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MARK I CONTAINMENT PROGRAM QUARTER SCALE PLANT UNIQUE TESTS

TASK NUMBER 5.5.3, SERIES 2

VOLUME 2

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MARK I CONTAINMENT PROGRAM
1/4 SCALE PRESSURE
SUPPRESSION POOL SWELL TEST PROGRAM: PLANT UNIQUE TESTS
TASK NUMBER 5.5.3, SERIES 2

Volume 2, Appendix A

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Reviewed by: John M. Humphrey
John M. Humphrey
Mark I Containment Design

Approved by:
G.E. Wade, Manager
Mark I Containment Design

Approved by:
P.W. Ianni, Manager
Containment Design

NUCLEAR ENERGY PROJECTS DIVISION • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125

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INTRODUCTION - APPENDICES

The large quantity of data and descriptive material produced by each test series has necessitated the inclusion of a set of appendices with this report. The main report highlights data from a typical plant's tests and summarizes information of general interest. Eight Appendices have been included to present data for the remaining plants, to discuss in detail certain phenomena of particular interest, and to document areas that have received additional investigative effort. The contents of these appendices are summarized below.

Appendix A, which is a continuation of Section 3, presents the test data for the other sixteen plant configurations tested. The data in Section 3 and Appendix A are not necessarily design basis data. The Task 5.5.3-2 Plant Unique Tests were performed at conditions being evaluated for plant operation. Supplementary tests are being performed for several Mark I Utilities to evaluate alternate conditions including variations in water level, submergence, drywell/wetwell pressure differential and vent header deflector design. After a review of these data, a set of test conditions will be selected for each plant to serve as a design basis for pool swell loads.

Appendix B defines the methodology used for vent header pressure integration. The values used for the six point fits to the impact pressure transducer transients and the resulting pressure integrals are also provided.

Appendix C presents plant unique data comparisons and the results of a linear regression correlation of the plant unique test data.

Appendix D estimates the amount of pool mass that is suspended during the upload.

Appendix E presents a series of still pool swell pictures for each plant configuration.

Appendix F presents the results of a measurement uncertainty analysis.

Appendix G presents the specification for vent system resistance and the methods used to meet the specification.

Appendix H presents the results of evaluations of torus window related download oscillations in the plant unique data and a description of the methods employed to remove these effects for several plants.

APPENDIX A

The data for one typical test configuration was presented and discussed in Section 3. The data for the other sixteen configurations tested during the Task 5.5.3-2 Plant Unique Tests is presented and discussed in this appendix in the same format as Section 3.

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APPENDIX A

A.1 Hatch 2 Tests

A.1.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Hatch 2, Tests 2 and 6. Test 2 was a load definition test, which was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with no deflector. Test 6 was conducted with an initial drywell/wetwell differential pressure of 14.35" H_2O ΔP (full ΔP) and with no deflector.

A.1.1.1 Driving Conditions

Driving conditions for Hatch 2 Test 2 are presented in Figures A-1 through A-5. Similar plots for Test 6 are shown in Figures A-6 through A-10. Comparison of the driving conditions indicates that enthalpy flow into the pool starts at an earlier time and peaks out at a lower value in Test 6 with full ΔP (Figure A-5 versus A-10).

A.1.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Hatch 2 Test 2 are presented in Figures A-11 and A-12, respectively. The same pressures for Test 6 are shown in Figures A-13 and A-14. An oscillation can be observed in the downcomer internal pressure in Figure A-11, which is a characteristic of 0" ΔP runs. Net torus force from the pressure integral (Figures A-15 and A-16) shows no oscillation in downforce. Some oscillations in upforce, however, can be observed in Test 2 with 0" ΔP. Net torus force that is determined from the torus load cell (Figures A-17 and A-19) by applying inertial correction with the torus accelerometer (Figures A-18 and A-20) is shown in Figures A-21 and A-22 and compared

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with net torus force determined from the pressure integral. Figures A-23 and A-24 present the net torus force based on the torus pressure integral, corrected for inertia.

Upforce oscillations which occur in some of the plant tests (type II downcomer with 30° bend) are well illustrated in the Hatch 2 zero ΔP tests. These oscillations are caused by delayed breakthrough which allows the water slug to bounce between the torus freespace and the LOCA air bubbles. The upforce oscillations (Figure A-15), which correspond to oscillations in the acceleration of the water slug, are clearly visible in the downcomer (bubble) pressure (Figure A-11) as well as in the torus pool pressures (Figure A-12). The bubble and water pressures are together oscillating out of phase with the torus air pressure as the rising air slug alternately over compresses the freespace and then the bubble.

The high speed movies of previous reference plant tests show that the pool separates at the 45° downcomer bend. When the top of the bubble reaches this separated region, breakthrough is observed to begin in the films and in the data (as signified by an increase in the noise in the pressure integral). Movie of type II downcomer tests with 30° bends transitioning to vertical downcomers near the waterline do not exhibit separated flow behind the downcomers. The pool flows around the downcomers and does not appear to break through until well after peak upforce.

The "average" pool pressures for Hatch 2, Tests 2 and 6 are shown in Figures A-26 and 27. Figures A-25 and A-28 are the same as Figures A-23 and A-24 with force replaced by average pressure (force/ torus projected area).

The vent header impact pressures for Hatch 2 Test 2 are presented in Figures A-29 through A-31. Vent header impact pressures for Test 6 are presented in Figures A-32 through A-34.

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The vent header impact forces from the pressure integral and the corrected load cell agree reasonably well (Figure A-35). Vent header vertical acceleration measurements from Tests 2 and 6 are shown in Figures A-36 and A-37, respectively.

A.1.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-38 through A-41 for Hatch 2, Tests 1, 2, 3, and 5.

Pool surface displacement curves are shown in Figures A-42 and A-44. The pool surface velocity profiles are shown in Figures A-43 and A-45.

The pool surface displacement versus time and velocity profile viewed from the side window during Test 4 are shown in Figure A-46. The downcomer water slug displacement, velocity, and acceleration versus time for Test 2 are shown in Figure A-47.

A.1.3 Data Summaries

Tables A-1 and A-2 present the Hatch 2 test data for wetwell vertical forces.

Table A-3 presents the Hatch 2 test data for vent header impact forces.

A.1.4 Discussion and Analysis

Figure A-48 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. The enthalpy flow starts at an earlier time (vents clear at an earlier time) and reaches a lower steady state value in the full ΔP run (Test 6). The effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-49. Figure A-50 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The Hatch 2, Test 2 data parallels that for

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Test 8 of the "typical" plant in Section 3.0. The Hatch 2, Test 6 data parallels the "typical" Test 2 data.

The Hatch 2 load definition tests were conducted at 0" H_2O ΔP with no deflector. ΔP sensitivity tests at 14.35" H_2O ΔP (full ΔP) was also conducted. Downforce showed no oscillation, but upforce showed some oscillations in the 0" H_2O ΔP runs. The vent header impact force was significantly higher than for plants using deflectors.

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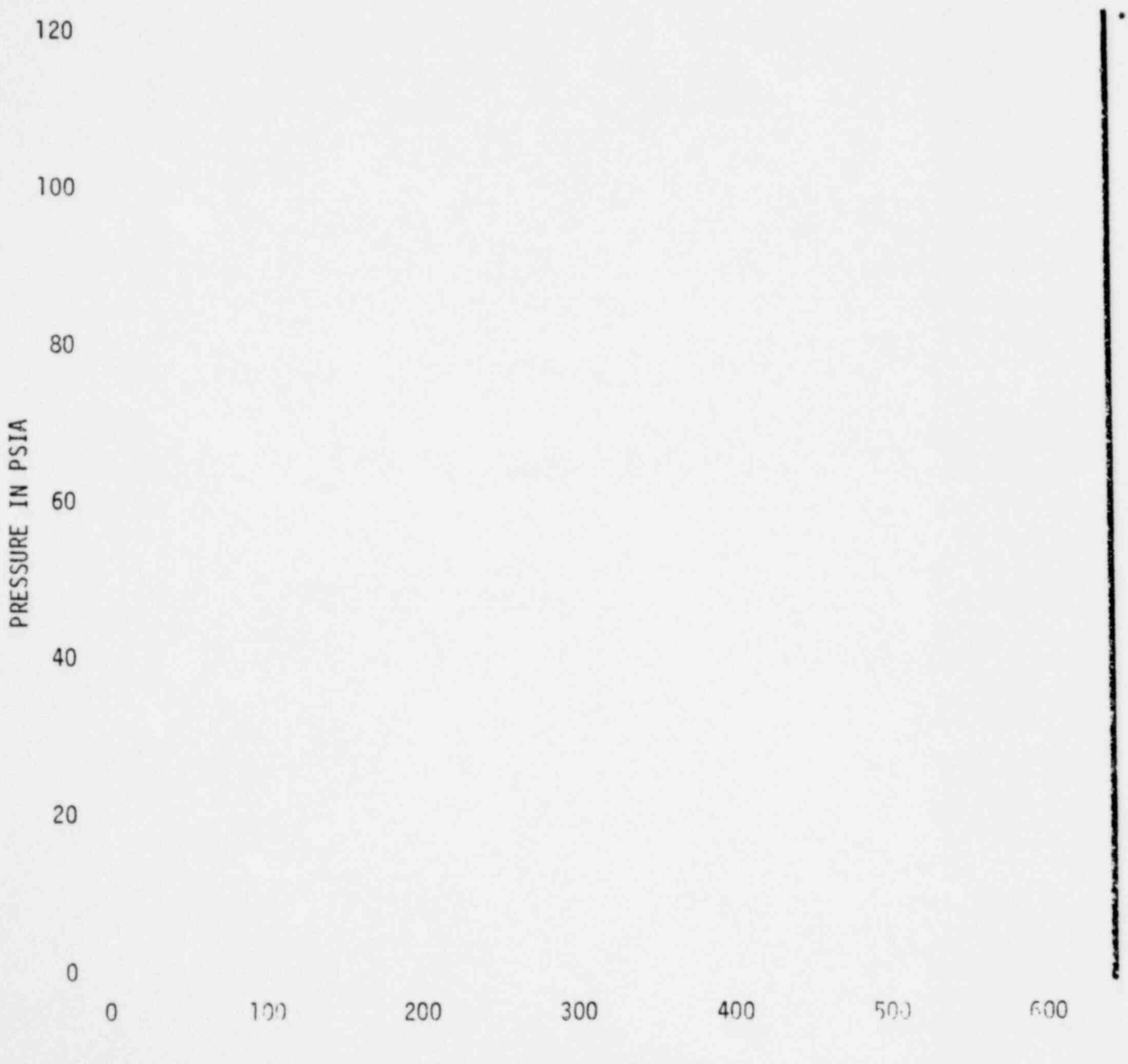
FIGURE A-1
DRYWELL ORIFICE UPSTREAM PRESSURE
Task 5.5.3-2 Hatch 2 Test 2



*Proprietary information deleted.

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FIGURE A-2

DRYWELL PRESSURE

Task 5.5.3-2 Hatch 2 Test 2

*Proprietary information deleted.

