GEND-INF--023-Vol.3

DE84 004115

DATA INTEGRITY REVIEW OF THREE MILE ISLAND UNIT 2: HYDROGEN BURN DATA

Jim K. Jacoby
Ralph A. Nelson
Charles L. Nalezny
Ron H. Averill

Published September 1983

EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Three Mile Island Operation Office
Under DOE Contract No. DE-AC07-76ID01570

ABSTRACT

About 10 hours after the March 28, 1979 loss-of-coolant accident began at Three Mile Island Unit 2 (TMI-2), a hydrogen burn occurred inside the Reactor Building. This report reviews and presents data from 16 channels of resistance temperature detectors (RTDs), 2 steam generator pressure transmitters, 16 Reactor Building pressure switches, 2 channels of Reactor Building pressure measurements, and measurements of Reactor Building hydrogen, oxygen, and nitrogen concentrations with regard to their usefulness for determining the extent of the burn and the resulting pressure and temperature excursions inside the building.

FOREWORD

At the request of the TMI-2 Technical Integration Office, a review was conducted by the EG&G Idaho Loss-of-Fluid Test (LOFT) Data Integrity Section of selected TMI-2 hydrogen burn data. The LOFT Data Integrity Section is responsible for qualification of LOFT data following each LOFT experiment.

Although other physical evidence is available related to the extent of burn and overpressure damage, estimation of the peak temperature reached during the burn from physical damage effects is difficult because of the apparent short duration of the high-temperature transient. Consequently, intepretation of Reactor Building temperature, pressure, and gaseous composition data is an important element in understanding what actually happened. It is important to know what peak spatial average temperature was reached so that the amount of hydrogen produced from zirconium-water reaction during the accident can be estimated.

ACKNOWLEDGMENTS

We would like to thank the following EG&G Idaho employees. James W. Mock provided tabulated data for 16 Reactor Building resistance temperature detectors (RTDs). B. Mack Galusha and J. Bruce Marlow were instrumental in entering the RTD data onto the Idaho National Engineering Laboratory Cyber computer. Douglas L. Reeder and Lorenzo D. Goodrich provided many helpful comments.

CONTENTS

DATA INTEGRITY REVIEW OF THREE MILE ISLAND UNIT 2 HYDROGEN BURN DATA

INTRODUCTION

All 16 resistance temperature detectors (RTDs) located inside the Three Mile Island Unit 2 (TMI-2) Reactor Building indicated a peak temperature following the hydrogen burn of less than 200°F. Using the equation of state for air, and the peak pressure (28 psig) shown by strip chart recorders during the burn, a peak Reactor Building spatial average temperature of about 1200°F may be calculated. In addition, physical damage to organic materials inside the Reactor Building indicates that temperatures greater than 450°F were reached. Calculations of the amount of hydrogen burned from oxygen depletion data in the containment atmosphere are not entirely consistent with any of the temperature or pressure data. The purpose of this investigation, therefore, is to determine which measurements are reliable indicators of what actually happened in the TMI-2 Reactor Building during and immediately following the hydrogen burn. A list of measurements reviewed is given in Table 1.

TABLE 1. LIST OF DATA REVIEWED

Resistance Temperature Detectors

AH-TE-5017, No. 1 Primary Shield
AH-TE-5018, No. 2 Primary Shield
AH-TE-5016, No. 3 Primary Shield
AH-TE-5019, No. 4 Primary Shield
AH-TE-5015, No. 1 Supply Air
AH-TE-5027, No. 2 Supply Air
AH-TE-5013, Ambient--Impingement Barrier
AH-TE-5010, Ambient--Sump area
AH-TE-5011, Ambient--let down cooler area
AH-TE-5012, Ambient--drain tank area
AH-TE-5020, Ambient--353-ft elevation
AH-TE-5021, Ambient--353-ft elevation
AH-TE-5023, Ambient--330-ft elevation
AH-TE-5022, Ambient--330-ft elevation
AH-TE-5014, Ambient--310-ft elevation
AH-TE-5088, Ambient--310-ft elevation

Once Through Steam Generators Pressures

OTSG Loop A steam pressures SP-6A-PT1 or SP-6A-PT2
OTSG Loop B steam pressures SP-6B-PT1 or SP-6B-PT2

Reactor Building Pressures (Strip Chart Records)

BS-PT-4388-1
BS-PT-4388-2

Reactor Building Pressure Switches (4 psig)

BS-PS-3570
BS-PS-3571
BS-PS-3572
BS-PS-3573

Emergency Suppression Building Spray Switches (28 psig)

BS-PS-3253
BS-PS-3254
BS-PS-3255
BS-PS-3256
BS-PS-3257
BS-PS-3258

Reactor Building Atmospheric Hydrogen and Oxygen Measurements

PRESENTATION OF DATA

Data from 16 Reactor Building RTDs and 2 once through steam generators (OTSG) pressure transducers listed in Table 1 have been entered into the INEL Cyber computer system under the file name TMIDATA, ID=BMG. Plots of these data are contained in Appendix A. Note that the OTSG pressure plots are designated as "qualified" data and the Reactor Building RTD data are designated "trend" data. The qualified designation indicates that the data are considered reliable indicators of the phenomena measured within the stated accuracy. The trend designation indicates that the data are not always reliable indicators of the phenomena measured and are useful only for discerning trends during some interval of the measurement.

Time sequenced data from the OTSG pressure transducers are given in Appendix B, and Appendix C contains strip chart records of the Reactor Building pressure as indicated by BS-PT-4388-1 and -2. Appendix D contains a record of the actuation and reset times for the Engineered Safety Features Reactor Building Pressure Switches, and Appendix E gives a compilation of Reactor Building atmosphere hydrogen, oxygen, and nitrogen analyses. Appendix F is a memorandum concerning the hydrogen phenomena, Appendix G is an interpretation of OTSG pressure data, and Appendix H is a report on the reactimeter zero offset shifts.

PERTINENT OBSERVATIONS

Temperature

Scorched paper indicated that Reactor Building gas temperatures had reached at least 450°F.[1] Polymers and numerous other objects were found that indicated temperatures of 480°F and 165 to 500°F respectively. The wide variation in indicated material temperatures reported in Reference 1 is probably due to variations in thermal diffusivities, surface area to volume ratios and heat capacities, and moisture content or moisture film thicknesses which existed on the samples just prior to the burn. Also, there is evidence, as reported in Appendix F, that the containment air circulation system was operating continuously during the accident. Since the Reactor Building atmosphere turnover time (free volume divided by the volumetric flow rate) was about nine minutes, it is unlikely that there could have been high local concentrations of hydrogen to account for the variations in material temperatures observed in Reference 1. In addition, Reactor Building pressure data indicate that the average Reactor Building gas temperature had decreased to between 220 and 240°F within two minutes of burn initiation and to between 190 and 210°F within four minutes. All these observations point to a maximum temperature during the transient of higher than 450 to 500°F.

CREDIBILITY OF DATA

Temperature

During the hydrogen burn transient, the Reactor Building RTD data plotted in Appendix A are only worthwhile for estimating trends. The data points were too far apart in time (6 min) to give a detailed understanding of the rapid heatup and cooldown transients during the burn. The RTD data are worthwhile for substantiating that a burn did occur, for indicating relative effects in various parts of the Reactor Building, and for studying more gradual temperature changes during the accident sequence.

Pressure

The OTSG steam pressure data when interpreted as suggested in Appendix G are reliable within the specified accuracy of the instruments (±2.7 psi for the sum of deadband, repeatability, hysteresis, and drift) for estimating the change in containment pressure during the period from burn initiation, 13:49:12, reactimeter time to 13:51:00 reactimeter time. Since the response time of the pressure transducers (1.17 s) is somewhat slow, and also since the sampling rate (1 point every 3 s) is low, the peak value of containment pressure was missed. A test is now underway to confirm that the peak indicated value is within the instrument error band (±2.7 psi) of the actual peak pressure. Back extrapolating the pressure decrease curve to its intersection with the linear pressure rise curve certainly provides a conservative estimate of the peak containment pressure.[2]

As explained in Appendix F, three out of the four OTSG pressure transducers were not affected by buildup of water on the containment floor and the general agreement of the OTSG pressure transducers indicates a high degree of confidence. The time shift between transducers could be partly due to one transducer being submerged. (See Appendix B).

The trip and reset pressures indicated for 28 psig and 4 psig engineered safety features pressure switches in Appendix D are accurate within

±1.0 psig for the 28 psig switches and ±0.2 psig for the 4 psig switches. This accuracy is attributable to the accuracy of the Heise gauges used for calibration.

Additional credibility is lent to all the pressure data including the strip chart recorders BS-PT-4388-1 and -2, because of the general agreement of peak indicated pressures. However, since timely calibration data and operating characteristics of BS-PT-4388-1 and -2 and their associated strip chart recorder are not available, it is not possible to put numerical limits on the uncertainty in the chart recorder pressure data.

CONTAINMENT BUILDING HYDROGEN AND OXYGEN DATA

The data reported in Appendix E are not reliable for determining the amount of hydrogen burned because (a) the accuracy of the analytical techniques is unknown, (b) the representativeness of the samples is unknown, (c) the amount of oxygen and hydrogen produced by radiolysis of the Reactor Building sump water is unknown, and (d) the amount of oxygen consumed and hydrogen produced by corrosion of Reactor Building components is unknown.

CONCLUSIONS

Based on instrument specification data and agreement between multiple redundant measurements, the OTSG steam pressure data, when interpreted as described in Appendix G, and 16 engineered safeguards pressure switches provide a reliable indication of Reactor Building pressure during the hydrogen burn.

Due to the low sampling rate, the RTD data are suitable only for estimating temperature trends at different locations in the building during the hydrogen burn. The RTD data should not be used as actual values for the temperatures that were present during the burn.

The containment atmosphere gas composition data shown in Appendix E are not reliable for determining the amount of hydrogen burned.

REFERENCES

1. H. W. Schutz, P. K. Nagata, Estimated Temperatures in the TMI-2 Containment Building during the 1979 Accident, GEND-INF-023, Vol. 2, August 1982.

2. J. O. Henrie, A. K. Postma, Analysis of the Three Mile Island (TMI-2) Hydrogen Burn, GEND-INF-023 Vol. IV. March 1983.

APPENDIX A

RTD AND OTSG PRESSURE INDICATIONS DURING THE TMI-2 HYDROGEN BURN

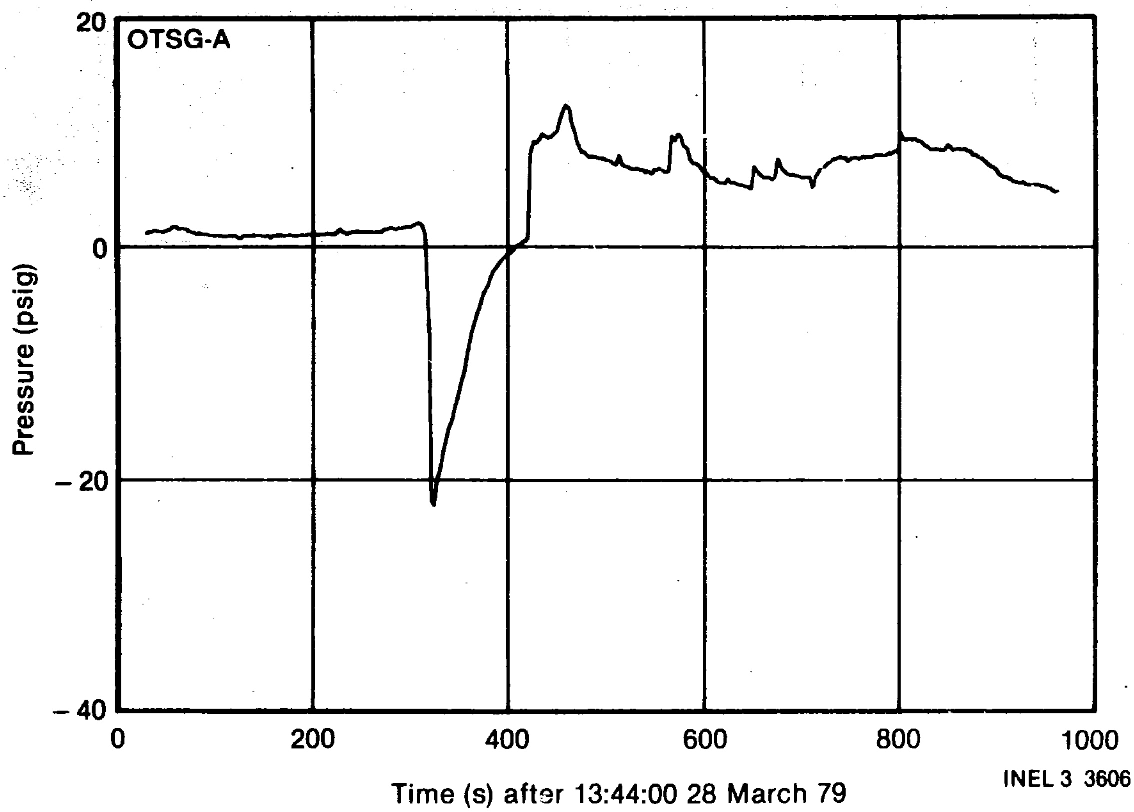

Figure A-1. OTSG-A steam pressure (qualified).

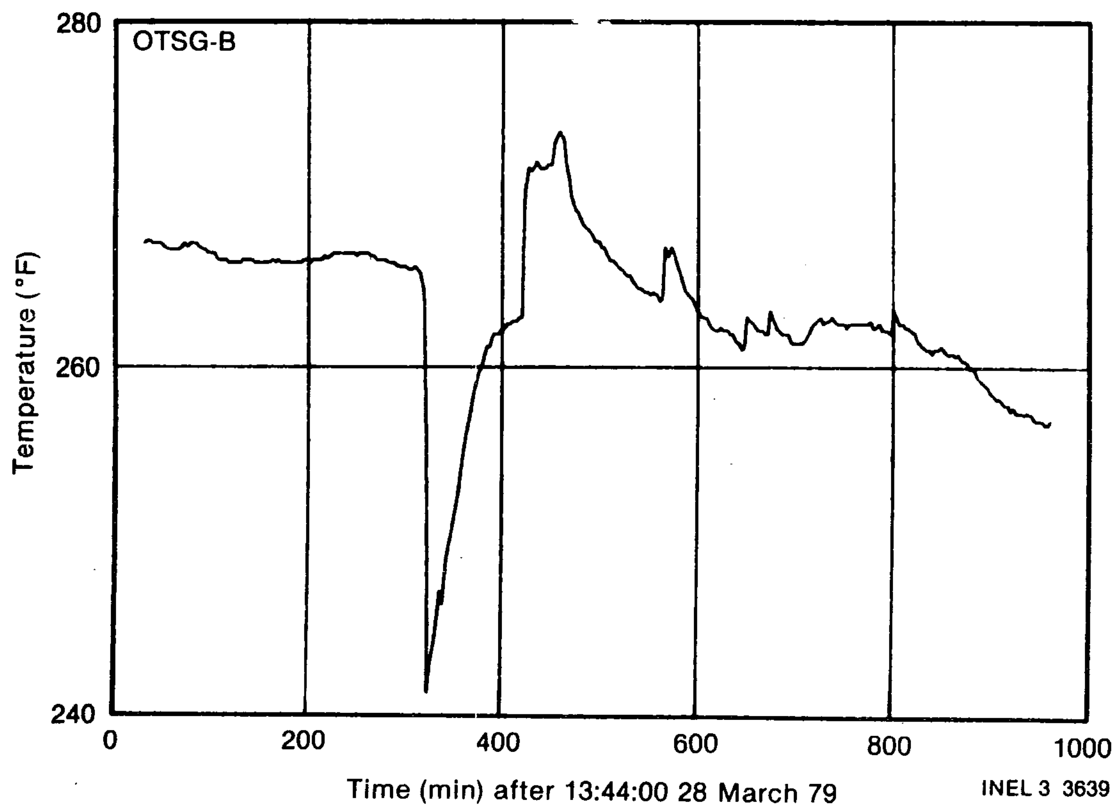

Figure A-2. OTSG-B steam pressure (qualified).

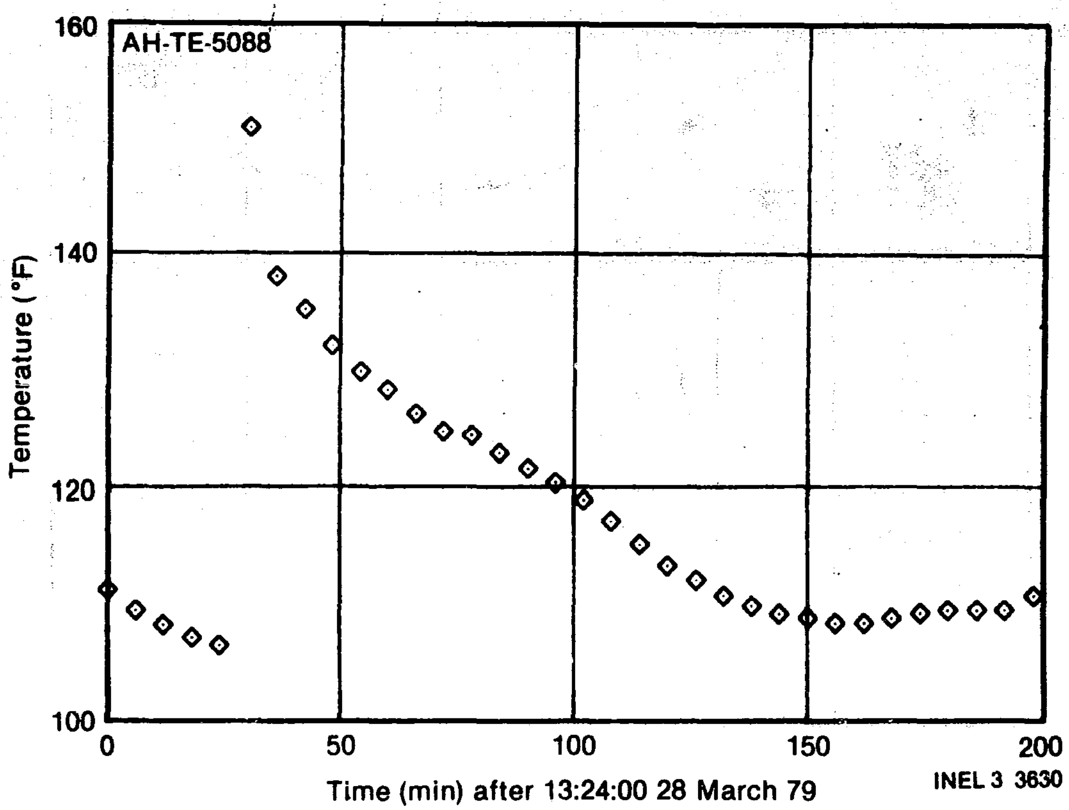

Figure A-3. Southeast stairwell ambient air temp 310 R-18A (short term trend).

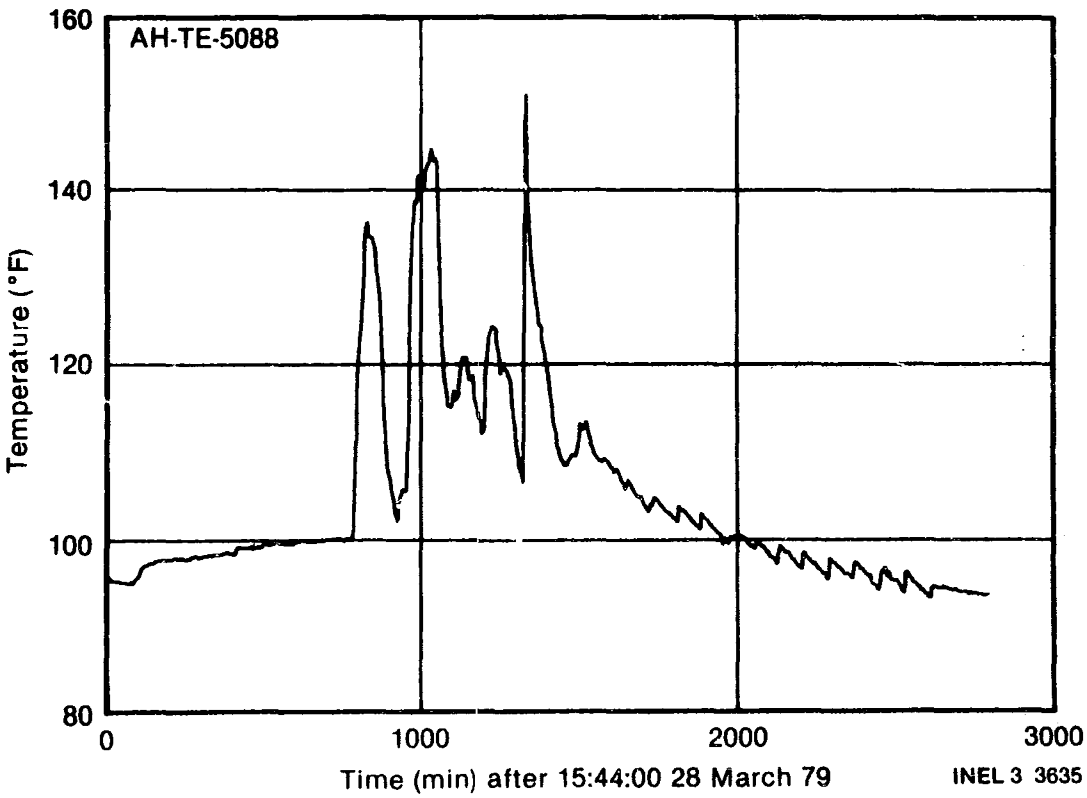

Figure A-4. Southeast stairwell ambient air temp 310 R-18A (long term trend).

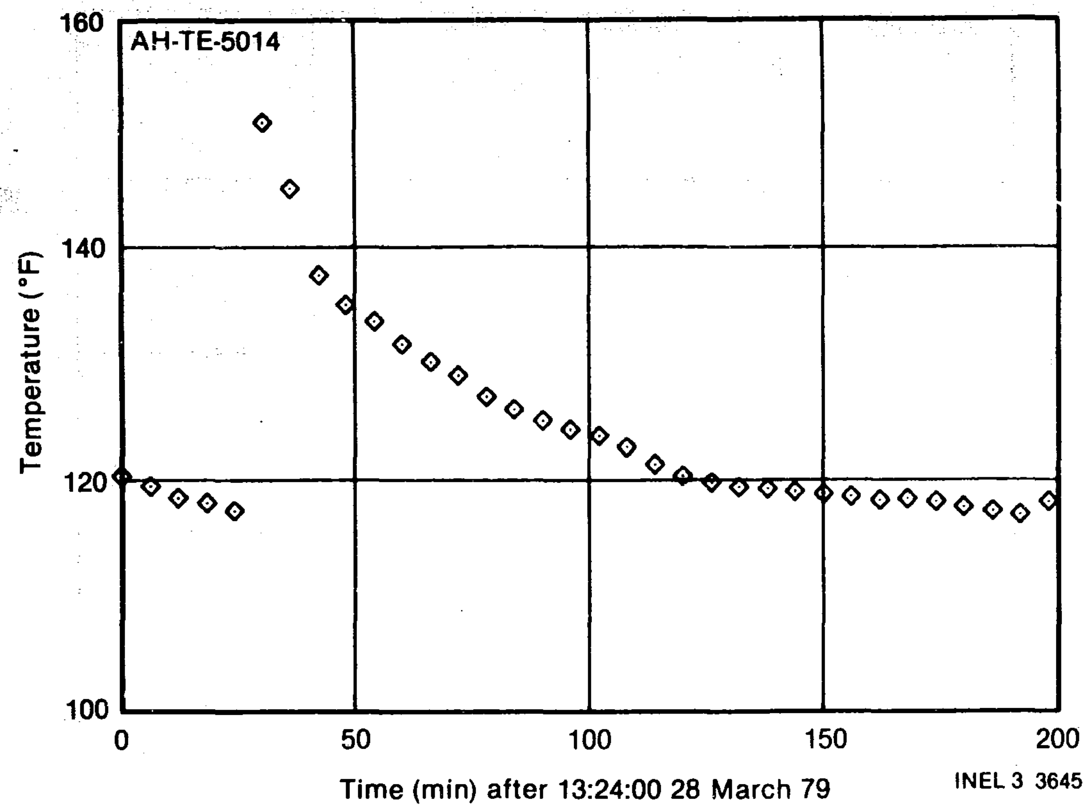

Figure A-5. Lower equipment hatch ambient air temp 305 (short term trend).

