Attachment 1
to U-603180

Calculation 19-AQ-02
(53 pages, without Attachments)

Calculation of Voltages for LOCA Block Start

CALCULATION COVER SHEET

SHEET 1 OF 53

CORP PREPARING THIS REV.	QUALITY RELATED YES or NO	DEPT/DIV	CALCULATION NO	REVISION
SL	YES	E/EPED	19-AQ-02	3

CONFIRMATION REQUIRED	TOPIC	READY FOR INCORPORATION	Addenda	VOLUME
☒ YES ☐ NO PAGE NO(s) 3	E95	YES OR NO NO RFI DATE(admin)		AS

TITLE:

EVALUATION OF VOLTAGES FOR LOCA BLOCK MOTOR START AND 89-10 PROGRAM MOV MOTORS

APPROVALS - NAME/SIGNATURE/DATE

PREPARED BY	OWNER'S REVIEW (If Corp is not IP)	HISTORICAL/TEMPORARY YES OR NO NO
J. P. Kish (PRINT)	MARK McMENAMIN (PRINT)	VOL. INCORP. ASSIGNMENT Engineering
DATE 3/4/99 SIGNATURE JPKish	DATE 3/5/99 SIGNATURE Mark McMenamin	
Location - SL Chicago Office		

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NA PRINT	AP048	☐ YES ☒ NO
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REVIEWED BY See Note 1 below	COMMENTS:
I. P. WARNER (PRINT)	This calculation is prepared under the S&L QA program.
DATE 3/4/99 SIGNATURE IPWarner	Review Method: Detailed review method used.
APPROVED BY P.J. SCHAFFER (PRINT)	Revised Pages: See Revision History below.
DATE 3-4-99 SIGNATURE [signature]	

SUPERSEDES & SUPPLEMENTS

This Calculation Supersedes (Calc#/Rev/Add/Vol):	This Calculation Supplements (Calc#/Rev/Add/Vol):
19-AQ-02 / 3 / A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, T, V, W, Y, AA, AB, AC, and AF.	

REVISION HISTORY

See the next page for the revision history.

APPLICABLE SYSTEMS & EQUIPMENT

SYSTEM CODES (or N/A)	EQUIPMENT IDENTIFICATION NUMBERS
AP	N/A

Support Numbers:	BLDG/ELEV/AREA (or NA)
N/A	N/A

FOR REFERENCE ONLY

REVISION HISTORY

Objective/Purpose:
This calculation evaluates the terminal voltages of safety related electrical loads under block start, single load start, and running conditions. These electrical loads include 89-10 Program MOV motors. The terminal voltages are calculated with the safety buses being connected to various offsite electrical sources.

Reason:
The reason for the change is:

- Prepare a volume in the style of a new base revision.
- Include any unchanged sheets, attachments, or pages from 19-AQ-02 revision 3 base calculation.
- Include the Ready for Incorporation Volume A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, R, T, V, W, Y, AA, AC, and AF.
- Include As Built and verified input data from "Not Ready for Incorporation" Volumes P, Q, and AB.
- Use the latest input data and ELMS AC files from calculation 19-AK-6.
- 19-AK-6 has various changes, including the addition of Static VAR Compensation (SVC), transformer tap changes, source impedance values, load changes including HVAC fan refined BHP's, cable impedance data from NSED Standard EE-02.00, and numerous other less significant changes.
- Calculation 19-AN-19 uses 4084V, 4035V, and 4149V as criteria for auxiliary power system parameters.
- ELMS-AC PLUS and ELMSCOMP programs were used.

Affected Pages are as follows:

- The entire calculation (i.e., every sheet and page) was revised including the attachments and labeled (as a minimum) with Volume "AS".
- Changes to the header portion of each page, in general , is not marked with a revision bar.
- Attachments that have no technical changes from either the base revision or a volume but, have header changes only are:
  Attachment 21, Table 1, Appendix A, B, C, D, and E.
  Attachments 22, 24, 27, 30, 31, 35, 36, and 37.
- Small technical changes within the body of pages are marked with a revision bar.
- Attachments that are partially revised and do show revision bars are:
  Attachment 21, Table 1
  Attachments 25 and 26
- Attachments that are completely new or have many changes and in general do not show revision bars are:
  Attachments 0.1 through 20.2 and 40 to 40.5
  Attachment 21, Tables, 2, 2B, 3, 3A, 3B, 4, 4A, 4B, and 4C.
- This volume change combines the offsite power case and reset study case into one case. Various assumptions were verified and ELMS output reports were relocated from Attachments 28 and 29 to 40 through 43. Hence, the following previously issued attachments are no longer required and have been deleted:
  Attachments 0.5, 2.2, 6.2,7.2, 8.2, 10.2 17.2, 18.2, 20.2, 23, 28, 29, 32, 33, and 34.
  Attachment 21 Tables: 2A and 2C

Confirmation Required

- M98 series MOV thrust calculations need to be updated with the voltages shown in Attachment 21. MOV thrust calculations will confirm the adequacy of the calculated voltages. Than the MOV assumption can be removed from this calculation assumption
- The minimum MCC bus voltage required by the contactors fed from control transformers located in the MCC buckets is assumed at or above 440 VAC. Calculations 19-AJ-70, 71, and 72 (Ref. 11.33, 11.35, and 11.36) require updates to verify this assumption. (See the Assumption Section.)
- Any Assumption Requiring Verification stated in Section 4.0 requires confirmation.

Note 1: *The reviewer's signature indicates compliance with S&L Standard SOP-0402 and the verification of, as a minimum, the following items: correctness of math for hand prepared calculations, appropriateness of input data, appropriateness of assumptions, and appropriateness of the calculation method.*

INPUTS / OUTPUTS / REFERENCES			
#	DOCUMENT NO.	INPUT/OUTPUT/ REFERENCE	DESCRIPTION
1	NSED Standard ME-06.00, Revision 5	Reference	Guidelines for Determining Fire Loads and Preparing Fire Load Calculations
2	NSED Procedure E.1, Rev 9	Reference	Calculation
3	S&L Project Instruction PI-CP-248, Rev 6	Reference	"Control of Clinton Design Calculations."
4	S&L Procedure GQ-3.08, Rev 7A	Reference	"Design Calculations."
5	S&L Standard Operating Procedure SOP-0402, Rev. 0	Reference	"Preparation, Review and Approval of Design Calculations"
6	S&L Standard Operating Procedure SOP-0403, Rev. 1	Reference	"Control of Design Input"
7	See Section 11 for other references	Reference	
8	See Attachment 21, Section 11	Reference	

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1.1. Definitions and Abbreviations

1.1. Block Start - An electrical load condition where electrical signals or process signal cause electrical loads to automatically start approximately at the same time. These starts may occur staggered in time by small time increments (i.e., mill-seconds to a few seconds) but, for this calculation they are generally considered to occur at the same time. This event starts at a time called T = 0 (zero). Block Start also considers loads started after T = 0. These loads typically have control circuits with timers, have process time delays, or are manually controlled.

1.2. LOCA - "Loss of Coolant Accident", LOCA is used in this calculation in various ways. LOCA in combination with Block Start, Signal, Loads, etc. means that the LOCA was the initiating event that started the event or load case being studied.

1.3. Load(s) - Within the context of this calculation the "loads" described in this calculation are those safety related electrical motors, heater, transformers, etc. fed from the safety related 4 KV and 480 VAC buses. The safety related buses are summarized on Figure 1 base on the single line drawing (Ref. 11.37).

1.4. Motor-Operated Valves - MOV(s)

1.5. 480 VAC Motor Control Center - MCC

1.6. Reset - Minimum Reset; The term "reset" is used in this calculation with reference to the analytical limit for the second level under-voltage relay setting of the minimum relay pick-up (reset) voltage. This voltage should be greater than or equal to the minimum 4KV safety related bus recovery voltage. The minimum 4 KV safety related bus voltage under recovery after successfully starting and running all required LOCA loads is considered to be 4084 V.

1.7. Maximum Reset - This term is used in this calculation with reference to the analytical limit for the second level under-voltage relay setting of the maximum relay pick-up voltage. The value is 4118 (Ref. 11.6). This voltage should be less than or equal to the minimum 4KV safety related bus voltage under steady state LOCA loading with offsite voltage at the minimum expected value. The minimum 4 KV SAFETY RELATED bus voltage under steady-state LOCA loading with the offsite voltage at the minimum expected value is considered to be 4149 V (Assumption 4.11).

1.8. Trip - Minimum Trip, The minimum 4 KV SAFETY RELATED bus voltage required to run the LOCA equipment is considered to be 4035 V.

1.9. 4 KV Safety Related Buses - The specific buses are numbered 1A1, 1B1, and 1C1.

1.10. RAT - Reserve Auxiliary Transformer

1.11. ERAT - Emergency Reserve Auxiliary Transformer

1.12. SVC - Static VAR Compensator

1.13. VAR - Volt Ampere Reactive

1.14. Ref. -Reference

1.15. ELMS-AC PLUS - Computer Program "Advanced Electrical Load Monitoring System For Alternating Current Loads (ELMS-AC PLUS) (Ref. 11.28 and is also referred to in this calculation simply by ELMS.

1.16. BHP - Brake Horsepower

1.17. BOP - Balance of Plant and is used in this calculation with reference to electrical loads.

2. OBJECTIVE/PURPOSE

2.1. Objective/Purpose

This calculation evaluates the terminal voltages of safety related electrical loads under block start, single load start, and running conditions. These electrical loads include 89-10 Program MOV motors.