FIGURE A-3

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Hatch 2 Test 2

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FIGURE A-4

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Hatch 2 Test 2

FIGURE A-5

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Hatch 2 Test 2

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FIGURE A-6

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Hatch 2 Test 6

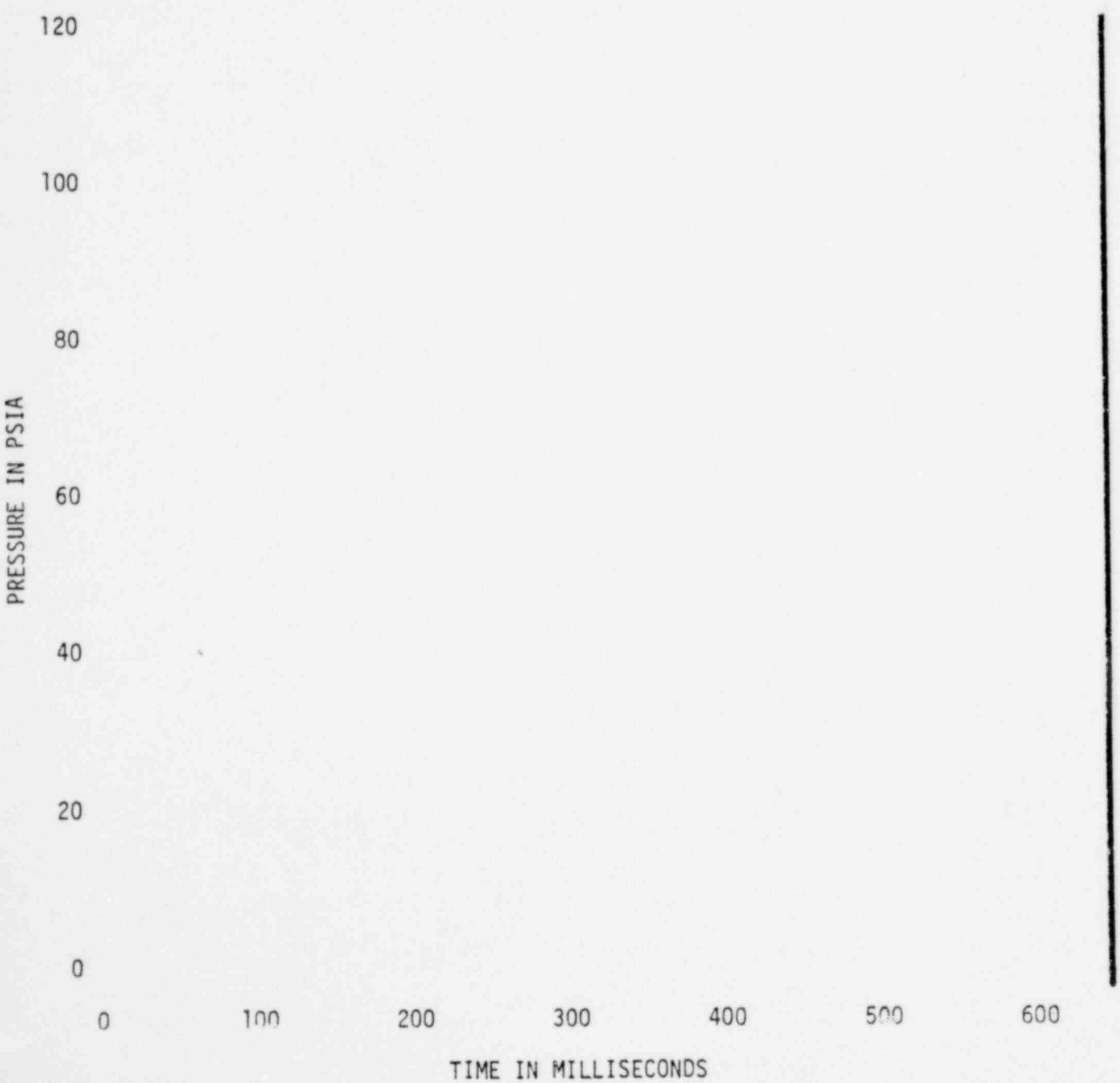

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FIGURE A-7

DRYWELL PRESSURE

Task 5.5.3-2 Hatch 2 Test 6

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FIGURE A-8

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Hatch 2 Test 6

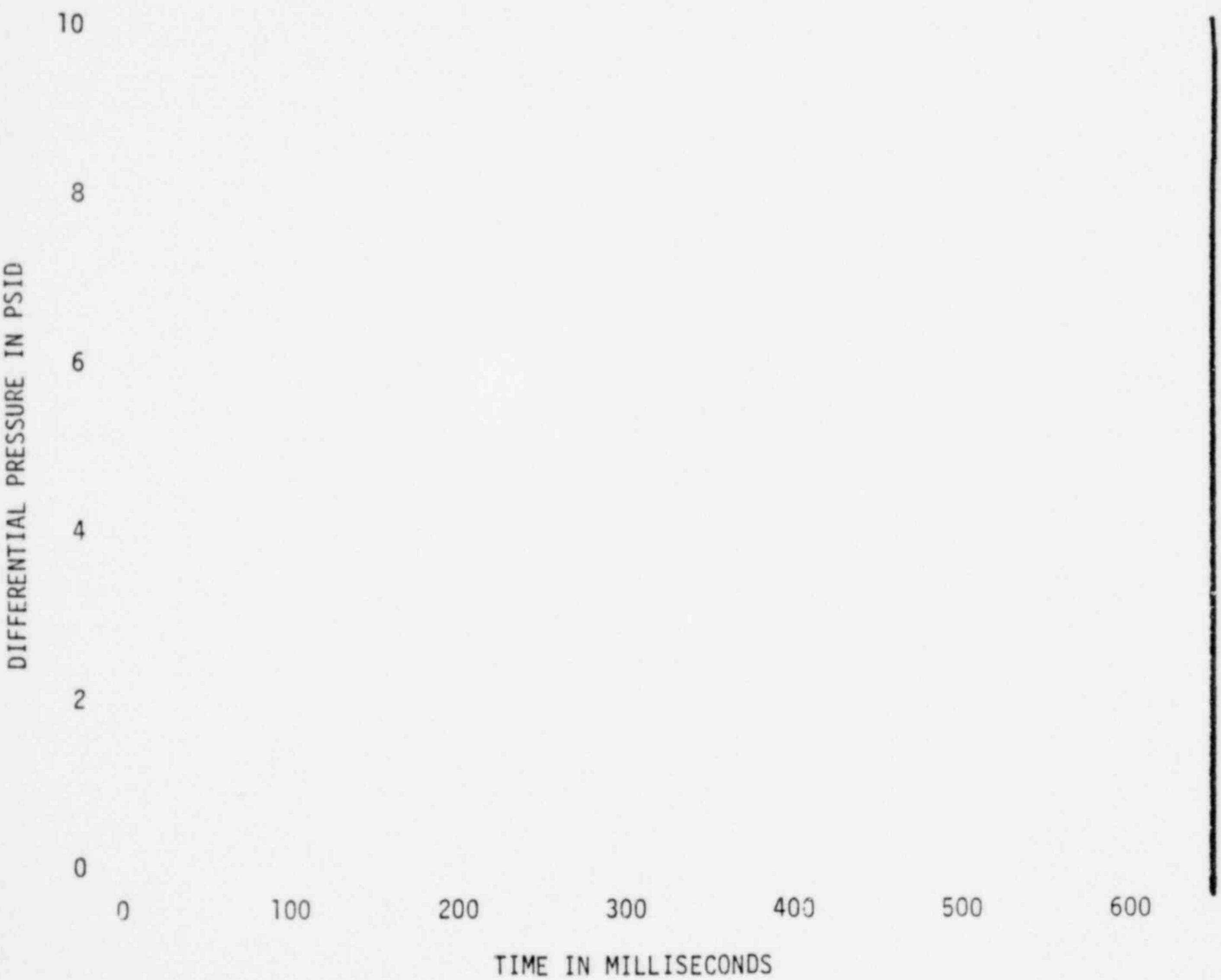

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FIGURE A-9

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Hatch 2 Test 6

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FIGURE A-10

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Hatch 2 Test 6

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FIGURE A-11

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Hatch 2 Test 2

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FIGURE A-12

WETWELL PRESSURES

Task 5.5.3-2 Hatch 2 Test 2

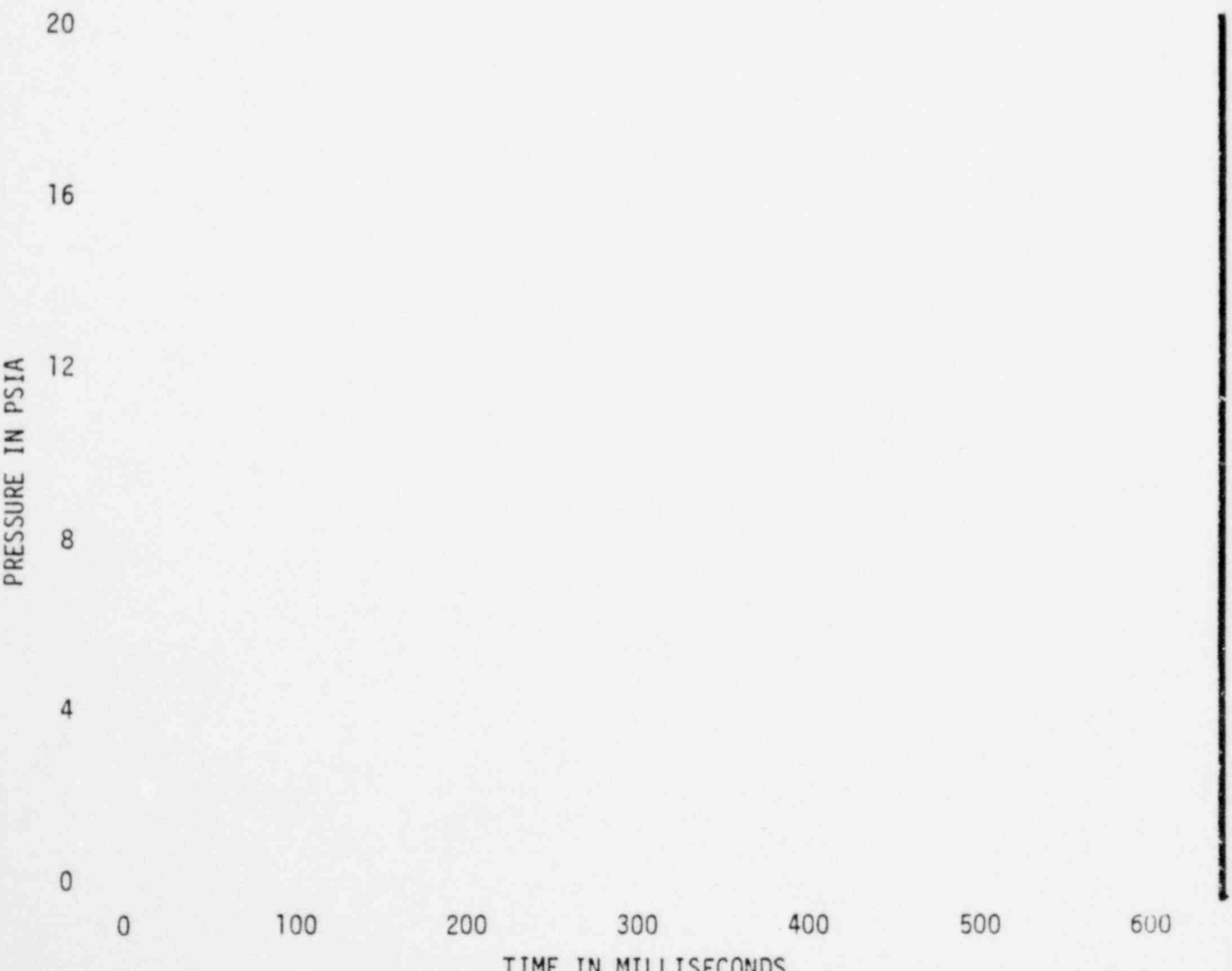

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FIGURE A-13

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Hatch 2 Test 6

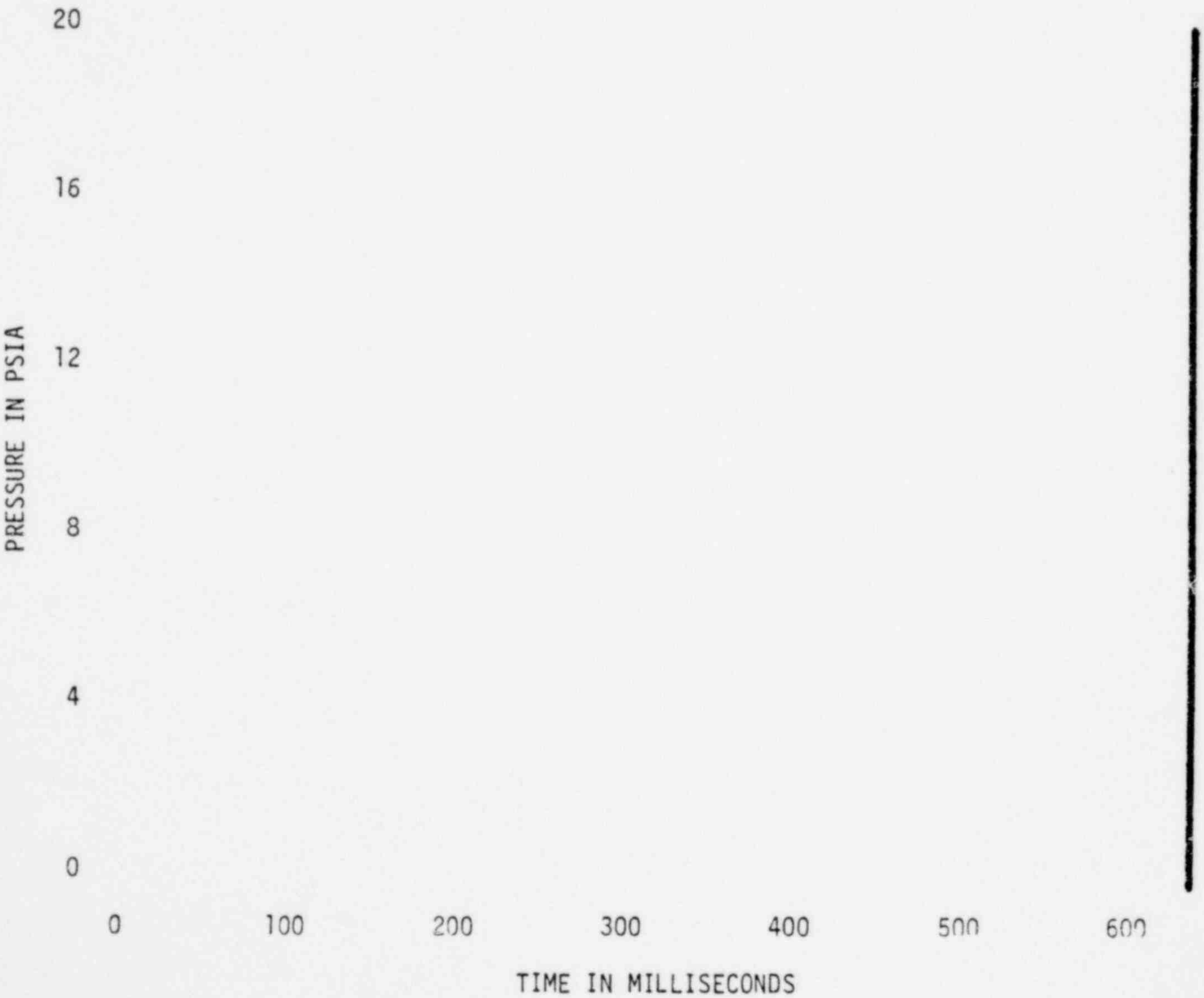

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FIGURE A-14

WETWELL PRESSURES

Task 5.5.3-2 Hatch 2 Test 6

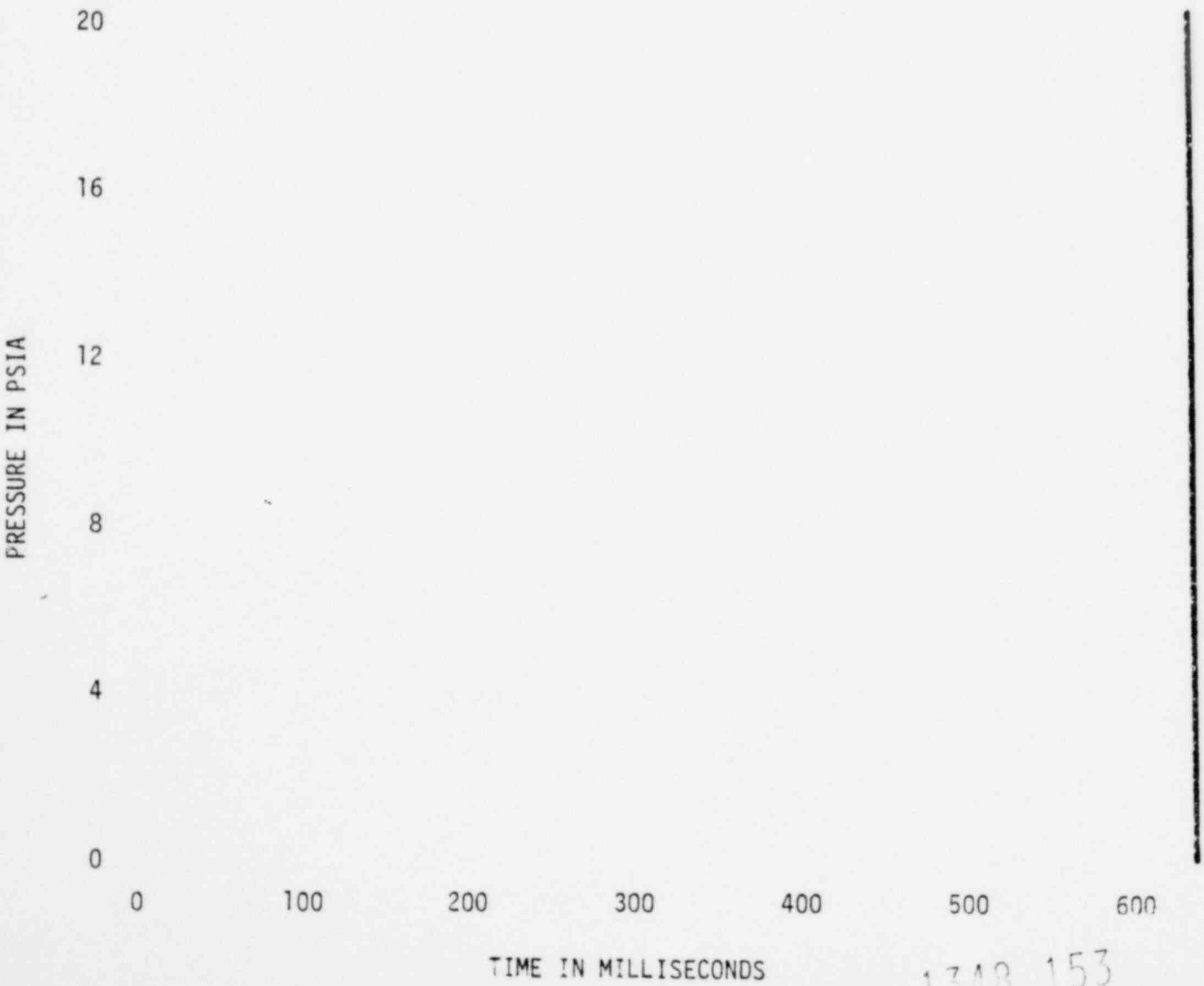

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FIGURE A-15

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Hatch 2 Test 2

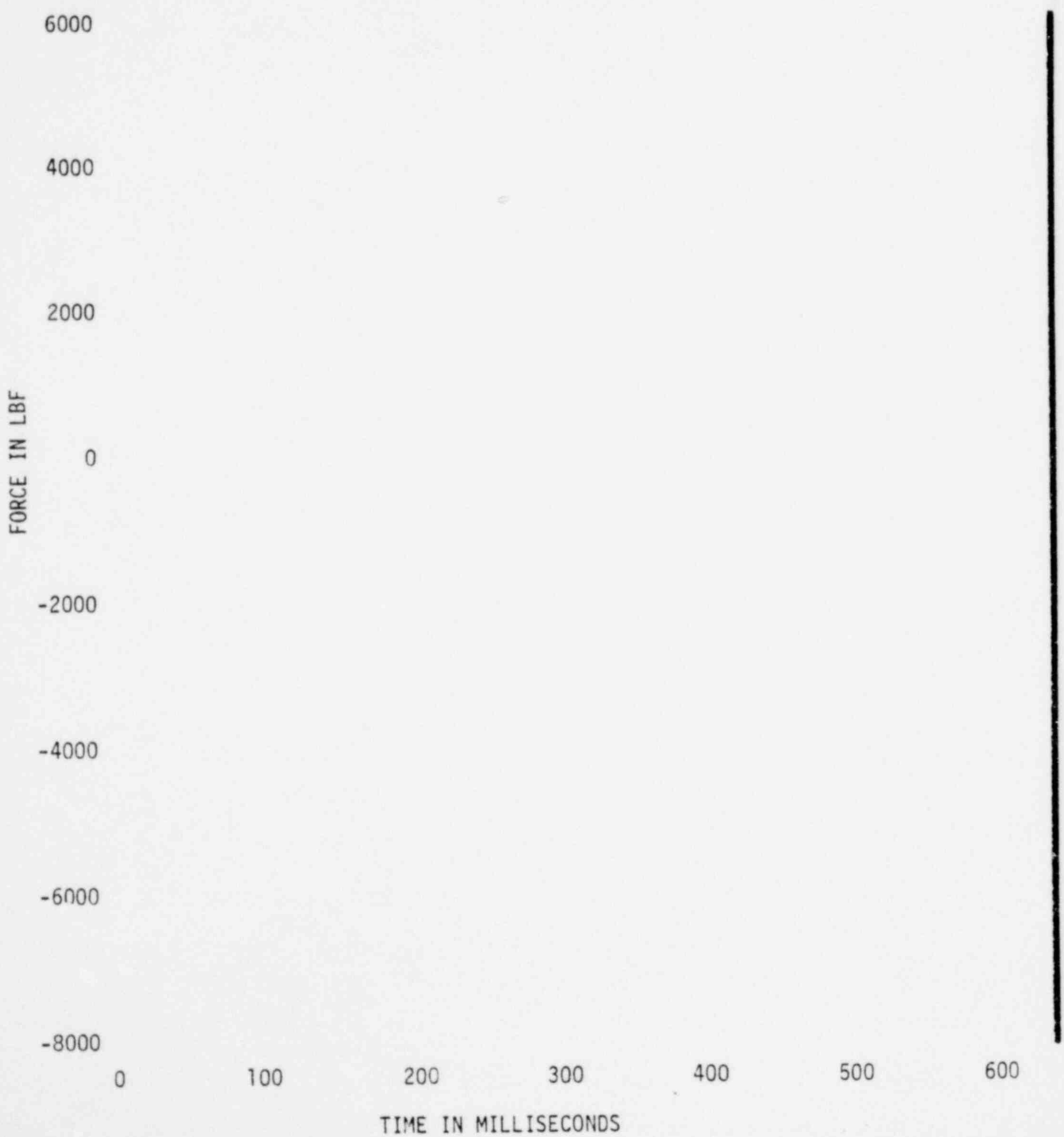

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FIGURE A-16

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Hatch 2 Test 6

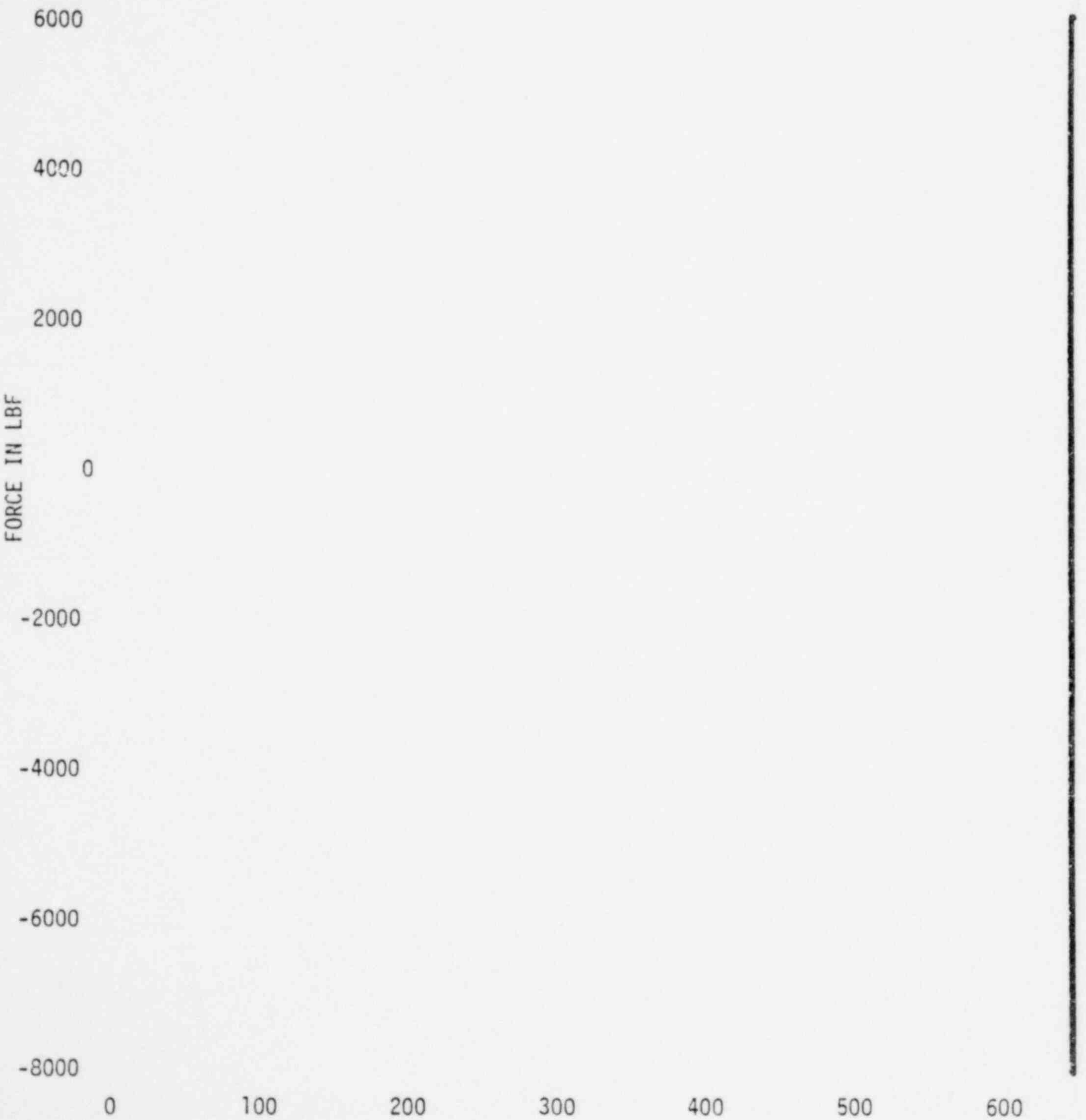

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FIGURE A-17

TORUS LOAD CELL

Task 5.5.3-2 Hatch 2 Test 2

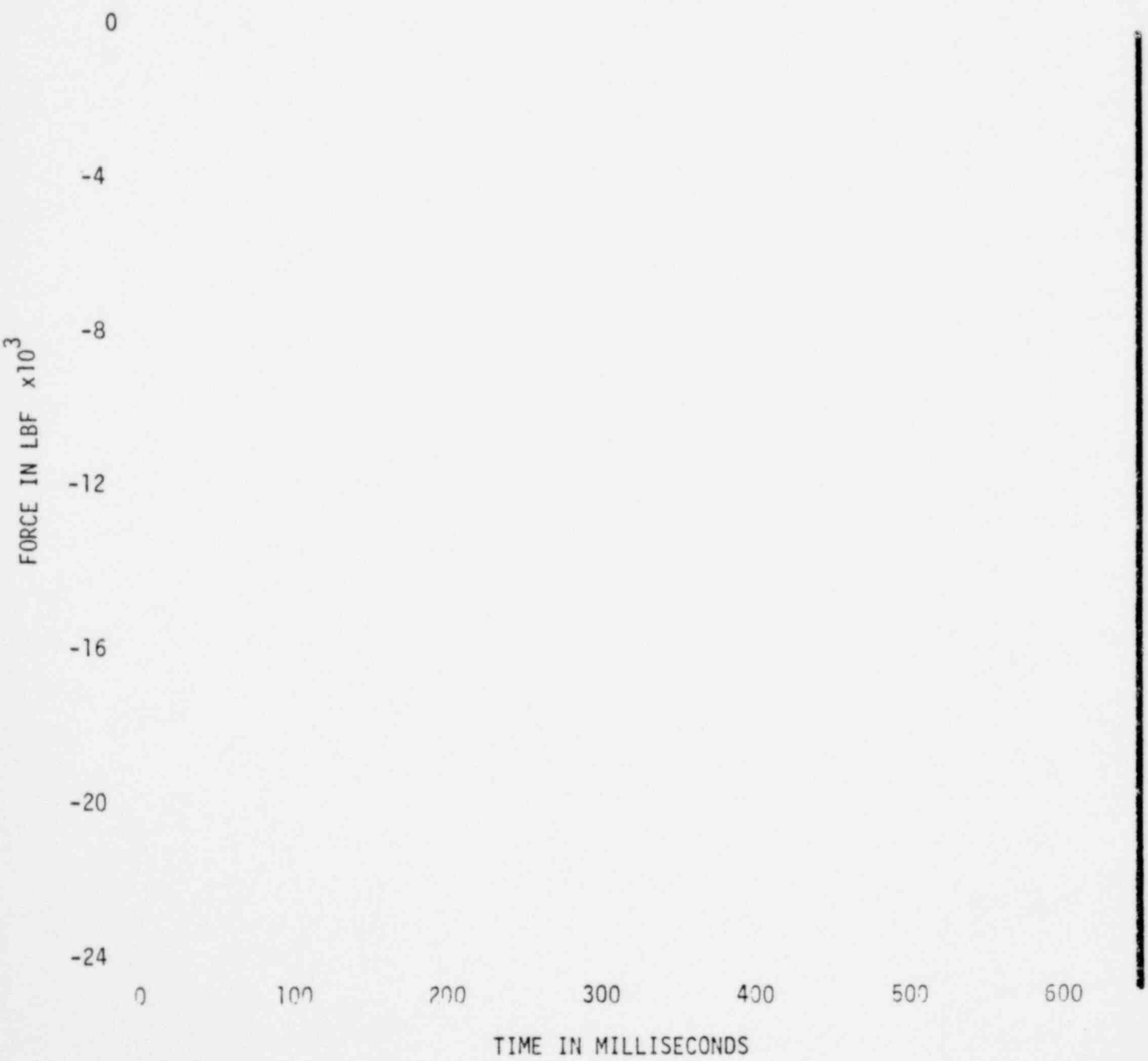

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FIGURE A-18

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Hatch 2 Test 2

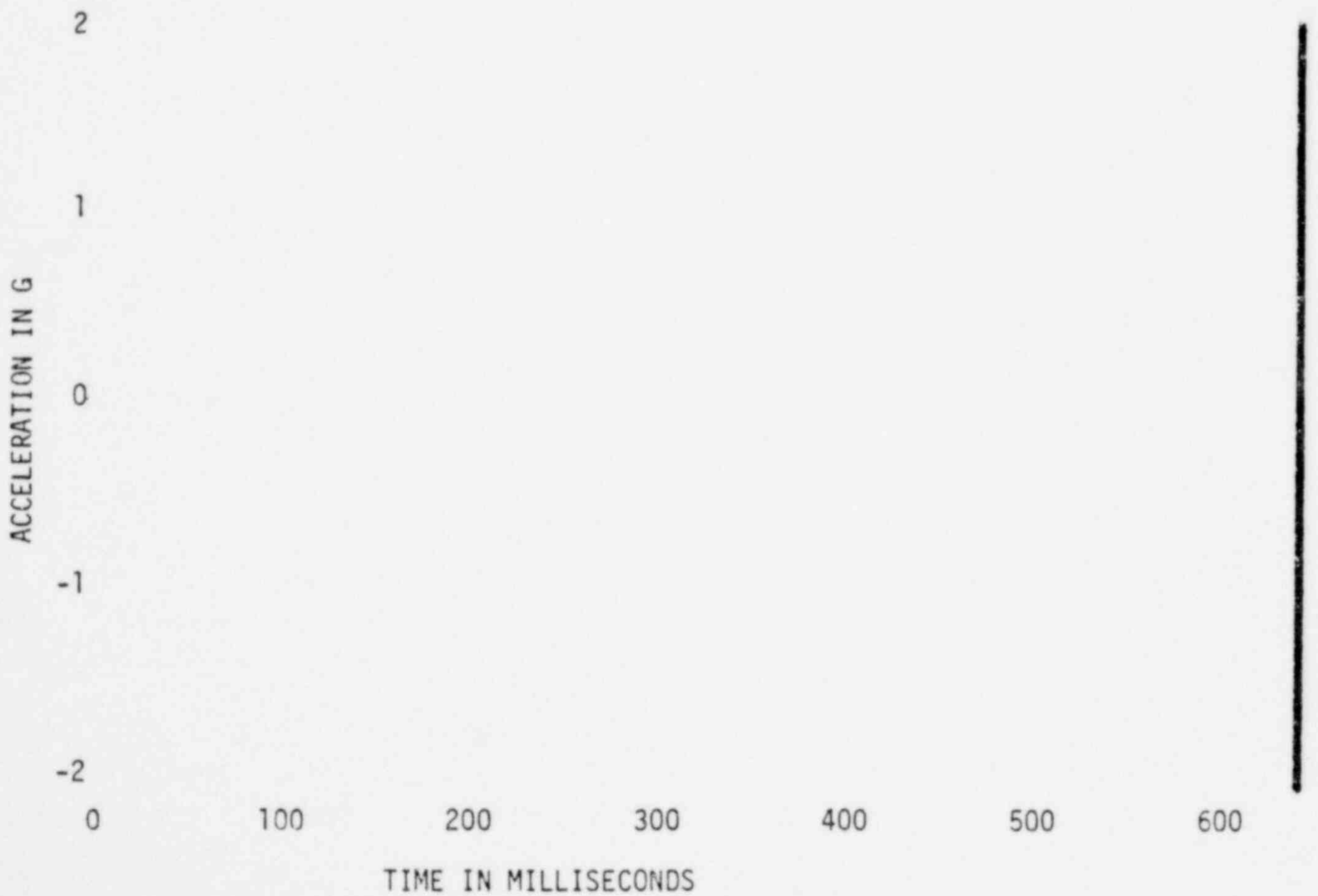

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FIGURE A-19

TORUS LOAD CELL

Task 5.5.3-2 Hatch 2 Test 6

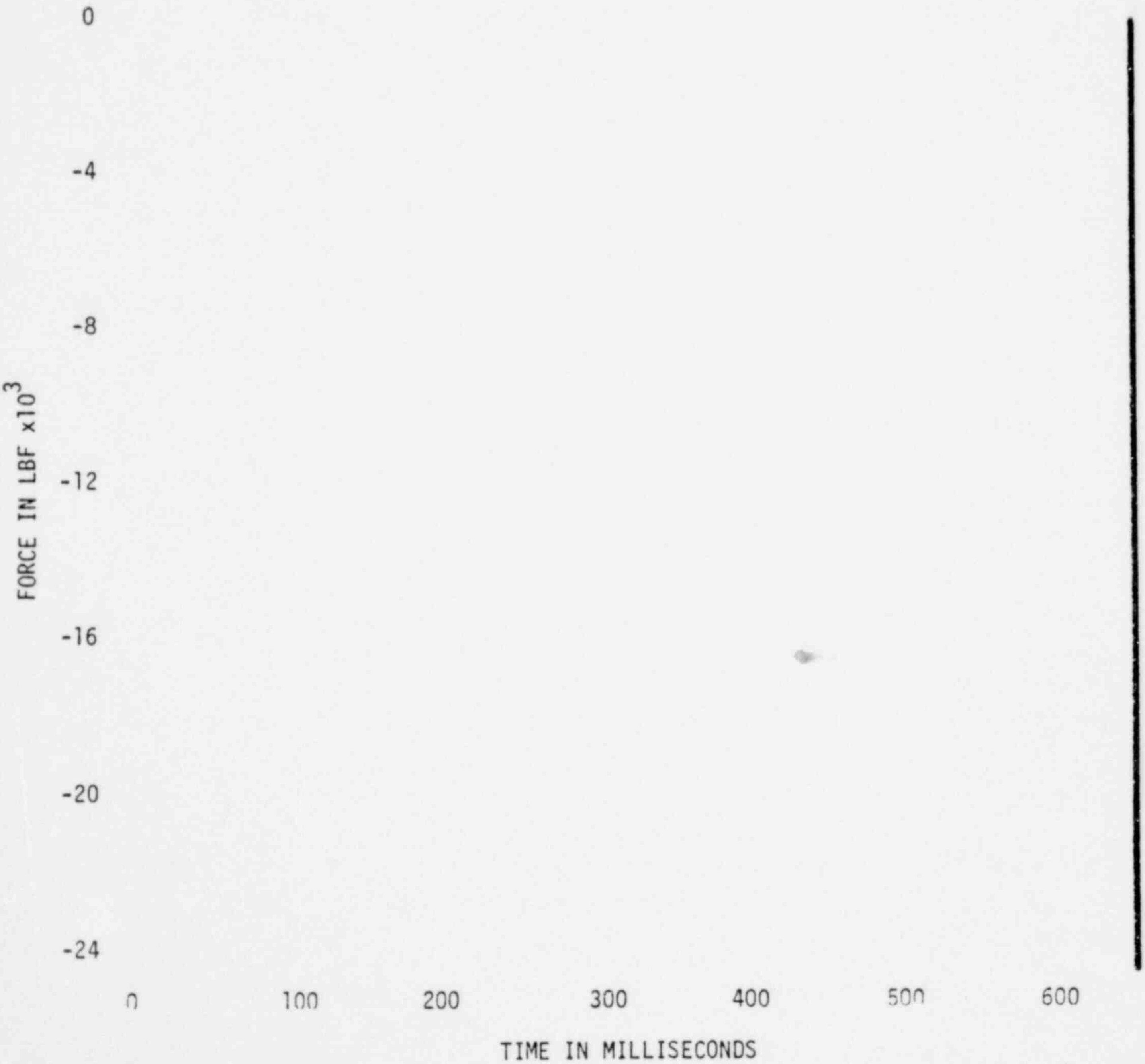

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FIGURE A-20

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Hatch 2 Test 6

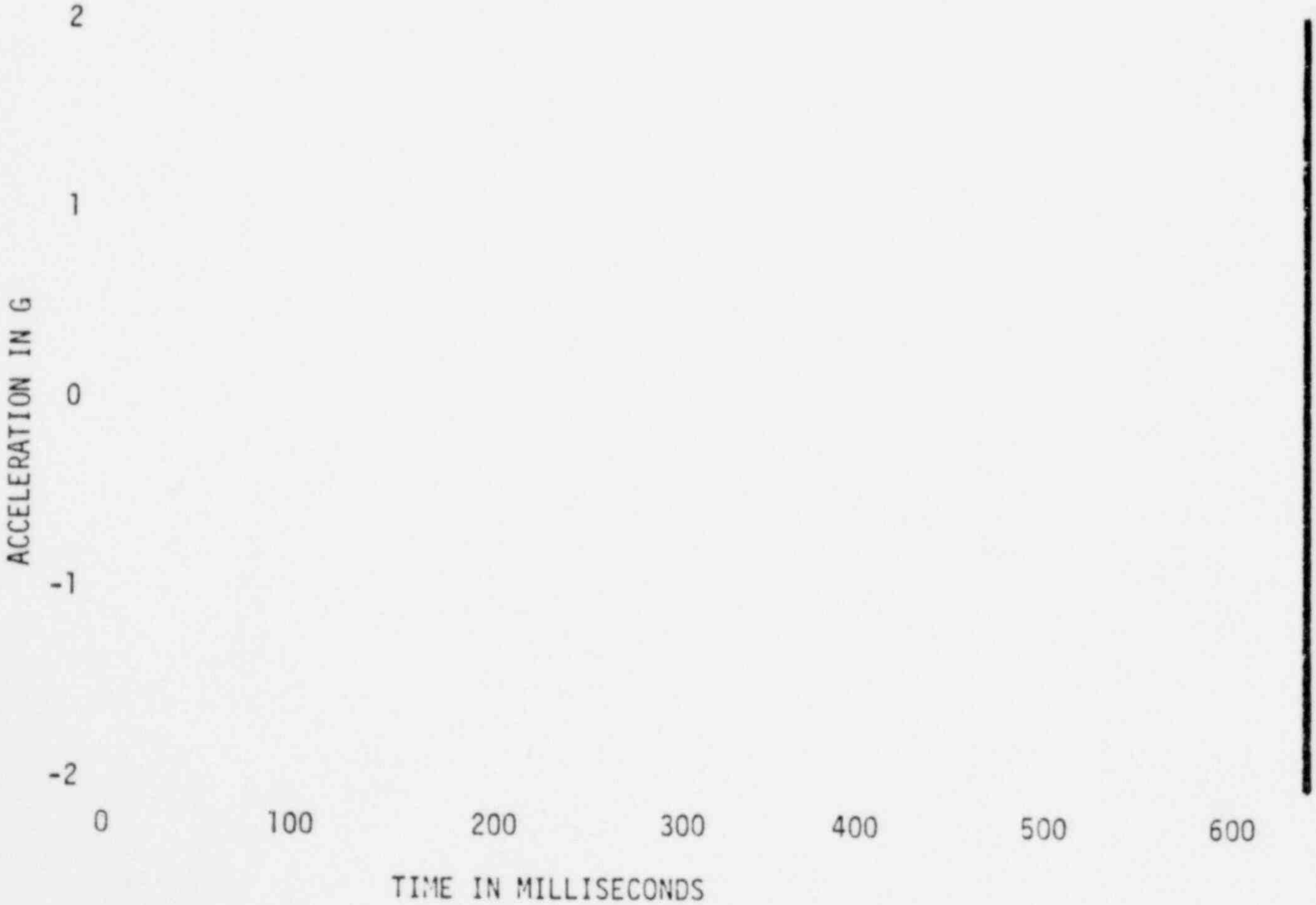

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FIGURE A-21 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Hatch 2 Test A2

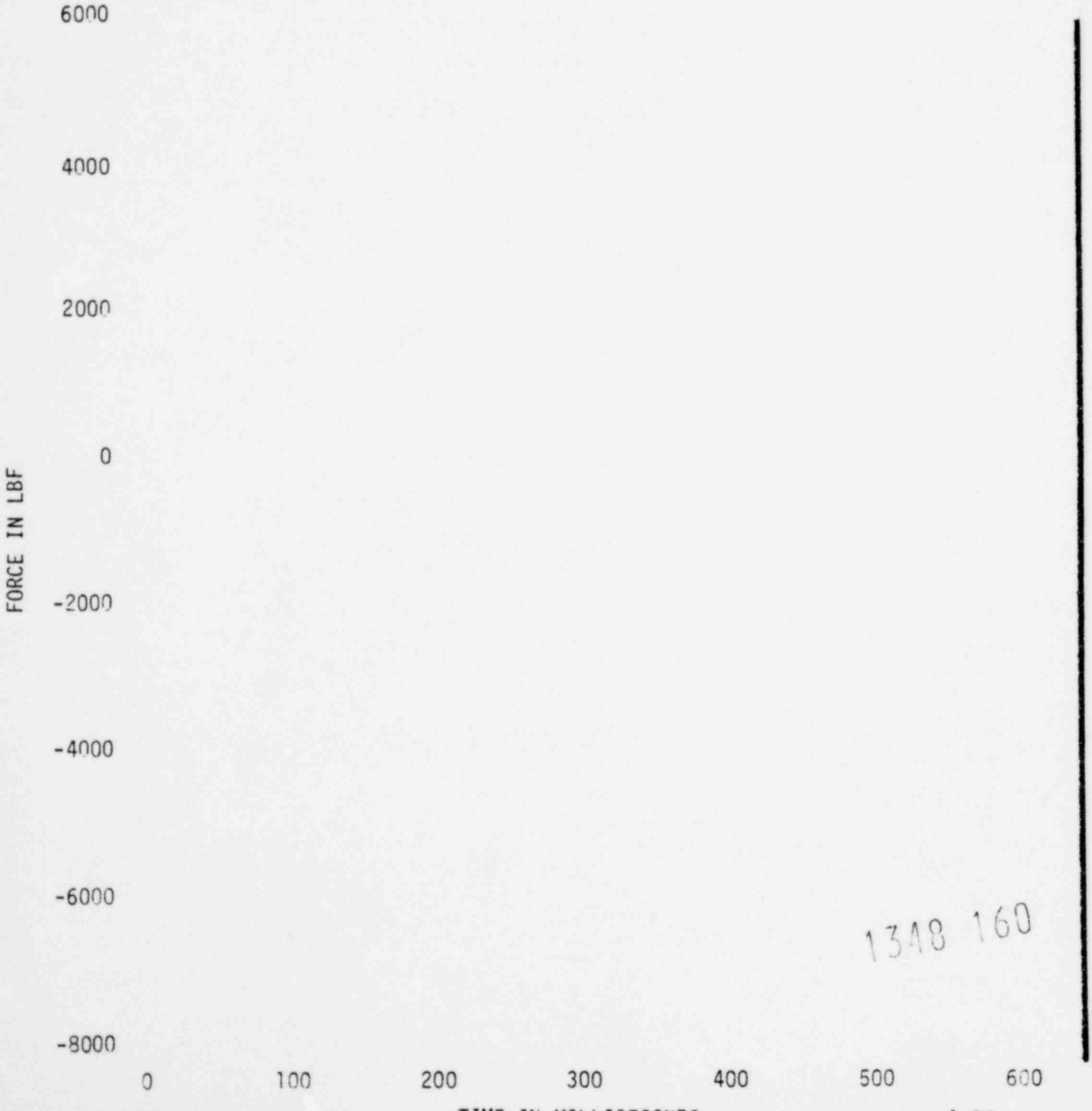

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FIGURE A-22

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL
WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA
Task 5.5.3-2 Hatch 2 Test 6

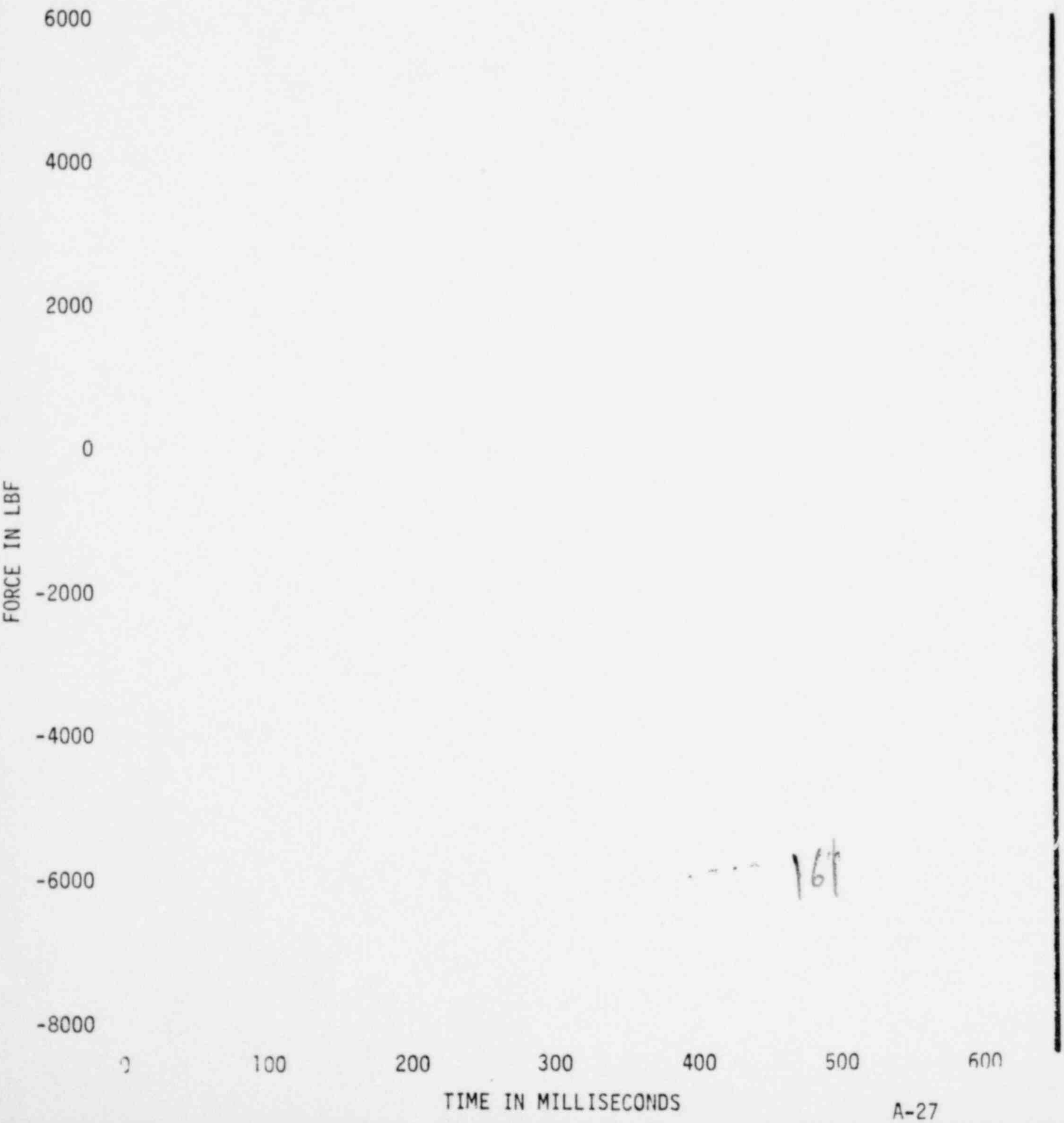

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FIGURE A-23

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 2

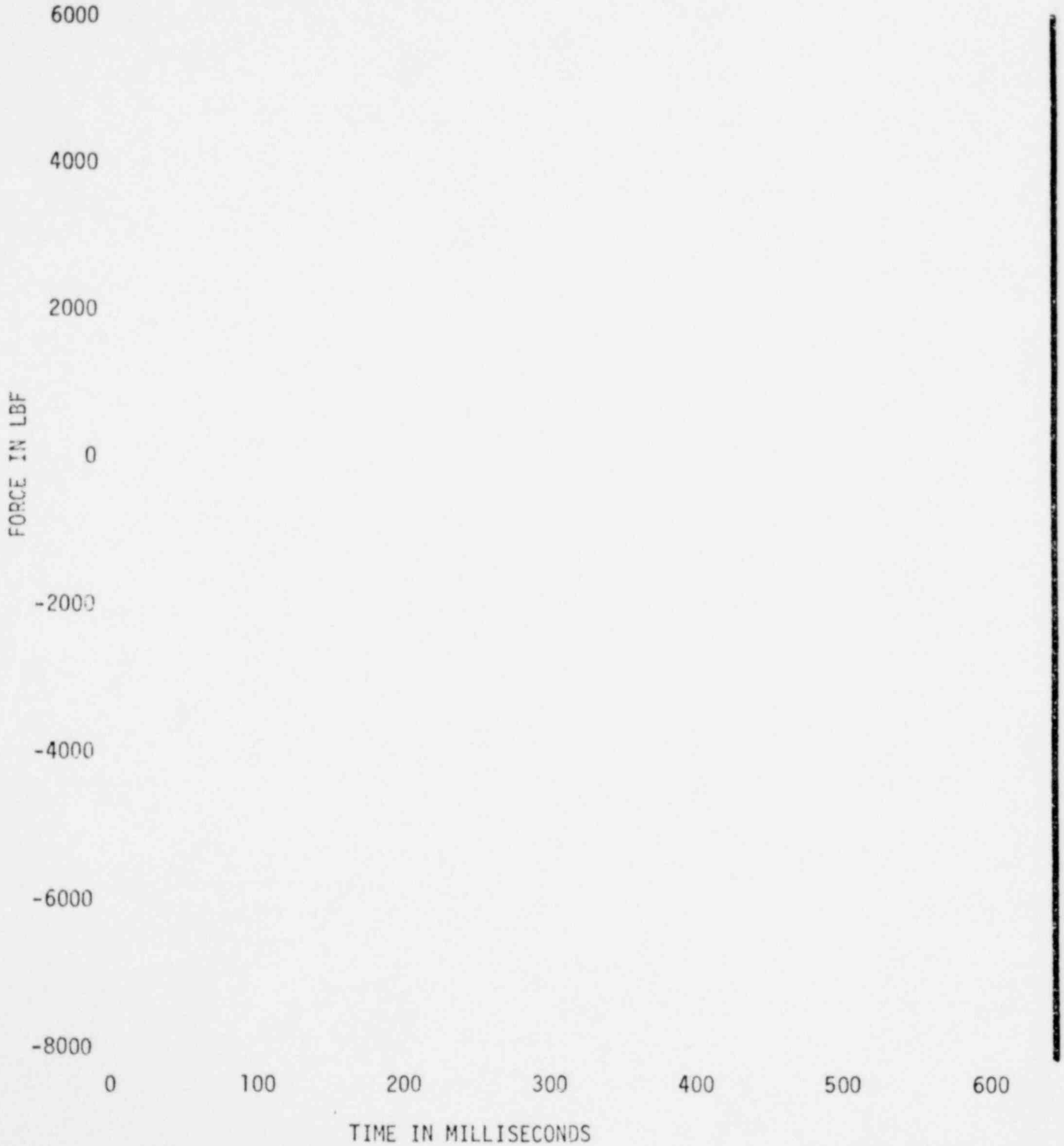

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FIGURE A-24

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 6

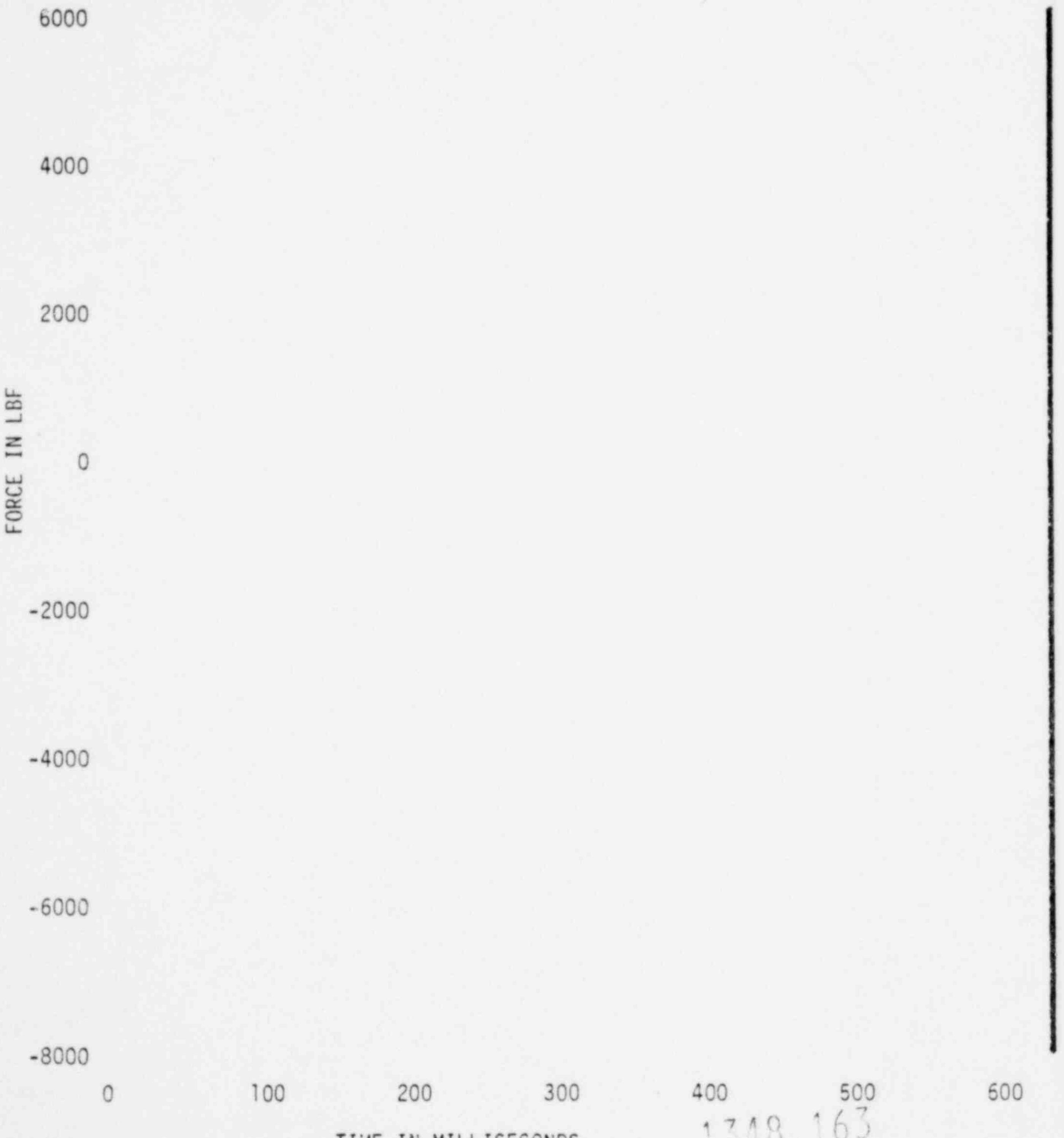

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FIGURE A-25

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 2

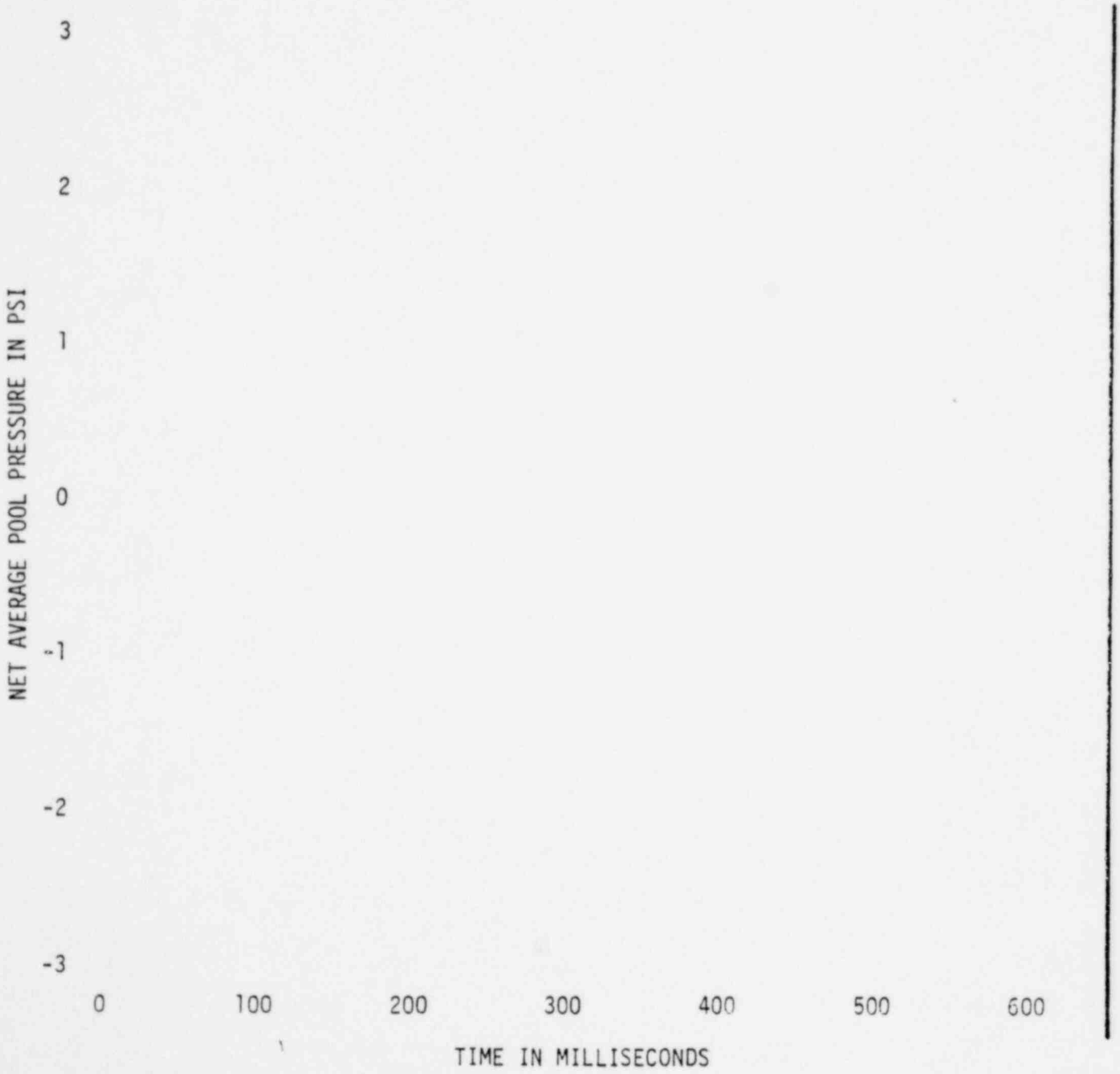

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FIGURE A-26

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 2

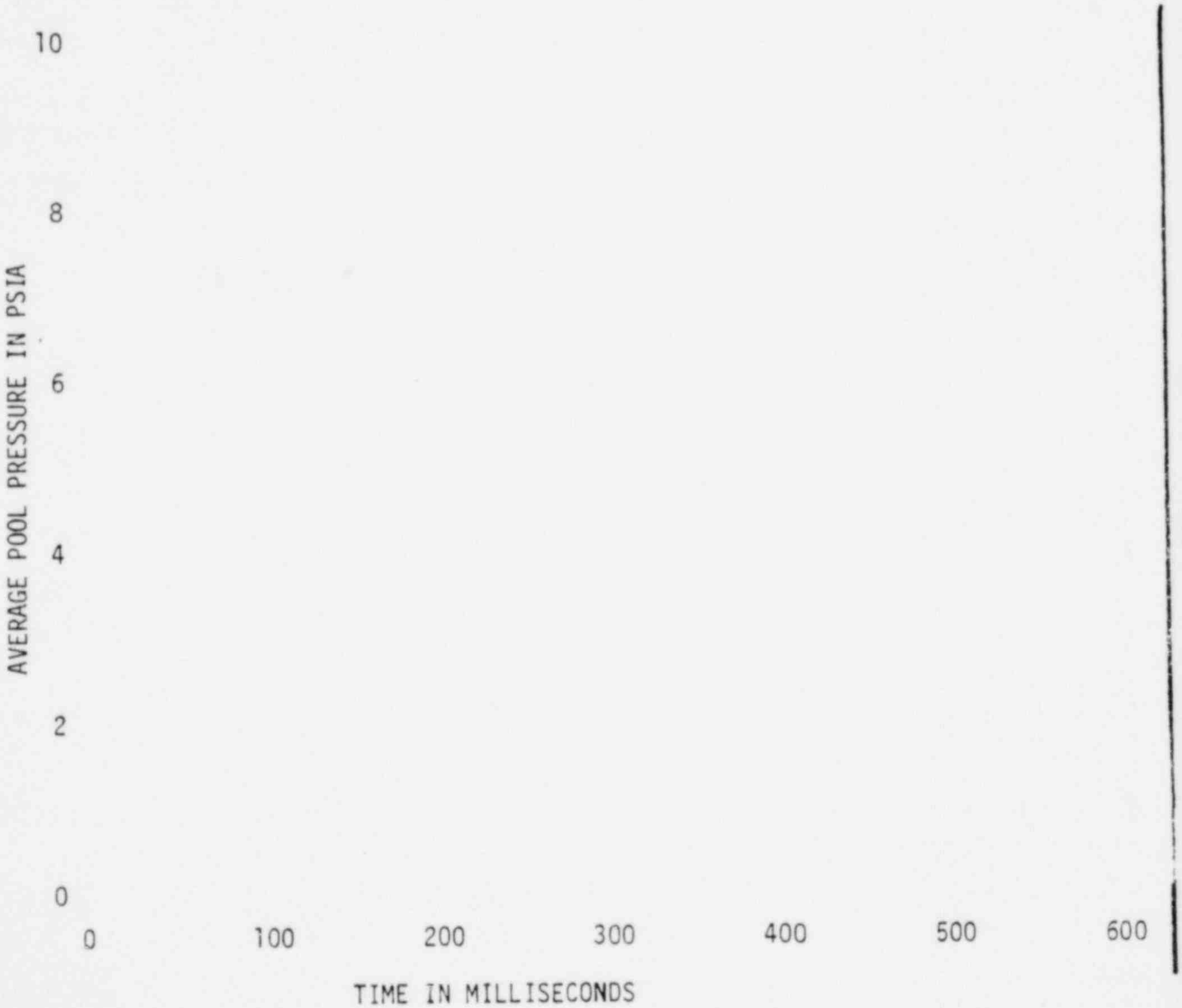

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FIGURE A-27

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 6

AVERAGE POOL PRESSURE IN PSI

10

8

6

4

2

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

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FIGURE A-28

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Hatch 2 Test 6

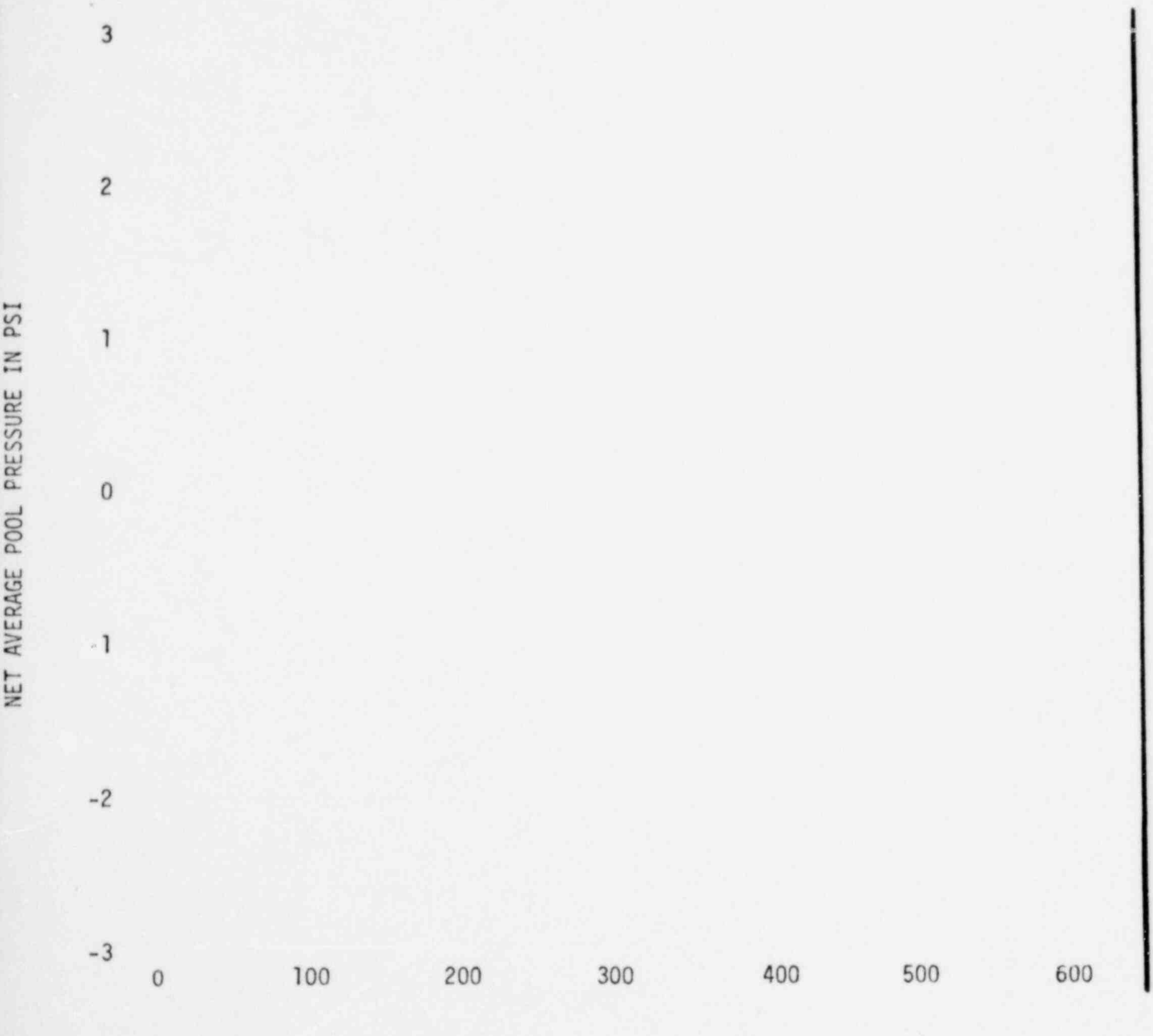

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FIGURE A-29

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Hatch 2 Test 2

PRESSURE IN PSIA

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VENT HEADER IMPACT PRESSURES

FIGURE A-30

Task 5.5.3-2 Hatch 2 Test 2

PRESSURE IN PSIA

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FIGURE A-31

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Hatch 2 Test 2

PRESSURE IN PSIA

FIGURE A-32 VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Hatch 2 Test 6

PRESSURE IN PSIA

FIGURE A-33

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Hatch 2 Test 6

PRESSURE IN PSIA

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FIGURE A-34 VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Hatch 2 Test 6

PRESSURE IN PSIA

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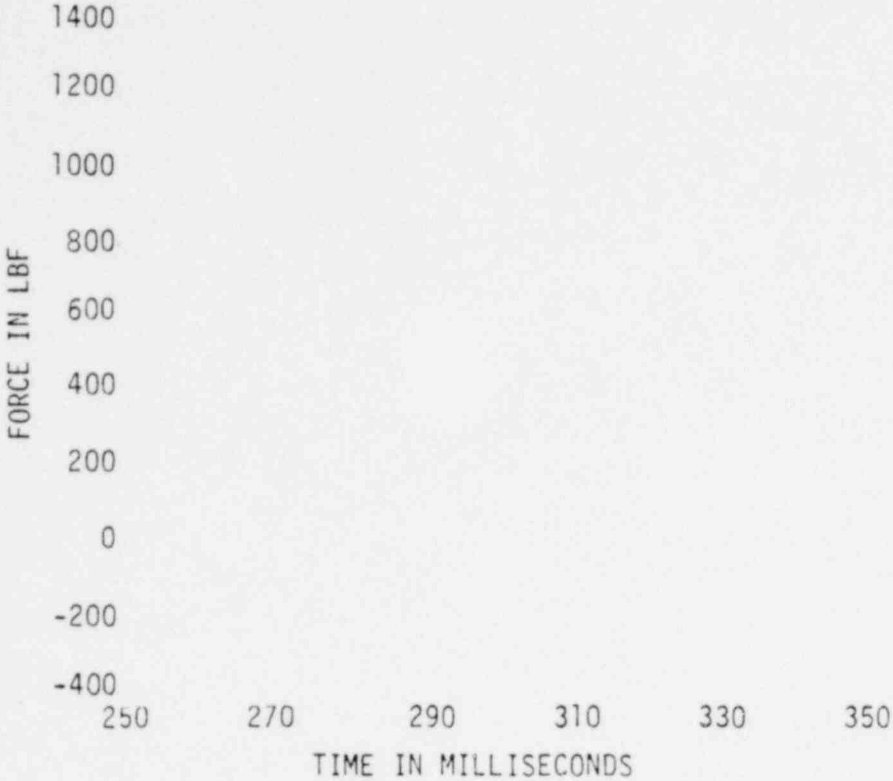
FIGURE A-35

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Hatch 2 Tests 2, 6



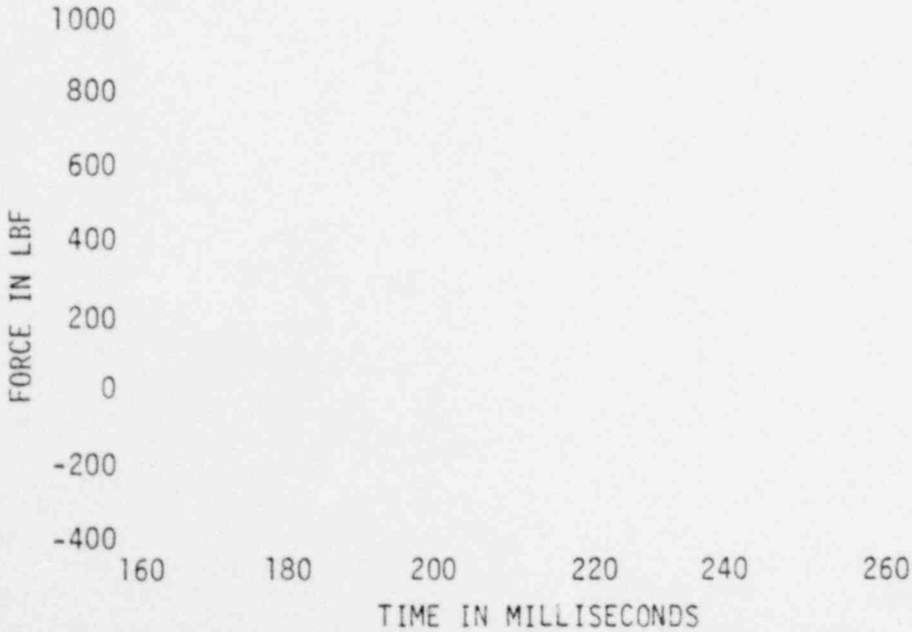


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FIGURE A-36

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Hatch 2 Test 2

ACCELERATION IN G

12

8

4

0

-4

-8

250. 260. 270. 280. 290. 300. 310. 320. 330.