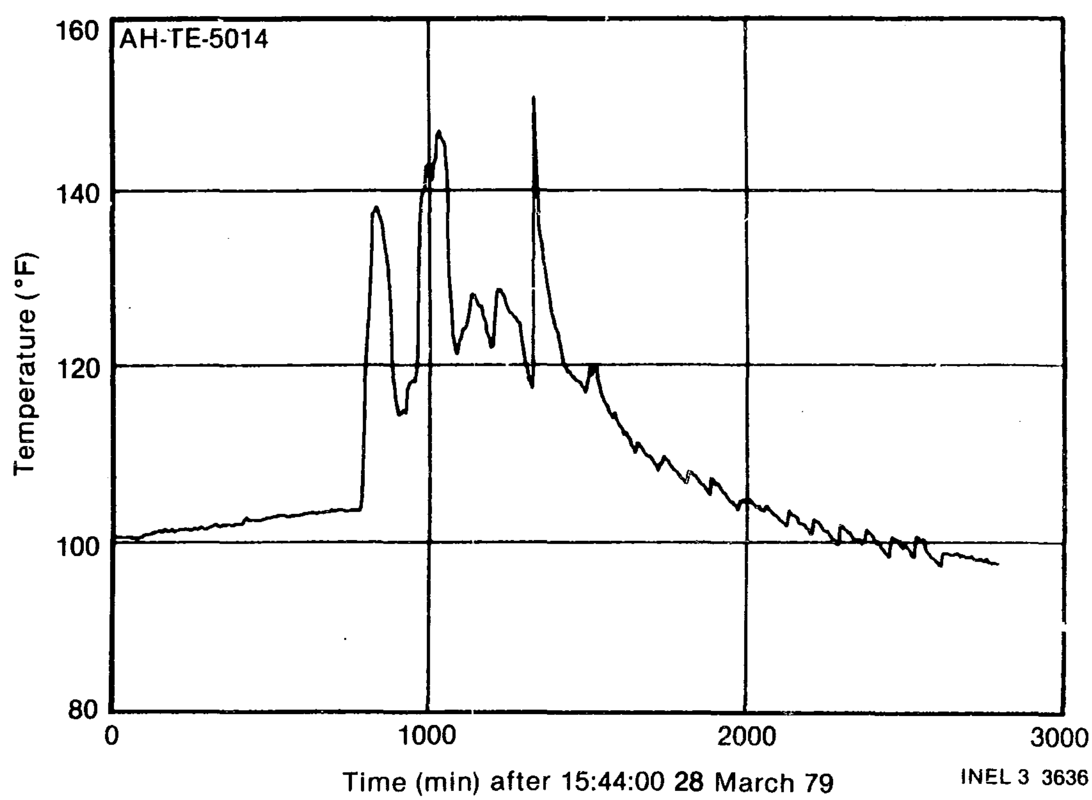

Figure A-6. Lower equipment hatch ambient air temp 305 (long term trend).

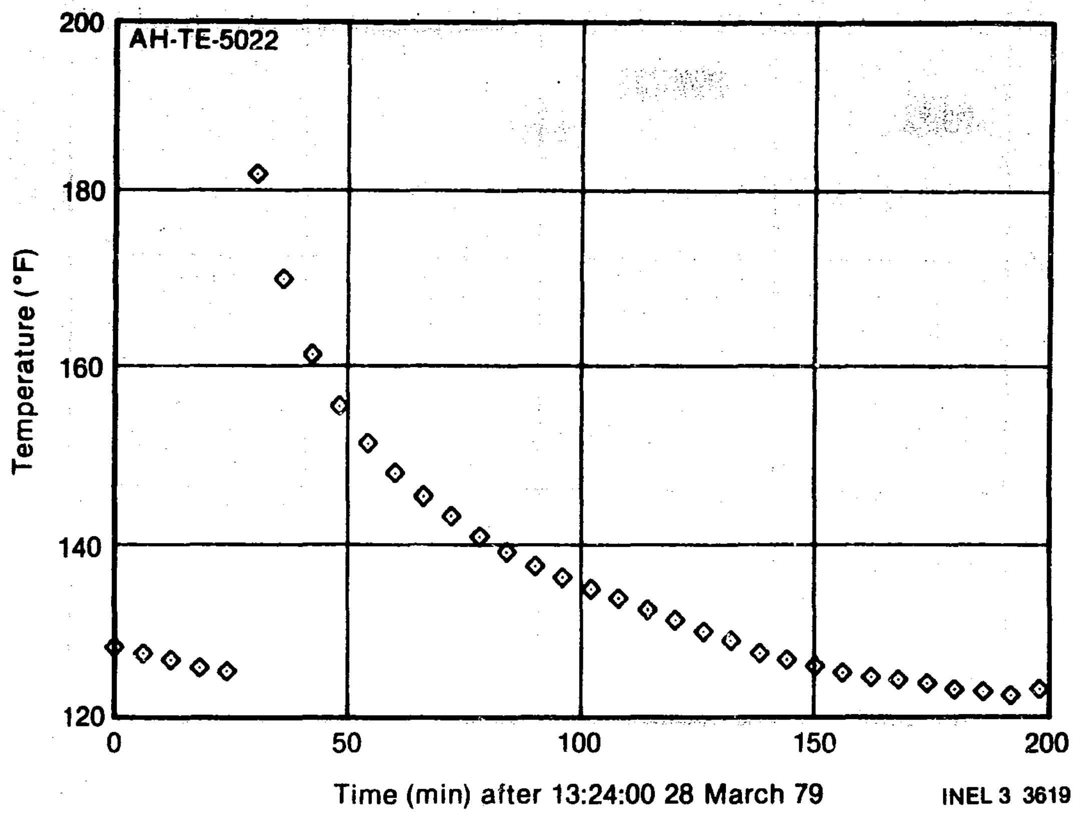

Figure A-7. Southeast stairwell ambient air temp 330 R-16A (short term trend).

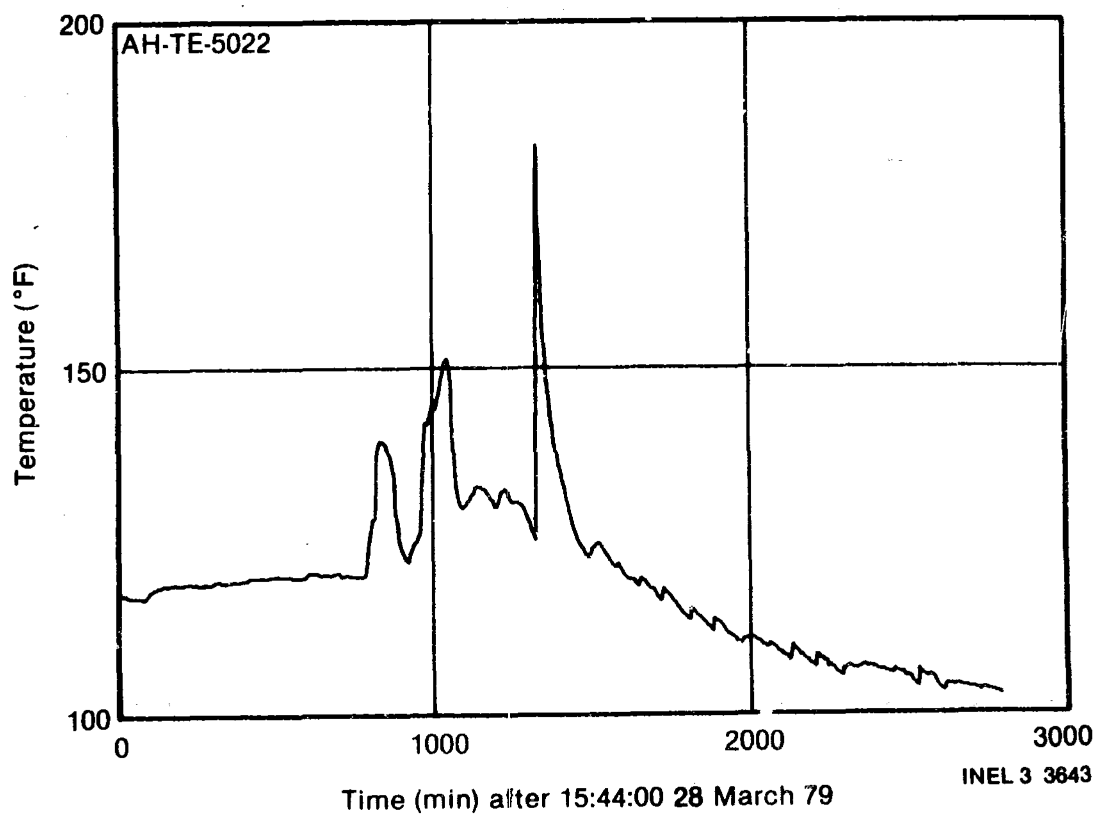

Figure A-8. Southeast stairwell ambient air temp 330 R-16A (long term trend).

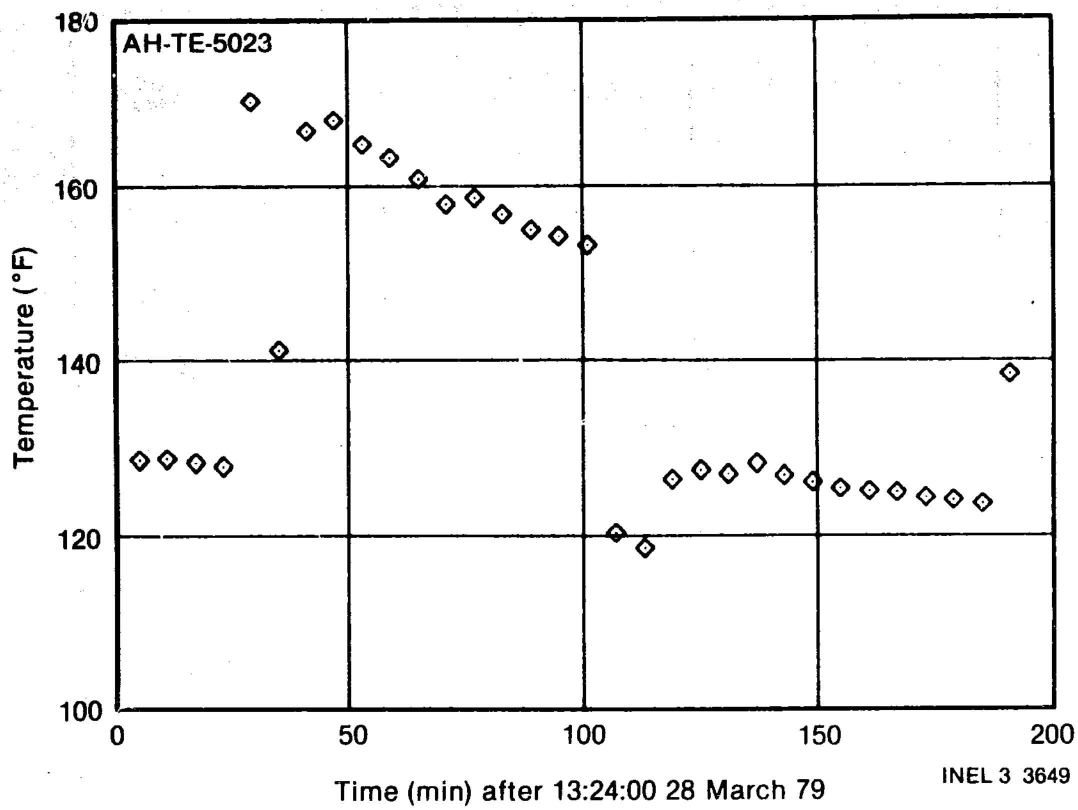

Figure A-9. West stairwell ambient air temp 330 R-5 (short term trend).

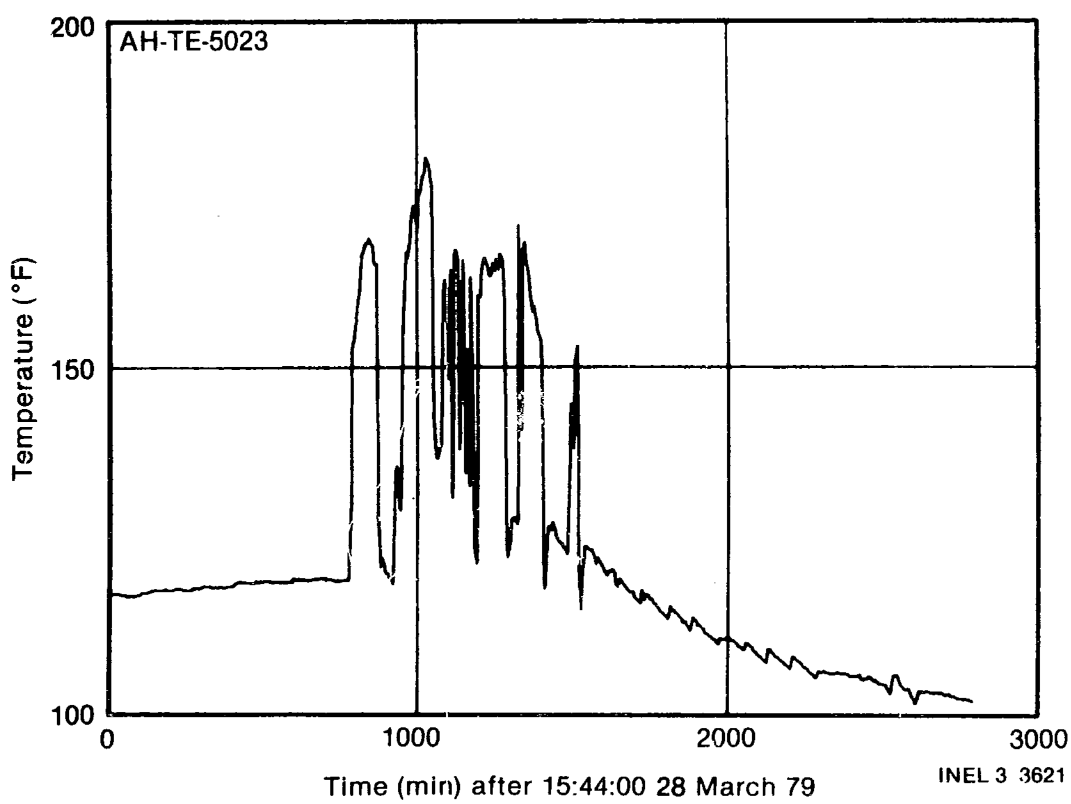

Figure A-10. West stairwell ambient air temp 330 R-5 (long term trend).

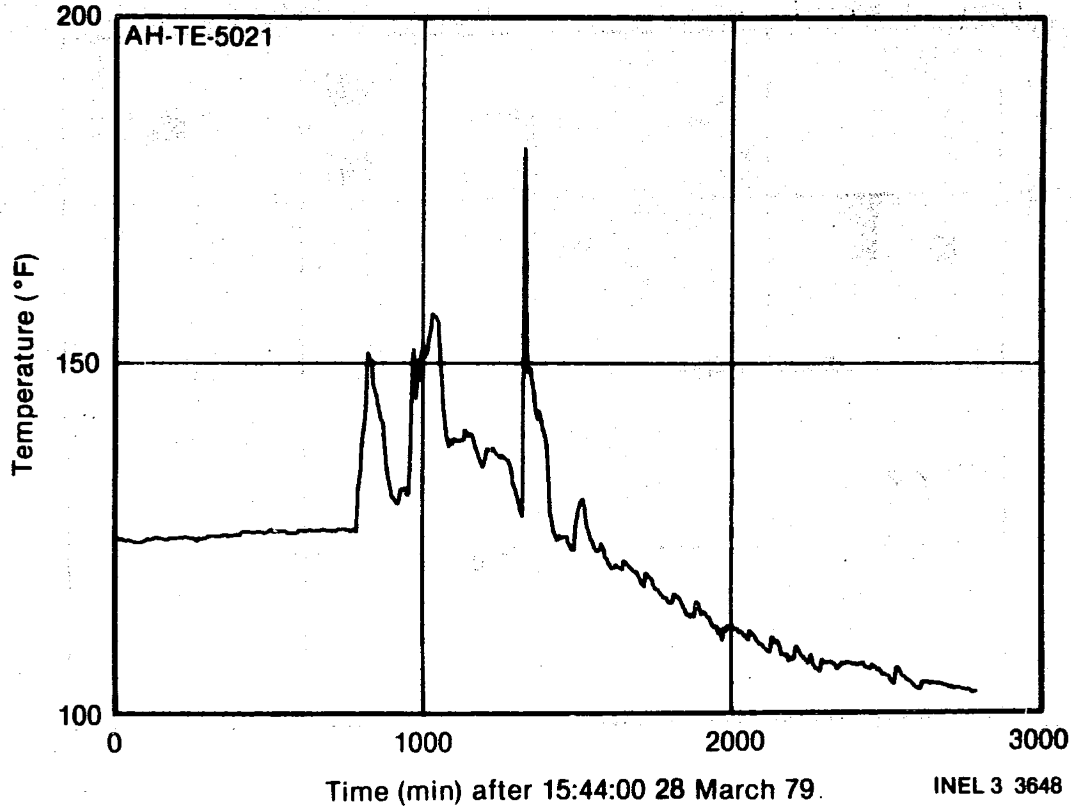

Figure A-11. Top ceiling ambient air temp 353 R-7 (short term trend).

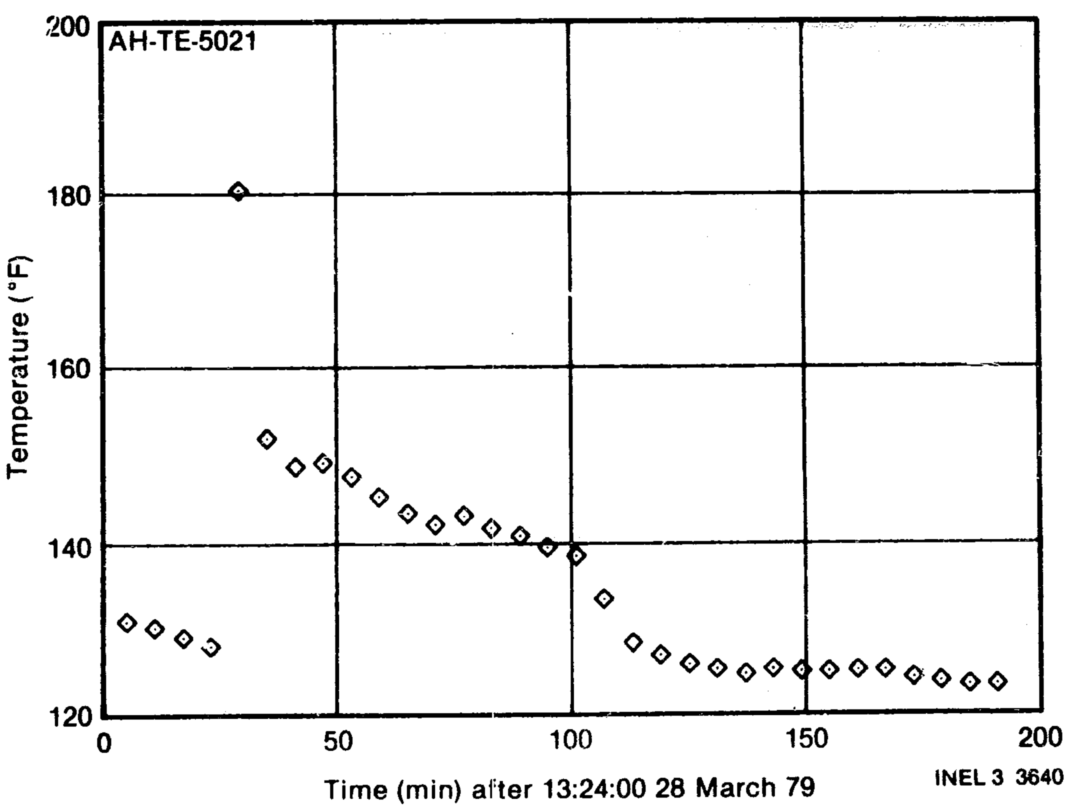

Figure A-12. Top ceiling ambient air temp 353 R-7 (long term trend).

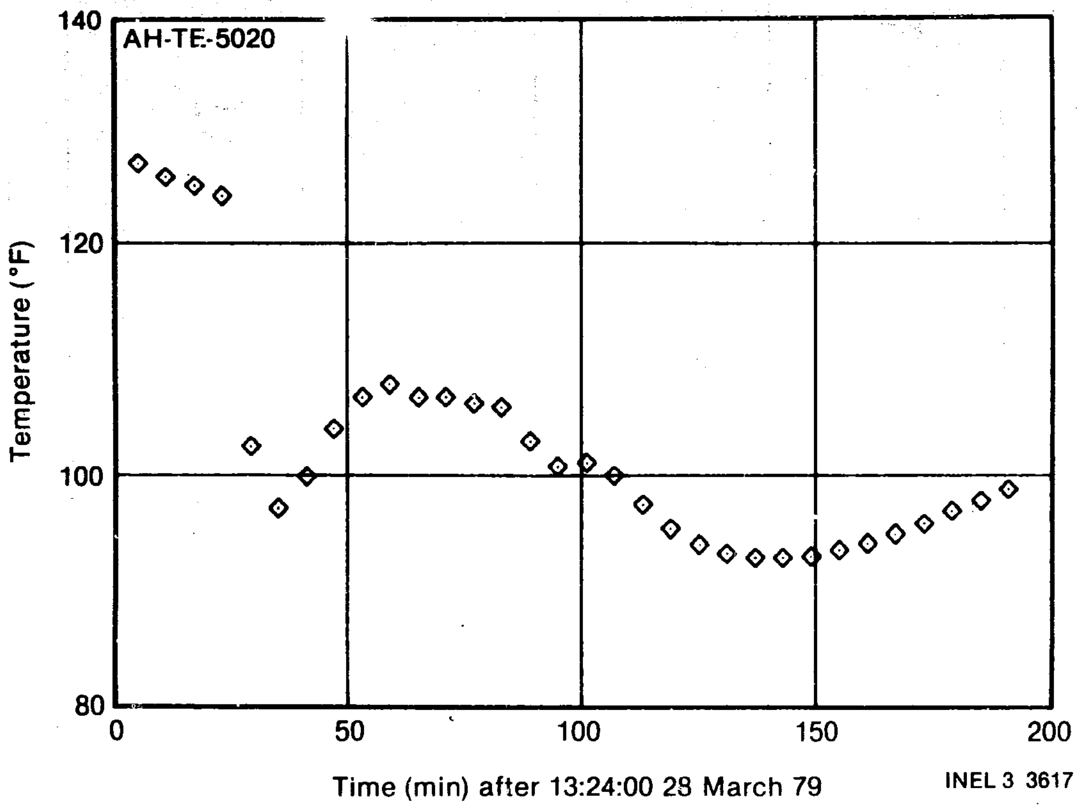

Figure A-13. Top ceiling ambient air temp 353 R-15 (short term trend).

