Nebraska Public Power District

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August 14, 1987

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Subject: Safety System Functional Inspection at
Cooper Nuclear Station, Brownville, Nebraska

Reference:
A. Docket 50-298
B. NRC Region IV Division of Reactor Safety and Projects letter dated July 9, 1987
C. Nebraska Public Power District's letter NLS700358 dated July 24, 1987

Gentlemen:

At a meeting held on June 30, 1987, at the Nuclear Regulatory Commission (NRC) Region IV office at Arlington, Texas, Nebraska Public Power District (NPPD) outlined its action plan for the major issues emanating from the recent Safety System Functional Inspection at the Cooper Nuclear Station (CNS). Reference B requested that NPPD document the completed actions and future plans in regard to the topics listed below:

- AC Voltage Studies/Sufficiency
- DC Voltage Studies/ Sufficiency
- Seismic Concerns
- Ventilation/Temperature Problems
- Service Water System Flows

NPPD responded to the Seismic and Service Water flow concerns and gave a partial response to the remaining items in Reference C. The District's supplemental response and plan of action on the outstanding issues are summarized in this letter. The calculations, studies, and evaluations described herein are available for review at NPPD Offices.

A. AC Voltage Studies/Sufficiency

1. The AC Voltage Drop Analyses have been performed by Burns and Roe and NPPD personnel. The analysis covering the segment of the distribution system from the off-site power lines to the MCC terminals on the 480 VAC system has been performed using Burns and Roe's Computer Program ELO 110. NPPD personnel are performing the voltage drop analysis for the remainder of the AC Distribution System at CNS.

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a. The Burns and Roe study indicates the following:

(1) For the 161 kV line supplied via the 345/161 kV transformer at CNS, the electrical distribution system powered via the Start-up transformer can withstand a "block" start of Emergency Core Cooling System (ECCS) equipment with the normal auxiliaries (essential and non-essential) remaining energized.

(2) For the 69 kV line supplied from the Omaha Public Power District (OPPD) system, the emergency off-site supply, the electrical distribution system powered via the emergency station transformer can withstand a sequential starting of ECCS equipment as well as a phased start of two Service Water pumps with all non-essential equipment de-energized.

The above cases meet the design requirements of the off-site power supply criteria for CNS; two independent power supplies in addition to the emergency diesel generators.

Attachment A gives a summary of the Voltage Drop Analysis to the 480 VAC MCC terminals.

b. NPPD is performing a voltage drop study on the 480 VAC and 120 VAC systems, NPPD Calculation 87-132. The complete and in-depth analysis of all circuits will not be complete for a considerable time due to the magnitude of the task. However, the circuits analyzed to date are adequate to perform their safety related functions under postulated voltage conditions. Voltage and current measurements have been taken to establish the margin between the calculation and the field condition for 120 VAC component already analyzed. The readings taken indicated there was a considerable margin of conservatism in the calculation. Additional readings will have been taken under Special Test Procedure 87-014 when the complete in-depth analysis has been completed.

2. The 4160 V AC Momentary Fault Study commissioned by NPPD indicates that while performing the monthly surveillance test on the emergency diesel generator, a phase-to-phase momentary fault, if it occurred, could be as high as 63,800 A. The switchgear is certified to withstand 60,000 A and the breakers 58,000 A faulted current.

The District has undertaken a study of the effects of such a faulted condition occurring. Following consultations with the manufacturer of the switchgear, General Electric, and discussions with consultant agencies, NPPD has determined that the ability to perform and maintain a safe shutdown of CNS from 100 percent power is not jeopardized by a phase-to-phase momentary fault on the 4160 V system during the surveillance testing of one of the diesel generators.

The bases for this statement are:

a. Only one diesel generator is tested at a time up to eight hours per month. There are two emergency diesel generators at CNS.

b. The magnitude of the fault, only 6½ percent above faulted capacity, is unlikely to cause damage to other equipment in the same division if the fault is associated with the breaker.

c. The fault can only occur on one safety-related division since only one diesel is tested at a time. Therefore, a fault would not damage the redundant safety-related division (G.E. concurs with this position).

d. For a fault of such magnitude to be produced, the fault has be occur at a specific point in the AC cycle to give a 1.6 DC offset.

e. The switchgear and breakers are inspected at regular intervals, and the condition of equipment is well documented. CNS has not experienced any problems of degradation of equipment in the switchgear during 13 years of commercial operation.

f. The probability of a phase-to-phase fault occurring under the conditions postulated above is remote, lower than 10^{-5} per reactor year.

g. The faulted capacity of the equipment is adequate if the diesel generators are not being operated in the test configuration.

Based on the above statements, it is considered that the probability of a fault of such magnitude occurring is extremely low, and if it did, it could not damage the redundant essential switchgear. Thus, the ability to perform a safe shutdown in the event of a transient or design basis accident is assured.

B. DC Voltage Studies/Sufficiency

The DC Voltage Drop Study and the DC Load Study have been completed. The studies were performed by CYGNA Energy Services. NPPD has completed an initial review of both studies and a full review is currently in progress.

1. The DC Load Study shows that the existing batteries and chargers are capable of supporting the system demand during accident conditions.

2. The DC Voltage Drop Study was satisfactory with the exception of the voltage drop associated with the closing coil circuits in relation to the 4160 V Breakers 1FS and 1GS (Start-up transformer breakers), as well as EG1 and EG2 (diesel generator breakers). The study shows a calculated voltage of 78 V at the coils. The coil manufacturer's specification states a 90 V minimum operating voltage is required. A Special Test Procedure (STP 87-013) was conducted to measure the

minimum voltage required to operate the coil. The results of the STP showed that depending upon the type of breaker (1200 A or 2000 A) the closing coils operated at voltages ranging between 40 V and 58 V. Repeatability of results was proven for each of the four breakers tested with less than five percent variance in readings. Even assuming a 20 percent variance on the 58 V reading, the minimum voltage for operation was demonstrated to be below the calculated minimum voltage of 78 V.

The DC Study indicates that the DC electrical distribution system meets the design criteria for CNS.

The DC calculations are available for review at NPPD Offices.

C. Control Building HVAC Study

In response to the concerns expressed during the Safety System Functional Inspection to the adequacy of the HVAC system in the Control Building, an HVAC study was initiated. NUTECH Engineers performed a thermal transient evaluation for: AC Switchgear Rooms 1F and 1G, DC Switchgear Rooms 1A and 1B, and Battery Rooms 1A and 1B.

The results of the study, given in Attachment B, show that should ventilation fail during an accident or normal operation, the temperatures in the rooms in question are maintained within equipment specifications; however, the use of portable HVAC equipment is required. Station Operating Procedures state that should ventilation fail, the dedicated portable ventilation equipment will be made operational within one hour. In addition, if at any time the temperatures in the switchgear rooms rise above 104°F, additional ventilation will be supplied using the portable dedicated equipment until the ambient temperatures can be maintained below 104°F.

In response to concerns about the ambient temperatures in the battery rooms during the winter, the calculations associated with the evaluation show the temperature would fall to to 71°F with a Control Building minimum design temperature of 65°F following a loss of Control Building HVAC.

Attachment B gives a summary of the results and conclusions from the evaluation in greater detail.

The NUTECH evaluation together with associated calculations are available for review at NPPD Offices.

NPPD is currently evaluating the undertaking of further studies and the possible modifications to further improve the margin of operability of essential systems at CNS.

Sincerely,

GATrevors

George A. Trevors
Division Manager of Nuclear Support

GAT/APH:cb112/4(PPGC1S)
Attachments

cc: Regional Office
USNRC - Region IV

Resident Inspector
Cooper Nuclear Station

Attachment A to Nebraska Public Power District's Letter
to the NRC dated August 14, 1987

This Attachment is a synopsis of the A voltage drop study performed by Burns and Roe.

1.0 Background

Nuclear Regulatory Commission (NRC), in attachment to its letter dated August 8, 1979, stipulated certain guidelines regarding the adequacy of Station Electric Distribution System voltages (Ref. 2.4.1). A voltage drop analysis computation (Ref. 2.1) was performed for Cooper Nuclear Station (CNS) in 1979 to verify the adequacy of system voltages to start and operate all safety-related loads.

During May and June 1987, the NRC performed a Safety System Functional Inspection (SSFI) of the CNS Emergency Electrical system. As a part of the SSFI, the NRC investigated the prevailing voltage profile study. The NRC noted that several values used in the prevailing voltage profile study were slightly different when compared with the present plant conditions.

In response to NRC questions, NPPD committed to undertake a systematic reevaluation of all the factors that may affect the plant voltage profile during a postulated Loss of Coolant Accident.

NPPD reanalyzed the transmission line network data to determine the system parameters which should be used for the CNS licensing basis. This information is provided in the Reference 2.7.

A Special Test Procedure, STP-87-010 (Reference 2.2) was written to aid in the determination of CNS plant load data. STP-87-010 was performed to obtain the actual load data while CNS was operating near its rated capacity. Based on these measured values and examination of the plant auxiliary system operational requirements, a conservative plant loading model was established which is documented in the NPPD load data calculation (Reference 2.3).