TIME IN MILLISECONDS

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FIGURE A-37

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Hatch 2 Test 6

ACCELERATION IN G

12

8

4

0

-4

-8

160. 170. 180. 190. 200. 210. 220. 230. 240.

TIME IN MILLISECONDS

FIGURE A-38

Time History Of

Pool Displacement

HATCH 2, TEST 1

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_o) - seconds

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FIGURE A-39

Time History Of
Pool Displacement

HATCH 2, TEST 2

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_o) - seconds

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FIGURE A-40

Time History Of
Pool Displacement

HATCH 2, TEST 3

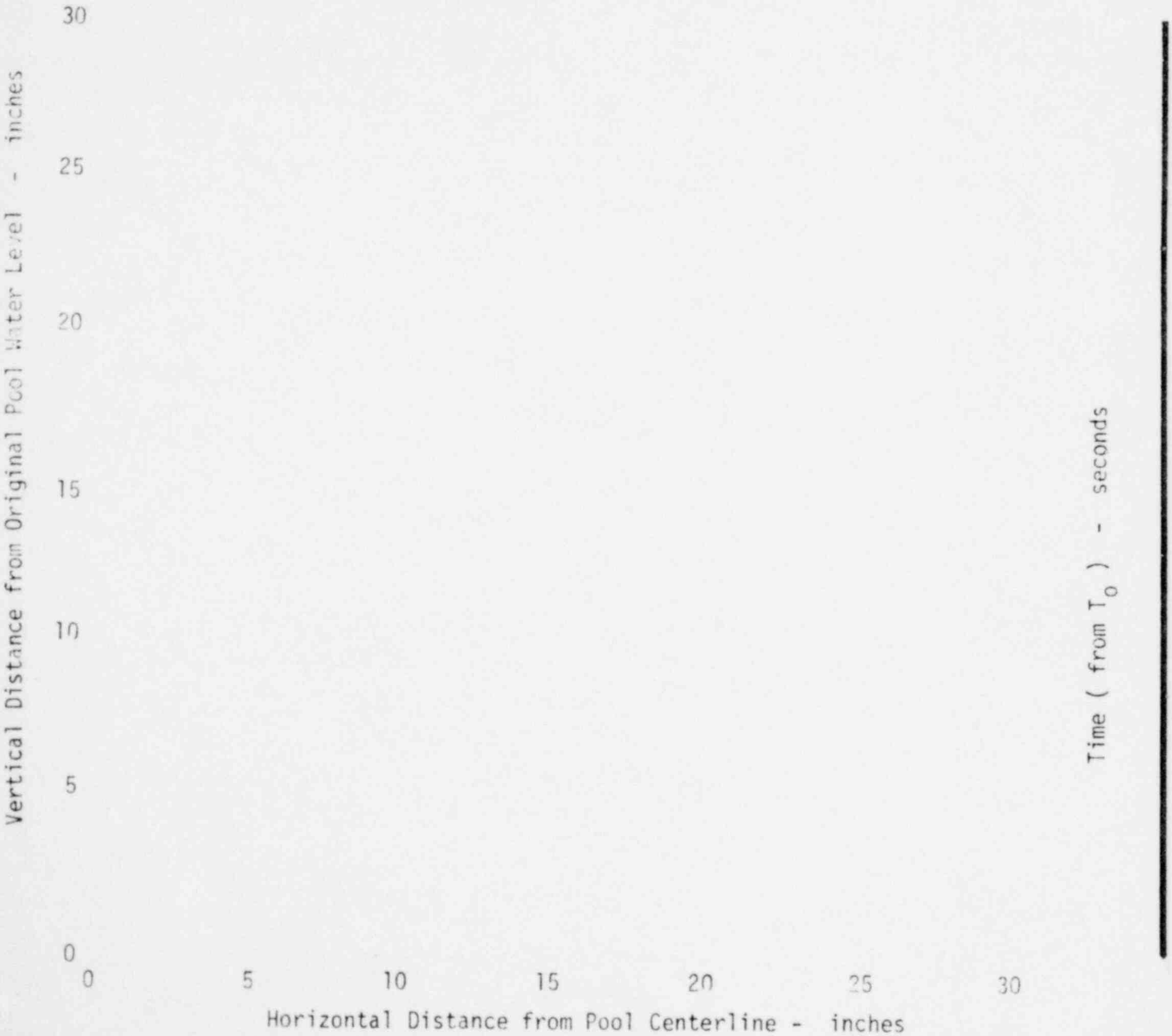

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FIGURE A-41

Time History Of

Pool Displacement

HATCH 2, TEST 5

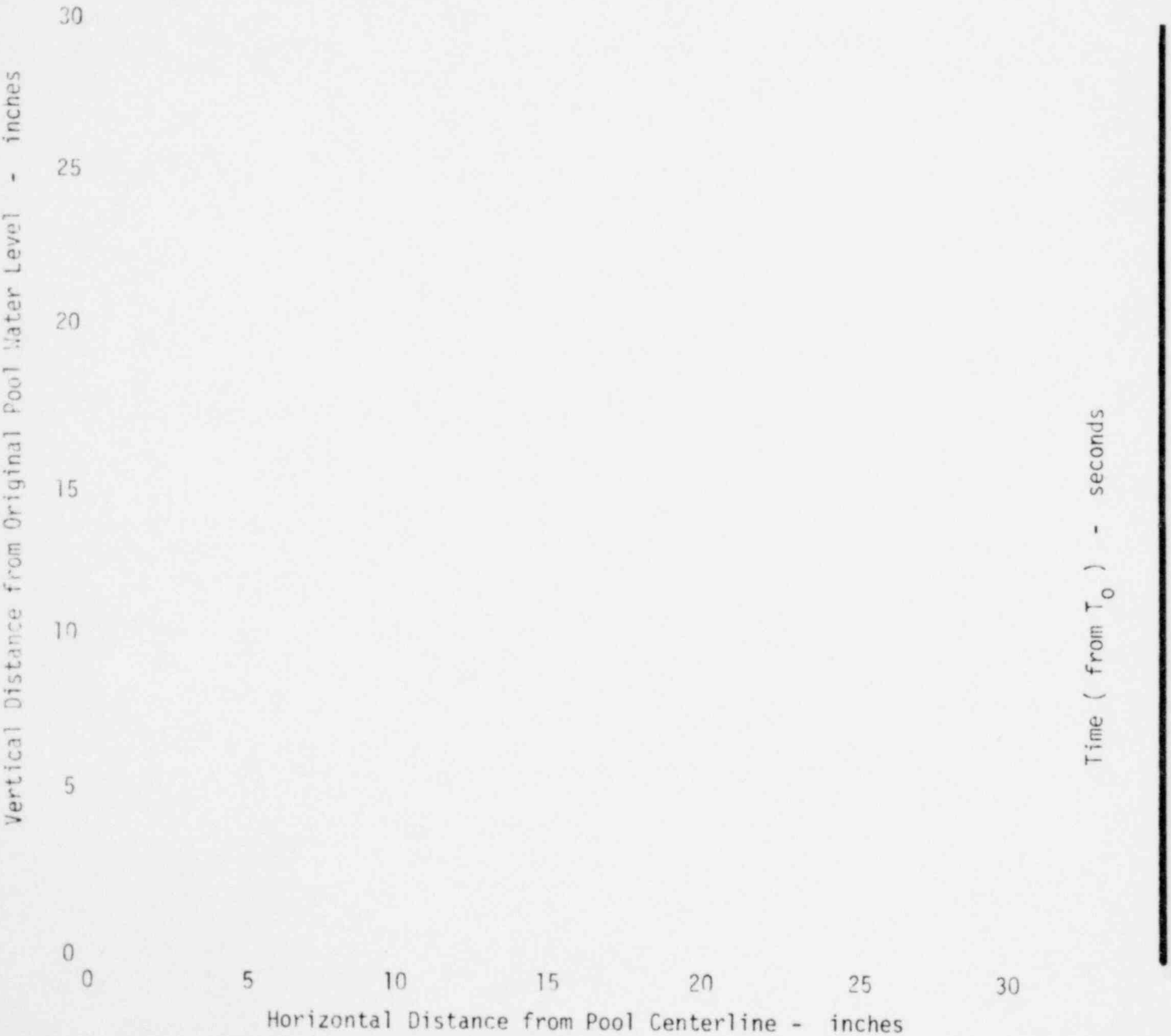

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FIGURE A-42

POOL SURFACE DISPLACEMENT

HATCH 2, TESTS 1, 2, 3

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FIGURE A-43 POOL SURFACE VELOCITY PROFILES

HATCH 2, TESTS 1, 2, 3

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FIGURE A-44

POOL SURFACE DISPLACEMENT

HATCH 2, TEST 5

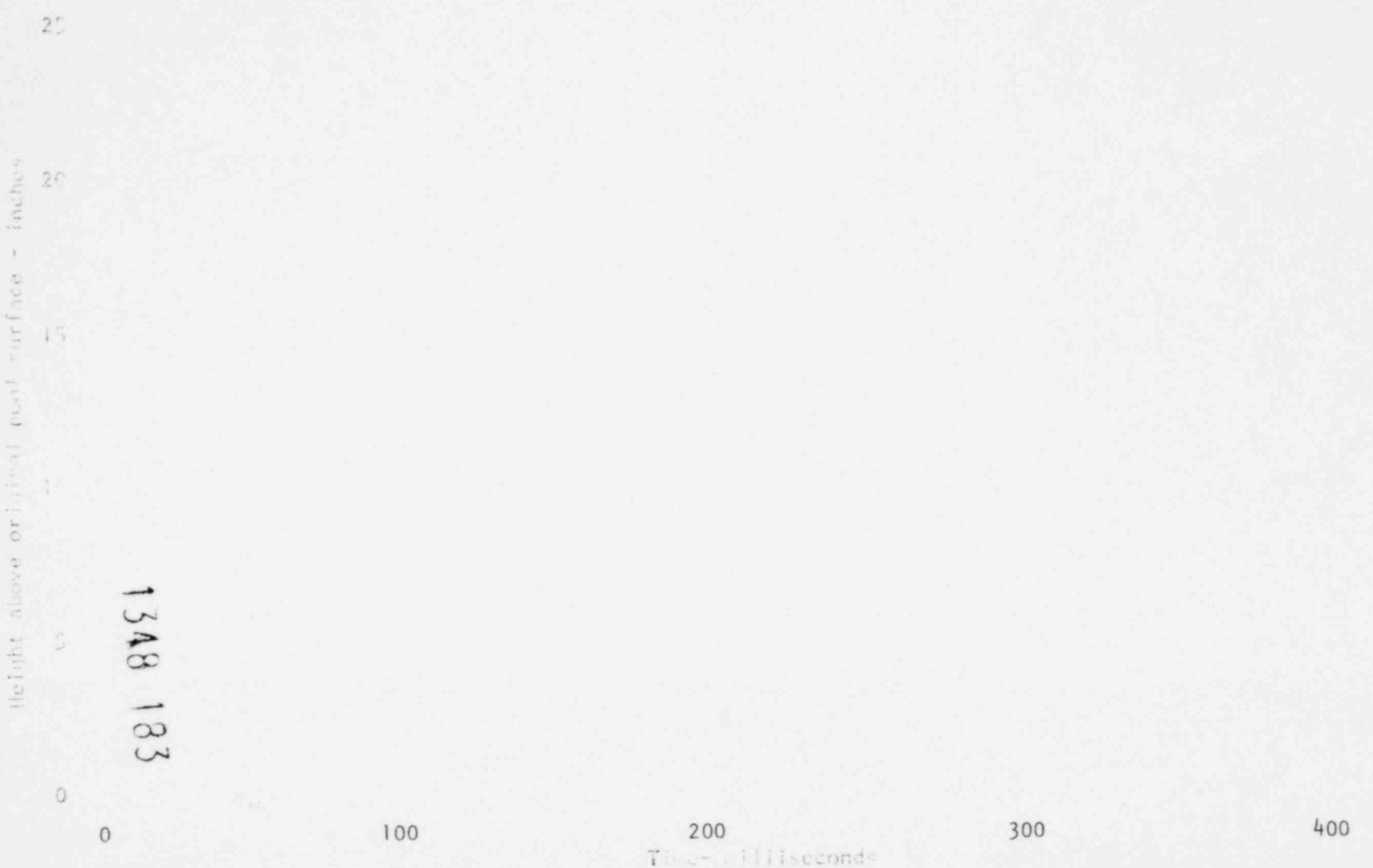

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FIGURE A-45 POOL SURFACE VELOCITY PROFILES

HATCH 2, TEST 5

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

DISTANCE FROM POOL CENTERLINE - INCHES

FIGURE A-46 SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

HATCH 2, TEST 4

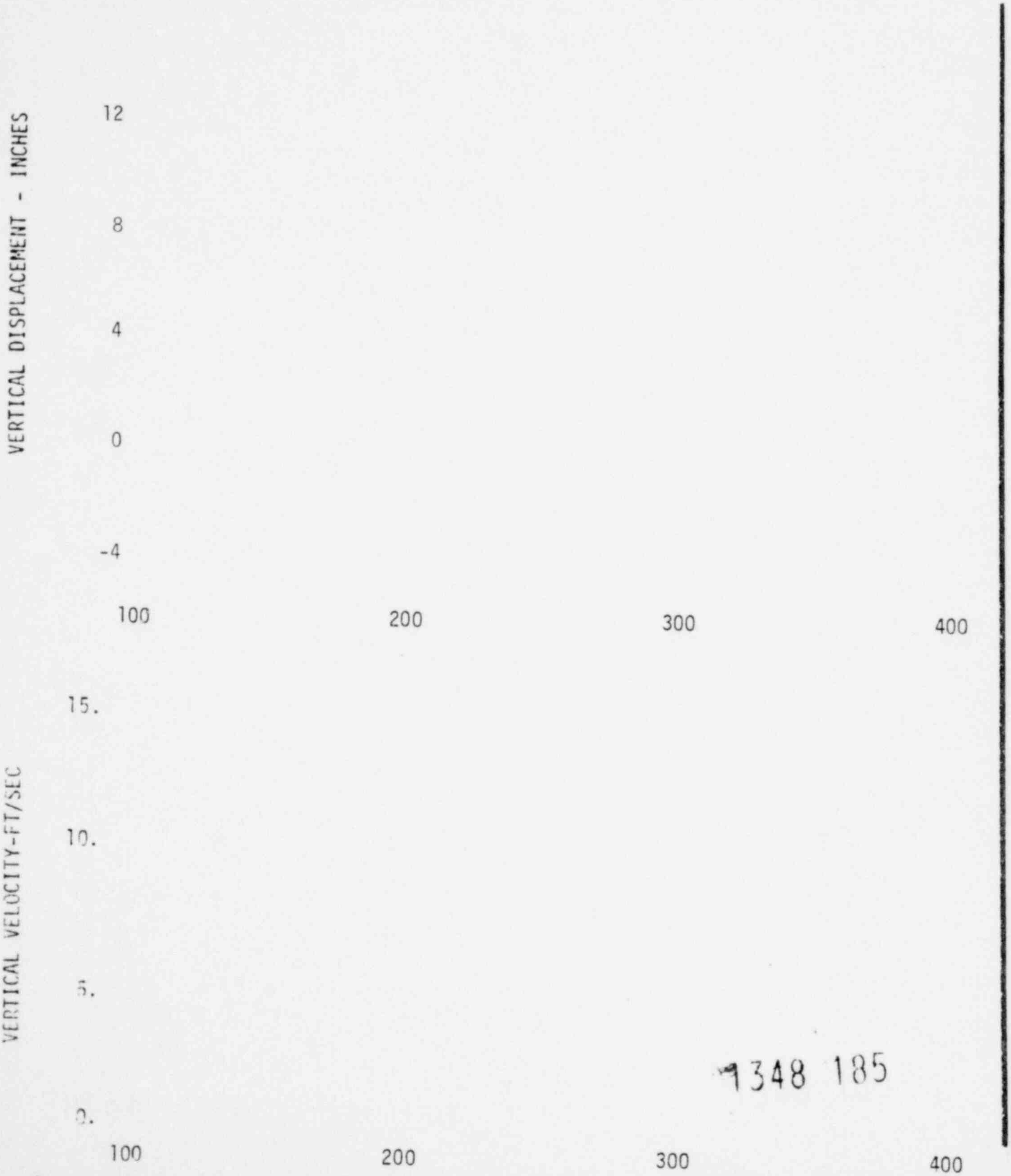

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FIGURE A-47

DOWNCOMER WATER SLUG EJECTION

HATCH 2, TEST 2

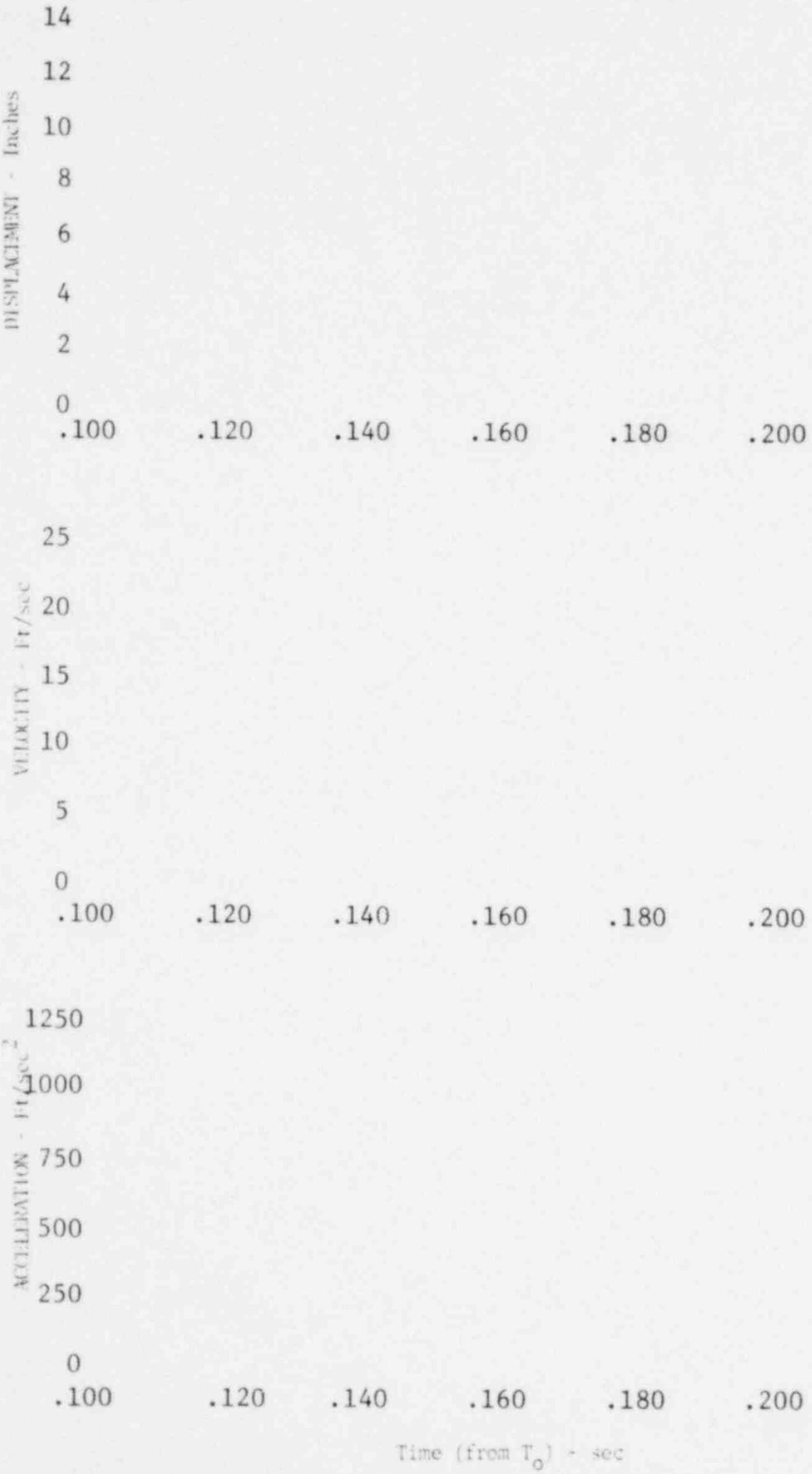

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FIGURE A-48

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Hatch 2 Tests

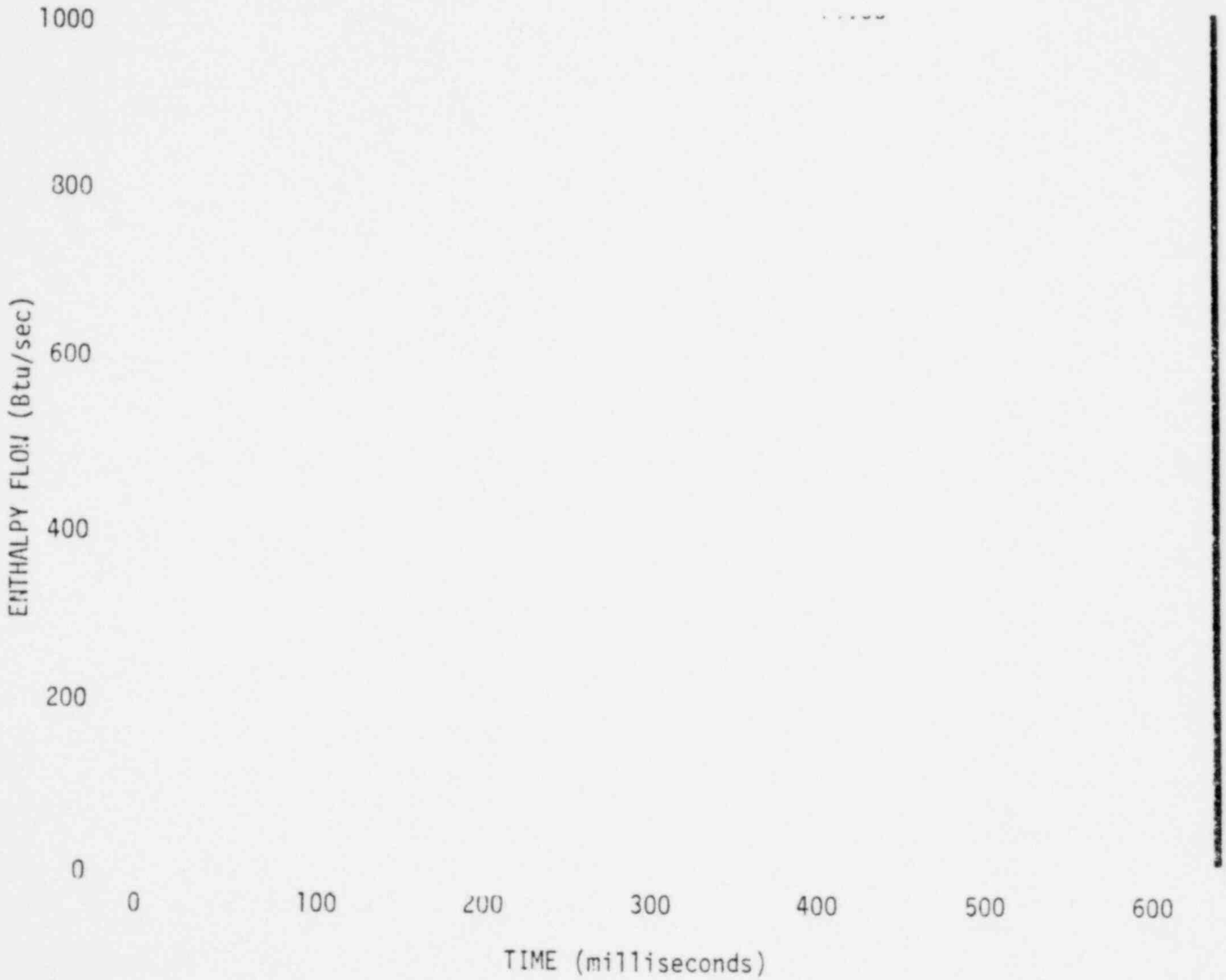

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FIGURE A-49

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Hatch 2 Tests

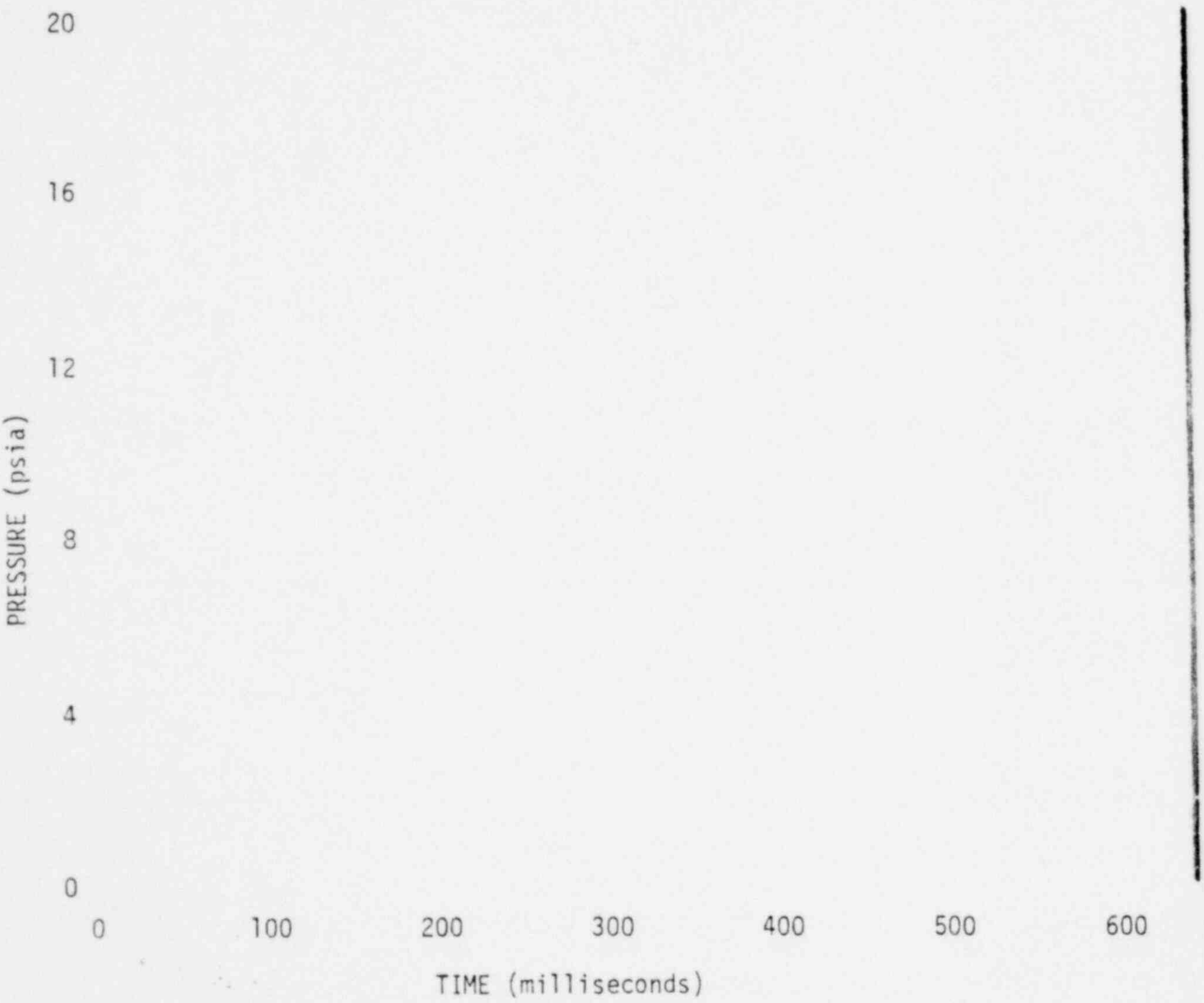

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FIGURE A-50

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Hatch 2 Tests

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TABLE A-1
DATA FOR WETWELL VERTICAL LOADS
Task 5.5.3-2 Hatch 2 Tests

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.
—No significant downforce valley or 2nd peak downforce.
*(1)Start-of-test reference time

Parameter \ Test No.	0" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.
T_o *(1) (sec)						
Vent Clearing Time* (sec)						
Peak Downforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Downforce Valley						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
2nd Peak Downforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
[Δt] Downforce Time**						
Pressure Integral (sec)						
Corrected Pressure Integral (sec)						
Corrected Load Cell (sec)						
Downforce Impulse						
Pressure Integral:						
Impulse (lb-sec)						

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*Time at force is zero (from T_o)

TABLE A-1 (Continued)
DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Hatch 2 Tests

Parameter \ Test No.		0" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.
Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Upforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Zero Force Time*							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						

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*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.
—No significant downforce valley or 2nd peak downforce.
*(1)Start-of-test reference time

TABLE A-2
DATA FOR WETWELL VERTICAL LOADS
Task 5.5.3 -2 Hatch 2 Tests

Parameter \ Test No.		14.35" ΔP (5)	(6)	(7)	(8)	Mean	Std. Dev.
T_o *(1)	(sec)						
Vent Clearing Time*	(sec)						
Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Downforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
[Δt] Downforce Time**							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						
Downforce Impulse							
Pressure Integral:							
Impulse	(lb-sec)						

*Time at force is zero (from T_o)

TABLE A-2 (Continued)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Hatch 2 Tests

Parameter / Test No.	14.35" ΔP (5)	(6)	(7)	(8)	Mean	Std. Dev.
Peak Upforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Upforce Valley						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
2nd Peak Upforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Zero Force Time*						
Pressure Integral (sec)						
Corrected Pressure Integral (sec)						
Corrected Load Cell (sec)						

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TABLE A-3

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Hatch 2 Tests

Parameter \ Test No.		0" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.
T_0 †	(sec)						
Vent Header Impact							
Pressure Integral:							
Maximum Force	(lb)						
Impulse	(lb-sec)						
Duration*	(sec)						
Load Cell Corrected:††							
Maximum Force	(lb)						
Impulse	(lb-sec)						
Duration	(sec)						
Pool Surface Velocity	(ft/sec)						
Time (from T_0)**	(sec)						

*(2) Offset 6" from pool centerline

* Based on impact pressure measurements

** At start of the first impact pressure recorded

† Start of reference time

†† represents peak of very noisy data (acceleration corrected); mean value would be lower

1348 194

TABLE A-3a

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Hatch 2 Tests

Parameter \ Test No.		14.35" ΔP (5)	(6)	(7)	(8)	Mean	Std. Dev.
$T_{O\dagger}$	(sec)						
Vent Header Impact							
Pressure Integral:							
Maximum Force	(lb)						
Impulse	(lb-sec)						
Duration*	(sec)						
Load Cell Corrected: ††							
Maximum Force	(lb)						
Impulse	(lb-sec)						
Duration	(sec)						
Pool Surface Velocity	(ft/sec)						
Time (from T_0)**	(sec)						

*(2) Offset 6" from pool centerline
* Based on impact pressure measurements
** At start of the first impact pressure recorded
† Start of reference time
†† represents peak of very noisy data (acceleration corrected); mean value would be lower

1348 195

A.2 Pilgrim Tests

A.2.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Pilgrim Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 10.9" ΔP and with a 4.20 inch pipe deflector (16 inch full scale). Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 4.20 inch pipe deflector.

A.2.1.1 Driving Conditions

Driving conditions for Pilgrim Test 3 are presented in Figures A-51 through A-55. Similar plots for Pilgrim Test 5 are shown in Figures A-56 through A-60. Pilgrim's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.2.1.2 Pool Response

Downcomer internal pressure and wetwell pressure for Pilgrim Tests 3 and 5 are presented in Figures A-61 through A-62 and A-63 through A-64, respectively. These pressure plots have the same characteristics as the "typical" plant in Section 3.0. However, the characteristic one cycle oscillation of the downcomer internal pressure is negligibly small at 0" H_2O ΔP.

Figures A-65 and A-66 present net torus force based on the torus pressure integral for Pilgrim Tests 3 and 5, respectively. The net torus forces show no or very little oscillations in downforce but show some oscillations in upforce.

1348 196

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-68 and A-70) to the torus load cell (Figures A-67 and A-69) is compared with the torus force obtained from the torus pressure integral in Figures A-71 and A-72. Residual oscillations are present in the corrected load cell. Figures A-73 and A-74 present the net torus force based on the torus pressure integral corrected for inertia.

The "average" pool pressures for Pilgrim Tests 3 and 5 are shown in Figures A-75 and A-77. Figures A-76 and A-78 are the same as Figures A-73 and A-74 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Pilgrim Test 3 are presented in Figures A-79 through A-81. Vent header pressures for Pilgrim Test 5 are presented in Figures A-82 through A-84. These figures indicate that the deflector was effective in reducing the peak local vent header impact pressure.

Figure A-85 presents a comparison of the vent header impact force derived from the pressure integral with that derived from the corrected load cell. Vent header vertical accelerations from Tests 3 and 5 are shown in Figures A-86 and A-87, respectively.

A.2.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-88 through A-91 for Pilgrim Tests 1, 2, 3, and 5.

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-92. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-93. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-94 and A-95, respectively.

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The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-96. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-97 and A-98.

Pilgrim pool dynamics are similar to those of the "typical" plant discussed in Section 3.0.

A.2.3 Data Summaries

Table A-4 presents the Pilgrim test data for wetwell vertical forces.

Table A-5 presents the Pilgrim test data for vent header impact forces.

A.2.4 Discussion and Analysis

Figure A-99 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-100. Figure A-101 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The data for Pilgrim parallels that for the "typical" plant in Section 3.0.

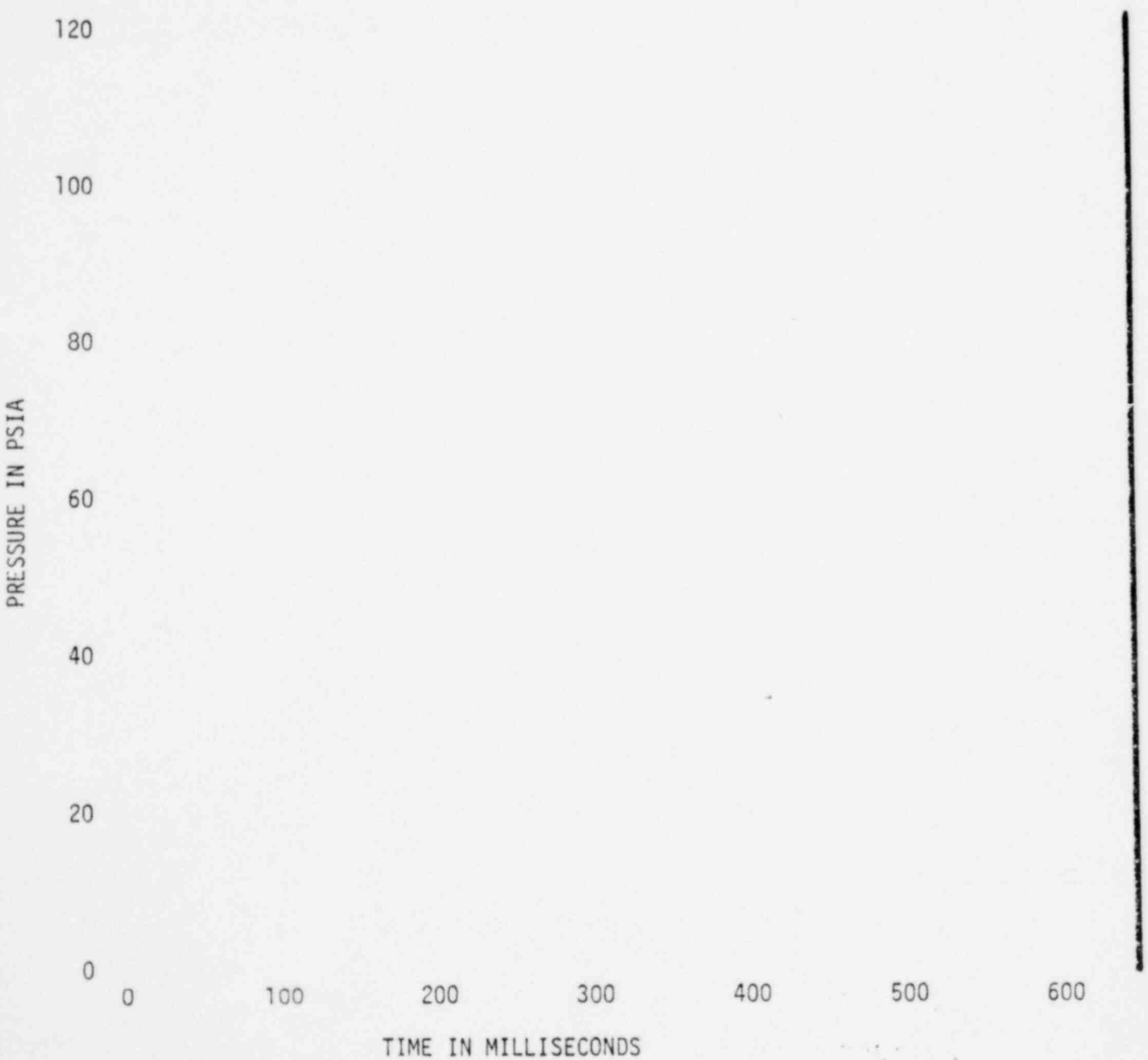
The Pilgrim load definition tests were conducted at 10.9" H_2O ΔP and with a pipe deflector installed below the vent header. A ΔP sensitivity test at 0" H_2O ΔP was also conducted. Downforce showed no or very little oscillations, but upforce showed some oscillations. The pipe deflector (16 inch full scale) effectively reduced vent header impact force.