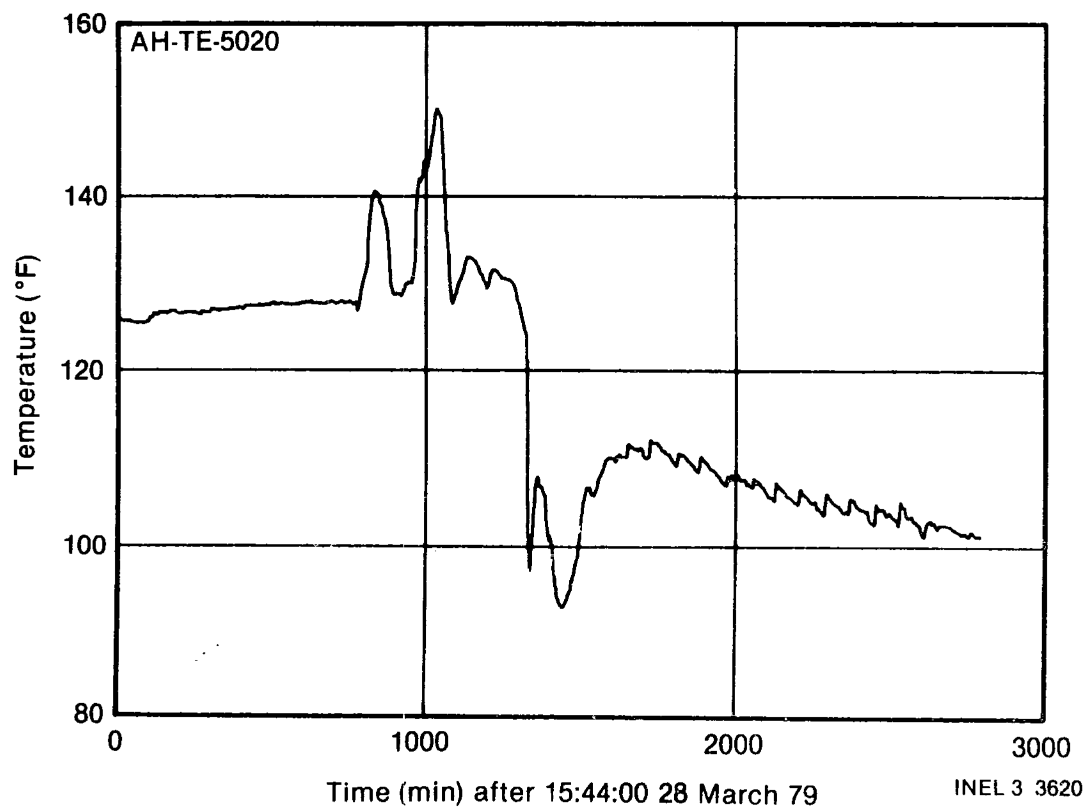

Figure A-14. Top ceiling ambient air temp 353 R-15 (long term trend).

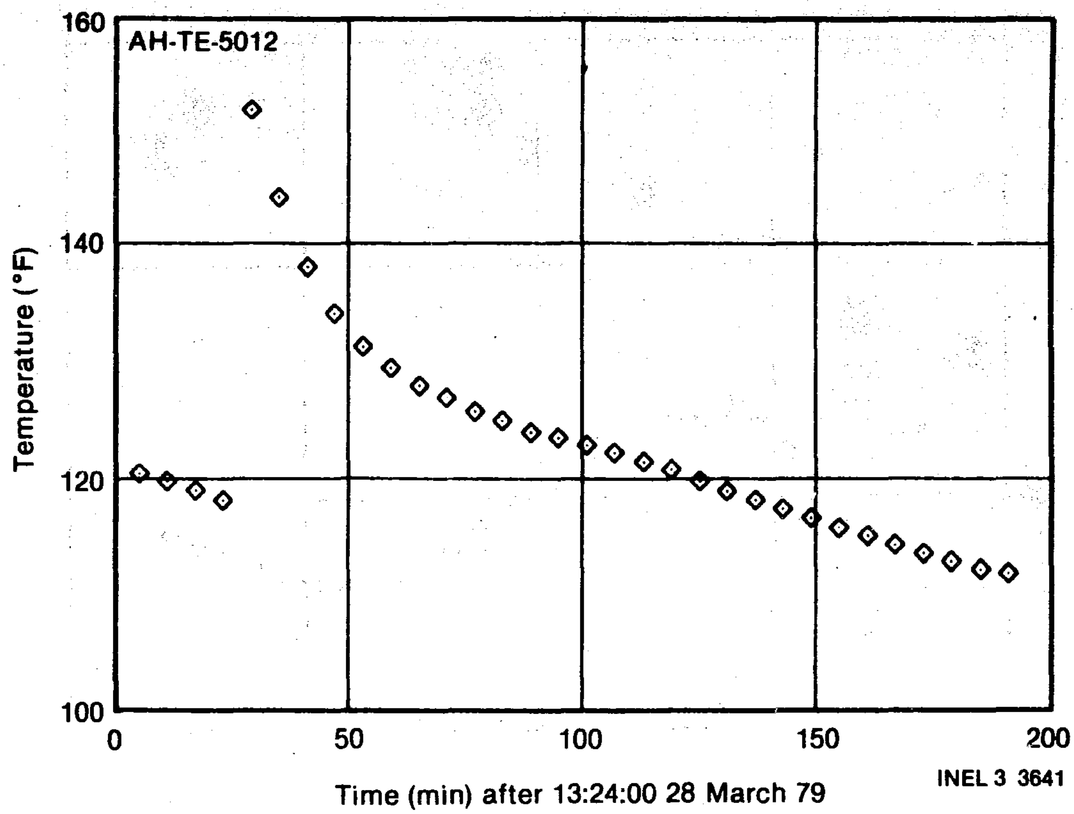

Figure A-15. Reactor coolant drain tank ambient air temp 282 (short term trend).

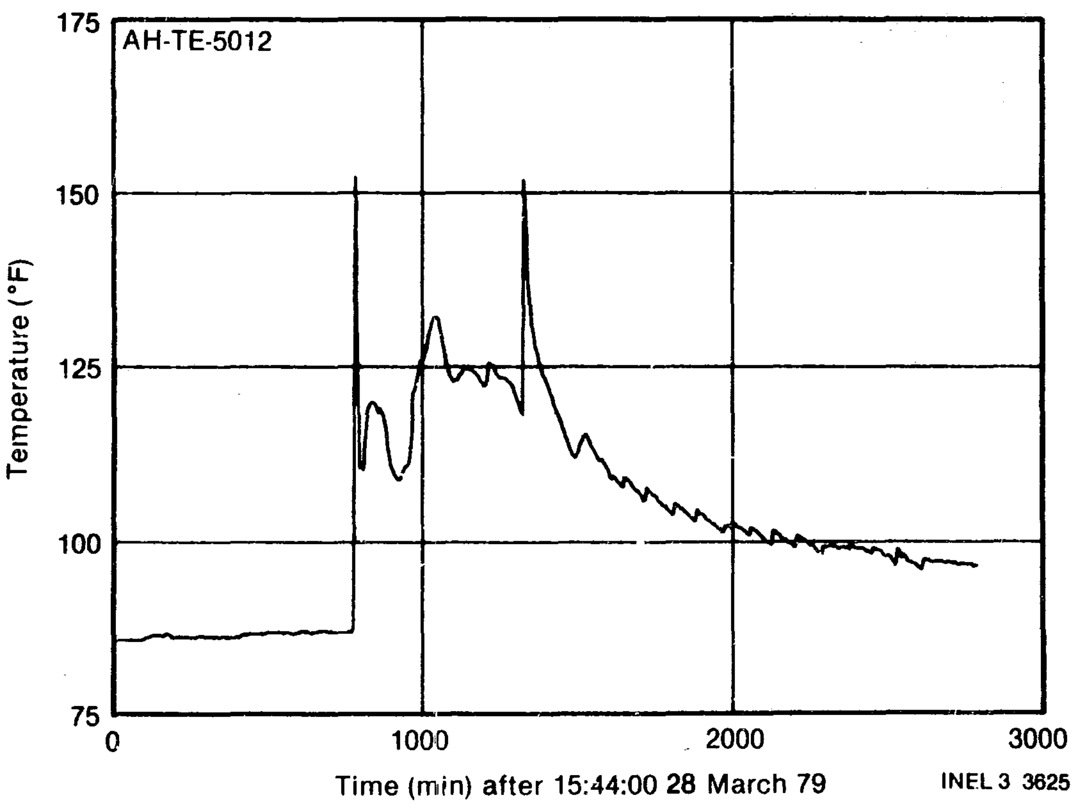

Figure A-16. Reactor coolant drain tank ambient air temp 282 (long term trend).

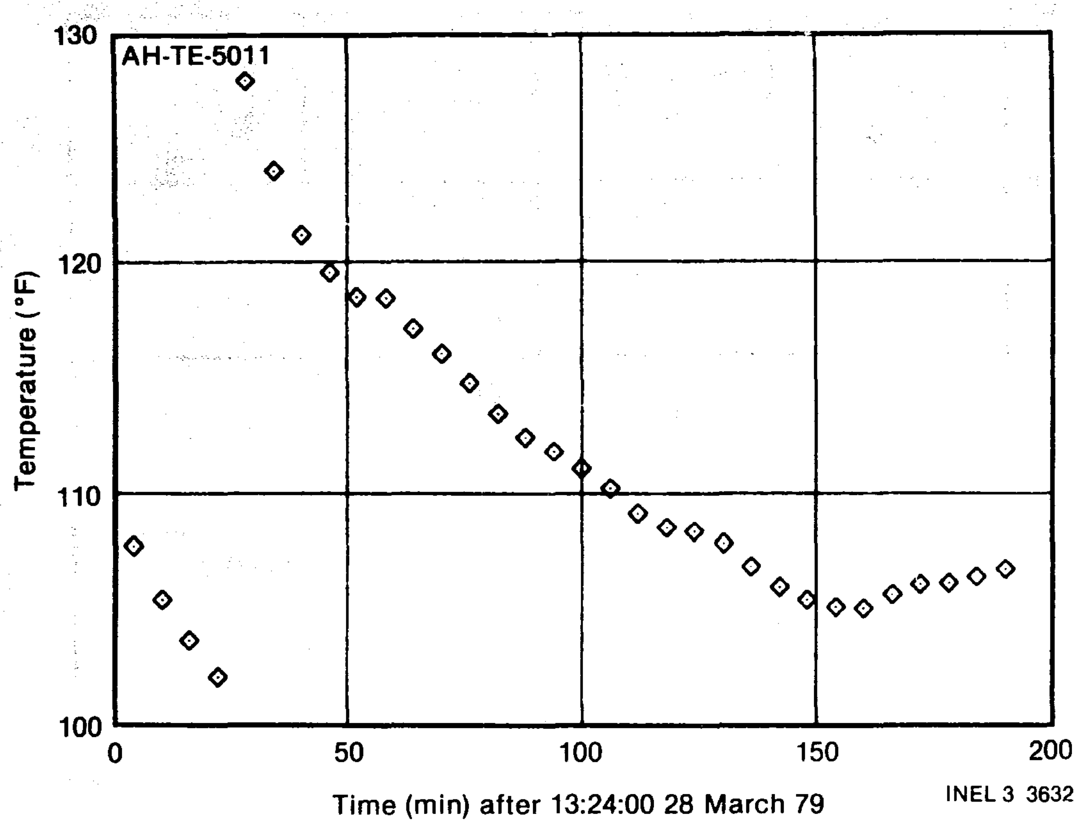

Figure A-17. Letdown cooler ambient air temp 282 (short term trend).

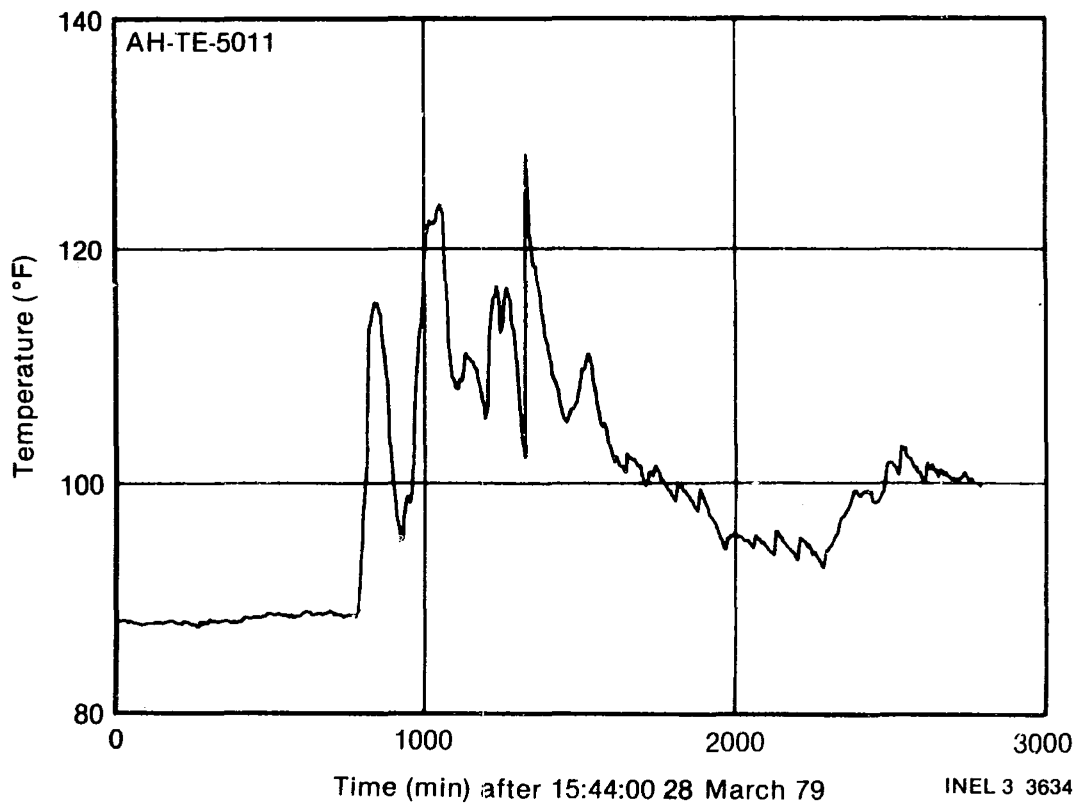

Figure A-18. Letdown cooler ambient air temp 282 (long term trend).

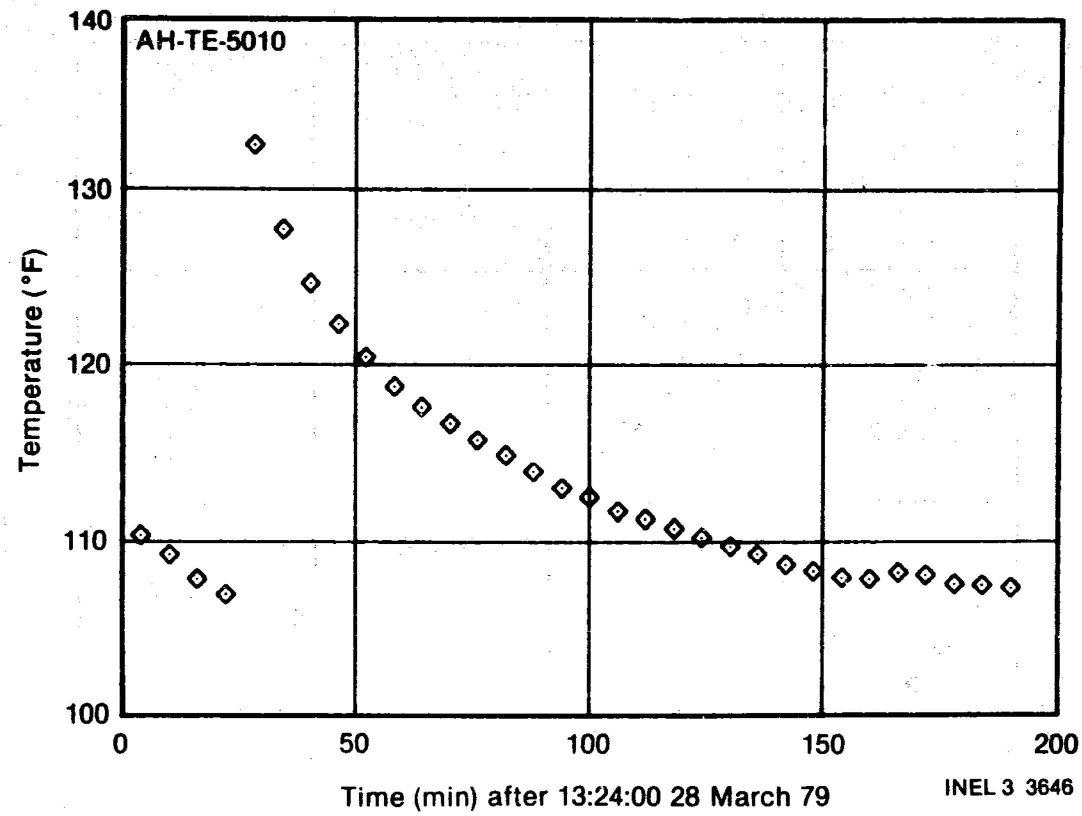

Figure A-19. Sump pump ambient air temp 282 pump room (short term trend).

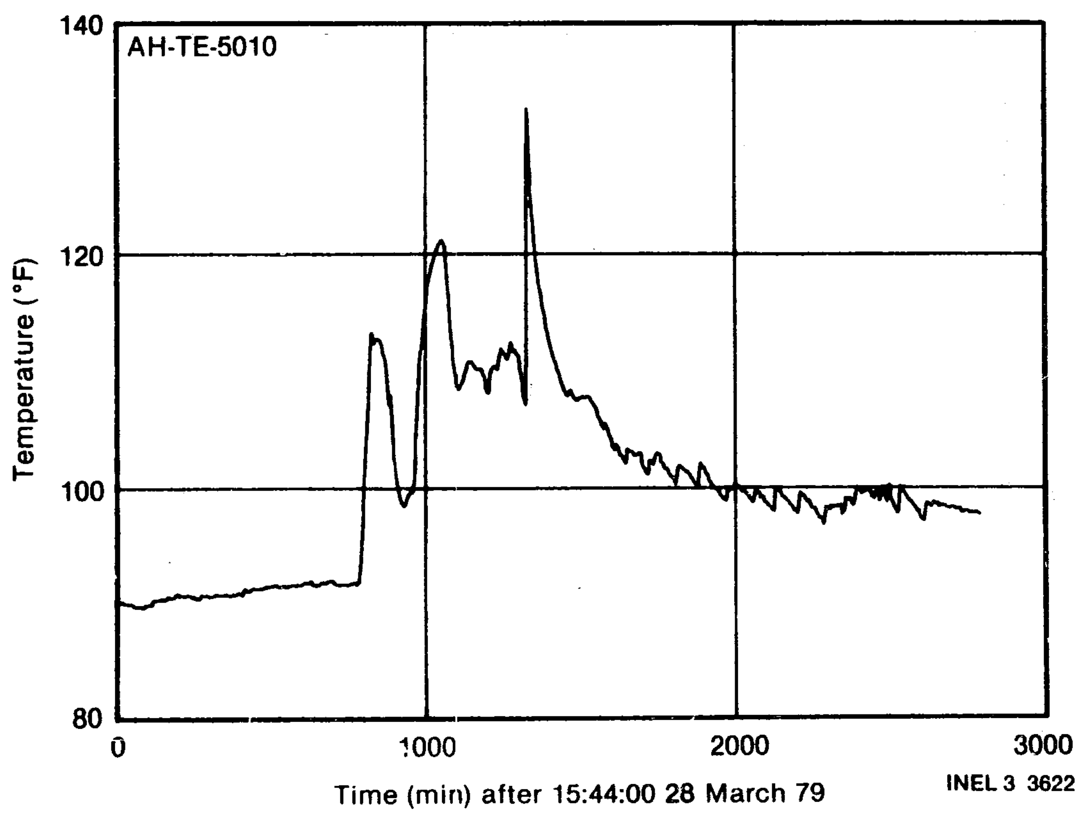

Figure A-20. Sump pump ambient air temp 282 pump room (long term trend).

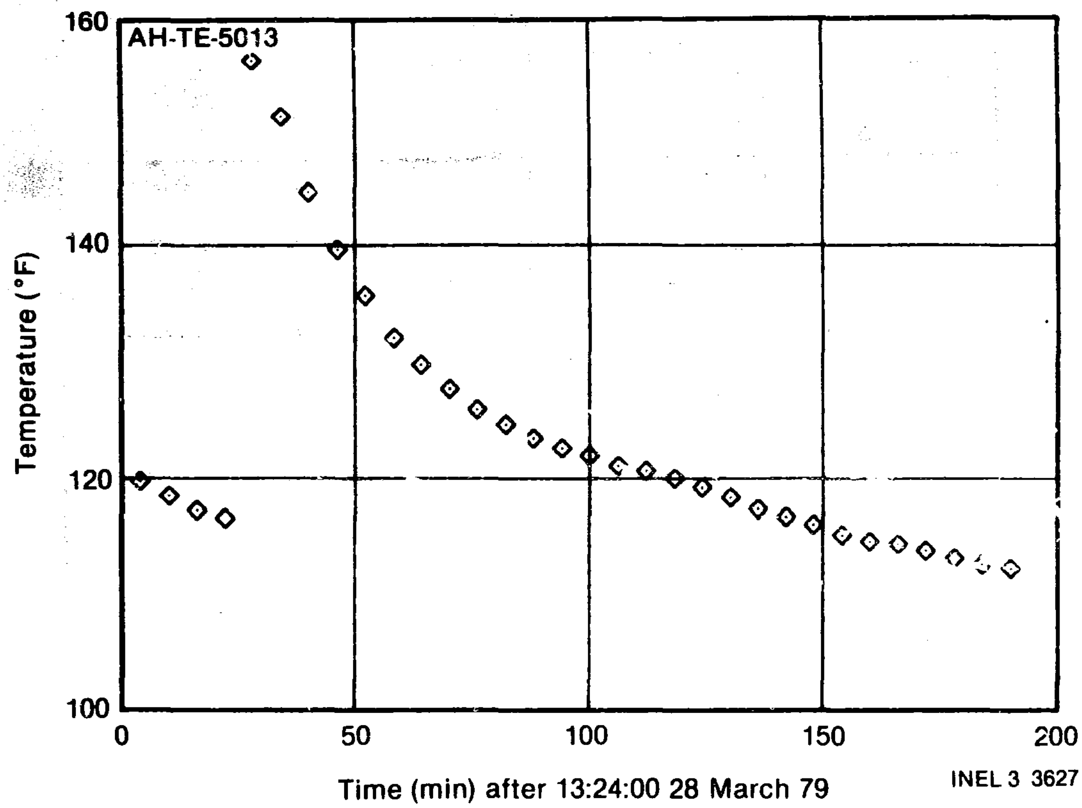

Figure A-21. Impinge bar ambient air temp 282 (short term trend).

