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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Three Mile Island Nuclear Generating Station, Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
10CFR50 Appendix R - Loss of HVAC

This letter confirms that the 10CFR50 Appendix R exemption requests for loss of HVAC in the control building, emergency feedwater pump rooms, diesel generator building, and nuclear services and decay heat closed cycle cooling pump room, previously submitted via GPUN letters dated February 28, 1987 (5211-87-2047) and October 16, 1987 (5211-87-2175), are no longer required.

The previously submitted exemptions allowed a twenty minute roving fire watch, in lieu of fire protection of ventilation system components, for those normally unoccupied areas in the plant where a fire could affect ventilation and allowed credit for personnel in normally occupied areas as a continuous fire watch for the above mentioned areas. Acceptance of the previously submitted exemption (5211-87-2047) was provided by NRC Safety Evaluation Report dated March 19, 1987.

Since that time, GPUN has undertaken an extensive analysis and testing program to assess the need for post-fire shutdown ventilation in these areas. It is our conclusion that the installed ventilation systems are not required for post-fire shutdown. Minimal manual actions for several areas defined in the enclosure will adequately compensate for a loss of HVAC in those areas. We have confirmed that these action items are achievable. Enclosed is a description of the evaluation results of each of the above mentioned areas justifying this conclusion.

The NRC review and concurrence with the attached justification is desired. The previous exemption requests for loss of HVAC, while still valid, are no longer necessary since ventilation in these areas is not required for safe shutdown under Appendix R.

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Thus the fire watch program is no longer required for loss of ventilation concerns. We will continue to take credit for normal occupancy of CB-FA-1 for Appendix R non-ventilation issues.

If any additional information is required, please contact us.

Sincerely,

H. D. Hukill
Vice President and Director, TMI-1

HDH/DJD:fg
Enclosure

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ENCLOSURE

1.0 GENERAL DISCUSSION ON VENTILATION

1.1 INTRODUCTION

GPUN letters dated February 28, 1987 (5211-87-2047) and October 16, 1987 (5211-87-2175) requested an exemption from the requirement of Section III.G.2 for providing fire protection of heating, ventilation, and air conditioning (HVAC) components for the emergency feedwater pump room, diesel generator building, control building, intake screen pump house (ISPH), and nuclear service and decay heat closed cycle cooling pump (NS & DC) room. In lieu of fire protection of ventilation system components, GPUN proposed an interim arrangement involving a twenty minute roving fire watch for each area which contains cables/components of HVAC whose damage could result in the loss of HVAC, except for the ISPH. For the ISPH, an exemption was granted to utilize portable ventilation equipment. For areas other than the ISPH, NRC granted the exemption allowing a roving fire watch on the basis that this arrangement provides an equivalent level of safety to that achieved by compliance with Section III.G of Appendix R.

GPUN has continued to evaluate the HVAC requirements for the Appendix R events in the four buildings. Several computations were performed for the temperature profiles of these areas under HVAC failure conditions by computer programs using analytical models. GPUN also conducted extensive field testing to determine the room temperatures. As expected when performing analysis and tests of this nature, differences existed between the results of the analysis and field testing. An evaluation was performed of the computer analysis results and the field test data to reconcile the differences and to more accurately predict the expected room temperature response for each area with loss of the ventilation system. The findings are included in GPUN Technical Data Report (TDR 900), entitled, "Reconciliation of Ventilation Systems Analyses and Tests".

1.2 DESCRIPTION OF COMPUTER ANALYSIS

The computation of the temperature profile for each area has been performed using a computer program called Transient System Analysis Program (TSAP). TSAP is a generalized heat transfer program which solves the set of simultaneous differential equations resulting from the thermal model input.

The room air, the heat sources, and the heat sink (structures and concrete) are represented in a relatively simple manner in the thermal model.

The thermal model is developed as a network of thermal capacitances representing the masses of heat sources, the air, and the heat sinks connected by the conductances which represent the various heat transfer mechanisms. The thermal model is primarily based on conduction and convection heat transfer; radiation is considered in some cases. Figure 1 is a typical schematic of the thermal model. The model shows the metal and concrete structures which act as heat sinks connected through air to the heat source by natural convection heat transfer (k_m, k_s and K_{nc}). The metal heat sinks contain one slab, while insulated structures are made up of two slabs. The concrete consists of several slabs in order to represent the thermal gradient. The room air is assumed to be well mixed providing a uniform temperature.

This basic thermal model is modified as follows for each building, to include some additional details in an attempt to provide a more accurate model of the actual installation.

a. Intermediate Building (EFW Rooms)

   The convection heat transfer through open doorways is included in the model.

b. Diesel Generator Building (DG)

   In the DG model, the heat load is described by the temperature history of the engine and exhaust pipe as a boundary. The diesel generator heat load is also imposed on the mass of the generator. The direct radiant heat transfer is also considered.

c. Control Building (CB)

   The connection to the HVAC System (K_v) is included in the CB model to assist in determining the expected initial temperature. This connection is deleted during the transient analysis to model the loss of air flow. The heat transfer to adjacent rooms (K_a) accounts for the heat transfer through ceilings, floors, and walls. For four rooms, more realistic assumptions were incorporated to reduce excess conservatism; heat source equipment mass, and radiation heat transfer from source to sink were added.

The heat sources are obtained by engineering estimates and calculations, based on typical equipment and vendor data, of the heat loads of the various electrical equipment and lighting fixtures. The mass of duct work, cable trays, equipment supports, and structural beams are also estimated. Concrete areas are calculated from layout drawings.

The results of the calculation are conservative. The conservatisms result from both the input and the model representation having simplified assumptions. The internal heat load has the most direct impact on the room temperature. The estimates of the passive heat sinks are intended to be conservative (the mass of cables is not included). The analysis ignores the mass of heat producing equipment which tends to absorb the heat before releasing it to the room. The effect of equipment mass is to lower the rate of the initial temperature rise. The analysis also does not consider the direct heat transfer from the source to the heat sink by radiation. Depending on the room geometry, the room air temperature may vary between five (5) to ten (10) degrees by the effect of the direct radiant heat transfer. This conservatism was reduced in some cases when the revised computation was made for the control building to consider the radiant heat transfer. Stratification is not considered in the model. It is expected that the air at the lower level, near the equipment will be cooler than the average uniform temperature of the analysis.

1.3 DESCRIPTION OF FIELD TESTS

Loss of ventilation field tests were performed in accordance with Special Temporary Procedures (STP) for each ventilation system. Equipment in the test areas that contributed to the heat loads is considered to bound the heat loads that would be present for a loss of HVAC transient. Temperatures were monitored and recorded throughout the building. Normally, ten (10) thermocouples located at nominal points provided a representative sample of space temperature of each building area. The test for the control building utilizes twenty-four (24) thermometers to provide temperature data for fourteen (14) rooms. Temperature data was collected several hours prior to the commencement of the test to establish the initial condition. HVAC was secured and the temperatures were recorded at regular intervals during the test to determine the rate of the temperature rise. HVAC was then restored. The test durations and the intervals for temperature recording are given below:

Building	Test Duration	Interval
Intermediate (EFW) Building	2 hours	5 minutes
Diesel Generator Building	2 hours	15 minutes
Control Building	1.5 hours	5 minutes
Nuclear Service Pump Room	21 hours	30 minutes/2 hours

1.4 RECONCILIATION OF COMPUTER ANALYSIS AND FIELD TESTS

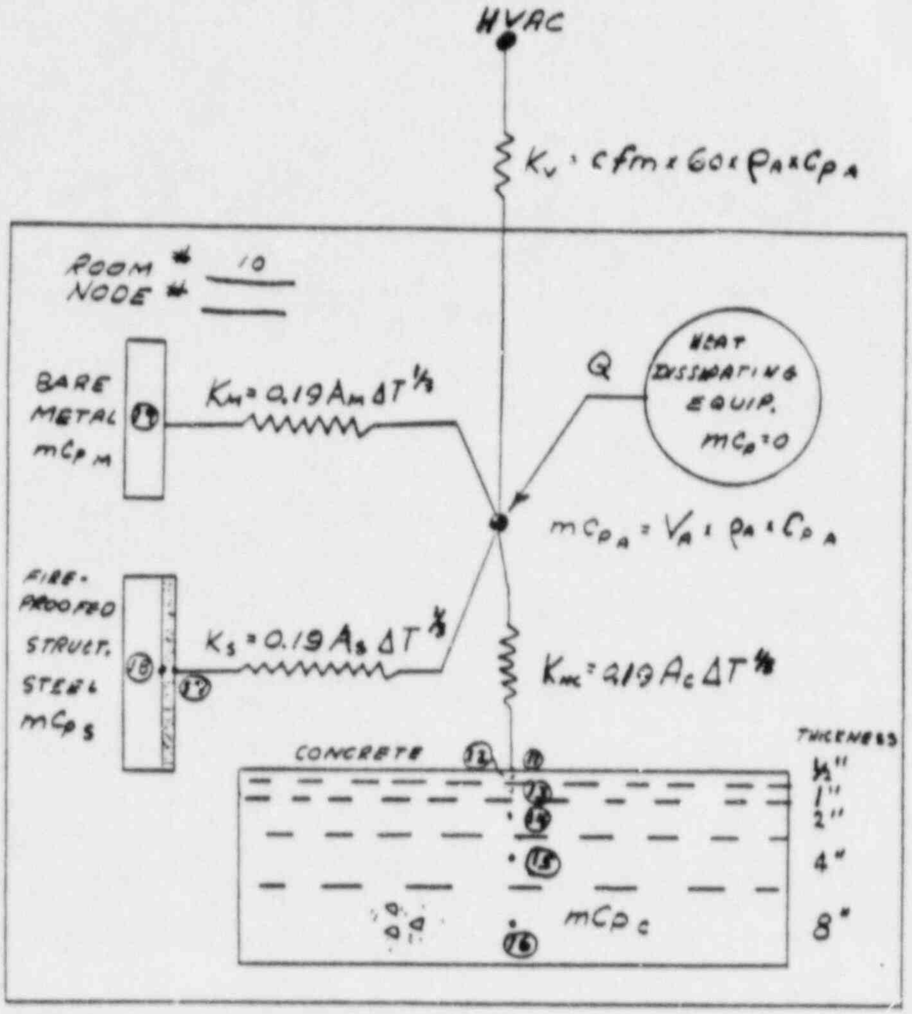
In order to reconcile the computer analysis and field tests, a comprehensive temperature evaluation was made to compare the actual test data and the results of the computer analysis. This evaluation provided the basis for the degree of correlation that could be drawn between the results of the computer analysis and test results for the four main areas. The temperature evaluation concluded that the test data, with adjustment for ambient temperature where applicable, represents the actual temperature response in two areas, the Intermediate Building, and the Nuclear Service and Decay Heat Closed

Cycle Cooling Water Pump Room. For the Control Building temperature responses, the temperature evaluation extrapolated the test data out to 72 hours based on the results of the computer analysis. For the Diesel Generator Building a best fit of analysis results to actual test data was performed (Figures 3A and 3B) and the analysis then extrapolated to provide the expected room profile over a 72 hour time period.

This evaluation of the field tests verified the validity of the analytical model for room temperature heat-up profile trending, and also confirmed that the model is conservative. This analysis and testing reaffirms our original conclusion that ventilation in the subject areas is not required for safe shutdown in the event of an Appendix R fire.

FIGURE 1

TYPICAL ROOM MODEL



LEGEND

Q	Heat transfer by convection in Btu/hr = $K\Delta t$
K	Conductance by natural convection = h x A = $(0.19\Delta t^{1/3})$ A
h	Natural convection coefficient = $0.19\ \Delta t^{1/3}$
K_v	Conductance to HVAC (Heat Removal Factor) = cfm x 60 x $C_{p_A} \times \rho_A$
K_m	Conductance from air to bare metal heat sink
K_s	Conductance from air to insulated structural steel
K_{nc}	Conductance from air to concrete
A	Area of surface of heat sink
Δt	Temperature difference between surface and air
mc_p	Thermal capacitance
ρ_a	Density of cooling air
cfm	Cooling air supply in cubic feet per minute
V_a	Volume of air

2.0 INTERMEDIATE BUILDING VENTILATION

2.1 APPENDIX R REQUIREMENT

The Appendix R components which are affected by the loss of ventilation air handling units AH-E-24A and AH-E-24B for the Intermediate Building are:

IB-FZ-2	
EF-P-1	Steam Driven Emergency Feedwater Pump
MS-V-4A, 4B	Atmospheric Steam Dump Valves
MS-V-2A, 2B	Steam Dump Header Isolation Valves
MS-V-10A, 10B	Steam Supply Valves to EF-P-1
MS-V-8A, 8B	Steam Dump to Condenser Bypass Valves
MS-V-6	EF Turbine Steam Control Valves
AS-V-4	Auxiliary Steam Isolation Valves
2HBUIA	Two Hour Backup Instrument Air
IB-FZ-3	
EF-P-2A, 2B	Motor Driven Emergency Feedwater Pumps
EF-V-2A, 2B	Steam Generator Cross-connect Valves
EF-V-30A, 30B 30C, 30D	EFW Flow Control Valves
FT788, 779, 782, 791	EFW Flow Transmitters
IA-P-1A, 1B	Instrument Air Compressors
2HBUIA	Two Hour Backup Instrument Air

AH-E-24A/24B are located in IB-FZ-3. One air handling unit normally provides heating and ventilation to emergency feedwater rooms and is designed to maintain the average room temperature at 115°F or less. Both air handling units may fail due to fire damage for a fire in CB-FA-1, CB-FA-2d, CB-FA-2f, CB-FA-3d, CB-FA-4b, and IB-FZ-3.

Steam driven pump EF-P-1 is not required until two hours after a fire in IB-FZ-3. HPI mode of heat removal is used initially for Appendix R shutdown in this zone.

The remaining EFW and MS system components are required for all other fires. Manual action is also required to operate some of these components. EF-P-1 must be started manually. Atmospheric dump valves (MS-V-4A/4B) and EFW flow control valves (EF-V-30A, 30B, 30C, and 30D) may be required to be controlled manually at the valve locations.

2.2 TEMPERATURE EVALUATION

The loss of ventilation test was performed with the plant in normal operation with all three emergency feedwater pumps operating in recirculation mode. "A" train instrument air compressor was also in operation. Temperatures were monitored with ten thermocouples located in the area. The test duration was two hours with temperatures being recorded every five minutes.

The resulting maximum room temperature at the end of two hours after the failure of HVAC, as determined by the computer analysis is 125°F for EF-P-2B room. The maximum temperature recorded during the test is 111.8°F at MS-V-4B area (the EF-P-1 ceiling area temperature of 119.1°F is not considered in the temperature evaluation since no equipment of concern or personnel are in this area). The ventilation test sequence is shown in Table 1 and test data are given in Table 2. The test data correlates with the analytical model data in profile shape after the first 15 to 20 minutes into the transient. The initial ramp and the absolute magnitude of the temperature on the flat portion of the profile differ to some extent.

The temperature evaluation concludes that the test data represents the actual temperature response for the Emergency Feedwater pump area. Because of the simplistic approach used in the analytical model, the initial ramp in air temperature is steeper than the actual temperature rise. Conservatively estimating the area heat load has resulted in the absolute magnitude of the profile being unrealistic. The evaluation also concludes that the EFW area is not affected by outdoor ambient temperature due to its location in respect to the outside, and that the room peak temperature is not a function of the initial starting temperature but affects the amount of time it takes to reach the peak temperature.

The evaluation concludes that the stabilized area temperature has been reached within the test period. The peak temperatures at the end of the test period are 108.7°F for EF-P-2B area, 102.6°F for EF-P-2A and 102.8°F for EF-P-1 area and 111.8°F for MS-V-4B area. Since the test was conducted under more stringent conditions (the plant was in normal [100% power] operation, three EFW pumps were in operation and one instrument air compressor was in operation), the room temperature under Appendix R shutdown condition is expected to be lower than the test condition. The expected room temperature profile, based on the test data, is shown in Figure 2. The maximum temperature in the area of required equipment is expected to be 113°F during the 72 hour time period.

2.3 EVALUATION

The emergency feedwater pump room is one room which is subdivided by missile barriers into four rooms: the two instrument air equipment rooms, motor driven EF pump room (IB-FZ-3), and turbine driven EF pump room (IB-FZ-2). Two of these rooms have specific components important to the operation of the safe shutdown systems described above, which have maximum temperature limits. The expected maximum temperature due to failure of AH-E-24A and AH-E-24B will also vary between these rooms.

A. Instrument Air Equipment Rooms (Part of IB-FZ-3)

The instrument air equipment rooms contain the AH-E-24A/B Air Handling Units, instrument air compressors IA-P-1A&B, backup instrument air compressor IA-P-2A and associated air receivers. The equipment located in these two rooms is not required for Appendix "R" safe shutdown because of the two hour backup instrument air bottles and local air bottles provided at the specific shutdown components and exemption requests previously granted by NRC for manual actions. Instrument air is not protected from fire damage and is assumed to be lost for most fire scenarios and no credit is taken for the availability of instrument air for shutdown. Normal back-up instrument air is not classified as a shutdown system.

B. Motor Driven Emergency Feedwater Pump Room (IB-FZ-3)

The emergency feedwater pump room is sectioned off into two cubicles. One cubicle houses EF-P-2A along with EFW valves EF-V-30A&C, EF-V-2A/B, and flow transmitters FT779 and FT788. The second cubicle houses EF-P-2B along with EF-V-30B&D, and flow transmitters FT782 and FT791.

The Emergency Feedwater System is required for safe shutdown in the event of a fire to remove heat from the primary system.

The EFW pump motors are rated for full load operation at 122°F ambient temperature. The EFW valves have a maximum design temperature limitation of at least 150°F. The flow transmitters are suitable for continuous operation at 250°F.

All Appendix R shutdown components are designed and rated to operate in an ambient temperature in excess of the maximum expected temperature of 113°F for the EF pump compartment and therefore will not be affected by loss of ventilation to the area.

Emergency feedwater flow control valves may be required to be manually operated in this compartment within twenty (20) minutes following certain Appendix "R" events. Since manual operation is a potential requirement during a loss of ventilation in this area, personnel effectiveness in performing these actions in elevated temperatures has been considered. The maximum temperature in the vicinity of the EF-V-30 valves is 106°F. Therefore, in the event manual operation of the EF-V-30 valves is necessary, TMI-1 Administrative Procedure 1501-ADM-1100.05, "Heat Stress Control," recommends work times for shorter operator exposures. During periods where the valves do not need to be manipulated, personnel can remain in the hallway where temperatures are lower. These stay times plus the time required to reach the stated temperature following loss of HVAC are well into the event, and qualified relief personnel are available to supplement TMI-1 manning capabilities during an emergency, if required.

C. Turbine Driven Emergency Feed Pump Room (IB-FZ-2)

This room houses the turbine driven emergency feed pump EF-P-1, and the main steam valves (MS-V-2A/B, MS-V-8A/B, MS-V-10A/B, MS-V-6, MS-V-4A/B, and AS-V-4).

The turbine driven EFW pump has a temperature rating of 115°F for continuous operation. All main steam valves except MS-V-10A/10B are rated for operation of at least 150°F. Valves MS-V-2A/2B, MS-V-4A/4B and MS-V-10A/10B can be manually operated as allowed by previous exemptions granted. Therefore, the loss of ventilation in this area has no impact on the operability of these valves.

Therefore, the safe shutdown components which are required to operate are rated for operation at an ambient temperature higher than the expected maximum temperature of 113°F, or are not impacted by the loss of ventilation.

The maximum temperature in IB-FZ-2 where manual operation of these valves may be required is 113°F. TMI-1 Administrative Procedure 1501-ADM-1100.05, "Heat Stress Control," recommends work times for shorter operator exposures. During periods where these valves need not be operated personnel can remain in the hallway where temperatures are lower. These stay times plus the time required to reach stated temperature following loss of HVAC are well into the event, and qualified relief personnel are available to supplement TMI-1 manning capabilities during an emergency, if required.

2.4 CONCLUSION

It has been determined by a rigorous evaluation of test data that the temperature rise in the Emergency Feedwater pump room will not exceed equipment design limits and is acceptably low for personnel occupancy. Each Appendix R required system in the Emergency Feedwater pump room has been reviewed for sensitivity to elevated temperatures and found to have appropriate ratings for the intended service. The loss of AH-E-24A and AH-E-24B will not challenge these ratings because the temperature limits will not be exceeded in the vicinity of Appendix R safe shutdown components for the Appendix R event. Therefore, the IB ventilation system is not required for safe shutdown under an Appendix R event and the roving fire watch in those areas in support of the IB ventilation concern is no longer required.

TABLE 1

INTERMEDIATE BUILDING VENTILATION TEST SEQUENCE

Date

9/22/87 o Ten point thermocouple reader installed with thermocouple locations as specified in STP-1-87-0039

o Data collection initiated 1600 hours for pretest information-ventilation system on

9/23/87 o 0830 - started EF-P-1 in recirculation mode

0836 - started EF-P-2A in recirculation mode

0838 - started EF-P-2B in recirculation mode

0840 - o secured AH-E-24A ventilation system

o initiated data collection every 5 minutes

1035 - stopped 5 minute data collection - continued hourly reading up to 1245 hours.