1348 198

FIGURE A-51

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Pilgrim Test 3



1348 199

FIGURE A-52

DRYWELL PRESSURE

Task 5.5.3-2 Pilgrim Test 3

1348 200

FIGURE A-53

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Pilgrim Test 3

1348 201

FIGURE A- 54

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

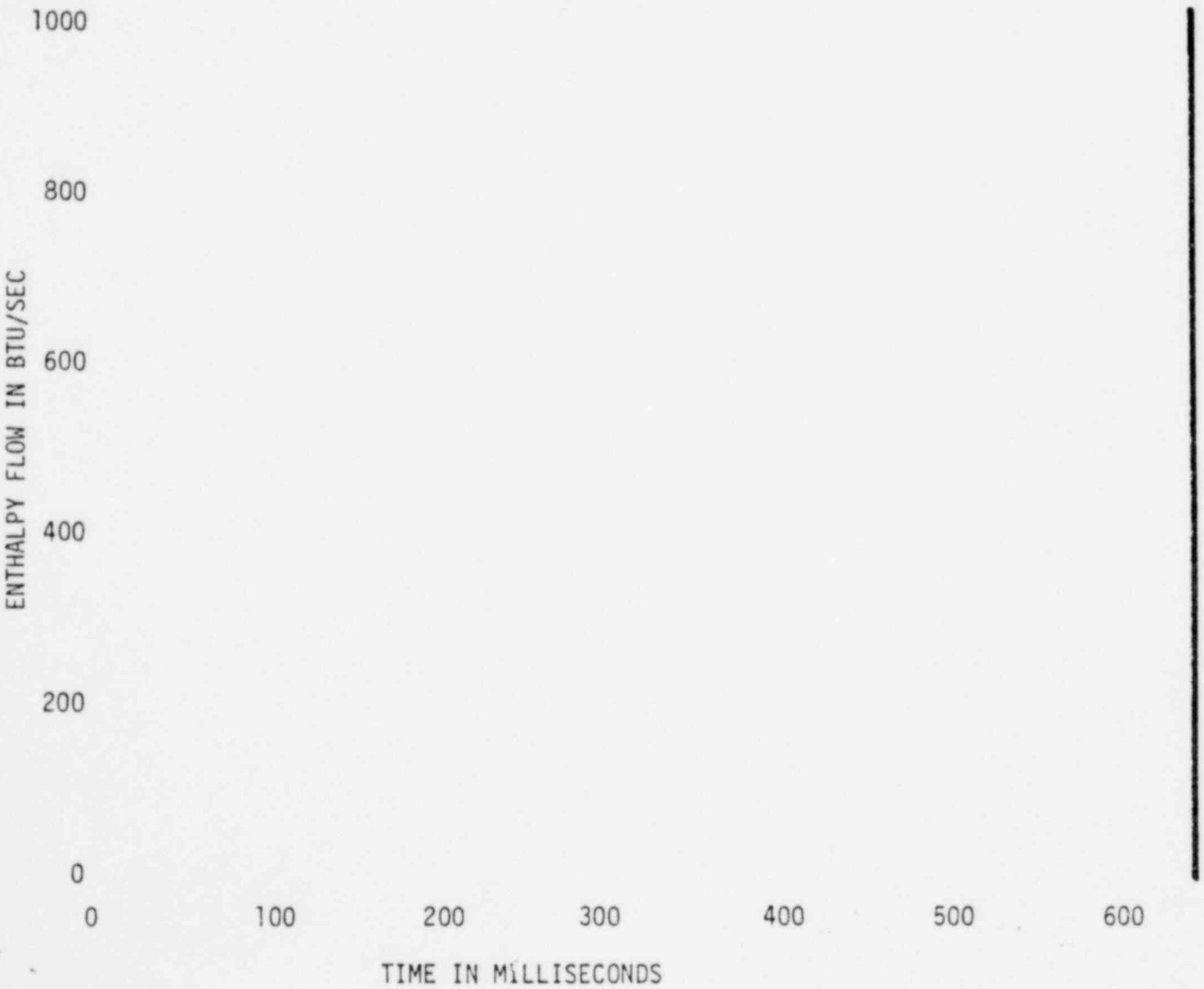
Task 5.5.3-2 Pilgrim Test 3

1348 202

FIGURE A-55

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Pilgrim Test 3

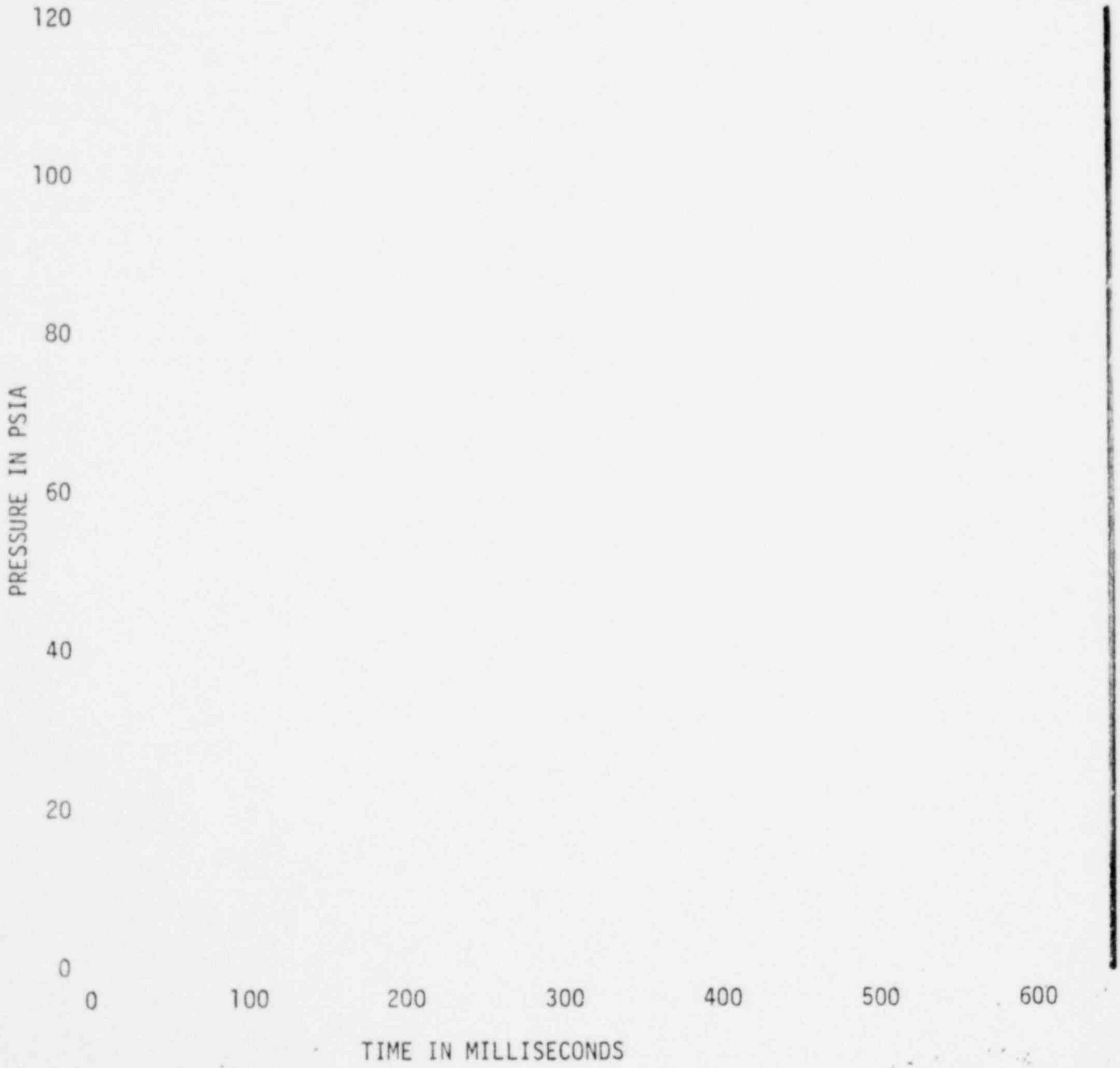


1348 203

FIGURE A- 56

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Pilgrim Test 5



1348 204

FIGURE A-57

DRYWELL PRESSURE

Task 5.5.3-2 Pilgrim Test 5

1348 205

FIGURE A-58

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Pilgrim Test 5

FIGURE A-59

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Pilgrim Test 5

1348 207

FIGURE A-60

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Pilgrim Test 5

1348 208

FIGURE A-61

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Pilgrim Test 3

1348 209

FIGURE A-62

WETWELL PRESSURES

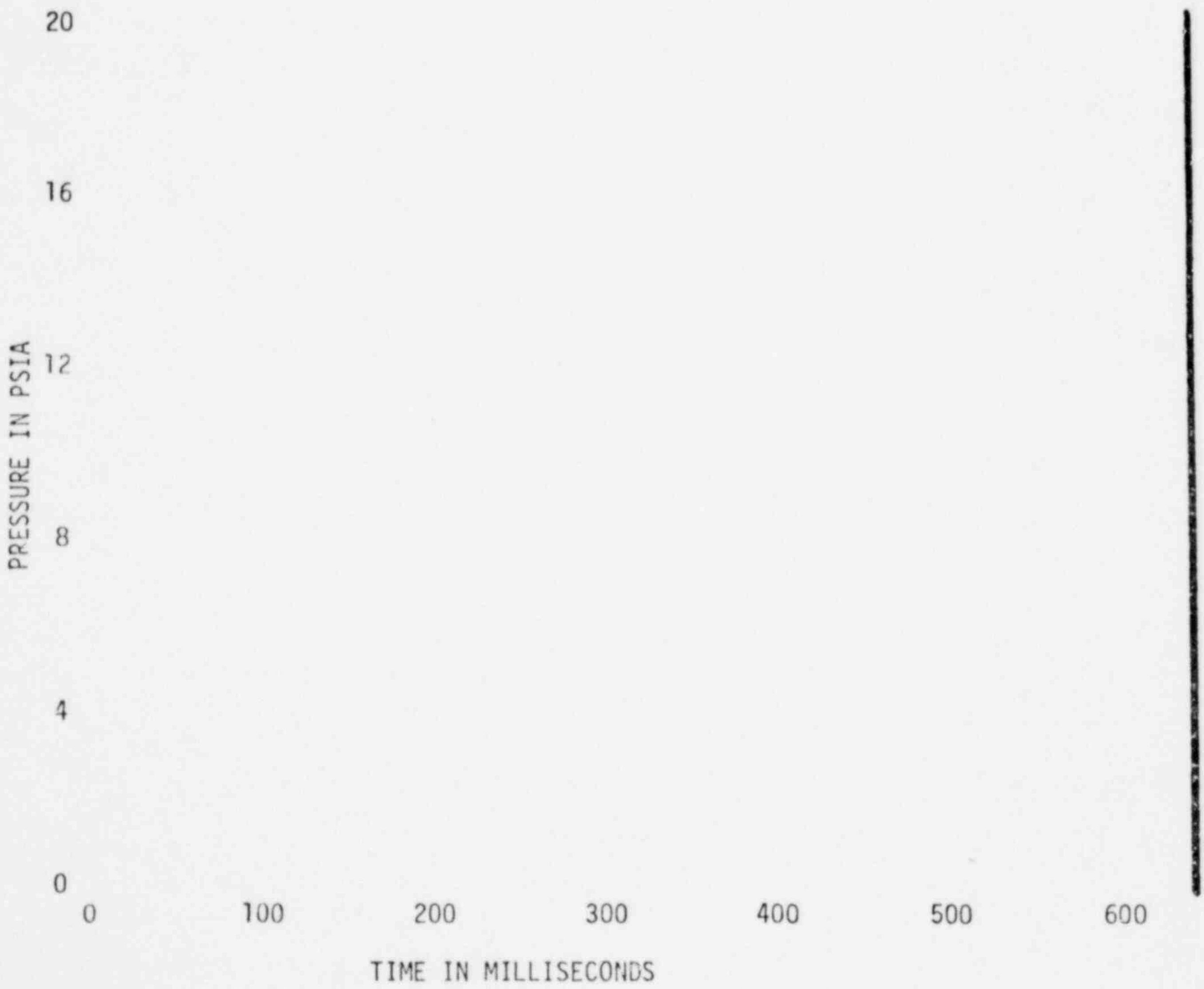
Task 5.5.3-2 Pilgrim Test 3

1348 210

FIGURE A-63

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Pilgrim Test 5

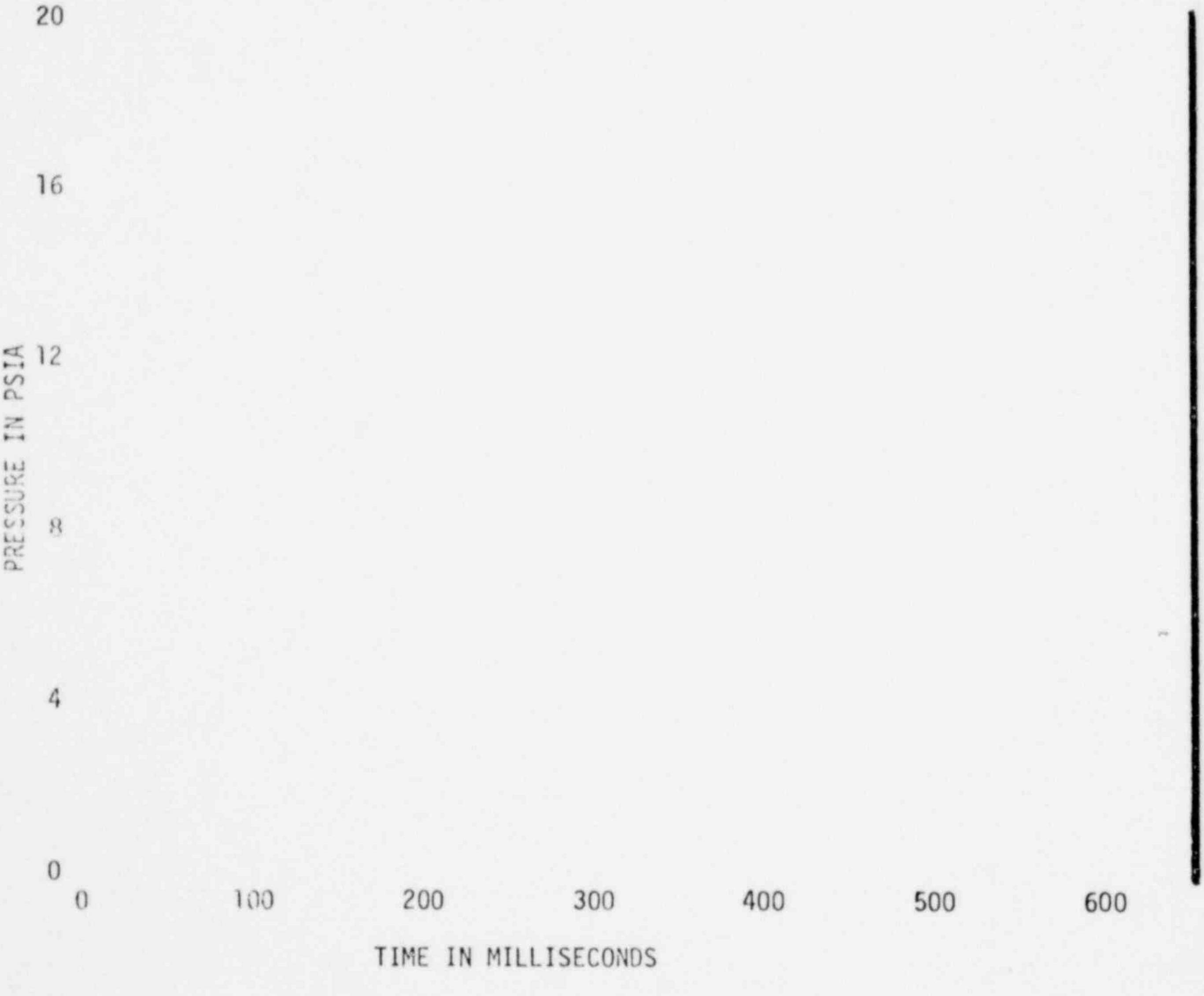


1348 211

FIGURE A-64

WETWELL PRESSURES

Task 5.5.3-2 Pilgrim Test 5

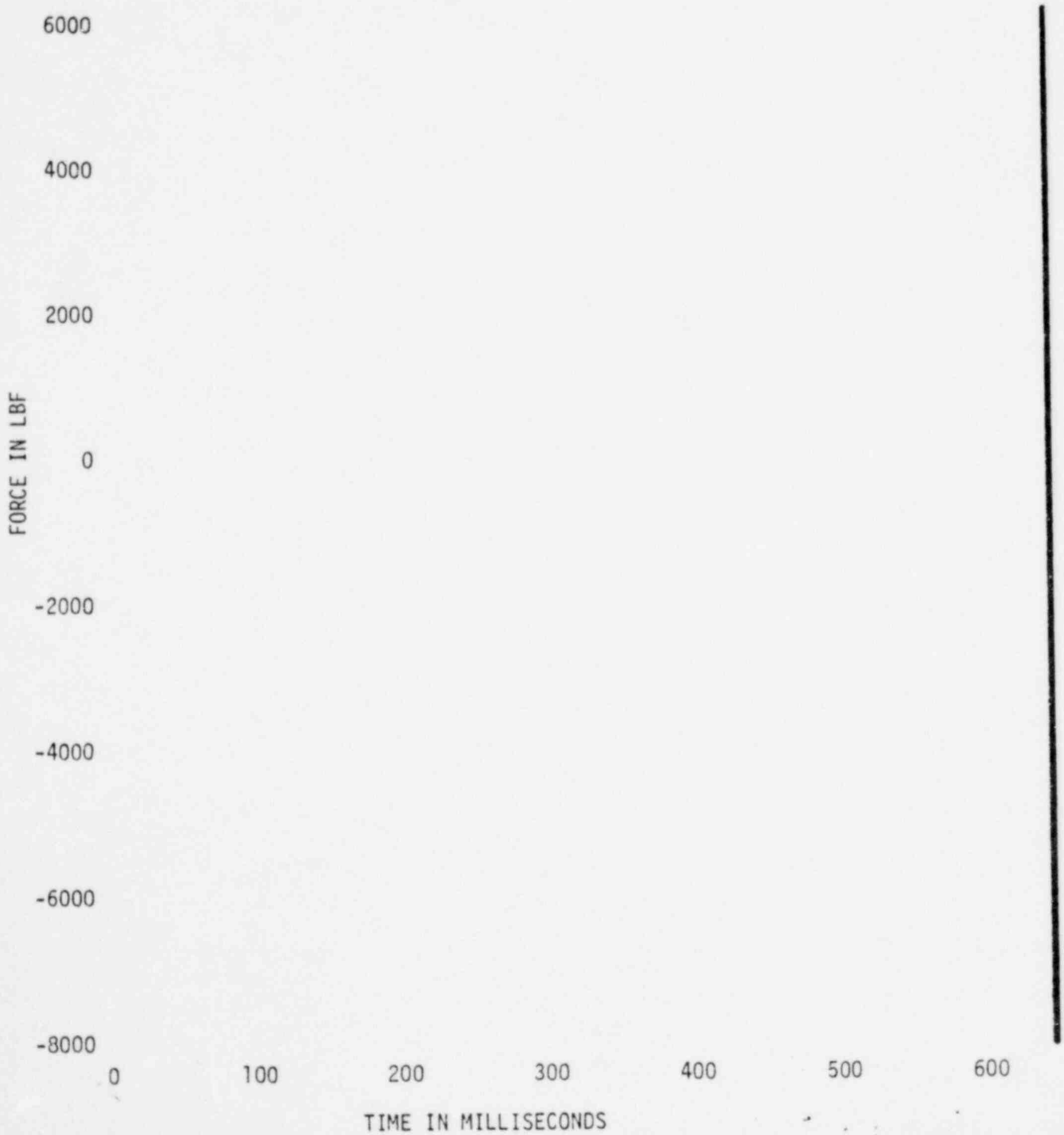


1348-212

FIGURE A-65

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Pilgrim Test 3

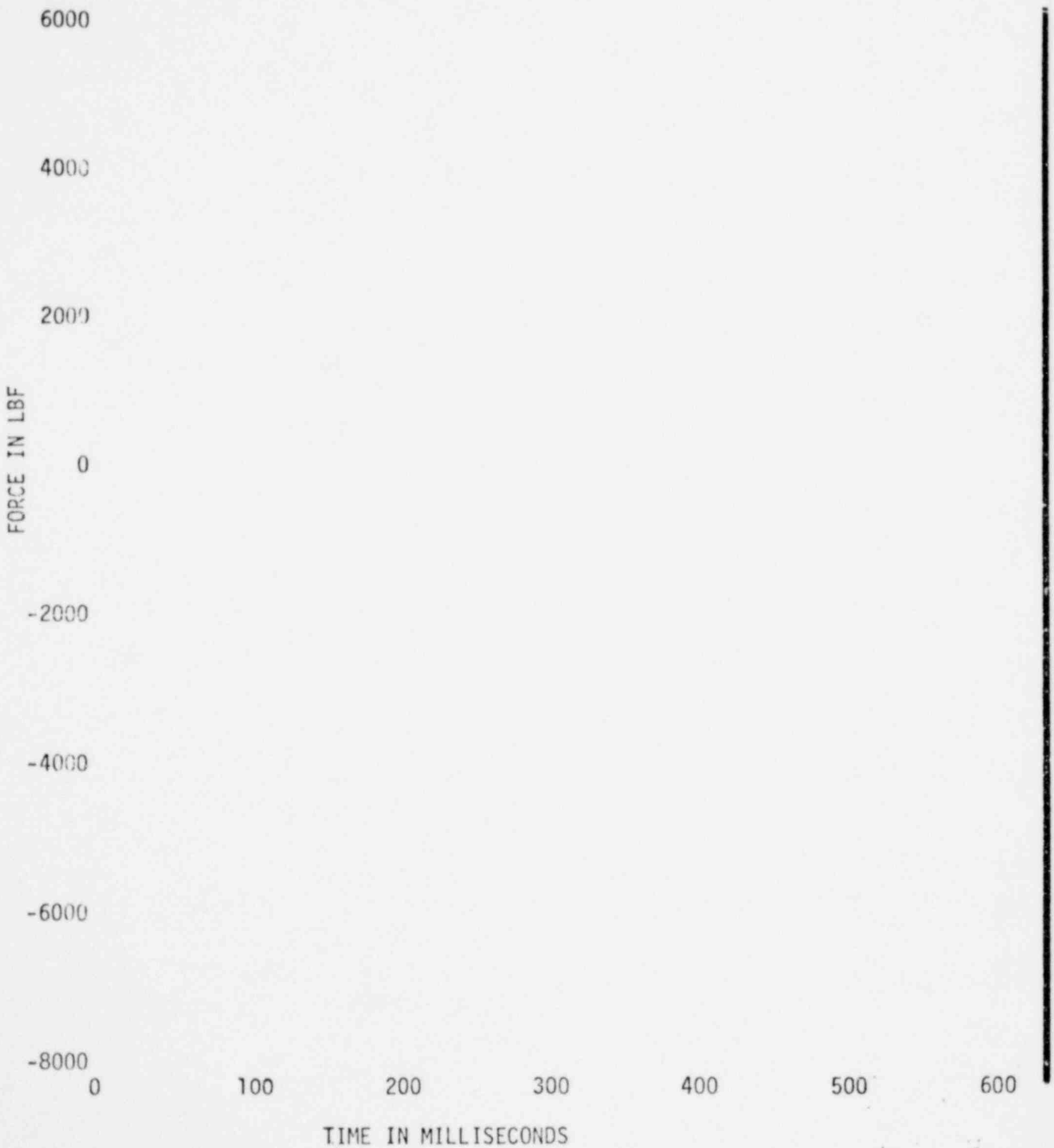


1348 213

FIGURE A-66

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Pilgrim Test 5

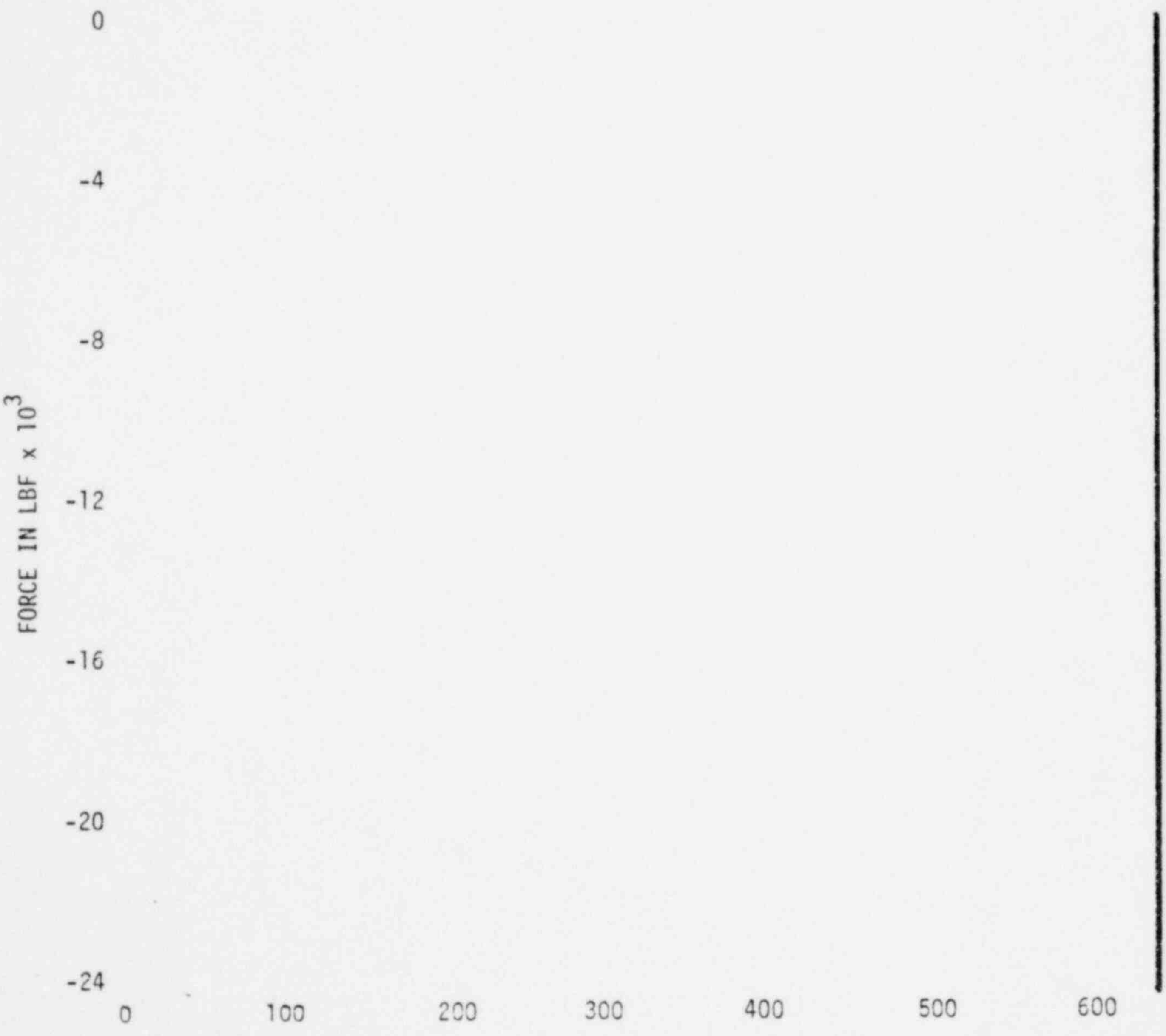


1348 214

FIGURE A-67

TORUS LOAD CELL

Task 5.5.3-2 Pilgrim Test 3

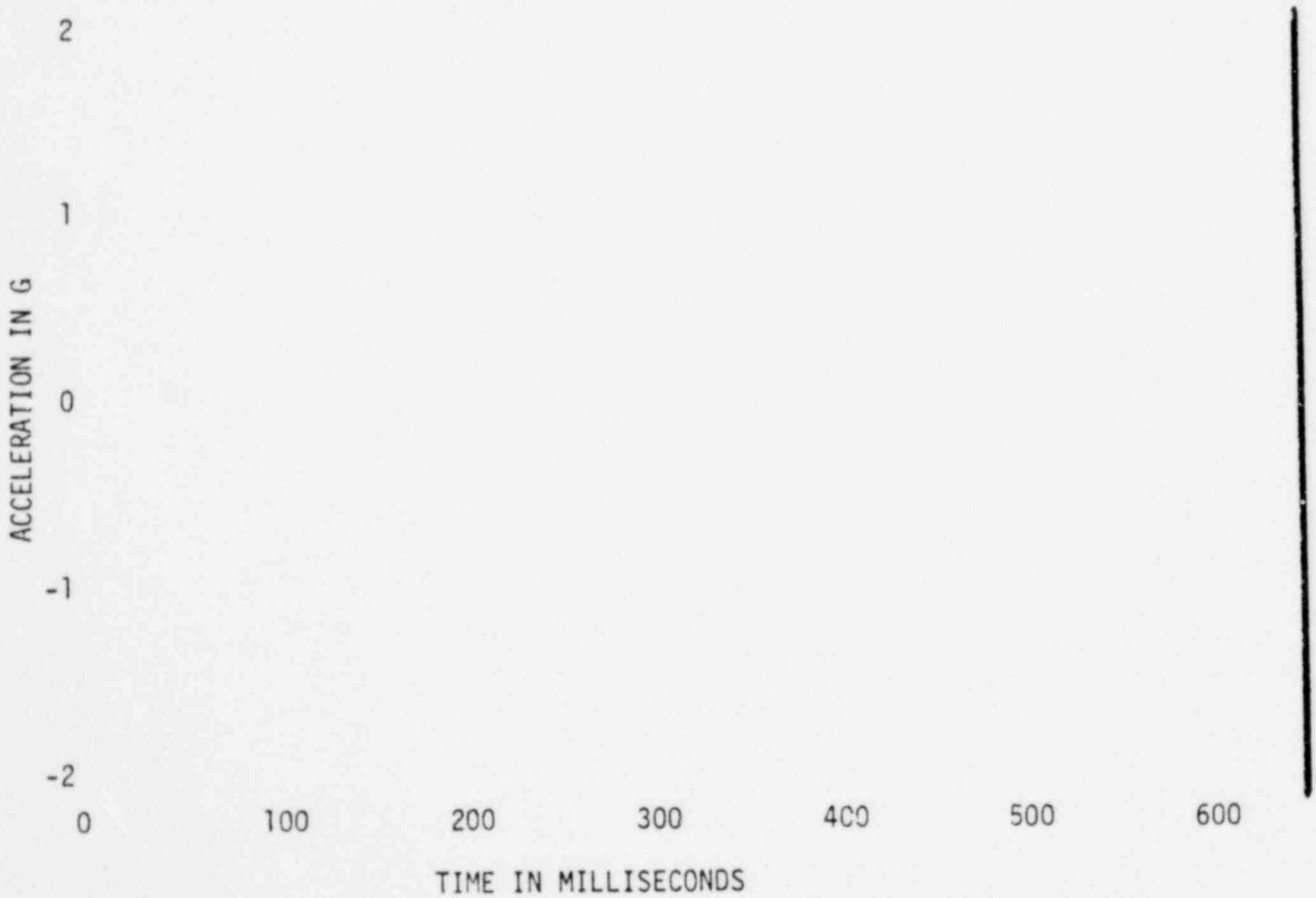


1348 215

FIGURE A-68

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Pilgrim Test 3

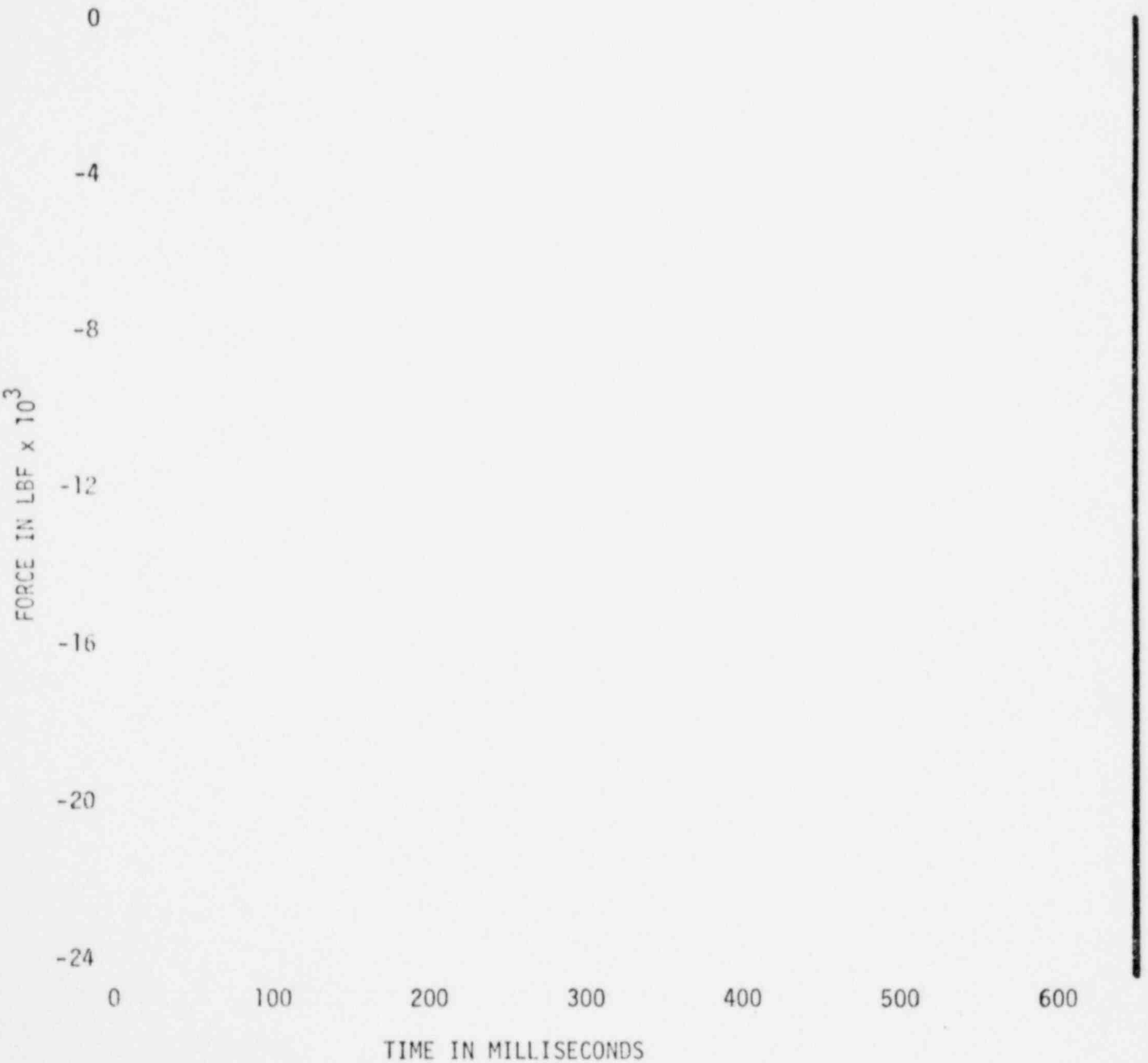


1348 216

FIGURE A-69