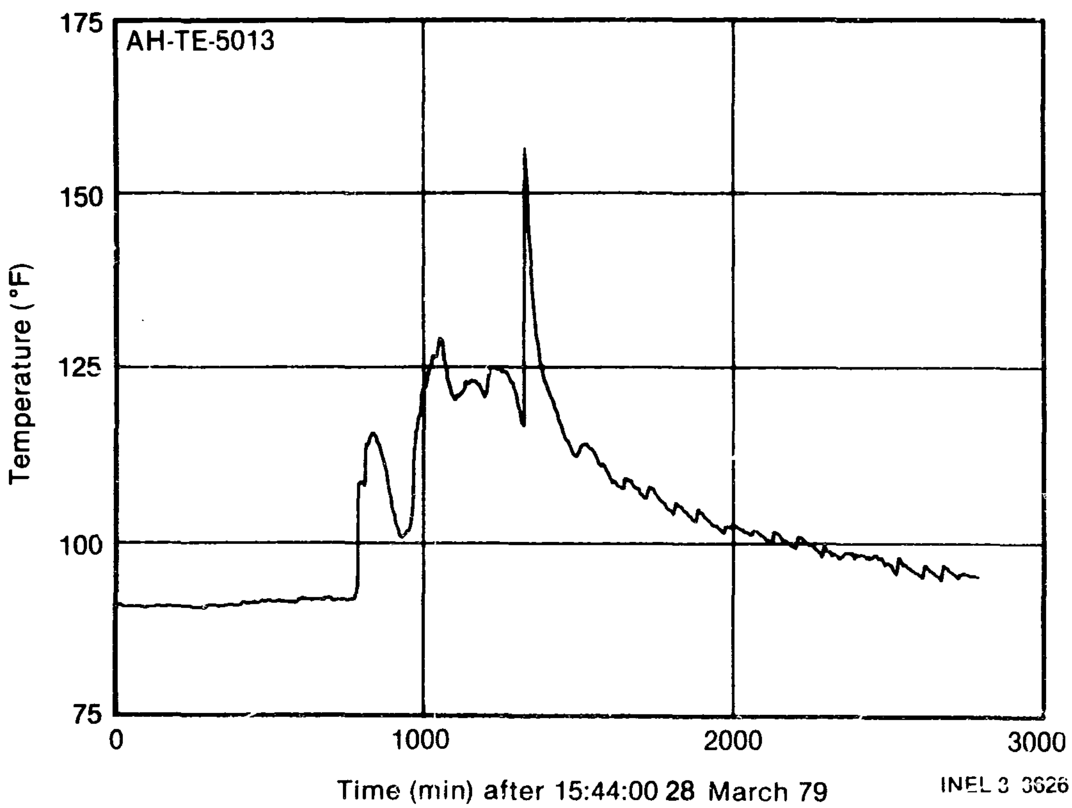

Figure A-22. Impinge bar ambient temp 282 (long term trend).

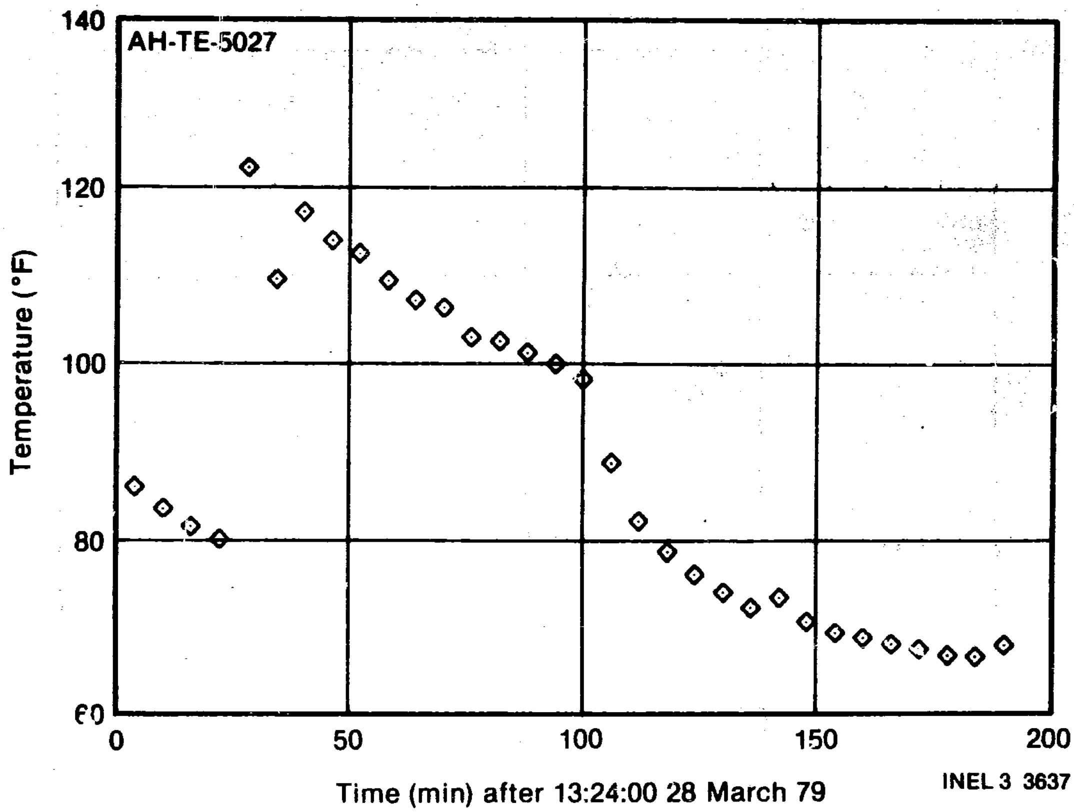

Figure A-23. Aircooler plenum outlet temp 305 R-01 (short term trend).

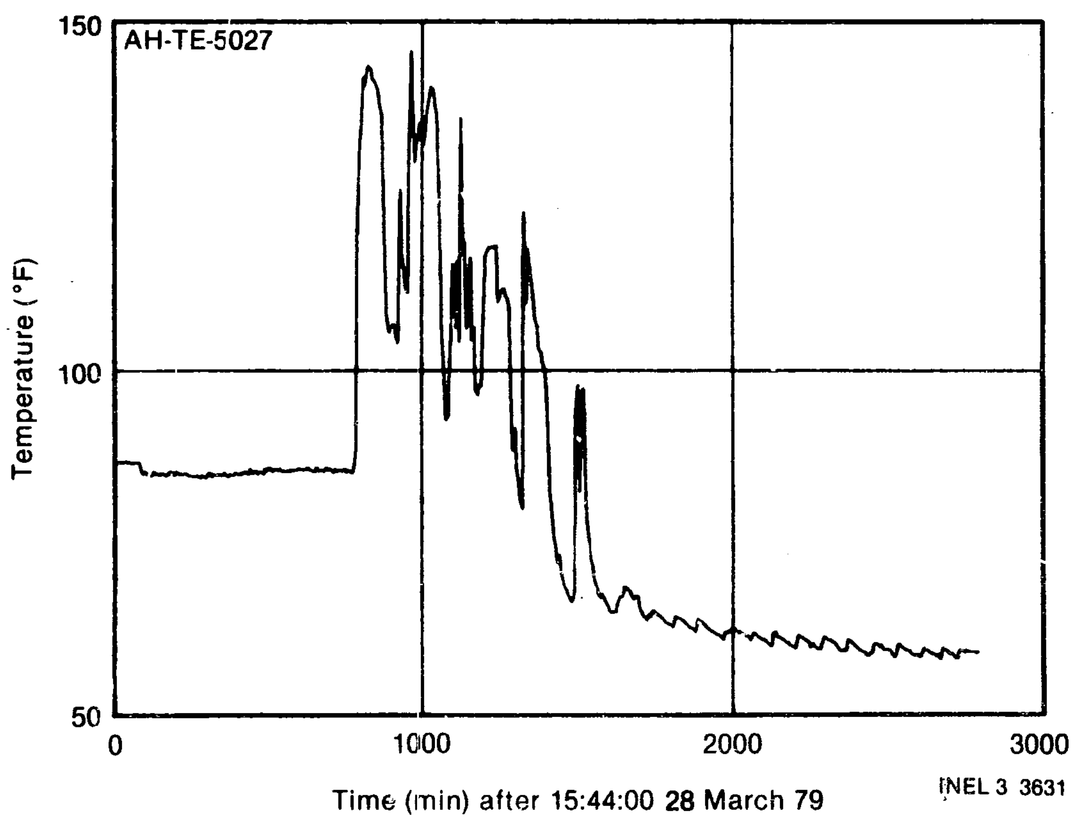

Figure A-24. Aircooler plenum outlet temp 305 R-01 (long term trend).

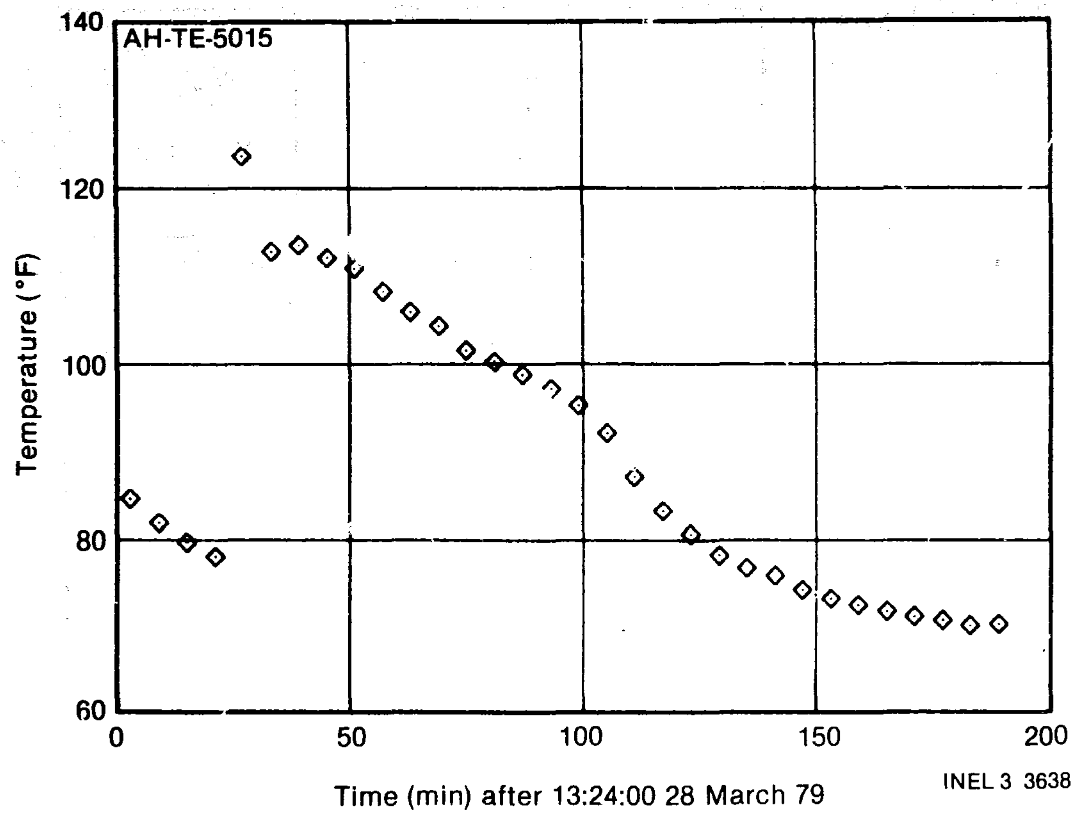

Figure A-25. Aircooler plenum outlet temp 319 (long term trend).

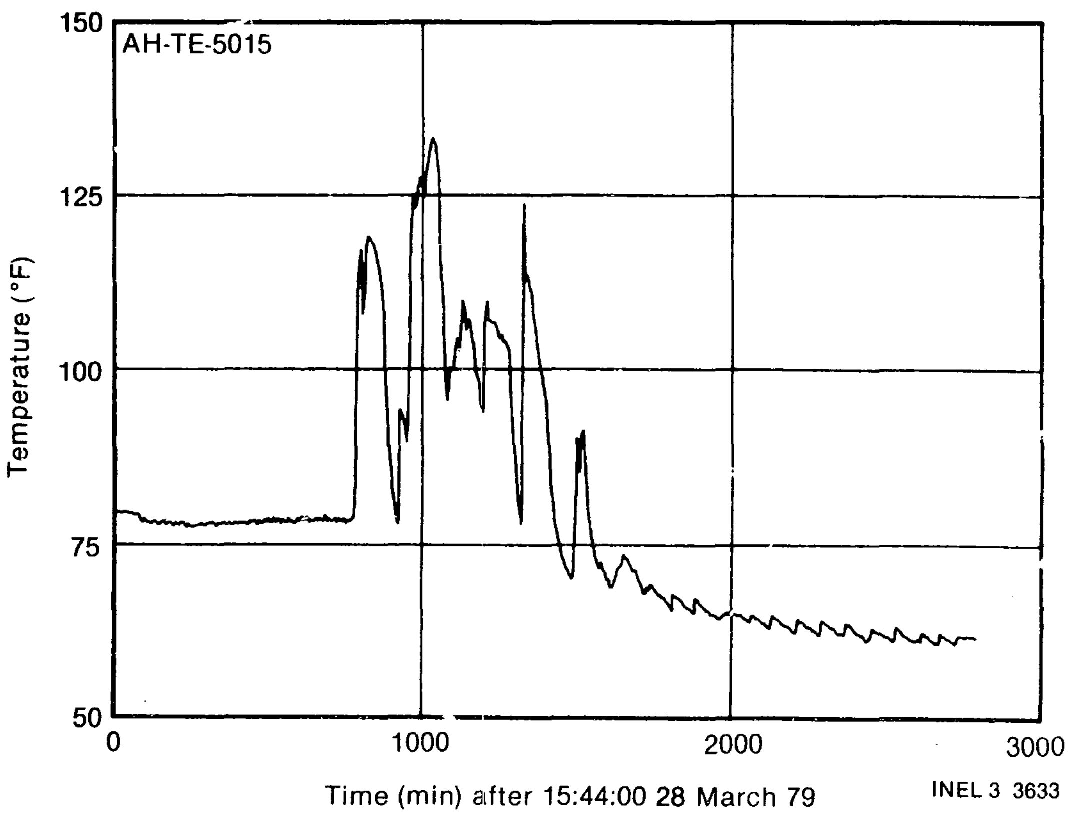

Figure A-26. Aircooler plenum outlet temp 319 (long term trend).

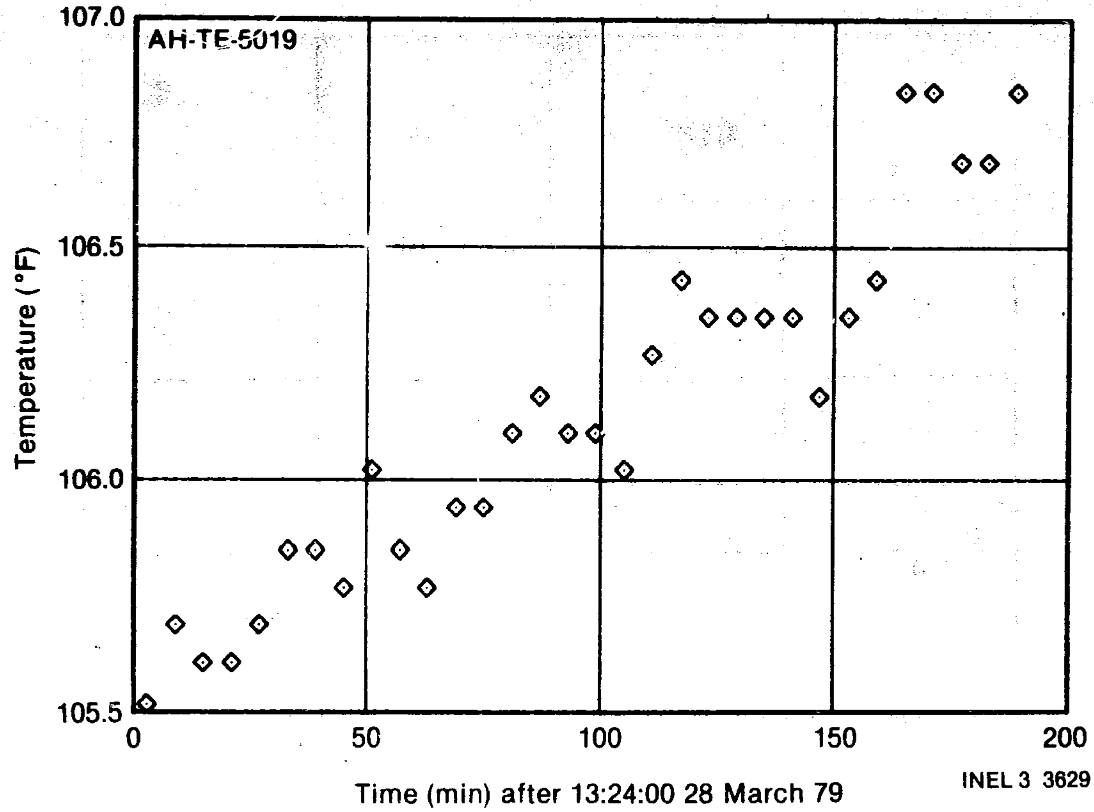

Figure A-27. Primary shield ambient air temp 282 (short term trend).

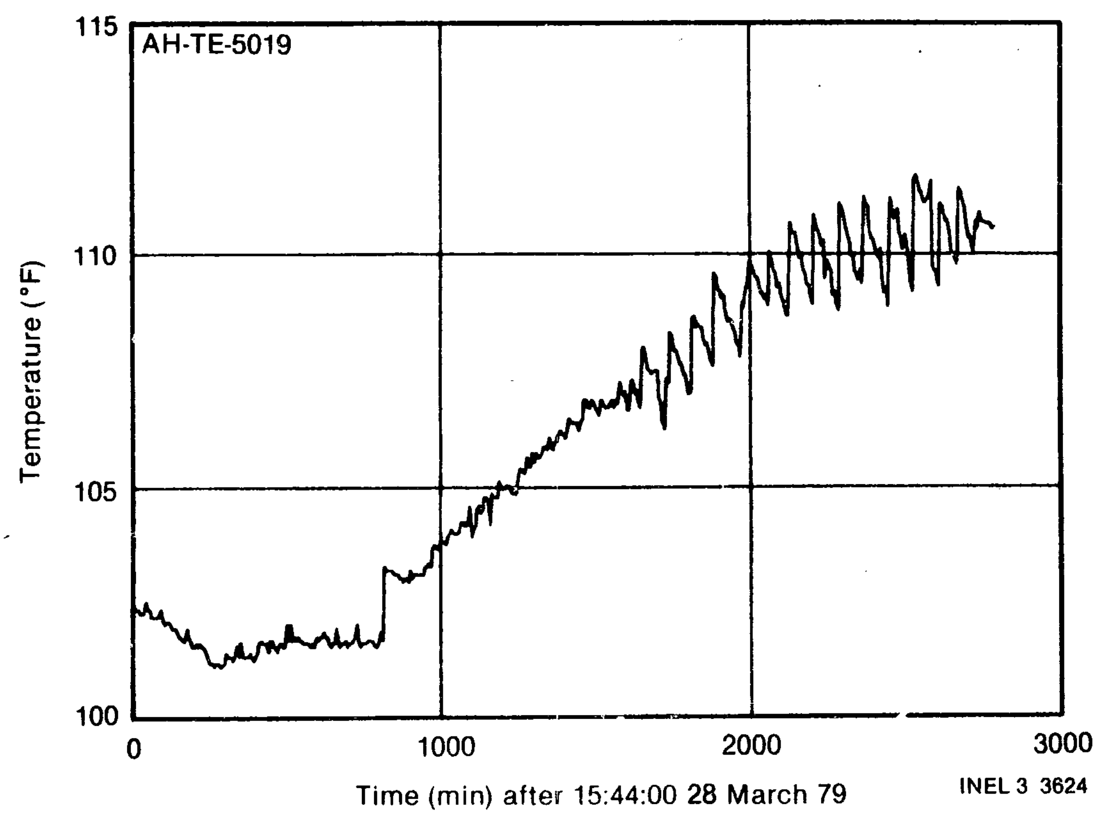

Figure A-28. Primary shield ambient air temp 282 (long term trend).

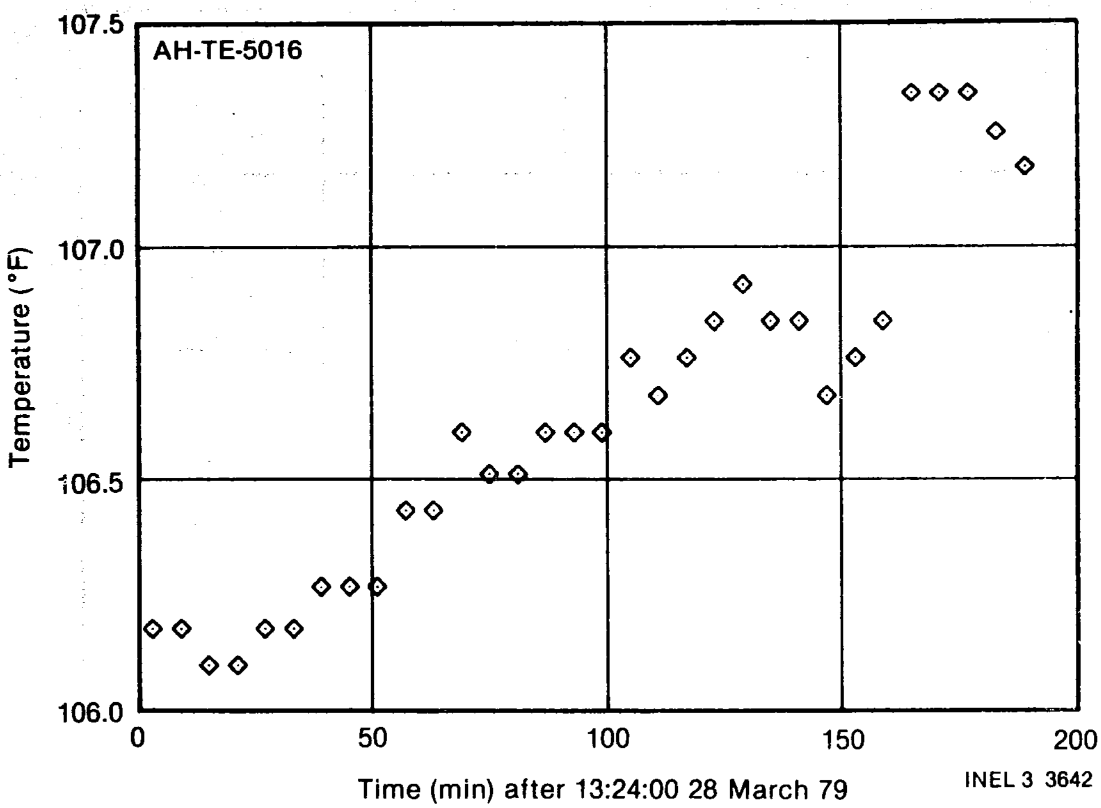

Figure A-29. Primary shield ambient air temp 282 (short term trend).

