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J. Phillip Bayne
Executive Vice President
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October 31, 1984
IPN-84-49

Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. Steven A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing

Subject: Indian Point 3 Nuclear Power Plant
Docket No. 50-286
Adequacy of Station Electric Distribution
System Voltages

References:

1) Letter from J. P. Bayne to S. A. Varga dated August 31, 1984 (IPN-84-35) entitled: "Degraded Grid Voltage (DGV) Protection for Class 1E Power Systems and Related Proposed Changes to the Technical Specifications."

2) Letter from S. A. Varga to L. W. Sinclair dated February 19, 1982 entitled: "Adequacy of Station Electric Distribution System Voltages," and Associated Safety Evaluation Report (SER).

3) Letter from J. P. Bayne to S. A. Varga dated July 16, 1984 (IPN-84-23) entitled: "Adequacy of Station Electric Distribution System Voltages."

4) Letter from William Gammill (then NRC Acting Assistant Director for Operating Reactors Projects) to Power Reactor Licensees dated August 8, 1979 entitled: "Adequacy of Station Electric Distribution System Voltages."

5) Letter from P. J. Early to S. A. Varga dated May 30, 1980 (IPN-80-53) entitled: "Degraded Grid Voltage and Adequacy of Station Electric Distribution System Voltages."

Dear Sir:

This letter provides information on the 480-volt voltage verification analyses for transient voltage conditions in accordance with Reference 1.

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The NRC's SER (Reference 2) concluded that the offsite power system and onsite distribution system for IP-3 will be capable of providing acceptable voltages at the terminals for Class 1E equipment for the worst case station electric load and grid voltages provided satisfactory results are obtained from: 1) voltage analyses verification testing, and 2) 480-volt motor starter voltage verification analyses for transient voltage conditions. Per Reference 3, the results of the Phase I and Phase II correlation studies for the voltage analyses verification testing were transmitted to you. Due to the Authority's continuing review of the results of the computer analyses and the test data obtained, minor revisions to the correlation study results previously reported have been made and are included in Attachment A to this letter.

Attachment B to this letter provides a description of the changes in the analytical techniques and assumptions utilized for the 480-volt voltage verification analyses for transient voltage conditions and Attachment C provides the results of these transient voltage analyses.

The Authority had previously responded to the NRC's Reference 4 letter per Reference 5. The Authority supersedes certain of the analyses' results previously submitted in Reference 5 with the information presented in Attachments A, B, and C to this letter.

Should you or your staff have any questions regarding this matter, please contact Mr. P. Kokolakis of my staff.

Very truly yours,

J. P. Bayne
First Executive Vice President
Chief Operations Officer

cc: Resident Inspector's Office
Indian Point Unit 3
U. S. Nuclear Regulatory Commission
P. O. Box 66
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Attachment A to IPN-84-49

Results of Phase I and Phase II Correlation Studies

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This attachment provides the results of the Phase I and Phase II correlation studies. The Phase I testing efforts involved the measurement of cable impedances, and motor terminal and motor starting voltages for the worst case safety related load feeders as identified by the original computer analyses. In addition, sample testing of 480-volt motor starters was performed to assess pick-up and drop-out voltage characteristics. Ths Phase I testing efforts were performed while the plant was shutdown. The Phase II testing efforts involved measurement of bus voltages, power flows, and safety related motor control conter (MCC) voltages with the plant at power.

Upon collection and tabulation of the test measurements, the correlation aspects of the verification tests were initiated. As part of the work associated with the verification tests and correlation studies, it was deemed appropriate to update the original computer model to more accurately reflect the plant electrical configuration as it currently exists. The testing effort described above included means to facilitate this updating. As such, the updated model rather than the original model developed in the late 1970's was used as the basis for the correlation effort.

As can be seen from the Phase I and Phase II correlation study results presented on the following pages, good correlation has been achieved and the validity of the revised computer model has been demonstrated.

Attachment B to this letter provides a description of the updated computer model in addition to the changes in the analytical techniques and assumptions utilized for the 480-volt motor starter voltage verification analyses for transient voltage conditions.

1.0 PHASE I Correlation Studies

1.1 Percent error between computed and measured motor terminal voltages:

		Voltage Measured (volts)	Voltage Calculated (volts)	Percent Error
1.1.1	SWP 32	469.3	471.8	+0.5
1.1.2	MOV 746	462.5	462.0	-0.1
1.1.3	MOV 899A	466.9	466.2	-0.1

1.2 Percent error between computer modeled and measured motor starting voltages:

		Voltage Measured (volts)	Voltage Calculated (volts)	Percent Error
1.2.1	SWP 32	391.5	390.5	-0.3
1.2.2	MOV 746	398.1	398.5	+0.1
1.2.3	MOV 899A	393.5	398.5	+1.3

2.0 PHASE II Correlation Studies

Percent error between computer modeled and measured 480v bus voltages:

2.1 Unit Auxiliary Transformer feeding 6.9 KV Buses 1, 2, 3, and 4:

	Voltage Measured (volts)	Voltage Calculated (volts)	Percent Error
2.1.1 Bus 2A	460.8	461.2	+0.1
2.1.2 Bus 3A	464.4	462.3	-0.5

2.2 Station Auxiliary Transformer feeding 6.9[illegible] Buses 1, 2, 3, 4, 5, and 6:

	Voltage Measured (volts)	Voltage Calculated (volts)	Percent Error
2.2.1 Bus 2A	456.0	464.7	+1.9
2.2.2 Bus 3A	457.2	465.1	+1.7
2.2.3 Bus 5A	448.8	458.3	+2.1
2.2.4 Bus 6A	452.8	458.2	+1.2
2.2.5 MCC 36A	439.2	458.3	+4.3 *
2.2.6 MCC 36B	442.4	458.3	+3.6 *

* Errors indicated are due to accuracy problems associated with the MCC strip chart recorder. The measured voltage at each MCC should have coincided with the measured voltage at each MCC's respective 480-volt bus, since there were no loads on either MCC.