TORUS LOAD CELL

Task 5.5.3-2 Pilgrim Test 5

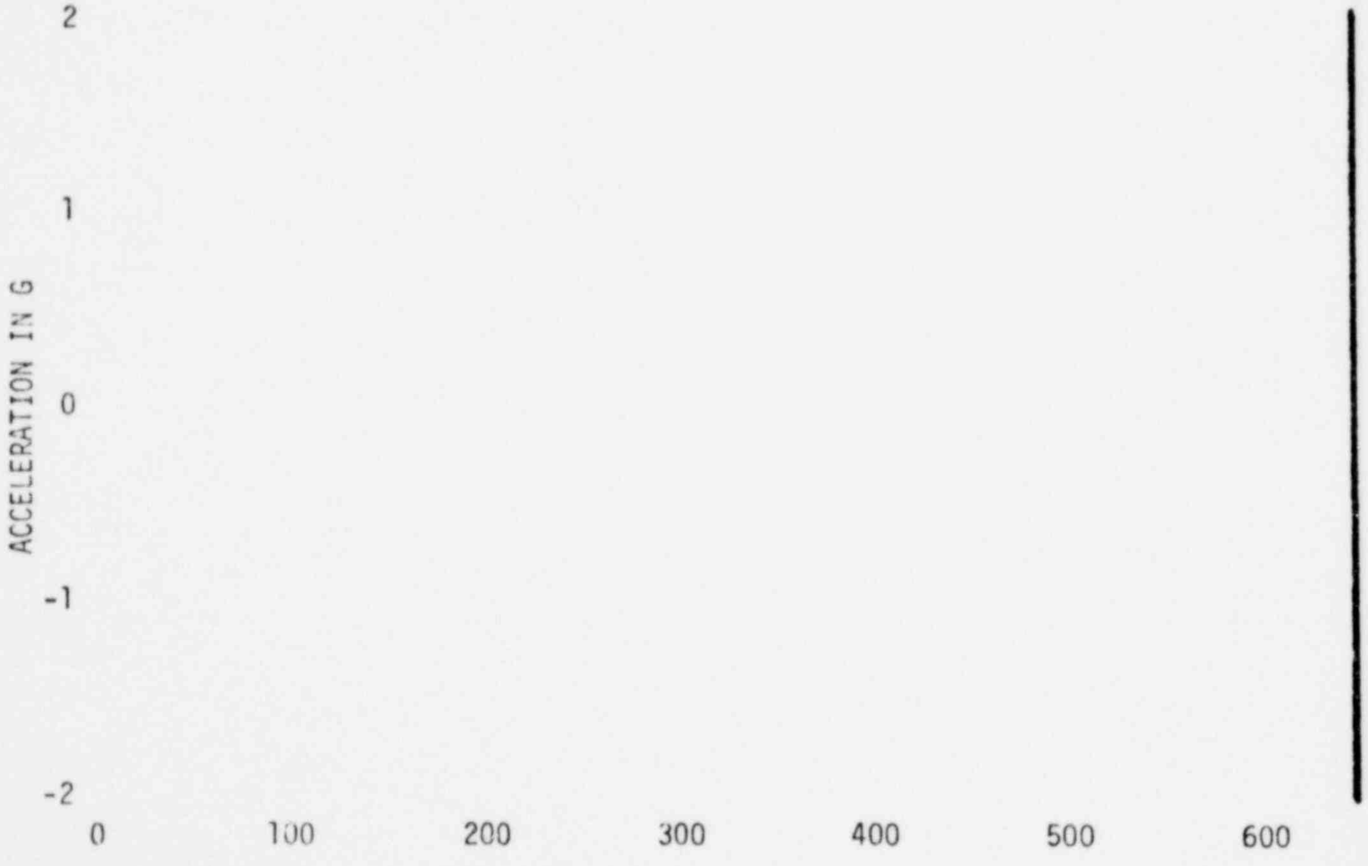


1348 217

FIGURE A-70

TORUS VERTICAL ACCELERATION

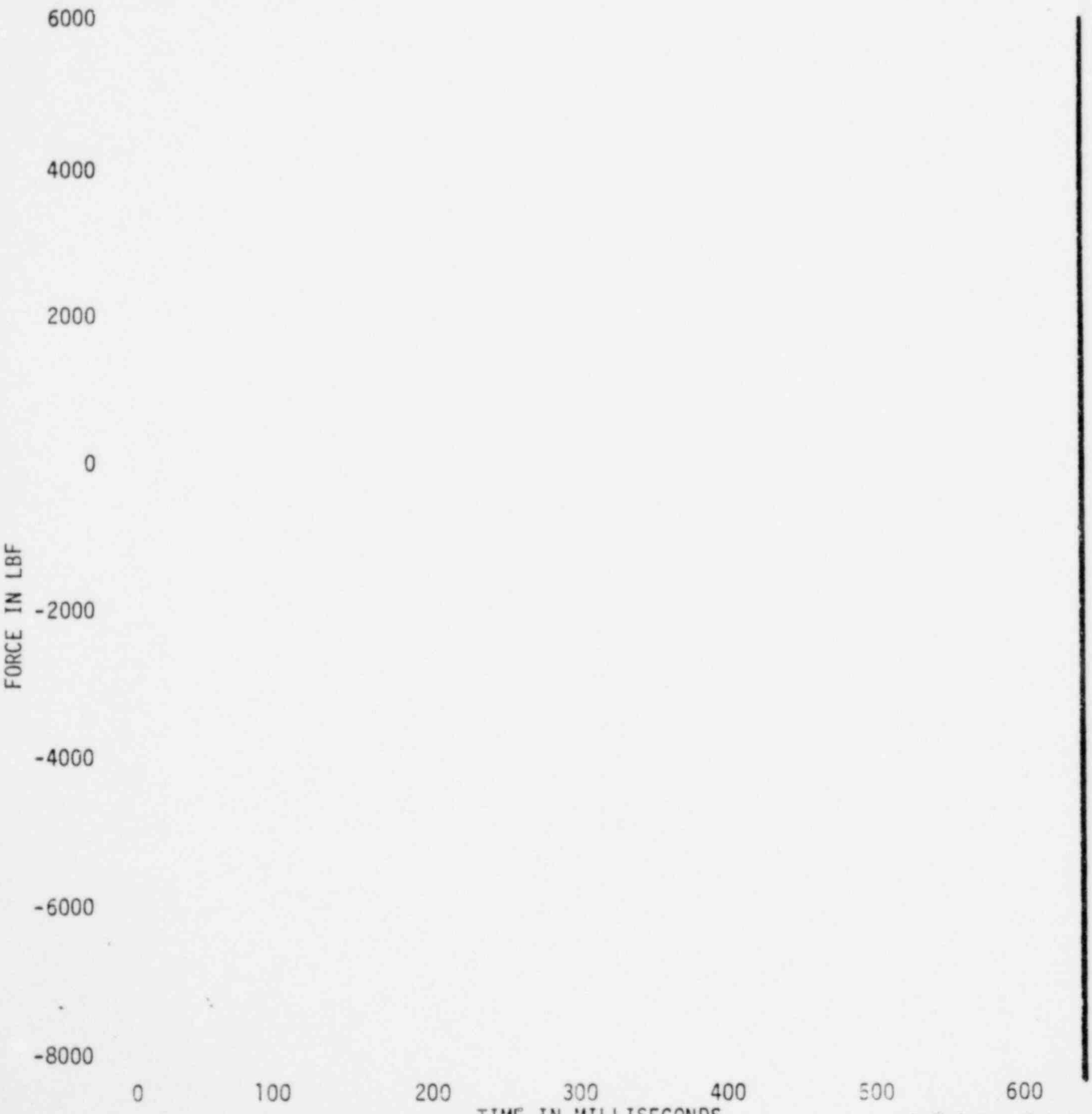
Task 5.5.3-2 Pilgrim Test 5



1348 218

FIGURE A-71 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

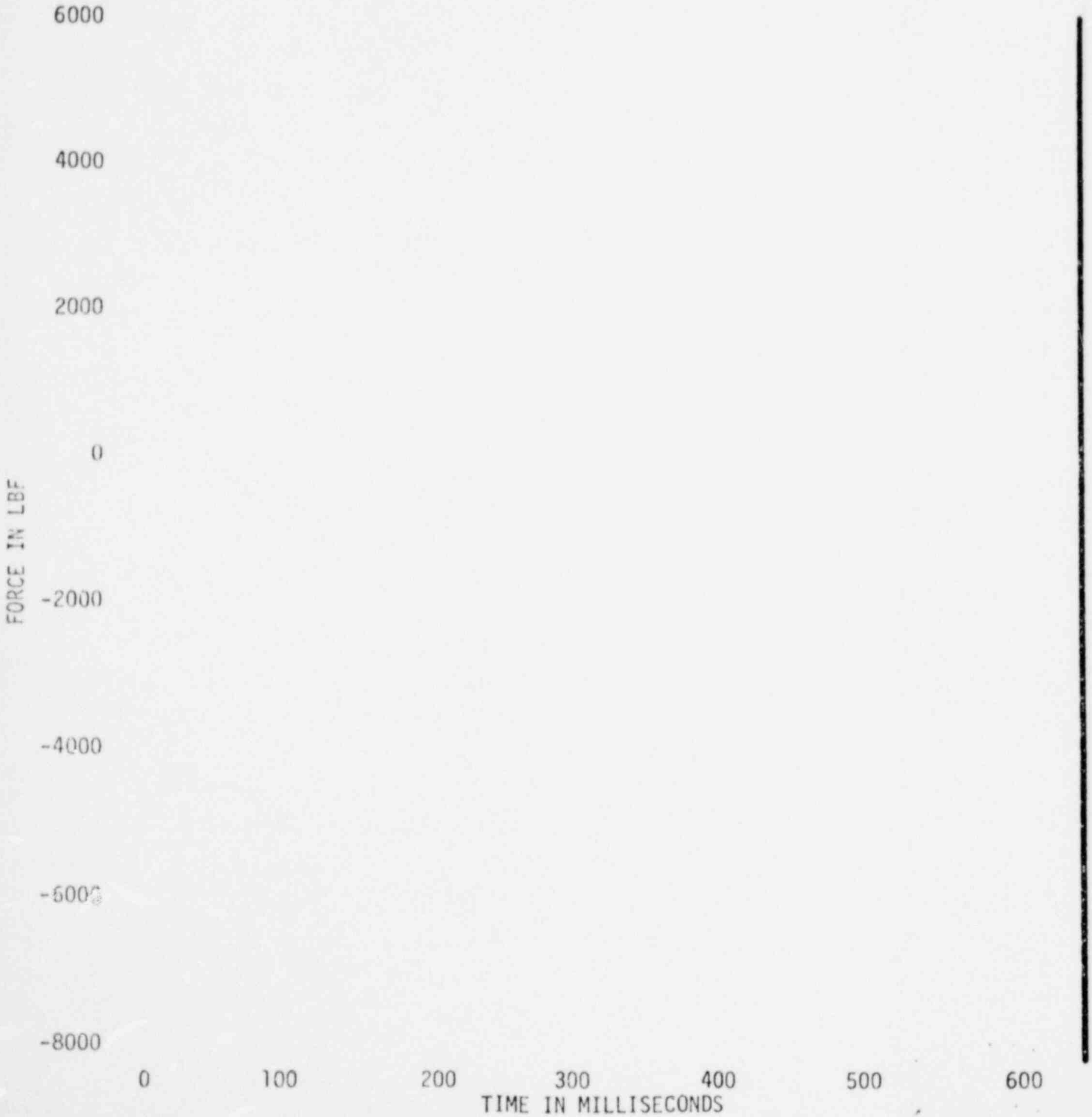
Task 5.5.3-2 Pilgrim Test 3



1348 219

FIGURE A-72 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Pilgrim Test 5



1348 220

FIGURE A-73

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 3

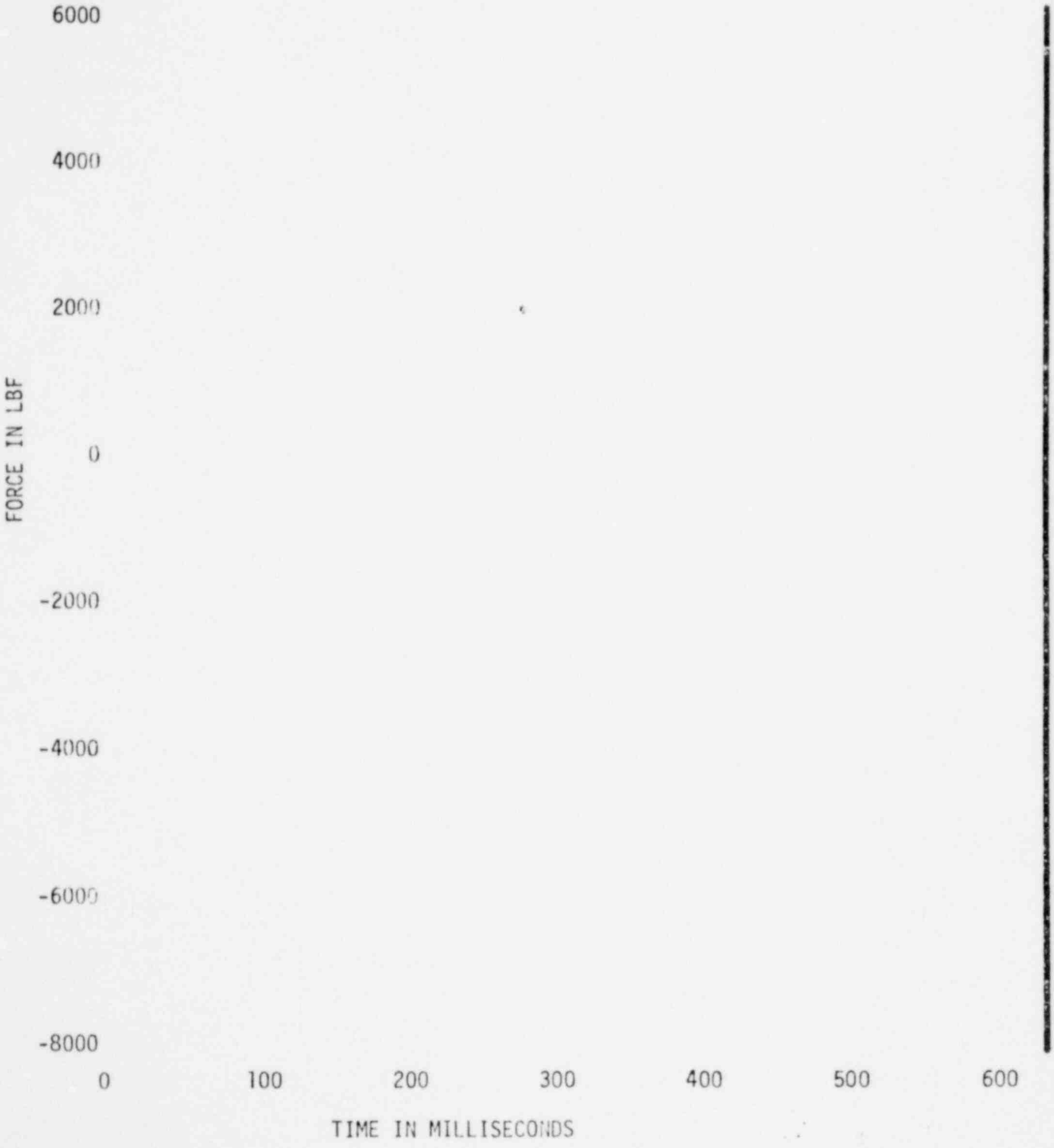
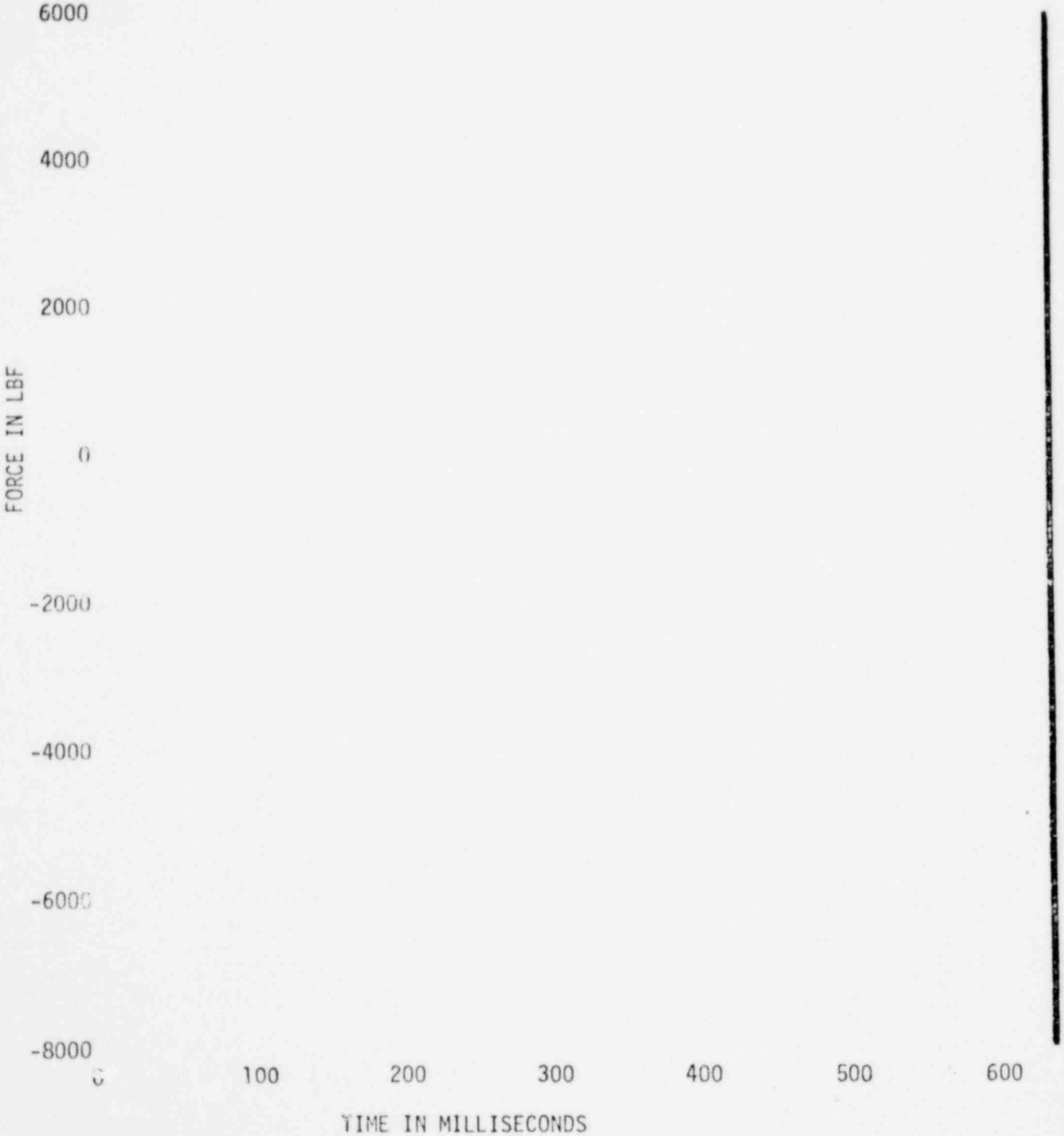


FIGURE A-74

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 5

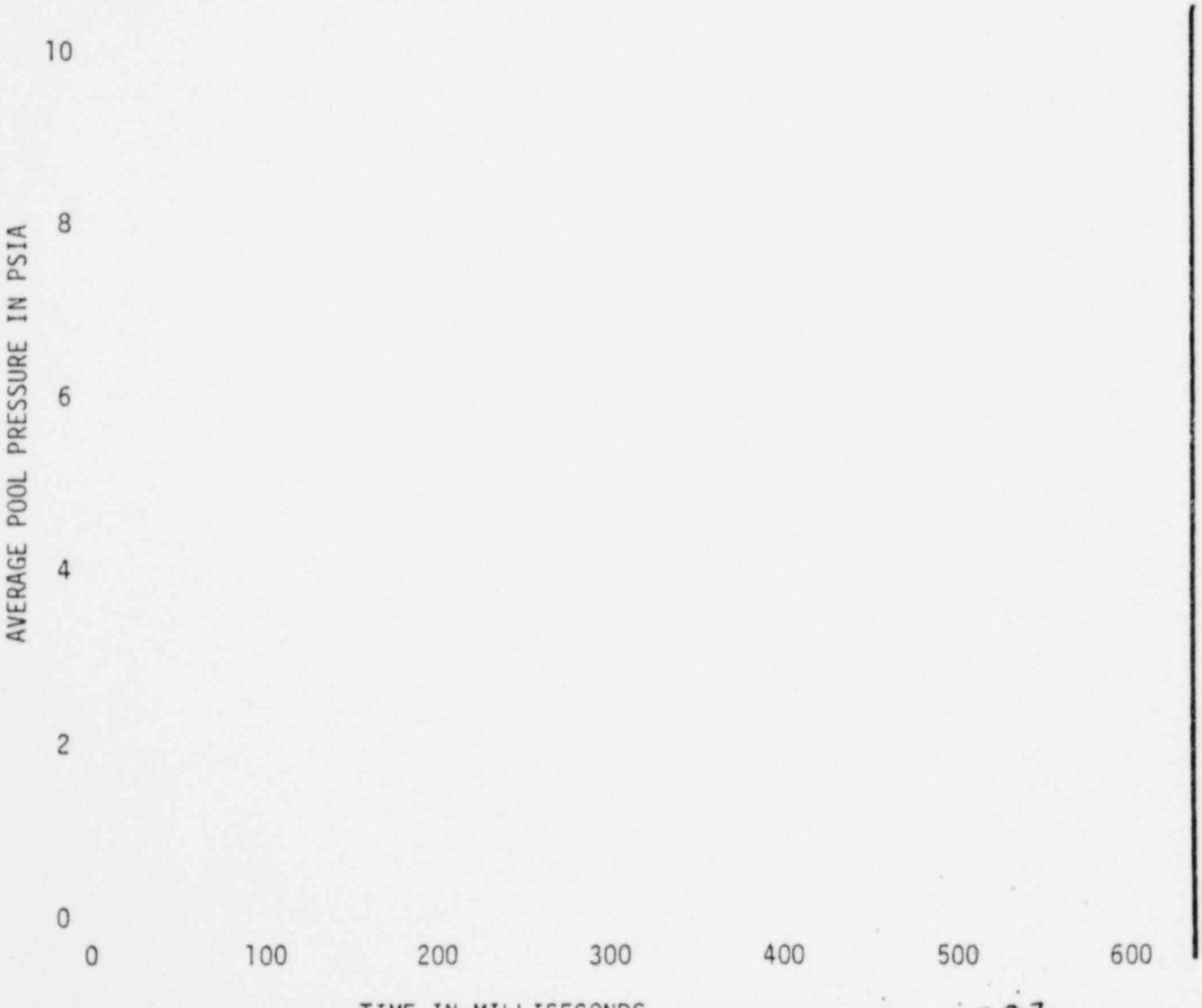


1348 222

FIGURE A-75

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 3

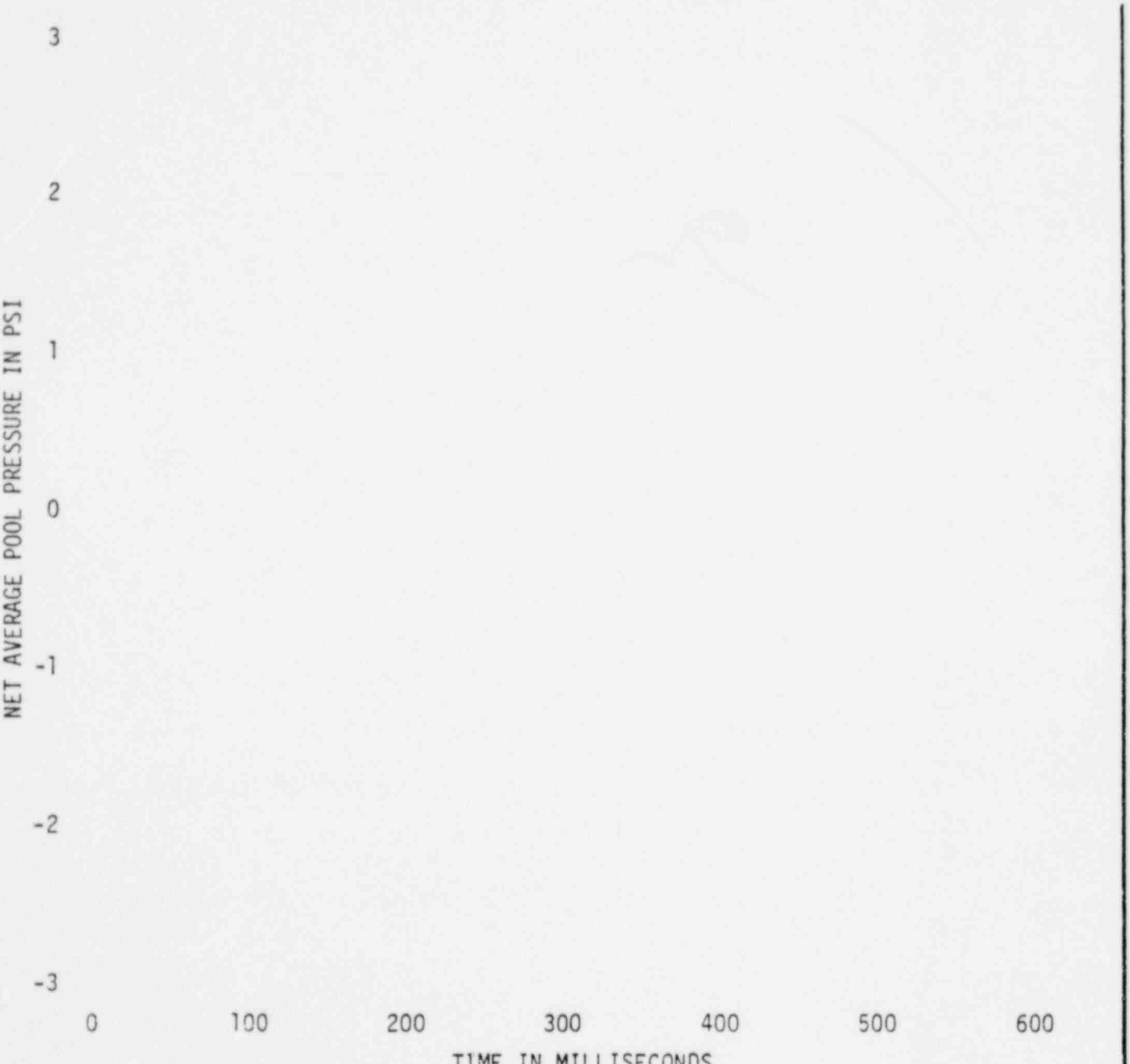


1348 223

FIGURE A-76

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 3

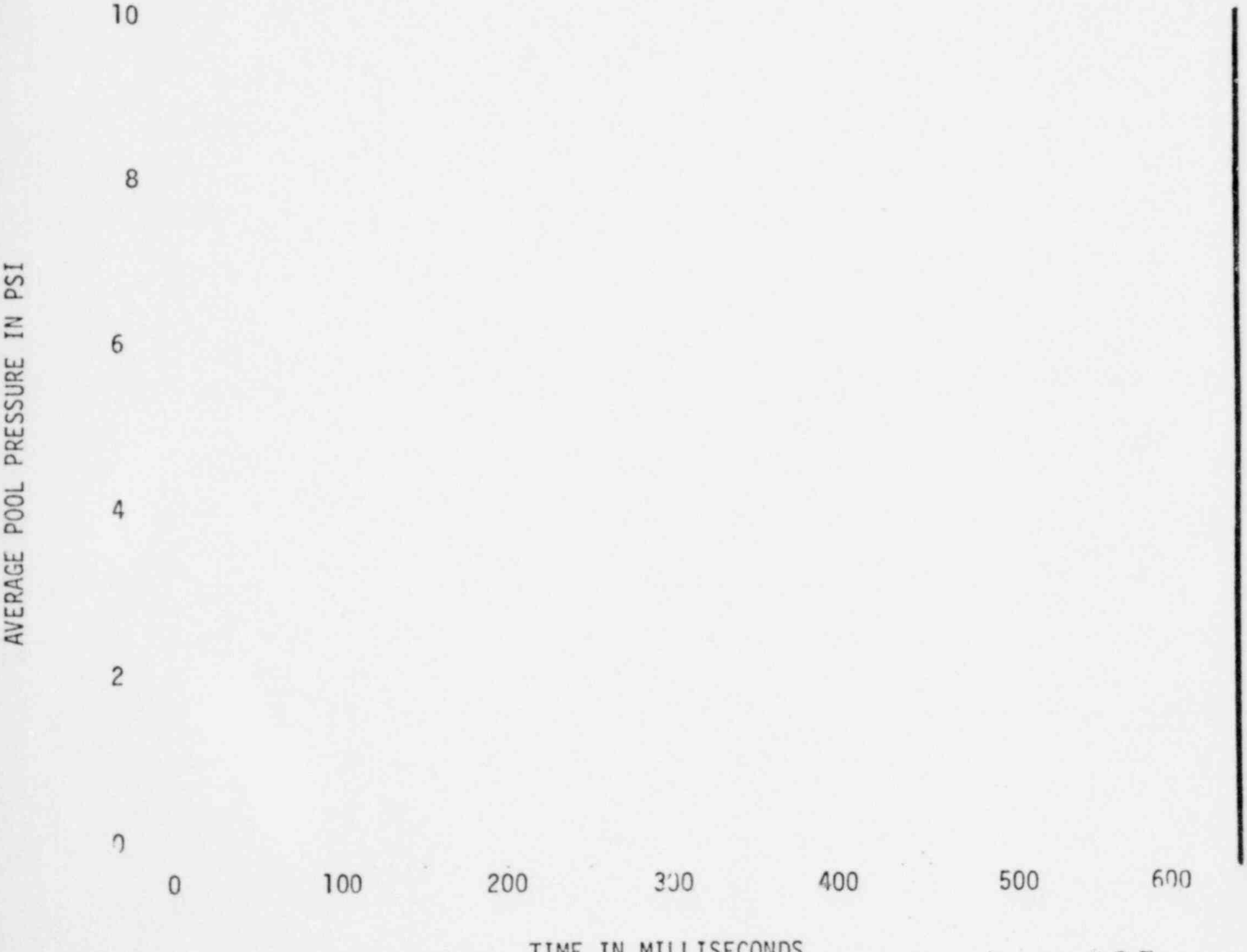


1348 224

FIGURE A-77

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 5

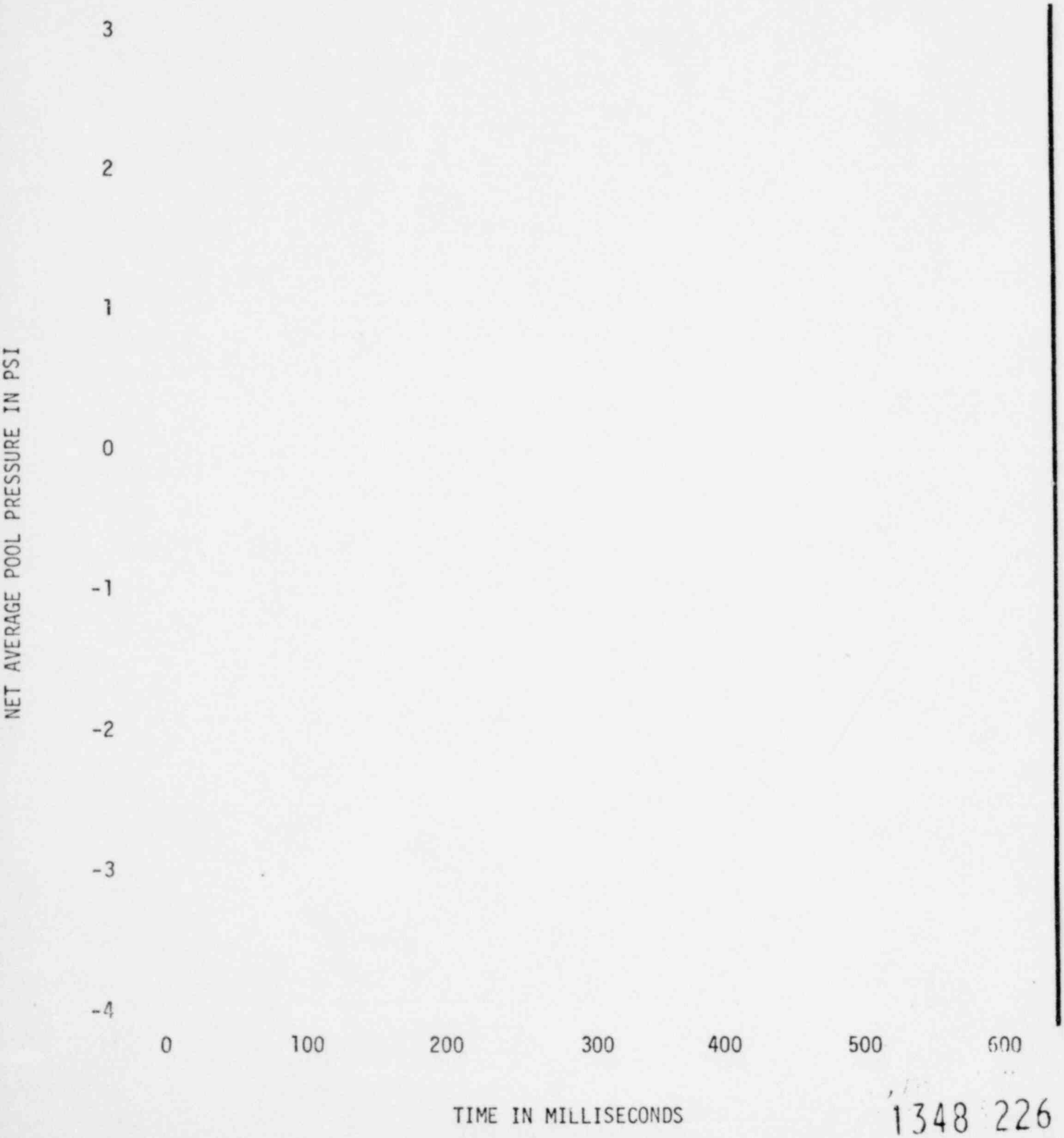


1348 225

FIGURE A-78

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Pilgrim Test 5



1348 226

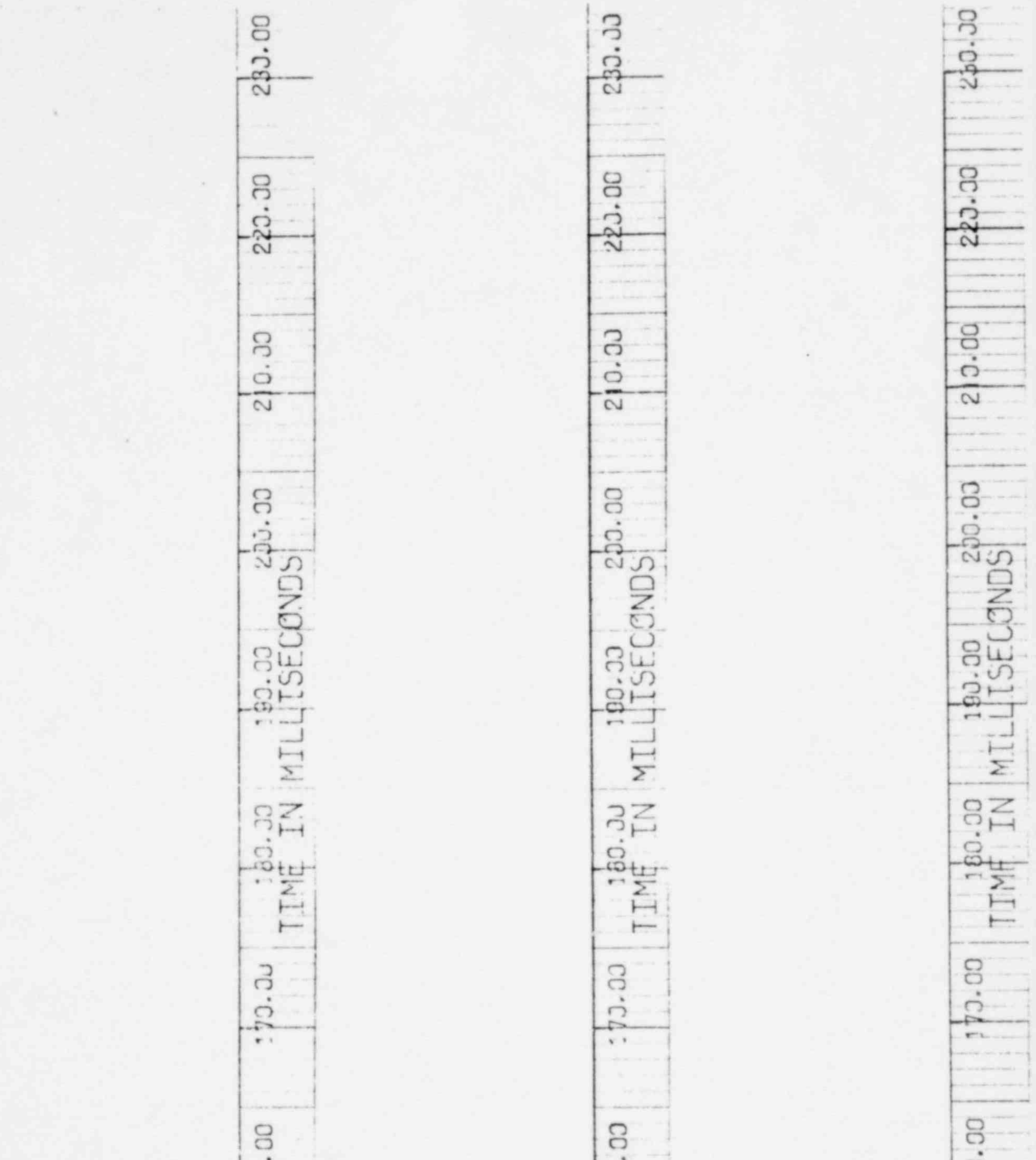
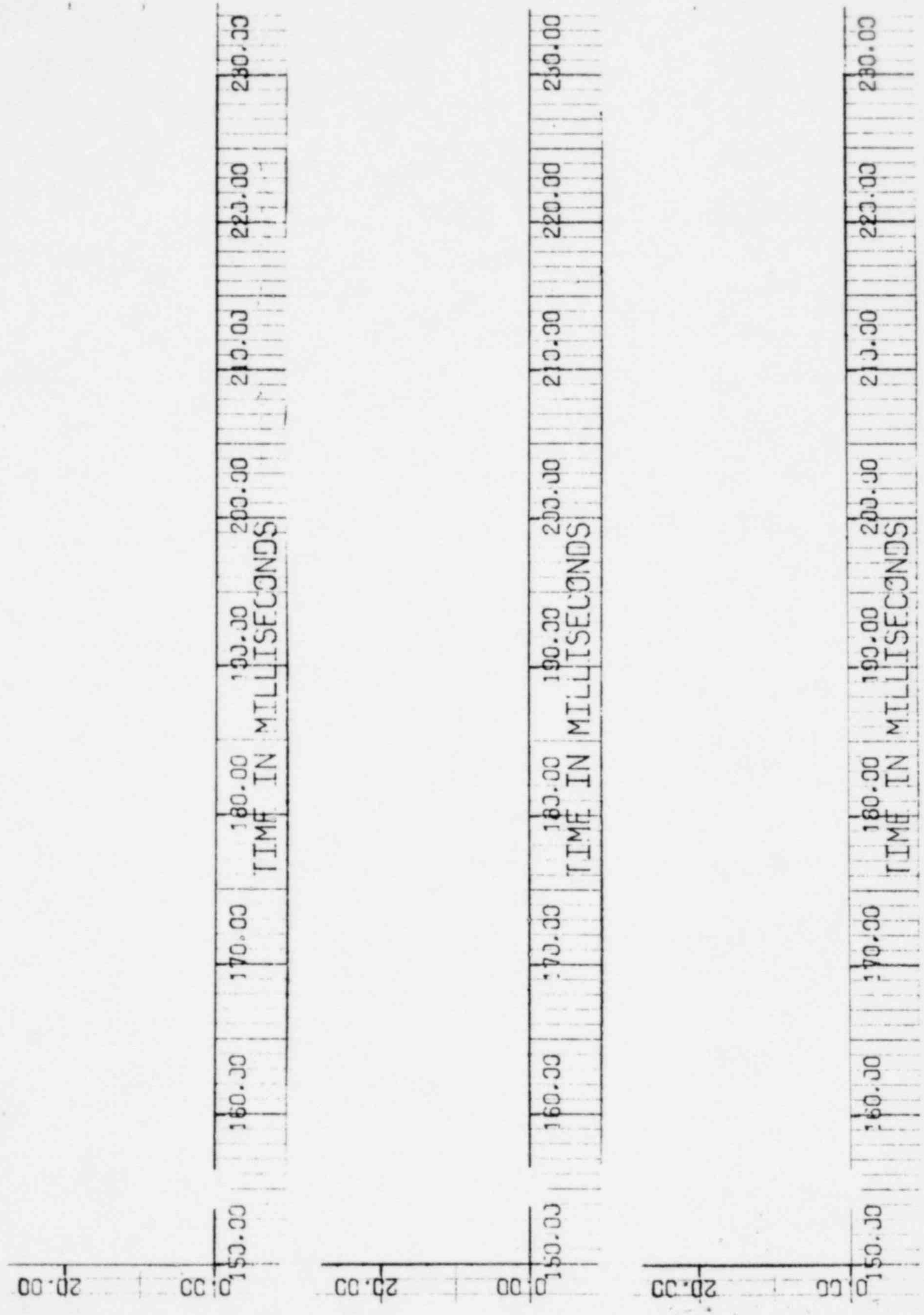


FIGURE A-79 VENT HEADER IMPACT PRESSURES
Task 5.5.3-2 Pilgrim Test 3

1348 227

FIGURE A-80 VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Pilgrim Test 3

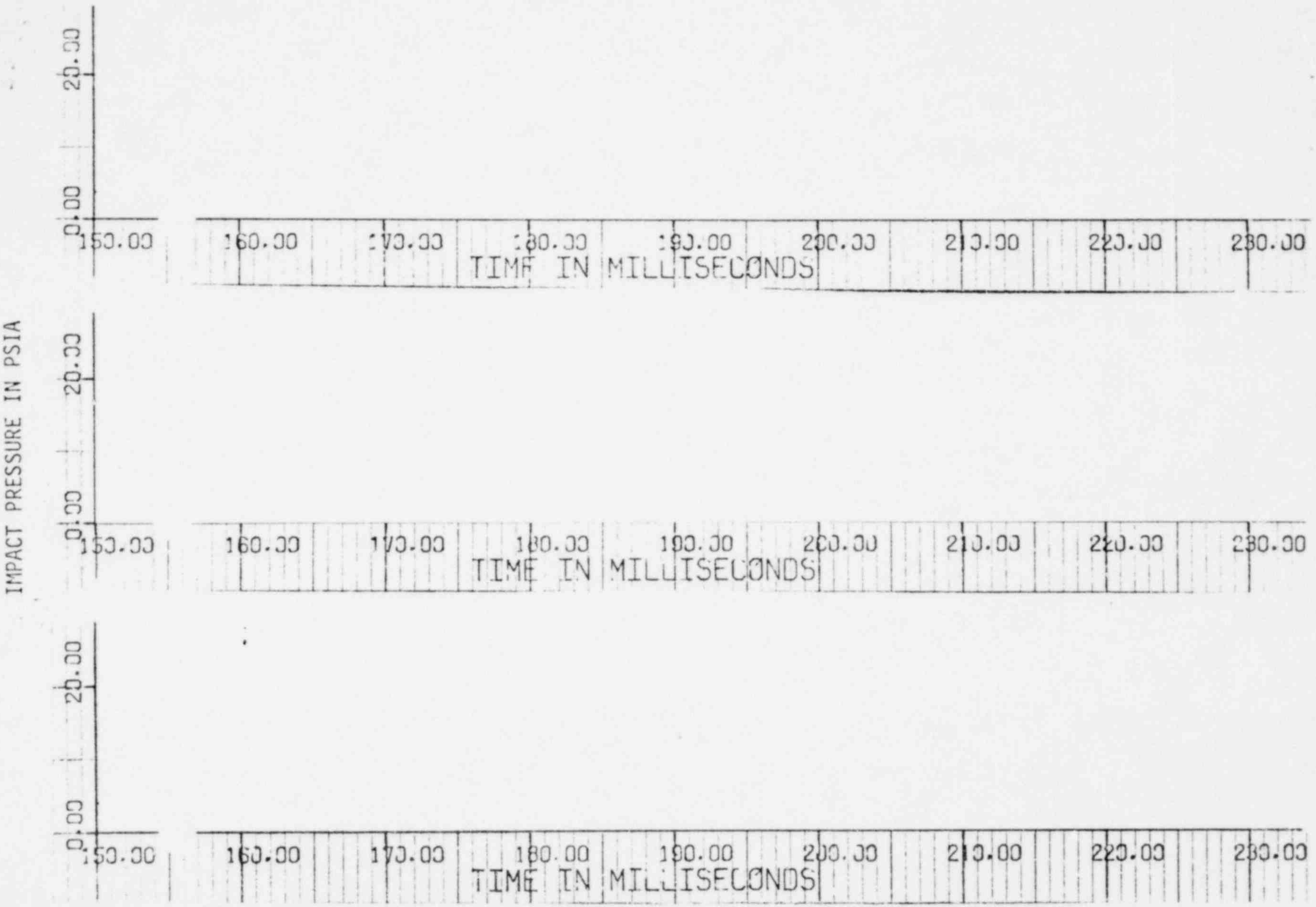


1348 228

FIGURE A-81

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Pilgrim Test 3



1348 229

FIGURE A-82

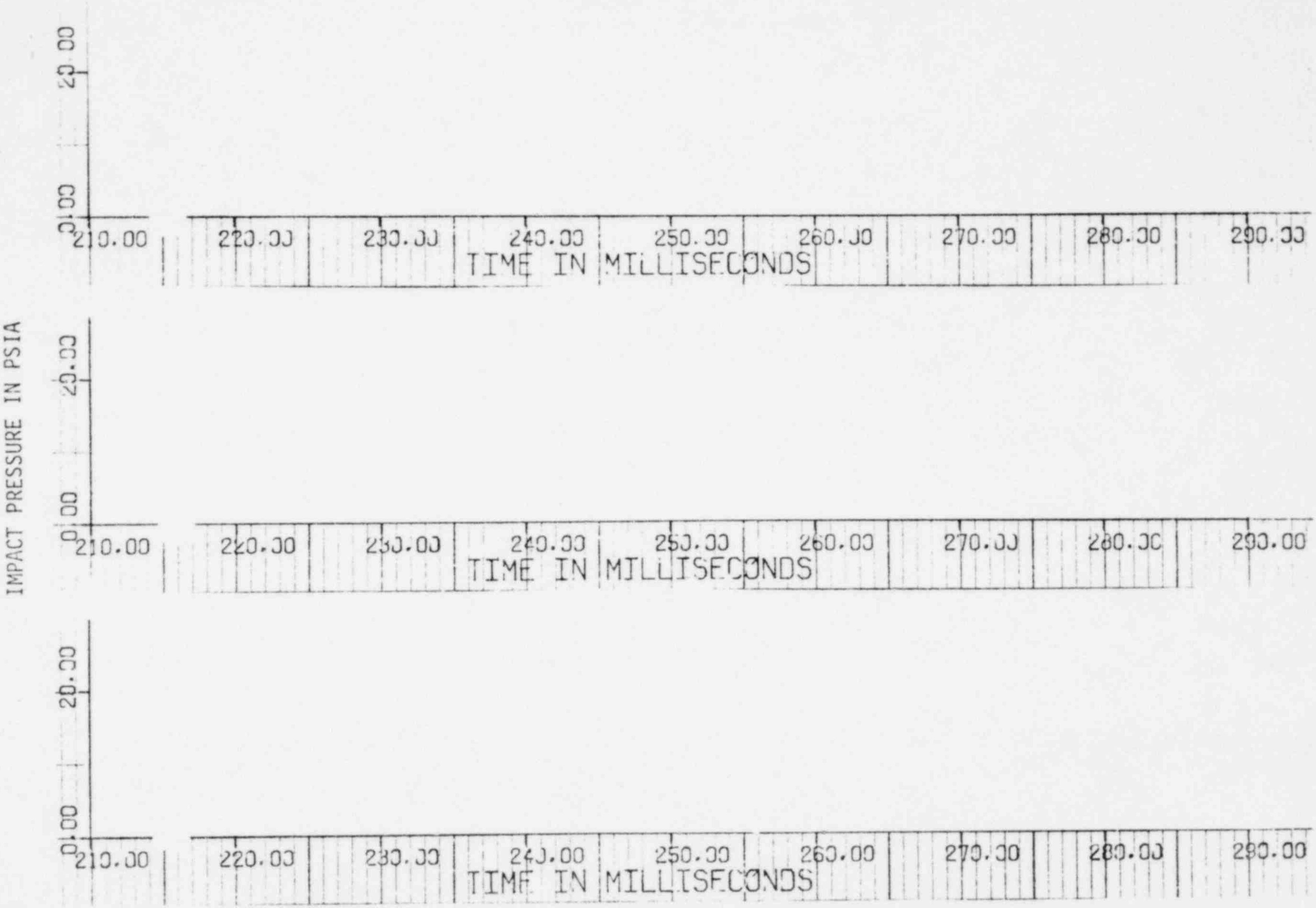
VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Pilgrim Test 5

1348 230

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Pilgrim Test 5



1348 231

FIGURE A-84

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Pilgrim Test 5

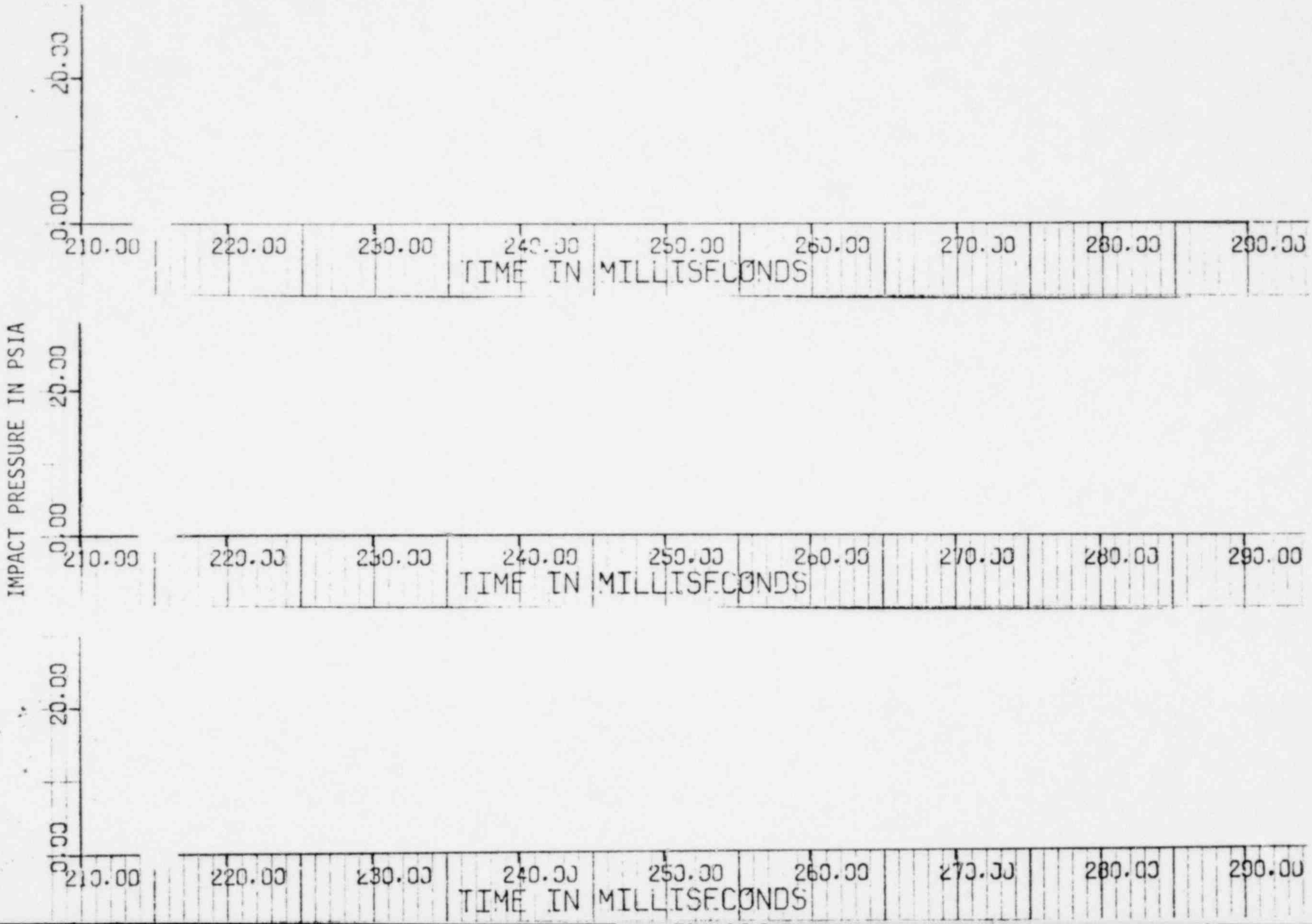
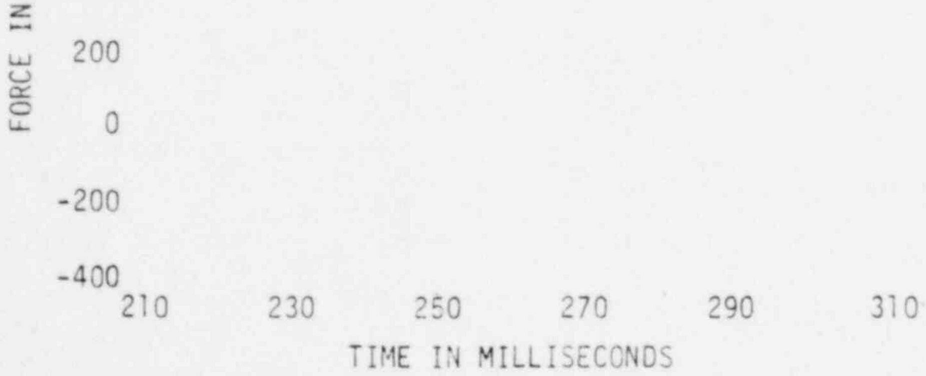