This calculation will determine if LOCA initiated continuous duty and damper motors receive adequate terminal voltage to accelerate. This calculation will also determine if steady state motor terminal voltages for LOCA initiated continuous duty and damper motors are at least 90% of motor rated voltages. This calculation will determine motor terminal voltages for motor-operated valves (MOV). The MOV terminal voltage information may be used as input to MOV thrust and torque switch (M98 series) calculations.

The evaluations are performed at 1) 4084 V for block start, and 2) 4035 V for steady state, 3) 4149 V to verify that the Second Level Undervoltage relay resets. These evaluations provide a basis for determining if these voltage levels are adequate 1) to allow LOCA block start motors to accelerate and 2) to provide adequate running voltage for Class 1E loads.

This calculation will verify that the following assumptions used in calculation 19-AN-19, Revision 2, Volume F (Ref. 11.6) were correct:

1. The minimum 4 KV SAFETY RELATED bus voltage under steady-state LOCA loading with the off-site voltage at the minimum expected value is considered to be 4149 V. This number is based on the maximum second Level Under Voltage Relay operating range of 4118 V plus a tolerance. This tolerance is related to the SVC Regulation. The maximum value is expected to be 4149 V which requires verification (See the assumptions).
2. The minimum 4 KV SAFETY RELATED bus voltage required to run the LOCA required equipment is considered to be 4035 V.
3. The minimum voltage to which the 4 KV SAFETY RELATED bus recovers after successfully starting and running all required LOCA loads is considered to be 4084V.

2.2. Scope

The scope of this calculation includes motors receiving a LOCA start signal as identified in Attachment 24. Attachment 21 will also determine motor terminal voltages for MOV's. The MOVs included are defined in Reference 11.31. Whether the MOV terminal voltages are adequate during the various LOCA times to produce the torque required for proper stroking is beyond the scope of this calculation and its Attachment 21.

The evaluation of all safety-related motors will be performed for both offsite sources, the Reserve Auxiliary Transformer (RAT), and the Emergency Reserve Auxiliary Transformer (ERAT).

Evaluation of MCC contactor protection (fuse blowing) for degraded voltage is not included in the scope of this calculation. See calculation 19-AJ-70 for this information (Ref. 11.33).

Evaluation of protective devices tripping of 460 V continuous duty motors is not included in the scope of this calculation except for a few cases.

This calculation determines the voltage available at the 480 V level to supply safety-related 120 VAC loads. The evaluation of the minimum acceptable voltage at the 120 V level is beyond the scope of this calculation.

3. INPUT DATA

3.1. 4 KV Safety Related Motors

The following are the acceleration times, safe stall times, and overcurrent relay trip times of the LOCA-initiated 4KV Voltage motors.

SERVICE, EQUIPMENT NO.	RATED VOLTAGE	ACCELERATION TIME (Sec.)	Thermal Limit (safe stall) (Sec.)	Overcurrent Relay Trip Time (Sec.)	REF.
HPCS 1E22-C001	100% 80% 75%	1.56 3.12 4.78	14 18 19	4.75 5.45 5.8	11.5 11.5 11.5
LPCS 1E21-C001	100% 80% 75%	1.085 2.17 4.00	14 18 ---	4.4 5.0 ---	11.4 11.4 11.19, 11.20
RHR 1E12-C002A, B, C	100% 80% 75%	1.25 2.40 3.30	14 18 ---	4.0 4.5 ---	11.4 11.4 11.19, 11.20
SSW 1SX01PA, B	100% 90% 75%	0.80 1.15 2.50	14 17 24.5	5.5 5.7 6.7	11.4 11.4 11.4

3.2 HVAC Motors Minimum Starting Voltages

The following motors have minimum starting voltages of 75% of motor rated voltage (Reference 11.17). Attachment 35 contains additional actual start time evaluation and fan manufacturer data.

0VG05CA	1VD01CC	1VX03CB	1VY01C	1VY05C
0VG05CB	1VH01CA	1VX03CC	1VY02C	1VY06C
1VD01CA	1VH01CB		1VY03C	1VY07C
1VD01CB	1VX03CA		1VY04C	1VY08CA
				1VY08CB

3.3. 0VG02CA & OVG02CB

The minimum starting voltages for 0VG02CA and 0VG02CB are not specified. However, the following is obtained from the vendor data (Reference 11.16):

HP Rating	30 hp
Calculated BHP required at the maximum specified driven equipment output	20 BHP

This data is used in the fan start time evaluation performed in Attachment 35.

3.4 Acceleration of Motor 1SX01PC

SSW 1C Pump 460V Motor 1SX01PC is required to accelerate to rated speed in a maximum of five seconds with a 75% rated terminal voltage (Reference 11.15). The start time for SSW 1C is evaluated in calculation 19-AQ-08 (Reference 11.34) and summarized below:

SERVICE, EQUIPMENT NO.	RATED VOLTAGE (460 V)	ACCELERATION TIME (Sec.)	FINAL MOTOR SPEED (RPM)
SSW 1SX01PC	100%	0.464	1760
	70%	1.624	less than 1760
	60%	4.647	less than 1144
	56%	2.126	less than 968

3.5. Blank

This Input Number was intentionally left blank.

3.6. MCC Contactors

The dropout voltage for ITE and GE MCC size 1 & 2 120 VAC rated contactors is 45 and 65 volts respectively. (Note: Sizes 3 & 4 contactors are 480 volt units) (Ref. 11.33).

3.7. MCC Control Transformers

The minimum MCC bus voltage required by the contactors fed from control transformers located in the MCC buckets is assumed at or above 440 VAC. See the Assumption Section for the basis of this value.

3.8. MOV Safe Stall Times

The maximum safe stall time at rated locked rotor current ranges from 10 to 30 seconds for various MOV motor sizes (Reference 11.25).

3.9. Minimum Motor Voltage

Minimum motor terminal voltage for steady state operation for NEMA frame motors is 90% of rated (Reference 11.24 NEMA MG-1).

3.10. Reset and Trip Voltages

The critical safety related bus voltages used in this calculation as discussed in the Definition and Purpose Sections are restated below:

Maximum Reset	4149 VAC
Reset (minimum)	4084 VAC
Trip (minimum)	4035 VAC

3.11. Blank

This Input Number was intentionally left blank. (See Input Data 3.1 for the information that was previously shown here.)

3.12. Minimum expected offsite source voltages

The minimum expected offsite source voltages per 19-AK-06 (Ref. 11.2) are as below:

Source	Volts (% of Rated)	Reference
345 KV (RAT) (ELMS-AC source 2)	324,300 (94%)	11.2
138 KV (ERAT) (ELMS-AC source 3)	122,820 (89%)	11.2

3.13. Auxiliary Power System Parameters

The Auxiliary Power System parameters are documented in calculations 19-AK-01, 19AK-02, 19-AK-06, and 19-AK-08 (References 11.46, 11.47, 11.2, and 11.48). For explanation, references, and other technical details of the ELMS model, bus connections, system parameters, transformer tap settings, load data, etc. The parameters were transferred to this calculation via the ELMS files discussed below.

3.14. ELMS-AC files

The following ELMS-AC computer files are input data for this calculation:

AQ2V33.001
AQ2AV33.001
AQ2BV33.001
AQ2CV33.001
ACAPV45.001

STARTT0.001
STARTT3.001
STARTT5.001
STARTT7.001
STARTT10.001
STARTT10.002

ACAPV45.002 (Note this is the same file as ACAPV45.001 except for the file extension number)

3.13. Time Delayed Continuous Duty Loads

The following continuous duty motors have time-delayed starting after the LOCA Block Start. These are the only differences between the Steady State data file and the T = 13 Seconds data file.

Load Equipment No.	Load Name	Supply Bus
1VX06CA	SWGR 1A HT RMVL COND UNIT	480V BUS 1A
1VX06CB	SWGR 1B HT RMVL COND UNIT	480V BUS 1B
1VX03CA	SWGR 1A & 1A1 HEAT RMVL FAN1A	A B MCC 1A1
1VX03CB	SWGR 1B HEAT RMVL FAN 1A	A B MCC 1B1
0VC05CA	CTL RM HVAC M-U AIR FAN A	C B MCC E1
1VX03CC	SWGR 1C1 HT RMVL FAN 1A	A B MCC 1C1
1VX06CC	SWGR 1C1 HT RMVL COND UNIT	A B MCC 1C1
0VC114YA	CTL RM FLT TRN A DMPR	DAMPER MCC A

3.14. HPCS Test Valves

The following MOV loads were conservatively included in the block start cases because of the condition that the HPCS system could be in test at the time of LOCA initiation. Separate condition were modeled without these valves.

Load Equipment No.	Load Name	Supply Bus
1E22-F010	HPCS Test Return Line Valve to RCIC Storage Tank	A B MCC 1C
1E22-F011	HPCS Test Return Line valve to RCIC Storage Tank	A B MCC 1C
1E22-F023	HPCS Test Return Line valve to Suppression Pool	A B MCC 1C

However, the HPCS system would be inoperable if it is in test at the time of LOCA initiation (Ref. 11.43 and 11.44). Division 3 bus voltage levels will be analyzed with HPCS not in test and Division 1 and 2 bus voltages will be analyzed with HPCS in test.

3.15. Load Measured Versus Modeled

The actual Balance of Plant (BOP) load data captured by the TRENDIT (the plant data acquisition and trending) program for the winter of 1995 (the months of January, February and December) was compared to the modeled loading in 19-AK-06 (Ref. 11.2) ELMS winter loading condition. This comparison identified that there is conservatism in the load modeled in 19-AK-06. For the purpose of this calculation, the conservatism was reduced by 75% as documented in Attachment 36. The difference between the AK-06 and TRENDIT data was 3.91 and 4.66 MVA for the 6.9 and 4.16 KV buses respectively. This calculation reduced the 6.9 KV bus 1A loading by 2933 KVA (75% of 3.91) and the 4.16 KV bus 1A loading by 3498 KVA (75% of 4.66) compared to the corresponding loading condition in 19-AK-06. (See Attachment 36). Note that this load data comparison was performed against trend data and ELMS data at one point in time. The difference in loading between the actual plant load and the ELMS model are expected to remain the same if compared with the latest plant operating configuration.