2.0 References

2.1 Burns and Roe "Voltage Drop Analysis Computations and Test Procedure to Verify Computed Values,", Rev. 1, December 18, 1979 (Calc. No. 2.15.01).

2.2 NPPD Special Test Procedure: STP-87-010-Measurement of Plant Electrical Loads.

2.3 NPPD Load Data: NPPD Calculation No. 87-104.

2.4 NRC Guide LInes & NPPD Response:

2.4.1 NRC Guidelines, attachment to NRC letter data August 8, 1979, "Ref: Adequacy of Station Electric Distribution Systems Voltages."

2.4.2 NRC letter Docket No. 50-298 dated June 3, 1977, addressed to NPPD with attachments.

2.4.3 NPPD letter dated July 18, 1977, addressed to NRC.

2.5 BRC Computer Program EL0110 Rev. 4 - "Electrical System Design for Three-Phase Short Circuit, Voltage Drop and Transformer Impedance Sizing" (Attachment I).

2.6 B&R Drawings:

1. Burns and Roe Drawing 3001, Rev. No. N3 - Main One Line Diagram.
2. Burns and Roe Drawing 3002, Rev. No. N13 - Auxiliary One Line Diagram, Sh. 1.
3. Burns and Roe Drawing 3003, Rev. No. N13 - Auxiliary One Line Diagram, Sh. 3.
4. Burns and Roe Drawing 3004, Rev. No. N9 - Auxiliary One Line Diagram, Sh. 3.
5. Burns and Roe Drawing 3005, Rev. No. N10 - Auxiliary One Line Diagram, Sh. 4.
6. Burns and Roe Drawing 3006, Rev. No. N23 - Auxiliary One Line Diagram, Sh. 5.
7. Burns and Roe Drawing 3007, Rev. No. N18 - Auxiliary One Line Diagram, Sh. 6.
8. Burns and Roe Drawing 3010, Rev. No. N25 - Vital One Line Diagram.
9. Burns and Roe Drawing 3401, Rev. No. N7 - Auxiliary One Line Diagram.
10. Burns and Roe Drawing 3412, Rev. No. N4 - Augmented Radwaste Bldg. and ACAD System-Lighting Panels and Fixture Schedules.
11. Burns and Roe Drawing 3012, Rev. N3 - Main Three Line Diagram, Sheet No. 3.
12. Burns and Roe Drawing 3019, Rev. N10 - Switchgear Elementary Diagrams, Sheet No. 3.
13. Burns and Roe Drawing E150.

2.7 NPPD Data:

2.7.1 System Impedance and Grid Voltage Data 69 kV line.

2.7.2 System Impedance and Grid Voltage Data 161 kV line.

2.7.3 Cable/Bus Impedance Data: NPPD Calculation No. 87-103.

2.7.4 NPPD Correspondence

1. 161 kV and 345 kV System Impedances
   Letter from R. Rahrs to R. Lindstrom dated July 17, 1987.

2. 69 kV System Impedances
   Letter from Jim Hackney to W. Fischer dated August 4, 1987.

3. 161 kV Bus Voltages
   Letter from J. Doudna to J. Hackney dated July 21, 1987.

4. 69 kV Bus Voltage
   Letter from I. Goering to W. Fischer dated July 6, 1987.

2.8 Vendor Data:

2.8.1 Start-up Station Service Transformer Test Data.

2.8.2 Emergency Station Service Transformer Test Data.

2.8.3 4.16 kV/480 V Sub-Station Transformer Test Data.

2.8.4 4 kV Motor Data.

2.8.5 460 V Motor Starter Data.

2.9 Cooper Nuclear Station - Updated Safety Analysis Report - May, 1985.

2.10 Cooper Bessemer Company to Burns and Roe - March 5, 1974. Certified report of engine field tests.

2.11 General Electric Pub. 362A648-0, Fig. 2.

2.12 Burns and Roe Calc. No. 2.09.06, Sh. 19.

2.13 Telecon: K. A. Bugenis (B&R) and A. Gelfen (Telemechanique).

2.14 ITE - Electrical Products catalog, Magnetic Starter Data Section 6.1.1.2, Page 7

2.15 Westinghouse - Magnetic Starter Data Section 8220, page 59.

3.0 <u>Discussion</u>

3.1 Start-up A.C. Power Source.

During normal plant operation, the station auxiliaries are powered from the Normal Station Service Transformer, which is connected to the CNS generator output. A unit trip results in the tripping of 345 kV breakers and the loss of feed to the Normal Station Service Transformer. An automatic fast transfer takes place to connect the Start-up Station Service Transformer in under 8 cycles, and the station auxiliaries continue to operate without interruption of power. The Start-up Station Service Transformer is connected to the grid via a 161 kV line.

If a Loss of Coolant Accident (LOCA) occurs, a CNS unit trip will take place, and as a result, the fast transfer will occur without interruption of power to the plant auxiliaries. Beside providing power to the running plant auxiliaries, the Start-up Station Service Transformer will also be subjected to an automatic block start of the safety loads such as: two (2) Residual Heat Removal (RHR) pumps and one (1) Core Spray Pump on each of the two 4160 V Emergency Power Buses 1F and 1G. In addition, certain other critical loads on the 480 V critical power buses will also be connected simultaneously.

3.2 Emergency A.C. Power Source

Should the 161 kV Start-up A.C. Power Source not be available in the event of a fast transfer, the 4160 V Critical Power Buses 1F and 1G would automatically be isolated from the other plant auxiliaries and then be connected to the Emergency Station Service Transformer. After securing the power on 4160 V Buses 1F and 1G, the 4160 V safety related loads are automatically connected and powered in a predetermined sequence. The 480 V MCC critical loads stay connected, hence, receive power as soon as voltage is available on the 4160 V Buses 1F and 1G. The LOCA signal also initiates the start of the Emergency Diesel Generator Sets 1A and 1B and keeps them ready, in the event of loss of power from the Emergency Station Service Transformer, which is connected to the 69 kV transmission line operated by Omaha Public Power District (OPPD).

3.3 Under-voltage Protection Schemes

Normally, the plant auxiliary power buses operate at a voltage range of 3950 to 4250 V corresponding to a nominal 345 kV grid system range of 345 to 365 kV (Ref. 2.9 section 3.6). In order to preclude damage to motors on essential equipment due to under-voltage conditions, the emergency 4160 V Power Buses 1F and 1G, are provided with two levels of undervoltage protection.

The first level of undervoltage protection at Buses 1F and 1G is provided by relays (GE Type IAV54E) 27/1F and 27/1G. Each relay initiates tripping of all motor breakers, isolates its respective bus and starts its associated Diesel Generator. These relays are induction disc type relays and as part of their design are subjected to an inherent time delay.. The second level undervoltage scheme is designed to protect the critical electrical equipment from a sustained degraded voltage condition. The second level undervoltage relays on Buses 1F and 1G and are also GE Type IAV 54E. Besides the inherent time delay associated with the

GE-IAV54E relays, there is an intentional 10 second time delay in the associated control circuit after which load shedding takes place to guard against a sustained undervoltage condition.

3.4 Transformers Taps

The Station Start-up Service Transformer tap setting is presently 2 which corresponds to 165,025 V with the secondary rated at 4160 V.

The Emergency Station Service Transformer tap setting is presently 2, which corresponds to 68,800 V with the secondary side rated at 4160 V.

3.5 Grid Voltages

Grid voltages associated with off-site electrical power supplies to CNS are given below.

The operating range for the 345 kV system is from 345 kV to 365 kV.

The NPPD 161 kV Bus at CNS is supplied by two sources, one being via a NPPD 345/161 kV transformer and the other being from the OPPD system, 161/kV line from Auburn.

A separate NPPD study has analyzed the 161 kV grid conditions . The minimum voltage for the 161 kV line from Auburn is estimated at 159.4 kV. For the 161 kV line supplied via 345:161 kV transformer the minimum voltage is estimated at 165.4 kV. Both cases evaluated assume a loss of CNS generation.

The high and low voltages for the 69 kV line are calculated to be 72.08 kV and 65.55 kV.

In the analysis performed by Burns and Roe all the above cases up to the 480 V MCC terminals have been considered. The results are tabulated in this Attachment.

Plant Load Data:

To reflect realistic loading conditions in the analysis which initially used nameplate data, a Special Test Procedure (STP 87-010) was written to determine the actual station electrical load while operating near 100 percent power. The results of the test procedure were scrutinized and further analyses were performed to determine the maximum credible electrical loading criteria (NPPD Calculation 87-104). The load information was used in the Burns and Roe calculations.

The voltage drop study was performed using Burns and Roe Computer Program EL0110 - Revision 4. The program is QA certified for use in the nuclear industry. Several cases were developed to represent plant parameters, and accordingly a number of computer iterations were performed for the different grid voltage conditions and plant loading criteria. The cases developed were:

a. Block starting of Emergency Core Cooling System (ECCS) equipment with all other auxiliaries operational and with the power source being supplied from either the 345:161 kV transformer or via the 161 kV line from Auburn through the Start-up Transformer.

b. Sequential starting of the ECCS equipment with all other auxiliaries operational and with the power source supplied from either 345:161 kV transformer or via the 161 kV line from Auburn through the Start-up Transformer.

c. Sequential starting of the ECCS equipment plus the phased starting of two Service Water pumps with all non-essential equipment "off line" and with power supplied from the 69 kV line via the Emergency Station Service Transformer.

