet the duty cycle of the dc system. In this case, that duty cycle is either a LOOP/LOCA or an SBO load profile. A single test is desired, so a duty cycle that envelops the two profiles will be developed. Since the test profile is different, the battery terminal voltage values (especially later in the profile) would be expected to be different than those calculated for each individual profile.

An EDSA Test model is included that reflects the test condition. The EDSA model used to develop the voltage acceptance criteria for the test represents the battery at standard temperature (77°F), without aging and no design margin. During testing, the test load is connected directly to the battery terminals. Therefore, the only cable in the model represents the inter-cell connectors, inter-tier and inter-rack cables. The only load in the model is the constant current load of the test set, which changes for each time step as required to meet the test profile.

The EDSA DC Load Flow program provides, as an output, the total load and current for each step of the analysis. This load data is calculated using actual loads based on the load flow analysis that included loads dependent on voltage. In addition to the load current at the battery, the battery voltage is also output. This data is compiled for use in establishing a load test profile. The test input current values for each time step are the maximum value for that time step taken from the analysis results in appendices M and N. These results are tabulated in Appendix T.

The cable resistance includes all of the inter-cell connectors and associated cables at their administrative maximum values (Ref. 6.25) plus two test connections at 100μΩ. The use of the full administrative limit for intercell connections provides a conservative enveloping of the in-service condition and assures adequacy of the test profile to envelope the actual load. This gives a resistance of:

| | |
|---|---|
| Inter-cell resistance | 112 x 50 = 5600 μΩ |
| Inter-tier cable resistance (29-30, 89-90) | 2 x 95 = 190 μΩ |
| Inter-rack cable resistance (15-16, 43-44, 73-74, & 105-106) | 4 x 85 = 340 μΩ |
| Inter-rack cable resistance (58-59)* | 1 x 265 = 265 μΩ |
| Test connections | 2 x 100 μΩ = 200 μΩ |
| Total | 6595 μΩ |

* Includes cable DC6C

It is desired that the service test profile be in full minute increments. Combining the LOOP/LOCA and SBO scenario profiles yields a four step test profile with periods of:

| Interval | Duration | Elapsed Time | Min Req'd Current (A) | Corrected Current (A) | Min. Accept. Voltage (V) |
|---|---|---|---|---|---|
| 0-1 minutes | 1 min | 1 min | 368.4 | 376 | 228.6 |
| 1-2 minutes | 1 min | 2 min | 379.6 | 388 | 228.3 |
| 2-60 minutes | 58 min | 1 hour | 116.5 | 119 | 234.6 |
| 60-240 minutes | 3 hrs | 4 hours | 155.6 | 159 | 231.6 |

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The service test profile envelopes the analyzed design basis load profiles. The current values shown in the minimum required current column are the highest value from the analysis results in Appendices M and N for either profile taken for the full duration of each time step in the test profile. The corrected current column reflects the addition of 2% to the minimum values to account for instrument and test equipment errors. The values are rounded up to the next whole ampere. This ensures that the actual test current will envelop the minimum required current profile. The values in the minimum acceptable voltage column represent the minimum acceptable voltage at the end of each time step. The test profile analysis is conducted at standard temperature (77 degrees F). ~~Additionally, no aging factor or design margin is applied in the development of the load profile which contributes to conservative minimum acceptable voltage values.~~

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The cable resistance includes all of the inter-cell connectors and associated cables at their administrative maximum values (Ref. 6.25) plus two test connections at 100μΩ. The use of the full administrative limit for intercell connections provides a conservative enveloping of the in-service condition and assures adequacy of the test profile to envelope the actual load. This gives a resistance of:

| | | |
|---|---|---|
| Inter-cell resistance | 112 x 50 = | 5600 μΩ |
| Inter-tier cable resistance (29-30, 89-90) | 2 x 95 = | 190 μΩ |
| Inter-rack cable resistance (15-16, 43-44, 73-74, & 105-106) | 4 x 85 = | 340 μΩ |
| Inter-rack cable resistance (58-59)* | 1 x 265 = | 265 μΩ |
| Test connections | 2 x 100 μΩ = | 200 μΩ |
| Total | | 6595 μΩ |