4. ASSUMPTIONS

4.1. Safe Stall Time

Data for Westinghouse NEMA motors with a service factor of 1.0 supplied to Buffalo Forge have a safe stall time at rated voltage (drawing locked rotor current) from 16 to 31 second and at 65% of rated motor voltage from 42 to 85 seconds. This is considered typical. Therefore, for the purposes of this analyses, a 15 second safe stall time at rated locked rotor current is assumed.

4.2. Reduced Voltages

Continuous duty motors with reduced voltage start accelerating at T=0 due to the large delta between available motor torque and required driven equipment torque at low speed (i.e., motors will not stall at T=0 seconds). (See Reference 11.34 for typical examples.)

4.3. Pump Inertia

Compressor and pump loads typically have low load inertia, WK^2 ,values in relation to the motor capability to accelerate the load.

4.4. 460 V Motor Acceleration Times

The acceleration times for 460-V continuous duty motors are estimated as starting or running at specific times in the block start model. (See Attachment 35.)

4.5. Power factor and Efficiency

Manufacturer full-load current data is available for certain 460 V motors and are used to determine power factors and efficiencies, as documented in Attachment 27. Otherwise, estimated power factors and efficiencies for 460-V continuous-duty motors are used, per Calculation 19-AK-6.

4.6. MOV Motor Torque

(Assumption Requires Verification)
The MOV motor terminal voltages calculated in Attachment 21, Table 2 and 2B are assumed to provide sufficient motor torque to seat/unseat the associated MOV. See Attachment 21 for more details. This assumption requires verification; the Series M98 MOV thrust calculations should be further evaluated.

4.7. MCC Contactors

MCC contactors energized prior to, or at T=0 are assumed to remain energized at $T=0^+$. This is conservative since it produces worst case T=0 motor terminal voltages. If some contactors drop out at T=0 due to the degraded bus voltage, then the initial starting load would be reduced. Devices typically have approximately a 20% difference between their pickup and dropout values and, therefore, contactors, which may drop out, are not expected to pick up until bus voltages improve by approximately 20%.

4.8. Damper Motors

A minimum starting voltage of 80% is assumed for damper motors. (See Reference 11.42 found in Attachment 31.)

4.9. 120 VAC Loads

(Assumption Requires Verification)
The 120 VAC loads, including contactors, will have adequate voltage provided the MCC feeder bus is at 440 VAC or higher. Applicable "AJ" series calculations will be revised to verify this assumption. Specific calculation that may be impacted include: 19-AJ-70, 19-AJ-71, and 19-AJ-72 (Ref. 11.33, 11.35, and 11.36).

4.10 SVC Regulation

(Assumption Requires Verification)
The SVC for the RAT & ERAT will be adjusted to control the safety related 4.16kV Class 1E bus voltage to a minimum value of 4135 V to 4149 V.

4.11 SVC Response Time

(Assumption Requires Verification)
The SVC response time (full inductive to full capacitive) is assumed to be less than 0.1 second and the actual response will not significantly impact this calculation. The analysis of large motor acceleration in this calculation is conservative enough to allow for no acceleration for large motors until 0.1 seconds following the LOCA Signal. A 0.1 second delay will not cause protective device actuation, motor overheating, or significantly impact the overall start time of the motors. Therefore, it is acceptable that the analysis models the SVC "On" at time equal to zero.

4.12 MOV Voltages

(Assumption Requires Verification)
It is assumed that the MOV voltages calculated in Attachment 21 are adequate. MOV thrust calculations will confirm the adequacy of the calculated voltages.

5. ACCEPTANCE CRITERIA

5.1 Start Time Sequence

The acceptance criteria for starting motors is that they accelerate within the allowable safe stall time which is assumed to be 15 seconds at rated locked rotor current for continuous duty 460-V motors. For conservatism, 13 seconds will be used as the acceptance criteria.

The minimum starting voltage required at the terminals of continuous duty motors is 75% of motor rated voltage for individual motor start as analyzed in Attachment 21, Tables 4 & 4C:

Minimum Required Starting Voltage for Continuous Duty Motors	
Motor Rated Voltage	Minimum Terminal Voltage
4000 Volts	3000 Volts
460 Volts	345 Volts

The minimum steady state operating (running) voltage required at the terminals of continuous duty motors is 90% of motor rated voltage (Refer to Attachment 21, Tables 4A & 4B):

Minimum Required Running Voltage for Continuous Duty Motors	
Motor Rated Voltage	Minimum Terminal Voltage
4000 Volts	3600 Volts
460 Volts	414 Volts

5.2 MOV Motors

Adequacy of voltage available to the MOV motors is analyzed in separate thrust/torque calculations (Series M98 Thrust Calculations). The minimum voltage available at the MOV motor terminals under transient and steady state conditions is calculated in Table-2 and Table-2B of Attachment 21. The voltage calculated in Table 2 or 2B for MOVs should be used in the associated thrust calculation. The calculation cover sheet will be marked "confirmation required" until the impact on the affected thrust calculations is resolved (See Assumption).

5.3 120 VAC

The minimum required MCC bus voltage for 120 VAC control and distribution circuits after the LOCA block starting (transient) period is determined in separate calculations as indicated in the following table:

Minimum Bus Voltage for 120 VAC Control and Distribution Circuits

Div.	Bus	Ckts fed from Control Xfmrs		Ckts fed from non-reg. dist. Xfmrs		Acceptance Criteria
		Volts	Ref.	Volts	Ref.	Min. Voltage
I	C B MCC E1	440	Ref.11.36	n/a*	Ref. 11.45	440
	C B MCC E2	440	Ref.11.36	421	Ref. 11.45	440
	C B MCC G	440	Ref.11.36	421	Ref. 11.45	440
	SSW MCC 1A	440	Ref. 11.33 & 11.35	n/a**	Ref. 11.45	440
	DG MCC 1A	440	Ref.11.36	n/a*	Ref. 11.45	440
	DAMPER MCC A	440	n/a***	n/a***	Ref. 11.45	440
	A B MCC 1A1	440	Ref.11.36	421	Ref. 11.45	440
	A B MCC 1A2	440	Ref.11.36	n/a*	Ref. 11.45	440
	A B MCC 1A3	440	Ref. 11.33 & 11.35	n/a*	Ref. 11.45	440
	A B MCC 1A4	440	Ref.11.36	425	Ref. 11.45	440
II	C B MCC F1	440	Ref.11.36	n/a*	Ref. 11.45	440
	C B MCC F2	440	Ref.11.36	421	Ref. 11.45	440
	C B MCC H	440	Ref.11.36	421	Ref. 11.45	440
	DAMPER MCC B	440	n/a***	n/a***	Ref. 11.45	440
	SSW MCC 1B	440	Ref. 11.33 & 11.35	n/a**	Ref. 11.45	440
	DG MCC 1B	440	Ref.11.36	n/a*	Ref. 11.45	440
	. B MCC 1B1	440	Ref.11.36	421	Ref. 11.45	440
	A B MCC 1B2	420	Ref.11.36	n/a*	Ref. 11.45	440
	A B MCC 1B3	440	Ref.11.36	n/a*	Ref. 11.45	440
	A B MCC 1B4	440	Ref.11.36	424	Ref. 11.45	440
III	A B MCC 1C1	440	Ref. 11.33 & 11.35	421	Ref. 11.45	440
	A B MCC 1C (HPCS MCC)	440	Ref. 11.33 & 11.35	n/a*	Ref. 11.45	440
	SSW MCC 1C	440	Ref.11.36	n/a**	Ref. 11.45	440

* No distribution panel in this MCC

** No essential circuits for LOCA mitigation

*** The dampers control circuits are fed from the distribution panels in other MCC's

5.4. Protective Relay/Overload Relay Evaluation

Protective Relay / Overload Relay Evaluation are outside the scope of this calculation. However, if evaluations are necessary the protection devices should not trip during motor starting.

5.5 Second Level Undervoltage Relay Setpoint

The acceptance criteria is as discussed in the purpose.

5.6 Damper Motors

The minimum steady state operating (running) voltage required at the terminals of damper motors is 75% for starting and 80% for running of 460V (or 368V) as indicated in reference 11.42.

6. METHODOLOGY

6.1 Introduction

This calculation analyzes the electrical load performance during the LOCA block start and steady state running conditions. Motor performance is determined by the loads ability to accelerate to operating speed under changing voltage and load conditions. The loads must obtain rated speed at least to the minimum rated voltage within specific time periods. Excessive motor start times and low voltages can cause load overheating, protective device trips, and failures of safety related functions. During the LOCA block start condition, the load and corresponding voltage will change with time. This type of analysis is referred to as dynamic transient starting analysis. Heaters and 480/120 VAC distribution transformers are also considered in the analysis.

The method for this calculation is to simulate the dynamic transient starting analysis by calculating load terminal and bus voltages at discrete points in time. The results are compared to the equipment's rating to determine whether the loads will operate within the required time period. When necessary detail load start times have been calculated based on available motor torque at reduced voltages.