The Station Distribution Network was modeled within the constraints of the Burns and Roe program up to the MCC terminals. Cable impedance values used in the study were computed on a percent basis of 100 MVA and are reflected in NPPD Calculation 87-103. The limitations of the program resulted in a number of conservatisms being adopted such as starting all 480 V machinery simultaneously. "Dummy" transformers and buses was utilized to reflect the varying conditions of the plant. A detailed account of the modeling procedure is given in the Burns and Roe Study 4107-013.

A detailed review of plant voltage profiles has been performed by NPPD for the worse cases, maximum and minimum supply voltage.

Results

The results of the Burns and Roe study are shown in tables at the back of this Attachment. The computer input, output, and records of all other calculations are available for review at the NPPD offices.

The results are summarized as follows:

a. For power supplied via the 345:161 kV transformer at CNS the systems evaluated can withstand a block as well as sequential starting of the ECCS equipment.

b. For power supplied from the 161 kV line from Auburn the essential bus bars will trip on undervoltage if the system is subjected to a block start of ECCS pumps. If the system is subjected to a sequential start, the essential bus bars will remain energized.

c. For power supplied from the 69 kV line via the Emergency Station Transformer the system will sustain a sequential start of ECCS and service water equipment with all non-essential systems deenergized.

The tables attached give a summary of the results.

Conclusion

The review of voltage profiles for CNS for the Offsite power supplies indicate that under normal and emergency conditions the electrical distribution system to the 480V MCC terminals is adequate to withstand a block/sequential start powered via 161 kV line from the 345:161 kV transformer or a sequential start powered via the 69 kV line.

COOPER NUCLEAR STATION
VOLTAGE DROP STUDY
161 kV OFFSITE SOURCE

RESULTS SUMMARY

TABLE 1: Sheet 1
Plant Auxiliaries Fed From
Start-up Station Service
Transformer (SSST)

SSST Tap Set At 2
:EXISTING TAP:

CASE NO.	TAP VOLTS kV	GRID VOLTS kV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 kV BUS RUN (kV)	START	VOLTAGE AT 4kV MTR. TERMINAL RUN (%)	START	START (V)	MCC	VOLTAGE AT BUS 480V SUBSTATION RUN (V)	START	460V MCC RUN (%)	START (%)	START (V)
161 kV LINE CONNECTED TO OPPD AUBURN SUBSTN:															
VD-02		Min.		BUS-1F	3.5622	2.6787	88.96	66.49 RHR-P1A	2.6596	MCC-K	398.7	297.9	86.66	64.68	297.5
	165.25	159.4	Block Start	BUS-1G	3.5622	2.6787	88.81	65.42 RHR-P1C	2.6368	MCC-S	404.3	303.0	87.84	65.66	302.0
										MCC-DG2	402.9	279.3	87.49	60.42	277.9
VD-30		Max.		BUS-1F	3.8136	2.8653	95.24	71.12 RHR-P1A	2.8448	MCC-K	426.8	318.6	92.77	69.19	318.3
	165.025	168.0	Block Start	BUS-1G	3.8136	2.8653	95.07	70.51 RHR-P1C	2.8205	MCC-S	432.9	324.1	94.04	70.24	323.1
										MCC-DG2	431.3	298.8	93.66	64.63	297.3
161 kV LINE CONNECTED TO NPPD 345/161 kV SOURCE:															
VD-06		Min.		BUS-1F	3.8076	2.9408	95.09	73.00 RHR-P1A	2.9198	MCC-K	426.2	327.0	92.63	71.01	326.7
	165.025	165.83	Block Start	BUS-1G	3.8076	2.9408	94.92	72.37 RHR-P1C	2.8949	MCC-S	432.2	332.6	93.89	72.09	331.6
										MCC-DG2	430.6	306.6	93.51	66.33	305.1
VD-11		Max.		BUS-1F	3.8686	2.9871	96.61	74.15 RHR-P1A	2.9658	MCC-K	433.0	332.2	94.11	72.13	331.8
	165.025	168.0	Block Start	BUS-1G	3.8686	2.9872	96.44	73.51 RHR-P1C	2.9405	MCC-S	439.1	337.9	95.39	73.22	336.8
										MCC-DG2	437.5	311.5	95.01	67.37	309.9

COOPER NUCLEAR STATION
VOLTAGE DROP STUDY
161 kV OFFSITE SOURCE

RESULTS SUMMARY

TABLE 1: Sheet 2
Plant Auxiliaries Fed From
Start-up Station Service
Transformer (SSST)

SSST Tap Set At 2
:EXISTING TAP:

CASE NO.	TAP VOLTS kV	GRID VOLTS kV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 kV BUS RUN (kV)	START	4kV MTR. TERMINAL RUN (%)	START	START (V)	MCC	VOLTAGE AT BUS 480V SUBSTATION RUN (V)	START	460V MCC RUN (%)	START (%)	START (V)
161 kV LINE CONNECTED TO OPPD AUBURN SUBSTN:															
VD-19		Min.		BUS-1F	3.6517	3.2778	91.20	81.36 RHR-P1A	3.2545	MCC-K	408.7	364.5	88.83	79.15	364.1
	165.025	159.4	LOCA Load Start Sequence 1	BUS-1G	3.6517	3.2779	91.04	80.67 RHR-P1C	3.2266	MCC-S	414.5	370.8	90.04	80.35	369.6
										MCC-DG2	413.0	341.8	89.69	73.73	340.1
VD-31		Max.		BUS-1F	3.8942	3.4942	97.25	86.73 RHR-P1A	3.4692	MCC-K	435.9	388.6	94.73	84.38	388.1
	165.025	168.0	LOCA Load Start Sequence 1	BUS-1G	3.8942	3.4942	97.08	85.99 RHR-P1C	3.4396	MCC-S	442.0	395.2	96.02	85.65	394.0
										MCC-DG2	440.4	364.3	95.64	78.81	362.5
161 kV LINE CONNECTED TO NPPD 345/161 kV SOURCE:															
VD-10		Min.		BUS-1F	3.8791	3.5188	96.87	87.34 RHR-P1A	3.4937	MCC-K	434.2	391.3	94.37	84.97	390.9
	165.025	165.83	LOCA Load Start Sequence 1	BUS-1G	3.8791	3.5189	96.71	86.60 RHR-P1C	3.4639	MCC-S	440.3	398.0	95.65	86.26	396.8
										MCC-DG2	438.7	366.9	95.27	79.37	365.1
VD-12		Max.		BUS-1F	3.9384	3.5723	98.36	88.67 RHR-P1A	3.5468	MCC-K	440.8	397.2	95.81	86.26	396.8
	165.025	168.0	LOCA Load Start Sequence 1	BUS-1G	3.9384	3.5723	98.18	87.91 RHR-P1C	3.5165	MCC-S	447.0	404.1	97.11	87.57	402.8
										MCC-DG2	445.4	372.5	96.73	80.57	370.6

COOPER NUCLEAR STATION
VOLTAGE DROP STUDY
161 kV OFFSITE SOURCE

RESULTS SUMMARY

TABLE 1: Sheet 3
Plant Auxiliaries Fed From
Start-up Station Service
Transformer (SSST)

SSST Tap Set At 2
:EXISTING TAP:

CASE NO.	TAP VOLTS kV	GRID VOLTS kV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 kV BUS RUN (kV)	4.16 kV BUS START	4kV MTR. TERMINAL RUN (%)	4kV MTR. TERMINAL START	START (V)
161 kV LINE CONNECTED TO OPPD AUBURN SUBSTN:									
VD-20		Min.		BUS-1F	3.6072	3.2475	89.93	79.90 RHR-P1B	3.1959
	165.025	159.4	LOCA Load Start Sequence 2	BUS-1G	3.6072	3.2475	90.06	80.45 RHR-P1D	3.2182
VD-[illegible]2		Max.		BUS-1F	3.8539	3.4694	96.08	85.36 RHR-P1B	3.4133
	165.025	168.0	LOCA Load Start Sequence 2	BUS-1G	3.8539	3.4694	96.22	85.95 RHR-P1D	3.4381
161 kV LINE CONNECTED TO NPPD 345/161 kV SOURCE:									
VD-07		Min.		BUS-1F	3.8434	3.4967	95.82	86.03 RHR-P1B	3.4411
	165.025	165.83	LOCA Load Start Sequence 2	BUS-1G	3.8434	3.4966	95.96	86.63 RHR-P1D	3.4651
VD-13		Max.		BUS-1F	3.9036	3.5512	97.32	87.37 RHR-P1B	3.4948
	165.025	168.0	LOCA Load Start Sequence 2	BUS-1G	3.9036	3.5512	97.46	87.98 RHR-P1D	3.5192

COOPER NUCLEAR STATION
VOLTAGE DROP STUDY
161 kV OFFSITE SOURCE

RESULTS SUMMARY

TABLE 1: Sheet 4
Plant Auxiliaries Fed From
Start-up Station Service
Transformer (SSST)

SSST Tap Set At 2
:EXISTING TAP:

