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Subject: W. O. 3900/4000
Washington Public Power Supply System
WNP-2
Defect and Noncompliance
Evaluation Report No. 83-09
D.C. Motor Starting Resistors

August 12, 1983
BRGO-83-003, Rev. 1

U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive
Suite 1000
Arlington, Texas 76011

Attention: Mr. J. P. Collins, Regional Administrator

Gentlemen:

In accordance with Burns and Roe Project Procedure WNP-2-ED-003, Report of Defects and Non-Compliance (Nuclear Projects), Burns and Roe has determined that the subject deficiency is reportable under 10CFR21 and notified your Mr. D. Fox on August 4, 1983. A copy of Defect and Noncompliance Evaluation Report No. 83-09 is being provided with this letter as required by 10CFR21.

Very truly yours,

F. J. Patti

FJP/pn
Attachment

F. J. Patti
Chief Nuclear Engineer

c.c.: Mr. R. T. Johnson - WPPSS - 1 w/1
Director, Office of Inspection & Enforcement - 1 w/3
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

IE:19
1/1

DEFECT AND NONCOMPLIANCE EVALUATION REPORT

BURNS AND ROE, INC.
185 Crossways Park Drive
Woodbury, New York

Project----WNP-2----------Evaluation Report----#83-09----------

Work Order-----3900----------Date------6/3/83----------

Specific Areas of Concern---1) D.C. Cable Voltage Drops are in excess of those allowed by B&R Criteria, 2) Improperly Set D.C. Motor Starting Resistors, and 3) Absence of Surge Protection of D.C. Motor Shunt Fields

1. Description of Potential Defects or Noncompliances

The following potential defects or noncompliances are all related to Class 1E D.C. Motors used in valve operators and to drive pumps:

.1 D.C. cable voltage drops are in excess of those allowed by B&R criteria.

Excessive cable voltage drops may occur when the cable size is too small for the operating load currents and the circuit length is too long. Excessive cable voltage drops can cause inadequate starting currents and thus failure of motors to start.

.2 D.C. motor starting resistors may not be properly set.

Too small a starting resistor setting will result in too large a current flowing to a D.C. motor causing possible damage. Too large a starting resistor setting will cause insufficient starting currents to meet the starting torque requirements of the driven equipment.

.3 D.C. motor shunt fields do not have surge protection.

Absence of surge protection of the shunt fields of D.C. motors can result in shunt field failure caused by voltage transients during switching conditions. Loss of the shunt field causes the motor to overspeed, usually resulting in a jammed valve.

2. Date and Method of Discovery

Burns and Roe was advised of four potential problems by Supply System letter WPBR-F-0333, dated 12/1/82. It was determined that three of these problems relating to 1) excessive cable voltage drops; 2) improperly set starting resistors; and 3) absence of surge protection of D.C. motor shunt fields could be applicable to the WNP-2 Project. These potential

MATCHED ORIGINAL

Reported By Rheanne Clark

problems were submitted for evaluation of reportability under 10CFR21 and potential reportability under 10CFR50.55e on 5/4/83. The fourth problem relating to improperly sized overcurrent devices was reported (Evaluation Report No. 83-07) to NRC by B&R letter BRGO-83-003, dated 6/6/83.

3. Analysis of Safety Implications

.1 D.C. Cable Voltage Drops:

Cable sizes to some D.C. motors may be too small, thereby causing excessive voltage drops during starting conditions, inhibiting the motors from running. The existing Burns and Roe calculations were revised using as-built data. The allowable voltage drop criteria were exceeded by twelve (12) motor operated valves as shown in Attachment No. 1, Problem No. II.a.

An analysis was made to determine if the motors would start with the original cable sizes. It was determined that the motors would have started under these conditions, and therefore this item is not reportable under 10CFR21 or potentially reportable under 10CFR50.55e. However, in order to provide additional design margin, cable changes were recommended.

.2 Improperly Set Starting Resistors:

The D.C. motor control center vendor (Gould) drawings for WNP-2 do not specify the ohmic value of motor starting resistors. Field inspection of the starters indicate that the resistors provided have no discernable markings to permit identification. Burns and Roe performed a calculation to determine required starting resistor ohmic settings for the affected motors, and the results are given in Attachment 2, Problem No. II.b. Field determination of the ohmic setting of the resistors showed that the motors might not have started at fully loaded condition if they were left at the values set by the manufacturer. Although this defect would have been discovered during testing, it is considered reportable under 10CFR21 and potentially reportable under 10CFR50.55e, since it would have affected the safe operation of WNP-2.