1040 - started AHE-24A - ventilation system

1041 - secured EF-P-1

1042 - secured EF-P-2A/B

TABLE 2 (SHEET 1 OF 2)

INTERMEDIATE BUILDING VENTILATION TEST DATA

Temperature (°F)

Time/ Location	EF-V-30A AREA	EF-V-30B AREA	EF-P-2B AREA	EF-P-2A AREA	OPERATING AIR COMP. AREA	MS-V-4B AREA	EF-P-1 AREA	EF-P-1 CEILING AREA	EF-P-2A CEILING AREA	HALLWAY T/C	OUTSIDE AMBIENT pt. 92
9/22/87											
1600	82.5	88.5	88.7	82.1	87.7	96.9	96.0	99.0	86.8	91.8	56
1700	88.7	88.7	88.9	88.2	88.1	96.1	93.8	99.4	87.5	91.8	62
1800	82.6	88.7	89	82.2	87.7	96.7	95.9	100.4	86.6	91.8	63
1900	82.7	88.9	83.6	82.4	87.8	96.6	96.2	101.1	87.2	91.8	62.5
2200	82.6	88.7	88.9	82	87.8	96.8	95.7	100	87.1	91.9	61.2
9/23/87											
0200	82.5	88.3	88.5	81.9	87.6	96.2	95.4	99.0	86.9	91.7	59.4
0600	81.9	88.0	88.3	81.5	87.7	96.1	95.6	99.0	86.2	91.5	59.4
0830-0838 PUMPS STARTED											
0835	84.4	90.0	90.0	85.3	89.1	100.5	94.8	109.7	87.7	91.5	60.2
HVAC SECURED											
0840	89.8	94.5	93.2	91.1	92.5	105.9	95.5	113.7	91.2	91.8	60.1
0845	91.8	97.0	95.0	92.8	93.7	106.4	96.3	114.3	92.9	91.9	60.5
0850	93.2	99.2	96.9	94.4	94.5	107.3	97.3	115.8	94.7	92.0	60.5
0855	94.2	99.5	97.7	95.4	95.5	108.[illegible]	96.7	115.1	96.1	92.2	60.2
0900	94.7	101.1	99.0	96.2	96.2	108.1	97.5	116.2	96.5	92.3	60.7
0905	95.7	102.2	100.0	97.1	96.1	108.6	96.7	116.[illegible]	97.5	92.6	60.6
0910	96.1	102.3	101.0	97.8	96.6	109.3	97.6	117.0	98.1	92.8	60.8
0915	96.6	102.6	102.1	98.6	96.8	109.3	98.9	117.3	98.6	93.1	60.8
0920	97.7	103.9	102.9	99.0	97.6	109.6	99.1	117.4	99.4	93.4	60.8
0925	97.9	104.1	103.4	99.5	97.8	110.3	100.0	117.2	99.7	93.6	60.8
0930	97.8	103.6	103.6	99.9	98.6	110.1	99.5	117.6	100.0	93.6	60.8
0935	98.4	105.3	105.1	100.1	98.4	110.3	98.3	117.5	100.5	93.9	61.0

TABLE 2 (SHEET 2 OF 2)

INTERMEDIATE BULDING VENTILATION TEST DATA (CONT'D.)

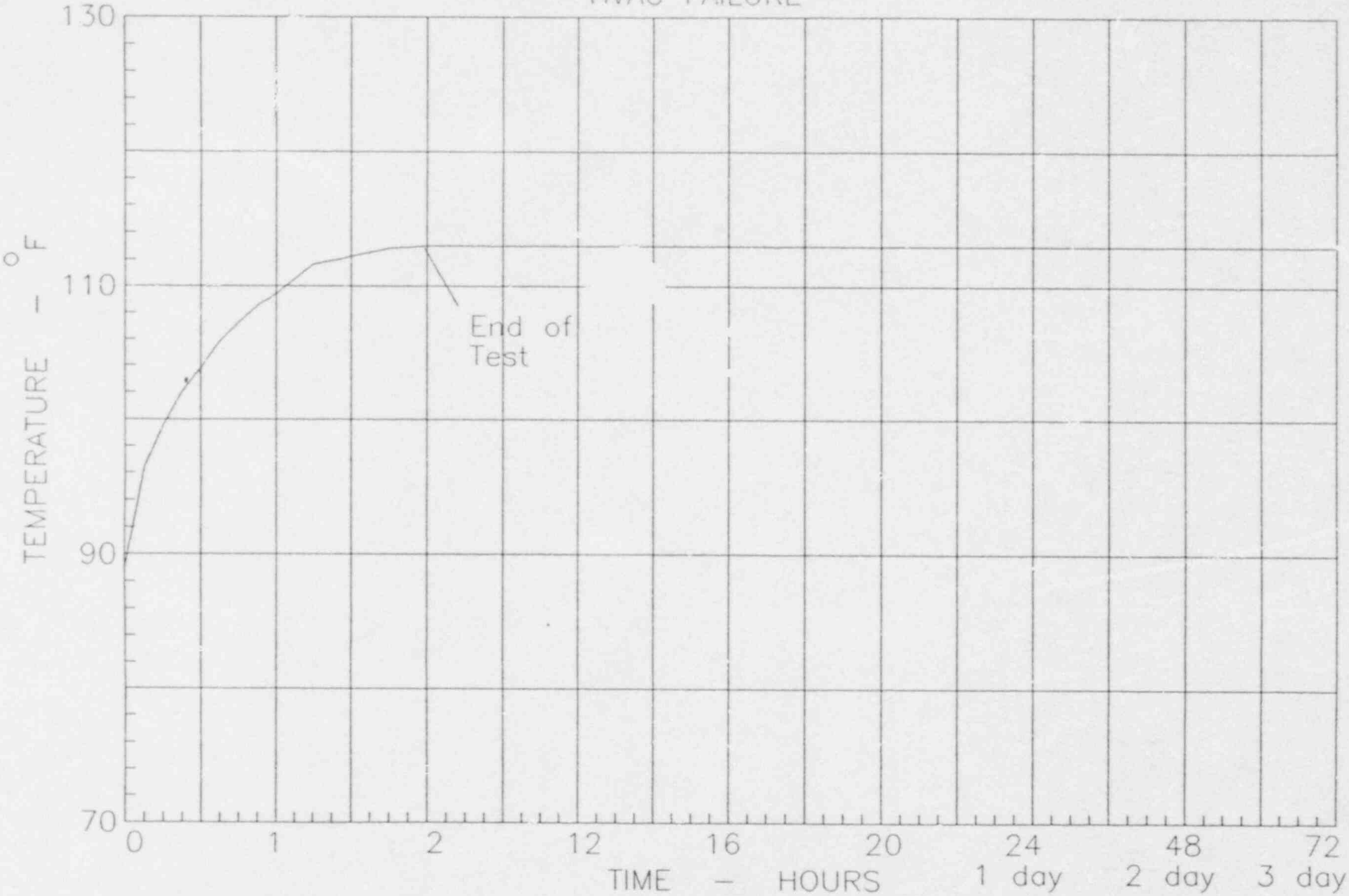
Temperature (°F)

Time/ Location	EF-V-30A AREA	EF-V-30B AREA	EF-P-2B AREA	EF-P-2A AREA	OPERATING AIR COMP. AREA	MS-V-4B AREA	EF-P-1 AREA	EF-P-1 CEILING AREA	EF-P-2A CEILING AREA	HALLWAY T/C	OUTSIDE AMBIENT pt.92
0940	98.4	104.9	106.1	100.4	98.3	110.4	98.6	118.3	100.7	94.0	61.1
0945	98.9	104.9	106.1	101.0	99.2	110.3	98.5	117.8	101.2	94.0	61.1
0950	99.2	105.1	105.5	101.0	99.5	110.6	99.0	117.6	101.3	94.2	61.2
0955	99.5	105.0	106.6	101.2	99.8	110.5	98.6	118.5	101.6	94.3	61.5
1000	99.7	105.3	106.2	101.5	99.7	110.8	98.6	118.3	102.2	94.5	61.7
1005	99.8	105.4	107.5	101.7	100.1	111.0	99.0	118.3	101.9	94.6	61.7
1015	100.5	105.0	108.0	102.5	100.4	111.3	98.9	119.0	102.3	94.8	62.0
1020	100.6	105.9	107.9	102.2	100.6	111.5	99.2	118.8	102.5	94.8	62.0
1025	100.7	105.3	108.2	102.3	100.4	111.2	98.7	119.0	102.7	94.9	62.4
1030	101.1	105.5	108.7	102.3	100.9	111.0	99.7	119.1	102.9	95.1	62.6
1035	101.1	105.3	107.6	102.6	100.7	111.8	101.0	119.1	102.9	95.1	62.5
1045	88.7	92	92.8	86.4	91.6	101.2	102.8	104.7	88.6	93.2	62.8
1145	85.4	89.8	90.1	83.5	89.5	98.3	98.6	101.3	86.2	92.4	64.2
1245	84.1	89.0	89.7	82.6	88.3	96.9	98.1	99.8	85.7	92.1	65.5

FIGURE 2

TMI-1 EMERGENCY FEEDWATER PUMP AREA - TEMPERATURES

HVAC FAILURE



3.0 DIESEL GENERATOR BUILDING

3.1 APPENDIX R REQUIREMENT

The Appendix R components which are affected by the loss of ventilation unit AH-E-29A or 29B for the Diesel Generator Building are the Diesel Generator A, Diesel Generator B, the Instrument Air System and the Two Hour Backup Instrument Air System (2HBUIA). One diesel generator is required for shutdown during loss of off-site power (LOOP) condition. 2HBUIA is required for operation of the control valves MS-V-6, MS-V-4A/4B and EF-V-30A/30B/30C/30D. No credit is taken for the availability of Instrument Air for shutdown. The fire areas where the air handling unit may fail due to fire damage, coincident with the diesel generator operation are CB-FA-1, CB-FA-2d, CB-FA-2f, CB-FA-3d, CB-FA-4b, IB-FZ-3, IB-FZ-5, and DG-FA-2.

3.2 TEMPERATURE EVALUATION

The analytical computation produces overly conservative room temperatures even though the effect of direct radiant heat transfer and the heat absorbing mass are factored into the calculation. The resulting maximum temperature at the end of a two hour period (calculation was made for two hours) is 158°F.

The ventilation test was performed for both "A" and "B" diesel generator rooms. Ten thermocouples (Table 3) were installed throughout the diesel generator rooms in each test. The diesel generator was started and fully loaded to 3 MW during the test. The test duration was two hours for both tests with temperatures being recorded every fifteen minutes.

The test data shows a moderate temperature rise (Tables 4 and 5). The maximum average temperature does not exceed 115°F during the test. The test data does not correlate with the analytical model in absolute magnitude. The two major factors for the differences between the analytical results and the test data are the introduction of cooling air drawn into the diesel generator room during the test by the diesel engine radiator fan and the differences in outdoor ambient temperature. These factors were conservatively omitted from the analytical model.

The operation of the diesel engine radiator fan creates a negative pressure in the DG room, resulting in cooling air being drawn in from the surrounding areas including outside air. Hence the test room temperatures are much lower when compared to analytical results where no cooling air was assumed. Ambient outdoor temperature will have an effect on the absolute temperature of the diesel generator room. Since the DG ventilation does not employ mechanical cooling, the normal DG indoor temperature depends on the temperature of the outdoor air which is used as a cooling medium. The test initial room temperatures as well as the final test temperatures are a function of test-day outdoor ambient temperature. The temperature evaluation concludes that the test temperatures, when adjusted to account for the temperature difference between the test-day and the design-day ambient outdoor temperatures, depict the worst indoor temperatures expected at the diesel generator building during loss of ventilation.

The average test temperatures are calculated by using the temperature reading of the thermocouples 2, 3, 5, 6, 7, 8, and 9 (Table 3). Thermocouples at locations 0 and 1 are not included because equipment of specific interest are not located there. Thermocouple 4 is for a separate room where the diesel generator control panel is located. The 95°F design-day 24 hour profile varies from a low of 81°F to a high of 95°F. A best fit of analysis results to actual test data was performed (Figures 3A and 3B) and the analysis then extrapolated to provide the expected room profile over a 72 hour time period (Figures 3C and 3D). The final diesel generator Room A temperature at 72 hours after the loss of ventilation is expected to be 123°F. The final diesel generator Room B temperature at 72 hours after loss of ventilation is expected to be 140°F. The DG ventilation system is designed to maintain a maximum ambient temperature of 120°F.

3.3 EVALUATION

The DG Building is comprised of two independent diesel generator rooms which are each subdivided into three rooms. Each of these rooms has specific components important to the operation of the safe shutdown system. The maximum temperature expected in each room is evaluated against the maximum temperature limits that the equipment can operate safely.

a. Diesel Engine Radiator Room

The radiator room contains an air-cooled radiator and engine driven fan. The jacket coolant system is conservatively designed to dissipate the heat rejected by the engine water jacket and lube oil at rated load and at ambient temperature up to 105°F. During Appendix R shutdown the diesel generator will be operating at significantly less than rated load.

The air flow induced by the radiator fan is primarily from the outside through large ventilation openings. Some air is also drawn through openings to the diesel engine room. The air flow from the engine room is also through a 17" x 18" damper in the radiator housing itself and is introduced after the radiator cooling core. Therefore it does not affect the cooling air temperature which approximates the outdoor air ambient temperature.

Existing operating procedures require that the engine parameters be monitored during the diesel generator operation. The engine jacket coolant and lube oil temperature gauges will be monitored to ensure the engine is adequately cooled.

b. Electrical Equipment Room

This room houses a control and relay cabinet for the generator. The relays installed in the cabinet are designed in accordance with IEEE 313-1971 to withstand a 131°F ambient temperature of the air immediately surrounding the relay cases. Other electrical apparatus in the cabinet also have an ambient temperature rating of at least 131°F. This cabinet is force ventilated with ambient air.

The temperature evaluation concludes that the air temperature of this room is not affected by the DG unit heat rejection and therefore will approximate the outside air ambient temperature (95°F maximum), since the heat load rejected from the cabinet is insignificant (based on Thermocouple No. 4).

Since the 95°F maximum cooling air temperature is the same as the normal plant design basis, it is concluded that the loss of DG ventilation will have no detrimental effect on the operation of the electrical cabinet.

c. Diesel Engine Generator Room

The engine room contains the engine, fuel system, air starting system generator, exciter and voltage regulator. In addition, the DG-B engine room houses the normal and two hour backup instrument air system. The Appendix R shutdown system components located in the DG room are determined to be operable at least to 120°F. The diesel manufacturer has provided information that the diesel will operate acceptably at 120°F. During diesel engine operation under the loss of diesel generator ventilation condition, the maximum expected temperature (on a 95°F design day) is 123°F for Room A and 140°F for Room B, as discussed above. Airflow to the A generator room is through leakage around door and through openings in the wall. Additional outside air is introduced through the normal ventilation ductwork. Air exits the room through the 17" x 18" damper to the radiator fan and the dampered opening in the wall. During the loss of ventilation test, significant airflow was observed. Opening of doors D-106 and D-107 within one hour after loss of ventilation is considered sufficient to limit diesel generator Room A temperatures to below 120°F after 72 hours.

Computer modeling of the "A" diesel using actual test data indicated that the temperature in the engine room would reach 123°F. This occurs even without opening the doors which would allow significant amounts of outside air into the control panel room and then into the diesel engine room. Based on the flow rate and heat load estimated in the computer model, an increase in airflow by approximately 8% would be required to achieve the 120° figure. Again by estimation, the opening of the door increases the open area (21 sq. ft.) into the engine room by approximately 140%. By engineering judgment the increase in the open area is enough to reduce the resistance to airflow through this path to allow the required quantity of outside air to enter the engine.

A more restrictive airflow path exists for the B generator room resulting in the higher final expected temperature. Airflow is from the Service Building through the normal ventilation ductwork and then through the 17" x 18" damper to the radiator fan and the dampered opening in the wall. Opening the Service Building roll-up door and doors SB-157 and D-101 removes the restrictions to airflow and allows the radiator fan to provide considerable airflow which is considered sufficient to limit diesel generator Room B temperature to below 120°F after 72 hours.

The negative pressure created by the operation of the radiator fan induces outside air to flow through the openings (140 $ft.^2$ free area) in the west wall. With the opening of the doors noted above, a parallel path to that of the normal outside air path is established. It is reasonably estimated, given the free area of the openings and the rated radiator fan flow rate (173,000 cfm), that a negative pressure of approximately 0.1 inch water gauge would be developed in the diesel engine radiator room. A higher pressure differential exists across the 18" by 17" dampered opening since it would be exposed to the - 0.1" w.g. plus the additional negative pressure caused by the radiator core itself.

Since the pressure drops across the parallel paths of flow must be equal, the expected air quantities through each path can be estimated. Doing this for the "B" diesel results in an expected flow rate of approximately 25,000 cfm through the diesel engine generator room.

The analysis performed on the "B" diesel provided a reasonable correlation between the test data and analysis. From the heat load used in the analysis, a flow rate of approximately 20,000 cfm is required to limit the diesel engine generator room to 120°F when 95°F air is introduced. Since the air flow through the generator room induced by the operation of the radiator fan is greater than the flow required, a temperature of 120°F should not be exceeded as long as the doors are opened. The expected room profile is shown in Figure 3E.

Within an hour, plant operations personnel will open the above doors to induce additional air flow to the engine room. In conclusion, the system performance for the diesel engine generator units and two-hour backup instrument air system will not be adversely affected by the failure of DG ventilation system during Appendix R shutdown.

3.4 CONCLUSION

Based on the field test results, the temperature evaluation and component evaluation described above, it is concluded that DG building ventilation is not required to support operation of the diesel engine generator units during an Appendix R fire. Emergency fire procedures will specify actions to open the above doors within one hour to ensure that 120°F is not exceeded in the vicinity of Appendix R components. Therefore, the DG ventilation system is not required for safe shutdown under an Appendix R event and the roving fire watch in those areas in support of DG ventilation concern is not required.

TABLE 3

THERMOCOUPLE LOCATION

DIESEL GENERATOR "A" VENTILATION TEST

0	-	Ceiling above generator end
1	-	West wall, south side of D/G 1/2 way up wall
2	-	South wall, 3 ft. off floor, 15 ft. inside D/G room
3	-	D/G relay control box (next to generator)
4	-	D/G relay and DC panel - room east of D/G Room
5	-	Fuel oil Xfer pump stand
6	-	EMMSB - engine mounted motor starting box
7	-	Crank case pressure switches (NE end of engine block)
8	-	Handrail on step, north side of engine block
9	-	Handrail on step, south side of engine block

DIESEL GENERATOR "B" VENTILATION TEST

0	-	Ceiling above generator end
1	-	West wall, north side of D/G 1/2 way up wall
2	-	South wall, 3 ft. off floor, 15 ft. inside D/G room
3	-	D/G relay control box (next to generator)
4	-	D/G relay and DC panel - room east of D/G Room
5	-	Fuel oil Xfer pump stand
6	-	EMMSB - (engine mounted motor starting box)
7	-	Crank case pressure switches (NE end of engine block)
8	-	Handrail on step, north side of engine block
9	-	Handrail on step, south side of engine block

TABLE 4

"A" DIESEL GENERATOR VENTILATION TEST SUMMARY

Temperature (°F)

Time/ Location	0	1	2	3	4	5	6	7	8	9
0545	80.2	79.1	76.3	76.9	75.2	76.6	77.3	78.1	77.9	77.5
— DIESEL IA STARTED, HVAC SECURED										
0600	80.0	79.3	74.3	76.2	74.1	72.9	74.6	77.6	74.5	77.1
0615	89.6	87.7	78.3	79.9	76.7	78.8	82.0	82.6	79.6	82.0
0630	93.4	93.8	79.8	81.7	74.6	79.0	81.7	83.3	80.5	84.4
0645	96.1	97.1	80.7	81.4	73.9	80.7	82.5	86.1	81.3	85.1
0700	97.7	95.1	82.0	83.9	78.0	83.3	87.1	85.9	83.5	87.5
0715	99.3	100.2	82.0	84.5	76.1	83.4	87.3	88.3	84.2	88.2
0730	100.4	101.0	82.7	84.7	76.4	83.0	88.1	89.8	85.2	88.7
0745	100.7	103.0	85.4	82.2	76.1	84.1	87.5	91.3	85.6	90.6
0800	102.0	103.2	84.3	85.7	74.9	84.1	88.1	90.5	86.3	89.6
0809 - DIESEL STOPPED										

TABLE 5

"B" DIESEL GENERATOR VENTILATION TEST SUMMARY

Temperature (°F)

	0915	0955	1025	1055	1115	1130	1155	1200	1215	1230	1255	1300	1315	1330	1345
					1105 Diesel 1B started										1335 Diesel stopped.
0	92.4	92.5	92.2	92.5	98.5	109.3	116.8	117.4	123.2	125.4	125.9	127.1	127.6	128.4	116.3
1	91.4	91.9	91.9	91.4	96.5	105.6	112.8	114.9	119.6	120.4	121.4	123.4	123.8	124.8	112.5
2	86.8	87.3	87.1	85.6	87.5	92.3	96	97.3	99	100.8	101.4	101.5	102.1	103.0	97.0
3	86.9	87.5	87.6	85.1	89.6	95	98.6	100.6	102.7	104.3	105.1	106.3	105.4	106.1	97.7
4	81.0	80.9	80.9	81.0	81.1	80.5	81.2	80.8	81.1	81.3	81.0	81.4	81.1	81.8	82.2
5	86.3	86.5	86.3	85.5	89.3	92.3	95.2	96.6	98.5	98.4	100.6	99.1	100	98.0	94.2
6	88.6	89.9	88.7	86.8	92.3	99.3	100.5	103.1	104.2	104	107.2	109.9	111.1	109.9	99.5
7	89.7	90.6	90.0	88.9	93.8	98.6	101.6	103.6	104.7	106.4	107.1	110.5	108.9	107.2	105.8
8	89.8	89.9	89.8	88.2	94.6	101.5	105.9	108.4	111.3	113.2	113.4	114.5	115.8	113.2	106.4
9	89.5	89.8	89.2	87.0	90.9	101.8	105.3	106.2	107.8	110	113.1	114.9	113.3	111.8	104.4