Attachment B to IPN-84-49

Description of Changes in Analytical Techniques and Assumptions

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This attachment provides a description of the changes in the analytical techniques and assumptions utilized to facilitate the 480-volt motor starter transient voltage verification analyses and also provides the basis for which these changes were made.

The previous analysis performed for the Authority contained modeling aspects with respect to the electrical distribution systems which precluded the accurate prediction of voltage values at the 480-volt MCC motor contactors during transient voltage conditions. The original analysis was performed by creating a model that sectionalized the electrical distribution system into the different voltage levels that comprise the various electrical buses at IP-3. Calculations were then performed independently for each section. Voltage drops were calculated assuming lumped loads for the buses and the calculated voltages were, in turn, used as a source voltage for the lower order section. The 480-volt system analysis lumped the 480-volt motor loads at each bus and did not reflect the feeder losses while the 480-volt MCC's were represented by their respective ampacity ratings at an 80% power factor. Motor terminal voltages for starting and running conditions were hand-calculated and motor-operated valve (MOV) cable impedances were derived from resistance-per-unit-length values with assumed reactances of one-tenth of the resistances. The motor starting calculations utilized constant bus voltage and nameplate locked-rotor current at a 30% power factor. In addition, the transformer impedances for the station auxiliary transformer and station service transformers were based on IP-2 rather than IP-3 data.

It is apparent from the above discussion that the original analysis did not provide the capability to accurately assess motor-starting and resulting effects on the overall plant electrical distribution systems. To address this limitation, corrections and improvements in the modeling techniques for the current analysis were made. The Authority generated a detailed model for the complete plant electrical distribution system which extended from the Buchanan 138kV bus down to the terminals of critical MOV's. This model enabled studies of various cause and effect relationships in the plant and was able to assess the impact of motor-starting transients in addition to fast-transfer schemes on the overall plant electrical distribution systems based on conservative assumptions.

The following listing provides some of the key corrections and improvements incorporated into the new model:

1) Using a more accurately estimated full plant loading of nearly 40 MW under accident conditions versus the previously assumed loading of 37 MW;
2) Utilizing a motor-loading schedule based on worst case FSAR requirements;
3) Utilizing the actual load-shedding and sequencing features for accident conditions on the 480v buses and including actual designed plant responses of loads on the 6.9kV and 480v systems;

4) Establishing a more definitive MCC loading value under accident conditions; i.e., the loads established were based on the recent load study rather than using a rated percentage;

5) Utilizing either measured or pro-rated cable impedances for all MOV and 350 KCM power cables;

6) Developing linear impedance models for motor-starting conditions that were employed in the composite power flow studies which properly simulate plant voltage dips;

7) Using IP-3 specific transformer impedances;

8) Analyzing the plant voltage profiles under "worst-case" degraded grid voltage (DGV) conditions, in accordance with NRC guidelines.

The new model was utilized to analyze the impact of motor-starting transients and fast-transfer schemes on the overall plant electrical distribution systems. This model was applied to determine the voltage profiles that would exist under the simultaneous postulations of maximum plant loading (i.e. LOCA conditions) and minimum 138kV system grid voltages. The results of these analyses are presented in Attachment C.

Attachment C to IPN-84- 49

Results of 480-Volt Motor Starter Voltage Verification Analyses for Transient Voltage Conditions

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This attachment provides the results of the 480-volt motor starter voltage verification analyses for transient voltage conditions. These verification analyses were performed to address the NRC's Reference 2 request that the Authority verify that: 1) no Class 1E motor starter will "drop-out" during start of any large Class 1E or non-Class 1E load at minimum grid and maximum load conditions, and 2) the starter will "pick-up" to start its load when called on during minimum grid and maximum load conditions. As part of these efforts, the Authority has also addressed the capabilities of safety related motors to start or, if running, to continue to run under the conditions of minimum grid and maximum load postulated.

The guaranteed minimum "pick-up" voltage for the MCC motor contactors was established as 85% of rated voltage (i.e., 408 volts) whereas the guaranteed minimum "hold-in" voltage for the contactors was established as 60% of rated voltage (i.e., 288 volts). To confirm these manufacturer-specified values, field testing of four MCC motor contactor sample types was conducted. The results of these tests more than confirmed the manufacturer-specified guaranteed values and are presented in Table C-1 ("MCC Motor Contactor Test Results")

There are three sources of offsite power available to supply power to the safeguards buses at IP-3. These sources consist of the 138kV system, the 13.8kV system, and the IP-2 6.9kV system through the IP-2/IP-3 tie breaker (GT-BT). For the purposes of the 480-volt voltage verification analyses, only the 138kV and 13.8kV systems were investigated. Although the IP-2 6.9kV system through the IP-2/IP-3 tie breaker (GT-BT) is an additional and available source of offsite power for IP-3, use of this power source is not required by General Design Criterion 17 ("Electric Power Systems") of Appendix A to 10CFR50 and hence was not included in the analyses. The analyses of the 138kV and 13.8kV systems were intially conducted without utilizing a dynamic simulation of the LOCA loading sequence in order to obtain a conservative overall voltage profile of the electrical distribution systems under both "steady-state" and transient (i.e., motor starting) conditions. Since the 138kV system is the normal source of offsite power for IP-3 and is subject to the "fast-transfer" scheme discussed below, this system was selected to undergo additional analyses that included dynamic simulation of the LOCA loading sequence. For the dynamic cases analyzed where safeguards power was being supplied by the 138kV offsite source via the station auxiliary transformer (SAT), the minimum expected voltage of 136kV was assumed on the 138kV buses in accordance with the original analysis. It should be noted, however, that the plant voltage profiles predicted immediately following the "fast-transfer" scheme discussed below would be the same for the range of 138kV grid voltages between 122.3kV and 141.6kV. For the cases analyzed where safeguards power was being supplied by the 13.8kV offsite source via the 13.8kV/6.9kV autotransformer, the minimum expected voltage of 13.7kV was assumed on the 13.8kV buses in accordance with the original analysis.