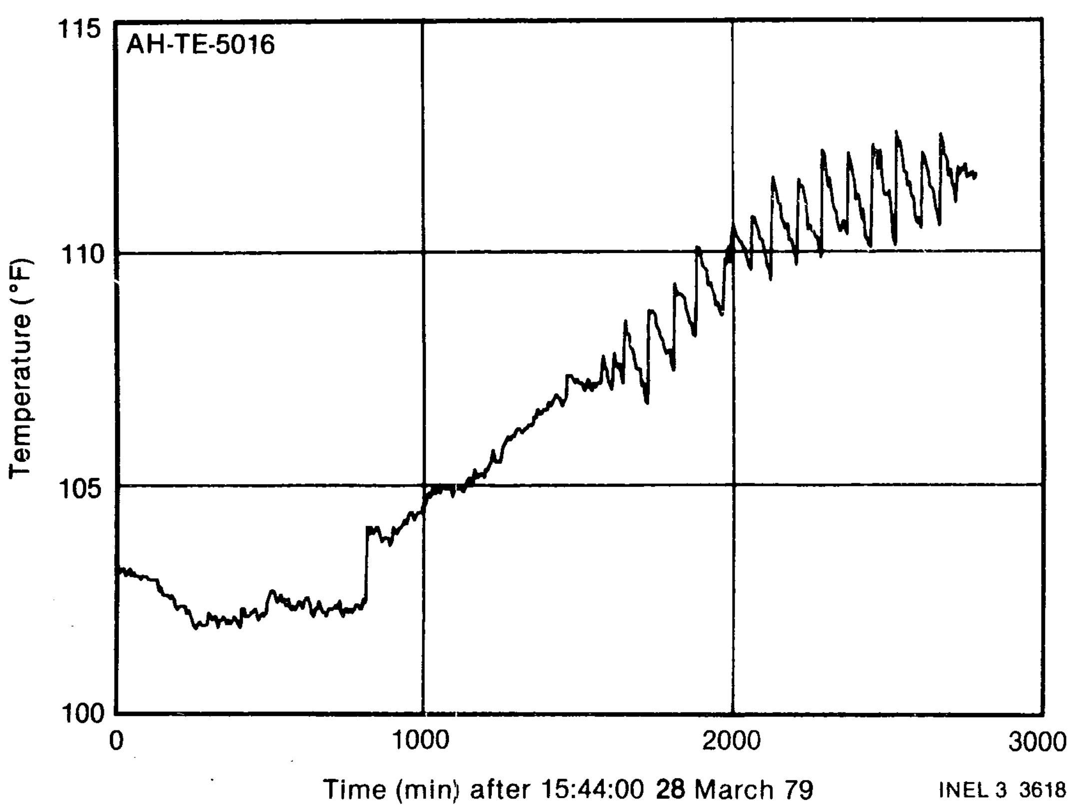

Figure A-30. Primary shield ambient air temp 282 (long term trend).

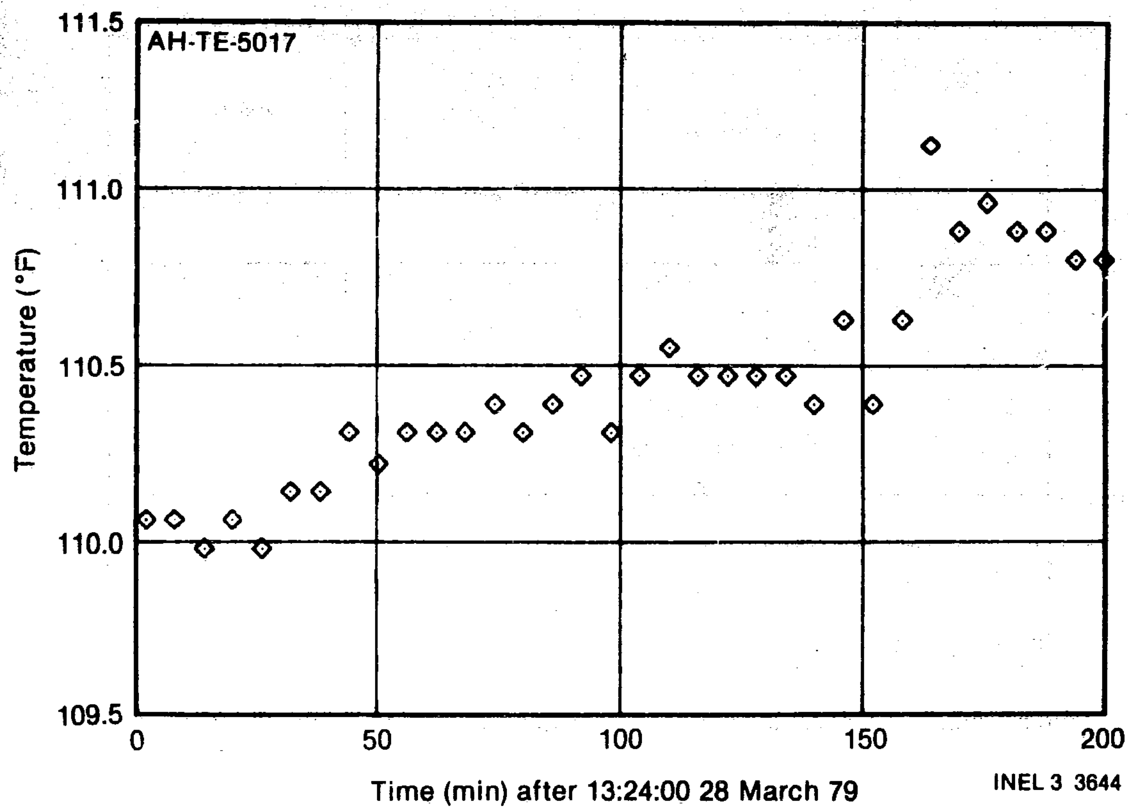

Figure A-31. Primary shield ambient air temp 282 (short term trend).

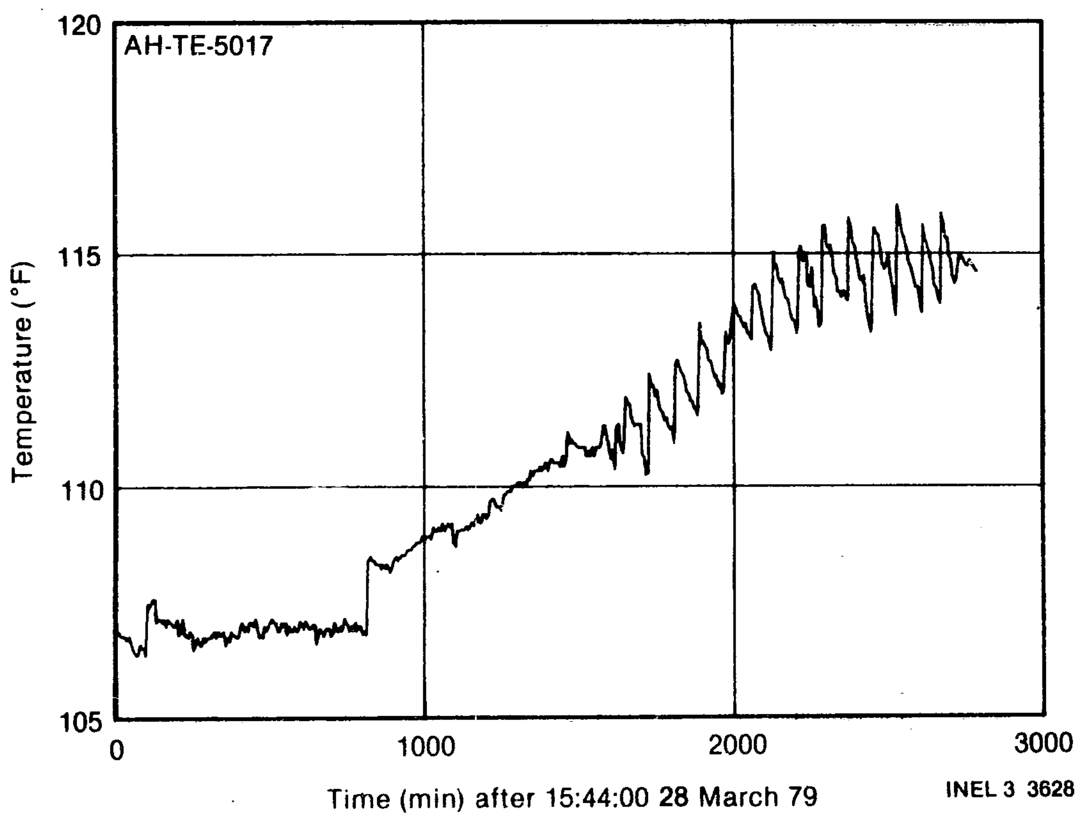

Figure A-32. Primary shield ambient air temp 282 (long term trend).

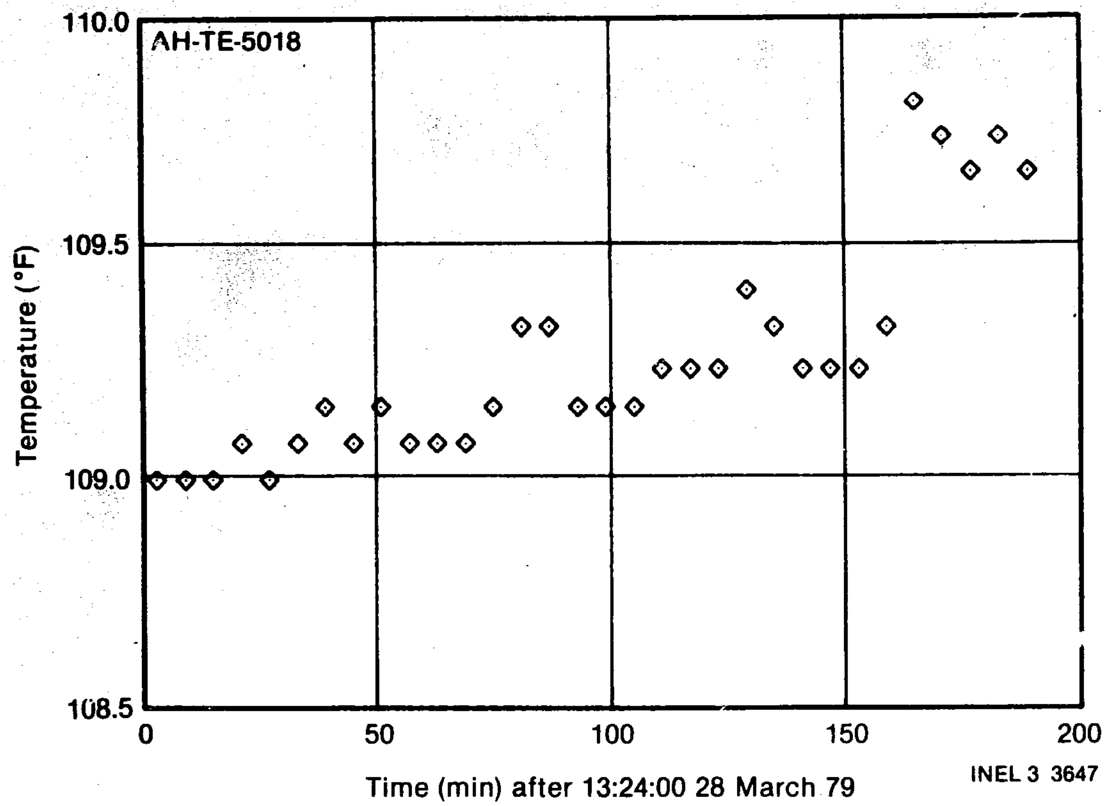

Figure A-33. Primary shield ambient shield air temp 282 (short term trend).

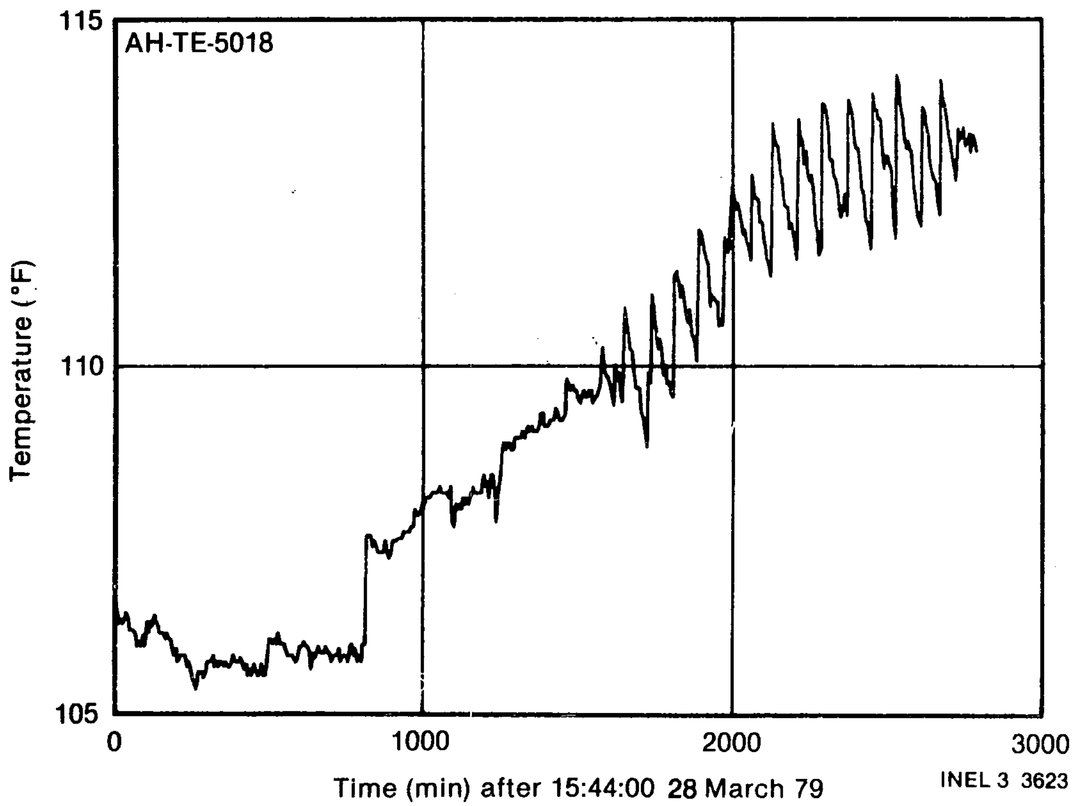

Figure A-34. Primary shield ambient air temp 282 (long term trend).

APPENDIX B

TMI UNIT 2

OTSG PRESSURES (DIGITAL)

13:44:30 to 14:00:03, 28 March 1979

APPENDIX B

TMI UNIT 2

OTSG PRESSURES (DIGITAL)

13:44:30 to 14:00:03, 28 March 1979

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:44:30	1.06274	267.037
13:44:33	1.24927	267.219
13:44:36	1.24927	267.219
13:44:39	1.34253	267.037
13:44:42	1.24927	267.037
13:44:45	1.24927	267.037
13:44:48	1.24927	267.037
13:44:51	1.34253	266.854
13:44:54	1.43535	266.671
13:44:57	1.62207	266.671
13:45:00	1.71533	266.671
13:45:03	1.43555	266.671
13:45:06	1.52881	266.671
13:45:09	1.43555	266.854
13:45:12	1.43555	267.037
13:45:15	1.24927	266.334
13:45:18	1.15601	267.037
13:45:21	1.06274	267.037
13:45:24	1.15601	267.037
13:45:27	1.06274	266.854
13:45:30	1.06274	266.671
13:45:33	0.87622	266.671
13:45:36	0.87622	266.489
13:45:39	0.87622	266.489
13:45:42	0.87622	266.489
13:45:45	0.87622	266.213
13:45:48	0.78296	266.123
13:45:51	0.78296	266.123
13:45:54	0.87622	266.123
13:45:57	0.78296	265.941
13:46:00	0.87622	265.941
13:46:03	0.68970	265.941
13:46:06	0.68970	265.941
13:46:09	0.87622	265.941
13:46:12	0.87622	266.123

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:46:15	0.87622	266.123
13:46:18	0.87622	266.123
13:46:21	0.87622	266.123
13:46:24	0.87622	265.941
13:46:27	0.87622	265.941
13:46:30	0.78296	265.941
13:46:33	0.87622	265.941
13:46:36	0.68970	265.941
13:46:39	0.87622	265.941
13:46:42	0.87622	266.123
13:46:45	0.87622	265.941
13:46:48	0.87622	266.123
13:46:51	0.87622	265.941
13:46:54	0.87622	265.941
13:46:57	0.87622	265.941
13:47:00	0.87622	265.941
13:47:03	0.87622	265.941
13:47:06	0.876	265.941
13:47:09	0.876	265.941
13:47:12	0.876	265.941
13:47:15	1.063	266.123
13:47:18	0.876	266.123
13:47:21	0.969	265.941
13:47:24	0.876	266.123
13:47:27	0.969	266.123
13:47:30	0.969	266.123
13:47:33	1.063	266.123
13:47:36	1.156	266.306
13:47:39	0.969	266.215
13:47:42	1.063	266.305
13:47:45	1.249	266.489
13:47:48	1.436	266.489
13:47:51	1.249	266.489
13:47:54	1.063	266.489
13:47:57	1.136	266.489
13:48:00	1.249	266.489
13:48:03	1.249	266.489
13:48:06	1.249	266.489
13:48:09	1.249	266.306

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:48:12	1.249	266.489
13:48:15	1.249	266.489
13:48:18	1.249	266.489
13:48:21	1.249	266.489
13:48:24	1.249	266.306
13:48:27	1.249	266.306
13:48:30	1.249	266.123
13:48:33	1.436	266.123
13:48:36	1.436	266.123
13:48:39	1.529	266.123
13:48:42	1.529	265.941
13:48:45	1.436	265.941
13:48:48	1.529	265.941
13:48:51	1.529	265.849
13:48:54	1.622	265.758
13:48:57	1.715	265.758
13:49:00	1.715	265.758
13:49:03	1.809	265.575
13:49:06	1.995	265.575
13:49:09	1.995	265.758
13:49:12	1.809	265.375
13:49:15	1.063	265.393
13:49:18	-6.396	264.388
13:49:21	-21.874	256.441
13:49:24	-22.247	241.460
13:49:27	-20.102	243.105
13:49:30	-18.983	244.383
13:49:33	-17.678	245.845
13:49:36	-16.652	247.306
13:49:39	-15.813	246.576
13:49:42	-14.850	249.133
13:49:45	-13.855	250.047
13:49:48	-13.109	250.778
13:49:51	-12.083	251.600
13:49:54	-10.778	232.970
13:49:57	-9.472	234.249
13:50:00	-8.2610	255.345
13:50:03	-7.2354	236.238
13:50:06	-6.1165	257.354
13:50:09	-5.3706	258.268

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:50:12	-4.8113	258.907
13:50:15	-3.9722	259.547
13:50:18	-3.4126	260.095
13:50:21	-2.8533	260.643
13:50:24	-2.2937	261.191
13:50:27	-1.9208	261.191
13:50:30	-1.4546	261.922
13:50:33	-1.1750	261.922
13:50:36	-0.9885	261.922
13:50:39	-0.7087	262.104
13:50:42	-0.5225	262.287
13:50:45	-0.3359	262.469
13:50:48	-0.0562	262.469
13:50:51	0.1384	262.652
13:50:54	0.3169	262.652
13:50:57	0.5034	262.635
13:51:00	0.6897	262.835
13:51:03	8.1487	270.145
13:51:06	9.0311	271.491
13:51:09	8.8945	271.239
13:51:12	9.1743	271.421
13:51:15	9.6406	271.787
13:51:18	9.4539	271.421
13:51:21	9.2676	271.421
13:51:24	9.4539	271.421
13:51:27	9.6406	271.604
13:51:30	9.9202	271.604
13:51:33	10.9658	272.883
13:51:36	11.5984	273.248
13:51:39	12.1580	273.522
13:51:42	11.3849	273.065
13:51:45	10.3865	271.604
13:51:48	9.8271	270.873
13:51:51	8.8945	269.777
13:51:54	8.1487	269.046
13:51:57	8.1487	268.864
13:52:00	7.8691	268.498
13:52:03	7.6826	268.133
13:52:06	7.6826	268.950
13:52:09	7.6826	267.768

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:52:12	7.5894	267.585
13:52:15	7.5894	267.219
13:52:18	7.40283	267.219
13:52:21	7.30957	266.854
13:52:24	7.30957	266.854
13:52:27	7.12305	266.489
13:52:30	7.02979	266.123
13:52:33	6.75000	266.123
13:52:36	7.02979	265.941
13:52:39	6.93652	265.758
13:52:42	6.75000	265.573
13:52:45	6.65698	265.393
13:52:48	6.56372	265.210
13:52:51	6.63698	265.210
13:52:54	6.56372	264.844
13:52:57	6.56372	264.862
13:53:00	6.37720	264.479
13:53:03	6.47046	264.479
13:53:06	6.28394	264.297
13:53:09	6.56372	264.297
13:53:12	6.56372	264.114
13:53:15	6.65698	264.297
13:53:18	6.47046	264.114
13:53:21	6.37720	264.114
13:53:24	6.47046	263.931
13:53:27	9.45386	266.854
13:53:30	9.08105	266.306
13:53:33	9.64063	266.854
13:53:36	9.45386	266.489
13:53:39	8.70801	265.941
13:53:42	8.33521	265.210
13:53:45	7.49609	264.753
13:53:48	7.12305	264.297
13:53:51	7.12305	264.114
13:53:54	6.93652	263.931
13:53:57	6.56372	263.566
13:54:00	6.37720	263.200
13:54:03	6.28394	263.018
13:54:06	5.81787	262.835
13:54:09	5.91113	262.835

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:54:12	5.72461	262.469
13:54:15	5.53809	262.287
13:54:18	5.44482	262.104
13:54:21	5.33156	262.104
13:54:24	5.81787	262.267
13:54:27	5.53809	262.104
13:54:30	5.53809	262.104
13:54:33	5.55156	261.922
13:54:36	5.25830	261.922
13:54:39	5.25830	261.556
13:54:42	5.16528	261.373
13:54:45	5.07202	261.008
13:54:48	4.97876	261.191
13:54:51	6.75000	262.335
13:54:54	6.37720	262.652
13:54:57	6.19067	262.469
13:55:00	5.91113	262.287
13:55:03	5.91113	262.104
13:55:06	5.91113	262.104
13:55:09	5.72461	261.922
13:55:12	5.91113	261.922
13:55:15	7.40283	263.200
13:55:18	6.65698	262.632
13:55:21	6.47048	262.287
13:55:24	6.28394	262.104
13:55:27	6.09741	261.922
13:55:30	6.09741	261.922
13:55:33	6.00415	261.922
13:55:36	6.00415	261.465
13:55:39	5.91113	261.373
13:55:42	5.91113	261.373
13:55:45	5.91113	261.373
13:55:48	5.91113	261.373
13:55:51	5.91113	261.556
13:55:54	6.00415	261.922
13:55:57	6.47046	262.287
13:56:00	6.65698	262.469
13:56:03	6.84326	262.652