FIGURE 3A
TMI-1 DIESEL GENERATOR ROOM A - TEMPERATURES
HVAC FAILURE TEST VS ANALYSIS

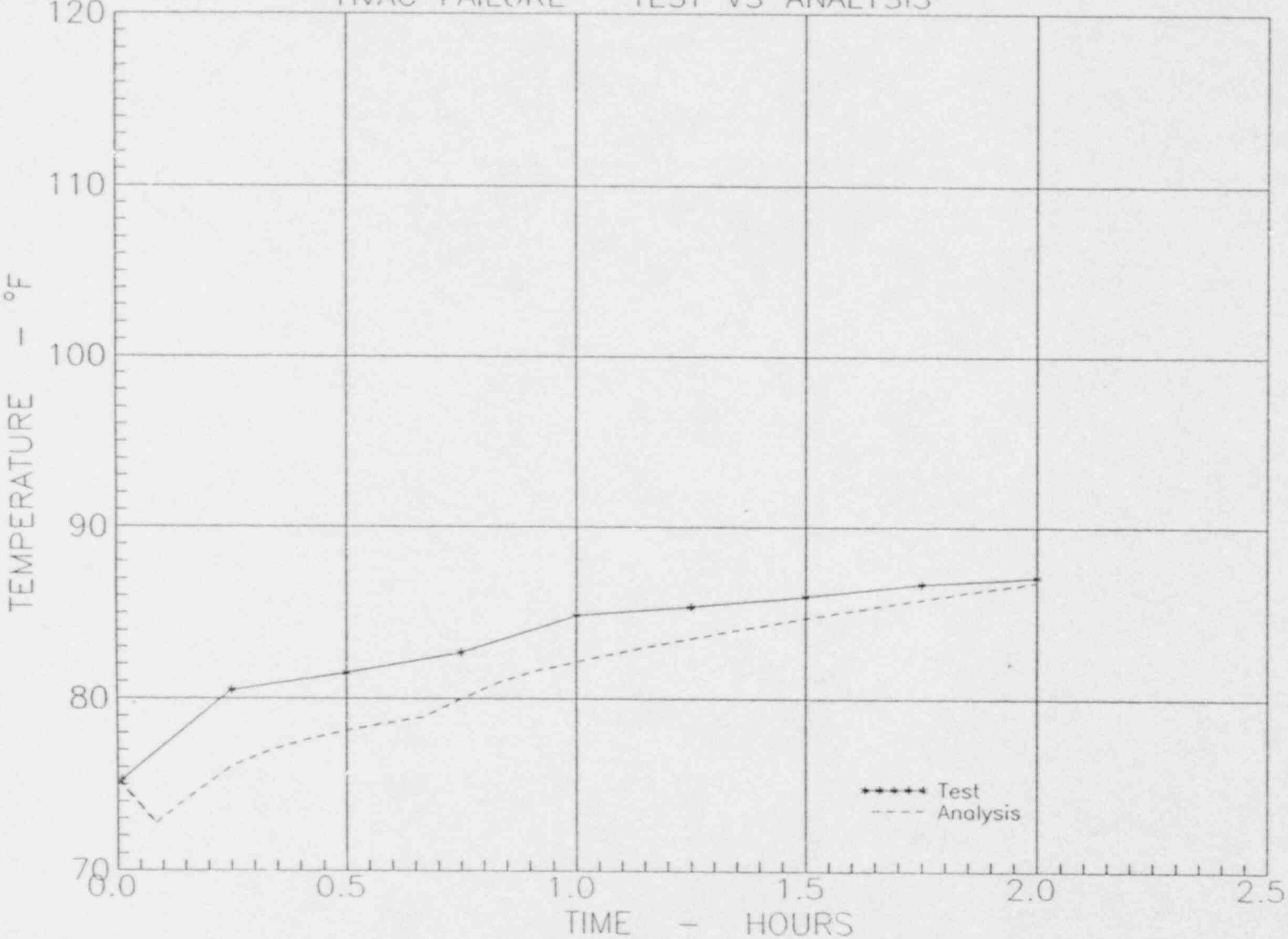


FIGURE 3B
TMI-1 DIESEL GENERATOR ROOM B - TEMPERATURES
HVAC FAILURE TEST VS ANALYSIS

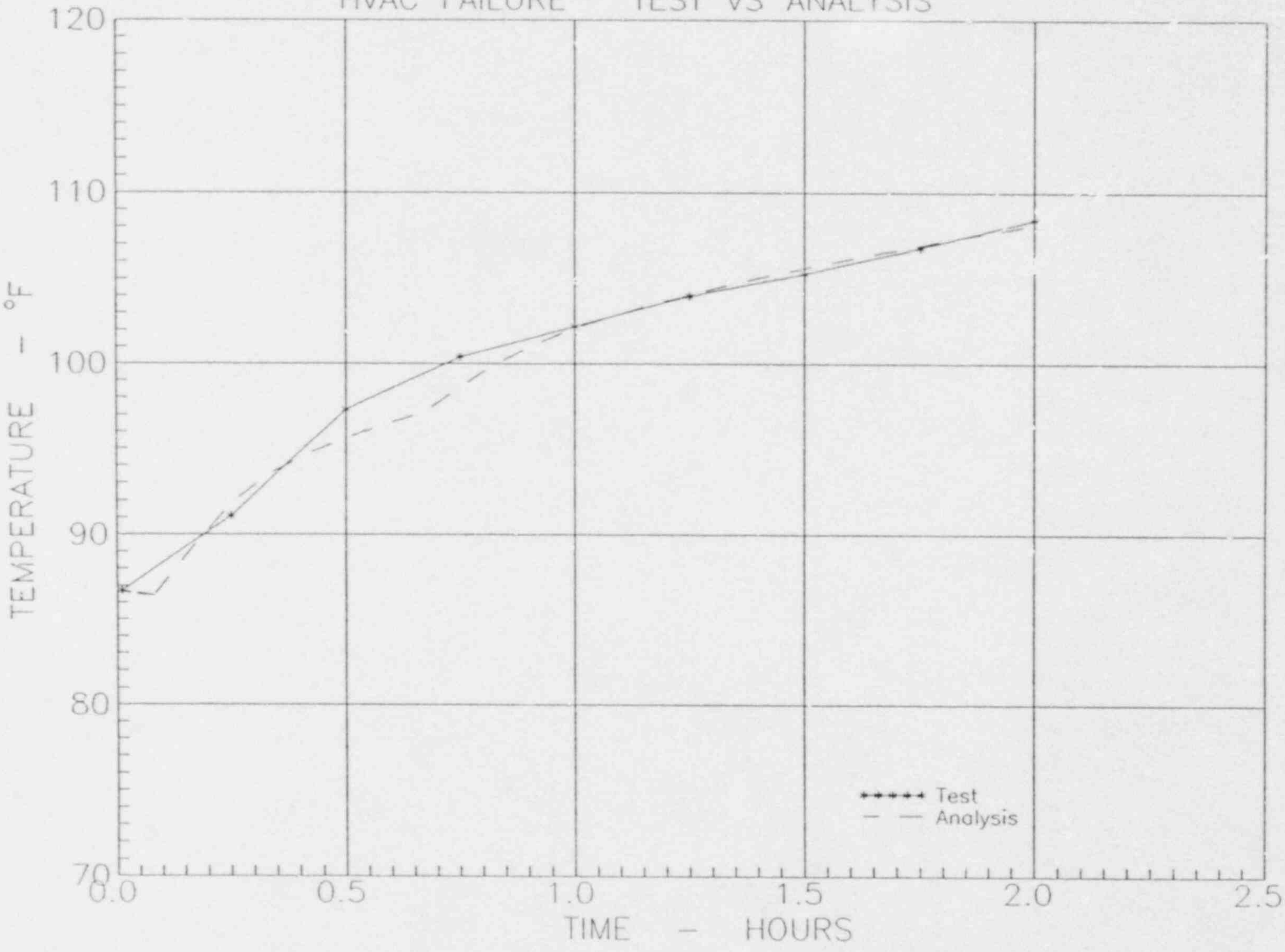
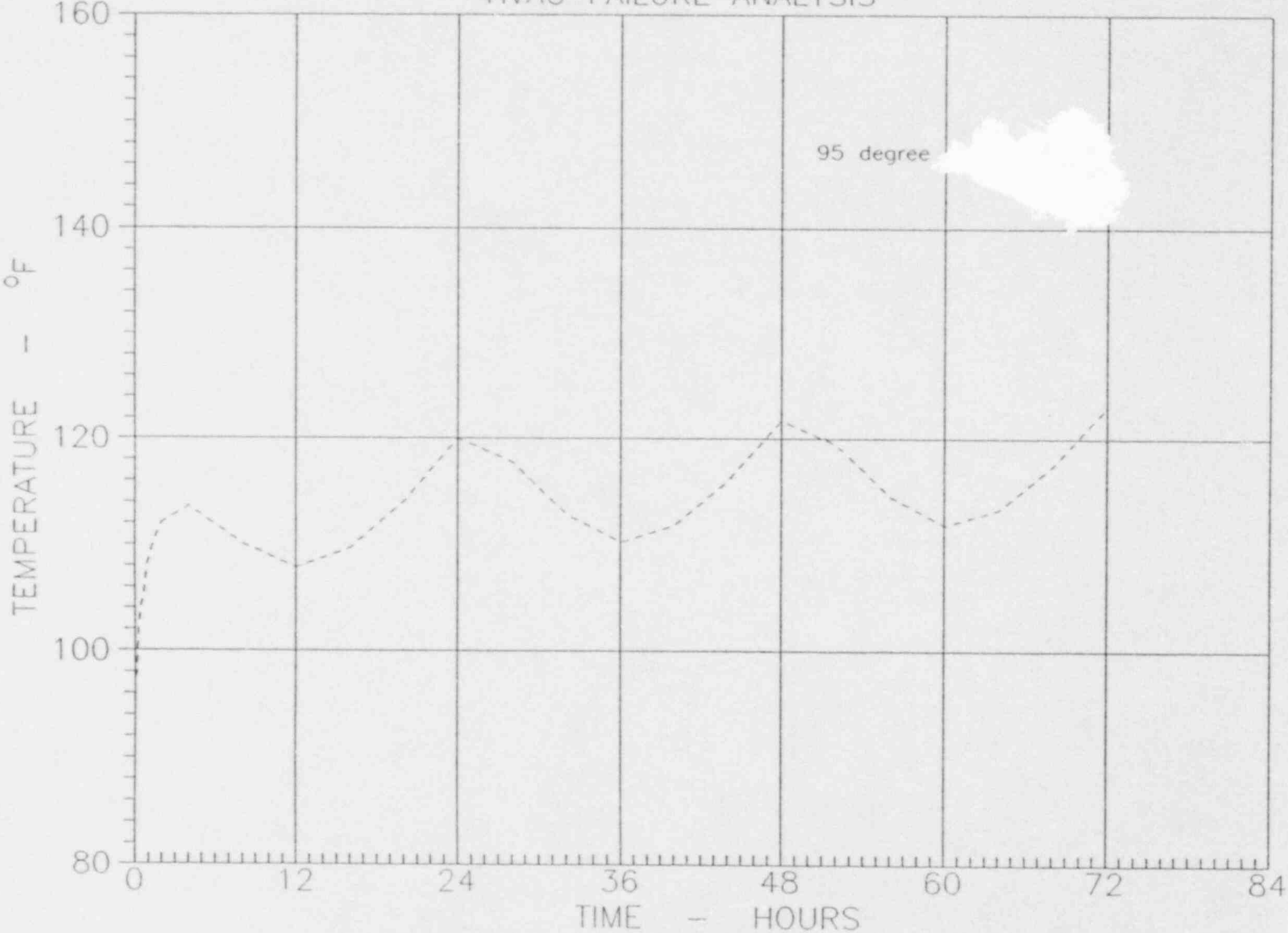


FIGURE 3C
TMI-1 DIESEL GENERATOR ROOM A — TEMPERATURES
HVAC FAILURE ANALYSIS



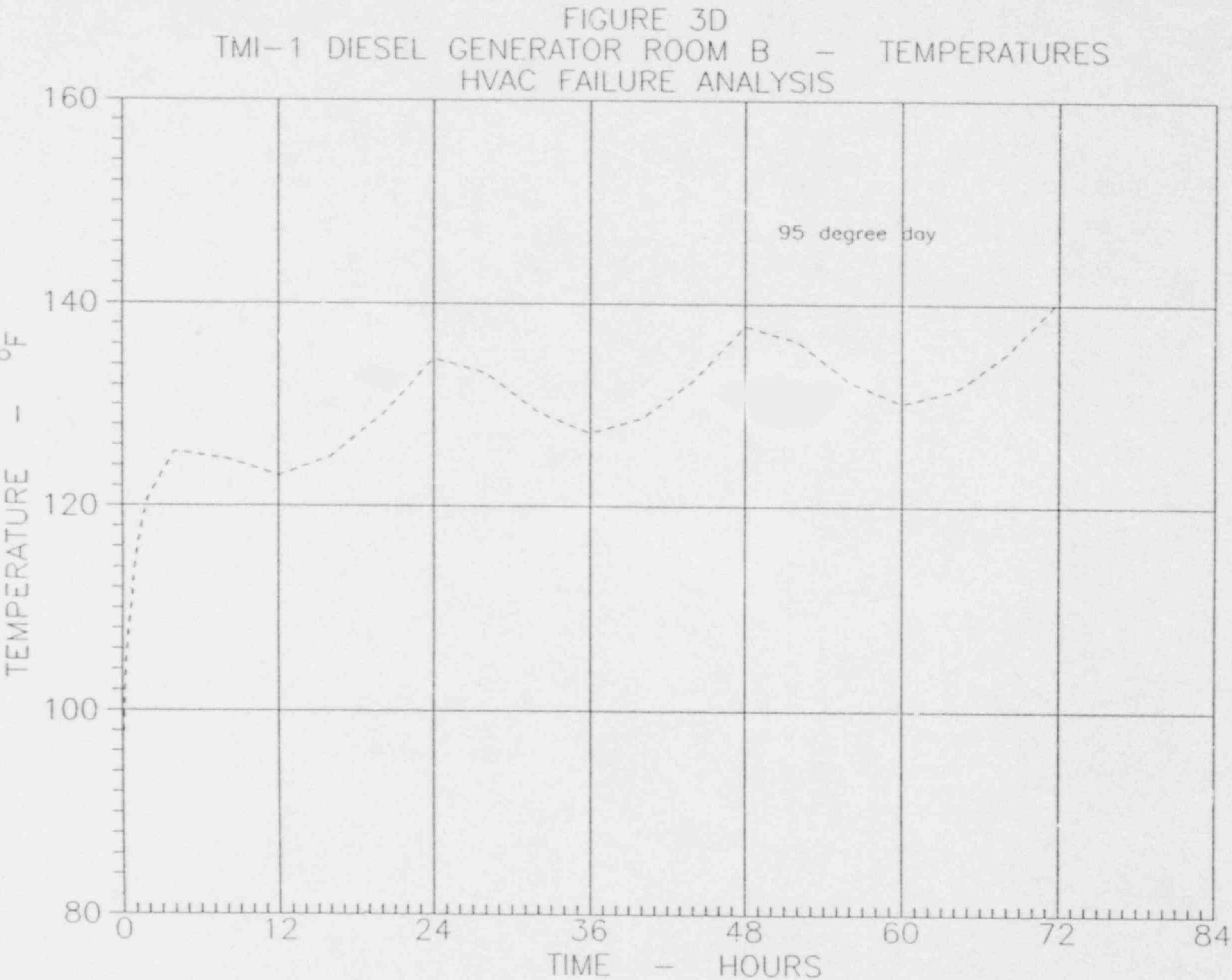
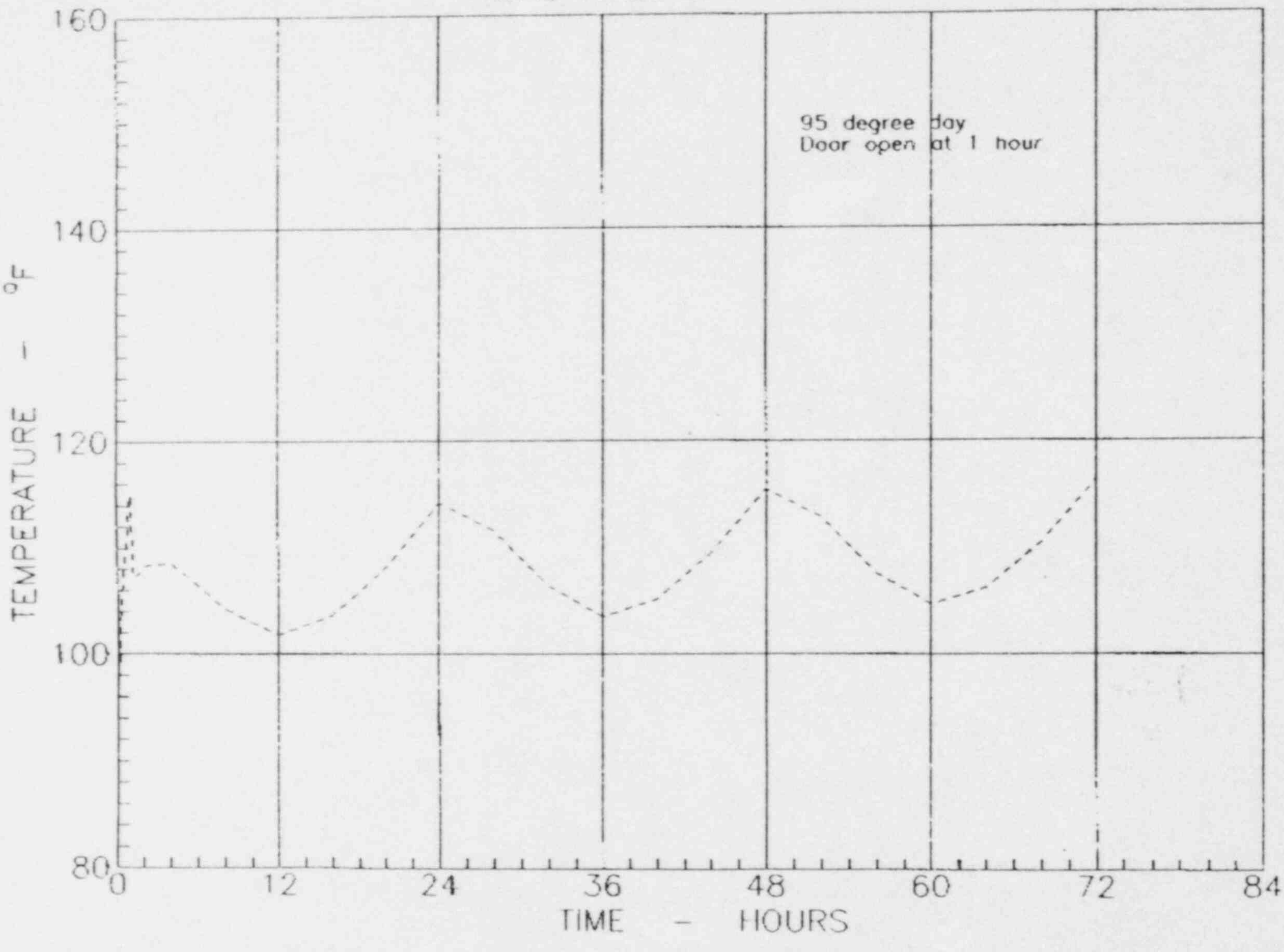


FIGURE 3D
TMI-1 DIESEL GENERATOR ROOM B - TEMPERATURES
HVAC FAILURE ANALYSIS
95 degree day
TEMPERATURE - °F
160
140
120
100
80
0
12
24
36
48
60
72
84
TIME - HOURS

FIGURE 3E
TMI-1 DIESEL GENERATOR ROOM B — TEMPERATURES
HVAC FAILURE ANALYSIS



4.0 CONTROL BUILDING VENTILATION

4.1 APPENDIX R REQUIREMENT

The Appendix R components which are affected by the loss of the control building ventilation are components of the instrumentation and control system and the plant class 1E electrical system. These components are listed in Table 6 below.

TABLE 6
CONTROL BUILDING SAFE SHUTDOWN EQUIPMENT

CB-FA-2a
1. EE-SGES-1P (480V SWGR)
2. EG-CCES-1A (480V Control Ctr.)

CB-FA-2b
1. EE-SGES-1S (480V SWGR)
2. EG-CCES-1B (480V Control Ctr.)
3. RS-TSP-B (Remote Shtd. Tran. Sw. Pnl.)

CB-FA-2c
1. EG-SEC-1C (480V Auto. Tran. Sw.)
2. EH-DP-1M (250/125V DC Dist. Pnl.)
3. RS-SCC-B (Rem. Shtd. Sig. Cond. Cab.)
4. RS-PA (Remote Shtd. Pnl.)
5. RS-PB (Remote Shtd. Pnl.)
6. RS-TSP-C (Remote Shtd. Tran. Sw. Pnl.)

CB-FA-2d
1. EG-DP-ATA (120V Reg. Dist. Pnl.)
2. EG-DP-ATB (120V Reg. Dist. Pnl.)
3. EG-DP-VBA (120V Vital Dist. Pnl.)
4. EG-DP-VBC (120V Vital Dist. Pnl.)
5. EH-INV-1A (Inverter)
6. EH-INV-1C (Inverter)
7. EH-INV-1E (Inverter)
8. EH-BC-1A (125V Bat. Chg.)
9. EH-BC-1C (125V Bat. Chg.)
10. EH-DP-1A (250/125V DC Dist. Pnl.)
11. EH-DPES-1E (DC Dist. Pnl.)

CB-FA-2e
1. EG-DP-VBB (120V Vital Dist. Pnl.)
2. EG-DP-VBD (120V Vital Dist. Pnl.)
3. EH-INV-1B (Inverter)
4. EH-INV-1D (Inverter)
5. EH-BC-1B (125V Bat. Chg.)
6. EH-BC-1D (125V Bat. Chg.)
7. EH-DP-1B (250/125V DC Dist. Pnl.)
8. EH-DPES-1F (DC Dist. Pnl.)

CB-FA-2f
1. Battery A
2. Battery C

CB-FA-2g
1. Battery B
2. Battery D

CB-FA-3a
1. ED-SGES-1D (4160V SWGR)

CB-FA-3b
1. ED-SGES-1E (4160V SWGR)

CB-FA-3c
1. ESAS Cabinets
2. RS-TSP-A (Remote Shtd. Tran. Sw. Pnl.)
3. RS-SCC-A (Rem. Shtd. Sig. Cond. Cab.)

CB-FA-3d
1. Relay Panels XCL
2. Relay Panels XCC
3. Relay Panels XCR
4. NNI/ICS Cabinets

The instrumentation and control system provides visual indication of process variables and input signals for automatic and manual control of the plant operation and shutdown. Instrumentation is needed for Appendix R shutdown to monitor source range flux, reactor coolant system (RCS) hot leg and cold leg temperature, RCS pressure, pressurizer level, steam generator pressure and level, and other diagnostic indication. The class 1E electrical system provides electrical power to all safe shutdown components. Either one of the two redundant class 1E power systems (designated as "A" train and "B" train) is needed for all shutdown scenarios.