6.2 Major Steps:

The method has the following major steps:

1. Identify safety related loads and their start times during a LOCA with offsite power and document the results on Attachments 24, 25, and 26.
2. Develop different load condition for each significant start time during the LOCA event.
3. Use the computer program ELMS-AC PLUS (reference 11.28) for voltage calculations. See the Instruction Manual for operating the program (Ref. 11.28).
4. Obtain the ELMS input data files from calculation 19-AK-06 (REF. 11.2) that shows Condition 4, LOCA plus winter with the 90°C connection impedance. This file is typically numbered ACAPxx.001, where "xx" is the revision of the file. Rename this file ACAPxxx.002 for use as a master source file.
5. Obtain the ELMS input data files for calculation 19-AQ-02. The files are typically numbered AQ2Vxx.001 or AQ2Vxx.EP1 where "xx" is the revision of the file and EP stands for an ELMS AC PLUS file. Various other files can be created with AV, BV, CV, etc. instead of the V or a different extension to represent other load cases.

6. Use calculations 19-AK-01, 19AK-02, 19-AK-06, and 19-AK-08 (References 11.46, 11.47, 11.2, and 11.48), for explanation and other technical details of the ELMS model, bus connections, system parameters, load data, etc.
7. Using the ACAPVxx.002 file either create a new master file for 19-AQ-02 or use ELMSCOMP to update AQ2Vxx.EP1. See the Instruction Manual for operating the program (Ref. 11.28). This file would than be the master file for 19-AQ-02. Rename the new or revised file with the next revision number.
8. Update AQ2Vxx.EP2 with unique data required for 19-AQ-02 that does not currently exist in ACAPVxx.001.
9. Simulate running MOV motors in ELMS by adjusting the LRC values per Attachment 22.
10. Simulate starting MOV motors in ELMS by adjusting the LRC values per Attachment 22.
11. Use the bus to load circuit impedance data from Attachment 21 and update ELMS for critical safety related loads.
12. Simulate a BOP loading similar to approximately 75% of the actual plant operating load. Reduced the 6.9 KV bus 1A loading by 2933 KVA (75% of 3.91) and the 4.16 KV bus 1A loading by 3498 KVA (75% of 4.66). Modify the BHP under condition # 4 for loads 1CW01PA (load # 2), 1CB01PC (load # 9), 1CD01PA (load # 12), 1CD01PC (load # 13), 1WS01PC (load # 20), or other BOP loads to obtain the reduction.
13. Record on Attachments 40 to 42 the ELMS Bus Data, Connection Data, and Load Data to document the master file.
14. Create unique ELMS files to represent the different times.
15. Record on Attachment 0.6 the ELMS File Cross Index to Attachments and Conditions.
16. Create unique ELMS-AC PLUS block load start files for different times.
17. Use the computer program ELMSCOMP (refere[illegible] 11.28) to maintain and verify differences between ELMS data files and [illegible]ment the results on Attachments 43.1 to 43.5.
18. Run ELMS-AC Plus to calculate bus voltages for various conditions as shown on Attachment 0.6.

19. Perform each run at the minimum offsite switchyard voltage.

20. Run each condition with a target voltage corresponding to either the minimum reset (4084 V), maximum reset (4149 V), or minimum trip (4035 V). Buses 1A1, 1B1, and 1C1 must be at (with a tolerance of +/- 0.2V)or above the target voltage except for when the SVC is at it's maximum VAR output. Vary the SVC VAR value under the ELMS condition 4 BHP column. The 2 SVC's are the last loads on the ELMS Load List as shown Attachment 42.

21. Document each run in Attachments 1 to 20.

22. Update Attachments 0.1 to 0.4 with the bus voltage values from the applicable ELMS run as shown on the attachments.

23. Update Attachment 21, Voltage Drop From Source Bus to Motor Terminals and Motor Feeder Circuit Data. See Attachment 21 for the method used.

24. Compare the results shown in Attachments 1 to 21 against the acceptance criteria and document the result.

6.3 Specific Timing

Based on past 19-AQ-02 revisions and numerous analysis iterations the following time sequence was determined and forms the base method for constructing the ELMS load files:

6.3.1 LOCA Block Start T=0

Starting:

The first LOCA block start case analyzed is at LOCA T=0. This case models bus and motor terminal voltages (for critical case motors) in a locked rotor condition for motors and MOV motors receiving a LOCA signal. Excluded are MOV's 1IA012A and 1IA013A which are time delayed. Results of this case are used to evaluate voltages at MCC buses to identify if there is a potential for contactors to drop out.

Running:
None.

Off:
MOV motors 1IA012A, 1IA013A and other equipment with time delays.

Note that when the term motor is used in this calculation, it is in reference to continuous duty and damper motors. References to MOV motors will be specifically identified as such.

6.3.2. LOCA Block Start T=0+

The second LOCA block start case analyzed is at LOCA $T=0^+$. The difference between this case and T=0 case is that MOVs are modeled with current at the operator rated torque. Refer to Section 6.4 for a description of MOV modeling.

Data File for $T=0^+$

Starting:
Medium voltage motors (1SX01PA, 1SX01PB, 1E12-C002C, 1E21-C001, and 1E22-C001), 460-V continuous duty (including 1SX01PC) and damper motors, and MOV motors 1SX014A, 1SX014B, 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachments 2.1 & 12).

Running:
MOV motors 1IA012B, 1IA013B (simulated in ELMS as starting).

Off:
Medium voltage motors 1E12-C002A, 1E12-C002B, MOV motors 1IA012A, 1IA013A and other equipment with time delays.

The results of the T=0+ are evaluated to assess motor terminal voltages for large motors. A third time period is selected at which time some of the medium voltage motors are up to speed. This case models some LOCA block start motors as running if they have had sufficient voltage and acceleration time. The results of this case are evaluated and additional time periods are selected for additional cases as required. The purpose of the multiple cases is to confirm that at some time after $T=0^+$ all motors receive adequate voltage to allow the motor to accelerate within an acceptable time period.

6.3.3. Data File for T=3s

Starting:
1E21-C001 (LPCS) and 1E22-C001 (HPCS); 460-V continuous duty and damper motors; MOV motors 1SX014A, 1SX014B, 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachments 3 & 13).

Running:
1SX01PA, 1SX01PB, 1E12-C002C, and MOV motors 1IA012B, 1IA013B (simulated in ELMS as starting).

Off:
1E12-C002A, 1E12-C002B, MOV motors 1IA012A, 1IA013A, and other equipment with time delays.

6.3.4. Data File for T=4s

Starting:
1E22-C001 (HPCS); 460-V continuous duty and damper motors and MOV motors 1SX014A, 1SX014B, 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachments 4 & 14).

Running:
1E21-C001, 1SX01PA, 1SX01PB, 1E12-C002C, and MOV motors 1IA012B and 1IA013B (simulated in ELMS as starting).

Off:
1E12-C002A, 1E12-C002B, MOV motors 1IA012A, 1IA013A, and other equipment with time delays.

6.3.5. Data File for T=4.5s

Starting:
460-V continuous duty and damper motors and MOV motors 1SX014A, 1SX014B, 1SX173A, 1SX173B, 1E21-F005, 1E22-F004, 1IA012A, 1IA013A (see Attachments 5 & 15).

Running:
1E12-C002C, 1E21-C001, 1E22-C001, 1SX01PA, 1SX01PB , and MOV motors 1IA012B, 1IA013B, (simulated in ELMS as starting).

Off:
1E12-C002A and 1E12-C002B and other equipment with time delays.

6.3.6. Data File for T=5s

Starting:
RHR Pumps A and B (1E12-C002A and 1E12-C002B), 460 V continuous duty and damper motors and MOV motors 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachments 6.1 & 16).

Running:
1E12-C002C, 1E21-C001, 1E22-C001, 1SX01PA, 1SX01PB, and MOV motors 1SX014A, 1SX014B, 1IA012A, 1IA013A, 1IA012B, 1IA013B (simulated in ELMS as starting).

Off:
Equipment with time delays.

6.3.7. Data File for T=7s

Starting:
460-V continuous duty and damper motors and MOV motors 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachment 7.1 & 17.1).

Running:
All medium voltage motors, 1SX01PC, and MOV motors 1SX014A, 1SX014B, 1IA012A, 1IA013A, 1IA012B, 1IA013B (simulated in ELMS as starting).

Off:
Equipment with time delays.

6.3.8. Data File for T=13s

Starting:
MOV motors 1SX173A, 1SX173B, 1E21-F005, 1E22-F004 (see Attachment 8.1 & 18.1).

Running:
Medium voltage motors and 460-V continuous duty, damper motors, MOV motors 1SX014A, 1SX014B, 1IA012A, 1IA013A, (simulated in ELMS as starting)

Off:
MOV motors 1IA012B, and 1IA013B and other equipment with time delays.

6.3.9. Data File for Steady State

Running:
Medium voltage motors, 460-V continuous duty and damper motors, MOV motors. Time delayed continuous duty loads begin operating, but are modeled as running. The latter are 0VC05CA, 0VC114YA, 1VX03CA, 1VX03CB, 1VX03CC, 1VX06CA, 1VX06CB, and 1VX06CC, per Attachment 24.

Off:
All LOCA-initiated MOV's have or will be stroked and are considered off.

6.4. Modeling of MOV's

At T=0, MOV's are modeled with Locked Rotor Current. However, since MOV's start de-clutched, the motors are actually near rated speed when the clutch is engaged. Therefore, the initial Locked Rotor Current (inrush) is expected to last for less than 0.5 seconds provided the MOV motor has sufficient torque (Reference 11.22). LOCA MOV's will generally take more than 15 seconds to complete their stroke (Ref. 11.30).

Whether the MOV's receive adequate voltage for their torque is beyond the scope of this calculation. This calculation, per Attachments 0.2 and 0.3, only provides the MCC bus voltages at various points in time after a LOCA signal. This data is then used in Attachment 21, Tables 2 and 2B, to calculate the MOV motor terminal voltage. See Attachment 21 for more details.