CASE NO.	TAP VOLTS kV	GRID VOLTS kV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 kV BUS RUN (kV)	START	4kV MTR. TERMINAL RUN (%)	START	START(V)
161 kV LINE CONNECTED TO OPPD AUBURN SUBSTN:									
VD-21		Min.		BUS-1F	3.5623	3.1979	89.02	79.71 CSP-1A	3.1883
	165.025	159.4	LOCA Load Start Sequence 3	BUS-1G	3.5623	3.1979	89.00	79.57 CSP-1B	3.1828
VD-33		Max.		BUS-1F	3.8137	3.4246	95.30	85.36 CSP-1A	3.4144
	165.025	168.0	LOCA Load Start Sequence 3	BUS-1G	3.8137	3.4246	95.28	85.21 CSP-1B	3.4084
161 kV LINE CONNECTED TO NPPD 345/161 kV SOURCE:									
VD-03		Min.		BUS-1F	3.8077	3.4564	95.15	86.15 CSP-1A	3.4460
	165.025	165.83	LOCA Load Start Sequence 3	BUS-1G	3.8077	3.4564	95.13	86.00 CSP-1B	3.4400
VD-14		Max.		BUS-1F	3.8687	3.5118	96.68	87.53 CSP-1A	3.5013
	165.025	168.0	LOCA Load Start Sequence 3	BUS-1G	3.8687	3.5518	96.65	87.38 CSP-1B	3.4952

COOPER NUCLEAR STATION
VOLTAGE DROP STUDY - RESULTS
69 kV OFFSITE SOURCE

TABLE 2: Sheet 1
LOCA Loads Fed From
Emergency Station Service
Transformer (ESST)

ESST Tap Set At 2
EXISTING TAP:

CASE NO.	TAP VOLTS KV	GRID VOLTS KV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 KV BUS RUN (KV)	VOLTAGE AT 4.16 KV BUS START	VOLTAGE AT 4KV MTR. TERMINAL RUN (%)	VOLTAGE AT 4KV MTR. TERMINAL START	VOLTAGE AT 4KV MTR. TERMINAL START(V)	MCC	VOLTAGE AT BUS 480V SUBSTATION RUN (V)	VOLTAGE AT BUS 480V SUBSTATION START	VOLTAGE AT BUS 460V MCC RUN (%)	VOLTAGE AT BUS 460V MCC START (%)	VOLTAGE AT BUS 460V MCC START (V)
ET-05		Min.	LOCA LOADS SEQUENCE 1	BUS-1F	3.8582*	3.1071	92.75*	77.12 RHR-P1A	3.0549	MCC-K	440.4*	333.7	91.75*	72.35	332.8
	68.8	65.55		BUS-1G	3.8584*	3.1095	92.75*	76.52 RHR-P1C	3.0609	MCC-S	442.2*	345.4	92.13*	73.72	339.1
										MCC-DG2	436.1*	324.8	90.85*	70.24	323.1
ET-06		Min.	LOCA LOADS SEQUENCE 2	BUS-1F	3.7864	3.1981	94.40	78.68 RHR-P1B	3.1473						
	68.8	65.55		BUS-1G	3.7869	3.2004	94.54	79.29 RHR-P1D	3.1715						
ET-07		Min.	LOCA LOADS SEQUENCE 3	BUS-1F	3.7126	3.1205	92.78	77.78 CS-P1A	3.1122						
	68.8	65.55		BUS-1G	3.7132	3.1231	92.77	77.71 CS-P1B	3.1083						
ET-08		Min.	LOCA LOADS SEQUENCE 4	BUS-1F	3.6902	3.5303	92.09	87.60 SSW-P1A	3.5040						
	68.8	65.55		BUS-1G	3.6908	3.5315	92.10	87.63 SSW-P1B	3.5050						

* Concurrent start of several loads on MCCs has been simulated for Sequence #1. This model gives realistic 'start' voltages. However, the 'Run' voltages are unrealistic since they are computed based on this altered motor model. Hence, the 'Run' voltages are read at the bus "Before Motor Starting' voltages from Sequence #2. The 'Run Percentages" for this case are based on nominal bus terminal voltages of 4.16 KV and 480 V.

COOPER NUCLEAR STATION

VOLTAGE DROP STUDY - RESULTS

69 kV OFFSITE SOURCE

TABLE 2: Sheet 2

LOCA Loads Fed From Emergency Station Service Transformer (ESST)

ESST Tap Set At 2

EXISTING TAP:

CASE NO.	TAP VOLTS KV	GRID VOLTS KV	LOAD CONDITION	BUS	VOLTAGE AT 4.16 KV BUS RUN (KV)	4.16 KV BUS START	4KV MTR. TERMINAL RUN (%)	4KV MTR. TERMINAL START (%)	4KV MTR. TERMINAL START (V)	MCC	VOLTAGE AT BUS 480V SUBSTATION RUN (V)	480V SUBSTATION START	460V MCC RUN (%)	460V MCC START (%)	460V MCC START (V)
ET-13		Max.	LOCA LOADS SEQUENCE 1	BUS-1F	4.2600*	3.4393	102.40*	85.37 RHR-P1A	3.4147	MCC-K	486.3*	369.4	101.31*	80.08	368.4
	68.8	72.0		BUS-1G	4.2603*	3.4419	102.41*	84.70 RHR-P1C	3.3881	MCC-S	488.3*	382.4	101.73*	81.60	375.4
										MCC-DG2	481.5*	359.5	100.31*	77.75	357.6
ET-14		Max.	LOCA LOADS SEQUENCE 2	BUS-1F	4.1960	3.5348	104.61	86.97 RHR-P1B	3.4787						
	68.8	72.0		BUS-1G	4.1964	3.5374	104.77	87.64 RHR-P1D	3.5055						
ET-15		Max.	LOCA LOADS SEQUENCE 3	BUS-1F	4.1310	3.4650	103.23	86.37 CS-P1A	3.4547						
	68.8	72.0		[illegible]	4.1317	3.4679	103.22	86.29 CS-P1B	3.4515						
ET-16		Max.	LOCA LOADS SEQUENCE 4	BUS-1F	4.1114	3.9310	102.60	97.55 SSW-P1A	3.9018						
	68.8	72.0		BUS-1G	4.1122	3.9324	102.62	97.57 SSW-P1B	3.9030						

* Concurrent start of several loads on MCCs has been simulated for Sequence #1. This model gives realistic 'start' voltages. However, the 'Run' voltages are unrealistic since they are computed based on this altered motor model. Hence, the 'Run' voltages are read at the bus "Before Motor Starting' voltages from Sequence #2. The 'Run Percentages" for this case are based on nominal bus terminal voltages of 4.16 KV and 480 V.

<u>Attachment B to Nebraska Public Power District's</u>
<u>Letter to the NRC Dated August 14, 1987</u>

This attachment gives a summary of the results, assumptions, and methodology in regard to the Thermal Transient Evaluation for the Control Building at CNS performed by NUTECH Engineers.

1. In response to the NRC's concerns expressed during the recent Safety System Functional Inspection, NPPD initiated an evaluation of the ventilation systems associated with essential electrical equipment located in the Control Building at CNS. The evaluation was performed on Battery Rooms 1A and 1B, DC Switchgear Rooms 1A and 1B, and AC Switchgear Rooms 1F and 1G to develop the bounding transient room temperature profiles, resulting from Loss of Coolant Accident (LOCA), Loss of Offsite Power (LOOP), High Energy Line Break (HELB), and Loss of Ventilation (LOV) events.

2. The arrangement and function of the essential Battery and Switchgear Rooms is described in the Updated Safety Analysis Report (USAR) for CNS.

3. The Ventilation System for the Battery Rooms is provided by dedicated exhaust fans powered from the essential bus. The air is drawn out of the rooms utilizing one fan with the other acting as the redundant component. For the DC Switchgear Rooms, ventilation is provided by two supply fans (one for each room) powered from a non-essential bus which provide Control Building corridor air to these rooms. The air is then exhausted out of the rooms through a louver in the access door.

   For the AC Switchgear Rooms 1F and 1G ventilation is provided by a pair of redundant supply fans which provide outdoor air to the rooms. There are redundant discharge fans which draw air from the critical switchgear rooms and either recirculate or discharge the air outdoors. The electrical supplies for the supply and exhaust fans are non-essential.

   The dedicated portable ventilation system for the D.C. Switchgear Rooms consists of a 3,000 cfm fan drawing air from outside the Control Building and discharging through portable trunking into the rooms. The dedicated portable system for the AC Switchgear Rooms consists of two sets of fans and portable trunking. One fan rated at 4,000 cfm draws air through the north doors of Switchgear Room 1F and exhaust into Room 1G. The second fan, rated at 8,000 cfm draws air from Room 1G and 1F exhausting to the outside via the south door from Room 1G. Power for these units is essential.

4. The analysis was conducted for a combination of accident scenarios to determine the worst case. HELB combined with loss of ventilation is considered to be the worst case. The analysis for the summer condition is based on the climatic data given in the ASHRAE Handbook, for Omaha, Nebraska. The initial room temperatures for the summer conditions are assumed to be 104°F.

