CALCULATION CONTROL SHEET

Calculation No. JAF-CALC-HPCI-02094 Revision 0 IP3 ☐ JAF ■
Mod./Task No. N/A

QA Category of Calculation: I Calculation Type: Preliminary ___ Final X

Project/Task:	Generic Letter 89-10 MOV Analysis - Available Voltage/ Motor Torque
System No./Name:	23/ High Pressure Coolant Injection
Title:	Reduced Voltage Analysis for 23MOV-19

	Name	Signature	Date
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Approved:	J. Cameron	John Cameron	6-12-95

PROBLEM / OBJECTIVE / METHOD

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DESIGN BASIS / ASSUMPTIONS

See Page 1

SUMMARY / CONCLUSION

Minimum motor terminal voltage = 81.036 volts. However, with the Limitorque Maintenace Update 88-1 technique, available motor torque at minimum voltage was calculated as greater than or equal to the rated start torque, therefore the reduced voltage factor (RVF) may be considered as equal to 1.0 (no credit for more than rated start torque). See page 4 for additional discussion.

REFERENCES

See Page 1

AFFECTED SYSTEMS / COMPONENTS / DOCUMENTS

MOV analysis performed in accordance with MES-6; the alternate reduced voltage factor may be used to assess MOV capability.

__ VOIDED OR

__ SUPERSEDED BY: ______________________ (Calc. No.)

FOR REFERENCE ONLY

Distribution: NED (WPO); Technical Services: __IP3, __JAF; Site Engineering: __IP3 __JAF; CM&EP/DBD (WPO); Other ____

OBJECTIVE:

Determine motor terminal voltage and available motor torque under design basis degraded voltage conditions.

METHOD:

Determine minimum motor terminal voltage with the simple voltage divider analysis of the circuit model shown in the Figure 1 one line diagram. If the calculated motor terminal voltage is less than 90% of rated voltage then determine the reduced voltage factor (RVF). Calculate available motor torque from motor performance curve as described in Limitorque Maintenance Update 88-1 (ref. 13). This technique may be used to justify a higher RVF.

ASSUMPTIONS:

1. Assume cable temperature outside containment is 75°C (this assumption was used for the General Physics Generic Letter 89-10 analyses).
2. Assume EQ qualified BMCC temperatures for the thermal overload relay heaters (for BMCC-6: 131°F or 55°C).
3. Assume cable resistance from the National Electric Code (NEC).
4. Assume locked rotor current at rated voltage from motor nameplate or motor actuator data sheet.
5. Assume bus or BMCC source voltages from the battery duty cycle calculations (ref. 6) for MOVs in the battery duty cycle. Assume end of duty cycle battery voltage for MOVs which do not operate as part of the battery duty cycle (ref. 7).
6. Assume negligible effect from parallel current flow through high resistance shunt field winding.
7. Assume 10 ft length for unnumbered cable from junction box to MOV.

REFERENCES:

1. JAF Electrical Cable and Raceway Information System, Cable Schedule Report, Feb. 1, 1994.
2. Wiring Diagram Drawing SE-10AJ.
3. PEDB for Motor Controller, Equipment Name Plate Inquiry (overload heater number).
4. Earley, M.W. et al, Ed., *National Electric Code 1990 Handbook*, Chapter 9, Tables 8 and 9, National Fire Protection Association.
5. Marks, L.S., *Standard Handbook for Mechanical Engineers*, eighth edition, 1979.
6. Calculations JAF-CALC-ELEC-00426, Rev. 1 and JAF-CALC-ELEC-00427, Battery "A" and "B" 125 VDC Voltage Drop Analyses, approved 10/16/92 and 6/4/92.
7. NYPA Memorandum to P. Swinburne from T. Klein, NED-E-TK-92-162, DC MOV Degraded Voltage, dated August 25, 1992.
8. Limitorque Technical Update #92-02, Recommended Spring Pack Replacement Procedures for Limitorque SMB Actuators, issued October 9, 1992.
9. Fax Transmittal, C. Shirley (GE) to P. Swinburne (NYPA), CR123C,F,K,L size 1,2,3&4 Heater Resistances, March 22, 1993.
10. Limitorque Data Sheets for O/N 110119.01 (M1-87-026).
11. Peerless-Winsmith DC Motor Performance curves provided under P.O. S-91-12145.
12. JAF EQ Program, Envirnomental Parameters after Postulated LOCA and HELB Accidents, Rev. 3, October 1992, EQ Ref. #349.
13. Limitorque Maintenance Update 88-1, "Notes from the Field", DC Motors, dated Aug. 17, 1988.