.3 Absence of Surge Protection of D.C. Motor's Shunt Fields:

Vendor drawings do not show any type of voltage limiting devices across the shunt fields of D.C. motors. The shunt field is completely isolated when opening the starter and therefore will see a surge voltage. It is the D.C. motor control center vendor's (Gould) normal practice not to furnish surge protection unless requested (See Attachment 3, Problem II.c). Since none was required by the WNP-2

Contract No. 49 specification, no discharge resistors were provided. Limitorque Corp. presently recommends the use of surge protection to all customers, but prior to 1977 (the specification was issued for bid in 1973), they made no such recommendation. Surge protection is not essential for functioning of the motors and absence of surge protection would not have affected the safety of WNP-2. This item is not reportable under 10CFR21 or potentially reportable under 10CFR50.55e. However, it is being provided for additional protection.

4. Corrective Action

.1 The feeder cables for the twelve (12) motor operated valves indicated in Attachment 1 will be tested for voltage drop by Test and Startup. Those cables determined to be inadequate will be changed via field issued PED's.

.2 Determine ohmic rating of in-place resistors settings via field measurements and reset any not in accordance with the values listed in Attachment 2, Problem II.b. In addition, functional testing of these motors is required to verify the actual operating times and starting currents under design conditions.

.3 Install metal-oxide varistor surge protection on shunt fields of D.C. motors for additional protection as follows:

250 VDC: 3000 ohm, 25W
125 VDC: 1500 ohm, 25W

5. Required review and Individual Determination:

	Signature/Date	Reportable Item No.			Not Reportable Item No.			Engineering Study Required Item No.		
		1.1	1.2	1.3	1.1	1.2	1.3	1.1	1.2	1.3
Cog. Eng'g. Mgr.	[signature] 8/2/83	—	✓	—	✓	—	✓	—	—	—
Proj.QA Grp. Supv.	[signature] 8/3/83	—	✓	—	✓	—	✓	—	—	—
Cog. Grp. Supv.	[signature] 8/3/83	—	✓	—	✓	—	✓	—	—	—
Licensing Supv.	[signature] 8/2/83	—	✓	—	✓	—	✓	—	—	—
InitiatingEmployee	_____	—	—	—	—	—	—	—	—	—

6. Evaluation of Vice President of Engineering and Design: (If Required)

a. Further Review Required: Engineering Study to Be Completed by: _____

NRC to be informed of a Potential Deviation:

Item No.
- ☐ 1.1
- ☐ 1.2
- ☐ 1.3

Not currently considered a Potential Deviation:

Item No.
- ☐ 1.1
- ☐ 1.2
- ☐ 1.3

_____ Signature _____ Date

NRC Notified by _____ Date _____ Time _____

b. Defects or Noncompliances are:

Not Reportable:

Item No.
- ☑ 1.1
- ☐ 1.2
- ☑ 1.3

Reportable:

Item No.
- ☐ 1.1
- ☑ 1.2
- ☐ 1.3

Check as Appropriate:

Item No.
- ☐ 1.1
- ☑ 1.2
- ☐ 1.3

10CFR21;

Item No.
- ☐ 1.1
- ☑ 1.2
- ☐ 1.3

Potential 10CFR50.55(e):

c. Other Facilities which may be affected

Comments: _____

E. R. Kunmal /HM — Signature; 8/3/83 — Date; 4:00 PM — Time

7. Action Taken:

Item 1.1 _____

Item 1.2 Notified D. Fox USNRC Region IV

Item 1.3 _____

E. J. Patte — Licensing Supervisor Signature; 8/4/83 — Date; 1:15 - 1:30 PM — Time

PROBLEM NO. II.a

Response:

Burns and Roe calculations relating to DC System cable sizing are as follows:

a. Calc. 2.02.07 - MCC Load Calc.

b. Calc. 2.06.04 - R.W. Bldg. Feeder and Voltage Drop Calc.

c. Calc. 2.06.05 - Reactor Bldg. Feeder and Voltage Drop Calc.

d. Calc. 2.06.06 - T.G. Bldg. Feeder and Voltage Drop Calc.

e. Calc. 2.07.04 - DC MCC Feeder and Voltage Drop Calc.

Calc. 2.07.04 was performed in 1974 and has not been updated since. Calc. 2.02.07 has been updated twice, the most recent revision being 8/26/81. The 2.06.XX Series calculations have been updated at various times during plant design: most recently the three pertinent calculations were updated via PCN 7199 (dated 8/9/82).

During review of the 125VDC systems the planned reduction of battery sizing from 58 cells to 57 cells (per WPBR-F-81-290) was also addressed. The stated intent of eliminating one cell was to limit voltage at GE instruments in the Main Control Room to 140VDC maximum. Charger Vendor's instruction manual indicates that based upon 60 cells the maximum equalizing voltage setting for the unit furnished is 2.34V/C (140.40V). A continuously adjustable (130-150V) high voltage sensing relay, preset at 145VDC, is provided to trip the charger breaker. Battery manufacturer's recommendation for equalizing voltage is 2.3-2.4V/C for systems float charged between 2.17 and 2.21V/C.