For winter conditions, the worst case is air supplied at the minimum design basis temperature for the Control Building of 65°F, with an initial Battery Room temperature of 80°F.

5. The normal air flow rates have been measured as 900 cfm supplied to DC Switchgear Rooms 1A and 1B, 1250 cfm exhausted from the Battery Rooms 1A and 1B, 3800 cfm supplied to AC Switchgear Rooms, and 4200 cfm exhausted from the AC Switchgear Rooms.

6. The analytical methods are based upon standard HVAC formulae and techniques and have been computed using the NUTECH Engineers HVAC Computer Program, which has been verified and validated for use in the nuclear industry. The time steps in the computation were at 1-second intervals. The heat input included input from equipment as well as lighting. The heat loads from equipment were calculated assuming constant loading at nameplate parameter throughout the transient with the exception of the 4160 V:480 V transformer in Rooms 1F and 1G. The heat loads for the transformers was based on the maximum credible loads calculated from the results of STP 87-010.

7. The rooms being analyzed contain 298 essential devices representing 23 types of equipment by 7 different manufacturers. Correspondence from vendors, coupled with testing of components at Wyle Laboratories, gives a high degree of assurance that equipment will operate at the elevated temperatures of 140°F for the DC Switchgear Rooms and 150°F for the AC Switchgear Rooms for short durations during the postulated events.

8. The results of the evaluation are tabulated in this Attachment.

9. The conservatisms in the evaluation process are considered to give sufficient margin, so that in reality the peak of the temperature transients will be lower than calculated. In addition, where portable ventilation is utilized during a Loss of Ventilation incident the air flow rate into the DC Switchgear Room is approximately 40 percent greater than in the normal operating condition. This factor alone is considered to account for approximately a 9°F margin in conservatism. Other conservatisms in the calculation process are:

   a) In general, the heat loads for the equipment are based on the nameplate ratings of current, voltage, and power. The transformer heat load used in the analysis for Critical Switchgear Room 1F is at least 30 percent greater than the normal measured load on the transformer. In addition, the equipment is assumed to instantaneously reject heat at its maximum rate for a conservatively specified duration or for the entire duration of the transient. Minimal credit is taken for sequencing or tripping of loads which would actually occur during the postulated events.

   b) The initial temperatures for the Battery and Switchgear Rooms, and the adjacent room spaces are conservatively assumed to be at 104°F, the maximum design temperatures from the start of the incident. In addition, the maximum outdoor ambient temperature is assumed to exist throughout the duration of the transient. In reality, the maximum ambient temperature for a design basis day can be expected to vary by an average of 24°F over a 24-hour period based on ASHRAE figures.

c) The many heat sinks which exist in the battery and switchgear rooms have been neglected in the transient analysis. These included the thermal mass of equipment contained in the rooms and the energy transfer paths which occur at wall and floor penetrations for ducting, piping, and conduit. While these openings are well sealed, the higher heat conduction rate at these locations to the surrounding ares has been neglected.

   For the critical Switchgear Rooms, the heat absorption capacity of the non-heat generating devices located in these rooms can be expected to slow the rate at which the air temperature rises in the room such that the maximum temperatures would be lowered by about 5°F.

d) The equipment in the affected rooms would only be subjected to a high ambient air temperature for a short period of time until portable ventilation is made operational.

   The active components for each essential device are not directly exposed to transient room temperature conditions but are enclosed within metal clad switchgear or are within an equipment case. A thermal lag effect would occur such that the essential components would not be expected to reach the peak temperatures postulated, and would not be subjected to temperatures above 150°F for a significant length of time, i.e., on the order of minutes. The short duration temperature effects should not prevent proper operation of the equipment. These facts, coupled with the conservatisms outlined in above, plus the margin inherent in components of this type, give a high degree of assurance that the equipment would function adequately during the postulated abnormal events.

10. CNS has a very good record of operability of the Ventilation System associated with the Control Building. There has not been a loss of ventilation in 13 years of commercial operation. In addition, there have been no repeated failures of electrical equipment which may suggest a high temperature degradation problem.

    In addition, the annunciators associated with the Control Building Ventilation Supply and return fans are essential and, coupled with the redundancy plus annunciated 'failure to start' logic circuits, it is unlikely that a complete loss of ventilation would not be acted upon by the plant operators.

11. The postulated events during which the essential equipment located in the Battery and Switchgear Rooms would be subjected to high temperatures requires the simultaneous occurrence of a design basis day maximum temperature, a loss of offsite power or loss of ventilation and, in some instances, a worst case LOCA or HELB event. The likelihood of this event scenario is remote. The electrical grid in the CNS service area has

proven to be very stable and reliable such that a total loss of offsite power has not occurred in the thirteen-year operating history of CNS. Also, CNS is equipped with two emergency diesel generators such that the likelihood of a complete station blackout for CNS is even more remote. Thus, the probability of an event is low.

12. Conclusion

If a complete loss of ventilation was to occur for the DC Switchgear Rooms or for the Control Building Ventilation System, the temperature rise in the affected areas would be rapid. However, with regular monitoring of room temperatures and the availability of dedicated portable equipment powered from essential buses, the transient would be less than 75 minutes. Considering the conservatisms and the resulting margins, the temperatures of the CNS Battery and DC Switchgear Rooms are expected to peak well below 140°F. Similarly, the temperatures of the AC Switchgear Rooms 1F and 1G are not expected to exceed 150°F for a period of time long enough for the equipment to be heated to 150°F. (Even if the ambient temperature exceeds 150°F).

CNS System Operating Procedures, together with Abnormal Operating Procedures, give guidance as to the actions to take in the event of an LOV or in the event ambient temperatures exceed 104°F during normal operations.

13. References

   a) Updated Safety Analysis Report, Cooper Nuclear Station, Revision 4, July 22, 1986.

   b) HVAC Drawing, CNS-CB-1, Control Building Ducting Layout Elevations 882'-6" and 903'-6", Revision 5, May 15, 1974.

   c) General Arrange Drawing, 2061, General Arrangement - Reactor Building Plan at Elevation 931'-6", Revision 4, March 23, 1984.

   d) Flow Diagram, 2018, Turbine Generator Building and Control Building Heating and Ventilating, Cooper Nuclear Station, Revision 6, September 16, 1986.

   e) Auxiliary One Line Diagram, Sheet No. 4, 3005, Cooper Nuclear Station, Revision N10, June 13, 1986.

   f) Auxiliary One Line Diagram, Sheet No. 5, 3006, Cooper Nuclear Station, Revision N23, May 7, 1987.

   g) Cooper Nuclear Station, Technical Specifications, Section 3.12.D, Battery Room Ventilation, September 25, 1986 (for page 215C - Change No. 19, October 31, 1975).

   h) American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., ASHRAE Handbook 1981 Fundamentals.

14. The tables and graphs are taken from the Nutech evaluation which is available along with the calculation packages for review at NPPD Offices.

APH:rs13/1(1S)

BATTERY AND SWITCHGEAR ROOM

MAXIMUM HEAT LOADS

Room	LOV Heat Loads (Btu/hr)	LOOP Heat Loads (Btu/hr)	HELB+LOV Heat Loads (Btu/hr)	HELB+LOOP Heat Loads (Btu/hr)
Battery Room 1A(2)	6,570	12,744	6,570	12,744
Battery Room 1B(2,3)	5,544	27,613	5,544	27,613
DC Switchgear Room 1A	16,094	37,662	16,094	37,662
DC Switchgear Room 1B	15,895	37,788	15,895	37,788
Critical Switchgear Room 1-F	55,619	55,619	17,588	48,979
Critical Switchgear Room 1-G	42,722	42,722	12,368	34,785

Note:

1. The heat loads shown represent the maximum values applied for each event sequence. The heat loads vary with time for some event sequences,

2. The minimum heat loads are used in the battery room evaluation for winter conditions.

3. For LOOP and HELB+LOOP event sequences, the peak heat load is 57,847 Btu/hr from 3 to 4 minutes in the event.

LOSS OF VENTILATION

TRANSIENT ANALYSIS RESULTS SUMMARY

Room	Initial Temperature (°F)	Maximum Transient Temperature (°F)	Steady State Temperature (°F)
Battery Room 1-A	104.	105.	105.
Battery Room 1-B	104.	105.	105.
DC Switchgear Room 1-A	104.	136.	109.
DC Switchgear Room 1-B	104.	135.	109.
Critical Switchgear Room 1-F	104.	161.	105.
Critical Switchgear Room 1-G	104.	151.	105.

Note:

1. The temperatures shown are determined assuming auxiliary ventilation equipment in place and operating within one hour

2. The minimum calculated battery room temperature for this event during winter conditions with the USAR ventilation air temperature of 65°F is 71°F without auxiliary room heaters.

LOSS OF OFFSITE POWER

TRANSIENT ANALYSIS RESULTS SUMMARY

Room	Initial Temperature (°F)	Maximum Transient Temperature (°F)	Steady State Temperature (°F)
Battery Room 1-A	104.	105.	104.
Battery Room 1-B	104.	116.	103.
DC Switchgear Room 1-A	104.	133.	112.
DC Switchgear Room 1-B	104.	133.	110.
Critical Switchgear Room 1-F	104.	161.	105.
Critical Switchgear Room 1-G	104.	151.	105.