Figures C-1 through C-3 and Tables C-2 through C-5 provide the results of the voltage verification analyses using the improved electrical computer model discussed in Attachment B to assess the "drop-out" and "pick-up" characteristics of the 480-volt MCC motor starters, as well as the capabilities of safety related motors to start or, if running, to continue to run under the conditions of minimum grid and maximum load postulated. Figures C-1 through C-3 and Table C-2 provide the results of the dynamic cases analyzed where the safeguards buses were being supplied power from the 138kV system and Tables C-3 through C-5 provide the results of the cases analyzed where the safeguards buses were being supplied power from the 13.8kV system.

Figures C-1 through C-3 and Table C-2 represent the limiting design condition for the plant for which a safeguards actuation coincident with the "fast-transfer" scheme under maximum loading (i.e., LOCA) conditions has been simulated. The "fast-transfer" occurs as the unit auxiliary transformer transfers its 6.9kV buses 1, 2, 3 and 4 loads to the SAT. The condition modeled for this case represents actual dynamic LOCA injection phase loading in addition to balance-of-plant station loads and assumes that all automatic load shedding operates as designed and that the SAT load tap changer (LTC) is in its pre-transfer position (i.e., that the LTC is "frozen"). In addition, the effects of large Class 1E and non-Class 1E motor starts on the electrical systems at IP-3 under "steady-state" conditions (i.e., at some time t $>$ 120 seconds after safeguards actuation) have been analyzed and the results depicted in Figures C-1 through C-3. (It should be noted that the limiting "fast-transfer" scheme occurs as a result of a safeguards-actuation in conjunction with a unit electrical trip for which the "fast-transfer" occurs immediately. This is considered to be the most limiting and conservative case since a simultaneous electrical fault is postulated in conjunction with the safeguards actuation. Should a unit trip result from conditions other than that of an electrical fault, there is a 30 second delay for the "fast-transfer").

With respect to the large motor start cases analyzed under "steady-state" conditions, it should be noted that the safeguards actuation logic requires a minimum of 120 seconds before operator action can be initiated to manipulate safeguard loads. To demonstrate the effect of starting a large Class 1E motor on the electrical systems, it was postulated that service water pump (SWP) 33 starts at some time $t > 120$ seconds. The effect of a large non-Class 1E motor start on the electrical systems is demonstrated by postulating the start of 3000 HP condensate pump 33, which is a conservative approach since in actuality this pump would have already been running. This large non-Class 1E motor is also depicted as starting at some time $t > 120$ seconds, although the impact on the electrical distribution system would be the same if the pump was started immediately after completion of the automatic loading sequence (i.e., at time $t > 34$ seconds). The pre-starting "steady-state" voltages for these motor start cases are conservatively assumed as those existing at the end of the LOCA loading sequence.

As shown by Figures C-1 through C-3, acceptable voltage profiles are predicted on all safeguard buses and MCC's thus insuring that MCC contactors will "pick-up" their respective loads when called upon to perform their safety function and that the contactors will not "drop-out" these loads during start of any large Class 1E or non-Class 1E motors. It is also shown that all safeguard bus voltages are adequate for starting of all required loads and for maintaining running loads during the loading sequence.

Table C-2 provides the voltages predicted by the dynamic analyses at the 480 volt buses, motor terminals, and MCC's for the LOCA loading sequence. For motors that are starting, the voltages indicated are at the start time of the motor. For motors that are running and for the "pick-up" condition of the 480-volt MCC's, the voltages indicated are at the completion of the loading sequence and represent lowest expected continuous operating values. For the "drop-out" condition of the 480-volt MCC's, the voltages indicated represent the lowest expected instantaneous values during the LOCA loading sequence. It should be recognized that the IP-3 safeguards actuation logic does not strip LOCA loads if the loads had previously been running at the time of safeguards actuation and if offsite power continues to remain available. Therefore, these loads (e.g., certain containment recirculation fans and service water and component cooling pumps) were considered as running loads. The recirculation pumps, on the other hand, are manually loaded onto their respective buses thus precluding an accurate extrapolation of the resulting voltage profiles since load manipulations are taking place concurrently. The required running and starting values are also provided in this table.

As can be seen from Table C-2, the voltage values at the safety related MCC's are well above the required minimum "pick-up" value of 408 volts. With respect to the MCC voltage values indicated for the "pick-up" condition, it should be noted that these are conservative "steady-state" values and represent lowest expected continuous operating values, as indicated above. These values are considered conservative since the expected in-rush current with its corresponding instantaneous voltage drop of approximately 12 volts occurs in conjunction with the "fast-transfer" with the result that the contactors would operate under the pre-transfer profiles, which are significantly higher than the post-transfer profiles. The voltages predicted at safety-related MCC's 36A and 36B during and after the postulated large Class 1E and non-Class 1E motor starts are well above the guaranteed minimum "hold-in" voltage of 288 volts for the motor starters, thus precluding the motor starters from "dropping-out" as a result of these motor starts. In addition, the voltage profiles predicted at the terminals of safety related motors demonstrate that these motors will operate properly as required.

Tables C-3 through C-5 provide the results of the cases analyzed for which the safeguards buses are supplied power from the back-up offsite 13.8kV source via the 13.8kV/6.9kV autotransformer. Table C-3 represents the 13.8kV system base case in which no 6.9kV motors are running whereas Table C-4 and Table C-5 present variations of this case for the start of a large Class 1E motor (i.e., SWP 33) and large non-Class 1E motor (i.e., 6000 HP reactor coolant pump (RCP) 32) respectively. The required operating values for the components listed in these tables at their respective buses are the same as provided in Table C-2.