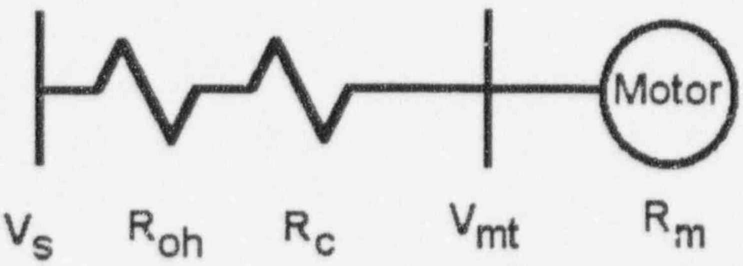


Figure 1 - DC Motor Circuit One-Line Diagram

Motor Data (references 10 and 11):

Rated Voltage:	$V_r := 125 \cdot volt$	Frame: D225	RPM: 1900
Locked Rotor Amps:	$I_{lr} := 810 \cdot amp$	Rated run amps:	$I_{run} := 80 \cdot amp$
Rated Start Torque:	$T_{st} := 150 \cdot ft \cdot lbf$	Curve: K-11216A	

Cable Data (references 1, 2 and 4):	Length	DC Resistance at 75°C
1HPIBBK042 (NFF-51, 1 cond. 750 MCM Al)	$L_1 := 110 \cdot ft$	$SR_1 := 0.0282 \cdot \frac{ohm}{ft \cdot 10^3}$
1HPIBBK041 (NFE-25, 3 cond. 500 MCM Al)	$L_2 := 120 \cdot ft$	$SR_2 := 0.0424 \cdot \frac{ohm}{ft \cdot 10^3}$
JB to MOV (2 NFE-08, 4 cond. 8 AWG Cu)	$L_3 := 10 \cdot ft$	$SR_3 := 0.786 \cdot \frac{ohm}{ft \cdot 10^3}$
Outside Containment Cable Temperature:	$Temp_c := 75$	

BMCC Minimum Voltage: $V_s := 107.44 \cdot volt$

Calculation JAF-CALC-ELEC-00427 determined the above BMCC voltage for 23MOV-19 based on operation at the 19th second of the two hour duty cycle.

Overload Heater Data (references 3, 5, 9 and 12):

Number: F104C	Resistance:	$R_{25} := 9.49 \cdot 10^{-4} \cdot ohm$ (at 25°C)	
	Temperature Coefficient:	$TC_{oh} := 0.17 \cdot 10^{-3}$	(from Marks' for nichrome)
	Ambient Temperature (°C):	$Temp_{oh} := 55$	(EQ temperature for BMCC-6)

Total cable resistance (for four runs for armature and series field):

$$R_c := SR_1 \cdot L_1 + 3 \cdot SR_2 \cdot L_2 + 4 \cdot SR_3 \cdot L_3 \qquad R_c = 0.0498 \cdot \text{ohm}$$

Overload heater resistance (two heaters in parallel) corrected for temperature:

$$R_{oh} := \frac{R_{25}}{2} \cdot \left[1 + TC_{oh} \cdot \left(Temp_{oh} - 25\right)\right] \qquad R_{oh} = 4.769 \cdot 10^{-4} \cdot \text{ohm}$$

Motor equivalent resistance: $R_m := \frac{V_r}{I_{lr}}$ $\qquad R_m = 0.154 \cdot \text{ohm}$

Maximum current: $I_{max} := \frac{V_s}{R_m + R_c + R_{oh}}$ $\qquad I_{max} = 525.1 \cdot \text{amp}$

Minimum motor terminal voltage: $V_{mt} := I_{max} \cdot R_m$ $\qquad V_{mt} = 81.036 \cdot \text{volt}$

Percent rated voltage available: $\text{Percent\_rated} := \frac{V_{mt}}{V_r}$ $\qquad \text{Percent\_rated} = 64.829 \cdot \%$

Because percent rated voltage is less than 90%, we need calculate a reduced voltage factor (RVF). For DC motors the RVF is simply the percent of rated voltage expressed as a fraction (ref. 8).