Note:

1. The temperatures shown are determined assuming auxiliary ventilation equipment in place and operating within one hour,

2. The minimum calculated battery room temperature for this event during winter conditions with the USAR ventilation air temperature of 65°F is 71°F without auxiliary room heaters.

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HIGH ENERGY LINE BREAK WITH LOSS OF VENTILATION TRANSIENT ANALYSIS RESULTS SUMMARY

Room	Initial Temperature (°F)	Maximum Transient Temperature (°F)	Steady State Temperature (°F)
Battery Room 1-A	104.	105.	105.
Battery Room 1-B	104.	105.	105.
DC Switchgear Room 1-A	104.	136.	109.
DC Switchgear Room 1-B	104.	135.	109.
Critical Switchgear Room 1-F	104.	126.	101.
Critical Switchgear Room 1-G	104.	121.	100.

Note:

1. The temperatures shown are determined assuming auxiliary ventilation equipment in place and operating within one hour,

HIGH ENERGY LINE BREAK
WITH LOSS OF OFFSITE POWER
TRANSIENT ANALYSIS RESULTS SUMMARY

Room	Initial Temperature (°F)	Maximum Transient Temperature (°F)	Steady State Temperature (°F)
Battery Room 1-A	104.	105.	104.
Battery Room 1-B	104.	116.	103.
DC Switchgear Room 1-A	104.	133.	112.
DC Switchgear Room 1-B	104.	133.	110.
Critical Switchgear Room 1-F	104.	156.	100.
Critical Switchgear Room 1-G	104.	144.	100.

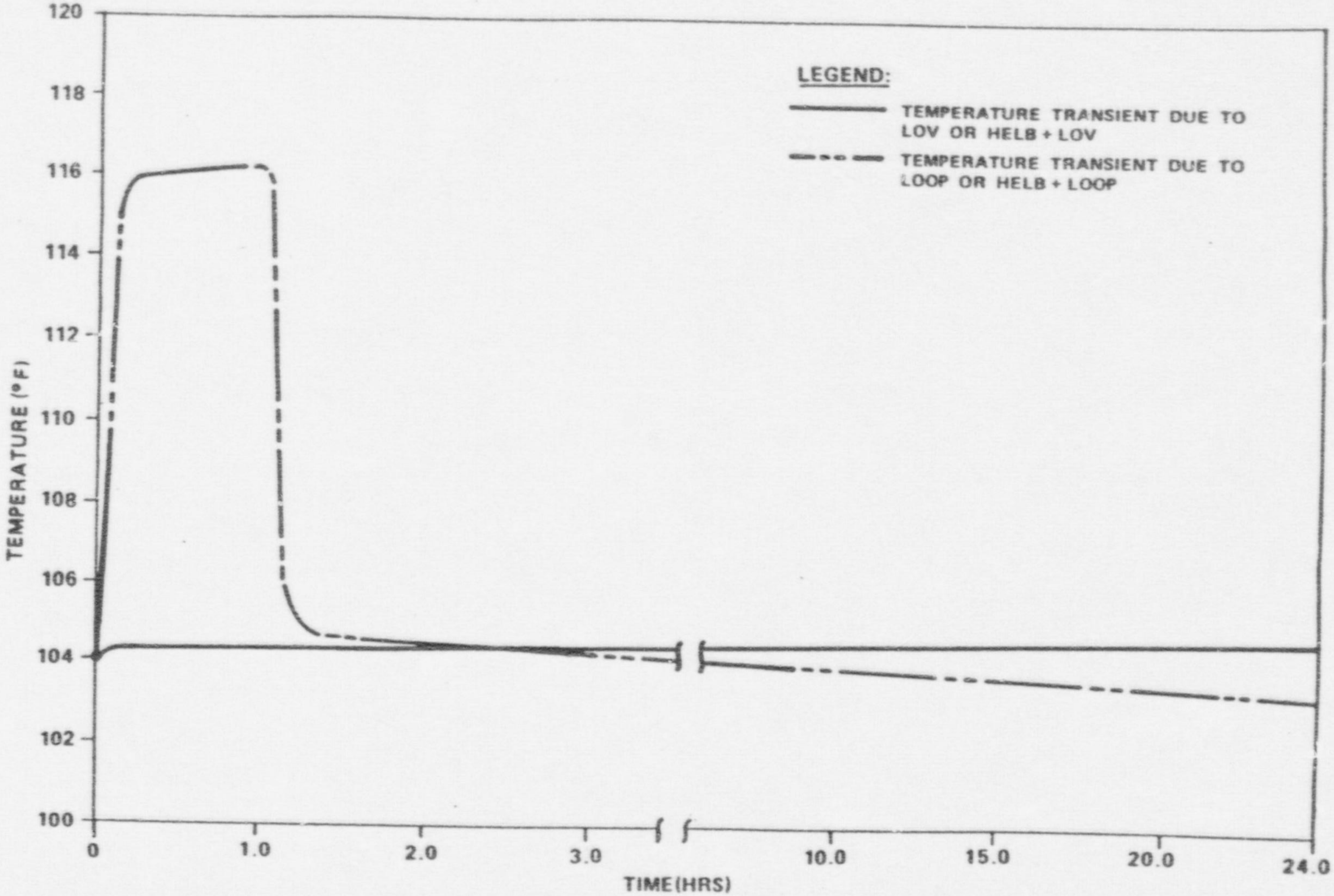
Note:

1. The temperatures shown are determined assuming auxiliary ventilation equipment in place and operating within one hour,

ASSESSMENT SUMMARY FOR ESSENTIAL EQUIPMENT DEVICES

IN BATTERY AND SWITCHGEAR ROOMS

Location	Manufacturer	Model	Description	Quantity	Operability Temperature Confirmed (°F)
Battery Room 1A & 1B	ASCO	307A23C	125 VDC Transfer Switch	2	158.
Battery Room 1A & 1B	Exide	FHGS-19	250 VDC Battery	2	140.
Battery Room 1A & 1B	Exide	FHGS-23	125 VDC Battery	2	140.
Battery Room 1A & 1B	GE	QMR	125 VDC Distribution Panel	4	230.
DC Switchgear Room 1A & 1B	Exide	USF-130-3-150	125 VDC Battery Charger	2	140.
DC Switchgear Room 1A & 1B	Exide	USF-260-3-200	250 VDC Battery Charger	2	140.
DC Switchgear Room 1A & 1B	Westinghouse	DB-25	Circuit Breaker	22	162.
Switchgear Rooms 1A, 1B, 1F & 1G	Westinghouse	DB-50	Circuit Breaker	24	162.
Switchgear Room 1F & 1G	Agastat	E7012	Relay	4	150.
Switchgear Room 1F & 1G	Agastat	E7022	Relay	3	150.
Switchgear Room 1F & 1G	Furnas Electric	BJXPL16	Switch	20	150.
Switchgear Room 1F & 1G	GE	CR120A	Relay	2	150.
Switchgear Room 1F & 1G	GE	AMH	Circuit Breaker	22	150.
Switchgear Room 1F & 1G	GE	HEA	Relay	10	150.
Switchgear Room 1F & 1G	GE	HFA	Relay	12	150.
Switchgear Room 1F & 1G	GE	HGA	Relay	44	150.
Switchgear Room 1F & 1G	GE	IAC	Relay	49	150.
Switchgear Room 1F & 1G	GE	IAV	Relay	4	150.
Switchgear Room 1F & 1G	GE	IFC	Relay	2	150.
Switchgear Room 1F & 1G	GE	NGA	Relay	2	150.
Switchgear Room 1F & 1G	GE	SB1	Switch	59	150.
Switchgear Room 1F & 1G	Sylvania	4UG120	Relay	2	150.
Switchgear Room 1F & 1G	Westinghouse	ASL	Transformer	2	355.