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:56:06	7.12305	262.835
13:56:09	7.21631	262.469
13:56:12	7.40283	262.652
13:56:15	7.40283	262.652
13:56:18	7.68262	262.835
13:56:21	7.58936	262.652
13:56:24	7.58936	262.469
13:56:27	7.21631	262.469
13:56:30	7.58936	262.469
13:56:33	7.58936	262.287
13:56:36	7.58936	262.469
13:56:39	7.49609	262.469
13:56:42	7.68262	262.469
13:56:45	7.58936	262.469
13:56:48	7.68262	262.469
13:56:51	7.58936	262.469
13:56:54	7.77588	262.469
13:56:57	7.77588	262.652
13:57:00	7.77588	262.287
13:57:03	7.77588	262.287
13:57:06	7.77588	262.469
13:57:09	7.96216	262.104
13:57:12	7.86914	262.104
13:57:15	8.05542	262.104
13:57:18	8.14868	261.922
13:57:21	9.64063	263.270
13:57:24	9.17432	262.835
13:57:27	9.08105	262.469
13:57:30	9.17432	262.469
13:57:33	9.08105	262.287
13:57:36	9.17432	262.287
13:57:39	8.98779	262.104
13:57:42	8.98779	261.922
13:57:45	8.70801	261.556
13:57:48	8.52173	261.373
13:57:51	8.33521	261.191
13:57:54	8.24194	261.008
13:57:57	8.33521	261.008
13:58:00	8.24194	260.825

Time	OTSG-A Pressure (psig)	OTSG-B Pressure (psig)
13:58:03	8.24194	261.005
13:58:06	8.24194	261.008
13:58:09	8.70801	261.191
13:58:12	8.52173	261.008
13:58:15	8.24194	260.825
13:58:18	8.33571	260.734
13:58:21	8.33571	260.225
13:58:24	8.24144	260.643
13:58:27	8.33521	260.734
13:58:30	8.14868	260.369
13:58:33	8.14868	260.367
13:58:36	7.77588	260.277
13:58:39	7.77588	259.912
13:58:42	7.58936	259.912
13:58:45	7.40203	259.547
13:58:48	7.21631	259.364
13:58:51	7.02979	259.181
13:58:54	6.75000	258.999
13:58:57	6.65698	258.907
13:59:00	6.47046	258.033
13:59:03	6.19067	258.430
13:59:06	5.91113	258.268
13:59:09	5.91113	258.268
13:59:12	5.81707	258.085
13:59:15	5.72451	257.902
13:59:18	5.53809	257.902
13:59:21	5.53809	257.537
13:59:24	5.35156	257.720
13:59:27	5.44482	257.446
13:59:30	5.23830	257.446
13:59:33	5.25830	257.446
13:59:36	5.16528	257.354
13:59:39	5.25830	257.446
13:59:42	5.25830	257.354
13:59:45	5.16528	257.171
13:59:48	5.16528	256.989
13:59:51	5.07202	256.989
13:59:54	4.97876	256.989
13:59:57	4.69897	256.806
14:00:00	4.60371	256.806
14:00:03	4.69897	256.989

APPENDIX C

STRIP CHART RECORDS

APPENDIX C
STRIP CHART RECORDS

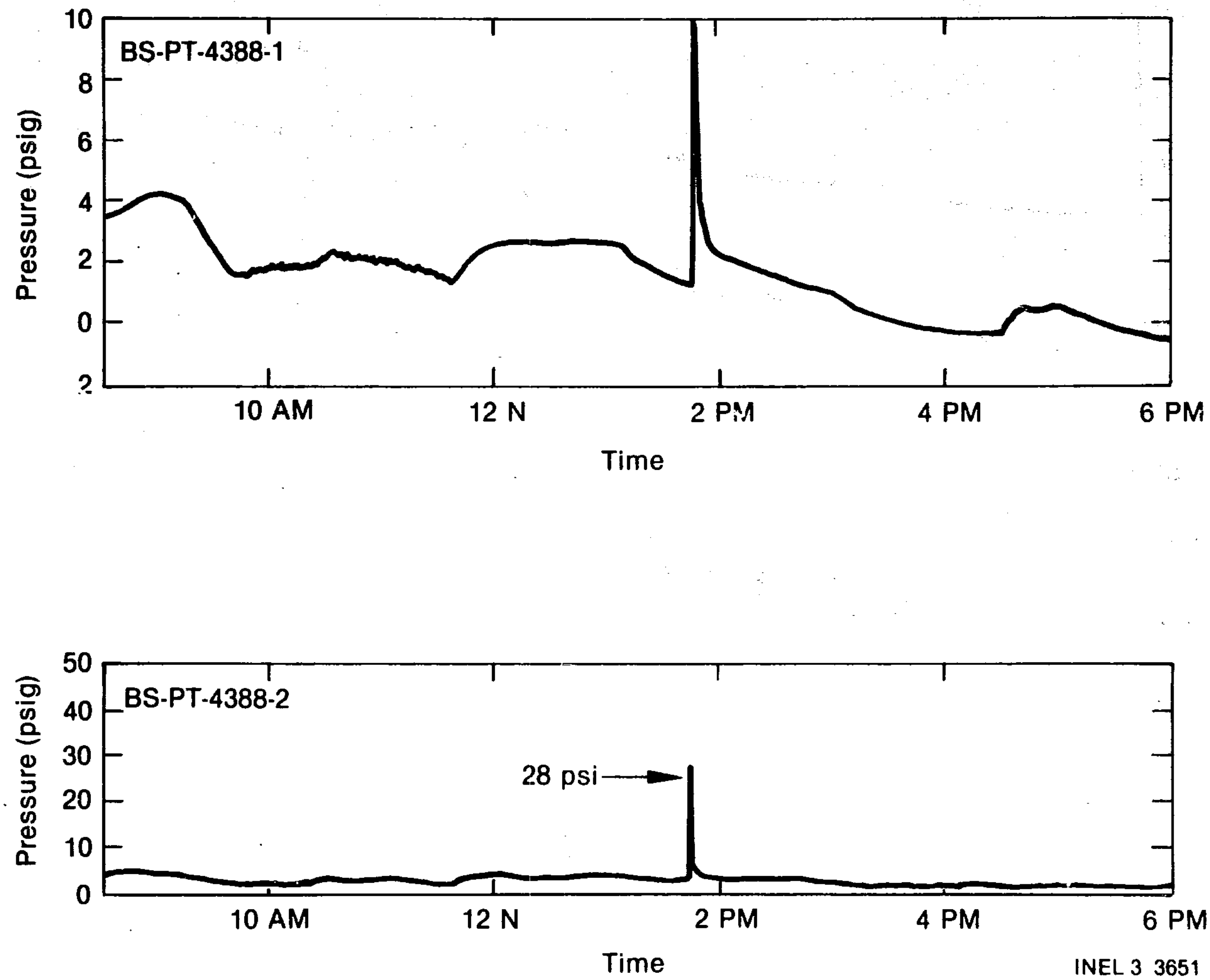

Figure C-1. Reactor Building pressure stripchart records (28 March 1979).

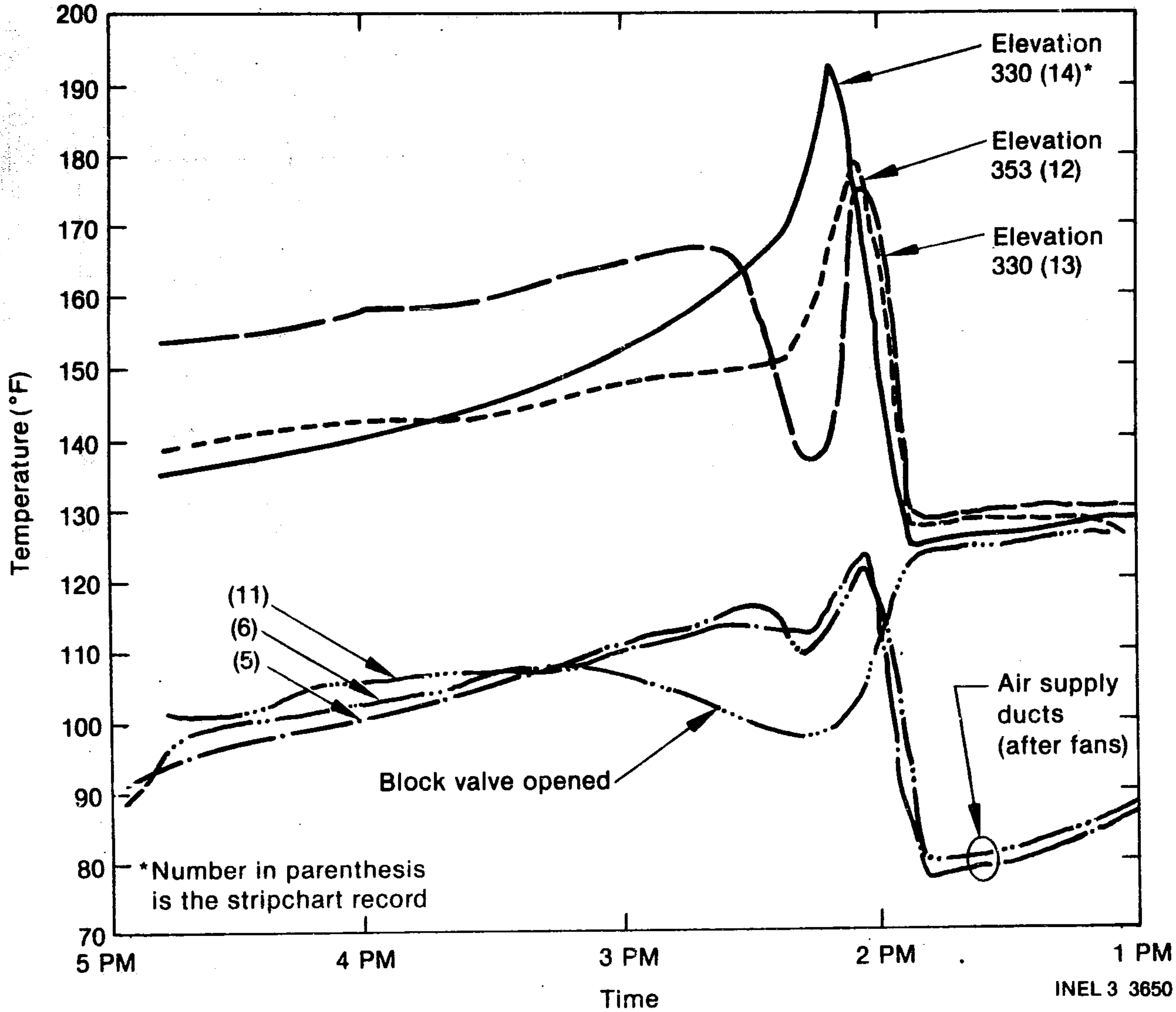

Figure C-2. Reactor Building resistance temperature detector readouts.

APPENDIX D

TMI-2 ALARM PRINTER PRINTOUT SEQUENCE FOR 4 PSIG REACTOR BUILDING PRESSURE CHANNELS AND 28 PSIG ENGINEERED SAFEGUARDS BUILDING SPRAY ACTUATION PRESSURE SWITCHES

APPENDIX D

TMI-2 ALARM PRINTER PRINTOUT SEQUENCE FOR 4 PSIG REACTOR BUILDING PRESSURE CHANNELS AND 28 PSIG ENGINEERED SAFEGUARDS BUILDING SPRAY ACTUATION PRESSURE SWITCHES

Time	Input Number	Channel Designation	Action	Set Point (psig)
13:50:21	3167	4 PSI RB Pressure Red Ch Trip	High	3.6
13:50:21	2833	4 PSI RB Pressure Red Ch Trip	High	3.6
13:50:21	3278	4 PSI RB Pressure Red Ch Trip	High	3.6
13:50:21	3168	4 PSI RB Pressure Grn Ch Trip	High	3.6
13:50:21	2834	4 PSI RB Pressure Grn Ch Trip	High	3.6
13:50:21	3279	4 PSI RB Pressure Grn Ch Trip	High	3.6
13:50:21	3169	4 PSI RB Pressure Yel Ch Trip	High	3.6
13:50:21	2835	4 PSI RB Pressure Yel Ch Trip	High	3.6
13:50:21	3280	4 PSI RB Pressure Yel Ch Trip	High	3.6
13:50:22	3170	4 PSI RB Pressure Blue Ch Trip	High	3.6
13:50:26	3264	ES Bldg Spray Sw Act B Ch 2 Trip	Trip	26.6
13:50:27	2836	ES Bldg Spray Sw Act A Ch 1 Trip	Spray	27.05
13:50:27	2837	ES Bldg Spray Sw Act A Ch 2 Trip	Spray	27.30
13:50:27	2838	ES Bldg Spray Sw Act A Ch 3 Trip	Spray	27.75
13:50:27	3265	ES Bldg Spray Sw Act B Ch 3 Trip	Trip	27.35
13:50:27	3281	ES Bldg Spray Sw Act B Ch 1 Trip	Trip	27.85
13:50:31	3265	ES Bldg Spray Sw Act B Ch 3 Trip	Norm	26.20
13:50:31	3281	ES Bldg Spray Sw Act B Ch 1 Trip	Norm	26.75
13:50:32	3264	ES Bldg Spray Sw Act B Ch 2 Trip	Norm	25.40
13:50:32	2836	ES Bldg Spray Sw Act A Ch 1 Trip	Norm	25.80
13:50:32	2837	ES Bldg Spray Sw Act A Ch 2 Trip	Norm	26.30
13:50:32	2838	ES Bldg Spray Sw Act A Ch 3 Trip	Norm	25.80
13:52:53	3170	4 psi RB Pressure Blue Ch Trip	Norm	3.2
13:53:14	3167	4 psi RB Pressure Red Ch Trip	Norm	3.2
13:53:32	3280	4 psi RB Pressure Yel Ch Trip	Norm	3.4
13:53:37	2833	4 psi RB Pressure Red Ch Trip	Norm	3.4
13:53:49	3169	4 psi RB Pressure Yel Ch Trip	Norm	3.1
13:54:01	2834	4 psi RB Pressure Grn Ch Trip	Norm	3.3
13:54:03	3279	4 psi RB Pressure Grn Ch Trip	Norm	3.3
13:55:15	3278	4 psi RB Pressure Red Ch Trip	Norm	2.9
13:59:15	2835	4 psi RB Pressure Yel Ch Trip	Norm	3.3
14:01:44	3168	4 psi RB Pressure Grn Ch Trip	Norm	3.0

APPENDIX E

REACTOR BUILDING ATMOSPHERE

HYDROGEN, OXYGEN, AND NITROGEN ANALYSIS DATA

APPENDIX E

REACTOR BUILDING ATMOSPHERE

HYDROGEN, OXYGEN, AND NITROGEN ANALYSIS DATA

Date	Time	Sampling Method	% H_2	% O_2	% N_2	Reference
3/31/79	06:00	U[a]	1.7	15.7	82.6	NSAC-1[b]
3/31/79	06:00	U	1.7	16.5	81.8	NSAC-1
3/31/79	21:00	G[c]	2.0	--	--	GPU[d]
3/31/79	22:00	G	1.7	--	--	GPU
3/31/79	23:30	G	2.3	--	--	GPU
4/1/79	07:00	G	1.9	19.2	78.9	GPU
4/1/79	09:30	A[e]	2.4	--	--	GPU
4/1/79	12:00	G	2.1	19.1	78.8	GPU
4/1/79	12:25	A	2.0	--	--	GPU
4/1/79	13:30	G	2.1	18.9	79.0	GPU
4/1/79	13:30	A	2.1	--	--	GPU
4/1/79	15:00	G	2.0	18.7	79.3	GPU
4/1/79	15:00	A	2.0	--	--	GPU
4/1/79	18:30	G	2.0	21.8	76.2	GPU
4/1/79	19:00	A	2.0	--	--	GPU
4/1/79	23:00	G	2.3	18.9	78.9	GPU
4/2/79	06:00	G	2.4	17.6	79.9	GPU
4/2/79	10:30	G	2.1	18.4	79.5	GPU
4/2/79	23:36	A	2.1	--	--	GPU
4/2/79	23:42	A	2.1	--	--	GPU
4/3/79	10:10	A	1.95	--	--	GPU
4/3/79	10:21	A	2.0	--	--	GPU
4/3/79	23:00	G	2.3	17.7	80.1	GPU
4/4/79	16:10	A	1.5	--	--	GPU
4/6/79	20:00	R[f]	1.65	--	--	GPU
4/6/79	22:45	A	1.8	--	--	GPU
4/7/79	06:00	R	1.59	--	--	GPU
4/7/79	14:00	A	1.65	--	--	GPU
4/8/79	02:30	A	1.65	--	--	GPU
4/8/79	13:45	A	1.74	--	--	GPU

Date	Time	Sampling Method	% H_2	% O_2	% N_2	Reference
4/9/79	04:30	A	1.95	--	--	GPU
4/9/79	04:40	A	1.2	--	--	GPU
6/1/79	--	--	0.6	14.5	--	NSAC-1
8/2/79	--	--	0.6	14.1	--	NSAC-1

a. Unknown.

b. Nuclear Safety Analysis Center (EPRI), Analysis of Three Mile Island Unit 2 Accident, NSAC-80-1, March, 1980.

c. Grab sample analyzed by a gas partitioner.

d. GPU/TMI-2 secondary chemistry log books.

e. On-line gas chromatograph.

f. Calculations based on recombiner inlet and outlet gas temperature.

APPENDIX F

INVESTIGATION OF THE TMI HYDROGEN PHENOMENA

OF MARCH 28, 1979

Inter-Office Memorandum

GPU Nuclear

Date	MARCH 26, 1982		
Subject	INVESTIGATION OF THE TMI HYDROGEN PHENOMINA OF MARCH 28, 1979		7132-82-167
To	G. R. EIDEM	Location	THREE MILE ISLAND

The following information is provided to assist in the investigation of the TMI Hydrogen Phenomina of March 28, 1979.

1. Reactor Building Ventilation and Purge System

   a. Fan cooler units
   Four fan cooler units are operated under normal conditions. Four fan coller units are also operated under LOCA conditions. Ref. TMI Unit 2 FSAR Section 6.2.2.2.2.1 through 6.2.2.2.8 (see page 6.2-25b AM59 10-7-77) and 9.4.15.1. The system description and FSAR Sections 1.2.3.1.4 AM48 11-15-76 and 7.3.1.1.3 AM59 10-7-77 incorrectly state three fans operating under normal conditions anf five under LOCA conditions.

   b. LOCA Dampers, D-5127 A&B

   The LOCA dampers are designed to open on reactor building isolation when ES actuation secures instrument air to the LOCA dampers by closing AH-V-72 (ES actuation A) and AH-V-71 (ES actuation B). This event occurred at 07:56 on March 28, 1979.

   NOTE: ES actuation A at 07:56:23 and ES actuation B at 07:56:13.

   Reactor building pressure remained above the 3.58 PSI ES actuation setpoint until about 09:30 a.m. Therefore the LOCA ducts would have remained open during this period. This would be a major flow path for reactor building ventilation; fan coolers through the open LOCA dampers, up the LOCA ducts and exiting the gravity dampers (which are welded open) at the 416' 8" level. The ducts are directed toward the reactor building dome (see B&R Dwg. 2041 and GPU Vendor Dwg. 63-01-0088). Moreover, it is likely that the dampers remained open during the entire accident. Damper position is indirectly indicated by the position of valves AH-V-71, AH-V-72 & AH-V-74, if any of these valves are closed, instrument air to the dampers is secured and the dampers open. After an ES signal the valves close and must be manually repositioned by handswitch (Ref. FSAR section 7.3.2.1 P AM59 10-7-77). There are no records of these valves being repositioned following the 07:56 RB isolation. It is unlikely that they were repositioned prior to the hydrogen phenomina. It is therefore possible for a relatively high concentration of hydrogen to have accumulated in the vicinity of the reactor building dome prior to the conflagration.

NOTE: Specific times given in the above discussion were obtained from computer alarm summary printout.

2. a. Main Steam Pressure Transmitters

There are four main steam pressure transmitters. Two per steam generator. These devices measure differential pressure (main steam outlet pressure / R. B. pressure) and transmit indication to the ICS computer and B&W supplied mini computer (reactimeter) through a manual selector switch (one per steam generator). The position of the selector switches at the time of pressure spike is not known therefore, which two of the four pressure transmitters were logged on the reactimeter's magnetic tape is also unknown. At the time of the hydrogen burn the water level in the reactor building would have submerged one transmitter and three would be above water.

Presented below are some parameters of interest in this discussion:

Transmitter	Rack	Elevation	Penatration Elevation
SP-6A-PT1	426	288.0'	292.0'
SP-6A-PT2	424	288.5'	292.0'
SP-6B-PT1	MTG R13	284.0'	342.0'
SP-6B-PT2	428	288.5'	292.0'

b. Calculation of Water Level in the Reactor Building Basement at the Time of the Hydrogen Burn.

Although it is not possible to calculate the exact water level in the building at the time in question, it is possible to calculate an upper bound water level based on available data. The two primary sources of water were the reactor building coolers, operating by use of the river water as a cooling medium, this accounts for 1251 gallons, and the borated water storage tank accounting for an addition 231,702 gallons by 17:20 on 3/28/79. Combining these figures gives a water depth in the basementof 2.83 ft., water had reached the 285.33' level.

Data

Inventory released to the reactor building floor via the BWST is based on level indications taken from shift supervisor and CRO logs and the TMI-2 tank log.

Level	Date	Data Source
54.7 ft.	3/27/79	TMI-2 Tank log DRMG File TL-0001.04
26.5 ft.	3/28/79 @ 17:20	Shift Supervisor log and CRO Log

The volume calculation must be done in two parts 1: 54.7 ft to 51.0 ft. and 2: 51.0 ft. to 26.5 ft. This method accounts for the oblate hemispherical tank top. (Gallans per ft. varies from 7375 gal/ft to 8261 gal/ft). Combining both parts of the calculation, a total of 231,702 gallons were released from the BWST.

Water released to the reactor building by the river water cooling system is calculated to be 180,000 gallons based on recovery engineering calculation #75 as referenced in recovery engineering letter Sept. 10, 1981, 5530-81-095 from R. H. Greenwood to D. K. Croneburger titled "Reactor Building Floording Following the TMI-2 Accitent."

To arrive at a water level in the reactor building at the time of the hydrogen phenomina one must back this calculation 59 days.

NOTE: The calculation concludes that about 180,000 gallons were added to the building between 3/28/79 and 5/27/79.

59 days = 84,960 minutes

180,000 gallons/84,960 minutes = 2.12 gpm

or 2.12 gallons per minute were being added to the building via the reactor building coolers using river water as a cooling media.

Assuming this leak rate was constant and projecting forward to the time of the detonation (3/28/79, 13:50) one obtains 1251 gallons added to the reactor building basement by this mechanism.