For more information on MOV modeling, see the following sections on initially-Closed a initially-Open MOV's. (Ref. 11.30 identifies the MOV's). For additional information o MOV modeling, see References 11.38 and 11.39.

6.4.1. Initially-Closed MOV's that receive an Open signal

At T=0+ (when motor terminal voltages have dipped) through T=13, MOV motors for initially-closed gate or globe valves may generally be modeled with Locked Rotor Current and at Starting Power Factor. These motors are presumed to stall until enough bus voltage is available to provide sufficient torque to unseat the valves. Section 8.4.4 cites four such MOV's.

Eventually, the bus voltages should recover from the LOCA dip. With the motor approaching rated speed, the initially-closed MOV's begins unseating. The MOV motors should then draw Current at Rated MOV Torque See Attachment 21, Sections 6.2.4. and 6.2.5 for the voltage drop calculations. For the stalled MOV's cited in Section 8.4.4, their recovery are expected during Steady State.

6.4.2. Initially-Open MOV's that receive a Close signal

At T=0+ through T=13, MOV motors for initially-open gate or globe valves are presumed not to stall. Open MOV's do not require an unseating torque during the initial start; hence they are expected to operate at 20-40% of the Rated MOV Torque until the valves approach the closed position (Reference 11.22). Attachment 21, Appendix B, Section 3.2 also supports this by stating that Open MOV's require about 10 to 25% of the Rated MOV Torque. Nevertheless, Open MOV's are modeled with a Current equal to that required to produce Rated MOV Torque, for conservatism. For example, for a 25 ft-lb. operator, the current associated with 25 ft-lb. is used. This is significantly higher than the current associated with the Nominal Torque (5 ft-lb) which Limitorque refers to as the motor full-load current.

The initially-open gate and globe valves should only require a seating torque during Steady State since LOCA MOV's generally have stroke times greater than 15 seconds. When the gate and globe valves finally do stroke close, the voltages will have improved significantly because all of the continuous duty and damper motors will have accelerated.

Butterfly valves are not torqued closed and therefore will not require a seating torque at the end of the stroke.

6.5. HPCS Test Valves

HPCS test valves are modeled and analyzed both ON and OFF as shown in Attachment 0.6. The lowest voltage from the two cases is used.

A T=13 sec. case similar to the one described in section 6.1 will be analyzed with HPCS test valves removed from the block start population. Effects of HPCS Test valves actuating will be analyzed for the impact on the Division 1 and 2 bus voltages. The effect of the HPCS test valves is expected to be same regardless of the source, therefore only case with RAT source will be analyzed. A comparison of bus voltage with and without HPCS test valves actuating is shown in Attachment 0.4. The effect on Division 3 bus voltage is of no significance since HPCS is declared "not in operation (INOP)" during test mode.

6.6. Effect of VC Train on Bus Voltage

In the ELMS-AC data files, Train A of the Control Room HVAC (VC) system is supplied from the Division I buses. In Attachment 0.1, the impact of supplying Train B of the VC system from the Division II buses was determined. In Attachment 0.1, the results will be used to calculate a bus voltage correction factor for each bus whose voltage would be lower when Train B of the VC system is supplied from Division II. These correction factor will be applied to the Division 2 bus voltage analysis performed using ELMS-AC data files which only model VC train A running.

7. CALCULATIONS

7.1. ELMS Files

The ELMS files were created as discussed in the Section 6, Methodology. Various cases were studied and the results documented. Attachment 0.6 provide a cross reference to the cases studied. Each ELMS file contain only one load case filed under load condition 4. Cases were performed with the switchyard at the minimum voltage. Both HPCS test valves and VC trains A and B were modeled.

Following are the files:

FILE NAME	BYTES	DATE	TIME
AQ2BV33.001	257,262	3/31/02	12:32a
AQ2BV33T.001	257,262	1/15/99	01:30p
AQ2CV33.001	257,262	3/31/02	12:42a
AQ2CV33T.001	257,262	1/15/99	01:32p
AQ2V33.001	257,262	4/5/02	01:34a
AQ2V33P.001	362,874	1/15/99	02:10p
AQ2V33T.001	257,262	1/13/99	09:09a
AQ2AV33.001	258,312	3/31/02	12:13a
AQ2AV33T.001	258,312	1/15/99	01:29p
AQ2AV33P.001	364,212	1/27/99	02:51p
AQ2CV33P.001	362,874	1/27/99	02:43p
AQ2BV33P.001	362,874	1/27/99	02:35p
STARTT10.EP2	4,404	11/13/97	10:06a
AQ2CONF.CFS	362,874	1/28/99	01:52p
DIR.OUT	0	2/24/99	09:47a

7.2. Bus Voltage

Calculations of bus voltages and a select number of motor terminal voltages at various time intervals were prepared. Results of these calculations are included in Attachments 1 through 10 for the RAT source, and in Attachments 11 through 20 for the ERAT. The Table of Content provides a complete list of attachments.

7.3. Minimum Voltage Summaries

Voltage reports from ELMS-AC analysis are summarized in Attachments 0.2 (T=13sec) and Attachment 0.3 (Steady State). The effect of the VC train is applied to the bus voltage determined based on the relay settings which is the limiting case. The minimum voltage is determined from RAT or ERAT which ever is the lowest. The minimum voltage levels calculated in Attachment 0.2 and 0.3 were used to determine voltage at the MOV motors (Tables 2 and 2B in Attachment 21).

8. COMPARISON OF RESULTS WITH ACCEPTANCE CRITERIA

8.1 Start Time Sequence

Motor terminal voltages are analyzed at various time intervals to determine the point in time at which each motor has sufficient voltage to accelerate to full speed.

8.1.1 Voltages at T=0 Seconds

The T=0 case models all MOV's and Continuous Duty (including Damper) motors as starting on a LOCA signal with locked rotor current. Attachments 1 and 11 document the bus and motor terminal voltages at T=0 for the RAT and ERAT sources, respectively.

The MCC bus voltages at T=0 are sufficiently low to allow some MCC contactors to drop out. For conservatism, all contactors are assumed to remain operating for the purpose of the block start analyses. This approach is conservative since it increases the total block start load during the first few seconds. That is, a dropout of some 460-V motors would more evenly distribute the total load over time and would allow T=0 loads to accelerate more quickly. See Section 8.3 for further discussion on contactor dropout.

8.1.2 Voltages at T=0+ Seconds

The voltages at $T=0^+$ reflect that MOVs which are not unseating are modeled operating at currents equal to that of their rated torque of associated MOVs.

Voltages at terminals of 4 KV and 460 V Continuous duty motors are adequate to start accelerating most continuous duty motors since the torque requirements for most of the driven equipment (fans and pumps) are relatively low at low speed (see Reference 11.8 for typical curves).

4160 bus voltages range from approximately 79.3% to 81.7% of 4 KV (See attachments for actual values). The worst case cable voltage drop of a 4-KV motor feed is to the SSW 1A (1SX01PA).

The medium voltage pump mctors starting at T= 0+ seconds are HPCS, LPCS, RHR 1C, SSW 1A, and SSW 1B. The voltages and acceleration times for three of these motors are shown below:

ACCELERATION TIME (SEC.)			
	(4000 V Base)		
Motor	%Volt at T=0+	75% V	80% V
RHR 1C (1E12-C002C)	82.6	3.3	2.4
SSW 1A (1SX01PA)	79.3	2.5	---
SSW 1B (1SX01PB)	80.6	2.5	---

Attachment 2.1 documents that RHR 1C, SSW 1A, and SSW 1B receives greater than 75% terminal voltage at $T=0^+$.

Based on the terminal voltages at these motors at T=0+, all three of these motors are expected to accelerate to full speed in approximately three seconds. Therefore, the RHR 1C, SSW 1A, and SSW 1B motors will be modeled as running for the three-second case.

8.1.3 Voltages at T=3 Seconds

Bus and motor terminal voltages at T=3 seconds for the RAT source are tabulated in Attachment 3.

The LPCS (1E21-C001) motor will be the next medium voltage motor to reach full speed. The voltage profile for the LPCS motor is as follows:

	4 KV Base VOLTS@	4 KV Base VOLTS@	ACCELERATION TIME (SEC) @		
LPCS	T=0+	T= 3	75% V	80% V	100% V
	81.7	92	4.00	2.17	1.085

Based on LPCS terminal voltages, this motor is expected to accelerate to full speed in less than four seconds (approximately 2.4 seconds based on interpolation). Therefore, the LPCS motor will be modeled as running for the four-second case, which is conservative.

Most 460-V continuous duty motors are assumed to be accelerating during the time interval.

8.1.4 Voltages at T=4 Seconds

Bus and motor terminal voltages at T=4 seconds for the RAT source are tabulated in Attachment 4.

The HPCS motor will be the next medium voltage motor to reach full speed. The voltage profile for the HPCS (1E22-C001) motor is as follows:

	4 KV Base					
	VOLTS@	VOLTS@	VOLTS@	ACCELERATION TIME (SEC) @		
HPCS	T=0+	T= 3	T= 4	75% V	80% V	100% V
	80.3	90.3	94.6	4.78	3.12	1.560

Based on HPCS terminal voltages, this motor is expected to accelerate to full speed in less than 4 (3.75 sec. interpolated) seconds. Therefore, the HPCS motor will be modeled as running for the 4.5 second case to be conservative.

The 460-V continuous duty motors are assumed to be accelerating during this interval.

8.1.5 Voltages at T=4.5 Seconds

Bus and motor terminal voltages at 4.5 seconds for the RAT source are tabulated in Attachment 5.