FIGURE A-85

COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3 Pilgrim Tests 3, 5

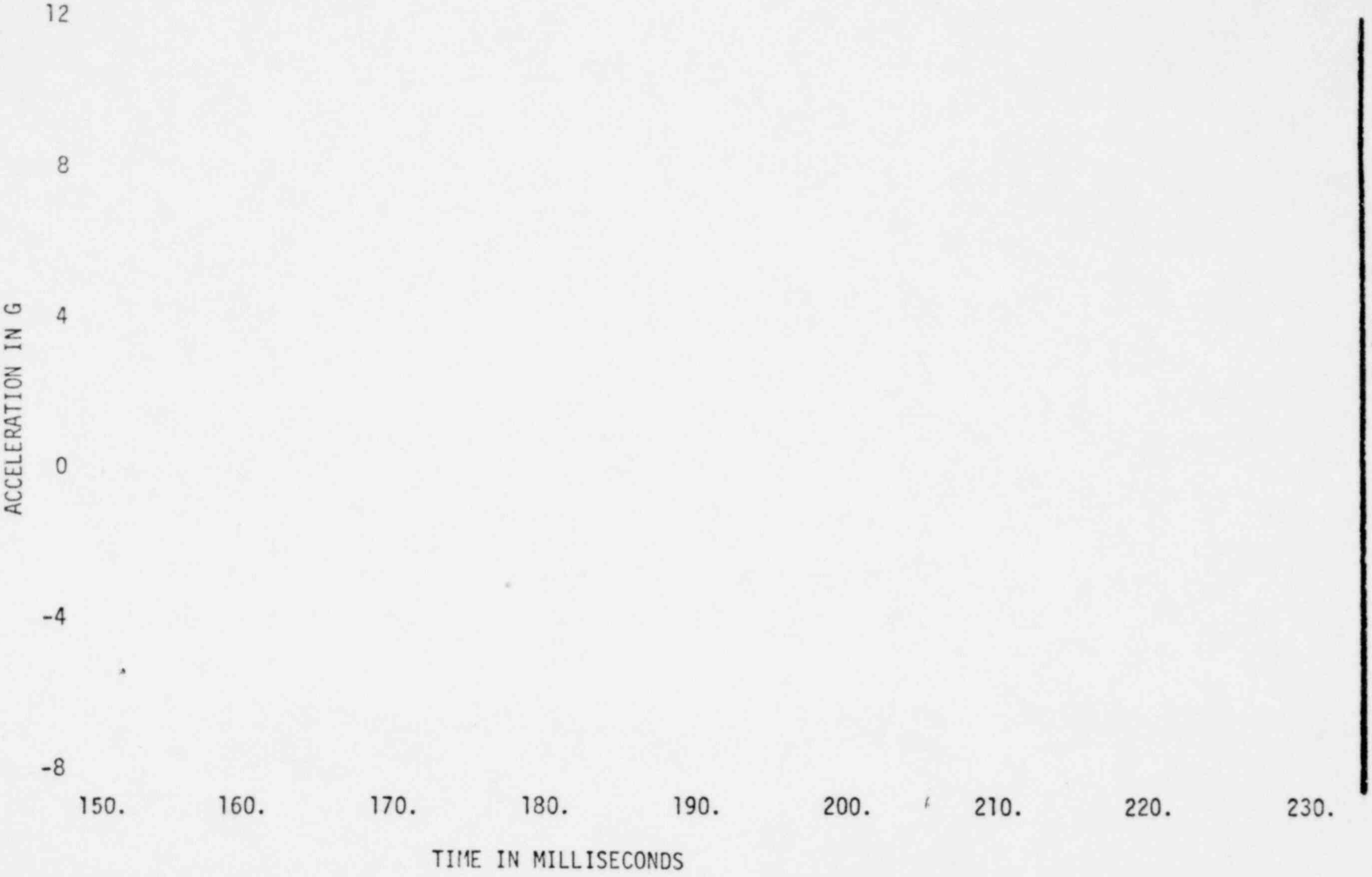


1348 233

FIGURE A-86

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Pilgrim Test 3



1348 234

FIGURE A-87

VENT HEADER VERTICAL ACCELERATION

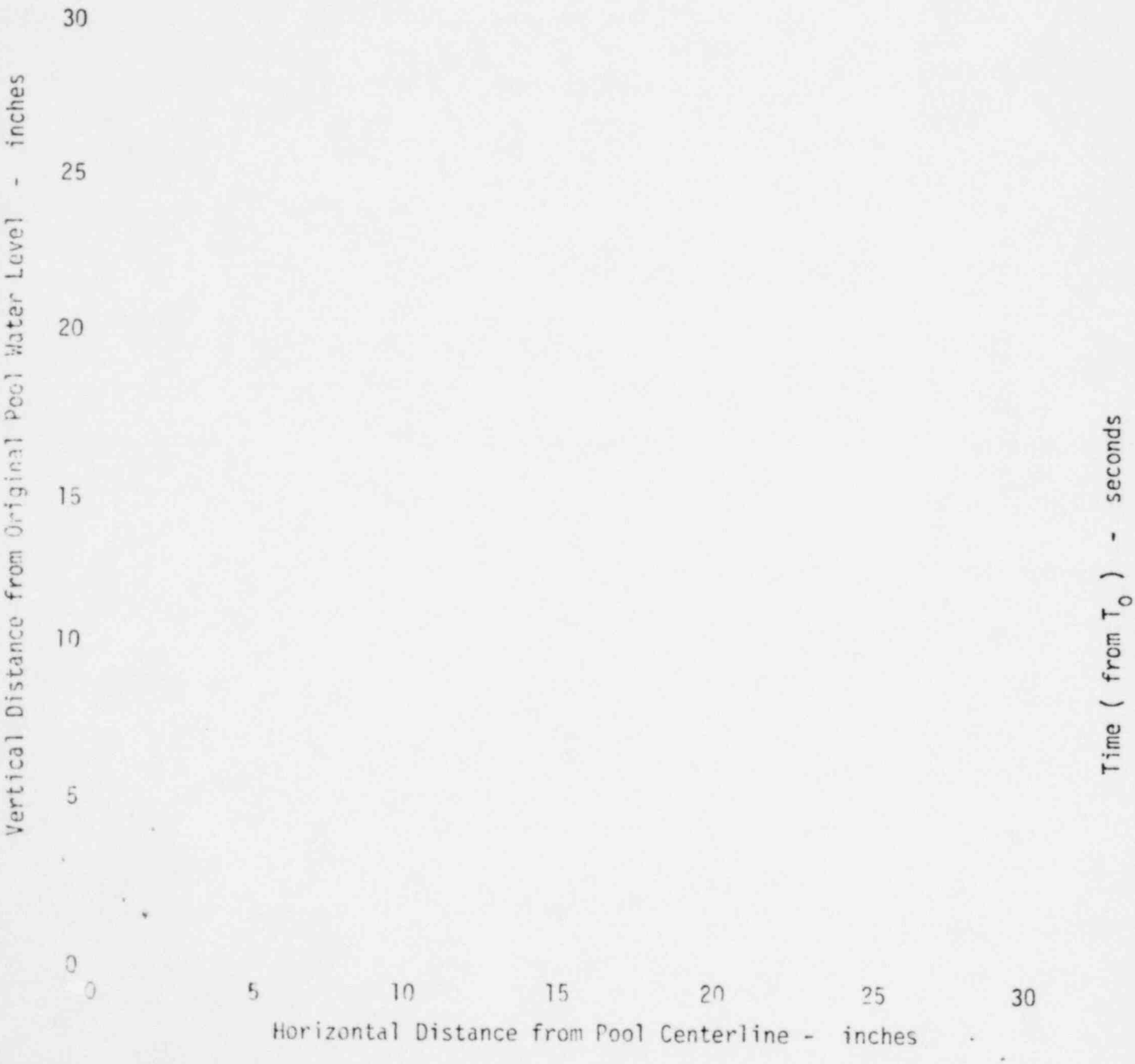
Task 5.5.3-2 Pilgrim Test 5

1348 235

FIGURE A-88

Time History Of
Pool Displacement

PILGRIM, TEST 1

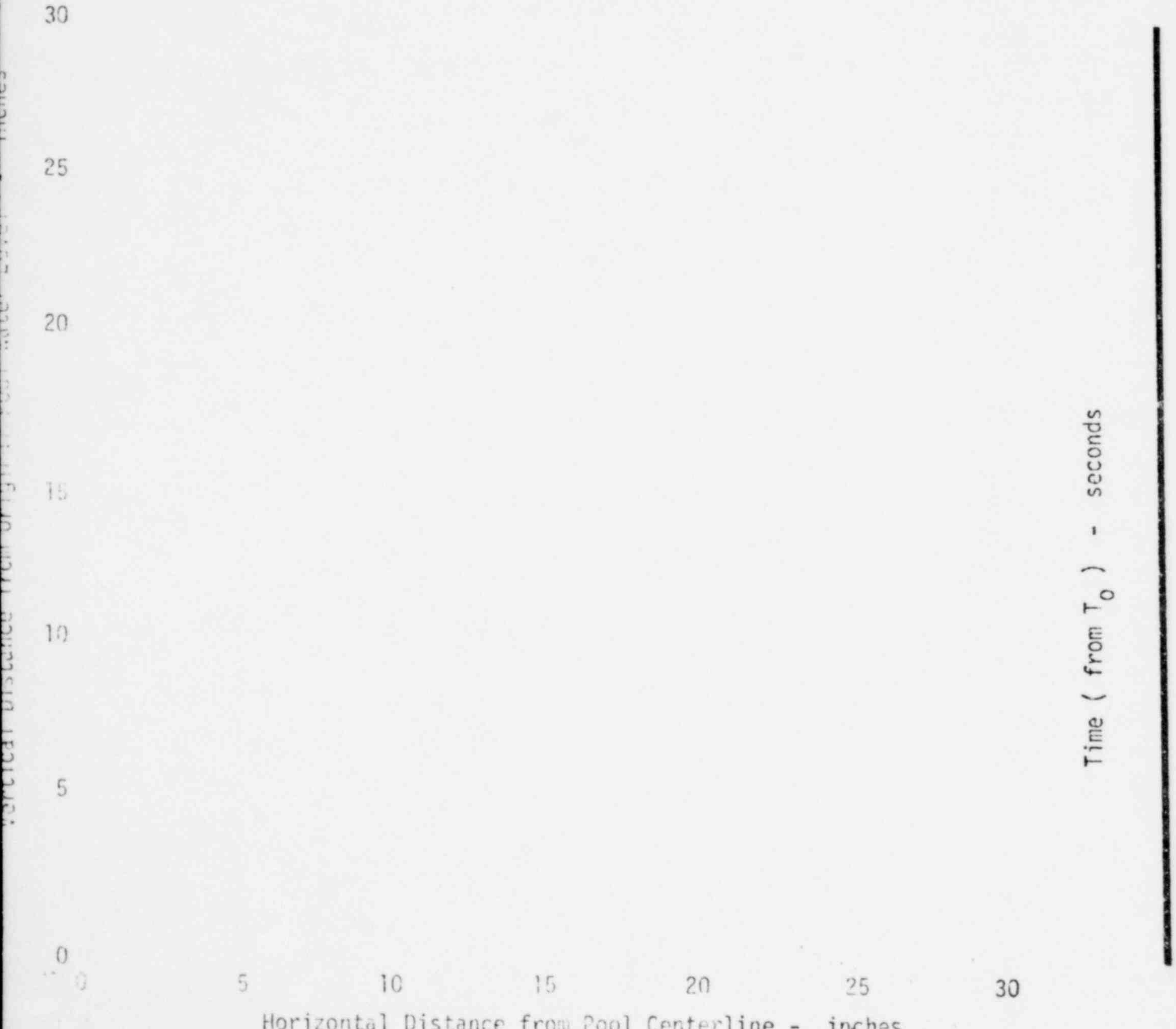


1348 236

FIGURE A-89

Time History Of
Pool Displacement

PILGRIM, TEST 2



1348 237

FIGURE A-90

Time History Of
Pool Displacement

PILGRIM, TEST 3

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

Time (from T_0) - seconds

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

1348 238

FIGURE A-91

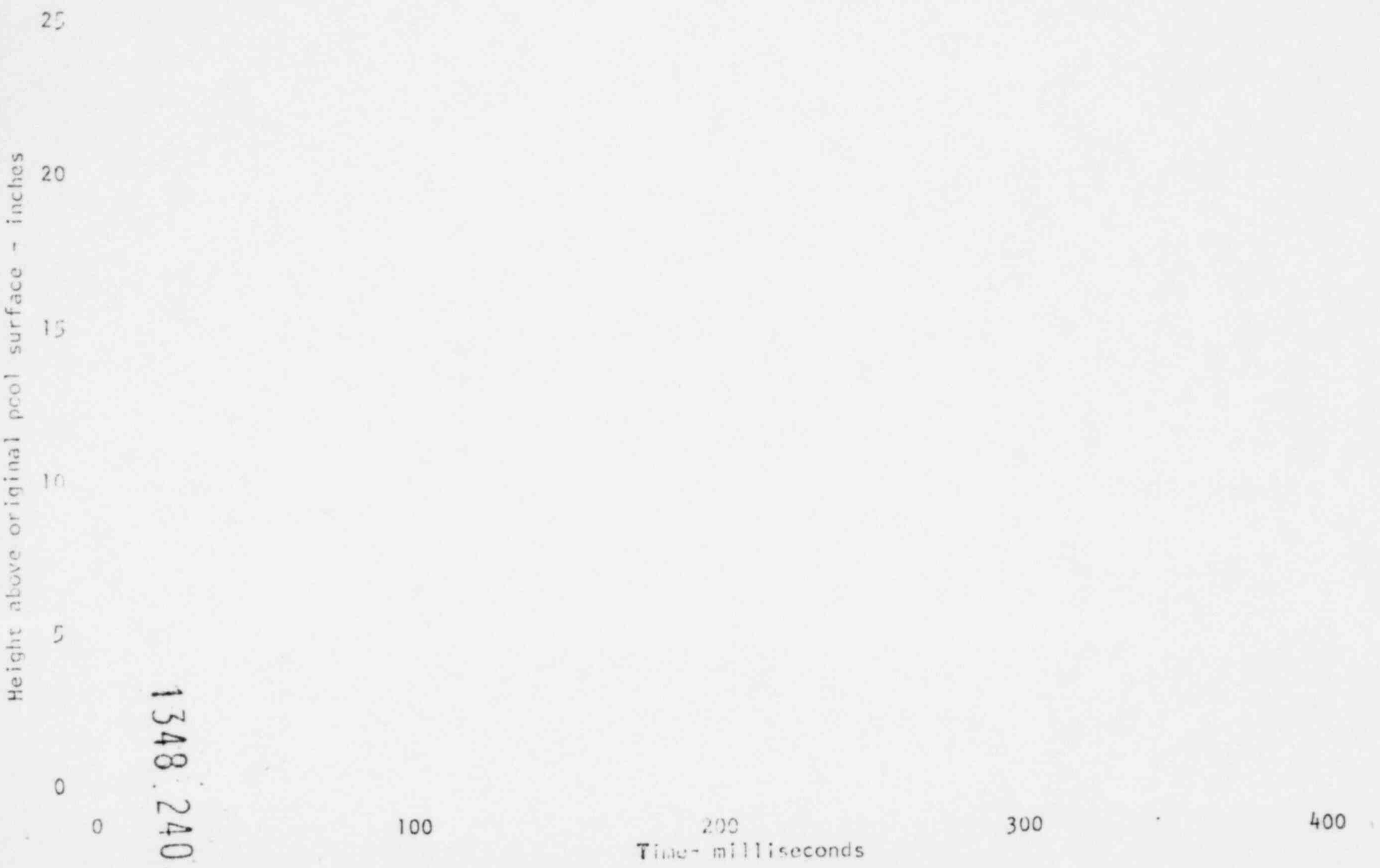
Time History Of
Pool Displacement

PILGRIM, TEST 5

1348 239

FIGURE A-92 POOL SURFACE DISPLACEMENT

PILGRIM, TESTS 1, 2, 3



1348 240

FIGURE A-93 POOL SURFACE VELOCITY PROFILES

PILGRIM, TESTS 1, 2, 3

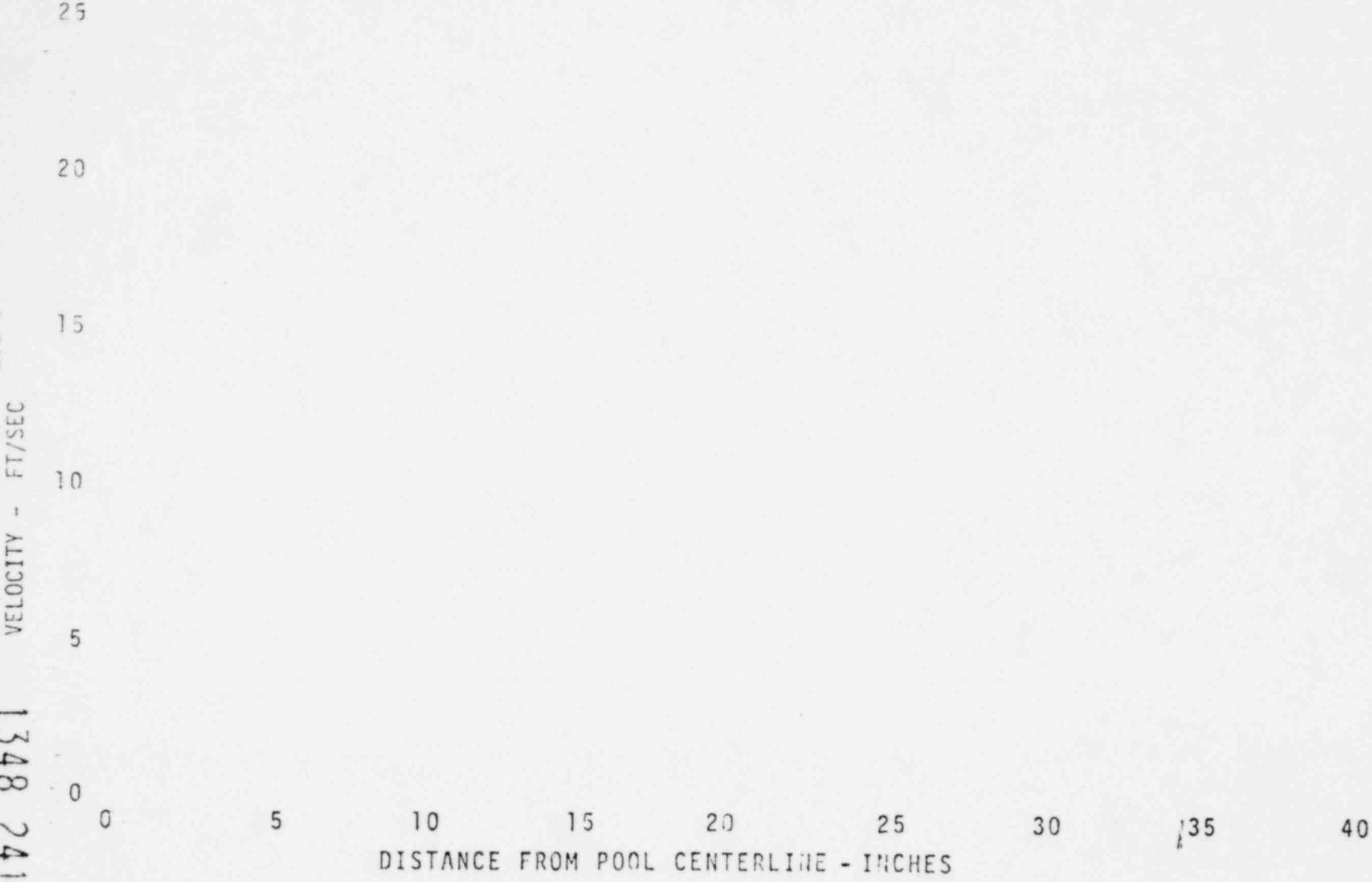


FIGURE A-94 POOL SURFACE DISPLACEMENT

PILGRIM, TEST 5

25

20

15

10

5

0

Height above original pool surface - inches

0 100 200 300 400

Time- milliseconds

1348 242

FIGURE A-95 POOL SURFACE VELOCITY PROFILES

PILGRIM, TEST 5

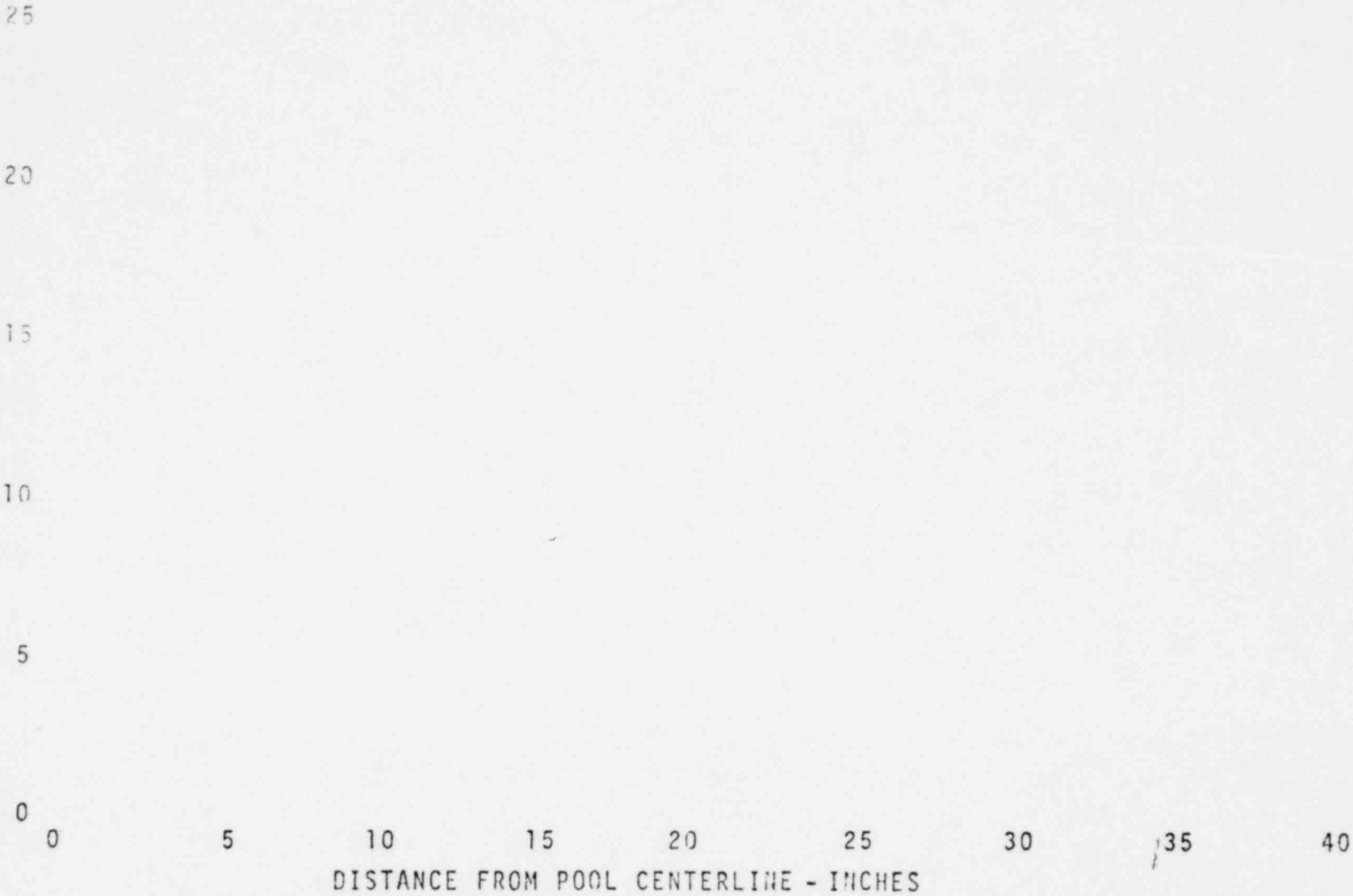


FIGURE A-96 SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

PILGRIM, TEST 4

VERTICAL DISPLACEMENT - INCHES

16

12

8

4

0

-4

.150 .250 .350 .450

15.

VERTICAL VELOCITY-FT/SEC

10.

5.

0.

.150 .250 .350 .450

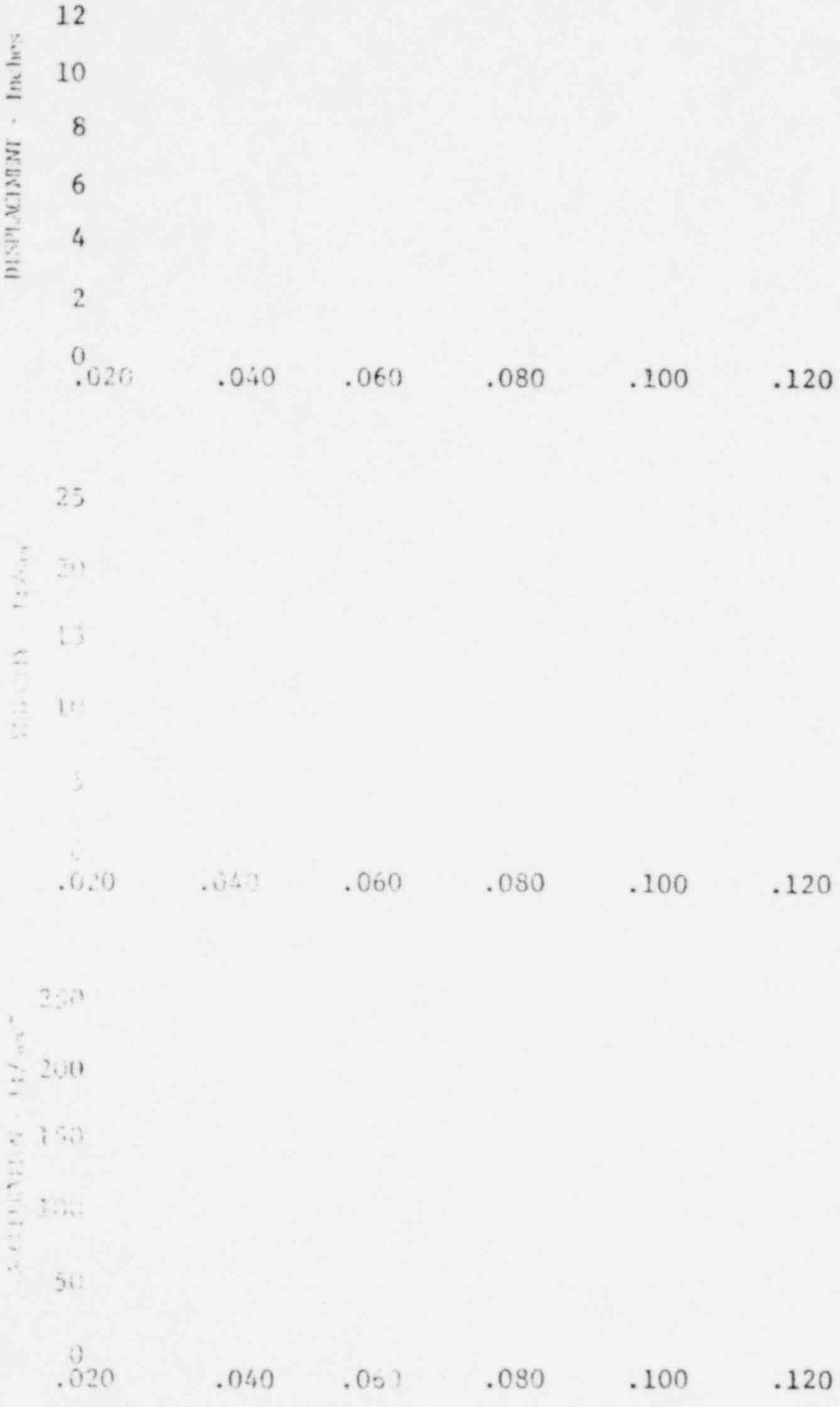
TIME - Seconds

1348 244

FIGURE A-97

DOWNCOMER WATER SLUG EJECTION

PILGRIM, TEST 3



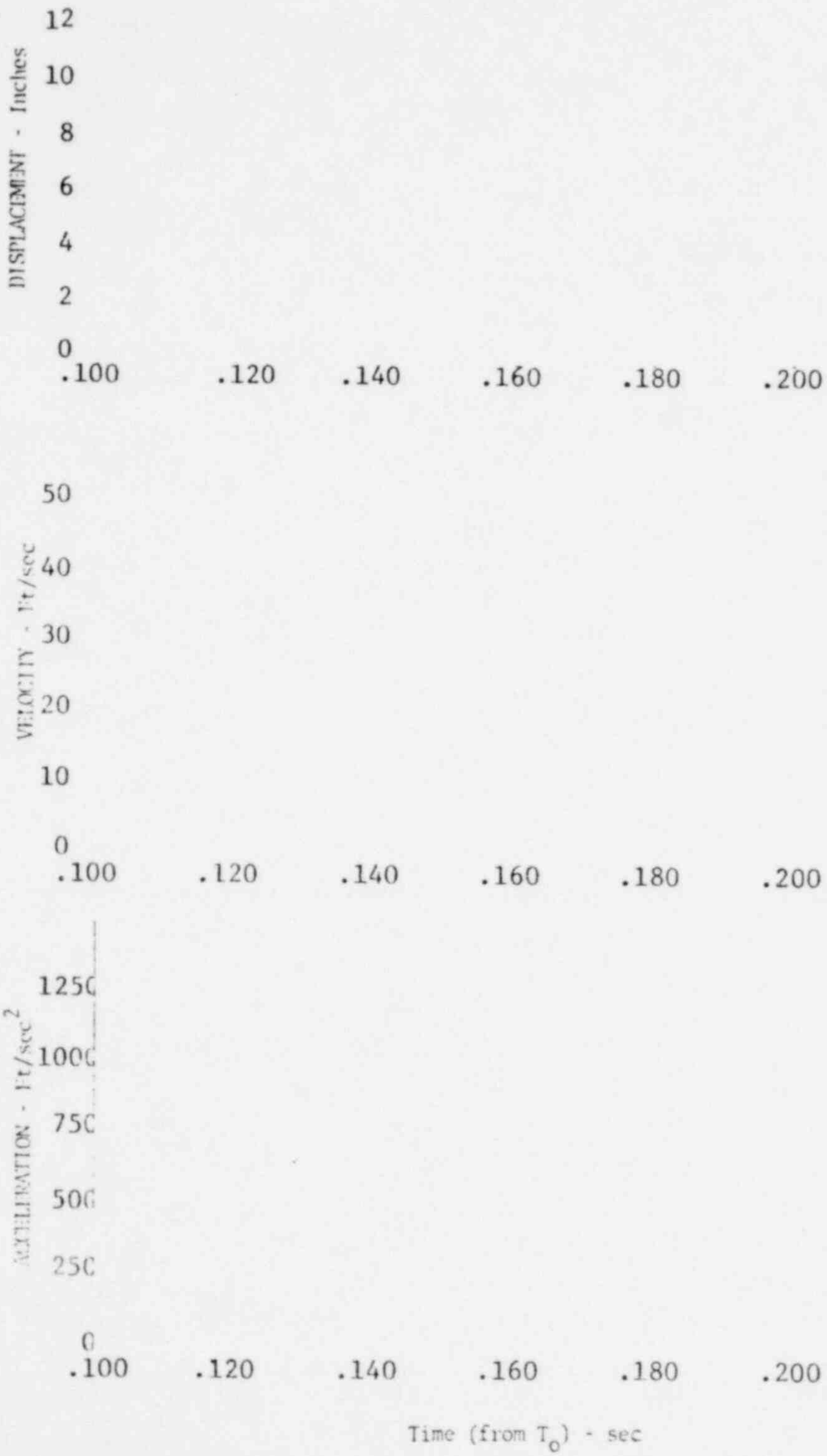
1348 245

~~1348 243~~

FIGURE A-98

DOWNCOMER WATER SLUG EJECTION

PILGRIM, TEST 5



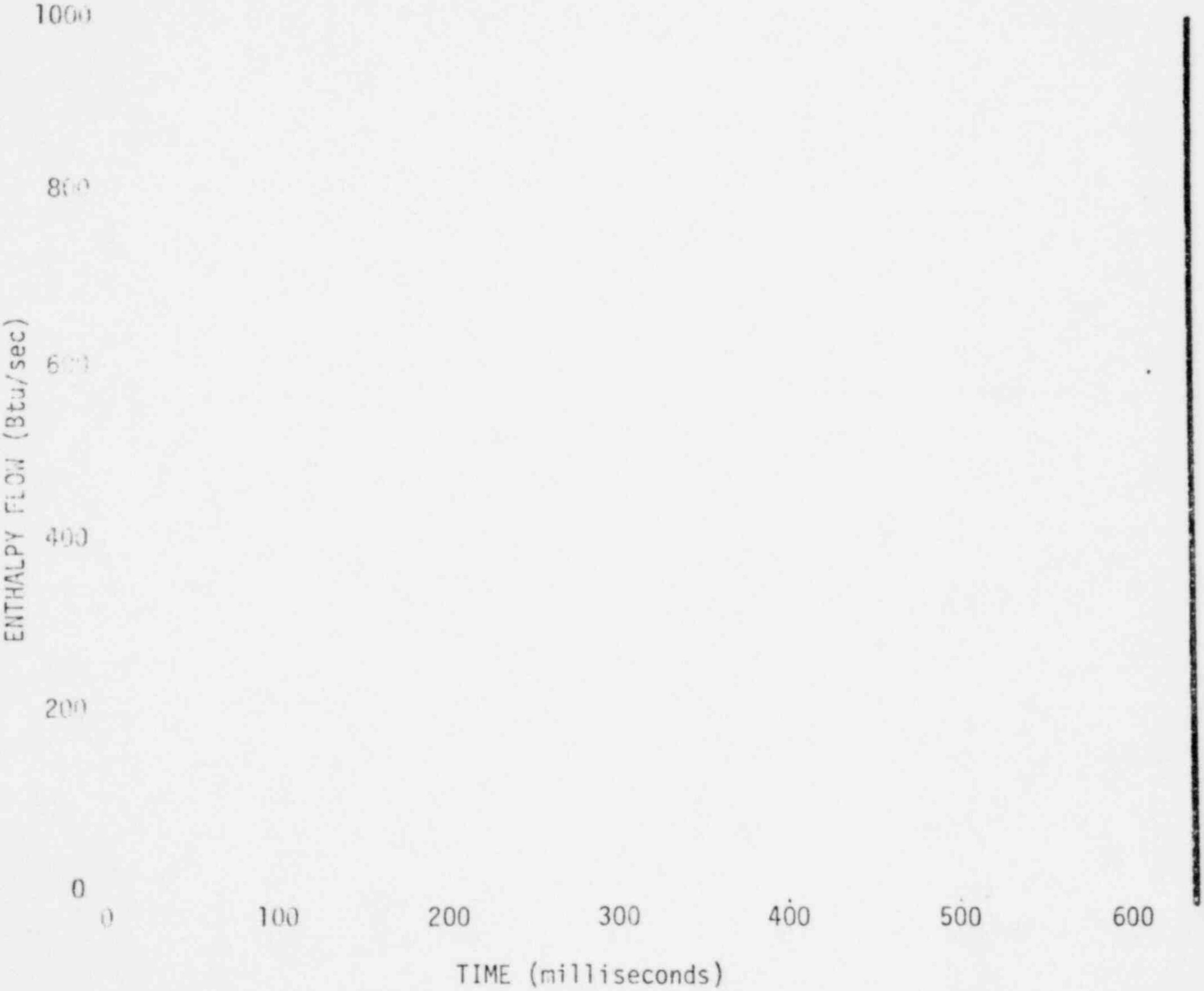
1348 246

FIGURE A-99

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Pilgrim Tests



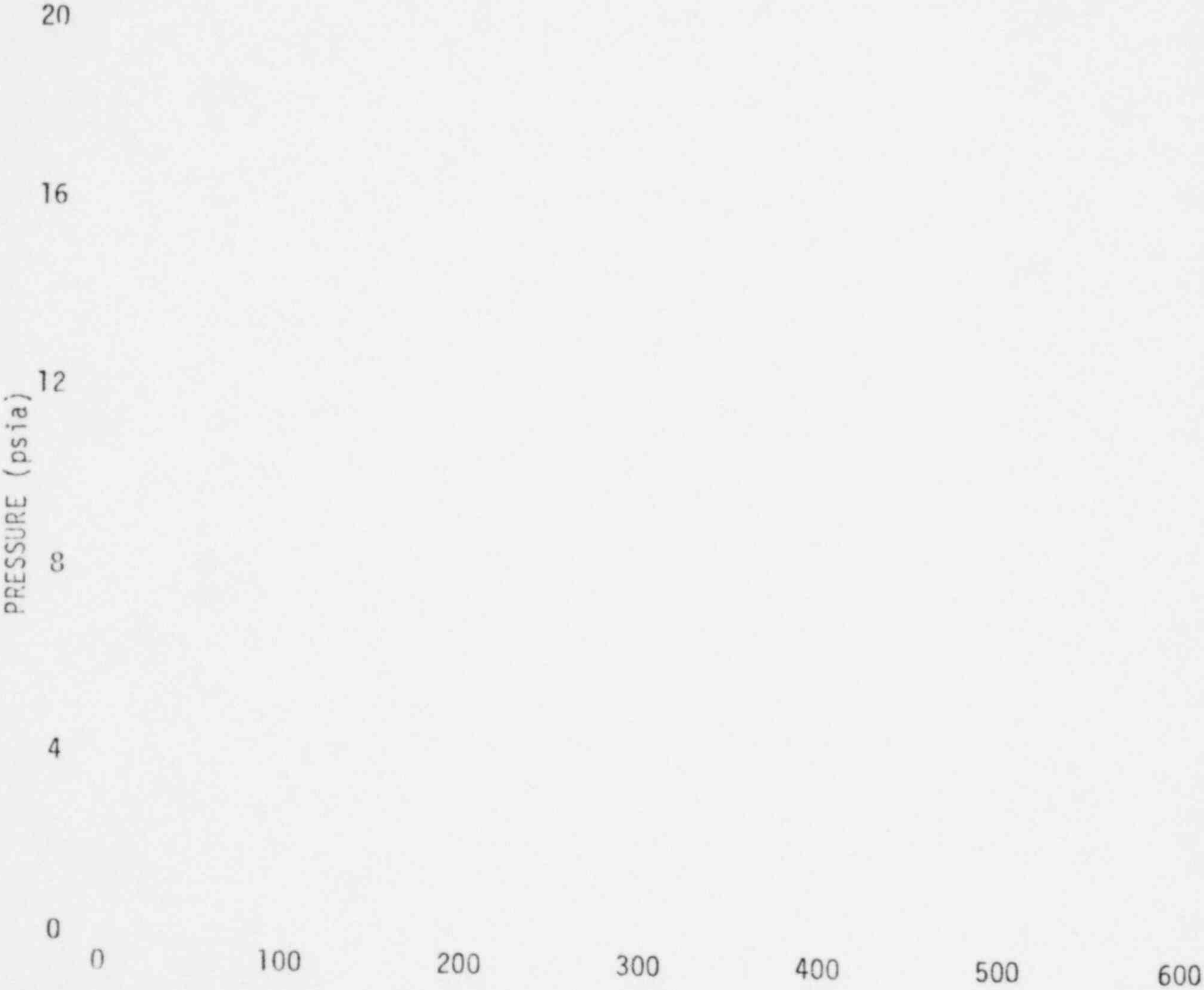
1348 247

FIGURE A-100

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Pilgrim Tests



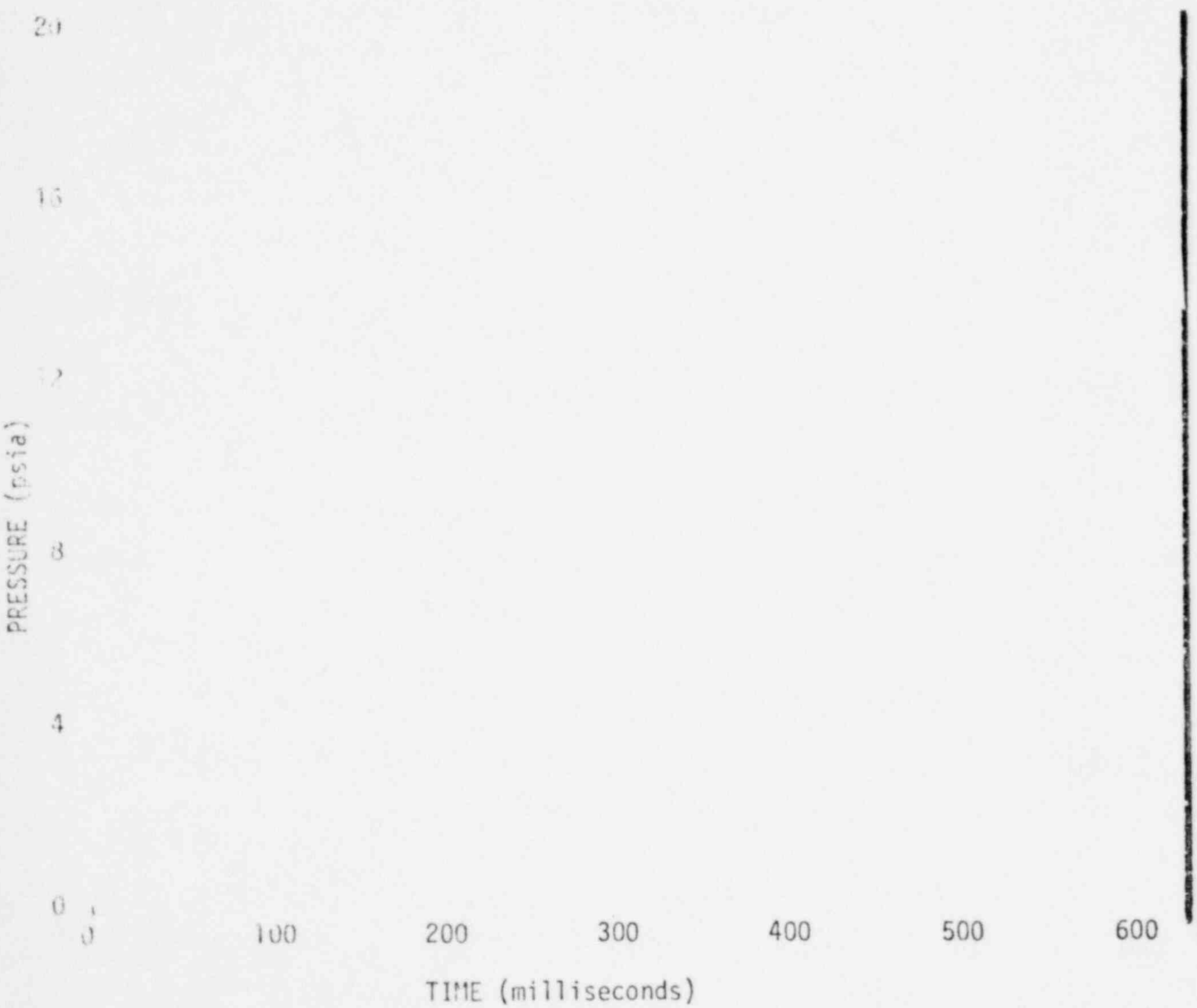
1348 248

FIGURE A-101

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Pilgrim Tests



1348 249

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforre.
—No significant downforce valley or 2nd peak downforce.
*(1)Start-of-test reference time

TABLE A-4

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Pilgrim Tests

Parameter / Test No.	10.9" ΔP, 4.20" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o *(1) (sec)							
Vent Clearing Time* (sec)							
Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Downforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
[Δt] Downforce Time**							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							
Downforce Impulse							
Pressure Integral:							
Impulse (lb-sec)							

1348 250

*Time at force is zero (from T_o)
*(1) Data not available

TABLE A-4 (Continued)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Pilgrim Tests

Parameter / Test No.	10.9" ΔP, 4.20" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Upforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Zero Force Time*							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							

1340 251

TABLE A-5

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Pilgrim Tests

Parameter	Test No.	10.9" ΔP, 4.20" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP, 4.20" Deflector (5)
T_o +	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected:++								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*(2) Offset 6" from pool centerline
* Based on impact pressure measurements
** At start of the first impact pressure recorded
\+ Start of reference time
++Represents peak of very noisy data (acceleration corrected); mean value would be lower

1348 252

A.3 Fermi 2 Tests

A.3.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Fermi 2 Tests 3 and 7. Test 3 was a load definition test conducted with a partial drywell/wetwell differential pressure of 7.03" H_2O and with a 6.566 inch "T" deflector (25.8" full-scale).* Test 7 was conducted with 0" H_2O ΔP and with the same "T" deflector.