990 minutes x 2.12 gallons per minute = 1250.8 gallons

The total water in the TMI-2 basement at the time of the hydrogen phenomina is then:

231,702 gal.	BWST Injection
1,251 gal.	River water Leakage
-2,500 gal.	Sump Volume
-7,240 gal.	RC Drain Tank Volume
-12,400 gal.	Sump Pump Transfer
210,813 gals.	Total in Bldg.

Assuming 6,200 gallons/in from RB water level memmo TMI-II-R-2352, February 14, 1980.

Then: 210,813 gal/6,200 Gal/In
= 34.0" or 2.83 ft. of water had accumulated or water had reached the 285.33' level.

NOTE: The 12,400 gal. figure used in calculation #75 is probably incorrect. Reactor building sump pump acceptance tests. REF: TMI-2 Startup Test TP 235/1, would indicate a value of 8,400 gallons transferred. This value would increase level by 0.65 inches.

3. Reactor Building Temperature

Review of previously published reports indicates that there is some question as to location of reactor building temperature elements. The table presented below will, hopefully, clear up these uncertainties. The Points refer to PEN numbers of multipoint recorder AH-YMTR-5017.

Point	Location	Temp. Element	B&R Dwg.	*Temp °F
1	#1 Primary Shield	AH-TE-5017	2227	[b]110
2	#2 Primary Shield	AH-TE-5018	2227	[b]109
3	#3 Primary Shield	AH-TE-5016	2227	[b]106
4	#4 Primary Shield	AH-TE-5019	2227	[b]106
5	#1 Air Supply	AH-TE-5015	2229	123
6	#2 Air Supply	AH-TE-5027	2229	122
7	Ambient Imp. Barrier	AH-TE-5013	2227	156
8	Ambient Sump Area	AH-TE-5010	2227	132
9	Ambient Letdown Cooler	AH-TE-5011	2227	128
10	Ambient Drain Tank	AH-TE-5012	2227	152
11	Ambient Elev. 353-1	AH-TE-5020	2227	[a]103
12	Ambient Elev. 353-2	AH-TE-5021	2227	180
13	Ambient Elev. 330-1	AH-TE-5023	2228	170
14	Ambient Elev. 330-2	AH-TE-5022	2228	182
15	Ambient Elev. 310-1	AH-TE-5014	2228	151
16	Ambient Elev. 310-2	AH-TE-5088	2228	151

NOTE: These points print on a 6 minute interval so that peak temperatures must be extrapolated from the stripchart.
* Maximum (unextrapolated) temperature at the approximate time of detonation.
a. Point 11 decreased by about 22°F at this time.
b. Points 1, 2, 3 & 4 remained relatively constant through the transient.

The attached figure is a copy of the AH-YMTR-5017 stripchart during the period of interest. Curves were drawn by this reports author.

James E. Flaherty
Technical Information Coordinator

JEF:dg
Attachment

cc: H. M. Burton (with attachment)
F. L. Meltzer "
CARIRS (w/o attachment)

APPENDIX G

INVESTIGATION OF THE TMI HYDROGEN PHENOMENA OF MARCH 28, 1979

APPENDIX G

INVESTIGATION OF THE TMI HYDROGEN PHENOMENA OF MARCH 28, 1979

The TMI-2 OTSG steam pressure transmitters indicate the difference between steam generator pressure and Reactor Building pressure, as Reactor Building pressure acts on one side of a pressure sensing bellows and steam pressure acts on the other side. Bellows movement is transmitted by a mechanical linkage to a mechanical/electrical transducer in the conventional manner. If it is assumed that steam pressure was constant (or nearly so) during the hydrogen burn period 13:49:12 to 13:51:00 h, then the indicated decrease in steam generator A and steam generator B pressure during this period can be interpreted as an increase in Reactor Building pressure, i.e.,

$$\text{Reactor Building pressure} = P_o - P(t) + P_{rb}$$

where

P_o = indicated steam pressure at 13:49:12

$P(t)$ = indicated steam pressure at time $13{:}49{:}12 \leq t \leq 13{:}51{:}00$

P_{rb} = Reactor Building pressure at 13:49:12.

For measuring a change in pressure such as that which occurred during the hydrogen burn period, 13:49:12 to 13:51:00 h, the sum of deadband, repeatability, hysteresis, and drift is judged to be the most applicable for stating data accuracy. This is specified by the manufacturer to be ±0.15% of the 180 psig instrument span or ±2.7 psi.

OTSG Pressure Transducer Data

Manufacturer	Foxboro
Model	E11GM SAE1
Accuracy	±0.5% of span
Span	200 to 2000 psi
Deadband	
Repeatability	±0.15% of span
Hysteresis	
Drift	
Temperature Sensitivity	±1.0%/100°F below 250°F body temperature ±2.0%/100°F above 250°F body temperature
Time Response	1.17 s

APPENDIX H
REACTIMETER ZERO OFFSET SHIFTS

Lorenzo D. Goodrich
James Adams
Jim K. Jacoby

APPENDIX H

REACTIMETER ZERO OFFSET SHIFTS

Introduction

J. O. Henrie and A. K. Postma have performed an investigation of selected TMI-2 Reactimeter Data which is reported in Reference H-1. This appendix reports a computer analysis of that data intended to determine the probability and frequency of nearly equal simultaneous voltage changes on multiple data channels.

It is suggested that the reader refer to References H-1 and H-2 for background prior to using the material presented in this Appendix.

Method

During examination of the OTSG data reported in Reference H-1, it was noticed that pressure in the steam generator took a sudden jump of about 7.5 psi at 13:51:00 reactimeter time. Similar jumps of smaller magnitude occurred at 13:53:24, 13:54:48, 13:55:12, and 13:57:18. Plots of the reactimeter data during this time period are shown on Figures H-1 thru H-11 with the sudden jumps indicated. The reactimeter patch schedule is given on Table H-1. Using the voltage/engineering unit conversions shown on Table H-2 to convert the engineering unit data changes at 13:53:24 to voltage changes, it was found that the voltage change on several of the channels was almost the same. This indicates an overall simultaneous zero offset calibration shift of these channels on the reactimeter, since a real physical event would not be expected to result in the nearly the same voltage change on so many data channels. In addition, a change in indicated turbine header pressure (MUX Channel 15) from 496.6 to 500.2 psig, which occurred at 13:51:00 reactimeter time, apparently does not represent a real change in pressure because the turbine header pressure transducer is a 600 to 1200 psi range instrument and the actual pressure in the turbine header at this time was near atmospheric as indicated by OTSG "A" steam pressure. Consequently, a test was performed in-situ on the turbine header pressure transducer. It was found that the pressure transducer would not respond to

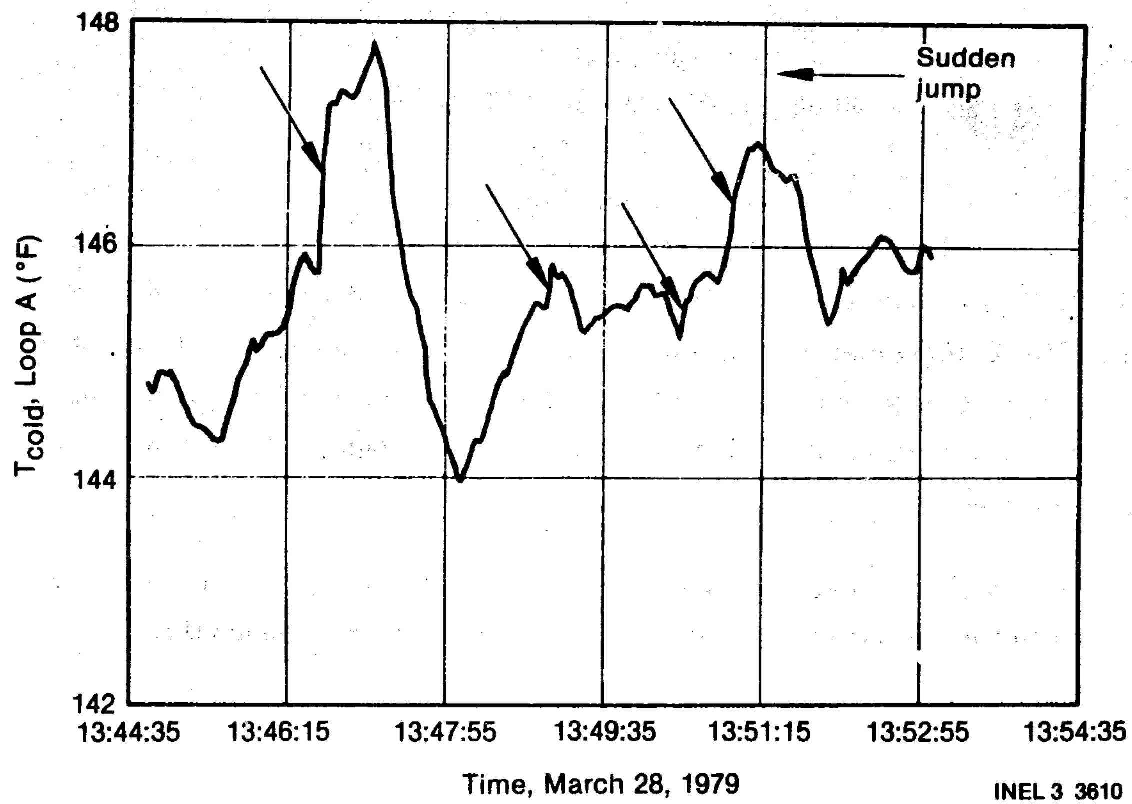

Figure H-1. Cold temperature of Loop A.

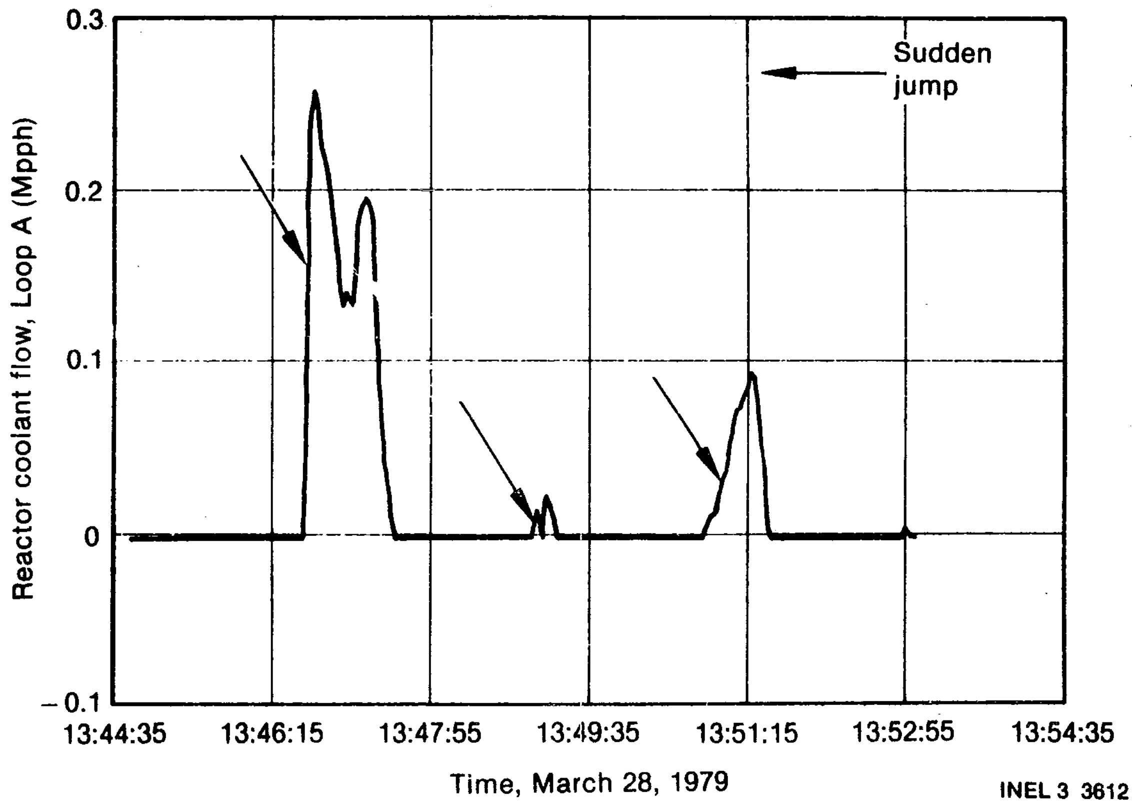

Figure H-2. Reactor coolant flow, Loop A.

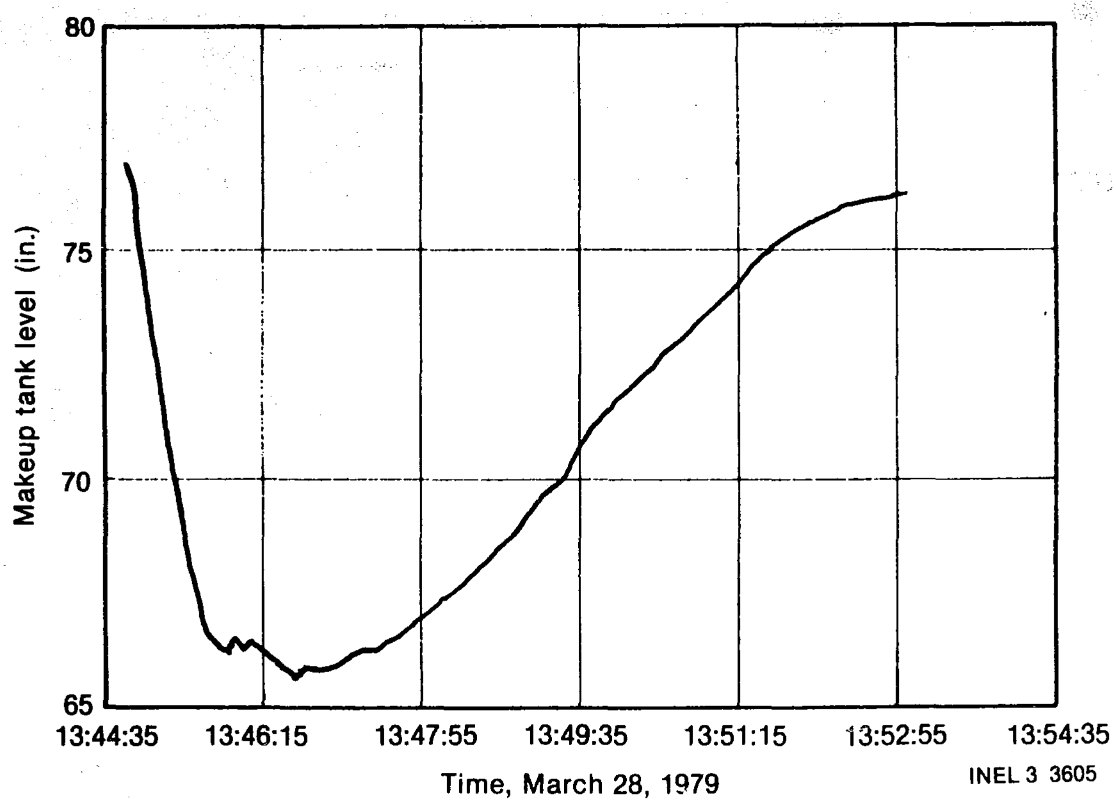

Figure H-3. Makeup tank level.

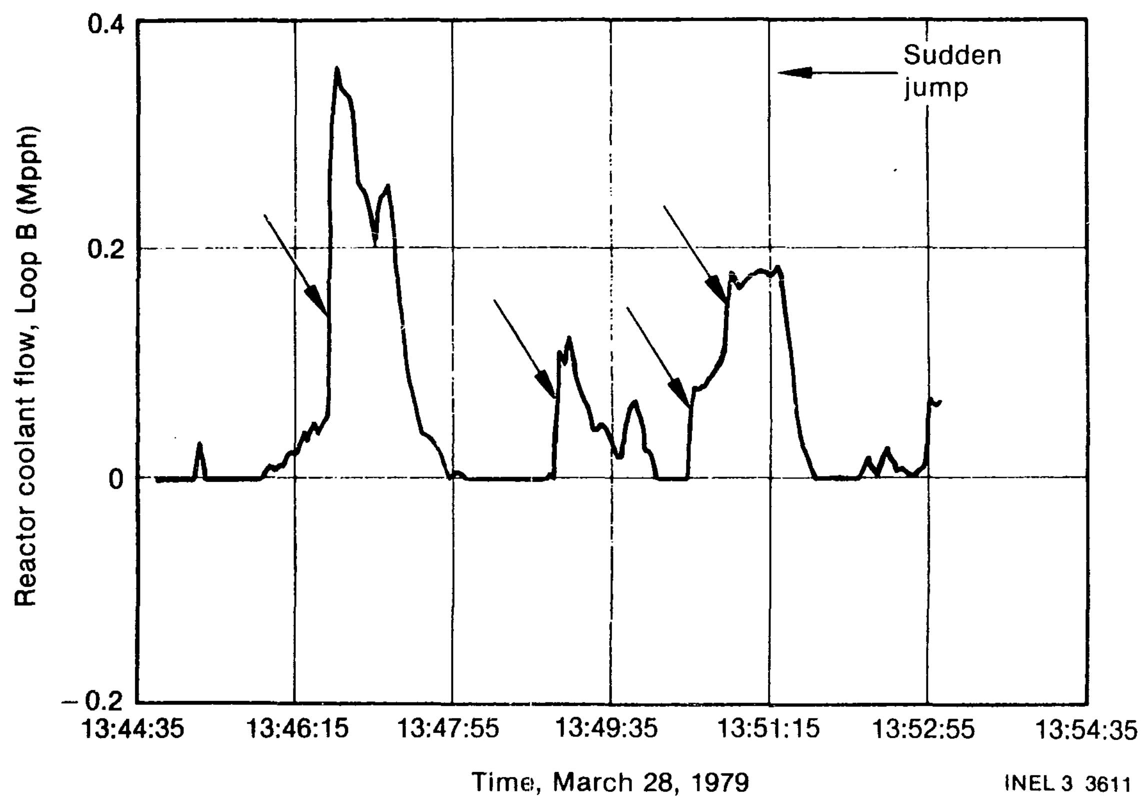

Figure H-4. Reactor coolant flow, Loop B.

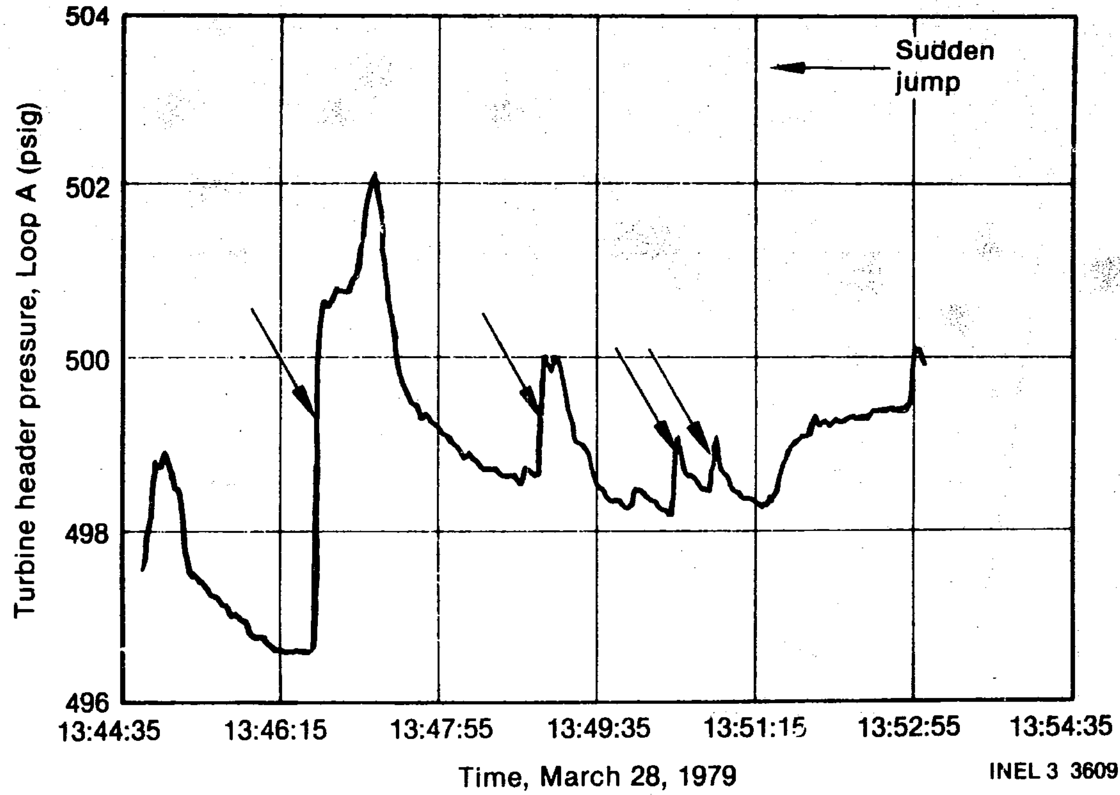

Figure H-5. Turbine header pressure, Loop A.

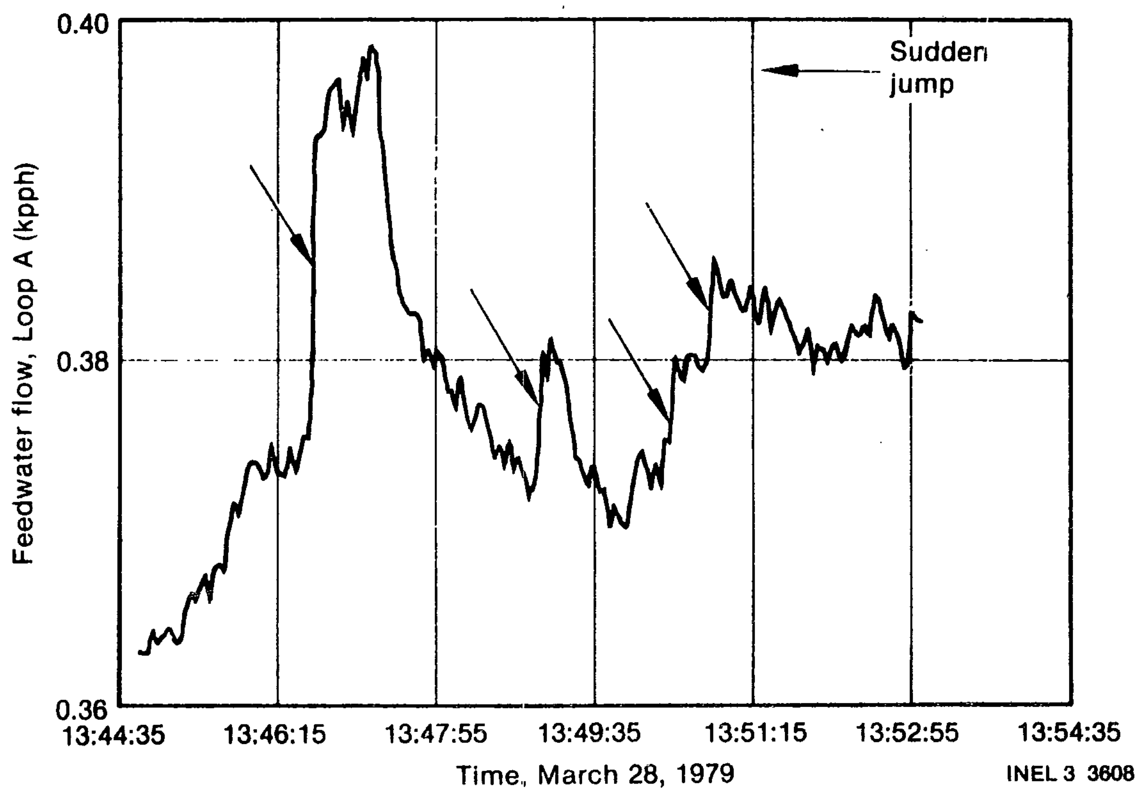

Figure H-6. Feedwater flow, Loop A.