The voltage values provided in Table C-3 represent the "steady-state" voltage profile which would exist several minutes into the maximum (i.e., LOCA) loading postulated. Thus, this table depicts the loads as running values, with the exception of two loads on safety related MCC's 36A and 36B (i.e., MOV 746 and 899A, respectively) for which the values specified are starting values, as indicated in the table. With respect to MOV 746 and 899A, the approach utilized is conservative in that it assumes these valves to start subsequent to their actual starting time under the postulated scenario. This conservatism was incorporated for these particular valves since these were among the "worst-case" valves (based on cable length and resulting voltage losses) as indicated by the original analyses and as confirmed by measurements taken for the correlation studies discussed in Attachment A. By analyzing these valves to assess their "pick-up" characteristics, the results obtained constitute a bounding evaluation for all other MOV's.

The voltage values provided in Tables C-4 and C-5 represent the instantaneous values which exist as a result of the postulated start of SWP 33 and RCP 32, respectively, from the "steady-state" condition depicted in Table C-3. In addition, MOV's 746 and 899A are also postulated to be starting at the same time as SWP 33 in Table C-4 and RCP 32 in Table C-5 for reasons specified above.

As can be seen from Table C-3, acceptable voltage profiles are predicted at MCC 36A and 36B in addition to the motor terminals of safety related motors. As can be seen from Table C-4, acceptable transient voltage profiles exist at MCC 36A and 36B in addition to the motor terminals of safety related motors under the postulated SWP 33 start, since start of a SWP is such a short duration transient (i.e., approximately one second). As such, the DGV protection proposed in Reference 1 would not be actuated under the postulated conditions.

These same conclusions, however, will not apply to the start of a large non-Class 1E motor since the resulting instantaneous voltages would be significantly lower and the subsequent recovery time significantly longer. This is evidenced by the results of the RCP 32 start provided in Table C-5 which indicate unacceptable transient voltage profiles at MCC 36A and 36B in addition to the motor terminals of safety related motors. However, it should be recognized that no 6.9kV motors would be automatically started under the postulated conditions. In any case, the DGV protection proposed in Reference 1 would provide the necessary protection to insure that all required equipment is capable of performing its intended safety function when called upon to do so.

A number of comments are in order with respect to the technical specification (T/S) DGV relay sensing value of ≥414 volts proposed in Reference 1 as it relates to and is justified by the 480-volt transient voltage verification analyses discussed above. The T/S limit of 414 volts is based on the limiting safety related electrical components at IP-3 which, as indicated in Reference 1, are the MCC motor starters.

These starters have a manufacturer-specified guaranteed "pick-up" voltage of 408 volts. Due to considerations of the voltage drops from 480-volt buses 5A and 6A to MCC's 36A and 36B (at full load conditions), respectively, and for purposes of establishing a conservative T/S, the $\geq$414 volt value was proposed in Reference 1.

The next most limiting safety related electrical components existing at IP-3 are safety related motors which will start or, if running, will continue to run at voltages as low as 80% rated motor voltage (i.e., 352 volts for 440-volt rated motors and 368 volts for 460-volt rated motors). Continous operation of these motors at such low voltage values would, however, impact upon the thermal capabilities of the motor insulation and as a result, the life that could be reasonably expected of the motor. For this reason, conservatively established industry standard values of 90% rated motor voltage (i.e., 396 volts for 440-volt rated motors and 414 volts for 460-volt rated motors) are generally recommended for continuous motor thermal protection. The indicated T/S limit of 414 volts, while providing DGV protection for the 480-volt MCC's also clearly provides continuous thermal protection for the safety related 440-volt rated motors factoring in the feeder voltage losses, thus precluding the potential for a reduction of the expected life of these motors. However, due to continuous (i.e., "steady-state") voltage drops from the 480-volt buses to the terminals of the safety related 460-volt rated motors under the accident conditions postulated, the T/S limit of 414 volts for the DGV relays on the 480-volt buses could allow voltages at the 460-volt motor terminals of slightly less than the generally recommended continuous thermal protection value of 414 volts (i.e., 90% of rated motor voltage) if the DGV relays were set at or very near their T/S limit of 414 volts. To be more specific, continuous 460-volt motor terminal voltages of as low as 407 volts, based on a conservatively estimated 7 volt 480 bus/460-volt motor terminal voltage drop and the limiting DGV relay setting of 414 volts, could exist without actuating the DGV protection.

The voltage sensing value of the DGV relays will obviously be set above the T/S limit of 414 volts to assure that the T/S is met. However, assuming a DGV relay setting at the T/S limit of 414 volts, continuous 460-volt motor terminal voltages of as low as 407 volts could result as indicated above, which corresponds to 88.5% versus 90% of 460-volt rated motor voltage. This 1.5% difference is not considered to be significant in terms of causing unacceptable motor thermal damage and in any case is within the error of the results obtained from the voltage verification analyses performed. It should also be noted that the DGV protection would be actuated at voltage levels below 407 volts at the 460-volt motor terminals and the corresponding 414 volt value at the 480-volt buses should the DGV conditions exist for longer than the time delays associated with the relay settings. Further, the conservative conditions utilized for the voltage verification analyses must be recognized as the "worst-cast" loading conditions. The voltage values predicted by the analyses conducted are actually lower than what would actually be exhibited since the voltage values predicted are based on a non-functioning

SAT LTC. If the LTC is assumed to operate properly, the voltage values that would exist would be significantly better than the "worst-case" voltage profiles predicted. In addition to the LTC, there exist other non-safety related components that provide a degree of undervoltage protection for the 480v system. An example is the undervoltage relays on the 6.9kV system. However, while the Authority realizes that credit cannot be taken for proper functioning of these non-safety related components in terms of DGV protection, it is maintained that they do afford thermal protection against long term undervoltage operation.