A.3.1.1 Driving Conditions

Driving conditions for Fermi 2 Test 3 are presented in Figures A-102 through A-106. Similar plots for Test 7 are shown in Figures A-107 through A-111. Fermi 2 driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.3.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Fermi 2 Tests 3 and 7 are presented in Figures A-112 through A-113 and A-114 through A-115, respectively. Net torus force from the pressure integral (Figures A-116 and A-117) shows relatively smooth upforce but some minor downforce oscillation. Net torus force tnat is determined from the torus load cell (Figures A-118 and A-120) by applying inertial correction with the torus accelerometer (Figures A-119 and A-121) is shown in Figures A-122 and A-123 and compared to net torus force determined from the pressure integral. Figures A-124 and A-125 present the net torus force based on the torus pressure integral, corrected for inertia.

---

* "T" deflector is a pipe with structural "Ts".

1348 253

The "average" pool pressures for Fermi 2 Tests 3 and 7 are shown in Figures A-126 and A-128. Figures A-127 and A-129 are the same as Figures A-124 and A-125 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Fermi 2 Test 3 are presented in Figures A-130 through A-133. These figures indicate that the "T" deflector was effective in mitigating vent header impact. Vent header vertical acceleration measurements from Tests 3 and 7 are shown in Figures A-134 and A-135, respectively.

A.3.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-136 through A-139 for Fermi 2 Tests 1, 2, 3, and 5.

Pool surface displacement curves for Tests 1, 2, and 3 are shown in Figure A-140. The pool surface velocity profiles for Tests 1, 2, and 3 are shown in Figure A-141. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-142 and A-143, respectively.

The pool surface displacement and velocity profile viewed from the side window during Test 4 are shown in Figure A-144. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 7 are presented in Figures A-145 and A-146.

A.3.3 Data Summaries

Tables A-6 and A-7 present the Fermi 2 test data for wetwell vertical forces.

Table A-8 presents the Fermi 2 test data for vent header impact forces.

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A.3.4 Discussion and Analysis

Figure A-147 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of ΔP on downcomer internal pressure is shown in Figure A-148. Figure A-149 presents the effect of ΔP on pool and freespace pressures. This data for Fermi 2 parallels that for the "typical" plant in Section 3.0, except that the air space and pool pressures did not oscillate out of phase, as in the typical plant, after peak upforce.

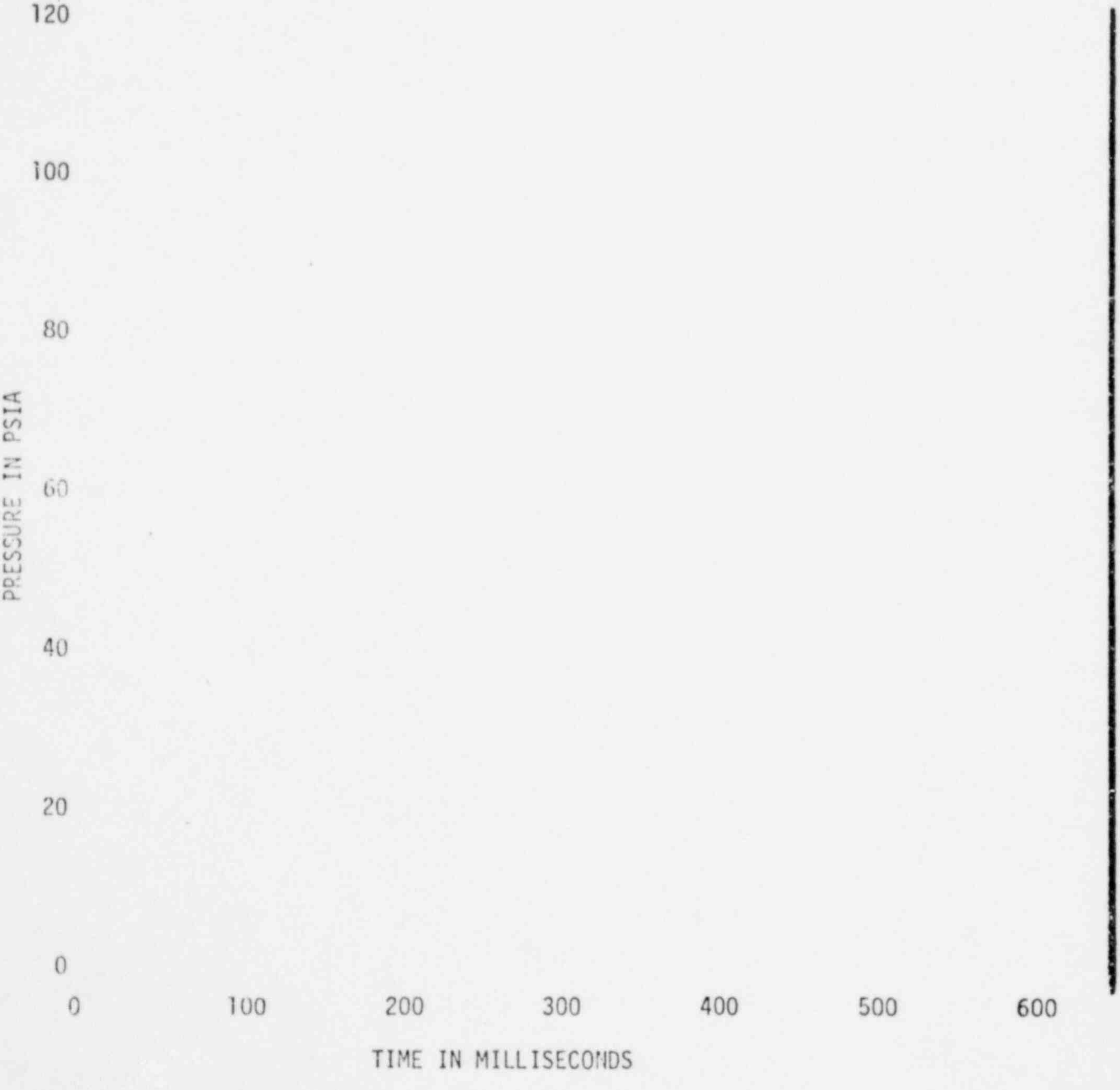
The Fermi 2 load definition tests were conducted at 7.03" H_2O ΔP and with a "T" deflector installed below the vent header. ΔP sensitivity tests at 0" ΔP were also conducted. Both the downforce and upforce were relatively smooth. The "T" deflector (25.8" full-scale) effectively mitigated vent header impact.

1348 255

FIGURE A-102

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Fermi 2 Test 3

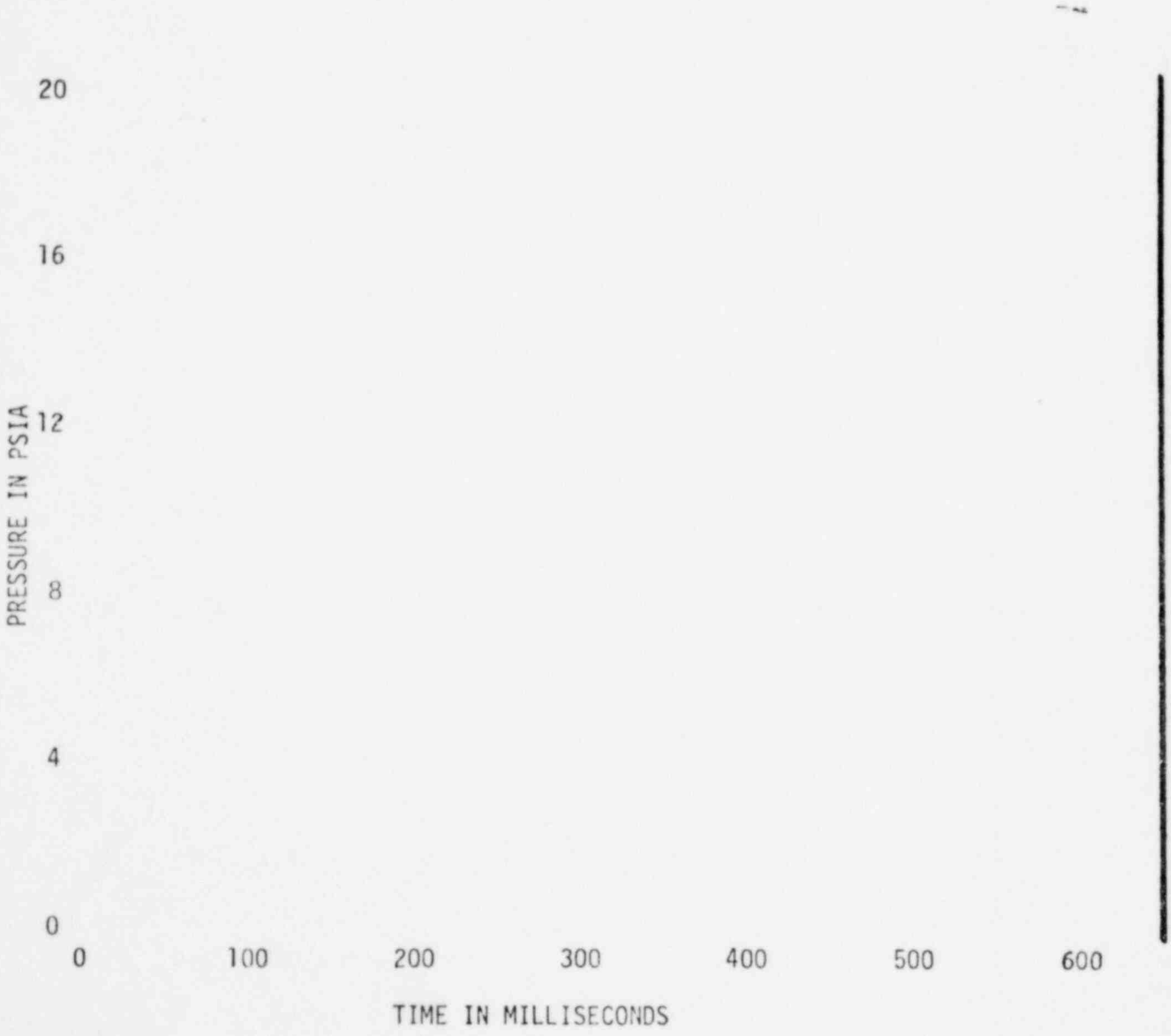


1348 256

FIGURF A-103

DRYWELL PRESSURE

Task 5.5.3-2 Fermi 2 Test 3

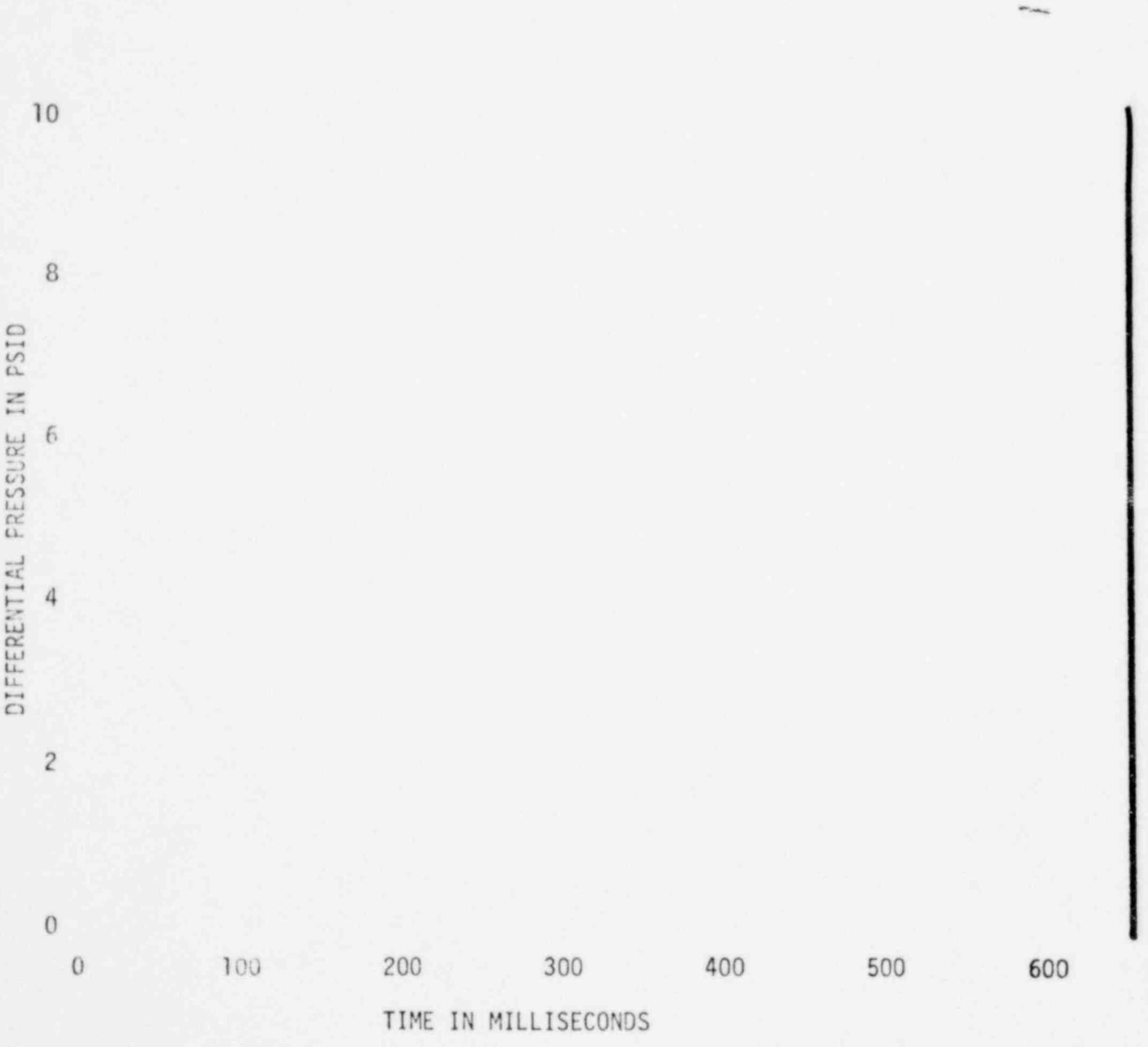


1348 257

FIGURE A-104

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Fermi 2 Test 3

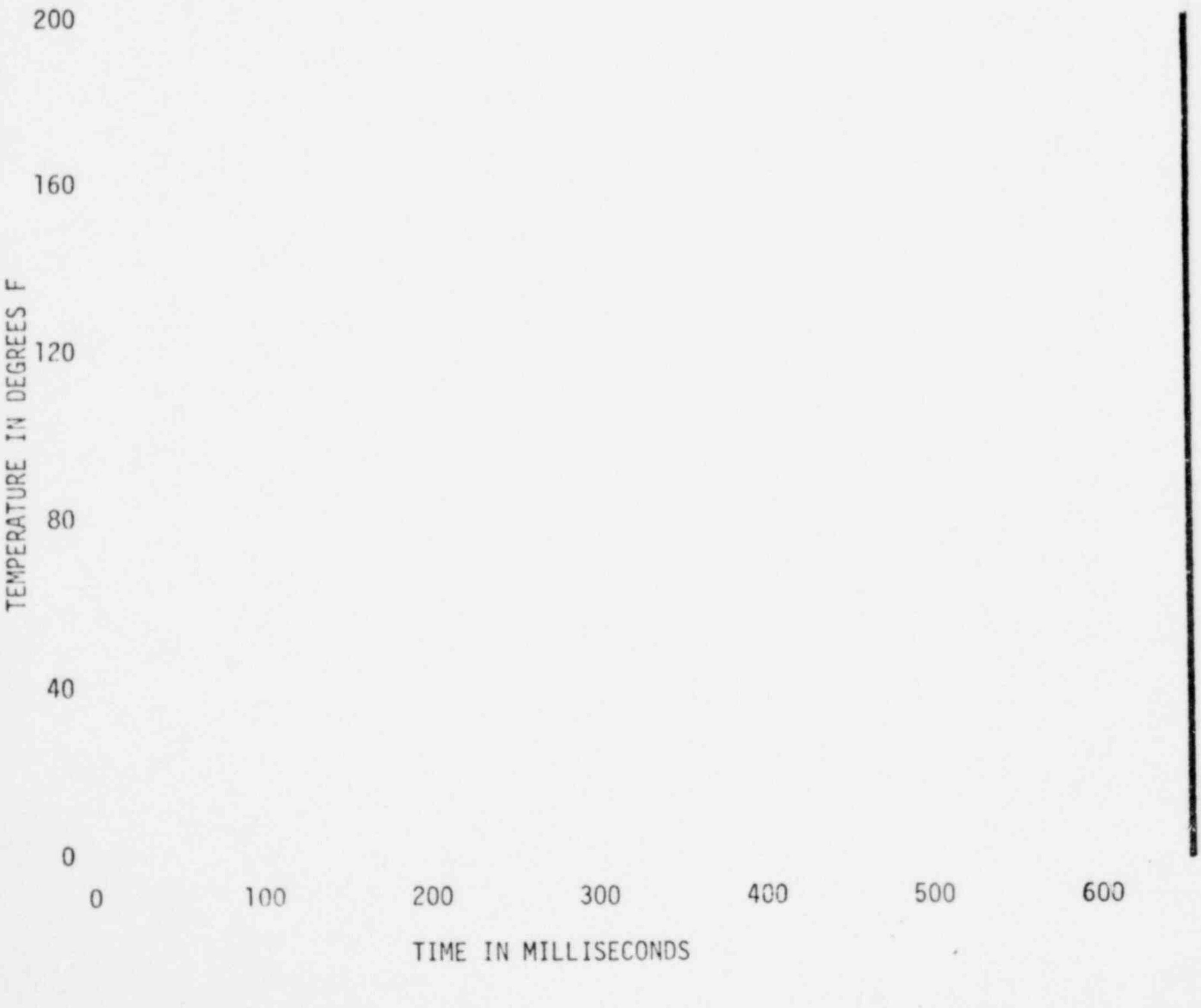


1348 258

FIGURE A-105

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Fermi 2 Test 3



1348 259

FIGURE A-106

ENTHALPY FLOW INTO POOL

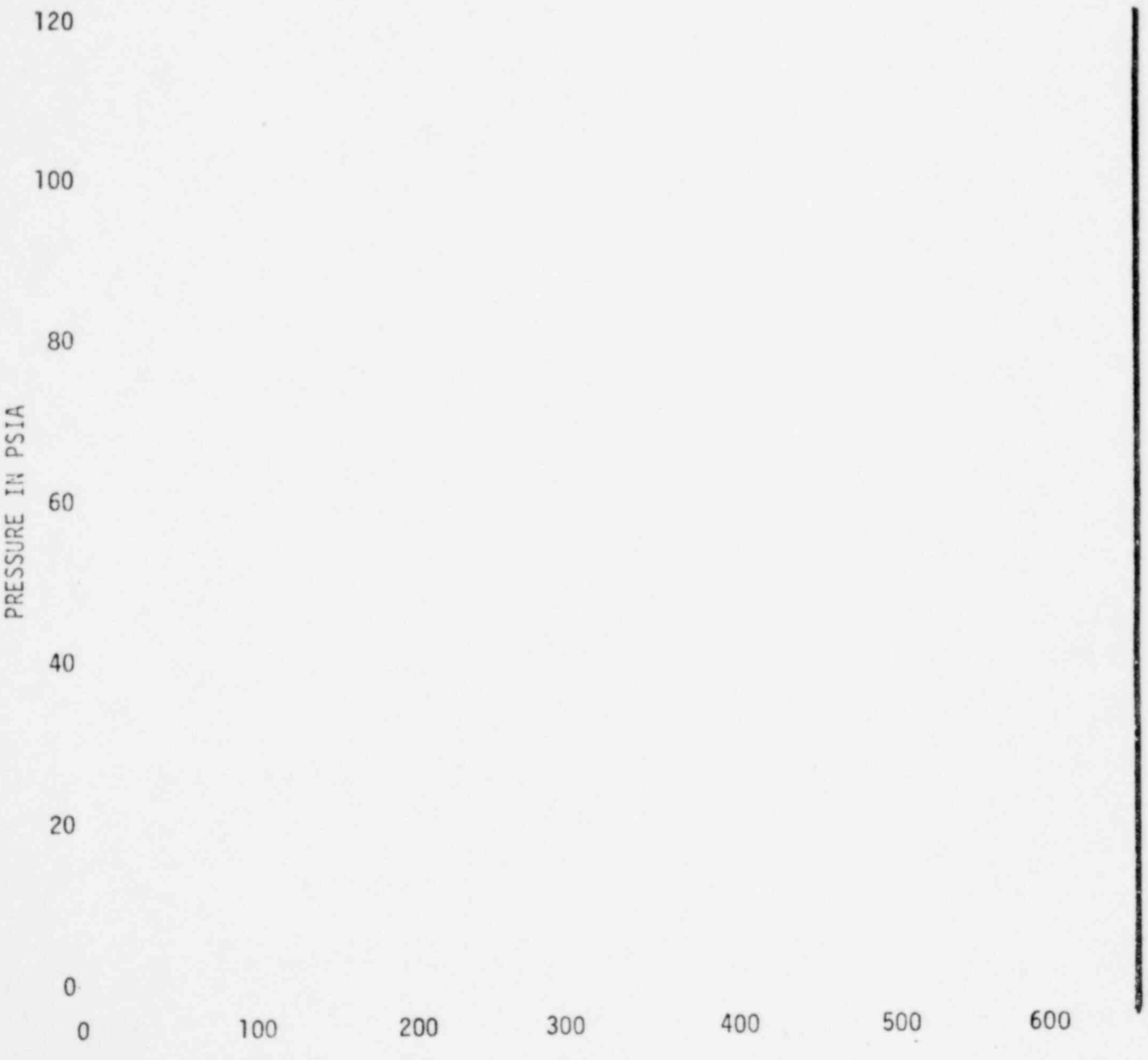
Task 5.5.3-2 Fermi 2 Test 3

1348 260

FIGURE A-107

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Fermi 2 Test 7



1348 261

FIGURE A-108

DRYWELL PRESSURE

Task 5.5.3-2 Fermi 2 Test 7

1348 262

FIGURE A-109

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Fermi 2 Test 7

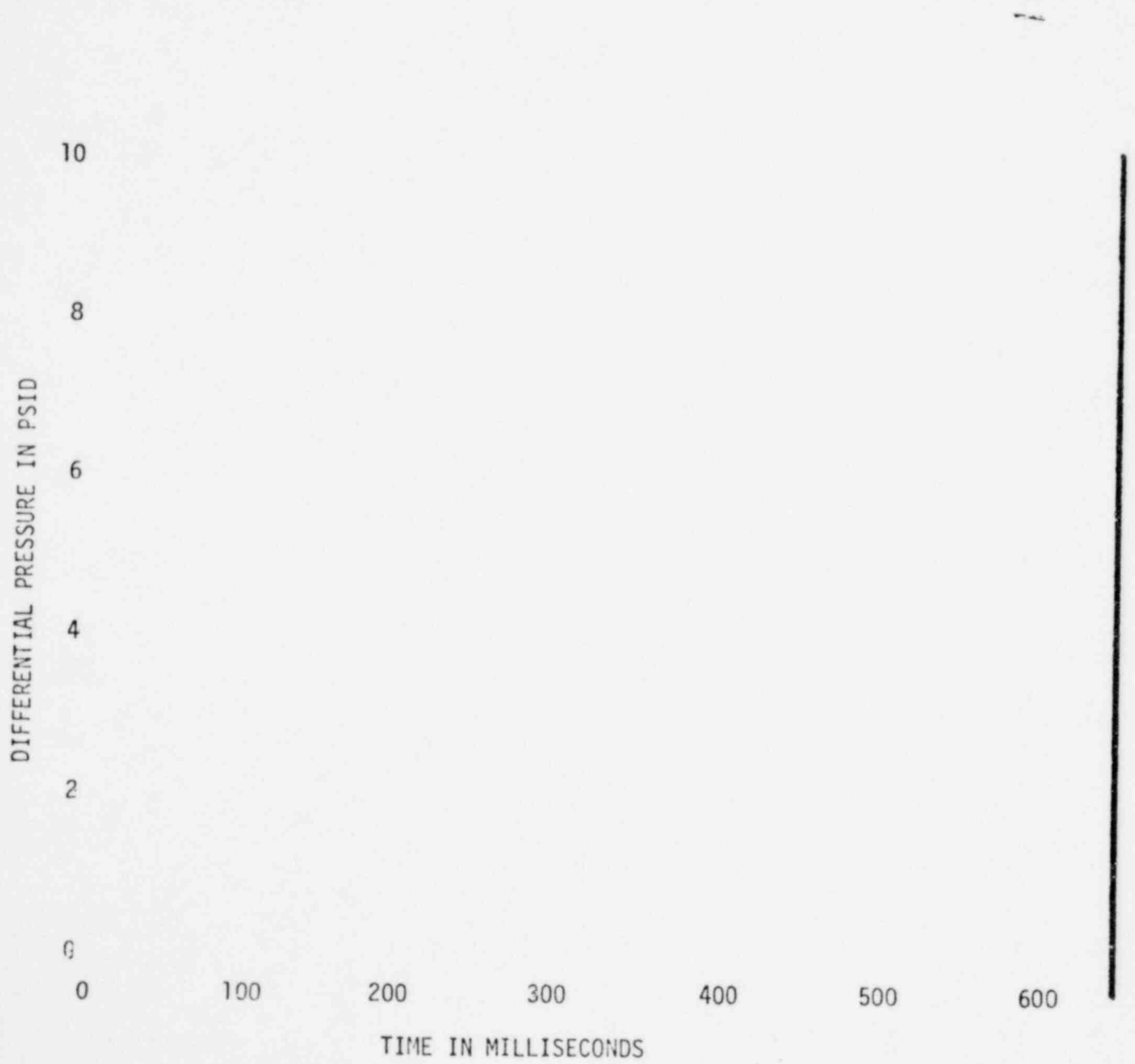
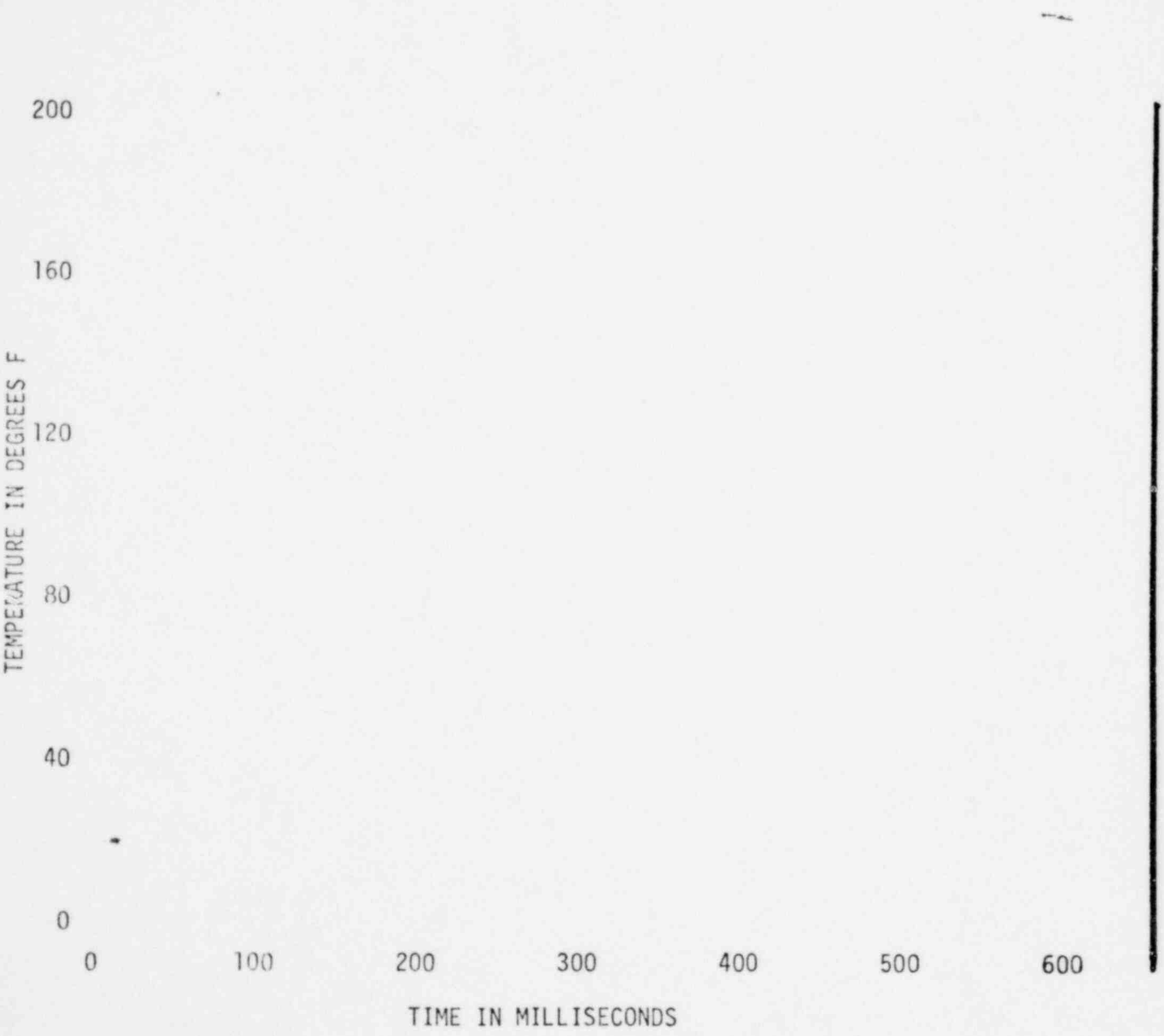