The charger is limited to an equalizing voltage output of 140.40V, regardless of the number of cells in the system. Less cells simply means that the maximum equalizing voltage level is arrived at on a higher volts-per-cell basis. Since the d.c. bus to MCR control board voltage drops in these systems are roughly 1/2 percent, instrumentation design voltage limits cannot be exceeded. The setpoint of the high voltage sensing relay is somewhat arbitrary, since it would only operate in the event of charger malfunction. This type of failure would likely drive the equalizing voltage significantly above the 140.40V level. It should be noted that recent equipment failures of concern in this area (See NRC IE Notice No. 83-08) are a result either of equipment being continuously subjected to float voltages at or above their design limits, or of equipment continuously subjected to equalizing voltages significantly above their design limits for excessive periods (over one month).

ATTACHMENT NO. 1-

1. Calculations have been revised based on present plant design utilizing the NEC cable resistance values and pull slip cable length (for selected worst case motors) and including battery to distribution panel voltage drop. The calculations show battery to MCC feeder drops as follows:

   a. B2-1 to MC-S2-1A (250V): 2.71V (1.08%)
   b. B2-1 to MC-S2-1B (250V): 3.35V (1.34%)
   c. B1-1 to MC-S1-1D (125V): 1.98V (1.58%)
   d. B1-2 to MC-S1-2D (125V): 1.204V (0.965%)

2. A review of motor feeder voltage drops show that there are cases where feeder voltage drops exceed 3%. Original calculations did not consider that design of reversing d.c. starter circuits requires that four times (4X) the one-way starter-to-motor length be utilized in arriving at the circuit length. Calculations have been revised. The results indicate that circuit revisions are required as follows:

Valve	Cable No.	Length	Present Size	New Size
RWCU-V-4	1M21A-70	440'	5-1/C #8 (G1)	9-1/C #8 (G1)
RCIC-V-31	1M11D-10	290"	5-1/C #8 (G1)	4-1/C #2 (G1) 1-1/C #8 (G1)
RCIC-V-10	1M11D-30	335'	5-1/C #8 (G1)	4-1/C #2 (G1) 1-1/C #8 (G1)
CAC-V-2	1M11D-80	415'	5-1/C #8 (G1)	9-1/C #8 (G1)
CAC-V-6	1M11D-90	476'	5-1/C #8 (G1)	9-1/C #8 (G1)
RCIC-V-110	1M11D-120	235'	5-1/C #8 (G1)	1-1/C #8 (G1) 4-1/C #2 (G1)
RCIC-V-68	1M11D-150	230'	5-1/C #8 (G2)	5-1/C #8 (G2) 4-1/C #8 (G1)
RCIC-V-46	1M11D-170	295'	5-1/C #10 (G1)	9-1/C #10 (G1)
RCIC-V-8	1M11D-50	470'	5-1/C #8 (G1)	4-1/C #2 (G1) 1-1/C #8 (G1)
CAC-V-11	2M12D-50	460'	5-1/C #8 (G1)	9-1/C #8 (G1)
CAC-V-15	2M12D-60	520'	5-1/C #8 (G1)	9-1/C #8 (G1)
CAC-V-8	1M11D-110	327'	5-1/C #8 (G1)	9-1/C #8 (G1)

Revisions are based upon "doubling up" on four of the existing five conductors (except for RCIC-V-110, RCIC-V-31, RCIC-V-10 and RCIC-V-8 where "doubling up" is not sufficient to reduce voltage drop to acceptable levels).

Assuming incorporation of these changes, the "worst case" motor feeder voltage drops will be:

a. MC-S2-1A: 6.28V (2.50%) to RHR-V-23
b. MC-S2-1B: 5.00V (2.00%) to TG-ASOBP-1
c. MC-S1-1D: 2.9V (2.3%) to MS-V-19
d. MC-S1-2D: 3.06V (2.45%) to CAC-V-17 or RCIC-V-113

Burns and Roe Standards covering voltage drop do not agree with those stated in the Problem Report. Burns and Roe Standard R167603E3 permits 1% V.D. in MCC supply feeders and 3% in MCC motor feeders. This is more conservative than NEC requirements of 5% overall voltage drop.

The revised design would essentially conform to the Burns and Roe standard of 4% overall voltage drop. Worst case voltage drops (battery to load) (assuming incorporation of required feeder changes) would be as follows:

a. B2-1 to RHR-V-23: 8.63V (3.59 %)
b. B2-1 to TG-ASOBP-1: 8.35V (3.34%)
c. B1-1 to MS-V-19: 4.88V (3.9%)
d. B1-2 to CAV-V-17 or RCIC-V-113: 4.26V (3.41%)

The analysis provided above is based on present plant loads; margin for the future addition of continuous duty load is not considered.