The Authority, in generating the DGV T/S proposed in Reference 1, recognizes that the protection proposed does not provide complete thermal protection against long term undervoltage operation for the small band of voltages between 407 volts and 413 volts at the 460-volt motor terminals due to the voltage drop considerations discussed above. However, it must be emphasized that a DGV T/S that would insure 90% rated motor voltage at the terminals of 460-volt motors (i.e., a T/S of $\geq$421 volts) would risk separation of many safety related loads from the offsite source. Consequently, unnecessary challenges to safety systems would result, all for the purpose of preventing a possible minor loss of life for certain safety related motors. This contention is supported by plant voltage data obtained during and after recent unit trips.

The Authority concludes, therefore, that the DGV protection proposed in Reference 1 is justified by the voltage verification analyses conducted and ensures that both safety related motors and MCC contactors will be available to perform their respective safety functions if ever called upon.

TABLE C-1

MCC MOTOR CONTACTOR TEST RESULTS

COIL CATALOG & STYLE NOS.

	A200M1CAC 765A840G01	A200M1CD 276A143G04	A200M2CXDM 764A967G09	A200M2CAC 765A842G01
INITIAL ENERGIZATION PERIOD 0 MIN.		RMS A.C. VOLTS/(%120V)		
INITIAL PICK-UP	71.7 (60%)	73.8 (62%)	74.1 (62%)	45.5 (38%)
FINAL PICK-UP	84.6 (71%)	89.1 (74%)	84.5 (70%)	53.4 (45%)
INITIAL DROP-OUT	84.5 (70%)	87.4 (73%)	76.1 (63%)	53.0 (44%)
FINAL DROP-OUT	69.1 (58%)	69.9 (58%)	72.4 (60%)	43.6 (36%)
INITIAL ENERGIZATION PERIOD 60 MIN.				
INITIAL PICK-UP	73.2 (61%)	73.9 (62%)	77.3 (64%)	48.1 (40%)
FINAL PICK-UP	90.7 (76%)	91.2 (76%)	95.7 (80%)	53.7 (45%)
INITIAL DROP-OUT	79.1 (66%)	88.9 (74%)	71.8 (60%)	54.0 (45%)
FINAL DROP-OUT	60.0 (50%)	72.4 (60%)	64.6 (54%)	45.4 (38%)

NOTE: INITIAL PICK-UP REFERS TO THE CONDITION OF 3-PHASE CONTACT CLOSURE WITH MINIMUM CLOSING FORCE ON THE CONTACTS.

FINAL PICK-UP REFERS TO THE CONDITION OF 3-PHASE CONTACT CLOSURE WITH ULTIMATE CLOSING FORCE ON THE CONTACTS.

INITIAL DROP-OUT REFERS TO THE CONDITION OF 3-PHASE CONTACT CLOSURE IN WHICH THE CLOSING FORCE ON THE CONTACTS BEGINS TO DIMINISH.

FINAL DROP-OUT REFERS TO THE OPENING OF THE 3-PHASE CONTACTS.

TABLE C-2

LOCA MOTOR VOLTAGES - 138 KV OFFSITE SOURCE
(Post Fast - Transfer With Frozen LTC)

BUS	LOAD	CONDITION	REQUIRED AT LOAD (2)	ACTUAL AT LOAD	REQUIRED AT BUS	ACTUAL AT BUS
2A	CCP32	Running	414	424	420	430
2A	SIP32	Starting	352	376	374	398
2A	SIP32	Running	396	425	401	430
2A	CRF32	Running	396	418	408	430
2A	SWP32	Running	396	423	403	430
3A	RHR31	Starting	368	389	386	407
3A	RHR31	Running	414	430	418	434
3A	CRF34	Running	396	424	406	434
3A	AFW31	Starting	352	382	372	403
3A	AFW31	Running	396	429	401	434
5A	SIP31	Starting	352	377	371	397
5A	SIP31	Running	396	420	400	424
5A	CCP31	Running	414	419	419	424
5A	CSP31	Starting	368	367	398	397
5A	CSP31	Running	414	417	421	424
5A	CRF31	Running	396	416	404	424
5A	SWP31	Running	396	416	404	424
5A	CRF33	Running	396	416	404	424
5A	RP 31	Starting	352	N/A(1)	392	N/A(1)
5A	RP 31	Running	396	N/A(1)	406	N/A(1)
5A	MCC36A	Pick-Up (3)	408	419	413	424
5A	MCC36A	Dropout (3)	288	392	293	397
6A	RHR32	Starting	368	377	393	402
6A	RHR32	Running	414	416	419	421
6A	SIP33	Starting	352	379	375	402
6A	SIP33	Running	396	416	401	421
6A	CCP33	Starting	368	369	406	407
6A	CCP33	Running	414	414	421	421
6A	CSP32	Starting	368	376	397	405
6A	CSP32	Running	414	415	420	421
6A	CRF35	Starting	352	358	405	411
6A	CRF35	Running	396	409	408	421
6A	SWP33	Running	396	413	404	421
6A	AFW33	Starting	352	358	388	394
6A	AFW33	Running	396	413	404	421
6A	RP 32	Starting	352	N/A(1)	391	N/A(1)
6A	RP 32	Running	396	N/A(1)	405	N/A(1)
6A	MCC36B	Pickup (3)	408	416	413	421
6A	MCC36B	Dropout (3)	288	390	393	395

NOTES TO TABLE C-2:

(1) These pumps are manually started by the operator during the Recirculation Phase of the accident sequence. See Text for discussion.

(2) Values for continuous running with no thermal damage to insulation are based on NEMA standard of minimum 90% nameplate rating; values for starting are based on minimum 80% nameplate rating. See Test for discussion.

(3) See Text for discussion.