The control building ventilation system employs two redundant trains of active air handling components. Each train can provide 100 percent of the air supply required during normal plant operation. However, a common air supply and return duct- work distributes the air from the conditioning equipment to rooms in all four floors of the control building and provides a return path. The ventilation duct system includes fire dampers and control dampers. The control dampers are operated by a dedicated CB instrument air system.

The CB ventilation system may fail due to fire damage to cables, duct work and active components. Table 7 shows area-by-area status of the CB ventilation failures.

As described in the following evaluation, upon loss of ventilation the temperature rise in the control building during Appendix R shutdown operation is enveloped by the specified equipment design limits except for CB-FA-2d and CB-FA-4b. In CB-FA-2d, where equipment design temperature limits could be exceeded, opening doorways provides preventive action to limit temperature rises to acceptable levels. In CB-FA-4b, where equipment design temperature limits could be exceeded, manual deenergizing of electrical lighting loads provides preventive action to limit temperature rises to acceptable levels.

4.2 TEMPERATURE EVALUATION

Twenty four thermometers (Table 8) were used to record temperature data for fourteen rooms during the ventilation test. The location of the thermometers was made in an attempt to achieve a representative sample of the space and to provide indication of particular component ambient temperatures. The test was terminated after 1.5 hours.

The CB test data (Table 9) differed from the computer analysis temperatures in ten (10) out of the fourteen (14) rooms. The main reason for the differences between the computer analysis and actual test data is the heat load estimates used in the analysis. A review of the heat loads of four rooms (CB-FA-2a, CB-FA-2b, CB-FA-2d, and CB-FA-2e) whose predicted temperature at 72 hours are above 104°F was made to evaluate the degree of conservatism that may be contained therein. Temperatures under 104°F are considered within equipment allowables and acceptable due to the conservative nature of the analysis. Steady state calculations for these rooms were performed utilizing initial test data, field measured flow rates (historical data), and as-built general arrangement drawings. The transient temperature computer analysis was also reperformed with the new "Q" loads provided by the steady-state calculation. As stated before, the computer reanalysis includes additional considerations for four rooms (CB-FA-2a, 2b, 2d, and 2e) to reduce excessive conservatism. The heat load imposed on the equipment mass and direct source to sink radiant heat transfer were factored into the model. Revised room temperature profiles were generated (see Figures 4 to 15).

A detailed comparison of the actual test temperature versus the predicted computer analysis temperature was made to determine the degree of correlation. The review indicates that the temperature difference (delta T) between the test temperature and the analysis temperature essentially remains constant (+1°F) after approximately twenty (20) minutes. This leads to the conclusion that the test room temperature profile can be considered to be "paralleling" the computer analysis room temperature profile. As an example, a graphical comparison of the recorded test temperatures and the analyses predicted room temperature profile for CB-FA-4b is shown in Figure 16. This graph demonstrates the relationship noted above. Differences are due to conservatisms in the analytical model. For this reason the temperature profiles given in Figures 4 thru 15 have been adjusted, where applicable, based on this correlation.

The temperature review also concludes that the outside air temperature is not considered to be a contributing factor in the result of the test. Initial ambient room temperatures up to 95°F were analyzed for in CB-FA-2a, CB-FA-2b, CB-FA-2d, and CB-FA-2e, and found acceptable for all cases. This analysis bounds all previously experienced ambient room temperatures. The higher initial ambient room starting temperatures cause a secondary effect in CB-FA-3a, CB-FA-3b and CB-FA-3d which result in slight changes to the maximum ambient temperature expected 72 hours after the loss of HVAC as follows: CB-FA-3a (+2°F), CB-FA-3b (+1°F), and CB-FA-3d (-2°F). These changes have been fully evaluated and remain within equipment design limits, and since the magnitude of the change is not significant, it is not graphically presented in the following discussion.

In conclusion, the temperature evaluation extrapolates the test data out to 72 hours by applying delta T to the computer analysis temperature profiles and provides the actual expected temperatures of various areas in the control building (see Figures 4 to 15).

4.3 EVALUATION

An evaluation was also performed to determine whether the electrical and electronic components located within the control building can be successfully operated without CB ventilation during Appendix R shutdown scenarios. This evaluation uses the maximum temperatures predicted by the temperature evaluation as baseline temperatures. The acceptability of the ambient room temperatures in each room is evaluated against the temperature limit of the electrical equipment located in that room.

Generally, all the electrical power and distribution components are designed for operation at ambient temperatures not exceeding 40°C (104°F) (see ANSI std.). However, the electrical components are allowed to operate under unusual conditions, if special considerations such as current derating factor and insulation correction factor are taken into account. They can be operated at higher ambient temperature without affecting the service life. The limiting factor is the hottest spot temperature (maximum ambient cooling air temperature + temperature rise of the equipment) which the equipment insulation can withstand without deterioration. The rated continuous current of the electrical equipment is based on the maximum permissible total hottest spot temperature limitations of the various parts of the equipment when it is carrying rated current at the usual maximum ambient of 40°C.

The total temperatures of these parts depend both on the actual load current and actual ambient temperature. It is, therefore, possible to operate the electrical equipment at a current higher than rated continuous current when the ambient temperature is less than 40°C provided the allowable total temperature limit is not exceeded. Similarly, the equipment can be operated at higher ambient temperature under reduced loading conditions by maintaining the total temperature under the allowable limit. Methods are available and guidances are provided by industrial standards (ANSI, IEEE, NEMA, ICPEA, and other national standards) for determining the loading under unusual conditions. The usual hottest spot temperature limitations for electrical distribution equipment are:

Part	Temp Rise θ_r above 40°C	Hottest Spot Total Temperature Limit θ_{max}.
Class 90 Insulation	50°C	90°C
Class 105 Insulation	65°C	105°C
Buses & Connections (Copper to Copper)	30°C	70°C
Buses & Connections (Silver to Silver)	65°C	105°C
Connections to Insulated Cable (Copper)	30°C	70°C
Connections to Insulated Cables (Silver)	45°C	85°C
External Surface Accessible to Operator	30°C	70°C

American National Standard C37.010 provides the following formula for calculating the allowable continuous load current that an electrical equipment can deliver at any ambient temperature.

$$I_a = I_r \left(\frac{\theta_{max} - \theta_a}{\theta_r} \right)^{1/1.8}$$

Where: I_a = Allowable continuous current at ambient temperature θ_a
I_r = Rated continuous current at ambient temperature of 40°C
θ_r = Standard temperature rise
θ_{max} = Standard hot spot total temperature

The evaluation: 1) addresses the effects of CB ventilation failure in terms of ambient temperature reached in each fire area/zone, 2) determines the allowable loading of the equipment in each fire area/zone if derating is required and, 3) evaluates the acceptability of the evaluated temperature for the operation of the shutdown components.

The discussion that follows lists the shutdown components located in the area, discusses the effect of a fire in the area, provides the elevated ambient temperature in case of loss of CB ventilation, and describes the condition under which the ventilation in the area under consideration can be lost.

A. CB-FA-1

This fire area has no active Appendix R shutdown equipment. The electrical cables which are required for operation of safe shutdown components located outside CB-FA-1 are routed through this fire area. The cables for the components which are needed for shutdown during a CB-FA-1 fire are protected from fire damage with one hour rated fire barrier wraps on the cable trays and conduits, or other means. Credit for normal occupancy of CB-FA-1 for non-ventilation issues remains applicable.

A fire in this area may lead to a failure of the CB ventilation system due to cable damage and loss of CB instrument air. CB ventilation to this room may also be lost for all other fire scenarios in the control tower due to closure of control damper AH-D-28. Since it contains no active shutdown equipment, the failure of CB ventilation has no effect on this fire area. The maximum ambient temperature which is expected upon the loss of CB ventilation in CB-FA-1 is 88°F.

This ambient temperature is acceptable for the use of electrical cables. The power and control cables are provided with high temperature insulation and flame retardant jacket, and are rated for 40°C with 50°C temperature rise. The ampacity of the safe shutdown power cables which are wrapped with a fire rated barrier have been derated for the fire wrap.

B. CB-FA-2a

This fire area houses 480 volt 1P unit substation, 480 volt 1A Engineered Safeguard Control centers and the relay and control cabinet for the RCS pressurizer heater group No. 8. These are train A electrical components. The 480 volt unit substation is a free standing power center with a high voltage section, a 1000/1333 kVA dry type transformer and 480 volt low voltage switchgear sections (Westinghouse type DB). The dry type power transformer is provided with fans for forced cooling. The control center is ITE series 9600 NEMA class 2 type B, totally enclosed motor control centers. The pressurizer heater control cabinet contains one control switch and three undervoltage relays.

CB ventilation to this room may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2d, CB-FA-2f and CB-FA-1. The failure of the CB ventilation will cause the ambient room temperature to rise gradually after an initial transient temperature rise. The maximum ambient temperature expected 72 hours after the loss of HVAC is 110°F (see Figure 4). Further analysis was performed up to 95°F, to bound all previously experienced higher ambient room temperatures in this area. The resulting maximum ambient temperature expected 72 hours after loss of HVAC in this case is 117°F (See Figure 4A).

The 480 volt switchgear is rated for operation at a maximum ambient air temperature of 40°C (104°F) outside the switchgear enclosure. The dry type power transformer rated (1200/1600A) is designed for an average temperature rise of 150°C over average ambient temperature of 30°C. The current rating of the motor control center is based on 50°C rise above enclosure ambient of 40°C. The 480 volt unit substation as a whole conforms to NEMA standard 210, "Secondary unit substation"; the switchgear section conform to ANSI C37.20 "Switchgear Assemblies"; the dry type transformer to ANSI C57.12.01 and C57.12.51 "dry type distribution and power transformers". The motor control center is designed in accordance with NEMA Standards ICS 1, 2, 3.

Using the lowest θ_r of 30°C and the ANSI formula given above, the allowable current at 110°F is calculated to be 93.6 percent (85.3 percent at 117°F) of the rated current for CB-FA-2a.

$$I_a = I_r \left(\frac{70 - 43.39}{30} \right)^{1/1.8} = I_r (0.887)^{1/1.8}$$

$$= 93.6\% \ I_r$$

The 480 volt bus bar and the main breakers and one feeder breakers for IA-ES control center are rated 1600 Amperes, the remaining feeder breakers are rated 600 amp. The allowable currents of the 480 volt switchgear at 110°F is 1497.6 A (1364.7A at 117°F); and that of a feeder is 561.6 A (511.8A at 117°F).

ANSI C57.96, Guide for Loading Dry-Type Distribution and Power Transformers, provides guidance for loading the transformer under higher ambient temperature. For this calculation an average ambient temperature is used. For each degree celsius that the average temperature of the cooling air is above the standard average temperature of 30°C, the transformer may be loaded 0.6 percent below its nameplate rating. Hence, for an average ambient temperature of 43.39°C and 47.44°C, the allowable transformer loading is 92 percent and 89.5 percent of the rating, respectively. This loading for normal life expectancy is 1104 amperes with natural cooling (1076A at 117°F).

The control center's temperature limitations are identical to switchgear limitations. The allowable continuous current that 1A ES control center can deliver at 110°F is 93.6 percent (85.3 percent at 117°F) of the rated current. The main incoming vertical bus and horizontal bus are rated 1200 amperes, and the vertical distribution feeder buses are rated 600 amperes. Therefore, the allowable loads are 1123 amperes on the main bus and 560 amperes (1023A main bus and 512A on vertical feeder bus at 117°F) on vertical feeder buses when operated at elevated temperatures.

The 480 volt 1P unit substation is normally loaded to approximately 1,367 amperes depending on the way the redundant loads are split between 480 volt 1P and 1S unit substations. During Appendix R shutdown using "A" train electrical power, the maximum Appendix R shutdown load of 643.4 amperes is expected on the 1P switchgear.. 1A-ES control center load is about 885.2 amperes under normal plant operating condition and is reduced to 249.8 amperes for Appendix R shutdown. The Appendix R loads on 1P unit substation and 1A-ES control centers are well below their allowable loads at 110°F to 117°F. 1P unit substation and 1A-ES control center can be safely operated at 110°F to 117°F without degrading the normal equipment life expectancy.

The protective relays in the pressurizer heater control cabinet are designed in accordance with ANSI standard C37.90, which stipulates that the relaying devices shall be suitable for operation at -20°C (-4°F) to +55°C (131°F) ambient air temperature around the relay case or other enclosures. Therefore, they are suitable for operation at 110°F to 117°F.

Therefore, it is concluded that the loss of CB ventilation system has no effect on the operability of electrical equipment in CB-FA-2a during Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

C. CB-FA-2b

This fire area houses 480 volt 1S unit substation, 480 volt 1B-ES control center, the remote shutdown transfer switch panel and the relay and control cabinet for pressurizer heater group No. 9. These are train "B" equipment and are identical to the equipment in CB-FA-2a.

Ventilation to this fire area may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2b, CB-FA-2a, CB-FA-2d, CB-FA-2f and CB-FA-1. This fire area will attain an expected maximum ambient temperature of 108°F at the end of a 72 hour period (see Figure 5). Further analysis was performed up to 95°F, to bound all previously experienced higher ambient room temperatures in this area. The resulting maximum ambient temperature expected 72 hours after loss of HVAC in this case is 113°F (See Figure 5A).

The allowable loadings of the electrical equipment in this fire area are essentially the same as that of CB-FA-2a.

Similar to CB-FA-2a, the electrical equipment is lightly loaded for Appendix R shutdown. The maximum Appendix R loads are 643.4 amperes on the 480 volt 1S switchgear, and 326.4 amperes on the 1B-ES control center. These are well below the allowable load currents of 1472 amps, and 1123 amps, respectively (1440A and 1080A at 113°F). The protective relays in the pressurizer heater control cabinet are suitable for operation up to 55°C (131°F) ambient air temperature around the relay case or other enclosures. Therefore, the resulting ambient temperature on the loss of CB ventilation has no effect on the operation of electrical equipment in CB-FA-2b.

However, the resulting ambient temperature is higher than the normal comfort temperature for human occupancy. CB-FA-2b must be entered to operate the remote shutdown transfer switch panel and to man 1S unit substation during Appendix R shutdown. The operator need not be stationed in CB-FA-2b. The TMI-1 Administrative Procedure 1501-ADM-1100.05, "Heat Stress Control," recommends work times for shorter exposures. This time is adequate to perform the desired actions in CB-FA-2b. In addition, this stay time plus the time required to reach stated temperature following loss of HVAC are well into the event, and qualified relief personnel are available to supplement TMI-1 manning capabilities during an emergency, if required.

The loss of ventilation to CB-FA-2b, therefore, has no effect on Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

D. CB-FA-2c

Safe shutdown electrical components located in CB-FA-2c are remote shutdown panels (RS-PA, RS-PB, and RS-PBX), signal conditioning cabinet B (RS-SCC-B), remote shutdown transfer switch C (RSTSP-C), automatic transfer switch 1C (EG-SEC-1C), automatic transfer switch for dc distribution panel 1M, and dc distribution panel 1M (EH-DP-1M).

Ventilation to this room may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2c, CB-FA-2d, CB-FA-2f and CB-FA-1. In the event of loss of ventilation, this area will reach an expected maximum temperature of 93°F at the end of 72 hours (See Figure 6).

Except for the transfer switch 1C and dc distribution panel 1M, there is no electrical power equipment. The remaining electrical panels and cabinets are for instrumentation and control. The electrical components included in these cabinets are relays, control switches, indicating instruments, and signal isolators.

The standard ambient temperature for relays (ANSI C37.90) and instruments (ANSI C39.1 and C39.2) are 55°C (131°F) and 50°C (122°F), respectively. Other components in cabinets are covered under switchboard (ANSI C37.20) and are rated for operation at 40°C.

The Foxboro signal conditioning cabinets are rated for operation at 104°F (Foxboro Product Specification PSS9-7A1A). The switchboard instruments and recorders are calibrated at 25°C. They are capable of indicating within their allowable accuracy when operated continuously at 50°C and are capable of sustaining an extreme temperature of 65°C (149°F).

Since the maximum ambient temperature in CB-FA-2c will not exceed the normal operating ambient temperature of 40°C, it is concluded that the electrical components in CB-FA-2c can be operated at the elevated temperature without affecting their performance. They will function properly within the specifications.

This room is occupied during Remote Shutdown operation. The maximum ambient temperature of 93°F is acceptable for human occupancy. The TMI-1 Administrative Procedure 1501-ADM-1100.5, "Heat Stress Control," recommends work times for shorter exposures.

The loss of ventilation to CB-FA-2c therefore, has no effect on Appendix R shutdown because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

E. CB-FA-2d

"A" train electrical components which are located in CB-FA-2d include inverters (EH-INV-1A, 1C, and 1E), battery chargers (EH-BC-1A and 1C), 120 volt vital ac distribution panels (EG-DP-VBA and VBC), 120 volt regulated ac distribution panels (EG-DP-ATA and ATB) and 125/250 volt dc distribution panel (EH-DP-1A and EH-DPES-1E). A non-automatic transfer switch for ICS/NNI power distribution panel ATA is also in this room. Most of these components are associated with the "A" train electrical system.

The ventilation to this fire area may be lost during a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2d, CB-FA-2e, CB-FA-2f and CB-FA-1. The ambient air temperature of this fire area is calculated to be 125°F at the end of a 72 hour period. Manual opening of the door between CB-FA-2d and CB-FA-2f within one hour after loss of ventilation would reduce this temperature to 113°F at the end of a 72 hour period (See Figure 7). This analysis assumed an initial ambient room temperature of 88°F which bounds previously experienced higher initial ambient room temperatures in this area.

The ANSI Standard C34.2 is written primarily around semiconductor power rectification equipment. However, the standard can be made applicable to semiconductor power inverters. The usual service ambient temperature is 40°C. However, the inverters at TMI Unit 1 are capable of continuous operation at 49°C (120°F) within their ratings (BM No. EH-4). The battery chargers at TMI-1 are also rated for operation at an ambient temperature of 50°C (BM No. EH-1). The panel boards and the ICS/NNI power supply transfer switch are suitable for operation at any ambient temperature condition, provided that the total temperature is limited to 70°C. The panel boards and the transfer switch can provide 75.8% of rated current at 125°F and 90% of rated current at 113°F, and are normally energized to less than 50% of their rated current.

Ambient temperature will be kept below 120°F by manually opening a door within one hour after loss of ventilation. The actual allowable time that can elapse before the above mentioned door is opened and the room temperature at 72 hours exceeds 120°F is 24 hours. TMI-1 Emergency Fire Procedures will identify this manual action. Therefore, it is concluded that the loss of ventilation to CB-FA-2d has no effect on Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature when the door identified above is manually opened within one hour after loss of ventilation.

F. CB-FA-2e

Similar to CB-FA-2d, CB-FA-2e houses two inverters (EH-INV-1B and 1D), two battery chargers (EH-BC-1B and 1D), 120 volt vital panels (EG-DP-VBB and VBD), and 125/250V dc panels (EH-DP-1B and EH-DPES-1F). These are "B" train equipment.

The ventilation to this room may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2d, CB-FA-2e, CB-FA-2f and CB-FA-1. The loss of ventilation results in an expected ambient temperature in this room of 114°F in 72 hours (See Figure 8). This analysis assumed an initial ambient room temperature of 85°F which bounds previously experienced higher initial ambient room temperatures in this area.

CB-FA-2e resulting maximum ambient temperature is lower than that of CB-FA-2d. The discussion given in CB-FA-2d also applies here. The inverters and battery chargers are operating within specified ambient temperature. The panel boards can provide 89% of their ratings at 114°F. Therefore, the loss of ventilation to CB-FA-2e has no effect on Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

G. CB-FA-2f

This area is specifically provided to house 125/250 volt batteries (station batteries A and C).

The ventilation to this fire area may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2d, CB-FA-2e, CB-FA-2f, CB-FA-2g and CB-FA-1. The loss of CB ventilation results in an expected ambient temperature of 88°F after 72 hours (See Figure 9). Manual opening of the door between CB-FA-2d and CB-FA-2f at one hour after loss of ventilation will raise this temperature to 96°F.

The standard temperature used in the rating of lead acid stationary batteries is 25°C (77°F). If the battery is operated at a higher than the standard temperature, the float current demand on the charger will be doubled for each increase of about 10°C (18°F). This can cause excessive wear on the plate and can shorten the battery service life expectancy, however battery cells can be replaced as necessary. Some increase in battery performance is also experienced as ambient temperature increases. The maximum temperature of 96°F (36°C) will not adversely affect the operation of the batteries. The duty imposed on the batteries during Appendix R shutdown is also much less than the normal duty. Released hydrogen gas during battery charging does not reach dangerous levels of concentration within the Appendix R shutdown duration.

Therefore, the loss of ventilation to CB-FA-2f has no effect on Appendix R shutdown, because all required electrical equipment can be safely operated at the maximum ambient temperature. No manual actions associated with loss of ventilation are required.

H. CB-FA-2g

This area also houses 125/250 volt batteries (station batteries B and D).

The ventilation in this area may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-2a, CB-FA-2b, CB-FA-2d, CB-FA-2e, CB-FA-2f, CB-FA-2g, and CB-FA-1. The expected maximum ambient air temperature will be 87°F at the end of 72 hour period with loss of CB ventilation (See Figure 10).

As discussed in CB-FA-2f above, this ambient temperature will not adversely affect the operation of the batteries. Therefore, loss of ventilation to CB-FA-2g has no effect on Appendix R shutdown because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. Released hydrogen gas during battery charging does not reach dangerous levels of concentration within the Appendix R shutdown duration. No manual actions associated with loss of ventilation are required.

I. CB-FA-3a

CB-FA-3a is a switchgear room housing the 4160 volt 1D switchgear ("A" train).

The ventilation to this fire area may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3a, CB-FA-3d, CB-FA-2d, CB-FA-2f, and CB-FA-1. The maximum expected ambient air temperature will be 95°F 72 hours after the loss of HVAC (see Figure 11).