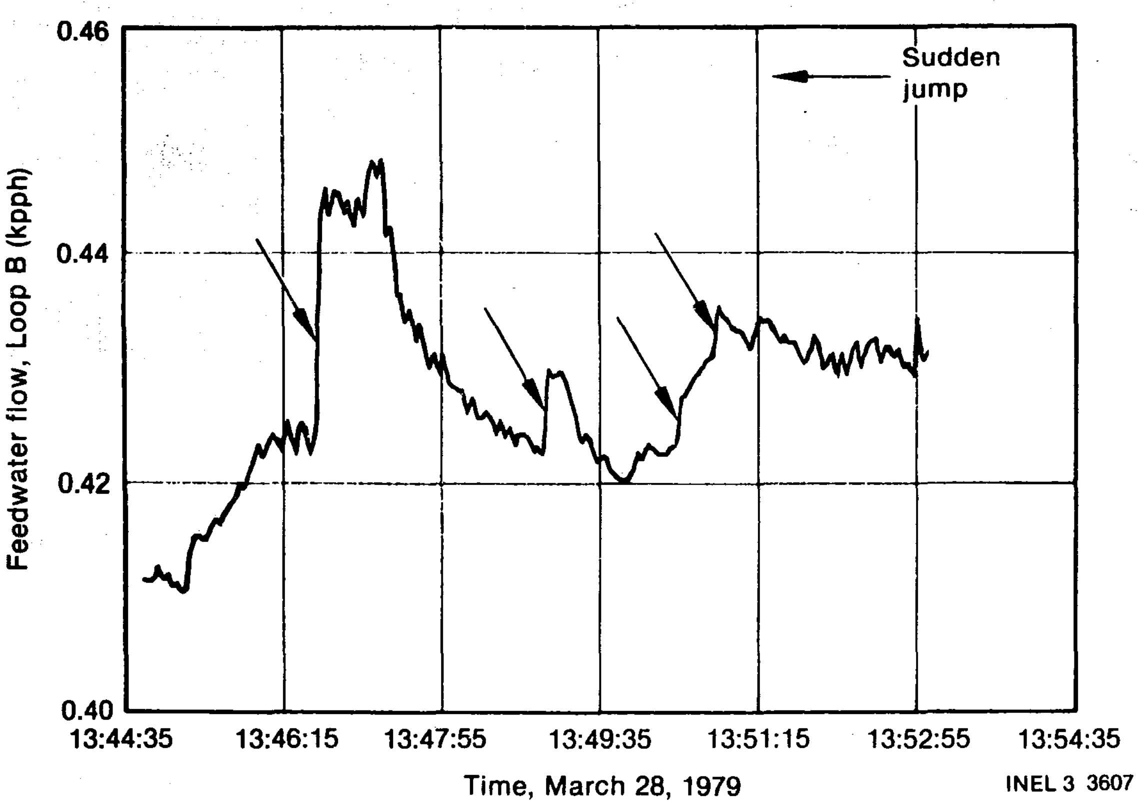

Figure H-7. Feedwater flow, Loop B.

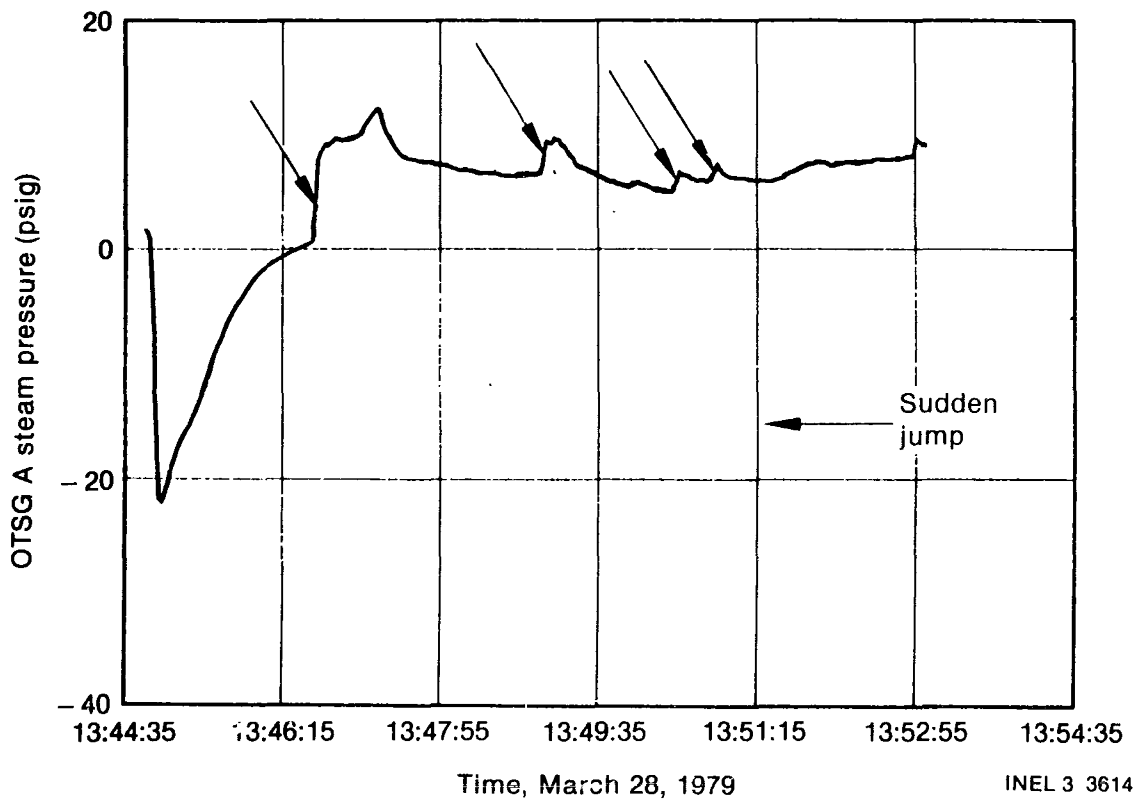

Figure H-8. OTSG A steam pressure.

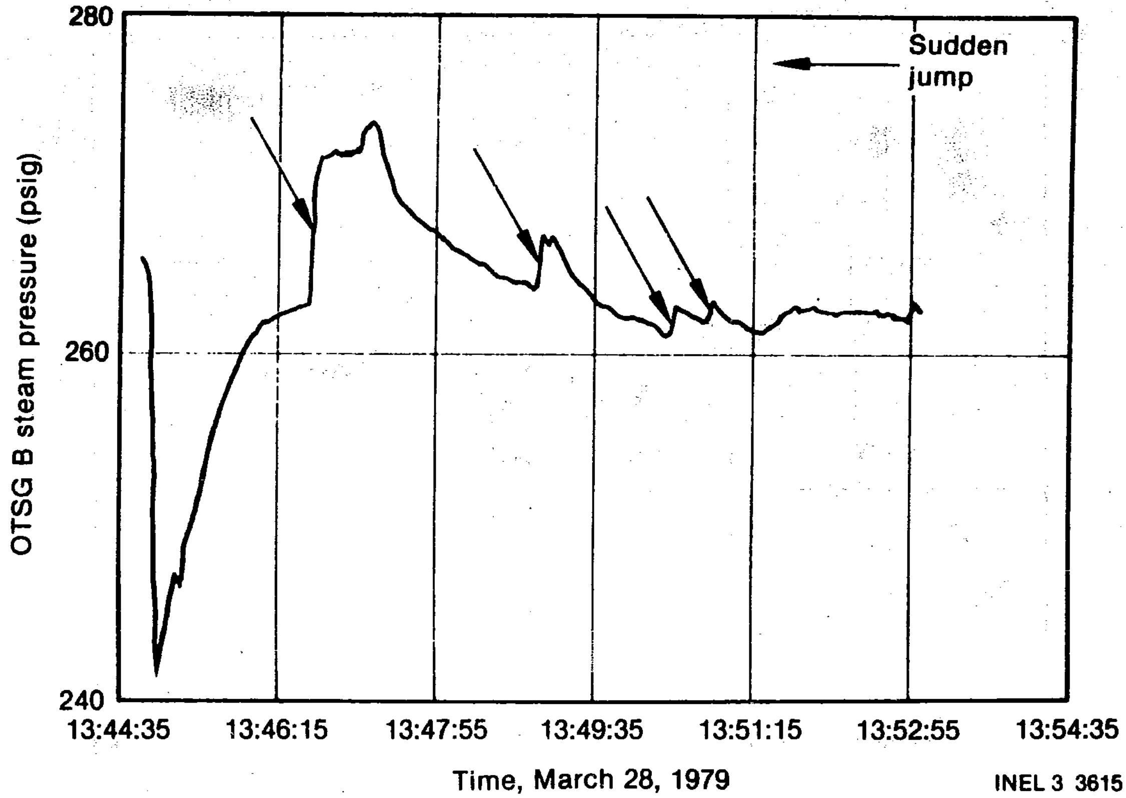

Figure H-9. OTSG B steam pressure.

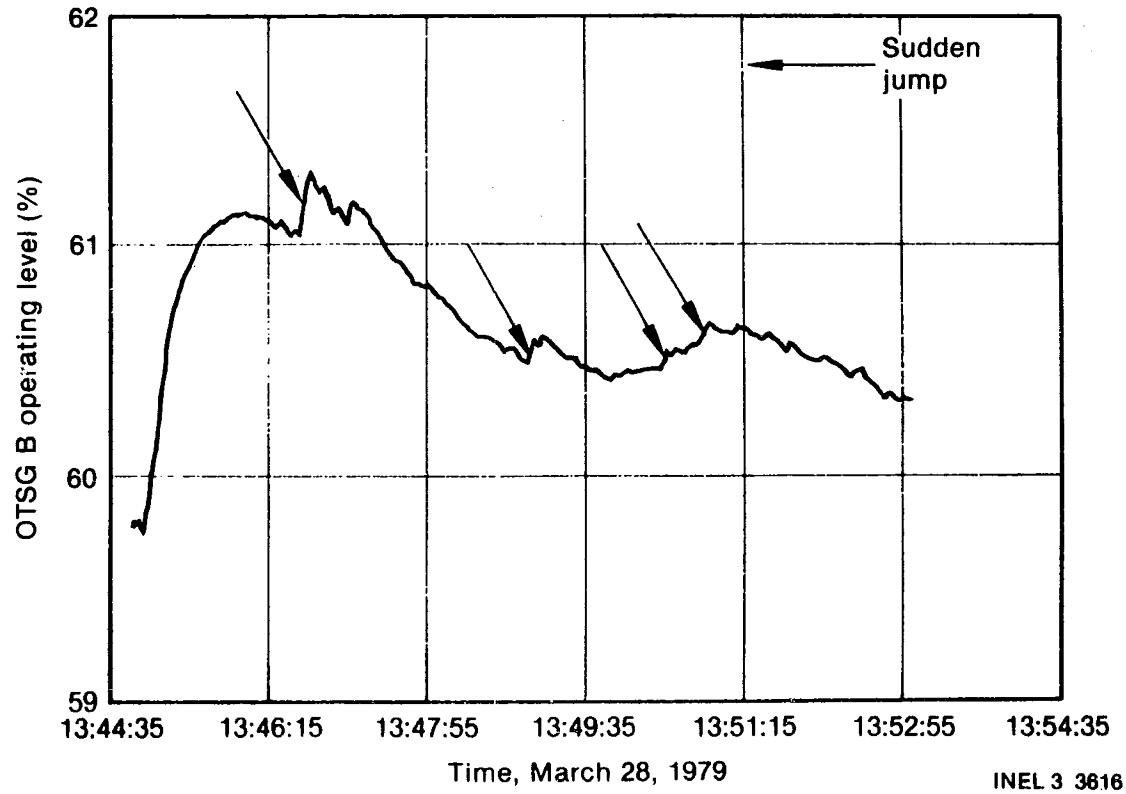

Figure H-10. OTSG B operating level.

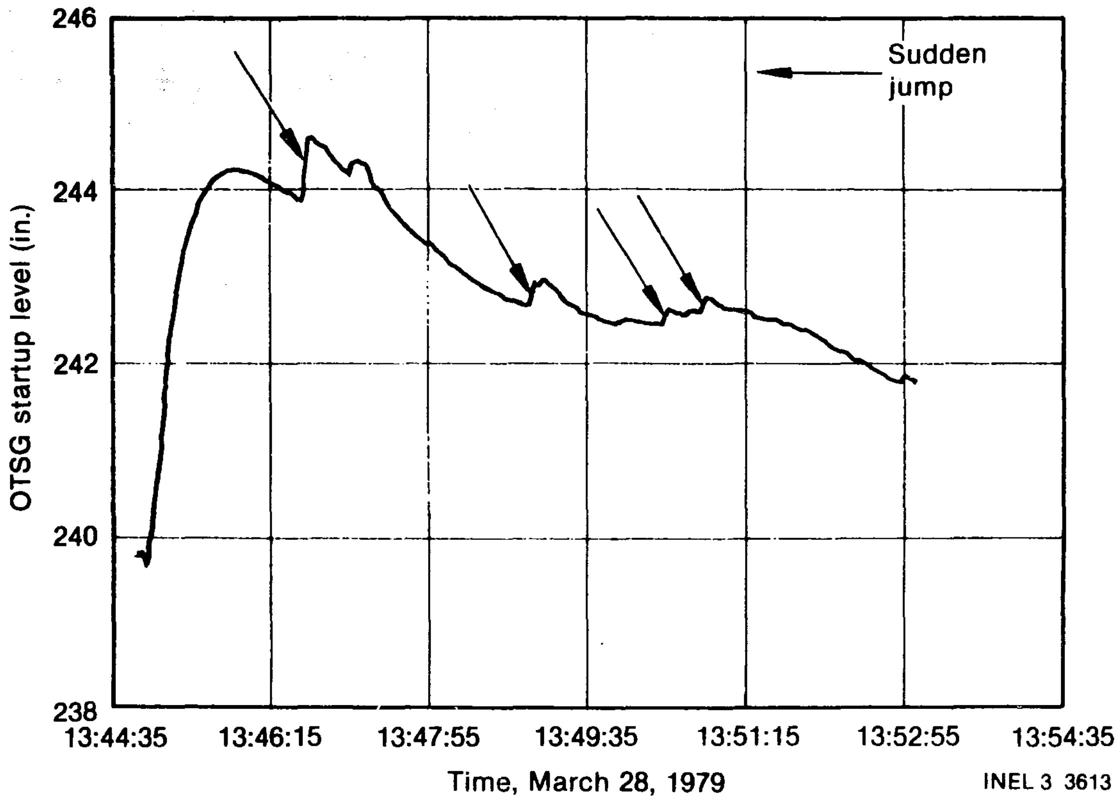

Figure H-11. OTSG startup level.

TABLE H-1. REACTIMETER PATCH-SCHEDULE

Mux Channel	Patchboard Number	DELOG	Logged Variance	Measurement ID.	Logged Variable Range if Different Than DASEY Range	
1	14	- 0125 + 0125	NI-5 Power Range		0/+10V	0/125%
2	28	+ 0520 + 0620	T HOT LP A NR	TE1 - 4A	-10/+10V	520/620°F
3	29	+ 0520 + 0620	T HOT LP B NR	TE1 - 4B	-10/+10V	520/620°F
4	31	+ 0050 + 0650	T COLD LP A WR	TE2 - 5A	-10/+10V	50/650°F
5	34	+ 0050 + 0650	T COLD LP B WR	TE2 - 5B	-10/+10V	50/650°F
6	45	+ 0000 + 0090	RC FLOW LP A TEMP COMP	RC-14A-DPT-1	-10/+10V	0/90 MPPH
7	22	- 0400 + 0000	PZR LVL TEMP. COMP.	RC-LT1-1ORCTE1-2	+10/-10V	0/400 IN
8	96	+ 0000 + 0100	MUT LVL	MU-14-LT1	-10/+10V	0/100 IN
9	19	- 9990 + 9999	PZR SPRAY VLV POS.	RC-V2	CLOSED	CC
10	65	- 0250 + 0250	DRAIN TANK PRESS.	WDL-1202-PT	0/+10V	0/250 PSIG
11	27	+ 0900 + 2500	RC PRESS. LP B NR	RC-3D-PT2	0/+10V	1700/2500 PSIG
12	1	- 9999 + 9999	REACTOR TRIP		TRIP - CC	
13	47	+ 0000 + 0090	RC FLOW LP B TEMP COMP	RC-3B-DPT-1	-10/+10V	0/90 MPPH
14	57	- 0500 + 0000	FEEDWATER TEMP.	SP-5A-TE-1	+10/-10V	0/500°F
15	110	- 0305 + 1203	TURBINE HDR. PRESS. LP A	SP-10A-PT1	+2/+10	600/1200 PSIG
16	49	+ 0000 + 0100	OTSG A OP LVL TEMP COMP	SP-1A-LT2	-10/+10V	0/100%
17	50	+ 0000 + 0250	OTSG A SU LVL	SP-1A-LT4	-10/+10V	0/250 IN.
18	62	+ 0000 + 6500	FEEDWATER FLOW LP A FE-8A	FW-8A-FE	-10/+10V	0/6500 KPPH
19	63	+ 0000 + 6500	FEEDWATER FLOW LP B FE-8B	FW-8B-FE	-10/+10V	0/6500 KPPH
20	85	- 9999 + 9999	TURBINE TRIP		TRIP - CC	
21	112	- 1833 + 1222	OTSG A STM. PRESS.	SP-6A-PT1	+2/+10V	0/1200 PSI
22	113	- 1796 + 1197	OTSG B STM. PRESS.	SP-6B-PT1	+2/+10V	0/1200 PSI
23	51	+ 0000 + 0100	OTSG B OP LVL TEMP COMP	SP-1B-LT2	-10/+10V	0/100%
24	52	+ 0000 + 0250	OTSG B SU LVL	SP-1B-LT4	-10/+10V	0/250 IN.

TABLE H-2. MUX VOLTAGE/ENGINEERING UNIT CONVERSIONS

Mux Channel	Patchboard Number	Equations
1	14	Mux 1 = 12.5* (Volt1)
2	28	Mux 2 = 570.0 + (5.0* Volt 2)
3	29	Mux 3 = 570.0 + (5.0* Volt 3)
4	31	Mux 4 = 350.0 + (30.0* Volt 4)
5	34	Mux 5 = 350.0 + (30.0* Volt 5)
6	45	Mux 6 = 45.0 + (4.5* Volt 6)
7	22	Mux 7 = 200.0 - (20.0* Volt 7)
8	96	Mux 8 = 50.0 + (5.0* Volt 8)
9	19	Mux 9 = Volt 9 (If [(Volt 9.GE.9.0) and (Volt 9.LE.10.0)] then Mux 9 = 10.0 If [(Volt 9.GE-1.0) and (Volt 9.LE.1.0)] then Mux 9 = 0.0
10	65	Mux 10 = 25.0* (Volt 10)
11	27	Mux 11 = 1700.0 + (80.0* Volt] 11)
12	1	Mux 12 = Volt 12 If [(Volt 12.GE.9.0) and (Volt 12.LE.10.0)] then Mux 12 = 10.0 If [(Volt 12.GE.-1.0) and (Volt 12.LE.1.0)] the Mux 12 = 0.0
13	47	Mux 13 = 45.0 + (4.5* Volt 13)
14	57	Mux 14 = 250.0 - (25.0* Volt 14)
15	110	Mux 15 = 600.0 + (75.4* Volt 15) - (2.0* 75.4)
16	49	Mux 16 = 50.0 + (5.0* Volt 16)
17	50	Mux 17 = 125.0 + (12.5* Volt 17)
18	62	Mux 18 = 3.25 + (325* Volt 18)
19	63	Mux 19 = 3.25 = (325* Volt 19)
20	85	Mux 20 = Volt 20 If [(Volt 20.GE.9.0) and (Volt 20.LE.10.0)] then Mux 20 = 10.0 If [(Volt 20.GE.-1.0) and (Volt 20.LE.1.0)] then Mux 20 = 0.0
21	112	Mux 21 = 152.75* Volt 21 - (2.0* 152.75)
22	113	Mux 22 = 149.65* Volt 22 - (2.0* 149.65)
23	51	Mux 23 = 50.0 + (5.0* Volt 23)
24	52	Mux 24 = 125.0 + (12.5* Volt 24)

input pressure changes if the absolute pressure was below 500 psig. This is another strong indication that the reactimeter data spikes in question were not real.

A statistical analysis of the voltage changes that occurred was performed to determine if the sudden jumps, with nearly equal voltage changes, were improbable events.

The coefficient of variation was analyzed for 116 events from the NSAC-1[H-2] Sequence of Events table at the event initiation time listed in Reference H-2. No events were found which had a coefficient of variation less than 1.0 out of the 116 times examined. In addition, for 27,168 data points examined on the reactimeter data tape out to 81,156 s total elapsed time, only 28 data points were found which had a coefficient of variation of less than 1.0.[H-3]

Eight out of these 28 correspond to sudden jumps illustrated on Figure H-1, and the sudden jump at 61,125 s has the lowest coefficient of variation found. On this basis, it was concluded that the probability of nearly equal voltage changes on several channels as a result of a real physical event is so low that the sudden voltage changes must have been due to a shift in the zero offset calibration of the data channels in question.

Although it could not be confirmed, the calibration shifts were most probably due to the reactimeter power supply being on a different grounding system than the instrument data channels. In that case, any ground faults in either system could be expected to result in a zero offset calibration. Numerous ground faults could have occurred as a result of the combined effects of the wet high humidity conditions, Reactor Building spray actuation which contained a conductive solution of NaOH, and the high temperature damage of electrical insulation caused by the hydrogen burn.

It was found that some data channels did not exhibit sudden jumps. Although it is beyond the scope of this document to explain why, it is related either to (a) the fact that the particular data channel was over-ranged at the time, or (b) the channel was on/off (i.e. reactor trip), or (c) the channel was a zero-to-ten volt output channel. The channel voltage outputs are shown on Table H-2.

The statistical analysis also indicated that after the hydrogen burn, zero calibration shifting was occurring so frequently, that the reactimeter data were rendered very unreliable. Any use of this data would have to be done with extreme caution unless a way was found to determine and apply a suitable zero calibration shift correction.

References

H-1. J. O. Henrie, A. K. Postma, Analysis of TMI-2 Transients, GEND-Inf-023, Vol V, to be published. Also published as SD-WM-TI-067 by Rockwell Hanford Operations May 1983

H-2. J. O. Henrie, A. K. Postma, Analysis of the TMI-2 Hydrogen Burn, GEND-Inf-023, Vol. IV, March 1983.

H-3. Nuclear Safety Analysis Center, Analysis of Three Mile Island-Unit 2 Accident, NSAC-80-1, March 1980.