TABLE C-3

BUCHANAN 13.8 KV BUS AT 13.7 KV;
LOCA WITH ALL SAFEGUARDS ON OFFSITE SOURCE;
NO. 6.9 KV MOTORS RUNNING
STEADY STATE VOLTAGES AT END OF LOADING SEQUENCE

	ACTUAL	MINIMUM STEADY STATE VOLTAGE REQUIRED
480V BUS 2A	451	*
SIP 32	445	396
CRF 32	439	396
SWP 32	442	396
480V BUS 3A	449	*
RHR 31	445	414
CRF 34	438	396
AUXFW 31	444	396
480V BUS 5A	443	*
SIP 31	438	396
CSP 31	435	414
CRF 31	434	396
SWP 31	433	396
CRF 33	438	396
MCC 36A	436	408
MOV 730	433	308
MOV 746 (Starting)	373	308
MOV 747	410	308
MOV 894A	428	317
MOV 894C	427	317
480V BUS 6A	434	*
RHR 32	429	414
SIP 33	429	396
CSP 32	428	414
CRF 35	421	396
SWP 33	425	396
AUXFW 33	426	396
MCC 36B	427	408
MOV 731	423	308
MOV 894B	418	343
MOV 894D	416	317
MOV 899A (Starting)	369	308
MOV 899B	399	308

*See Table C-2

TABLE C-4

BUCHANAN 13.8 KV BUS AT 13.7 KV: SWP 33 START;
LOCA WITH ALL SAFEGUARDS ON OFFSITE SOURCE;
VOLTAGES AS SEEN DURING SWP 33 START TRANSIENT

	ACTUAL	MINIMUM TRANSIENT VOLTAGE REQUIRED
480V BUS 2A	447	*
SIP 32	441	352
CRF 32	434	352
SWP 32	438	352
480V BUS 3A	445	*
RHR 31	440	368
CRF 34	434	352
AUXFW 31	440	352
480V BUS 5A	439	*
SIP 31	434	352
CSP 31	431	368
CRF 31	430	352
SWP 31	429	352
CRF 33	434	352
MCC 36A	432	408
MOV 730	428	308
MOV 746 (Starting)	369	308
MOV 747	405	308
MOV 894A	424	317
MOV 894C	423	317
480V BUS 6A	403	*
RHR 32	397	368
SIP 33	397	352
CSP 32	396	368
CRF 35	389	352
SWP 33 (Starting)	351	352
AUXFW 33	394	352
MCC 36B	395	408
MOV 731	391	308
MOV 894B	385	343
MOV 894D	384	317
MOV 899A (Starting)	342	308
MOV 899B	365	308

*See Table C-2

TABLE C-5

BUCHANAN 13.8KV BUS AT 13.7KV; RCP 32 START (6000 HP)
LOCA WITH ALL SAFEGUARDS ON OFFSITE SOURCE;
VOLTAGES AS SEEN DURING RCP 32 START TRANSIENT

	ACTUAL	MINIMUM TRANSIENT VOLTAGE REQUIRED
480V BUS 2A	385	*
SIP 32	379	352
CRF 32	371	352
SWP 32	375	352
480V BUS 3A	383	*
RHR 31	378	368
CRF 34	370	352
AUXFW 31	377	352
480V BUS 5A	376	*
SIP 31	370	352
CSP 31	366	368
CRF 31	365	352
SWP 31	365	352
CRF 33	370	352
MCC 36A	369	408
MOV 730	365	308
MOV 746(STARTING)	315	308
MOV 747	337	308
MOV 894A	359	317
MOV 894C	358	317
480V BUS 6A	365	*
RHR 32	358	368
SIP 33	358	352
CSP 32	357	368
CRF 35	349	352
SWP 33	354	352
AUXFW 33	355	352
MCC 36B	357	408
MOV 731	352	308
MOV 894B	345	343
MOV 894D	344	317
MOV 899A(STARTING)	308	308
MOV 899B	322	308