4160 volt switchgear, conforming to ANSI standard C37.20, is suitable for operation at maximum external ambient temp. of 40°C (104°F). The standard temperature rises stated above are pertinent to this medium voltage switchgear and the same criteria for temperature adjustment can also be applied.

Since the ambient temperature is lower than the maximum ambient stipulated for the switchgear, no rating adjustment is necessary. Therefore, the loss of ventilation to CB-FA-3a has no effect on Appendix R shutdown, because the 4160 volt switchgear can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

J. CB-FA-3b

"B" train 4160 volt switchgear 1E is located in CB-FA-3b.

The ventilation to this room may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-3b, CB-FA-2d, CB-FA-2f and CB-FA-1. The area will reach an expected maximum ambient temperature of 94°F 72 hours after the loss of HVAC (See Figure 12).

Since the ambient temperature is lower than the maximum ambient stipulated for the switchgear, no rating adjustment is necessary. Similar to CB-FA-3a, the loss of ventilation to CB-FA-3b has no effect on Appendix R shutdown, because the 4160 volt switchgear can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

K. CB-FA-3c

Electrical components located in this fire area are signal conditioning cabinet A (RS-SCC-A), remote shutdown transfer switch panel (RS-TSP-A) and Engineered Safeguard Actuation System cabinets (bistable cabinets and relay cabinets).

The ventilation to this fire area my be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3d, CB-FA-3a, CB-FA-3b, CB-FA-3c, CB-FA-2d, CB-FA-2f and CB-FA-1. The maximum ambient temperature expected upon the loss of CB ventilation is 94°F after a 72 hour period (See Figure 13).

The ambient temperature for normal operation as stated in Foxboro Product specification PSS-9-7A1A is 104°F for the signal conditioning cabinet. The ESAS cabinets are suitable for operation at 55°C (131°F). The auxiliary relay and control switches contained in the RS-TSP-A are rated for operation at 55°C and 40°C respectively (see CB-FA-2c). Since the maximum expected ambient temperature is below the standard ambient temperature, no operational restraint is imposed on the equipment for the loss of CB ventilation. This room must be momentarily entered during Appendix R Remote Shutdown to operate the remote shutdown transfer switch. The temperature of 94°F is sufficiently low for such occupancy. TMI-1 Administrative Procedure 1501-ADM-1100.05, "Heat Stress Control," recommends work times for shorter exposures.

Therefore, the loss of ventilation to CB-FA-3c has no effect on Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature. No manual actions associated with loss of ventilation are required.

L. CB-FA-3d

CB-FA-3d is a relay room as well as cable spreading room. The Appendix R shutdown equipment located in this area includes auxiliary relay cabinets (XCL, XCC, XCR) and NNI/ICS cabinets.

The ventilation in this fire area may be lost for a fire in CB-FA-4b, CB-FA-4a, CB-FA-3a, CB-FA-3d, CB-FA-2d, CB-FA-2f and CB-FA-1. The maximum ambient temperature at the end of 72 hour period is calculated to be 101°F (See Figure 14).

NNI/ICS cabinets have signal conditioning equipment for some Appendix R safe shutdown loops. The cabinets are suitable for operation at an ambient temperature of 110°F (Bailey Product Instruction E10.1). The auxiliary relays in cabinets XCL, XCC, XCR are capable of operating at 55°C (131°F).

Since the expected ambient temperature is less than the allowable temperature limit for all required equipment, it is concluded that the loss of ventilation to CB-FA-3d will not effect Appendix R shutdown. No manual actions associated with loss of ventilation are required.

M. CB-FA-4a

This fire area does not contain Appendix R safe shutdown components. The ventilation in this room will be lost for a fire in CB-FA-4a, CB-FA-4b, CB-FA-3d, CB-FA-2d, CB-FA-2f, and CB-FA-1. The ambient air temperature will be 102°F maximum after a 72 hour period.

Since no shutdown equipment is located here, this ambient temperature has no bearing on the functional performance of safe shutdown equipment.

N. CB-FA-4b

The control room houses control consoles, indicating instrument panels and CB ventilation control panel.

The ventilation to this room will be lost for a fire in CB-FA-4b, CB-FA-3d, CB-FA-2d, CB-FA-2f, and CB-FA-1. This room may be evacuated during a fire in CB-FA-4b or CB-FA-3d. The ambient temperature in the control room can reach up to 110°F in 72 hours after the loss of CB ventilation (See Figure 15). Manually deenergizing one half of the normal control room lighting system at one hour would reduce the expected temperature to 102°F at 72 hours. Remaining lighting is protected and is adequate for safe shutdown operations.

The indicating instruments conforming to ANSI C.39.1 are capable of indicating freely when operated continuously at any temperature from-20°C (-4°F) to +50°C (122°F). The vendor specified normal operating ranges are:

Bailey Instruments	40°F to 140°F
Weston Instruments	23°F to 122°F
Westinghouse Instruments	0°F to 150°F

Relays and miscellaneous control devices are suitable for operation of at least 40°C. Operation at higher temperatures is also allowed provided that the allowable total temperature is not exceeded. These devices are mounted in the control switchboard which conforms to ANSI Standard C37.20. The usual service ambient temperature for the switchboard is -30°C to +40°C around the enclosure of the switchboard. The standard stipulates that the temperature of the air surrounding all devices within an enclosed assembly, considered in conjunction with their rating and loading as used, shall not cause these devices to operate outside their normal temperature range when the enclosure of the assembly is surrounded by air within an ambient temperature range of -30°C to +40°C. The air temperature inside the control switchboard assemblies will be higher than the surrounding air temperature. It may be about 5°C to 15°C above the outside ambient depending on the ventilation provided and on the location of the switchboard. There is no load reduction element involved with the control switchboard.

Heat load reduction (deenergizing one half of normal control room lighting) must be affected within one hour to keep the control room temperature at an acceptable level of less than 102°F. This action will be specified in the emergency fire procedure for a fire in CB-FA-4b. TMI-1 Administrative Procedure 1501-ADM-1100.05 "Heat Stress Control," recommends work times for shorter control room operator exposures. These stay times plus the time required to reach stated temperature following loss of HVAC are well into the event, and qualified relief personnel are available to supplement TMI-1 manning capabilities during an emergency, if required.

Therefore, it is concluded that the loss of ventilation to CB-FA-4b has no effect on occupancy of the control room or Appendix R shutdown, because all required electrical equipment can be safely operated at the resulting maximum ambient temperature when the heat loads identified above are reduced within one hour after loss of ventilation.

O. CB-FZ-5a

This room contains the CB ventilation, "A" train supply fans (AH-E-17A & 18A) and return fans of both trains (AH-E-19A & 19B). A fire in this room will disable "A" train ventilation. This fire area does not contain Appendix R safe shutdown components. "B" train return path will also be blocked-out. CB instrument air may also be lost. No temperature analysis was made for this room. This room is not cooled by the CB ventilation; the air from the patio is drawn into this room through two louvers by a separate fan AH-E-22A. Therefore, no evaluation is necessary for this room. Loss of ventilation in this area has no impact on Appendix R safe shutdown.

Similarly, no evaluation is made for CB-FZ-5b as loss of ventilation in this room has no impact on Appendix R safe shutdown.

4.4 CONCLUSION

The failure of control building ventilation during an Appendix R event does not adversely affect safe shutdown. This has been determined by a rigorous evaluation of test data which verifies that the expected temperature rise in the control building without HVAC during Appendix R shutdown operation is enveloped by the specified equipment design limits except for CB-FA-2d and CB-FA-4b. In CB-FA-2d, where equipment design temperature limits could be exceeded, opening a door provides preventive action to limit temperature rises to acceptable levels. In CB-FA-4b where equipment design temperature limits could be exceeded, manual heat load reduction (deenergizing one half of normal control room lighting) within one hour, provides preventive action to limit temperature rises to acceptable levels. Emergency fire procedures will identify these preventive manual actions. Each Appendix R required system in the control building has been reviewed for sensitivity to the expected elevated temperatures and found to have appropriate ratings for the intended service. The loss of the control building ventilation will not challenge these ratings because the equipment hot spot total temperature limits will not be exceeded for the Appendix R fire. Therefore, the CB ventilation system is not required for safe shutdown under an Appendix R fire and the roving fire watch in those areas in support of CB ventilation concern is not required.

TABLE 7
CONTROL BUILDING VENTILATION EVALUATION

Area of Fire	Areas Requiring Cooling (Note 1)	HVAC System Available				Duct Problems		Discussion (Note 2)
		Supply Fan	Return Fan	Booster Fan	Chiller	Supply	Return	
CB-FA-1	'B' Areas	No	No	No	No	No Problem	No Problem	CB ventilation may not be available.
CB-FA-2a	'B' Areas	'B' Fan	B	B	B	To 2nd Floor	From 2nd Floor	CB ventilation available for third and fourth floors.
CB-FA-2b	'A' Areas	'A' Fan	A	No	A	To 2nd Floor	From CB-FA-2c	CB ventilation available for third and fourth floors.
CB-FA-2c	'A' Areas	'A' Fan	A	A	A	No Problem	No Problem	CB ventilation available.
CB-FA-2d	B' Areas	No	No	No	B	No Problem	From CB-FA-2e, 2f, 2g	CB ventilation may not be available.
CB-FA-2e	'A' Areas	'A' Fan	A	A	A	To CB-FA-2d, 2f, 2g	No Problem	CB ventilation available for all except to 2d and 2f.
CB-FA-2f	'B' Areas	No	No	No	B	No Problem	From CB-FA-2g	CB ventilation may not be available.
CB-FA-2g	'A' Areas	'A' Fan	A	A	A	To CB-FA-2f	No Problem	CB ventilation available except CB-FA-2f.
CB-FA-3a	'B' Areas	'B' Fan	B	B	B	To 2nd & 3rd Floors	From 2nd & 3rd Floors	CB ventilation available for fourth floor.
CB-FA-3b	'A' Areas	'A' Fan	A	A	A	To CB-FA-3c	From CB-FA-3c & 3d	CB ventilation available to the required rooms.

TABLE 7
CONTROL BUILDING VENTILATION EVALUATION

Area of Fire	Areas Requiring Cooling (Note 1)	HVAC System Available				Duct Problems		Discussion (Note 2)
		Supply Fan	Return Fan	Booster Fan	Chiller	Supply	Return	
CB-FA-3c	RSD Areas	'B' Fan	'B'	B	RSD	No Problem	No Problem	CB ventilation will be available.
CB-FA-3d	RSD Areas	No	No	No	RSD	No Problem	No Problem	CB ventilation may not be available.
CB-FA-4a	'A' or 'B' Areas	'B' Fan	B	B	B	To 2nd & 3rd Floors	From All Areas	CB ventilation available for fourth floor.
CB-FA-4b	RSD Areas	No	No	No	RSD	To All Areas	No Problems	CB ventilation may not be available.
CB-FZ-5a	'A' or 'B' Areas	'B' Fan	No	B	B	No Problem	From All Areas	CB ventilation available.
CB-FZ-5b	'A' or 'B' Areas	'A' Fan	A	A	A	No Problem	No Problem	CB ventilation available.
FH-FZ-2	'A' Areas	'A' Fan	A	A	No	No Problem	No Problem	CB ventilation available without chiller.
FH-FZ-5	'A' Areas	'A' Fan	A	A	A	Loss of Outside Air	Loss of Outside Exhaust	CB ventilation available in recirculation mode.
FH-FZ-6	'B' Areas	'A' or 'B' Fan	'A' or 'B'	'A' or 'B'	No	No Problem	No Problem	CB ventilation available without chiller.

Note 1: 'A' areas include CB-FA-2a, 2d, 2f, 3a, 3d, and 4b
'B' areas include CB-FA-2b, 2e, 2g, 3b, 3d, and 4b
RSD areas include CB-FA-2b, 2e, 2g, and 3b

Note 2: Loss of CB instrument air for a fire in all of these areas/zones can lead to closure of control dampers.

TABLE 8

CONTROL TOWER INSTRUMENTATION LOCATIONS

Room	Elev.	Location No.	Description
411	355'	1	In front of A&B RPS Cabinets - Control Room - 5 to 6 feet off floor
411	355'	2	In front of C&D RPS Cabinets - Control Room - 5 to 6 feet off floor
411	355'	3	Behind Panel PC - Control Room - 5 to 6 ft. off floor
303	338'	4	Between ESAS Relay & Actuation Cabinets - 5 to 6 feet off floor
302	338'	5	In front of IE-4160V SWGR - 5 to 6 feet off floor
301	338'	6	In front of 1D-4160V SWGR - 5 to 6 feet off floor
304	338'	7	Between CRDM Power & Control Cabinets - 5 to 6 feet off floor
304	338'	8	In front of XCC & XCR Cabinets - 5 to 6 feet off floor
304	338'	9	In front of ICN/NNI Cabinets - 5 to 6 feet off floor
	338'	10	Amongst HSPS Cabinet - 5 to 6 feet off floor
	338'	11	In front of CRDM 6 transformers - 5 to 6 feet off floor
203	322'	12	RSD Area West of Pump Power monitors - 5 to 6 feet floor
201	322'	13	P SWGR Room - 5 to 6 feet off floor
202	322'	14	In front of S SWGR MG - 5 to 6 feet off floor
201	322'	15	In front of MG Set - 5 to 6 feet off floor
204	322'	16	In front of C&E Inverter - 5 to 6 feet off floor
205	322'	17	In front of D&B Inverter - 5 to 6 feet off floor
206	322'	18	East end of A&C Battery - 5 to 6 feet off floor
207	322'	19	S-W of D Battery
411	338'	20	Hottest ICS Cab. ventilation exhaust
411	338'	21	Hottest HSPS Cab. ventilation exhaust
411	355'	22	Hottest RPS Cab. ventilation exhaust
411	355'	23	Hottest RMS Cab. ventilation exhaust
		24	Outside Air Temperature pt. 92 computer
	338'	25	S Bus Current as read on SI-02 (IE-4160V Bus)
	338'	26	P Bus Current as read on PI-02 (ID-4160V Bus)

TABLE 9 (Sheet 1 of 2)

CONTROL TOWER VENTILATION TEST

Temperature (°F)

Thermometer / Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0915	73	72	75	72	70	70	73	70	71	75	76	76	77	80
1015	73	72	75	73	70	70	73	70	71	74	75	76	76	80
1115	73	73	75	72	70	71	73	70	71	72	71	77	77	80
1215	73	72	75	73	70	70	73	70	71	74	75	77	77	80
1333 (HVAC SECURED)	73	73	75	72	70	71	73	72	72	72	74	78/87	77	81
1338	78	79	78	72	71	71.5	74	72	73	74	75	78	80	81.5
1343	80	80	80	74	71	72	74	73	73	74.5	76	78	83	82
1348	80	81	80	74	71.5	72.3	75	73	73	75	76	79	84	83
1353	81	81.5	81	75	72	72.8	75	73	73	75	76	79	84	83
1358	81.5	82	81	75	72	72.8	76	73	73	75	76	79	85	83
1403	82	82.5	81.5	75	72	73.2	76	74	74	75.5	76.5	79	85	84
1408	82.5	83	82	76	72	73.5	76	74	74	76	76.5	79	87	84
1413	83	83.5	82.5	75.8	72	73.6	77	74	74	76	77	79	87	84
1418	83	84	83	75.8	72	73.8	77	74	74	76	77	79	87	84
1423	84	84.5	83	75.8	72.2	74.1	77	74	74	76	77	79	87.5	84
1428	84	85	83.5	75.8	72.2	74.2	77	74	74	76	77	79	88	84.5
1433	84	85	84	76	72.5	74.2	77	74	74	76	77.5	79	88	85
1438	85	85	84	76	72.8	74.5	77	75	74	76.5	77.5	79	88	85
1443	85	85	84	76.2	73	74.5	78	75	74	76.5	78	79	88	85
1448	85	86	85	77	73	74.8	78	75	75	76.5	78	79	89	85
1453	86	86	85	77	74	75	78	75	75	76.5	78	79	89	85
1458	86	87	86	77	74	75	78	75	75	77	78	80	89	85.5
1503 (HVAC RESTORED)	86	87	86	77	74	75				77	78	83/87	89	86
1508				77	73.5	75				77	78		89	86

TABLE 9 (SHEET 2 OF 2)

CONTROL TOWER VENTILATION TEST (CONT'D.)

Thermometer Time	Temperature (°F) 15	16	17	18	19	20	21	22	23	Current (A) 24	25	26
0915	82	83	81	77	79					59.1	100	80
1015	82	83	80	75	74	78	80	81	99	60.5	100	80
1115	82	83	79	75	74	78	80	82	100	61.9	105	80
1215	82	83	79	75	74	78	81	81	99	67.5	100	80
1333	82	83	80	75	75	78	81	81	97	63.7	95	80
1338	83	85	81	75	75	78	81	83	98	63.7	95	80
1343	85	85.5	82.5	75.5	75	78	81.5	84.5	99	63.8	94	80
1348	85	87	83	75.5	75	78	82	85	99.5	63.8	94	80
1353	86	87.5	83	75.5	75	79	82	86.5	100	63.8	94	80
1358	86	88	83	75.5	75	79	82	87	100.5	63.8	94	80
1403	86	88	83.5	75.5	75	79	82	88	101	64.1	95	82
1408	87	88.5	84	76	75	79	82	89	101.5	64.3	86	82
1413	87	88.5	84	76	75	79	82	89	102	64.2	88	81
1418	88	89	84	76	75.5	79	82	90	102	64.3	90	82
1423	88	89	84.5	76	75.5	79	82	90.5	103	64.2	83	81
1428	88	89	84.5	76	75.5	79	82	91	103.5	64.4	90	81
1433	88	89.5	85	76	75.5	79	82	91.5	103.5	64.6	89	82
1438	89	89.5	85	76	75.5	80	82	92	104	64.5	89	82
1443	89	90	85	76	75.5	80	82.5	93	104	64.5	88	81
1448	89	90	85	76	75.5	80	82.5	93	105	64.6	90	81
1453	89	90	85	76	75.5	80	82.5	93	105	64.6	94	81
1458	89	90	85	76	75.5	80	83	94	106	64.6	97	81
1503	90	90.5	85.5	76	76		83	84	106	64.5	88	81