Reduced voltage factor: $RVF := \text{Percent\_rated}$ $\qquad RVF = 0.648$

Per LMU 88-1 maximum current as multiples of rated FLA: $\frac{I_{max}}{I_{run}} = 6.564$ $\qquad$ Cable size does meet Limitorque's recommendation to provide 5 times rated current (FLA)

Evaluate torque available based on motor curve K-11216A. Apply conservative +15% to current vs. torque curve.

Motor curve K-11216A for 150 ft-lbf motor, as 3rd order polynomial:

Data points from recorded data files:

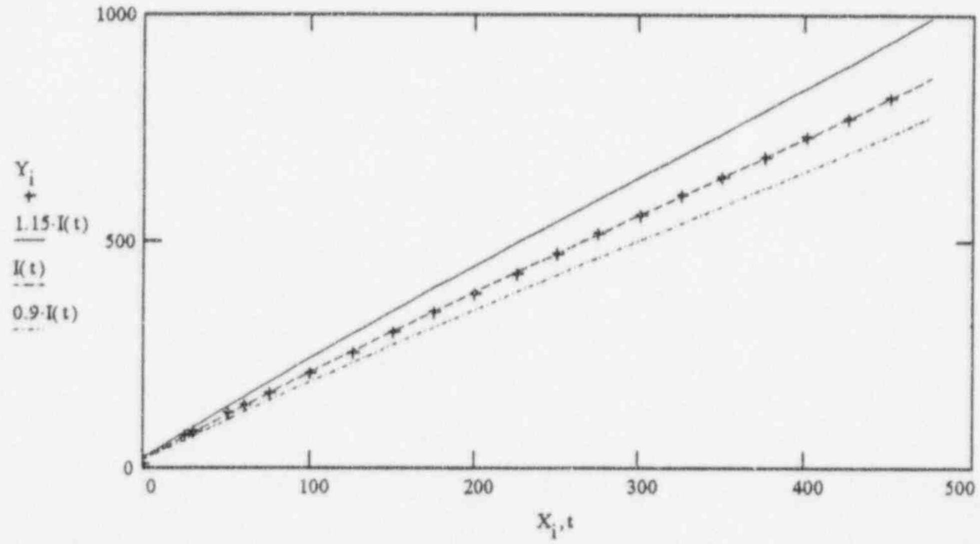
$i := 0..20$ (21 data points) $\qquad X := READPRN(tq150) \qquad Y := READPRN(amps150)$

Vector for curve fit: $F(x) := \begin{bmatrix} x^3 \\ x^2 \\ x \\ 1 \end{bmatrix}$ 3rd order fit function: $S := \text{linfit}(X, Y, F)$ $S = \begin{bmatrix} 1.408 \cdot 10^{-6} \\ -0.001 \\ 2.033 \\ 18.278 \end{bmatrix}$

Current from curve fit polynomial: $I(t) := F(t) \cdot S$ $t := 0, 25 .. 475$

Curve K-11216A showing +15%/-10% limits:

Current (amps)



Motor torque (ft-lbf)

$I_{max} = 525.1 \cdot amp$

guess value: $t := 100$

Available torque at I_{max} (with +15% allowance) is: $\tau_{avail} := \text{root}(1.15 \cdot I(t) \cdot amp - I_{max}, t) \cdot ft \cdot lbf$ $\tau_{avail} = 240.166 \cdot ft \cdot lbf$

The above torque is greater than the rated torque for this motor (150 ft-lbf). We should not take credit for more than rated torque capability but we need not apply an RVF.

CONCLUSION:

This analysis shows that 23MOV-19 has less than 90% of rated voltage available under degraded voltage conditions. If we consider the guidelines for motor torque capability provided in LMU 88-1 (ref. 13) and motor curve K-11216A (ref. 11) we can show more than rated torque capability at reduced voltage conditions. Therefore we can use RVF = 1.0.