* SEE TABLE C-2

FIGURE C-1

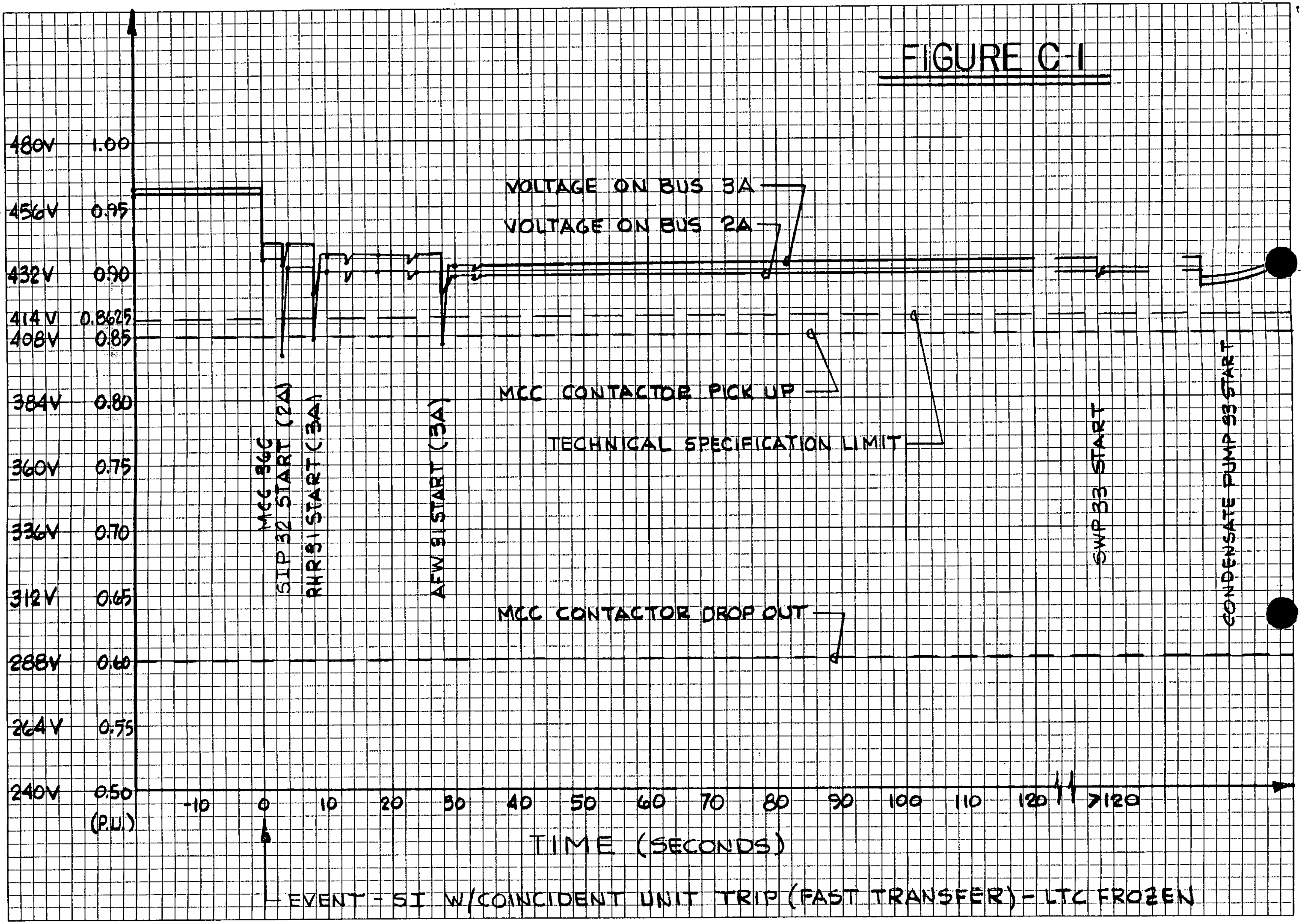
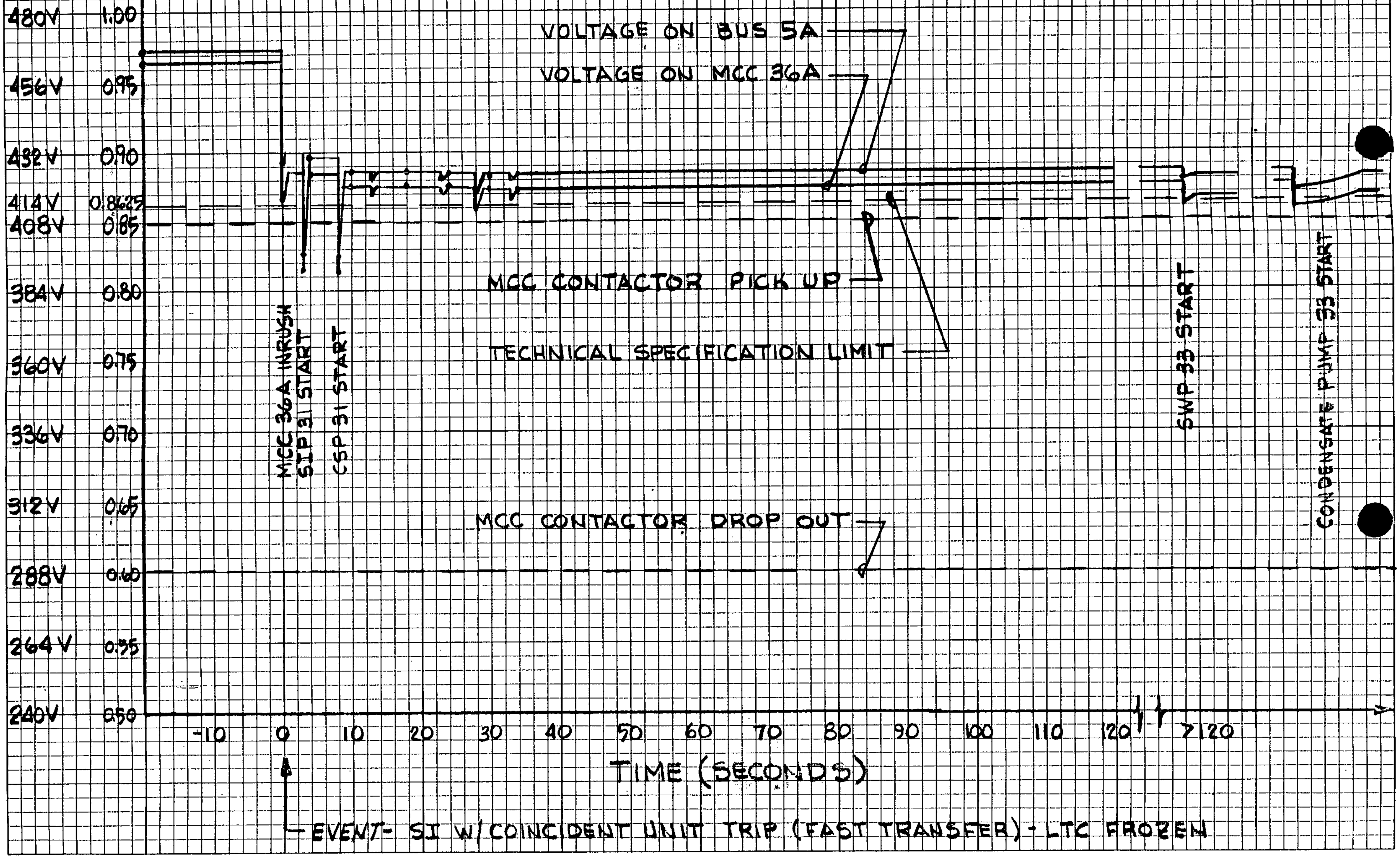
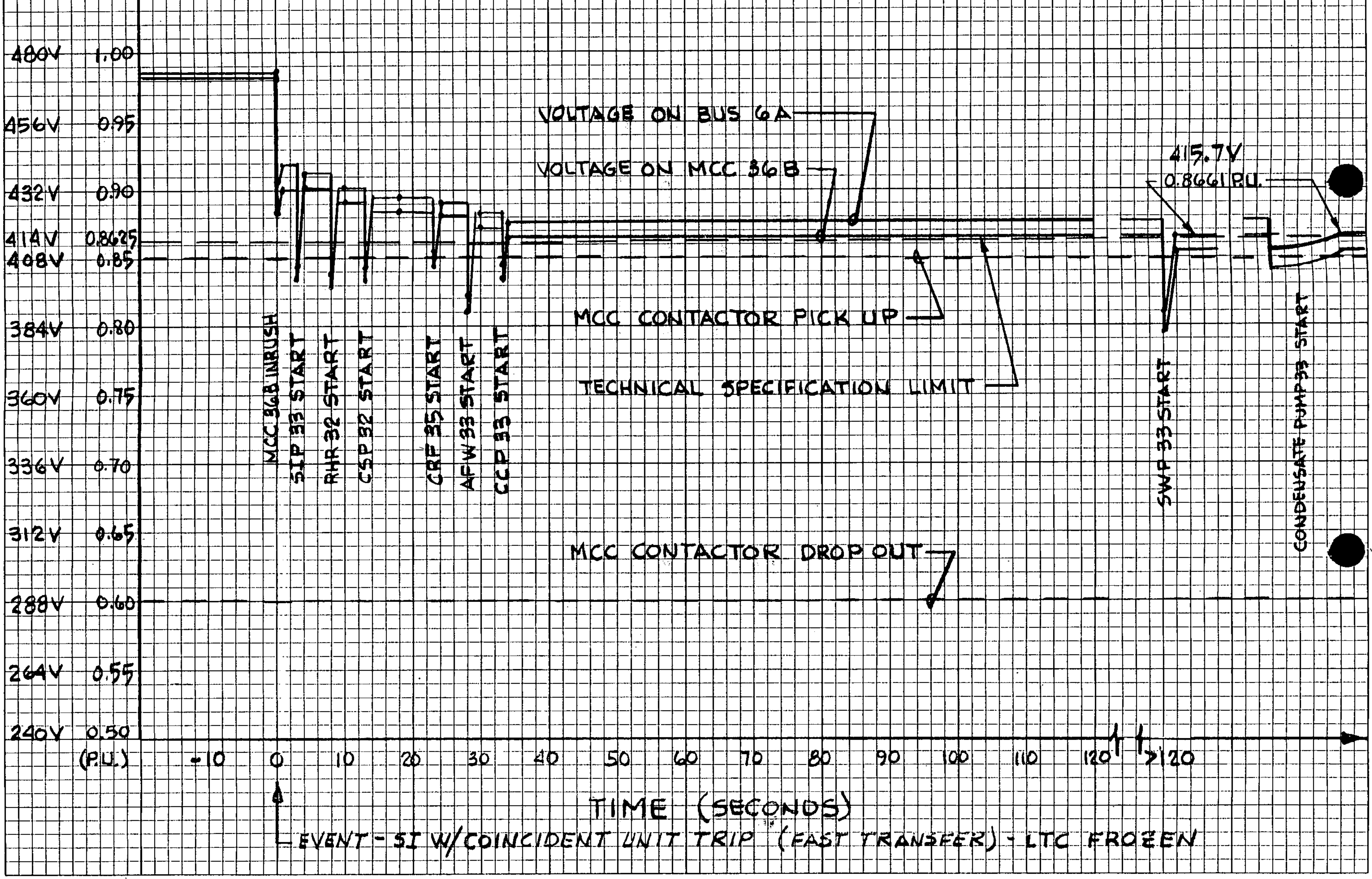