* Includes cable DC6C

It is desired that the service test profile be in full minute increments. Combining the LOOP/LOCA and SBO scenario profiles yields a four step test profile with periods of:

| Interval | Duration | Elapsed Time | Min Req'd Current (A) | Corrected Current (A) | Min. Accept. Voltage (V) | |
|---|---|---|---|---|---|---|
| 0-1 minutes | 1 min | 1 min | 368.4 | 376 | 229.3 | |
| 1-2 minutes | 1 min | 2 min | 379.6 | 388 | 229.0 | |
| 2-60 minutes | 58 min | 1 hour | 116.5 | 119 | ~~235.6~~ | 234.8 |
| 60-240 minutes | 3 hrs | 4 hours | 155.6 | 159 | ~~233.8~~ | 232.7 |

RWM 5/29/02

The service test profile envelopes the analyzed design basis load profiles. The current values shown in the minimum required current column are the highest value from the analysis results in Appendices M and N for either profile taken for the full duration of each time step in the test profile. The corrected current column reflects the addition of 2% to the minimum values to account for instrument and test equipment errors. The values are rounded up to the next whole ampere. This ensures that the actual test current will envelop the minimum required current profile. The values in the minimum acceptable voltage column represent the minimum acceptable voltage at the end of each time step. The test profile analysis is conducted at standard temperature (77 degrees F). Additionally, no aging factor or design margin is applied in the development of the load profile which contributes to conservative minimum acceptable voltage values.

## 5.0 CONCLUSIONS

The EDSA run-results, including a data input echo print, are provided in Appendices M, N, and P. The results are summarized and discussed in the following sections.

### 5.1 RESULTS SUMMARY

The individual load start and stop times are given in Appendices F and H. Cable resistances are provided in Appendix D. Required minimum MOV voltage requirements are from NEDC 93-022 (Ref. ~~6.5~~). 6.8 The required minimum voltage for the pump motors is per Assumption 3.1. From Appendices A and B, the minimum bus voltages are provided in the table below. The battery load profile derived from the EDSA DC Load Profile data is summarized in Appendix T. The one line diagram provided in Appendix ~~U~~ V depicts the network topology and EDSA analytical model.

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| DESCRIPTION | EDSA ID | | Req. Volts | EDSA Results | EDSA Results |
|---|---|---|---|---|---|
| | # | ID | | SBO | LOCA |
| 250VDC RX BLDG STR RK (MO53A) | 5 | RX-STRT1 | 195 | 230.9 | 197.4 |
| 250VDC RX BLDG STR RK (MO25A) | 6 | RX-STRT2 | 195 | 230.9 | 197.0 |
| EE-STRR-250RCIC | 7 | RCIC-BUS | N/A | 228.5 | 225.9 |
| INVERTER A | 14 | INV 1A | 210 | 229.8 | 227.6 |
| RCIC-MOT-VP | 13 | RCIC-VP | 216 | 225.5 | 223.0 |
| RCIC-MOT-CP | 12 | RCIC-CP | 216 | 225.7 | 223.1 |
| RHR-MO-25A CONTROL | 9 | C-RHR25A | 184 | 230.4 | 196.1 |
| RR-MO-53A CONTROL | 11 | C-RR53A | 184 | 230.4 | 196.5 |

### 5.2 DISCUSSION OF RESULTS

The following provides a comparison of results and the requirements as stated in section 2.0.

a) The components in the starters EE-STR-250(53A) and EE-STR-250(25A) have the worst case (lowest) voltages greater than the required voltages for valve operation. Therefore, all safety-related components in the control circuits of the starters will operate properly.

In addition, all 250 VDC starter rack bus voltages are greater than the required 125 VDC required to maintain operability of the undervoltage relays in the RCIC starters for the entire 4 hours time period.

b) The lowest motor terminal voltage to the RCIC Condensate Pump and Vacuum Pump is greater that 90% of rated voltage which is within the NEMA requirements for proper motor operation.

c) The lowest terminal voltage to the NBPP inverter is well above the minimum required 210 VDC; therefore the inverter will operate properly throughout the 4 hour scenario.

d) NEDC 93-022 used 195.0 VDC as the minimum allowable starter rack voltage that is required for proper operation of the MOVs on the 250 VDC Division I system. The starter bus voltage is greater than this assumed minimum at all times during the load period.