TEMPERATURE PROFILES FOR BATTERY ROOM 1 - B

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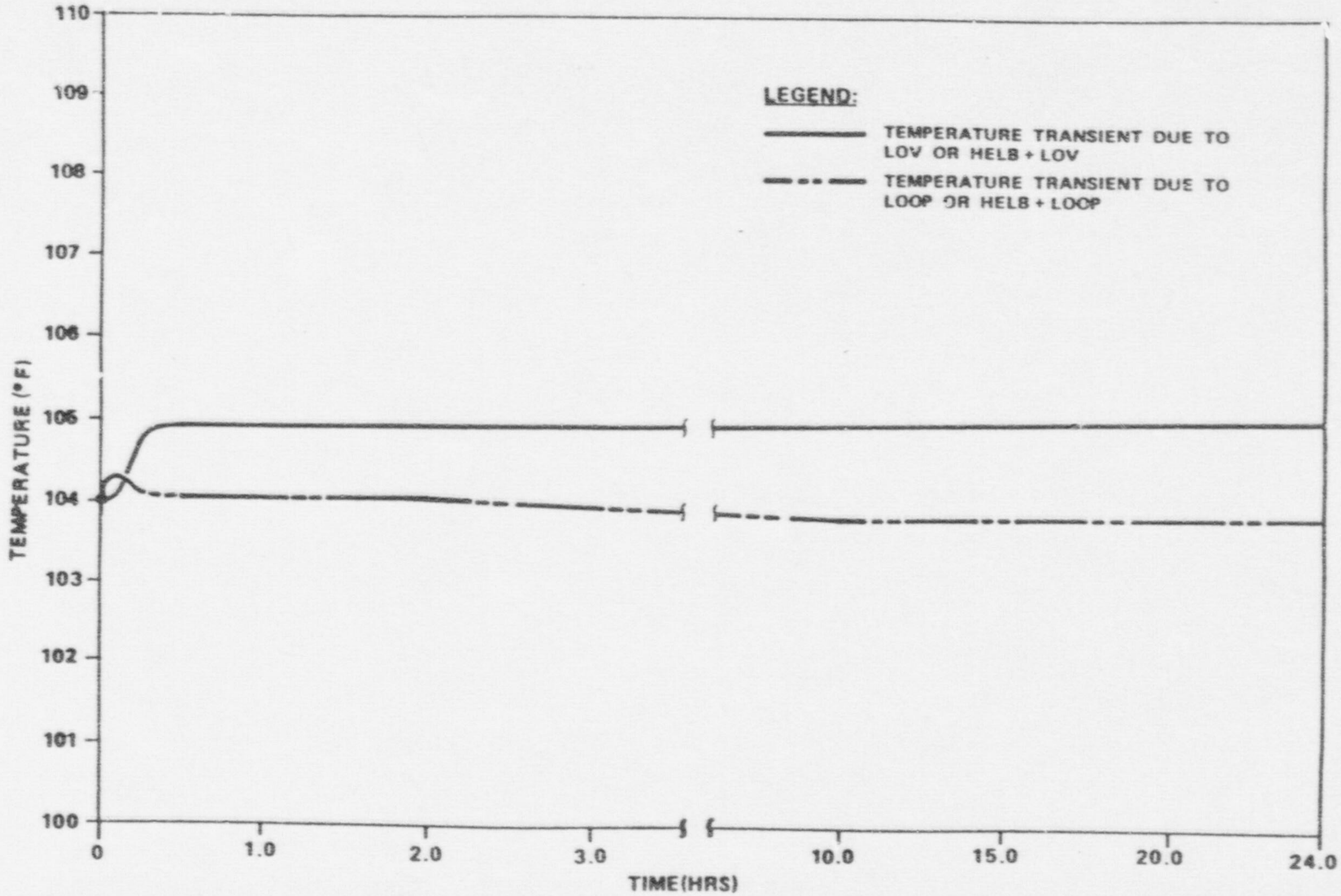

TEMPERATURE PROFILES FOR BATTERY ROOM 1-A

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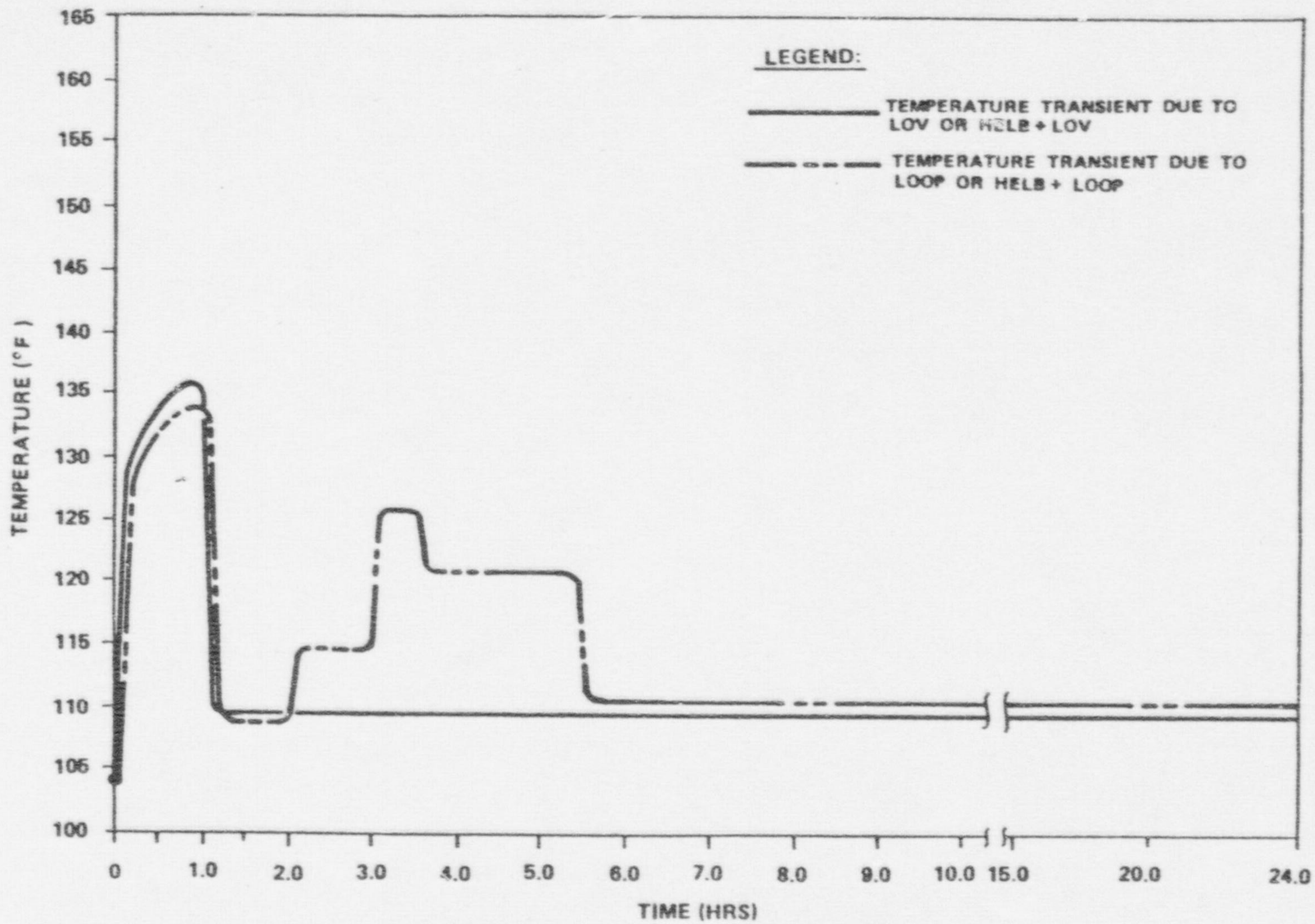

TEMPERATURE PROFILES FOR DC SWITCHGEAR ROOM 1 - A

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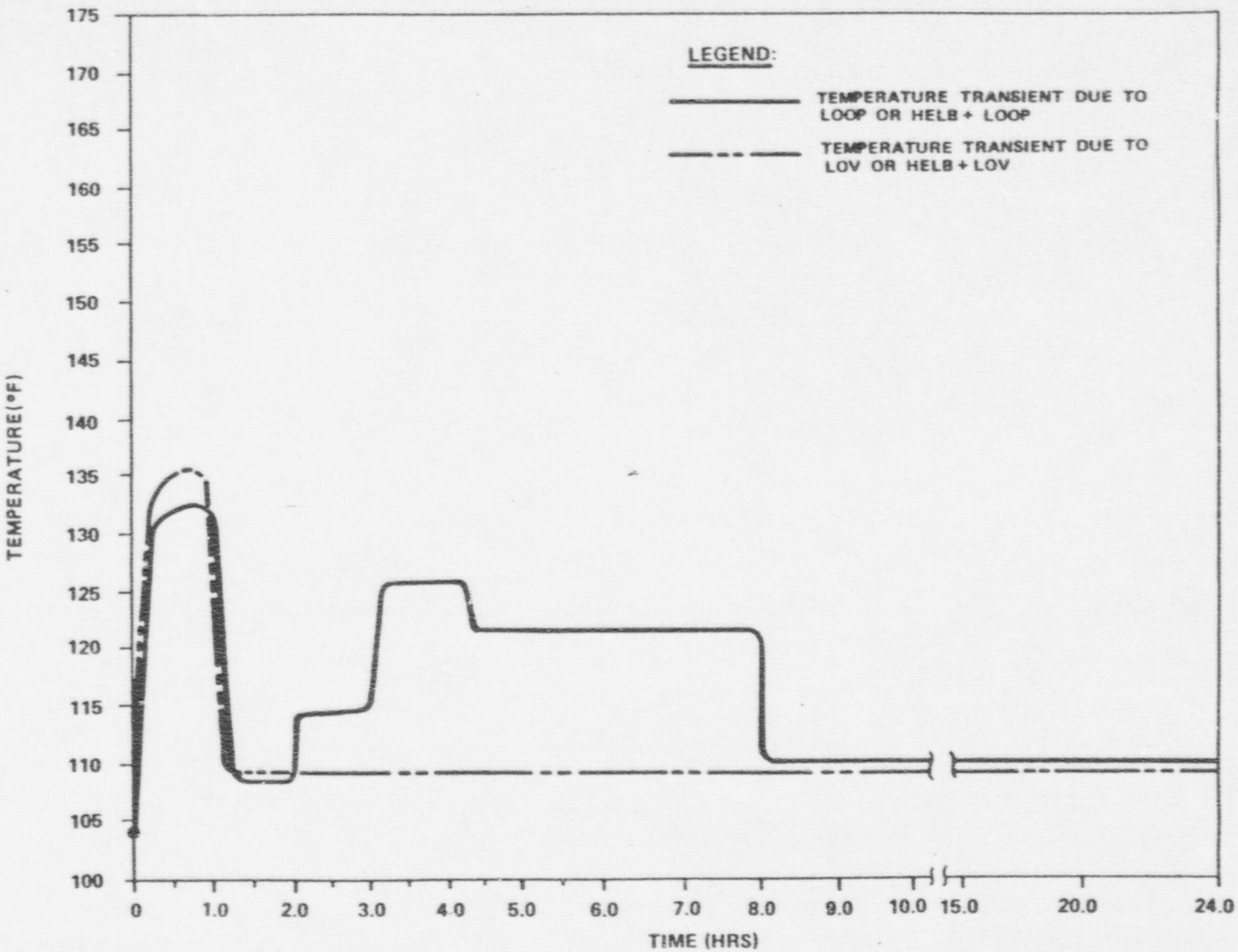