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INDEPENDENT DESIGN VERIFICATION CONTROL SHEET

VERIFICATION OF: JAF-CALC-HPCI-02094, Rev. 0
Document Title / Number

SUBJECT: Reduced Voltage Analysis for 23MOV-19 (Voltage)

MOD/TASK NUMBER (If Applicable): N/A

QA CATEGORY: I

DISCIPLINE:	ELEC	MECH	C / S	I & C	FIRE PROTECT	OTHERS (SPECIFY)
Check as required:	☒	☐	☐	☐	☐	☐
METHOD USED (1):	DR					
VERIFIER'S NAME:	F. A. Mulcahy					
VERIFIER'S INITIALS / DATE:	FAM 6-9-95					

APPROVED BY: John [signature] DATE: 6/12/95

REMARKS / SCOPE OF VERIFICATION:

(1) Method of Verification: Design Review (DR), Alternate Calculations (AC), Qualification Test (QT)

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DESIGN VERIFICATION CHECKLIST
DESIGN REVIEW METHOD

VERIFICATION OF: JAF-CALC-HPCI-02094, Rev. 0
Document Title / Number

SUBJECT: Reduced Voltage Analysis for 23MOV-19 (Voltage)

MOD/TASK NUMBER (If Applicable): N/A

DESIGN VERIFIER: F. A. Mulcahy *F.A. Mulcahy MOV Engineer 6-9-95*
Signature / Title / Date

DISCIPLINE:	ELEC	MECH	C / S	I & C	FIRE PROTECT	OTHERS (SPECIFY)
Check as required:	☒	☐	☐	☐	☐	☐

	Yes	NA
1. Were the inputs correctly selected and incorporated into the design ?	☒	☐
2. Are the physical and functional characteristics of the proposed design within the approved design basis of the system(s) structure(s) or component(s) ?	☒	☐
3. Does the proposed design incorporate license commitments ?	☒	☐
4. Are assumptions necessary to perform the design activity adequately described and reasonable: Where necessary, are the assumptions identified for subsquent reverification when the detailed design activities are completed ?	☒	☐
5. Are the appropriate quality and quality assurance requirements specified ? e.g., safety classification.	☒	☐
6. Are the applicable codes, standards and regulatory requirements including issue and agenda properly identified and are their requirements for design met ?	☐	☒
7. Have applicable construction and operating experience been considered ?	☐	☒

DESIGN VERIFICATION CHECKLIST
DESIGN REVIEW METHOD

		Yes	NA
8.	Have the design interface requirements been satisfied ?	☐	☒
9.	Was an appropriate design method used ?	☒	☐
10.	Is the output reasonable compared to inputs ?	☒	☐
11.	Are the specified parts, equipment and processes suitable for the required application ?	☐	☒
12.	Are the specified materials compatible with each other and the design environmental conditions to which the materials will be exposed ?	☐	☒
13.	Have adequate maintenance features and requirements been satisfied ?	☐	☒
14.	Are accessibility and other design provisions adequate for performance of needed maintenance and repair ?	☐	☒
15.	Has adequate accessibility been provided to perform the in-service inspection expected to be required during the plant life ?	☐	☒
16.	Has the design properly considered radiation exposure to the public and plant personnel ? (ALARA / Cobalt Reduction)	☐	☒
17.	Are the acceptance criteria incorporated in the design documents sufficient to allow verification that design requirements have satisfactorily accomplished ?	☒	☐
18.	Have adequate pre-operational and subsequent periodic test requirements been appropriately specified ?	☐	☒
19.	Are adequate handling, storage, cleaning and shipping requirements specified ?	☐	☒

DESIGN VERIFICATION CHECKLIST
DESIGN REVIEW METHOD

	Yes	NA
20. Are adequate identification requirements specified ?	☐	☒
21. Are conclusions drawn in the Safety Evaluation fully supported by adequate discussion in the test or Safety Evaluation itself ?	☐	☒
22. Are necessary procedural changes specified, and are responsibilities for such changes clearly delinated ?	☐	☒
23. Are requirements for records preparation, review, approval, retention, etc., adequately specified ?	☐	☒
24. Have supplemental reviews by other engineering disciplines (seismic, electrical, etc.) been performed on the integrated design package.	☐	☒
25. Have the drawings, sketches, calculations, etc. included in the intergrated design package been reviewed ?	☒	☐
26. Have review been performed to identify any effect on the Check Valve Maintenance Program ?	☐	☒
27. Does the design for check valves meet the intents of INPO SOER 86-03 ?	☐	☒
28. Is the plant reference simulator physical and functional fidelity affected and it's design change been factored into the cost ?	☐	☒
29. References used as part of the design review which are not listed as part of the design calculation / analysis ?	☐	☒