FIGURE 4
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2a ROOM 201

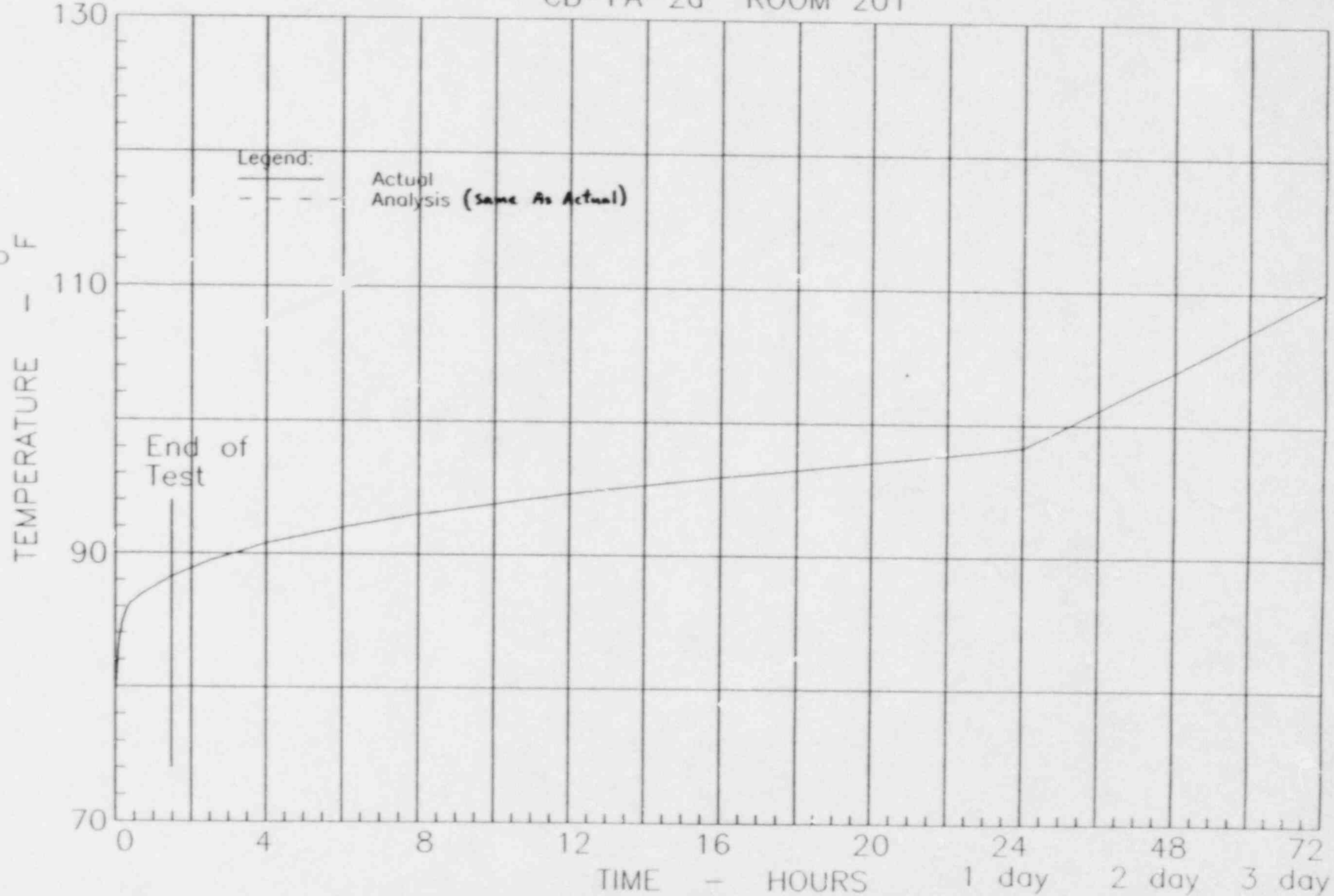


FIGURE 4 A

TMI-1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES

CB-FA-2a ROOM 201

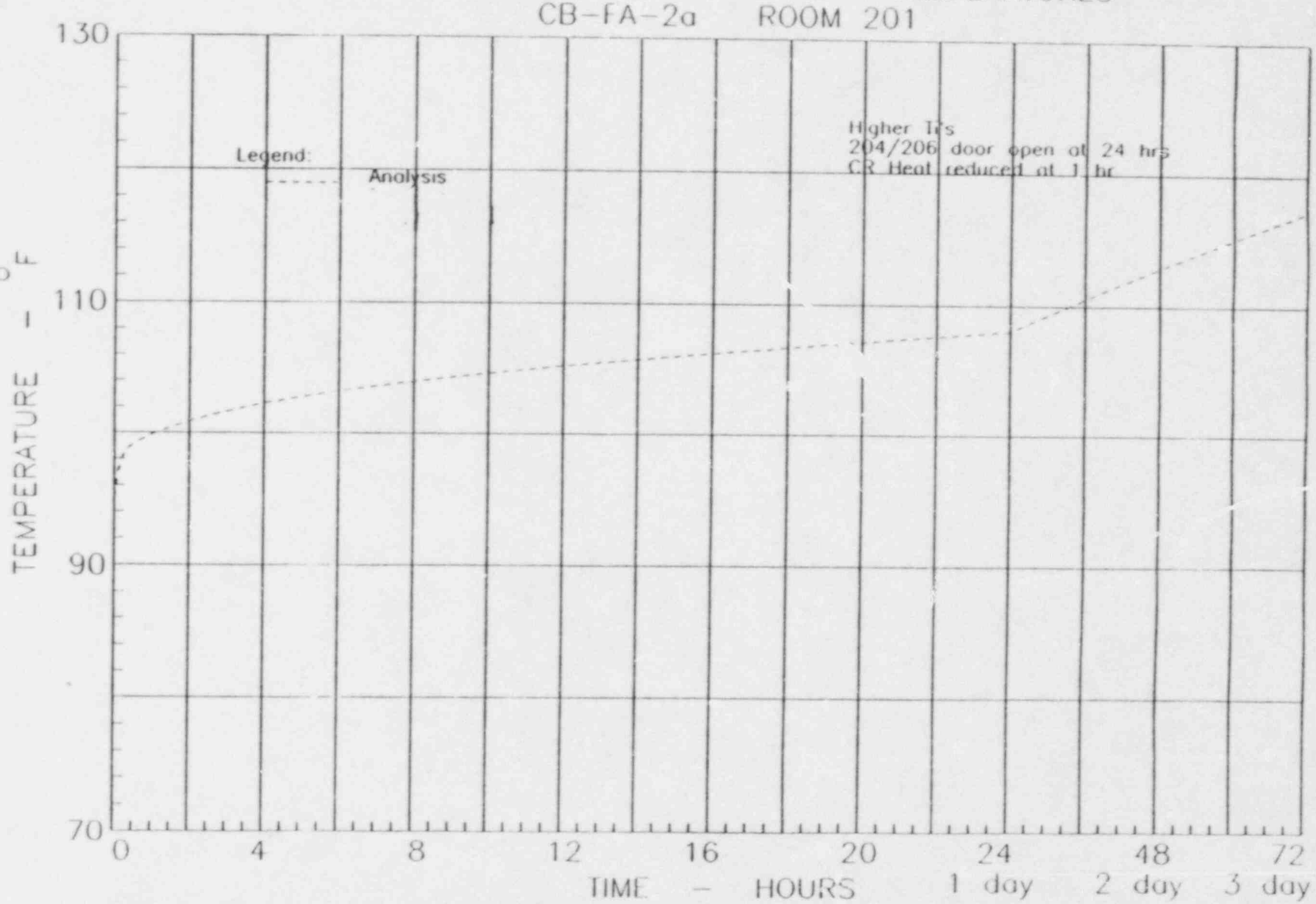


FIGURE 5
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2b ROOM 202

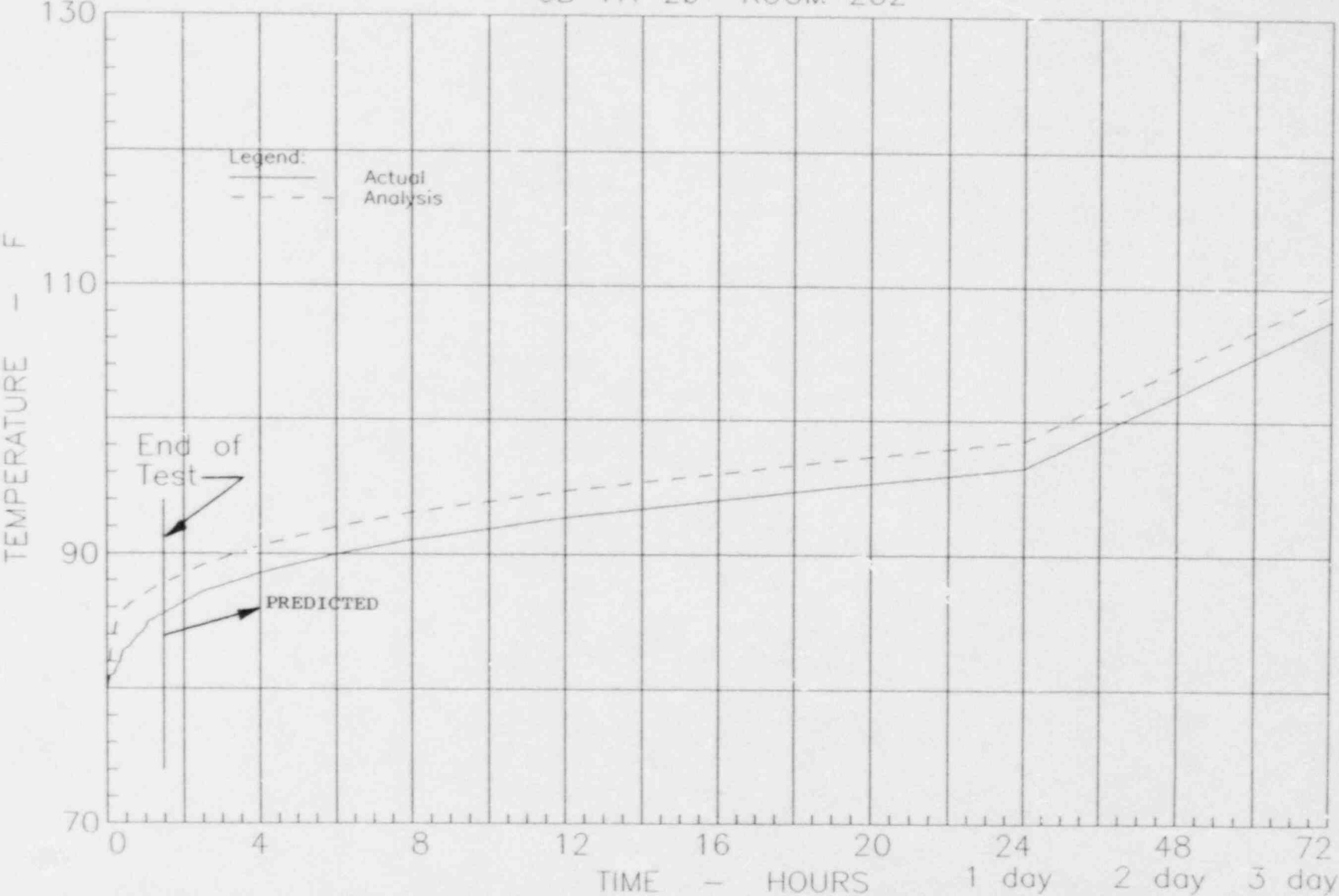


FIGURE 5A
TMI-1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2b ROOM 202

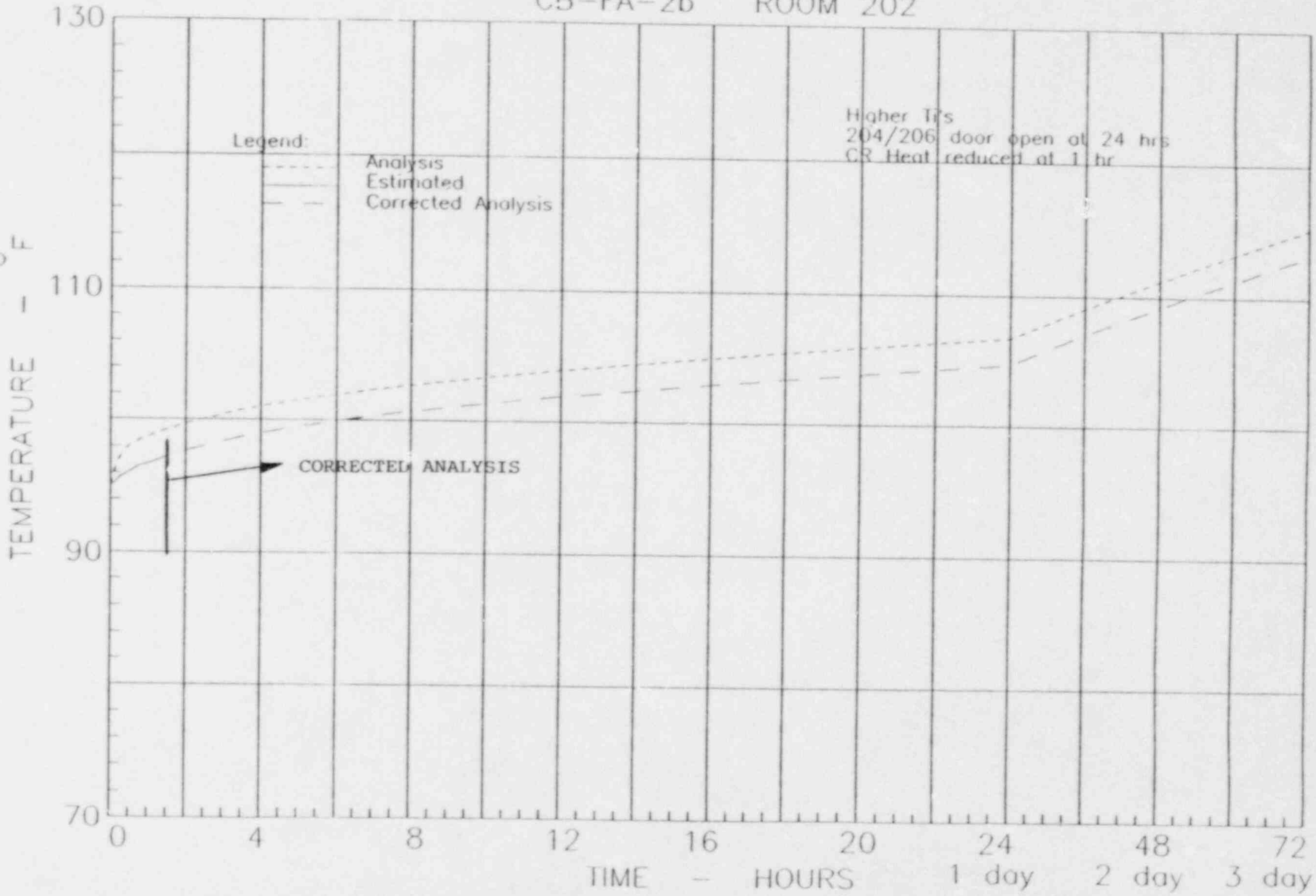


FIGURE 6
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2c ROOM 203

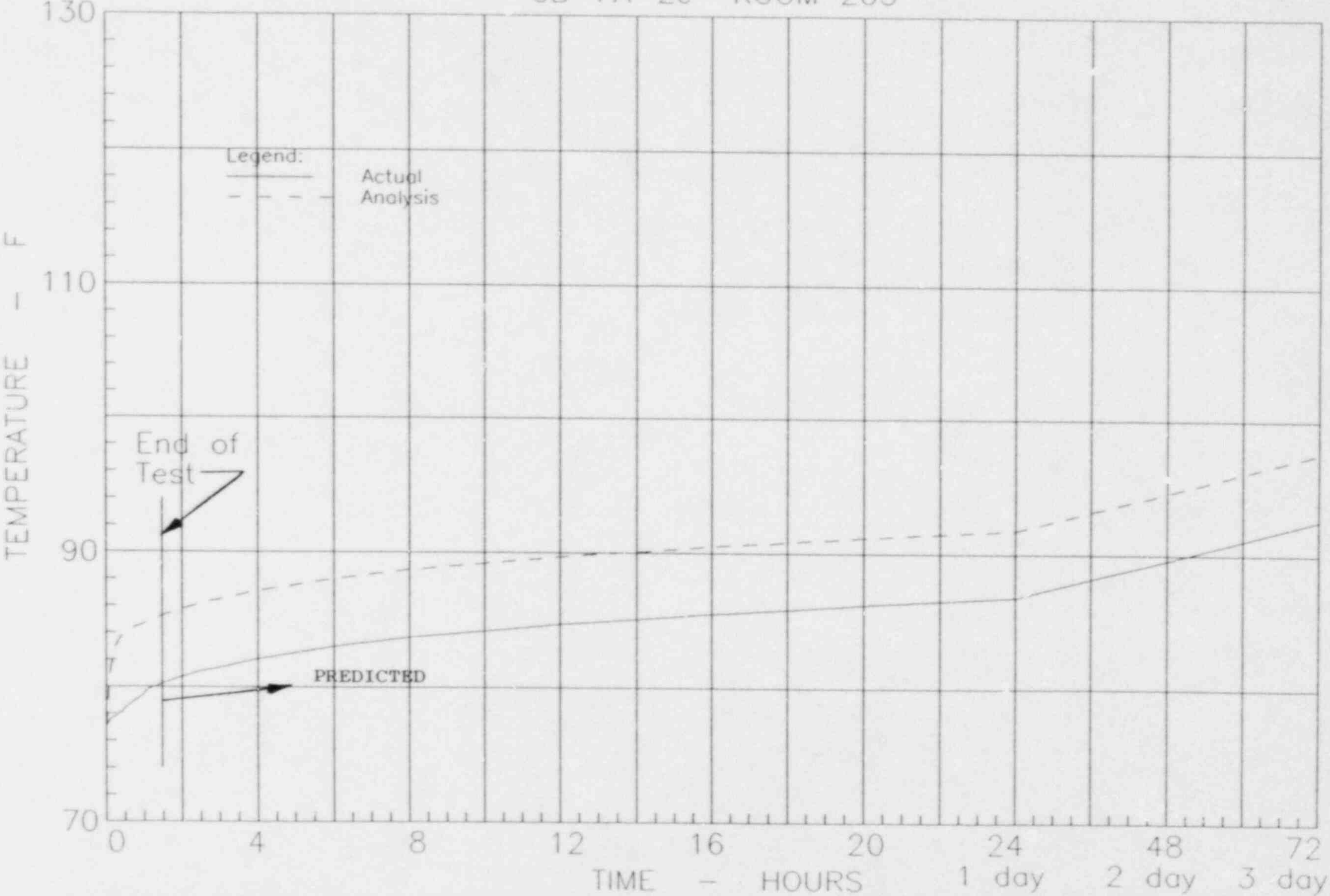


FIGURE 7

TMI-1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES

CB-FA-2d ROOM 204

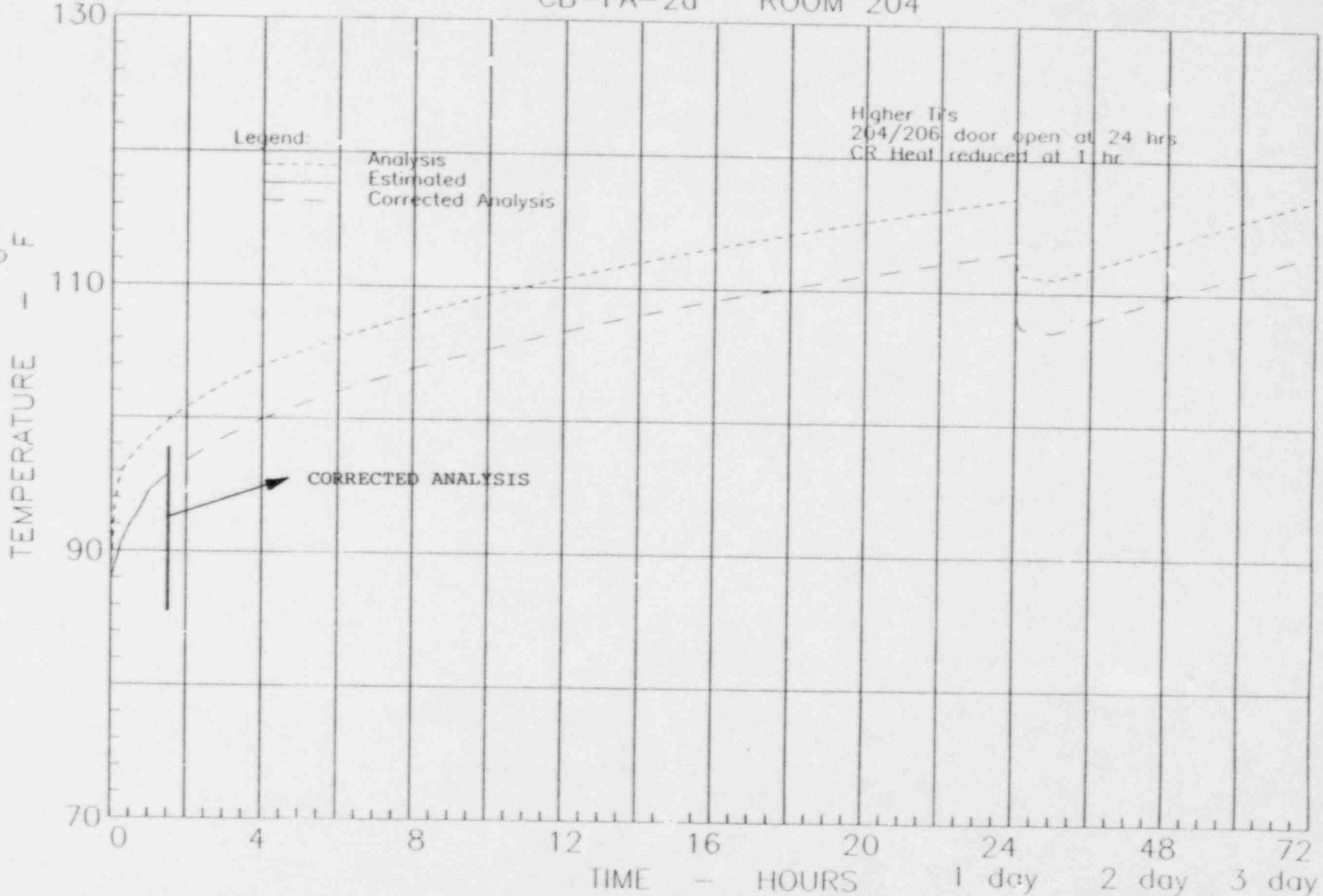


FIGURE 8
TMI-1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2e ROOM 205