Recommendations:

1. The scheduled change to reduce the 125VDC systems to 57 cells should be deleted. These systems should remain at 58 cells.

2. Set 125VDC charger high voltage relays at 143V.

3. Revise B&R Dwg. E505, Note 6 to indicate an equalizing voltage of 140.4V (2.42 V/C) and a float voltage of 126V (2.17 V/C).

4. Add replacement of 125VDC Div. 1 and Div. 2 batteries to Deferred Items List (This is a result of scaling and stratification problems caused by failure of Contractor 218 to keep batteries charged during storage. This problem is not specifically addressed above).

5. Increase feeder size for twelve (12) MOV's as indicated above.

PROBLEM NO. II.b

Response:

Gould's reply to requests for data (letter - Brown Boveri to J. J. Verderber - dated 3/3/83) is somewhat non-responsive. They have merely provided a listing of starting resistor with quantities, description numbers, resistance and continuous amperes which were provided with equipment shipped. They have not indicated in which starters the various resistors have/should been provided, nor confirmed their proper supply with equipment shipped). Field inspection of starters indicate that the resistors provided have no discernable markings to permit identification.

Burns and Roe has performed a calculation (2.05.08) to determine required starting resistor sizes, including an acceptable tolerance on the resistor size selected. The calculation was performed in accordance with recommendations contained in "Theory and Design of NEMA Resistors for Motor Starting and Speed Control", AIEE Transactions, May, 1940, Vol. 59. The calculation results are summarized below:

Motor	Starter Location	Resistor Sizing (Ohms)
TG-EOP-1	MC-S2-1B	$r_3 = 0.0484$ $r_2 = 0.1314$ $r_1 = 0.3566$
TG-ASOBP	MC-S2-1B	$r_2 = 0.2735$ $r_1 = 0.8648$
RFT-EOP-1A	MC-S2-1B	$r = 5.39$
RFT-EOP-1B	MC-S2-1B	$r = 5.39$
RCIC-P-4	MC-S2-1A	$r = 7.68$
RCIC-P-2	MC-S2-1A	$r = 8.7$
RHR-V-8	MC-S2-1A	$r_2 = 0.02$ $r_1 = 0.13$
RCIC-V-64	MC-S2-1A	$r_2 = 0.02$ $r_1 = 0.13$
RCIC-V-22	MC-S2-1A	$r = 1.04$

Tolerance on resistor sizing is $\pm$ 10% for valve and +0%, -25% for pump starters.

Limitorque has been contacted regarding the need for reduced voltage starting for valves RCIC-V-13 and 59. Their general recommendation is for use of reduced voltage starting for valve motors 3 H.P. and above. Their specific recommendation is for use of reduced voltage starting for valves having starting torque requirements of 40 ft-lb and above for Reliance motors and 150 ft-lb and above for Peerless motors. The pertinent parameters for the subject valves are:

RCIC-V-13: 2.89 H.P./40 ft-lb/Peerless
RCIC-V-59: 2.90 H.P./40 ft-lb/Peerless

Recommendations:

1. Determine ohmic rating of in-place resistors via field measurement.

2. Replace any resistors not in accordance with the valves (inlcuding tolerances) indicated above.

3. A change to reduce voltage starting for valves RCIC-V-13 and 59 is not required.

PROBLEM NO. II.c

Response:

Gould responded that their normal practice is not to furnish surge protection unless requested. Since none was requested in the WNP-2 Contract No. 49 Specification, no discharge resistors were provided. They also indicated that surge protection is normally not requested of them for starters smaller than Size 3.

This is in general agreement with "Switchgear and Control Handbook-1982" (R. Smeaton, McGraw Hill Book Co.) which states that for small motors utilizing constant speed definite time starters ".....no discharge resistor is required since the field has a discharge path through the motor armature circuit" (p.24-6).

Limitorque Corp. has advised (letter - Limitorque to B&R - dated 3/3/83) that the recommended value for field discharge resistor is 1½ to 3 times the shunt field resistance for 250 volt D.C. motors and 3 to 4 times the shunt field resistance for 125 volt motors. The purpose of these resistors is to limit inductive voltage as discussed in "Surge Arrester Prevents D.C. Motor Failures" (J.E. Timperley, Power Engineering, October, 1977, p. 102). Further conversations with them have determined:

1. They presently recommend use of surge protection to all customers.
2. Prior to 1977 they made no such recommendation.
3. Their standard recommmendation for surge protection is for use of metal-oxide varistor as follows:
   a. 250VDC: 3000 Ω, 25W
   b. 125VDC: 1500 Ω, 25W