Therefore, all safety-related MOVs in the CNS MOV Program Plan including the MOVs that have an active safety function during the LOOP/LOCA and SBO scenarios will have adequate voltage to perform their safety function.

## 5.3 FINAL CONCLUSIONS

The final conclusion of this NEDC is that all safety-related 250 VDC components powered from the 250 VDC Division I battery at CNS will have adequate voltage and current to perform their safety function for the LOOP/LOCA and SBO scenarios.

## 6.0 REFERENCES

6.1 NEDO-24045, Loss of Coolant Accident Analysis Report for CNS

6.2 Cable Resistance values from NEDC 91-044, Rev. 4 “Cable Resistance Calculation for 125 VDC & 250 VDC Buses & Loads”

6.3 NUMARC 87-00 "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors."

6.4 Not used

6.5 STP 92-034, Rev. 0 "DC Motor Performance Test"

6.6 NEDC 91-080, Rev. 2 “Review of ERIN’s System Level Design Basis Review for The Residual Heat Removal System MOV’s”

6.7 NEDC 91-244, Rev. 1 “Review of ERIN’s System Level Design Basis Review for The Reactor Recirculation System MOV’s”

6.8 NEDC 93-022, Rev. 5 “NED Review of ERIN MOV Electrical Calc C122-89-10.039”

6.9 NEDC 91-197, Rev. 1 “Low Voltage Drywell Penetration Short Circuit Withstand Calculation”

6.10 NEDC 91-238, Rev. 2 “Pump Load Calculation - RCIC Gland Exhaust Pump, TG Air Side Seal Oil Backup Pump, Emergency DC Bearing Oil Pump, Reactor Feed Lube Oil Pump”

6.11 NEDC 90-395B, Rev. 2 “Load Study for No Break Power Panel (NBPP)

6.12 CNS MOV Program Plan, Rev. 6

6.13 Procedure 14.10.11, Rev. 1.1 “Security System Uninterruptible Power Supply (UPS) Performance Testing”

6.14 Procedure 5.3SBO Rev. 2 “Station Blackout”

6.15 Not used

6.16 VM 1026

6.17 GE Specifications 22A1244AB Rev. 0

6.18 Inverter Final Test Report P.O. 332834.

6.19 Drawing 3058, Rev. N32, DC One Line Diagram

6.20 Technical Specification Manual Section 3.8.4.8.

6.21 Correspondence from G. Walker to A. Bitar, dated 5/1/97 “Technical Specification Limits for Operability, Inter-cell Connection Resistance 125 Volt and 250 Volt LCR-25 batteries”.

6.22 Maintenance Work Request 95-3529, Surveillance Procedure 6.EE.609 Performed 1/21/97.

6.23 DCD -35 Rev. 0 “Station Blackout”

6.24 Not Used

6.25 CNS Procedure 6.EE.609, Rev. 8, “125/250V Station Battery Inter-cell Connection Testing.”

6.26 IEEE Standard 450-1995, “IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented Lead-Acid Batteries for Stationary Applications”

6.27 EDSA 2.95 User Manual, © 2000 and EDSA software.

6.28 PIR 2-20634, CR 97-1425, dated 12/3/97 “Non-Conservative Assumption Regarding Inverter Part-Load Efficiency”

6.29 General Electric Specification 21A9222, Rev. 1, “Electric Motors, General”

6.30 Scenario Development References

6.30.1 NEDC 87-131A, REV 8, 250VDC Division I Load And Voltage Study

6.30.2 NEDC 87-131B, REV 7, 250VDC Division II Load And Voltage Study

6.30.3 Station Blackout Coping Assessment, Rev. 2 (9666-0008)

6.30.4 “Appendix R Post-Fire Safe Shutdown Topical Design Criteria Document”

6.30.5 Flow Diagram - Residual Heat Removal System (RHR) B5700*2040 Sh 1, Rev N69, B5700*2040 Sh 2, Rev N10

6.30.6 NEDO-21335, July 1976, “Cooper Nuclear Station Loss-of-Coolant Accident Analysis in Conformance with 10 CFR50 Appendix K with Modified Low Pressure Coolant Injection”