The primary purpose of this case is to establish bus voltage after medium voltage motors started at T=0 have accelerated and before RHR 1A and RHR 1B motors are started.

8.1.6 Voltages at T=5 Seconds

Bus and motor terminal voltages at 5 seconds for the RAT source are tabulated in Attachment 6.1.

The RHR 1A and 1B motors are modeled as starting at T=5 seconds. The terminal voltages and acceleration times for these motors are as follows:

	4 KV Base Volts @	ACCELERATION TIME (SEC.) AT		
	T = 5	75% V	80% V	100 % V
RHR 1A	99.8	3.3	2.4	1.25
RHR 1B	102.2	3.3	2.4	1.25

Based on the terminal voltages, RHR 1A and 1B motors are expected to accelerate to full speed in less than 2 seconds (1.4 interpolated). Therefore, the RHR 1A and 1B motors will be modeled as running for the T=7 second case.

The SSW 1C pump motor (460 V) has a specified acceleration time of less than 5 seconds at 75% voltage (Reference 11.15). The following is the voltage profile (ON A 460 V BASE) for this motor.

VOLTS @ T = 0+	VOLTS @ T = 3	VOLTS @ T = 4	VOLTS @ T = 4.5	VOLTS @ T = 5
64.9	72.9	76.4	81.2	79.8

Based on calculation 19-AQ-08 (Ref. 11.34), the motor is expected to accelerate at a reduced voltage in greater than 4.5 seconds but less than 7 seconds. The SSW 1C motor will therefore be shown as running for the T=7 second case.

All other 460 volt continuous duty motors are assumed to be accelerating during this time interval, because MCC bus voltages are above 75%. For conservatism no credit is taken for any of these motors having accelerated to full speed.

8.1.7 Voltage at T=7 Seconds

Bus and motor terminal voltages at T=7 seconds for the RAT source are tabulated on Attachment 7.1.

All medium voltage motors receiving a LOCA signal have been started and accelerated by T=7 seconds. Remaining analyses will concentrate on the performance of the low voltage distribution system. (The SSW 1C motor was analyzed in the previous section and is excluded from the following analysis.)

All 460-V fan and damper motors are modeled as accelerating at the T=7 second time.

The continuous duty motors larger than 1 HP, which receive a LOCA signal and start at T=0 are modeled with individual motor terminal buses. The following are voltage profiles for these motors which drive fan loads.

460 V Continuous Duty Fan Motors					% Voltage At Time =					
Motor	HP	Start time at 75% V (Att. 35)	Estimated Total Elapsed Start Time (sec)	Min Starting Volt. %	T=0+	T=3	T=4	T=4.5	T=5	T=7
Division 1										
0VG02CA	30	9	12	---	73.1	83.3	87.7	93	91.2	93
0VG05CA	5	5.5	8.5	75	70.3	80.1	84.3	89.3	87.6	89.3
1VD01CA	125	13.6	16.6	75	68.7	77.4	81.3	85.8	84.2	85.8
1VH01CA	15	15.8	18.8	75	71.4	80.5	84.5	89.2	87.6	89.2
1VY01C	7.5	5.8	8.8	75	70.5	79.4	83.4	88.0	86.4	88.0
1VY02C	5	6.2	9.2	75	71.4	80.5	84.5	89.3	87.6	89.3
1VY03C	5	6.2	9.2	75	70.8	79.9	83.8	88.5	86.9	88.5

460 V Continuous Duty Fan Motors					% Voltage At Time =					
Motor	HP	Start time at 75% V (Att. 35)	Estimated Total Elapsed Start Time (sec)	Min Starting Volt. %	T=0+	T=3	T=4	T=4.5	T=5	T=7
1VY04C	2	12.2	15.2	75	70.6	79.6	83.6	88.2	86.6	88.3
Division 2										
0VG02CB	30	9	10	---	77.8	87.9	92	96.8	96.7	98.4
1VD01CB	125	13.6	16.6	75	66.9	75.2	78.7	82.7	81.3	82.7
1VH01CB	15	15.8	18.8	75	73.2	82.4	86.2	90.6	89.1	90.6
1VY05C	5	6.2	9.2	75	71.7	80.7	84.4	88.7	87.2	88.7
1VY06C	5	6.2	9.2	75	73	82.2	85.9	90.3	88.8	90.3
1VY07C	5	6.2	9.2	75	72.8	81.9	85.7	90.0	88.5	90.0
OVG05CB	5	5.5	8.5	75	73.1	82.5	86.4	90.9	90.8	92.3
Division 3										
1VD01CC	75	6.4	10.4	75	65.8	74	77.5	82.3	80.9	85.7
1VH01CC	3	7.1	11.1	75	64.3	72.3	75.7	80.4	79.0	86.9
1VY08CA	5	6.2	10.7	75	63.5	71.4	74.9	79.5	78.1	82.7
1VY08CB	5	6.2	10.7	75	63.6	71.5	74.9	79.5	78.2	82.8

The "Start Time at 75% Voltage" is taken from Attachment 35. The "Estimated Total Elapsed Start Time" column is the Start Time plus any delay time when it is less than 75% voltage. This conservatively considers that the motor did not accelerate until the 75% terminal voltage was achieved. All motors start in less than 13 seconds except for 1VD01CA, 1VH01CA, 1VY04C, 1VD01CB & 1VH01CB. Attachment 35 performs a more detailed analysis on fans 1VD01CA & 1VD01CB and concludes these fans start before 13 seconds. It should be noted that only the last two columns from Table A (Attachment 35) are used for input to this calculation. These inputs values are conservative for the following reasons. The voltage derivation is shown to be conservative in Table B, and the motor terminal voltages have improved due to the Static VAR Compensator. Refer to the recommendation Section of this calculation. Attachment 35 motor thermal damage curves demonstrate that the motors can be accelerated for at least 20 seconds before damage to the motors occurs. Elapsed start times calculated are below 20 seconds. Additionally, Attachment 30 demonstrates that overcurrent device for 1VD01CA & 1VD01CB is adequately sized for starting the motors. Similar calculations could be performed for 1VH01CA(B) & 1VY04C, but the analysis for 1VD01CA & 1VD01CB is applicable and sufficient.

All but two of the fan loads listed above which receive a LOCA signal were specified to be able to start at 75% of rated voltage (Section 3.2 and Reference 11.17).

The two motors (OVG02CA and OVG02CB) for which 75% starting voltages were not specified have maximum brake horsepower, which are significantly less (66%), than the motor rating. These motors are therefore also expected to accelerate at reduced voltage due to the large differential between motor torque and required fan torque. (Reference Attachment 35.)

All of the motors listed above are expected to start accelerating at T=0 due to the low required fan torque at low speed. By the time T=3 seconds, all of the motors on Division 1 and 2 have at least 75% voltage. The motors with higher terminal voltages are expected to reach rated speed first. As these motors reach speed, the bus and terminal voltages improve for other motors which are still accelerating. Therefore, the terminal voltages on the last motors to accelerate will be significantly higher than the values shown for the T=5-13 time interval which models all of the above motors as starting through the T=5-13 interval. (Reference Assumptions 4.2 and 4.4.)

Motors 1D001PA, 1D001PB, and 1D001PC have minimum starting voltages of 75% (Reference 11.32). Attachment 7.1 confirms that these motors receive adequate starting voltage. The manufacturers data shows that these pumps will accelerate in less than 1 second at 75% voltage.

8.1.8 Voltage at T=13 Seconds

Bus and motor terminal voltages at T=13 seconds for the RAT source are tabulated in Attachment 8.1.

All medium and low voltage continuous duty motors have accelerated to rated speed for this case.

By the T=13 second time frame, the motor terminal voltages for all continuous duty motors modeled in Attachment 8.1 have recovered to greater than 90% of rated voltages. This is within the acceptance criteria for motor voltage (Section 5.1).

HVAC damper motors which operate small hydraulic pumps are modeled as starting through the T=7 second case. These motors are expected to accelerate more rapidly due to the lower WK^2 of these loads. These motors will accelerate to speed at 80% of rated voltage. An estimate of when these motors receive adequate voltage can be made by comparing MCC bus voltages at the T=13 SEC time interval to bus voltages modeled in Attachment 21, Table 4. All damper motors receive greater than 80% voltage by T=13 seconds.

Attachment 0.2 calculates the expected bus voltage at t = 13 seconds for the RAT and ERAT. These minimum expected bus voltages exceed the minimum required bus voltages calculated in Tables 4 & 4C . This demonstrates adequate voltage for individual motor starts at t = 13 seconds.

8.1.9 Voltage at Steady State RAT & ERAT (4035 V)

Attachment 0.3 calculates the expected bus voltage at steady state for the RAT and ERAT. These minimum expected bus voltages exceed the minimum required bus voltages calculated in Tables 4A & 4B . This demonstrates adequate voltage for individual motor running at steady state.

8.2. MOV Motors

Calculated MOV motor terminal voltages (based upon bus voltages calculated in Attachments 7.1, 8.1, and 10.1) are documented in Attachment 21, Table 2. Similarly calculated MOV motor terminal voltages (based upon bus voltages calculated in Attachments 17.2, 18.2, and 20.2) are documented in Attachment 21, Table 2B. These results will be utilized in calculations prepared by IPC to determine the MOV torque switch settings.

8.3. 120 VAC

8.3.1. Contactor Dropout

MCC contactors have a tested dropout voltage of 54-58 V (45% to 48% of 120 V) (Reference 29). Based on the MCC bus voltages at T=0 (Attachments 1 and 11), it is possible that some MCC contactors with long control circuit lengths may drop out. This would reduce bus loading and improve starting voltages for the remainder of motors being started. As MCC voltages improve, contactors which dropped out could be re-energized. This would add additional starting load later in the start sequence.