TEMPERATURE PROFILES FOR DC SWITCHGEAR ROOM 1 - B

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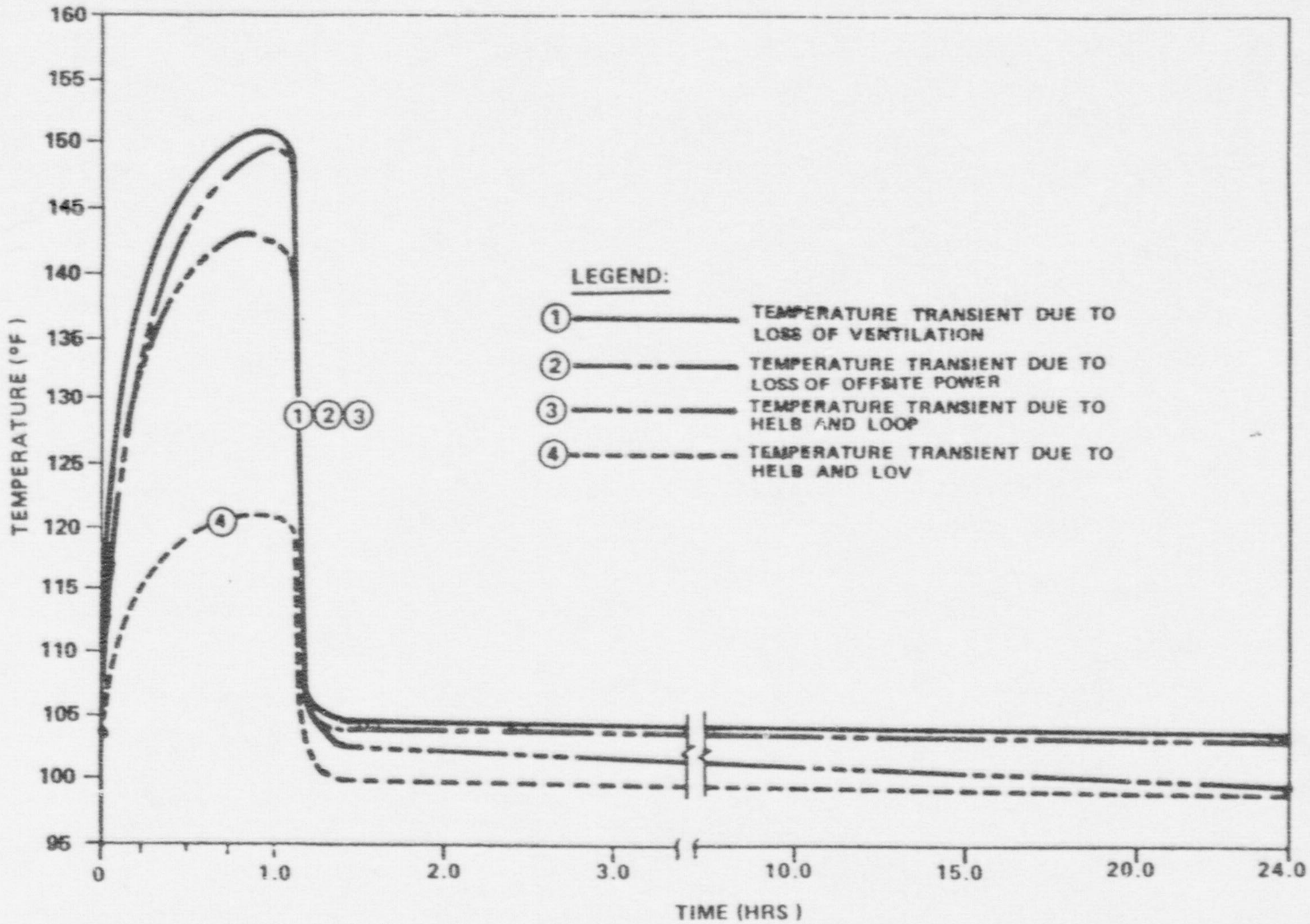
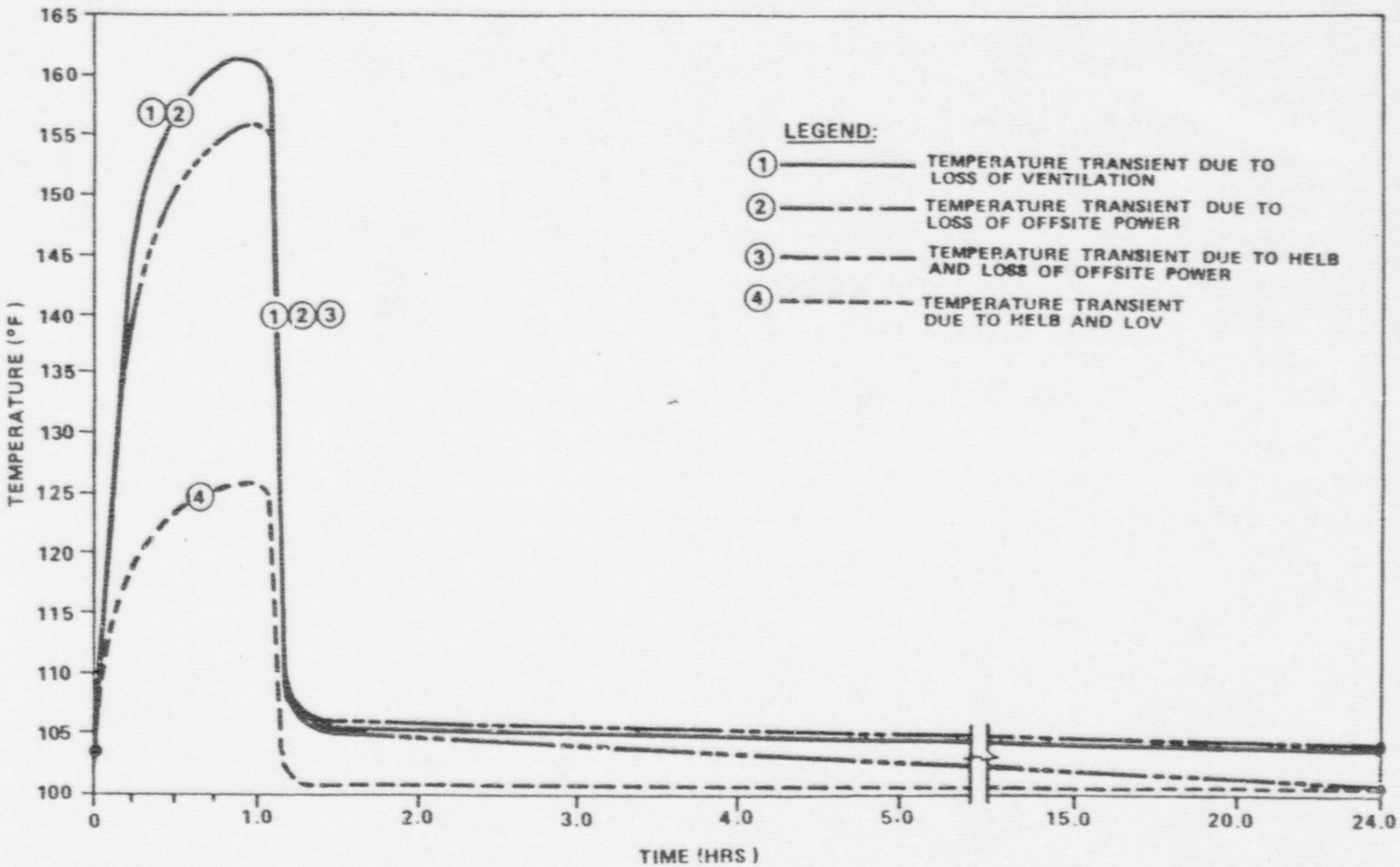


TEMPERATURE PROFILES FOR CRITICAL SWITCHGEAR ROOM 1-G



TEMPERATURE PROFILES FOR CRITICAL SWITCHGEAR ROOM 1 - F

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