6.30.7 NEDC 96-039, Rev. 1 “DC Powered Motor Operated Valve Stroke Time”

6.30.8 3071, Rev N22, Control Elementary Diagram

6.30.9 RHR System Elementary; G0800*791E261 Sh 1, Rev N15, G0800*791E261 Sh 2, Rev N12, G0800*791E261 Sh 3, Rev N24, G0800*791E261 Sh 4, Rev N15, G0800*791E261 Sh 5, Rev N17, G0800*791E261 Sh 6, Rev N06, G0800*791E261 Sh 7, Rev N14, G0800*791E261 Sh 8, Rev N19, G0800*791E261 Sh 9, Rev N05, G0800*791E261 Sh 10, Rev N18, G0800*791E261 Sh 11, Rev N11, G0800*791E261 Sh 12, Rev N14, G0800*791E261 Sh 13, Rev N07, G0800*791E261 Sh 14, Rev, N15, G0800*791E261 Sh 16, Rev N07, G0800*791E261 Sh 17, Rev N13, G0800*791E261 Sh 18, Rev N10, G0800*791E261 Sh 20, Rev N12, G0800*791E261 Sh 21, Rev N12, G0800*791E261 Sh 22, Rev N10, G0800*791E261 Sh 23, Rev N06, G0800*791E261 Sh 19, Rev N21, G0800*791E261 Sh 3A, Rev N05, G0800*791E261 Sh 12A, Rev N05, G0800*791E261 Sh 24, Rev N01

6.30.10 RCIC System Elementary; G0800*791E264 Sh 1, Rev N28, G0800*791E264 Sh 2, Rev N23, G0800*791E264 Sh 3, Rev N16, G0800*791E264 Sh 4, Rev N20, G0800*791E264 Sh 5, Rev N15, G0800*791E264 Sh 6, Rev N11, G0800*791E264 Sh 7, Rev N13, G0800*791E264 Sh 8, Rev N12

6.30.11 HPCI System Elementary; G0800*791E271Sh 1, Rev N39, G0800*791E271 Sh 2, Rev N14, G0800*791E271 Sh 3, Rev N17, G0800*791E271 Sh 4, Rev N21, G0800*791E271 Sh 5, Rev N19, G0800*791E271 Sh 6, Rev N15, G0800*791E271 Sh 7, Rev N17, G0800*791E271 Sh 8, Rev N18, G0800*791E271 Sh 9, Rev N15, G0800*791E271 Sh 10, Rev N18, G0800*791E271 Sh 1A, Rev N05, G0800*791E271 Sh 6A, Rev N03, G0800*791E271 Sh 11, Rev N00, G0800*791E271 Sh 4A, Rev N02

6.30.12 Flow Diagram - High Pressure Coolant Injection and Reactor Feed System (HPCI); B5700*2044 Rev N65

6.30.13 NEDC 91-078, REV 2, Review of ERIN's System Level Design Basis Review for High Pressure Coolant Injection System MOVs

6.30.14 ENR 122-98-31-48, RR-MO-25A Breaker Report

6.30.15 ENR 122-98-31-49, RR-MO-53A Report

6.30.16 ENR 122-98-31-50, Inverter Report

6.30.17 ENR 122-98-31-51, RR-MO-53B (Control) Report

6.30.18 ENR 122-98-31-52, HPCI-MO19 Report

6.30.19 ENR 122-98-81, 250 VDC Non-MOV Motor Load

6.30.20 NEDC-32675P, Rev. 1, Class III, June 1997 "Cooper Nuclear Station SAFER/GESTR-LOCA Analysis Basis Documentation"

6.30.21 CNS USAR, Section IV-7.5, "Reactor Coolant Systems", Revision XVI6

6.30.22 CNS USAR, Section VII-4.5.4.3, "Core Spray System Pump Control", Revision XVI6

6.30.23 CNS USAR, Section VII-4.5.5.3, "LPCI Mode Pump Control", Revision XVI6

6.30.24 CNS System Operating Procedure 2.2.69.1A, Rev. 5, "Residual Heat Removal System component Checklist (Div 1)"