To assess the magnitude of running load which could drop out, the following information was obtained from calculation 19-AK-6, Revision 0, Attachment C, "Load Summary by Bus," by adding up all motor loads running for Source 3, Condition 2. Source 3 information is used since comparable data is not modeled for Source 2. These loads are the total bus loads prior to the LOCA block start signal. If a portion of the T=0 block start loads and the pre-LOCA running loads drop out, the resulting restarts would not add significant additional starting load to any of the five Class 1E unit substation transformers since they would re-energize when some T=0 loads have reached rated speed. (Note that the following loads which are included in 19-AK-6 (Condition 2) are not included in the tabulation since they are modeled as starting in this calculation: 1VY01C through 1VY07C and 1VY08CA.)

Unit Substation 1A		Unit Substation 1B	
MCC	Motor Load (HP)	MCCs	Motor Load (HP)
SSW MCC 1A	0	SSW MCC 1B	0
DG MCC 1A	13.6	DG MCC 1B	8.6
DMPR MCC A	4.0	AB MCC 1B1	14.7
AB MCC 1A1	70.4	AB MCC 1B2	0
AB MCC 1A2	0	AB MCC 1B3	0
AB MCC 1A3	3.0	AB MCC 1B4	0
AB MCC 1A4	0		-----
	91.0		23.3

Unit Substation A		Unit Substation B	
MCC	Motor Load (HP)	MCC	Motor Load (HP)
CB MCC E1	35.8	CB MCC F1	0.5
CB MCC E2	41.5	CB MCC F2	43.0
CB MCC G	0	CB MCC H	0
	77.3	DMPR MCC B	0.4
			43.9

Unit Substation C	
MCC	Motor Load (HP)
AB MCC 1C1	5.9
AB MCC 1C	6.8
SSW MCC 1C	0
	12.7

8.3.2. Contactor Pickup

MCC contactors have a rated pickup voltage of 84 V (70% of 120 V).

MCC buses are required to recover to 440 volts or above after a LOCA block start to meet the acceptance criteria for maximum allowable control circuit lengths. This recovery must be achieved in approximately 12 seconds to equal the time delay on diesel generator start with loss of offsite power. The MCCs recover above the required minimum voltage.

8.4. Protective Relay/Overload Relay Evaluation

8.4.1. Medium Voltage Motors

The following are motor terminal voltages (as a % of rated voltage) estimated acceleration times, and overcurrent relay trip times for medium voltage motors started on a LOCA signal.

Equipment #	T=0+	T=3	T=4	T=5	Est. Accel time (sec)	OC Relay Trip Time (sec) 75%	80%	90%
1E12- C002A	-	-	-	90.1	2	-	4.5	-
1E12- C002B	-	-	-	90.4	2	-	4.5	-
1E12- C002C	82.6	Started	-	-	3	-	4.5	-
1E21- C001	81.7	92	Started	-	4	-	5	-
1E22- C001	80.3	92	94.6	Started	4.5	-	5.45	-
1SX01PA	79.3	Started	-	-	3	6.7	-	5.7
1SX01PB	80.6	Started	-	-	3	6.7	-	5.7

All medium voltage motors will accelerate to speed without tripping the associated protective devices.

8.4.2. 480-Volt Switchgear Motors

Evaluation: 1VD01CA, 1VD01CB

There are two loads at the 480-volt switchgear level that have less than 75% voltage for a portion of the acceleration time. These are the diesel generator room vent fans (1VD01CA and CB) rated at 125 hp. The starting time for the fans is estimated at 10 to 13 seconds (Reference Assumption 4.1). The protective device at the switchgear will trip at the reduced locked rotor current in 20 seconds. Therefore, the motor will not trip the protective device and will accelerate the load. The protective relaying curve for these loads is plotted and included in Attachment 30.

8.4.3. 480-Volt Motor Control Center Motors

The evaluation of MCC protective devices is outside the scope of this calculation.

8.4.4 MOV Motors

The thermal overload relays for MOVs receiving a LOCA signal are bypassed by a LOCA signal. Therefore, thermal overloads for MOV motors are not a concern for this calculation.

For MOVs which are not required to unseat at T=0, the motor will accelerate de-clutched and will be at or near rated speed when the clutch engages. These motors will experience locked rotor current for less than 0.5 seconds (Reference 11.22 of the base calculation). Therefore, circuit breaker tripping for these loads, due to the short locked rotor stall time (less than 0.5 seconds), are not a concern.

The following MOV motors are closed and are modeled as opening (unseating) on a LOCA signal:

MOV	HP	FLC	LRC	BREAKER SIZE	RATED TORQUE CURRENT
1E21-F005	2.6	7.0	38	15	19
1E22-F004	10.3	15.1	129.3	30	75
1SX173A	0.33	0.75	5.5	15	0.95
1SX173B	0.33	0.75	5.5	15	0.95

MOVs 1SX173A and 1SX173B have locked rotor currents less than the breaker rating and will not trip on locked rotor current.

MOVs 1E21-F005 and 1E22-F004 are started at T=0 and are expected to stall at locked rotor current until the MOV motors receive adequate voltage. The allowable stall times at locked rotor current prior to Type HE breaker tripping for MOV 1E21-F005 and type TEC (Magnetic (Mag.) only) breaker tripping for MOV 1E22-F004 are calculated below:

1E 21-F005

(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
				=D*(C/460)		=E/F	(from curves)	=B/H
Time Interval	Elapsed Time	Term Volt	LRC	Adjusted LRC	Breaker Rating	Per Unit Amps	Time for Min. Trip	% of Trip
0+ to 3	3	323.1	38	26.69	15	1.8	30	0.10
3 to 4	1	364.2	38	30.09	15	2.0	19	0.05
4 to 4.5	0.5	382.2	38	31.57	15	2.1	17	0.03
4.5 to 5	0.5	403.6	38	33.34	15	2.2	16	0.03
5 to 13	8	396.2	38	32.73	15	2.2	16	0.50
Total								0.71

1E22-F004

0+ to 3	3	308.2	129.3	83.3	30	2.8	Mag. Only	N/A
3 to 4	1	346.6	129.3	62.6	30	2.1	Mag. Only	N/A
4 to 4.5	0.5	363.2	129.3	66.5	30	2.2	Mag. Only	N/A
4.5 to 5	0.5	385.8	129.3	103.8	30	3.5	Mag. Only	N/A

5 to 13	8	379.1	129.3	98	30	3.3	Mag. Only	N/A
Total								N/A

The breaker size for 1E21-F005 is adequate if the valve starts to stroke in 12 seconds following a LOCA signal. The motor for this MOV has a safe stall time of 15 seconds at rated locked rotor current. Therefore, a 13 second stall time at reduced locked rotor current is acceptable. (Reference 11.25)

The breaker size for 1E22-F004 is adequate if the magnetic trip is greater than 130 amps plus tolerances.

8.5 Second Level Undervoltage Relay Setpoint

1. The minimum 4 KV SAFETY RELATED bus voltage under steady-state LOCA loading with the off-site voltage at the minimum expected value is considered to be 4149 V.

   Attachments 8.5 and 18.5 demonstrates that the safety related 4160 volt buses are at 4149V. The SVC also has additional capacity to increase the bus voltages higher. Therefore, this criteria is satisfied.

2. The minimum 4 KV SAFETY RELATED bus voltage required to run the LOCA required equipment is considered to be 4035 V.

   Attachment 0.3 demonstrates that the safety related 4160 volt buses are at 4035V or above. The calculated voltages summarized in 0.3 exceed the required voltages calculated in Tables 4A and 4B. Therefore, this criteria is satisfied.

3. The minimum voltage to which the 4 KV SAFETY RELATED bus recovers after successfully starting and running all required LOCA loads is considered to be 4084V.
   The second level undervoltage relay minimum pick-up and minimum drop-out voltages, at 4KV buses, which will be used by other calculations are 4084 volts and 4035 volts respectively.

   Attachment 0.2 demonstrates that the 4160 volt buses are at 4084V or above. The calculated voltages summarized in 0.2 exceed the required voltages calculated in Tables 4 and 4C. Therefore, this criteria is satisfied.

8.6 Damper Motors

Attachment 21 demonstrated that the damper motors have met their acceptance criteria. The calculated voltage required at the bus was compared to the Minimum Bus Voltages tabulated in Attachments 0.2 and 0.3. Attachment 0.3, which has the lower voltages, shows that the actual voltages available at the buses do meet the minimum calculated requirements.

9. CONCLUSIONS

9.1. Motor Terminal Voltages and Acceleration Times

The safety related 4.16-KV Bus voltage of 4084 V is adequate to ensure sufficient voltage is provided to continuous duty motors which receive a LOCA signal to allow these motors to accelerate to full speed in an acceptable period of time.

The safety related 4.16-KV Bus voltage of 4035 V is adequate to provide greater than 90% of rated voltages on motors under steady state conditions.

Adequate voltages are provided to all motors at minimum expected offsite source voltages.

9.2. Analyses of MCC Contactors

The voltages at some MCC buses at T=0 dip sufficiently low to create the potential for contactors with long control circuit lengths to dropout. By T=13 seconds, bus voltages on the MCCs have recovered sufficiently, and contactors will have energized sometime before T=13 seconds at 4084 V. Voltages recover to above acceptable voltage levels on the MCC buses for steady state trip conditions at 4035 V. Relays fed from starter control transformers on these buses should receive adequate voltage. Therefore, the general acceptance criteria is met for the MCCs, the analyzed bus voltages are acceptable.

Adequate voltages are provided to MCC buses to meet the 440V criteria for offsite source voltages at the minimum expected value for 120 VAC circuits.