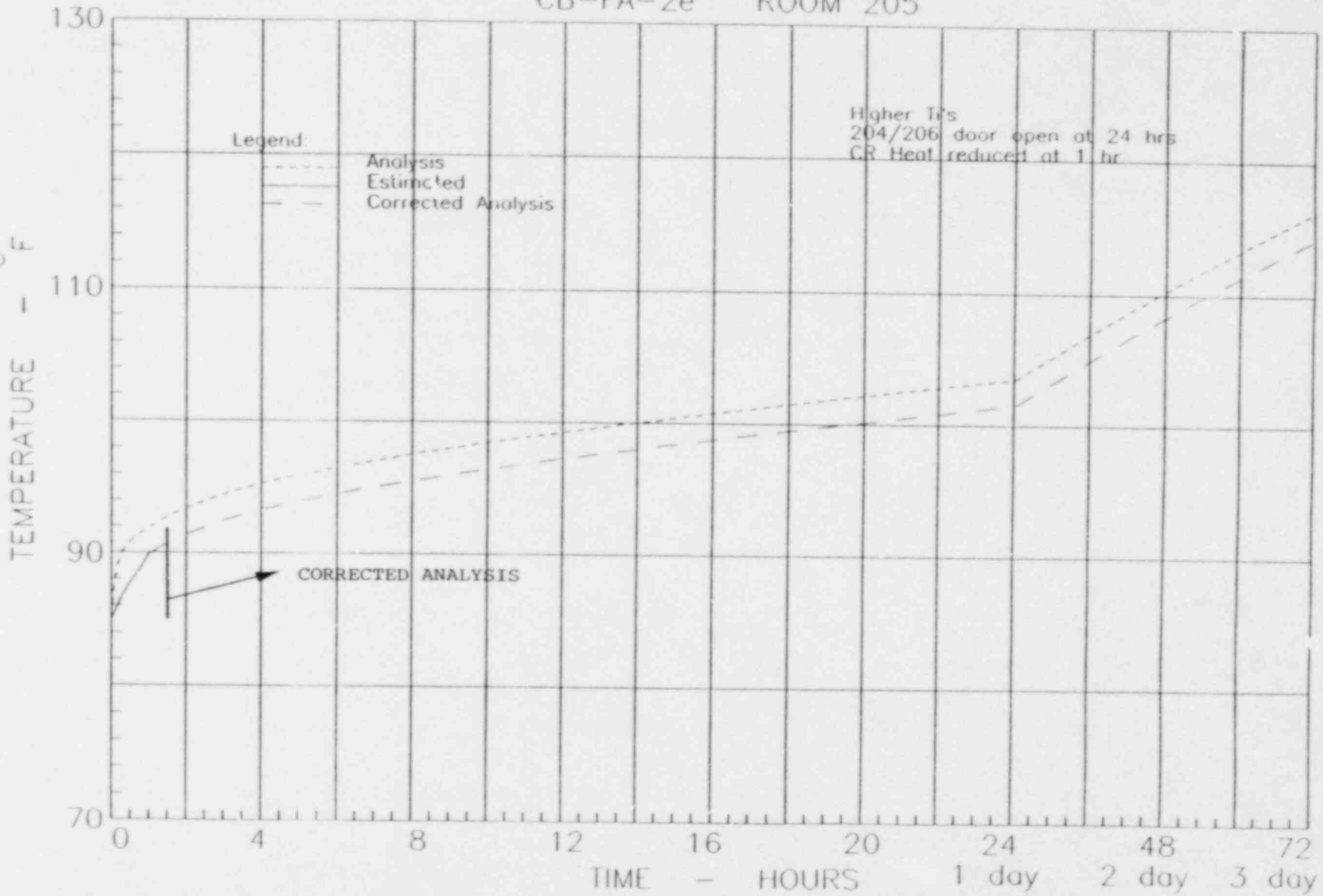


FIGURE 9
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2f ROOM 206

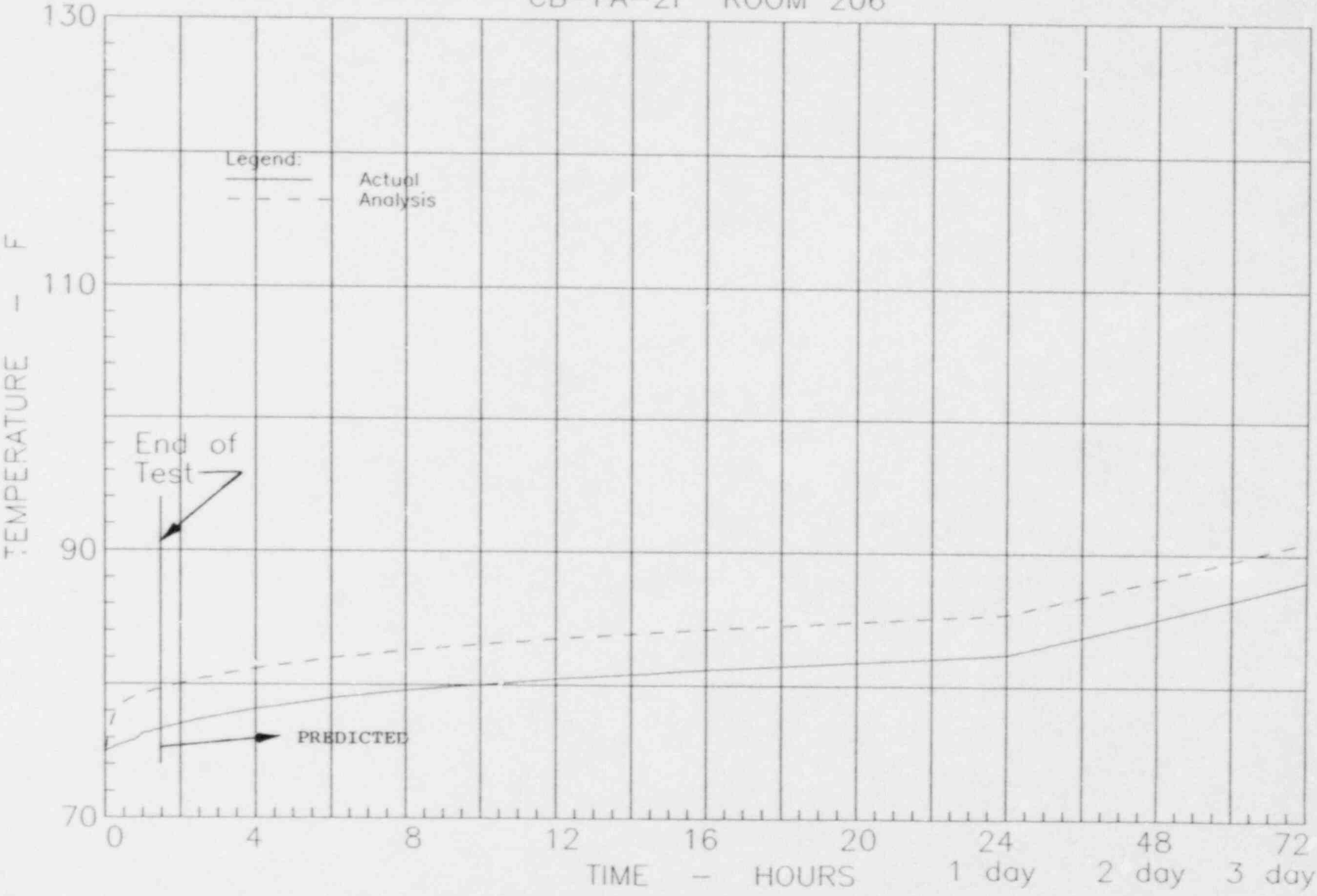


FIGURE 10
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-2g ROOM 207

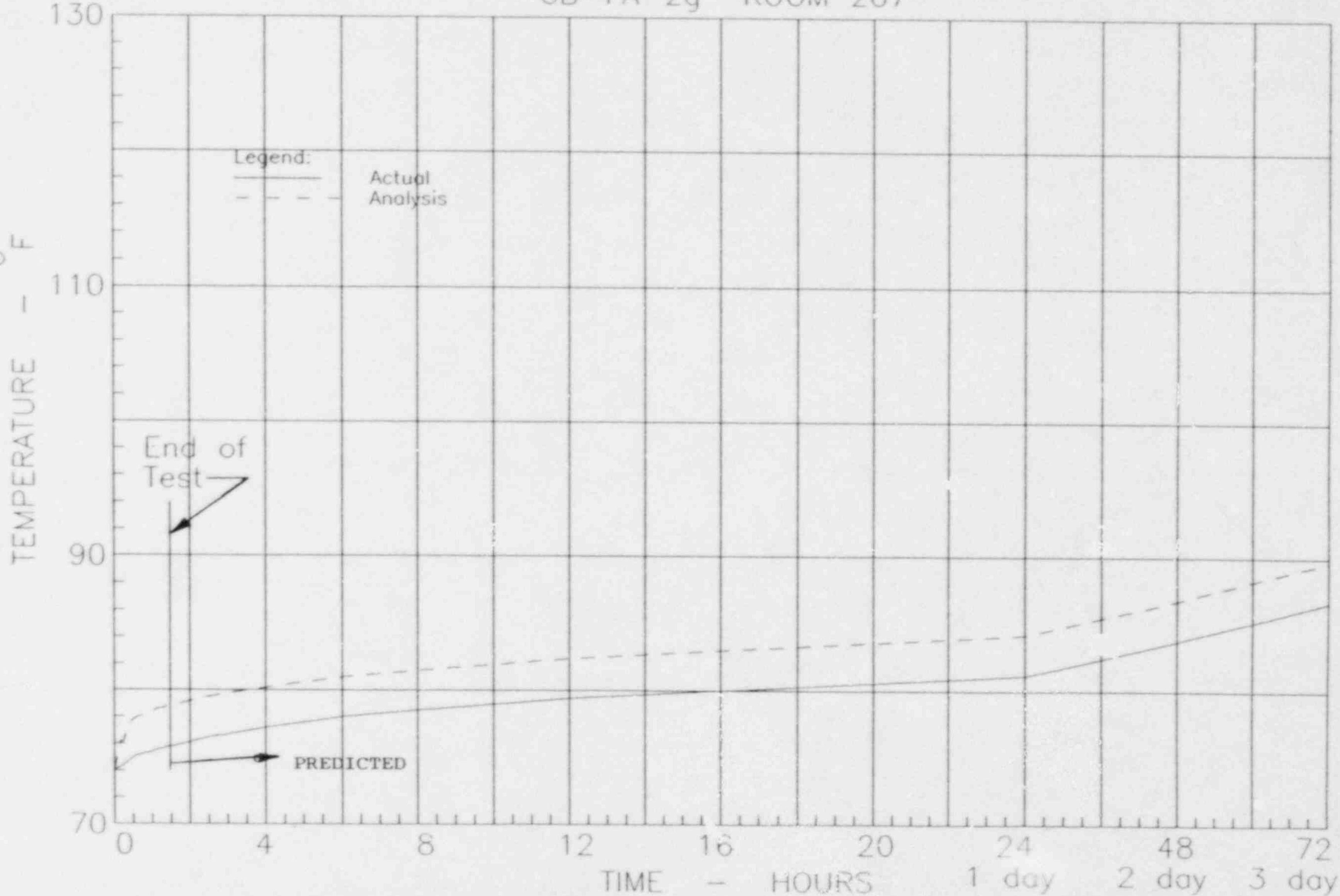


FIGURE 11
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-3a ROOM 301

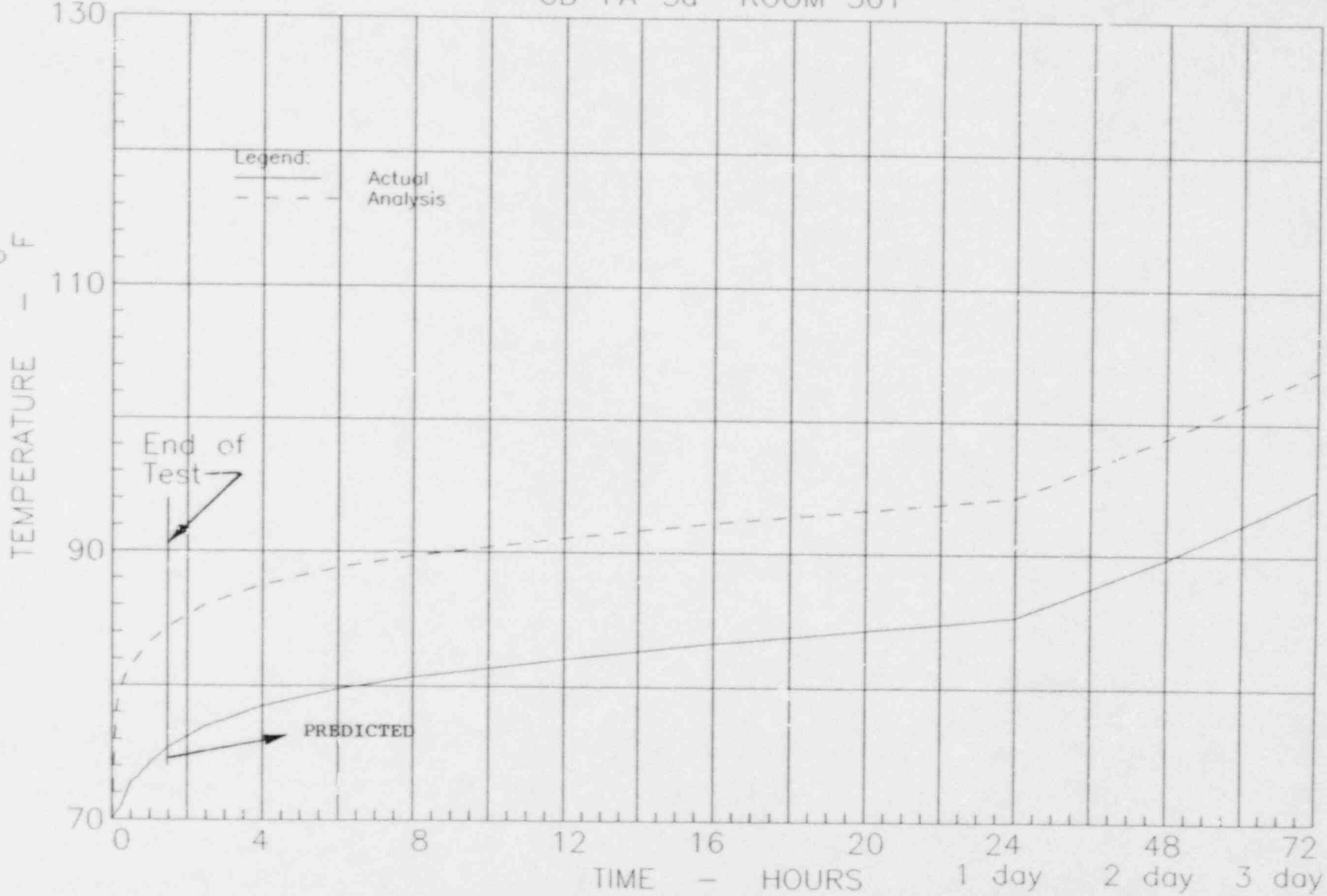


FIGURE 12
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-3B ROOM 302

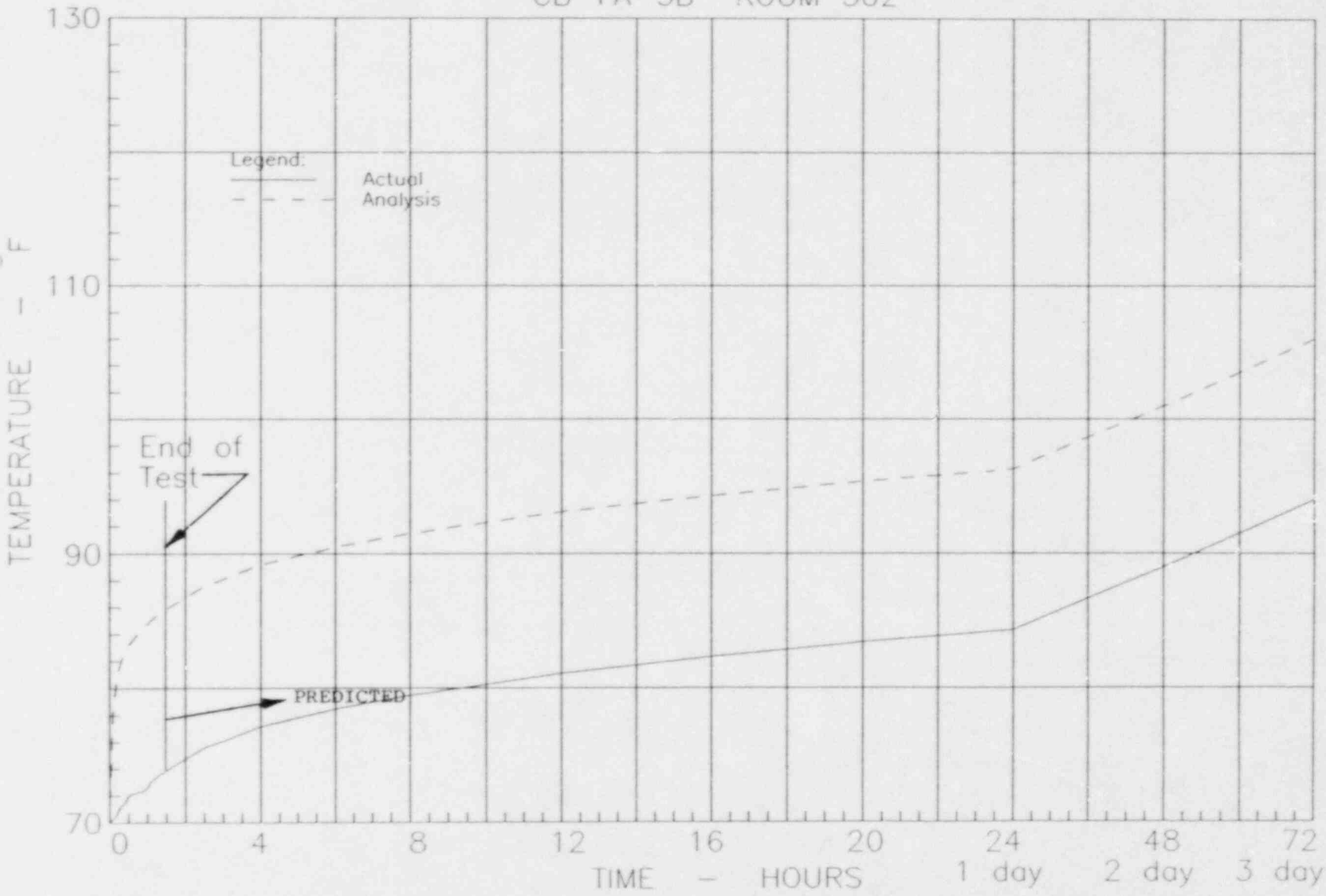


FIGURE 13
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-3c ROOM 303

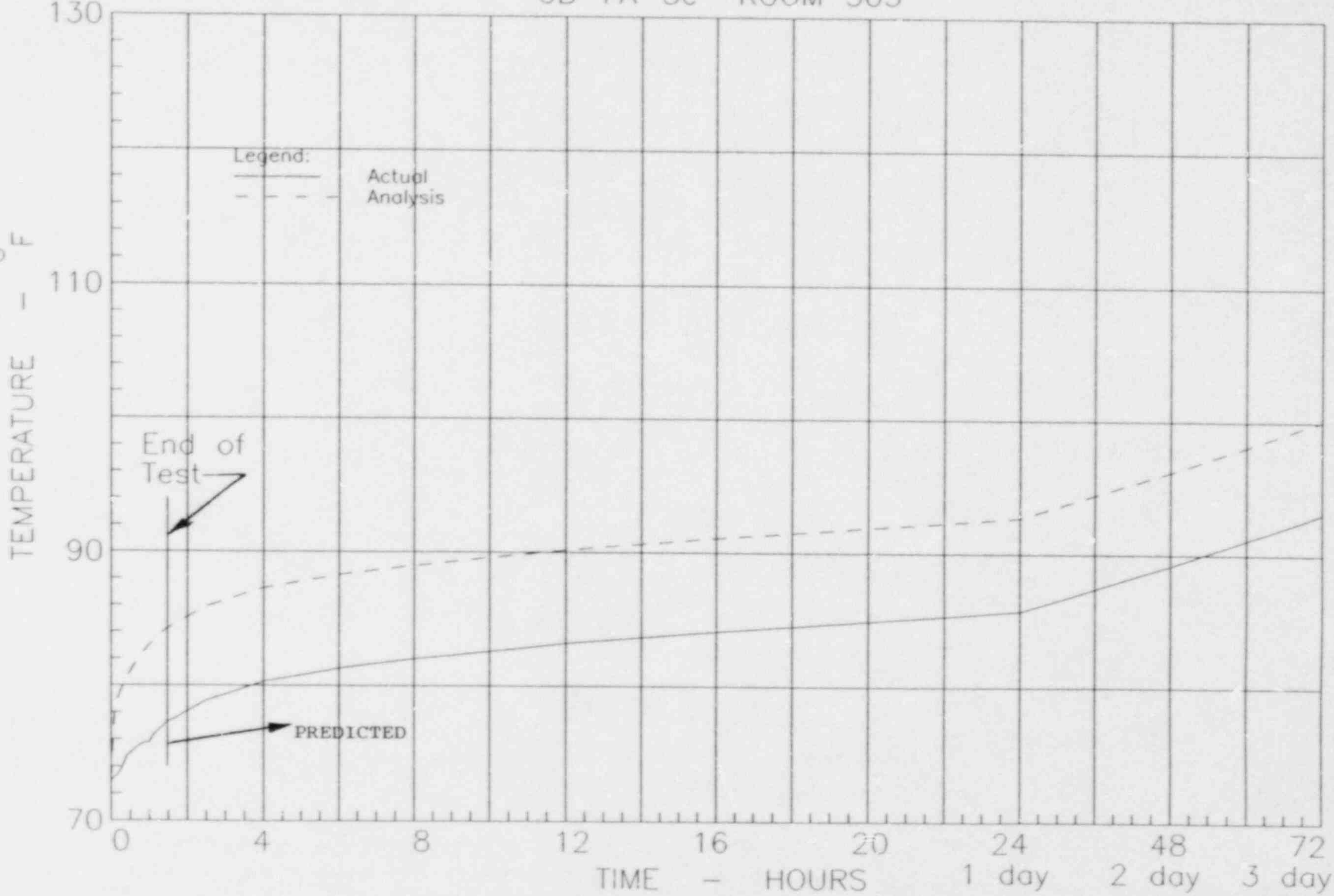


FIGURE 14
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-3d ROOM 304

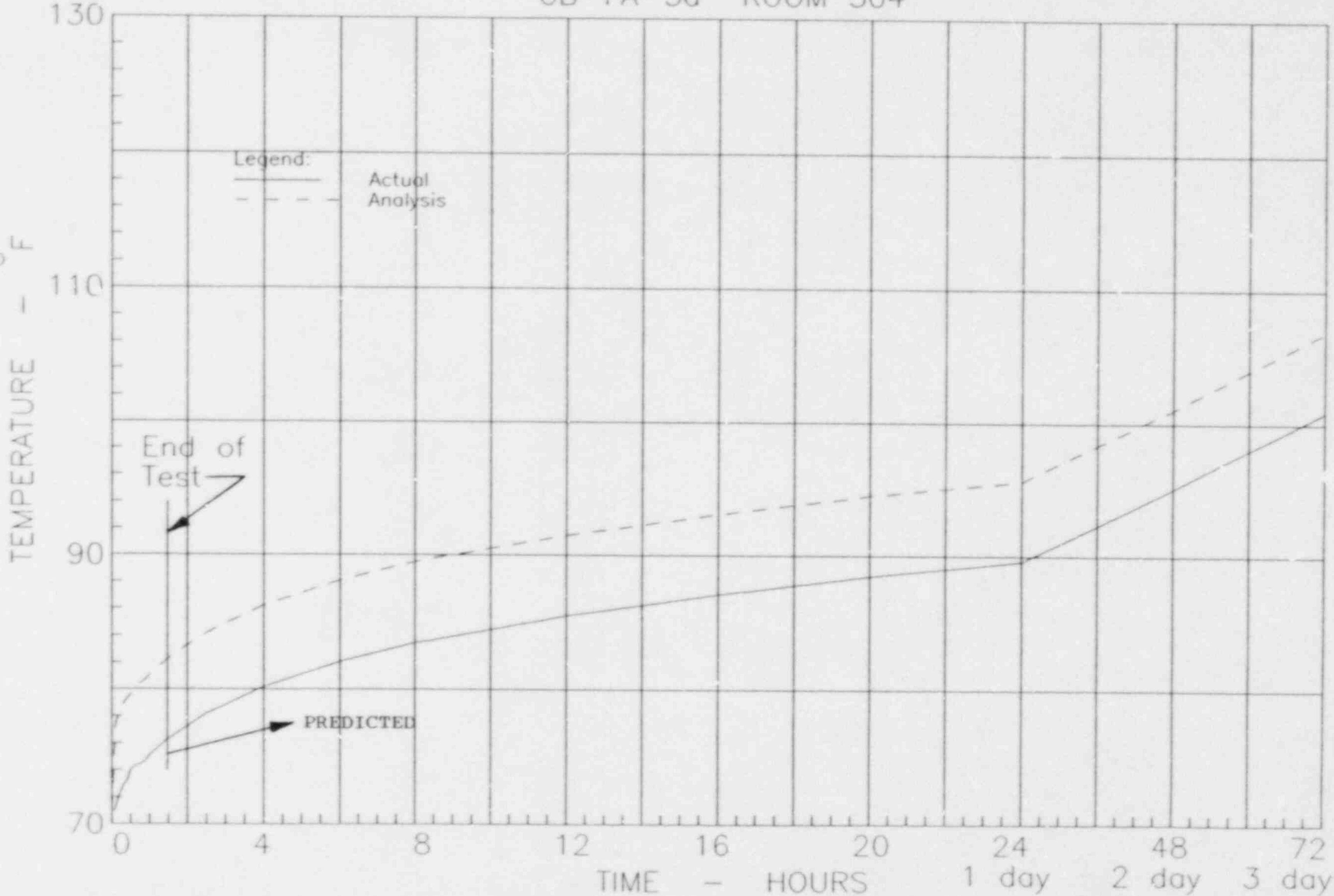


FIGURE 15
TMI1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-4b CONTROL ROOM