480V 1.00
456V 0.95
432V 0.90
414 V 0.8625
408V 0.85
384V 0.80
360V 0.75
336V 0.70
312V 0.65
288V 0.60
264V 0.55
240V 0.50
(P.U.)
VOLTAGE ON BUS 3A
VOLTAGE ON BUS 2A
MCC CONTACTOR PICK UP
TECHNICAL SPECIFICATION LIMIT
MCC CONTACTOR DROP OUT
MCC 36C
SIP 32 START (2A)
RHR 31 START (3A)
AFW 31 START (3A)
SWP 33 START
CONDENSATE PUMP 33 START
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 >120
TIME (SECONDS)
EVENT - SI W/COINCIDENT UNIT TRIP (FAST TRANSFER) - LTC FROZEN

FIGURE C-2



480V 1.00
456V 0.95
432V 0.90
414V 0.8625
408V 0.85
384V 0.80
360V 0.75
336V 0.70
312V 0.65
288V 0.60
264V 0.55
240V 0.50
VOLTAGE ON BUS 5A
VOLTAGE ON MCC 36A
MCC CONTACTOR PICK UP
TECHNICAL SPECIFICATION LIMIT
MCC CONTACTOR DROP OUT
MCC 36A INRUSH
SIP 31 START
CSP 31 START
SWP 33 START
CONDENSATE PUMP 33 START
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
>120
TIME (SECONDS)
EVENT - SI W/COINCIDENT UNIT TRIP (FAST TRANSFER) - LTC FROZEN

FIGURE C-3



480V 1.00
456V 0.95
432V 0.90
414V 0.8625
408V 0.85
384V 0.80
360V 0.75
336V 0.70
312V 0.65
288V 0.60
264V 0.55
240V 0.50
(P.U.)
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 >120
TIME (SECONDS)
EVENT - SI W/COINCIDENT UNIT TRIP (FAST TRANSFER) - LTC FROZEN
VOLTAGE ON BUS 6A
VOLTAGE ON MCC 36B
415.7V
0.8661 P.U.
MCC CONTACTOR PICK UP
TECHNICAL SPECIFICATION LIMIT
MCC CONTACTOR DROP OUT
MCC 36B INRUSH
SIP 33 START
RHR 32 START
CSP 32 START
CRF 35 START
AFW 33 START
CCP 33 START
SWP 33 START
CONDENSATE PUMP 33 START