9.3. Protective Device Evaluations

Medium switchgear protective device settings are adequate for a LOCA block motor start.

9.4. Overall Conclusion

Based on current relay setting and available grid voltage, the offsite source is capable of providing adequate minimum voltage to safety related continuous duty and damper motors.

This calculation determines the MOV terminal voltages and MCC bus voltages for use in MOV thrust calculations and 120 VAC device calculations.

10. RECOMMENDATIONS

10.1 Attachment 21, Table 1 Cable Parameters

The resistance and reactance values in Table 1 should be revised to use IP Standards. This will make Table 1 consistent with the other tables and values used in ELMS. This will have a negligible effect on the voltages.

10.2 Attachment 35 Enhancements

The following minimum changes should be made to Attachment 35:

- add reference for the equations.
- Add parentheses to the equations consistently.
- Utilize the approach in Table B for all the motors, and eliminate Table A. The Table B approach is easier to follow and revise, and is more closely aligned to how motors are actually selected.

11. REFERENCES

Ref.	*Description*
11.1	Deleted (Calculation 19-AJ-10, Revision 1, "Permissible Length of Cable for 120-VAC Control Circuits" was superseded by information on the minimum voltage required for MCC contactors in Reference 11.33).
11.2	Calculation 19-AK-06, Revision 0, Vol. AX, "Auxiliary Power System Analysis"
11.3	Calculation 19-AK-7, Revision 1, "Documenting Typical Values of Motor Starting"
11.4	Calculation 19-AN-8, Revision 3, "4160-V SAFETY RELATED Switchgear Buses 1A1 and 1B1 Motor Relay Settings"
11.5	Calculation 19-AN-9, Revision 0, "4160-V Division 3 SAFETY RELATED Bus 1C1 Motor Relay Settings"
11.6	Calculation 19-AN-19, Revision 2 Volume F, "Functional Requirements for First & Second Level Undervoltage Relays at 4-KV Buses 1A1, 1B1, and 1C1"
11.7	Calculation 19-BD-9, Revision 1, "Safety-Related Calculation for 120-VAC Relays used to Multiply LOCA Signals"
11.8	S&L Calculation 8986-15-04, Revision 0, "Calculation for Evaluation of 460-V Motor Minimum Voltage Starting Requirements"
11.9	S&L DIT No. CP-EPED-0390, "Starting Voltages for 460-V Motors" (11-01-84) (Attachment 31)
11.10	S&L DIT No. CP-EPED-0393, "Starting Voltages for 460-V Motors" (11-01-84) (Attachment 31)
11.11	IPC DIT No. E-001, "Motor Current Ratings for Motor Operated Safety-Related Valves" (10-16-91) (Attachment 31)
11.12	S&L DIT No. CP-HVAC-3914, "Start Time of 1VX03CAs and 1VX06As" after LOCA Signal" (01-22-92) (Attachment 31)
11.13	S&L DIT No. CP-PMED-3894-1, "Identified LOCA and Running Loads," 02-12-92 (Attachment 31)
11.14	S&L DIT No. CP-EPED-0389 (Untitled), 11-01-84 (Attachment 31)

Ref.	Description
11.15	Specification K-2828B, Shutdown Service Water Pump, Amd. 1, 05-15-79
11.16	Specification K-2900, Package Filter Units, 12-27-77
11.17	Specification K-2904, HVAC Fans, 06-22-77
11.18	Specification K-2905B, Refrigeration Equipment, 03-14-77
11.19	General Electric Company (GE) letter dated February 13, 1976, from Mr. J. R. Basak (GE) to Mr. R. I. Gavin (S&L) (Attachment 31)
11.20	IPC letter, dated April 20, 1976, from Mr. G. S. Green (IPC) to Mr. M. F. Lattin (GE) (Attachment 31)
11.21	Telecon (12-6-84) Between Mr. Gibson (Buffalo Forge) and R. Beavers (S&L), on The Starting Time of Fan 1VD01CA (Attachment 31).
11.22	90 WM 094-3EC, "Design Features and Protection of Valve Actuator Motors in Nuclear Power Plants," report by Working Group PES-NPEC-SC4.7, IEEE 90
11.23	"Standard Handbook for Electrical Engineers," Fink and Carroll, 10th Edition, Page 18-41
11.24	NEMA MG-1, Motors and Generators, 1987
11.25	MOV Motor Speed Torque Curves

413018-3-FT	4-20-76	(2 FT-LB)
413018-3-FS	4-20-86	(5 FT-LB Rated at 2 FT-LB)
41308-03-EM	2-24-77	(5 FT-LB)
M 2734	7-25-77	(5 FT-LB)
M 1454	7-25-77	(5 FT-LB)
413018-3-AL	6-6-76	(10 FT-LB)
413018-3-AM	6-6-76	(15 FT-LB)
413018-3-AN	7-14-70	(25 FT-LB)
M 1463	7-20-77	(25 FT-LB)
413018-3-AP	7-21-70	(40 FT-LB)
SL-59450	6-9-75	(40 FT-LB)
SK-59454	6-24-75	(60 FT-LB)
SK-59448	5-22-75	(80 FT-LB)
SK-34181	9-18-75	(150 FT-LB)
SK-34177	9-19-75	(200 FT-LB)

11.26	Specification K-2976, Drawing 409402-1, Size 0, 1, and 2 Overload Curve (processed 02-24-84) 40, Drawing 409403-1, Size 3 and 4 Overload Curve (processed 02-16-84)
11.27	Attachments 28 and 29 include references to schematics used in the evaluation of LOCA block start loads.

Ref. *Description*

11.28 ELMS AC Plus and ELMSCOMP — ELMSACPLUS12 Version 1.2 and ELMSCOMP program and user manuals were utilized in performing this calculation.

Lan Controlled Files, the Server (SOP-0402 requirement)
ELMSACPLUS12 Version 1.2
- Sargent & Lundy Program No. 03.7.379-1.2

ELMSCOMP Version 1.0
- Sargent & Lundy Program No. 03.7.589-1.0

User 0J2895 on PC2878
Controlled Files:
Drive V: = SNL1\SYS3: \
Detailed list of controlled files omitted at user request.
End of Controlled File Information scope

Data Files

AQ2V33.001 - used for T=0+ through T=4.5 ELMS runs
AQ2AV33.001 - used for T=5 through T=13 ELMS runs
AQ2BV33.001 - used for T=0 ELMS runs
AQ2CV33.001 - used for steady state ELMS runs

Base Files — The base file from 19-AK-6 (ACAPV45.002) was used as the initial input file for this calculation.

11.29 Deleted
(Calculation 19-AN-6, Revision 2, "Basis for Setting the Second Level UV Relays Located at 4160-V ESF Buses 1A1, 1B1, and 1C1" was replaced by 19-AN-19, Ref. 11.6)

11.30 Clinton Power Station ISI Program Manual, Revision 6, dated 05-25-90

11.31 Generic Letter 89-10, Scope Document, Y-97851, dated 10-03-91

11.32 K-2826A, "Miscellaneous Pumps - ASME Section III," Addendum 2

11.33 Calculation 19-AJ-70, Revision 1, "MCC Control Circuit Voltage Requirements". (Min. Voltage requirements for 120Vac circuits fed from control transformers) ; selected MCC's not meeting 427V).

11.34 Calculation 19-AQ-08 Rev 0 Estimated Start Time of SSW 1C Under Reduced Voltages.

11.35 Calculation 19-AJ-71, Revision 1, "Evaluation to determine if 427 volts at the MCC Bus is adequate to ensure that 120Vac end device fed from MCC bucket control transformer will operate".

11.36 Calculation 19-AJ-72, Revision 1, "Evaluation of the minimum voltage require at the safety related MCC buses to support the 120 volt loads fed from the MCC distribution panels".

Ref.	*Description*
11.37	Sargent & Lundy Drawing E02-1AP03 Rev H, "Electrical Loading Diagram, Clinton Power Station, Unit 1".
11.38	"Application Guide for MOV's in Nuclear Power Plants", NP-6660-D, Nuclear Maintenance Application Center
11.39	Limitorque Motors Bulletin, LM-77
11.40	Calculation 19-AQ-2 Rev. 2 (12-21-84) Cover sheet for Record. (Attachment 31).
11.41	Vendor drawing VPF 3831-043, Rev. 1, Nameplate drawing for Equipment No. 1E22-S003.
11.42	Record of coordination (ROC), FILE CODE D21-93(07-17)-6, By A. Haumann (IPC) on Minimum Running Voltage of NH90 Series Hydramotors, Dated 7-28-93. (Attachment 31)
11.43	CPS Procedure 9051.01, "HPCS SYSTEM PUMP OPERABILITY".
11.44	Licensing memo to NRC , "Deletion of Selected Valves from Scope of Program established at Clinton Power Station for Generic Letter 89-10", Letter No. U-602399 (File Code L30), Docket No 50-461, dated March 3, 1995.
11.45	Modification AP-32, AP-27, and AP-29 For Non-regulating Transformers and New UV Relays.
11.46	Calculation 19-AK-01, Rev. 16; "Aux-Block (ELMS-AC) Data Verification - Safety Related".
11.47	Calculation 19-AK-02, Rev. 11; "Aux-Block (ELMS-AC) Data Verification Non - Safety Related".
11.48	Calculation 19-AK-08, Rev. 2; "ELMS- AC Bus & Bus Connection Data Input Sheets For The ELMS-AC Files which Model The CPS Electrical Distribution System".

12. FIGURE LIST

See Table of Contents and the following pages.

13. ATTACHMENT LIST

See Table of Contents for the detailed listing of attachments.