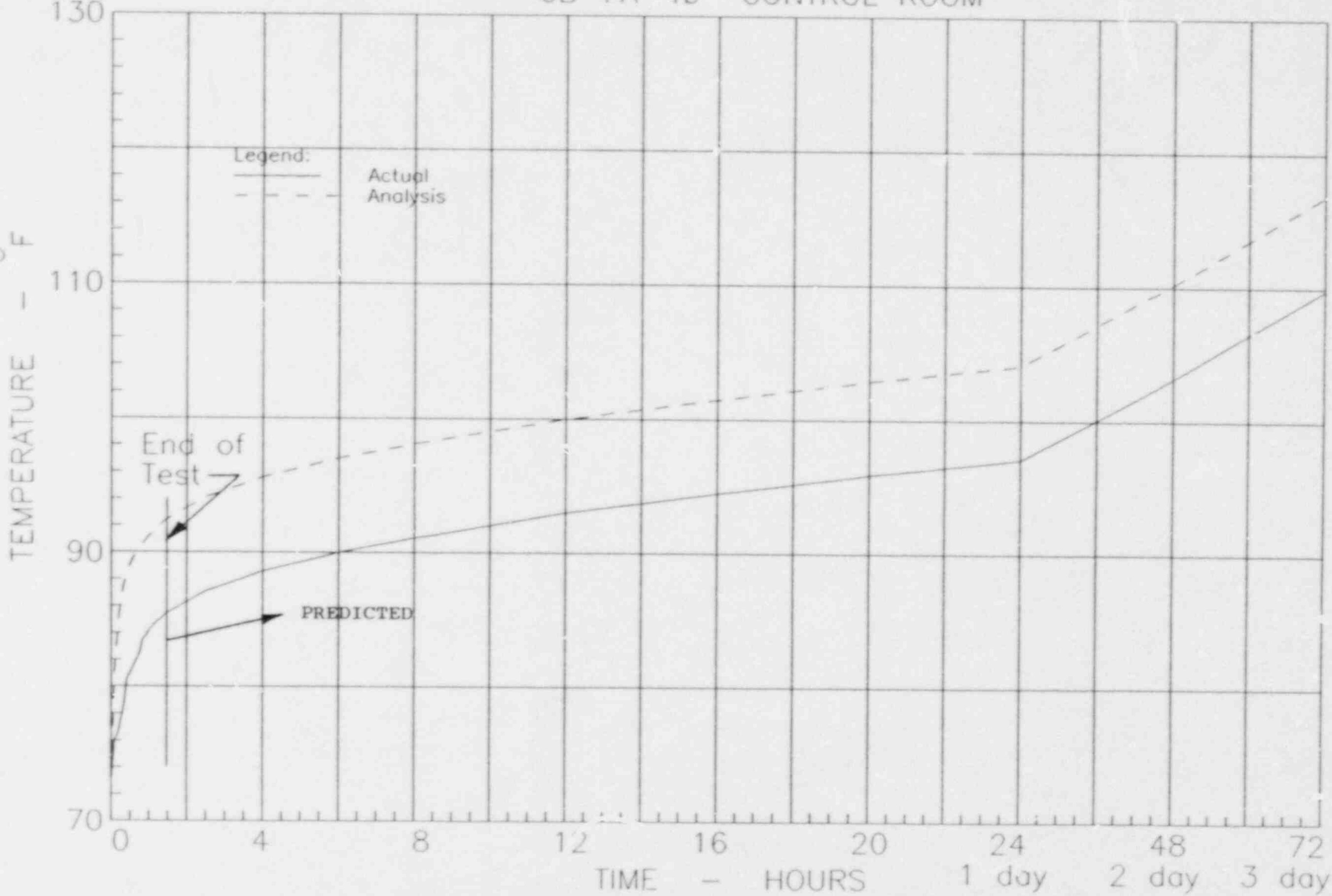
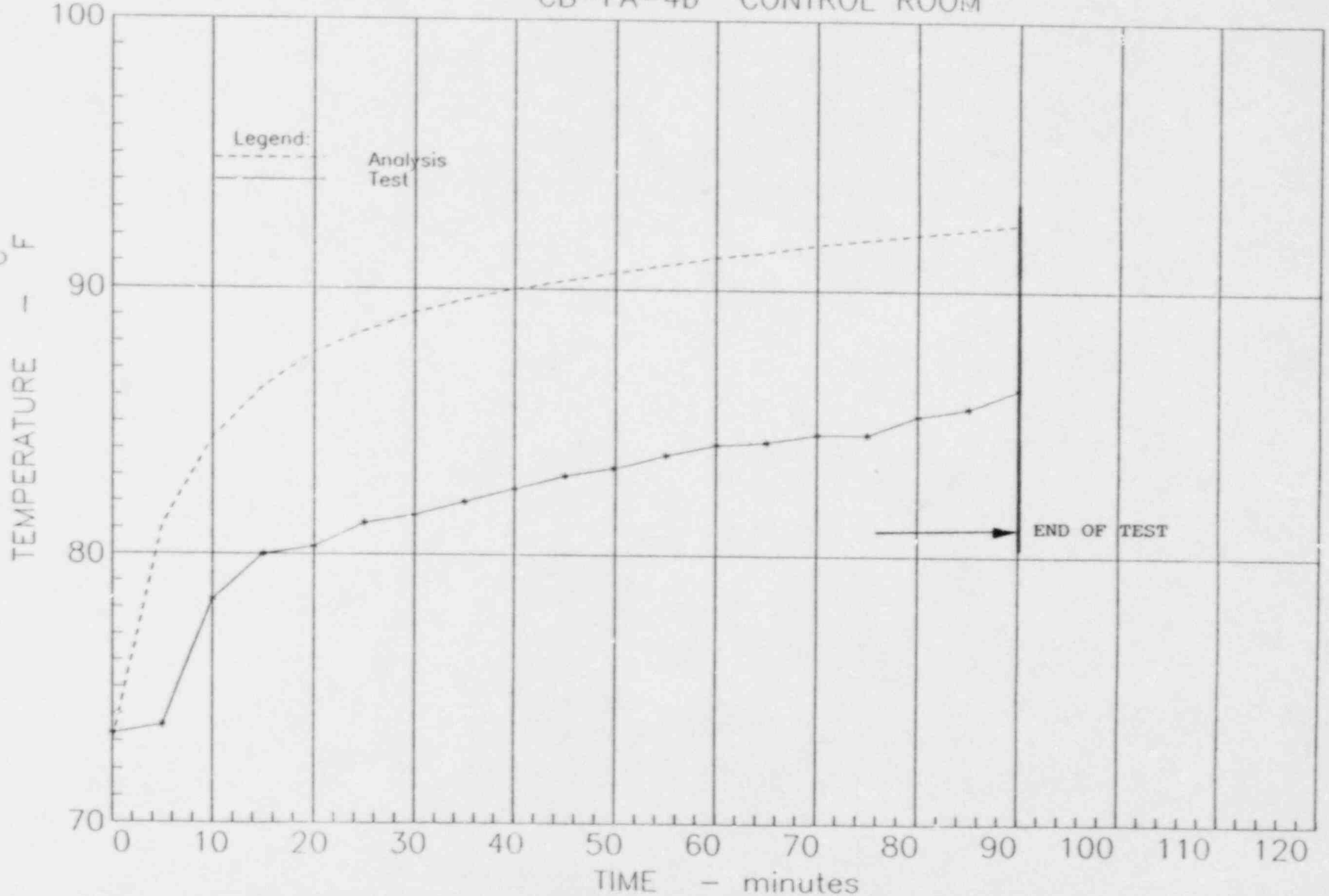


FIGURE 16
TMI-1 CONTROL BUILDING HVAC FAILURE - TEMPERATURES
CB-FA-4b CONTROL ROOM



5.0 NUCLEAR SERVICES AND DECAY HEAT CLOSED CYCLE COOLING WATER PUMP ROOM

5.1 APPENDIX R REQUIREMENT

The Appendix R components which are affected by the loss of ventilation units AH-E-15A and AH-E-15B are the Nuclear Service Closed Cycle Cooling Water Pumps NS-P-1A, NS-P-1B, and NS-P-1C; Intermediate Cooling Pumps IC-P-1A and IC-P-1B; Intermediate Cooling Valve IC-V-4; and Decay Heat Closed Cycle Cooling Water Pumps DC-P-1A and DC-P-1B.

The nuclear service closed cycle cooling water system provides closed cycle cooling water to makeup pump MU-P-1B, to Reactor Building ventilation fan motor coolers, to ventilation equipment for emergency feedwater pump rooms, and instrument air compressor rooms (AH-E-24A and B), to nuclear service and decay heat service pump area air coolers (AH-E-15A and B), to control building air conditioning and to reactor coolant pump motors. The system is required to operate during hot shutdown and cold shutdown whenever the equipment it is cooling is in operation.

The intermediate cooling system provides closed cycle cooling water to the letdown coolers in the letdown path of the makeup and purification system. It also provides cooling water to the reactor coolant pump seals via thermal barrier cooling. Thermal barrier cooling is a back-up for Reactor Coolant pump seal injection.

The decay heat closed cycle cooling water system provides cooling water to the makeup pumps, MU-P-1A and MU-P-1C, and to the decay heat removal pumps and coolers. Cooling water to the decay heat removal pumps and coolers are only required during cold shutdown. However, the DC system will be required for hot shutdown, when MU-P-1A or MU-P-1C is utilized for the reactor coolant inventory control.

The fire areas/zones where both air handling units may fail due to fire damage are AB-FZ-7, CB-FA-1, CB-FA-2d, CB-FA-2f, CB-FA-[illegible], CB-FA-3c, CB-FA-3d, and CB-FA-4b.

5.2 TEMPERATURE EVALUATION

The loss of room ventilation test was performed with the plant in normal operation with two (2) nuclear service pumps and one (1) intermediate cooling pump in operation. To monitor temperatures throughout the area during the test, ten (10) thermocouples were installed to provide a representative sample of the NSPC area (Table 10). Forty-five (45) hours of data was recorded with twenty-one (21) of which were test data without ventilation systems operational. Both room coolers (AHE-15A, -15B) were de-energized and the exhaust registers (to the Auxiliary and Fuel Handling Building exhaust system) were isolated.

The test data (Table 11) shows no significant temperature rise compared to the normal operating temperature before the ventilation systems were secured. The increase in temperature at each thermocouple only varied between 4.0 and 7.8°F from the beginning to the end of the five hour test. The maximum temperature rise was 13.6°F which occurred one hour into the test in the IC-Pump area. The maximum temperature recorded in any area did not exceed 99°F.

The test data correlates with the analytical model data in profile shape after the first 15-20 minutes into the transient. The initial ramp and the absolute magnitude of the temperature differ to some extent, due to simplistic modeling and conservative estimates of heat load. The evaluation concludes that the test data depict the actual heat loads and transient responses for this area. Since the outside air temperature does not have a significant impact on the temperature under loss of HVAC systems, the Nuclear Services Pump cubicle test data may be used directly in the assessment of expected room temperatures given a loss of ventilation for a 72 hour time period. The maximum temperature reached is 99°F. The temperature profile for this area is shown in Figure 17.

5.3 EVALUATION

This room contains NS pumps and DC pumps which are separated from each other by partial fire barrier, and also contains IC pumps and IC valve IC-V-4. During normal operation heat is dissipated from the two NS pumps and the one IC pump which are operating. Appendix R shutdown requires one nuclear services pump (or one decay heat pump) and one intermediate cooling pump to operate simultaneously.

The maximum expected temperature of 99°F is acceptable for the operation of NS-P-1A, NS-P-1B, NS-P-1C, DC-P-1A, and DC-P-1B since these pump motors are designed to continuously operate at an ambient temperature of 50°C or 122°F. This temperature is also acceptable for the operation of IC-P-1A and IC-P-1B since these pump motors are designed to continuously operate at an ambient temperature of 40°C or 104°F.

Failure of the HVAC will have no consequence to the operation of valve IC-V-4 because its solenoid coil is required to be deenergized to position the valve to its safe shutdown position (open). During normal operation the valve is in the open position.

The systems interfacing with these components will not be affected by the loss of AH-E-15A or AH-E-15B or both.

5.4 CONCLUSION

The fa'lure of AH-E-15A and AH-E-15B during an Appendix R event does not adversely affect Appendix R components. This has been determined by a rigorous evaluation of test data which indicates that the ambient air temperature in the nuclear service closed cycle cooling (NS), decay heat closed cycle cooling (DC), and intermediate cooling pumps' and valve IC-V-4 vicinity during operation of two NS and one IC pump is within the equipment design limits. In addition, a review of existing data in conjunction with the heat load from a fourth pump in operation was reviewed and concluded that room temperature is expected to stay within equipment operational limits.

Therefore, Nuclear Services and Decay Heat Closed Cycle Cooling Water Pump Room ventilation is not required for safe shutdown under an Appendix R event and the roving fire watch or remote monitoring in these areas in support of ventilation concerns is not required.

TABLE 10

NUCLEAR SERVICE PUMP VENTILATION TEST SUMMARY

T/C Locations

0	-	Ceiling, over RB purge duct
1	-	Handrail west of AH-E-15 suction (Mid level)
2	-	Attached to IC-V-6
3	-	3 ft. off floor near IC mix tank
4	-	NS-P-1C Cubicle, ~6ft. off floor
5	-	NS-P-1A Cubicle, ~6ft. off floor
6	-	IC-Pump Area, ~6ft. off floor
7	-	IC-Pump Area, ceiling
8	-	T/C Readout (IC-V-12B), ~4ft. off floor
9	-	T/C Readout (IC-V-12B), ~4ft. off floor

TABLE II

NUCLEAR SERVICE PUMP CUBICLE TEST DATA

Temperature (°F)

Time Init.	Air Temp	0 91.4	1 88.1	2 84.9	3 89.4	4 97.3	5 94.2	6 84	7 92.4	8 87.2	9 87.3
8/23/87											
1130	72.0	91.3	88.1	84.9	89.0	96.5	94.4	83.9	92.4	87.5	87.5
1330	73.9	91.8	88.4	85.4	89.7	96.5	94.8	85.1	92.4	88.5	88.7
1530	74.9	92.0	89.3	86.2	90.3	96.9	95.3	86.1	92.8	88.4	89.5
1730	74.8	92.5	89.7	86.4	90.9	97.5	95.2	86.6	92.9	88.3	89.6
1930	73.7	92.3	89.6	85.6	89.8	98	95.2	86.4	93	88	89.2
2130	71.3	92	89.2	85.4	90	98	95	84.4	92.8	87.5	89
2330	69.1	91.4	88.7	84.7	89.1	96.7	94.3	82.8	92.4	86.2	88
8/24/87											
0130	66.4	90.7	87.7	84.5	88.7	96.8	93.6	82.3	91.9	86.1	88
0330	64.4	90.4	86.9	82.7	87.3	94.8	92.7	80.2	91.5	84.1	86.2
0530	63.3	89.7	86.4	82.0	86.7	95.1	92.4	79.4	91.1	83.1	86.6
0730	64.4	89.2	85.7	81.4	86.9	94.4	91.7	79.1	90.8	83	84.7
0930 (HVAC SECURED)	71.2	88.7	88	77.4	88.6	92.9	90.9	75.6	89.7	80.7	82.7
1000	69.3	93.9	92.6	87.2	89.7	97.3	96.6	87.0	92.0	88.8	89.3
1030	69.3	93.2	93.8	88.9	90.7	98.4	97.7	88.2	93.1	90.4	90.6
1100	69.3	95.7	93.6	87.1	89.9	98.3	97.9	86.3	93.5	88.9	89.6
1130	69.3	95.9	92.9	85.0	88.5	96.8	97.3	82.7	93.5	86.9	88.1
1200	69.5	95.8	93.7	86.5	89.8	98.4	97.6	85.9	93.7	88.6	89.4
1230	70.6	96.7	94.1	87.0	90.0	98.5	98.1	86.6	94	89	84.5
1300	75.9	95.8	92.5	83.4	87.6	96.3	96.4	86.4	93.6	85.8	[illegible]
1330	76.1	95.8	92.7	83.2	87.5	96.3	96.6	81	93.6	85.8	87.2
1430	78.7	95.8	92.8	83.6	88	96.7	96.9	81.4	93.7	86.3	87.3
1630	78.3	96.4	93.9	86.5	89.6	98.1	97.9	85.3	94.2	88.4	89.1
1830	78	97.3	94.2	87.1	90.2	98.4	98.5	86.1	94.5	88.9	89.7
2030	70.7	97.2	94.3	86.8	89.9	98.4	98.5	85.2	94.5	88.6	89.5
2230	68	96.8	94.1	85.7	89.1	98.2	98.1	84	94.5	87.5	88.6
8/25/87											
0030	65.9	96.6	94	85.8	89.2	97.7	98	83.9	94.4	87.1	88.5
0230	63.8	96.5	93.6	84.7	88.5	97.2	97.4	83	94.2	85.5	87.4
0430	60.5	96.3	93.1	84.8	88.7	97.2	97.3	83.5	93.8	86.3	87.8
0630 (HVAC RESTORED)	59.2	96.1	92.8	84.6	88.1	96.8	96.7	82.9	93.7	86.5	87.7
0830	61.1										

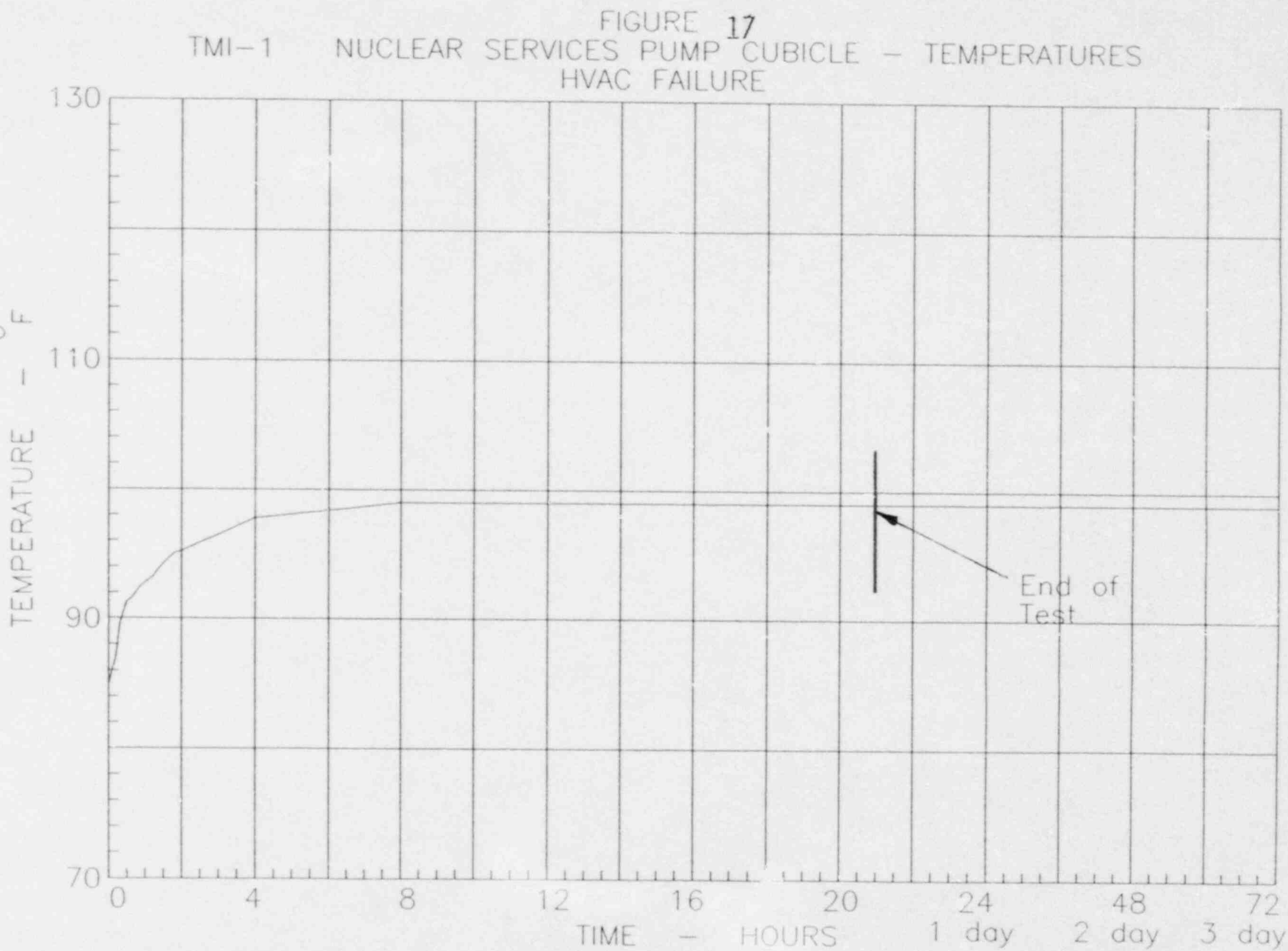


FIGURE 17
TMI-1 NUCLEAR SERVICES PUMP CUBICLE - TEMPERATURES
HVAC FAILURE
130
110
90
70
TEMPERATURE - °F
0
4
8
12
16
20
24
48
72
1 day
2 day
3 day
TIME - HOURS
End of Test