FIGURE A-110

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Fermi 2 Test 7



1348 264

FIGURE A-111

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Fermi 2 Test 7

1348 265

FIGURE A-112

DOWNCOMER INTERNAL PRESSURE

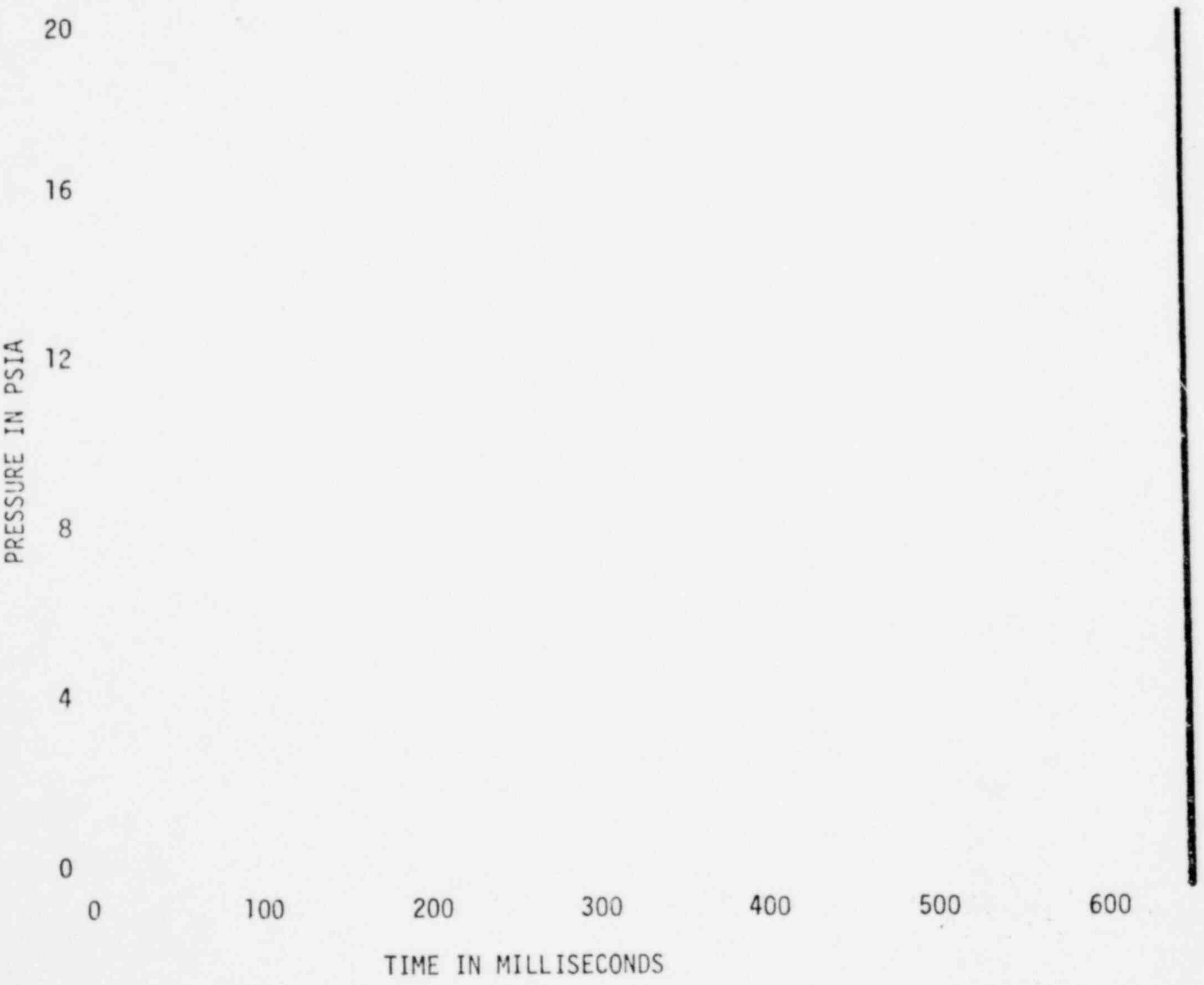
Task 5.5.3-2 Fermi 2 Test 3

1348 266

FIGURE A-113

WETWELL PRESSURES

Task 5.5.3-2 Fermi 2 Test 3

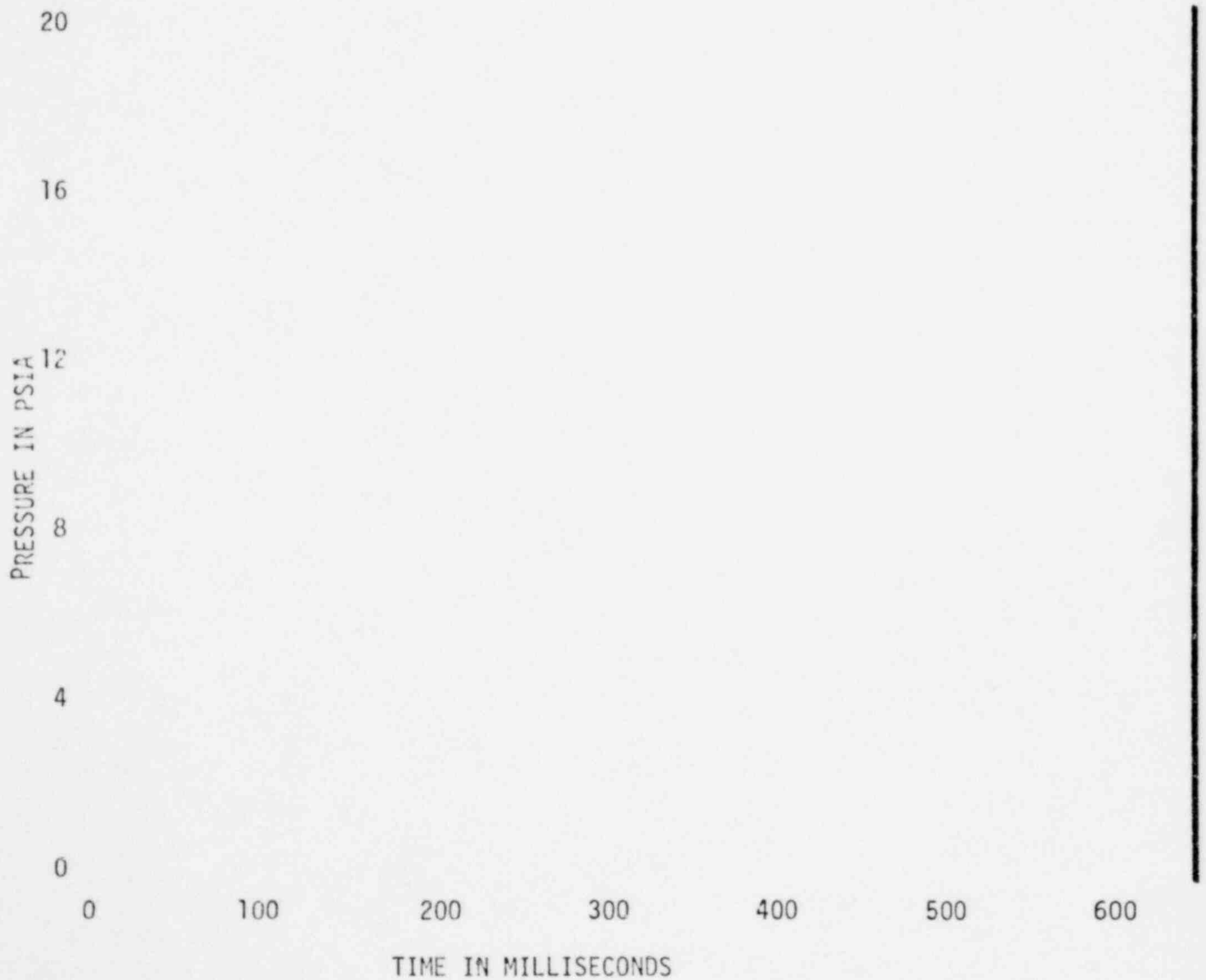


1348 267

FIGURE A-114

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Fermi 2 Test 7



1348 268

FIGURE A-115

WETWELL PRESSURES

Task 5.5.3-2 Fermi 2 Test 7

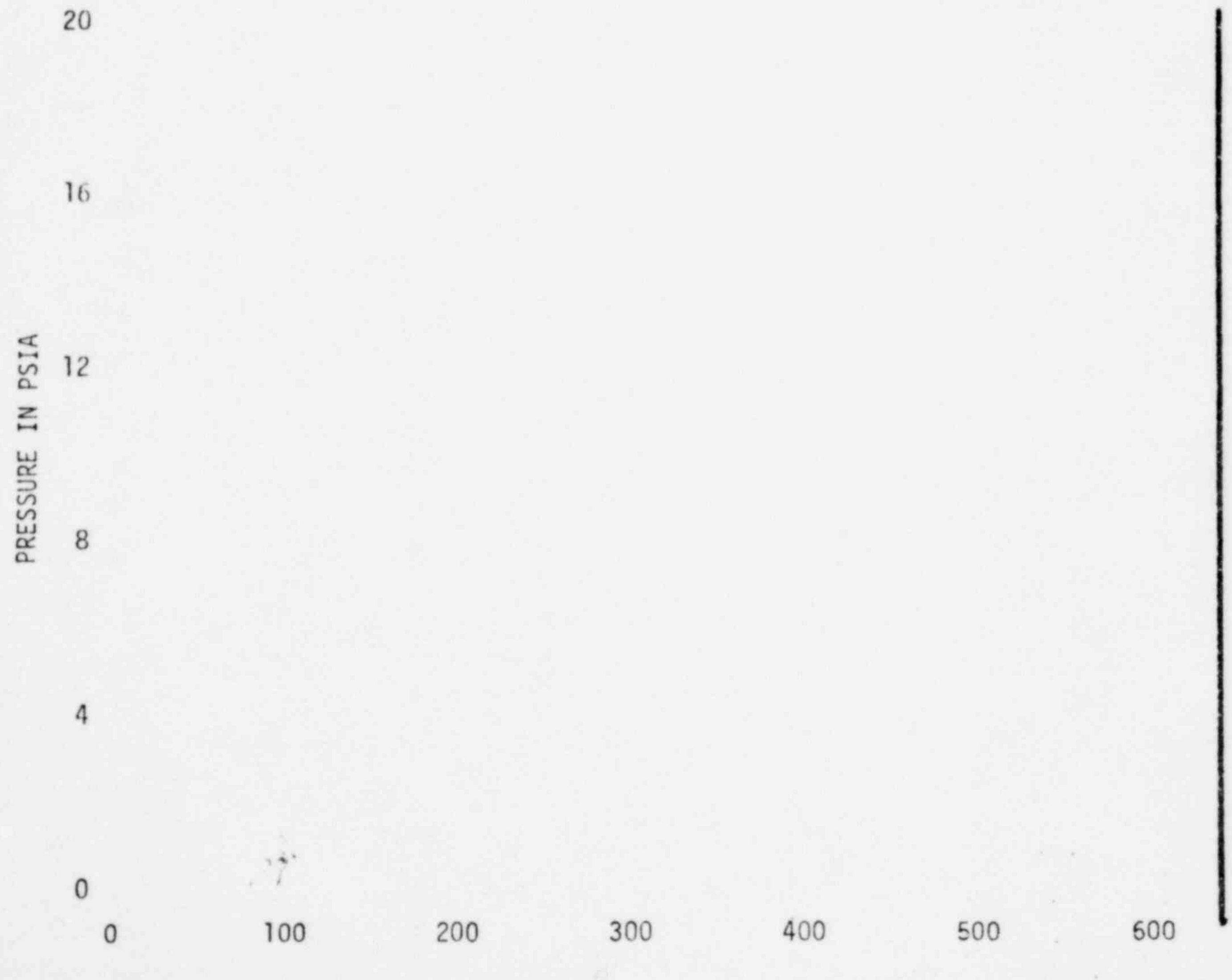
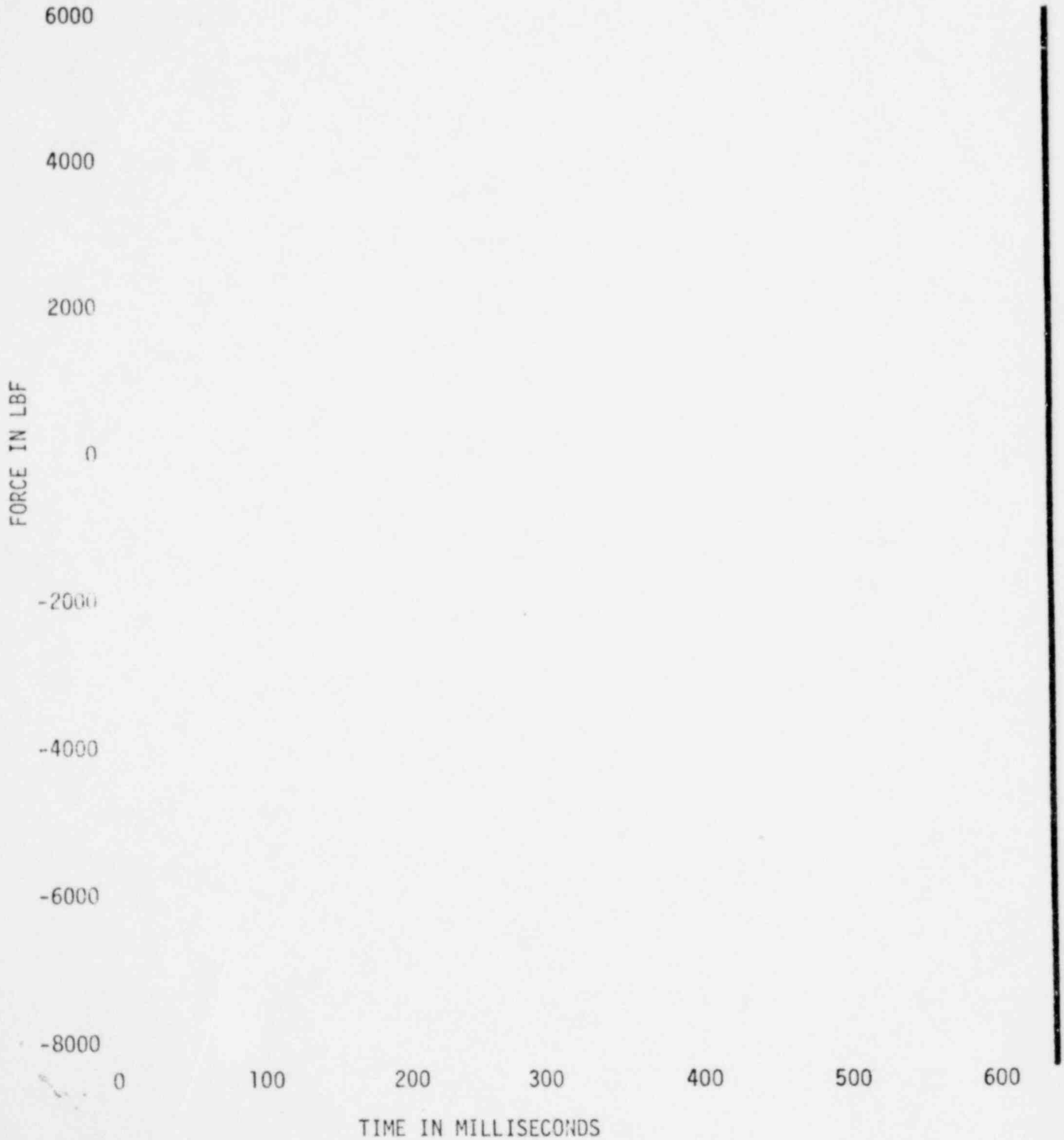


FIGURE A-116

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Fermi 2 Test 3

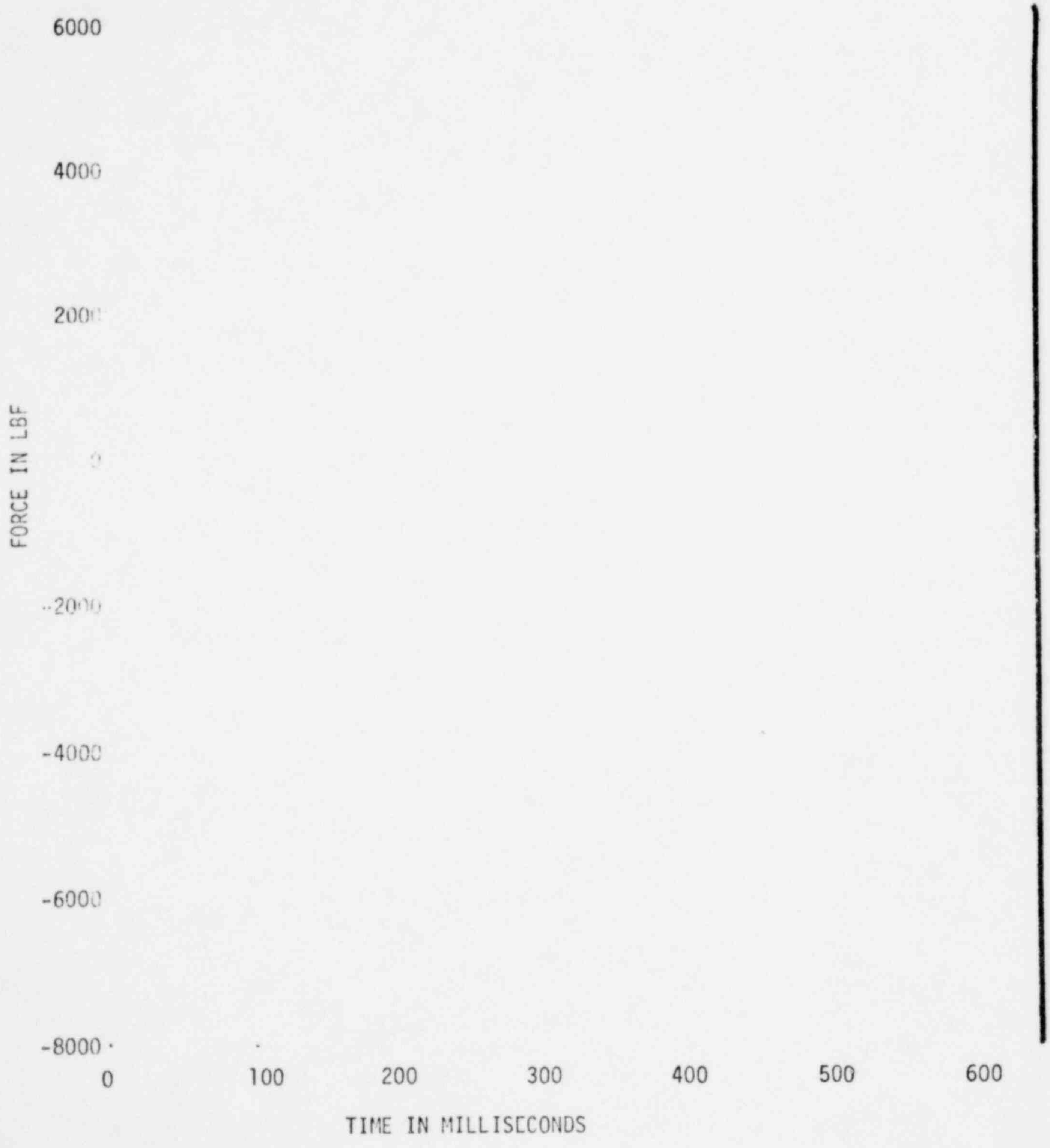


1348 270

FIGURE A-117

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Fermi 2 Test 7



1348 271

FIGURE A-118

TORUS LOAD CELL

Task 5.5.3-2 Fermi 2 Test 3

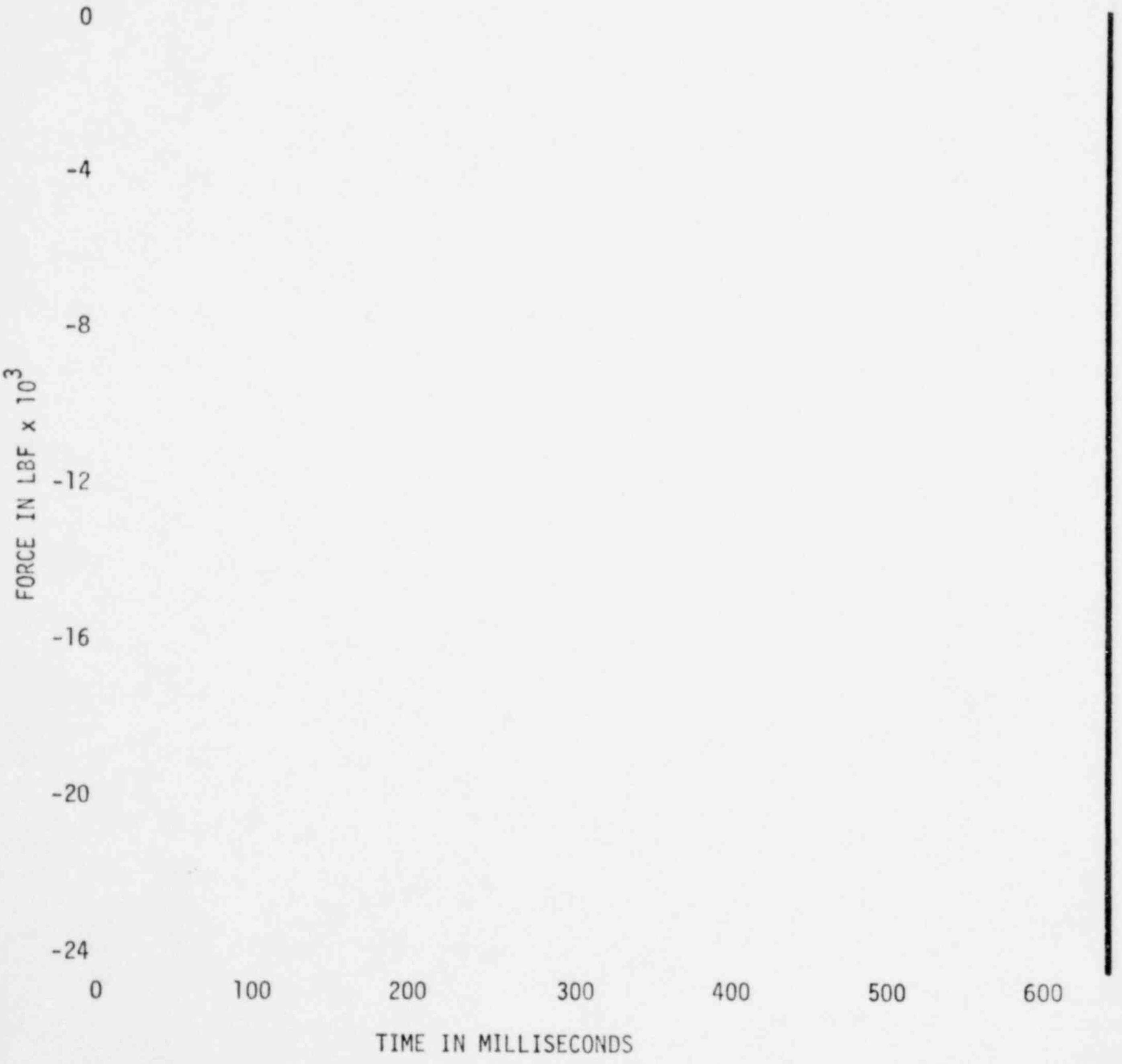


FIGURE A-119

TORUS VERTICAL ACCELERATION

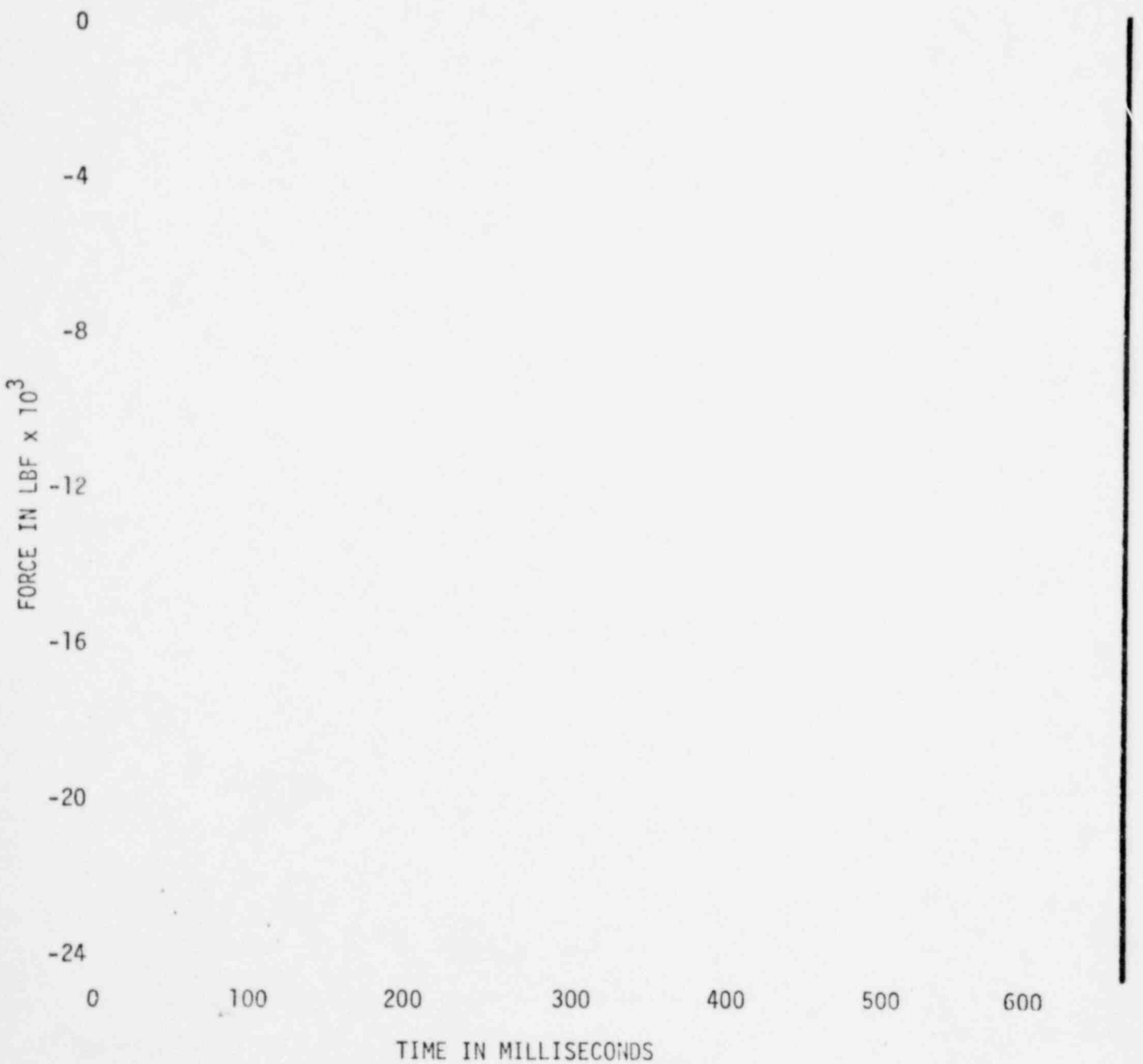
Task 5.5.3-2 Fermi 2 Test 3

1348 273

FIGURE A-120

TORUS LOAD CELL

Task 5.5.3-2 Fermi 2 Test 7

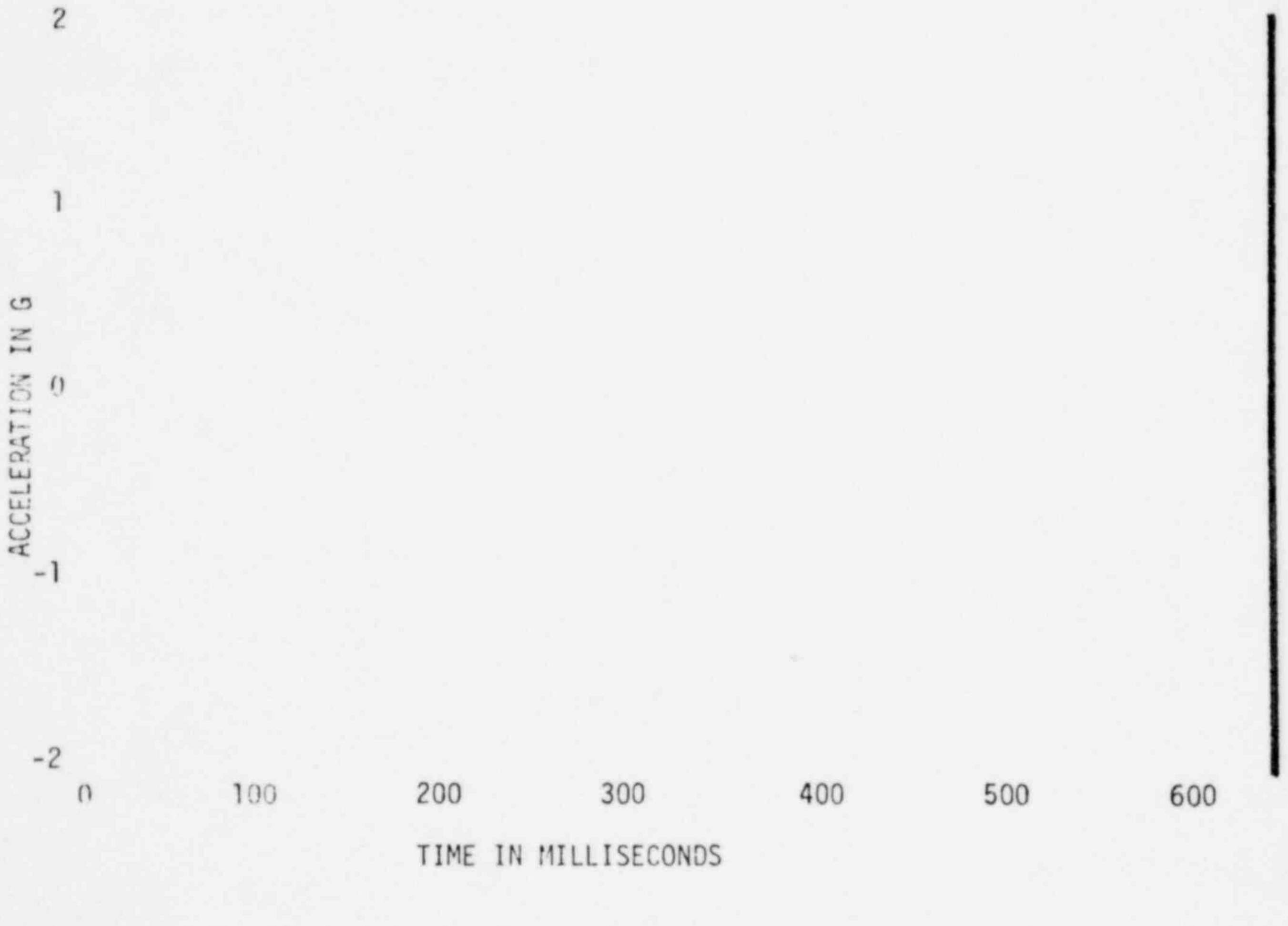


1348 274

FIGURE A-121

TORUS VERTICAL ACCELERATION

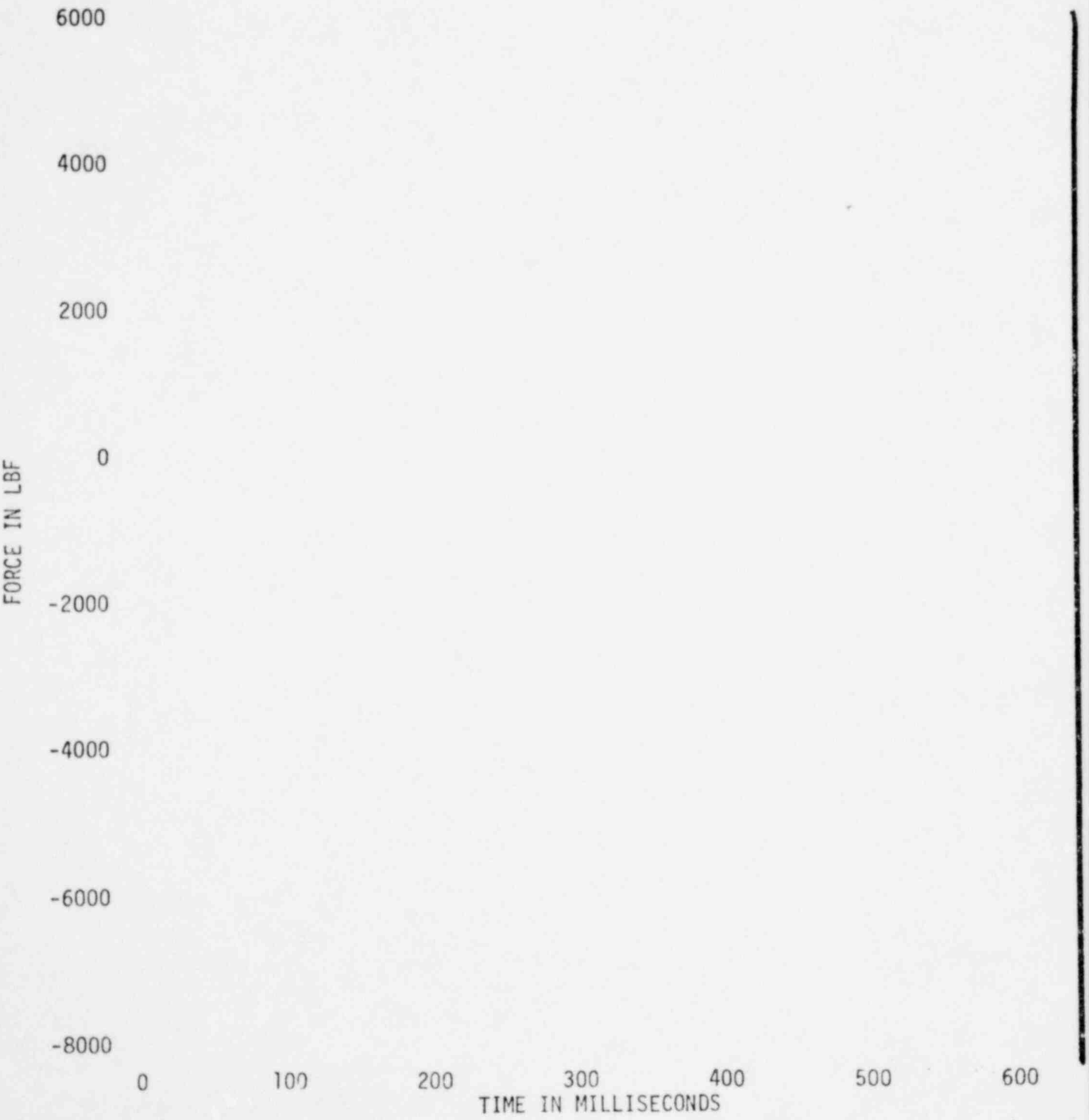
Task 5.5.3-2 Fermi 2 Test 7



1348 275

FIGURE A-122 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

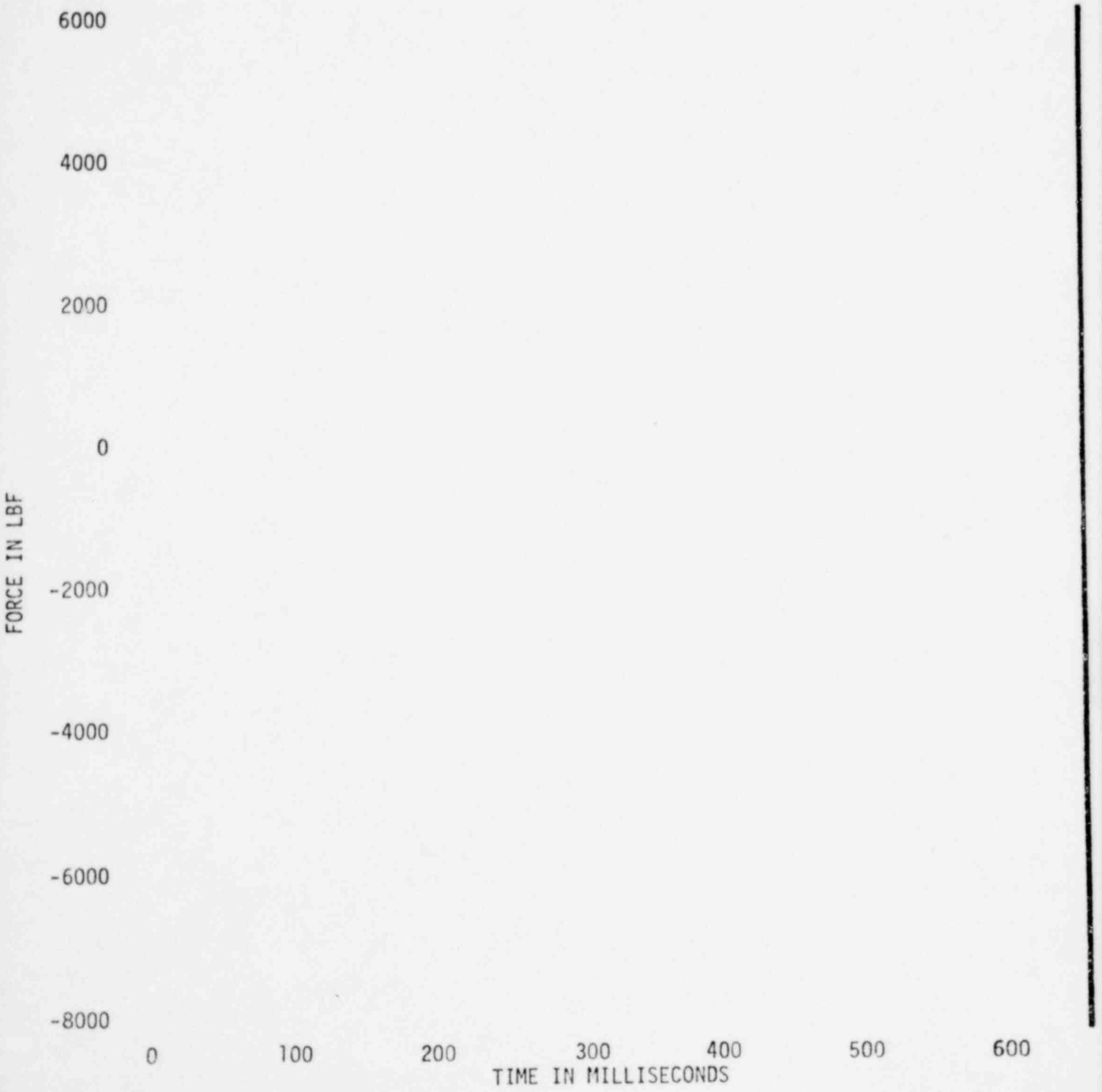
Task 5.5.3-2 Fermi Test 3



1348 276

FIGURE A-123 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Fermi Test 7

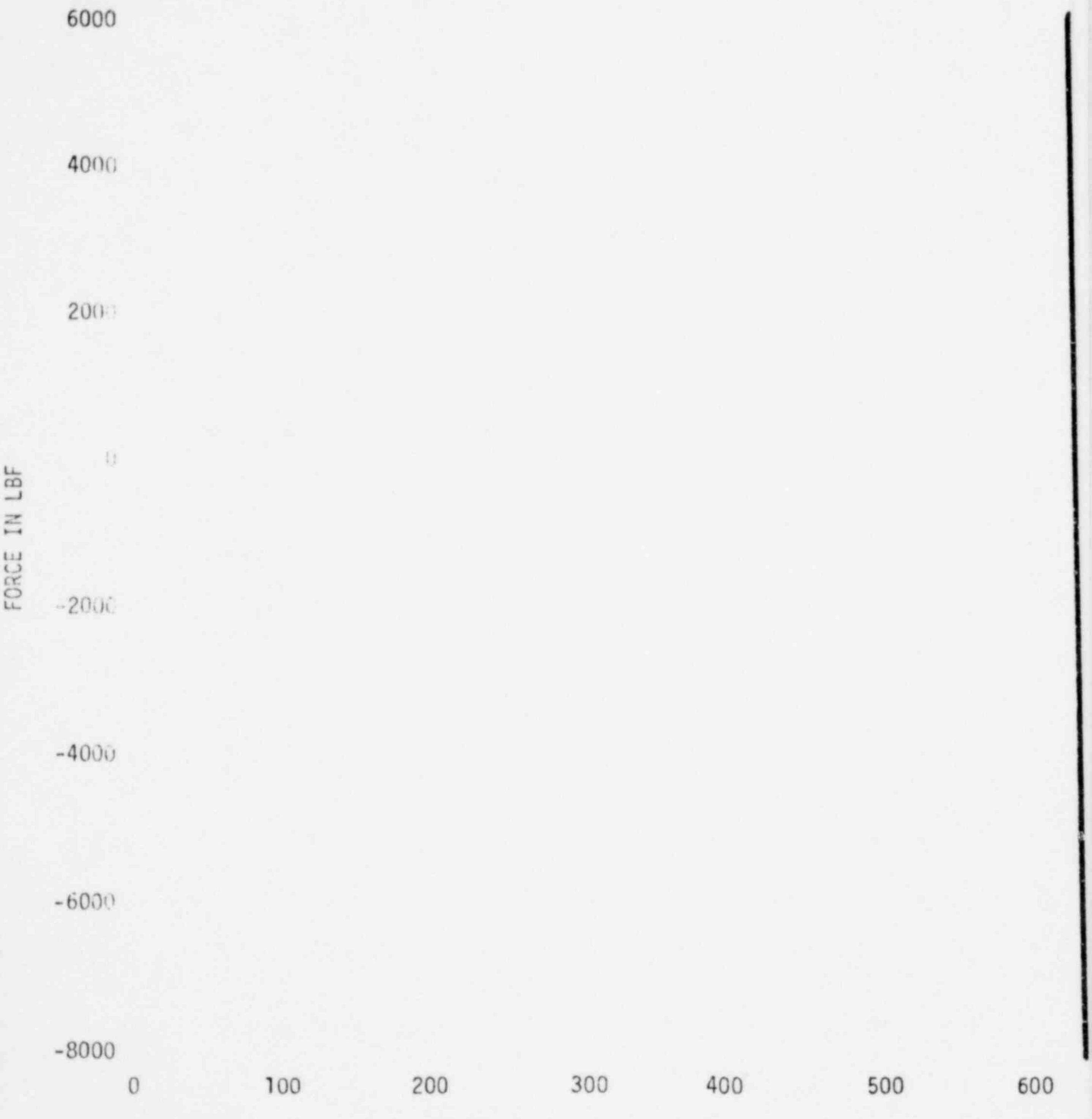


1348 277

FIGURE A-124

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTION FOR WATER INERTIA

Task 5.5.3-2 Fermi 2 Test 3

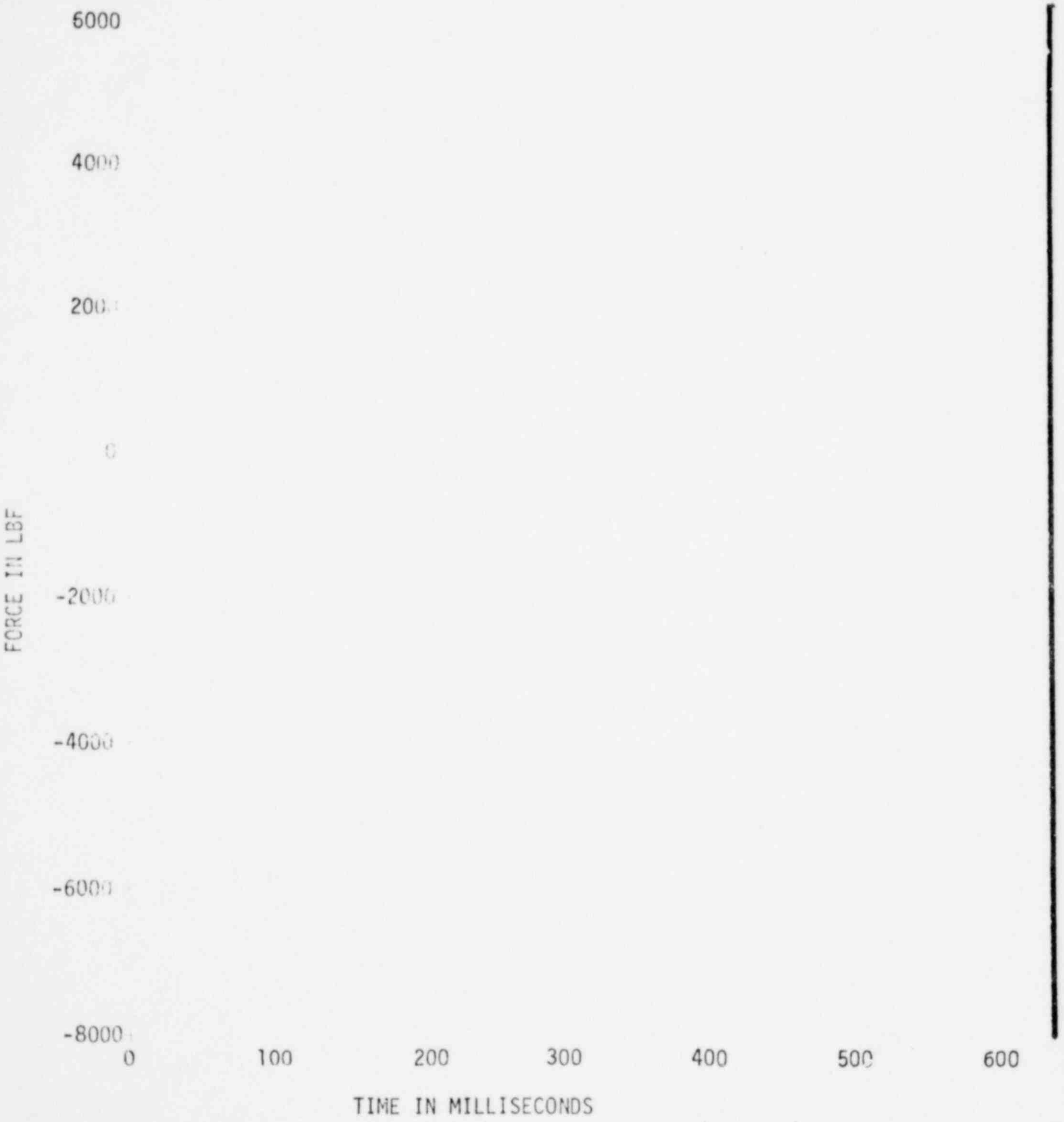


1348 278

FIGURE A-125

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Fermi 2 Test 7



1348 279

FIGURE A-126

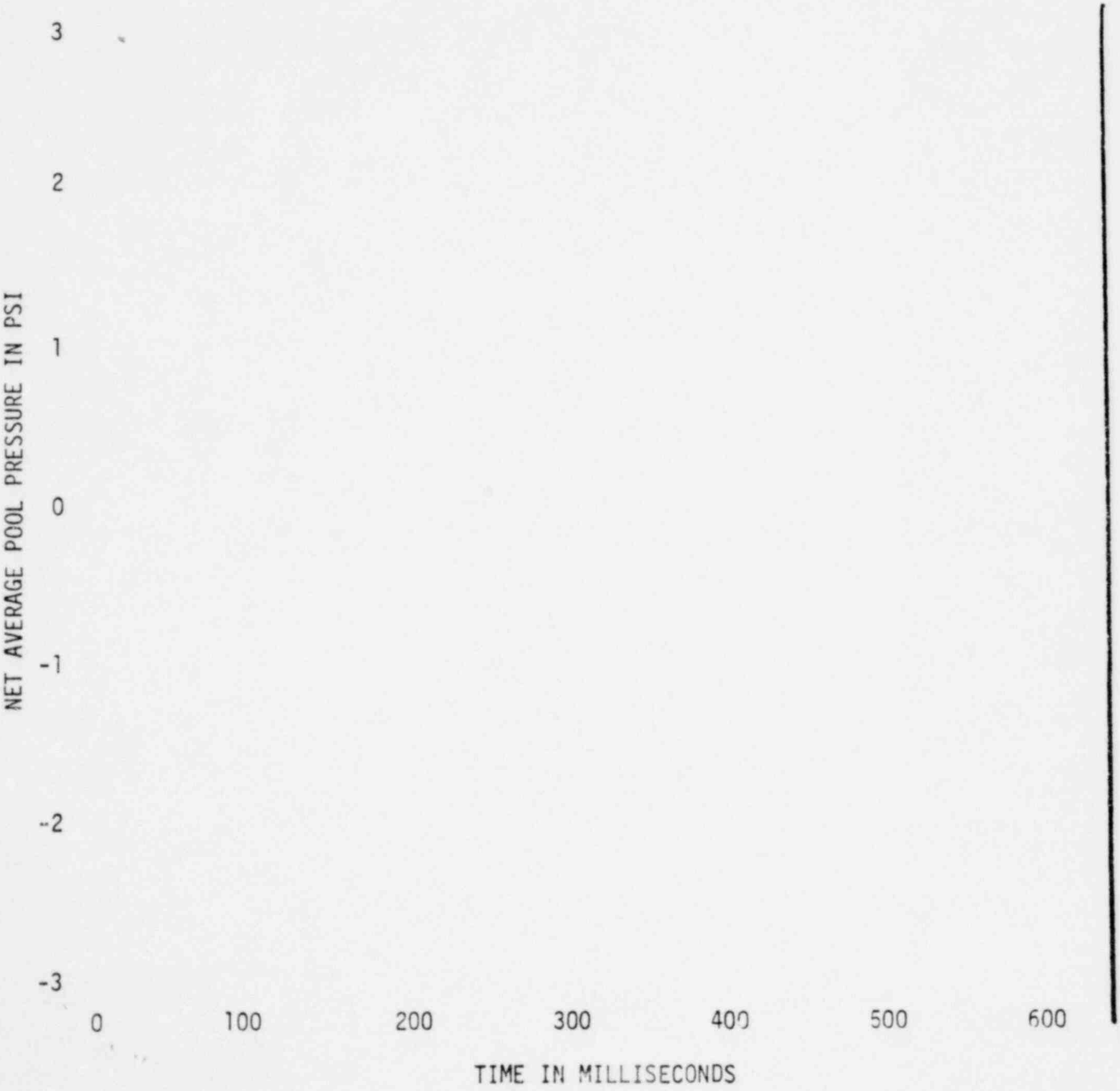
AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Fermi 2 Test 3

FIGURE A-127

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Fermi 2 Test 3



1348 281

FIGURE A-128

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

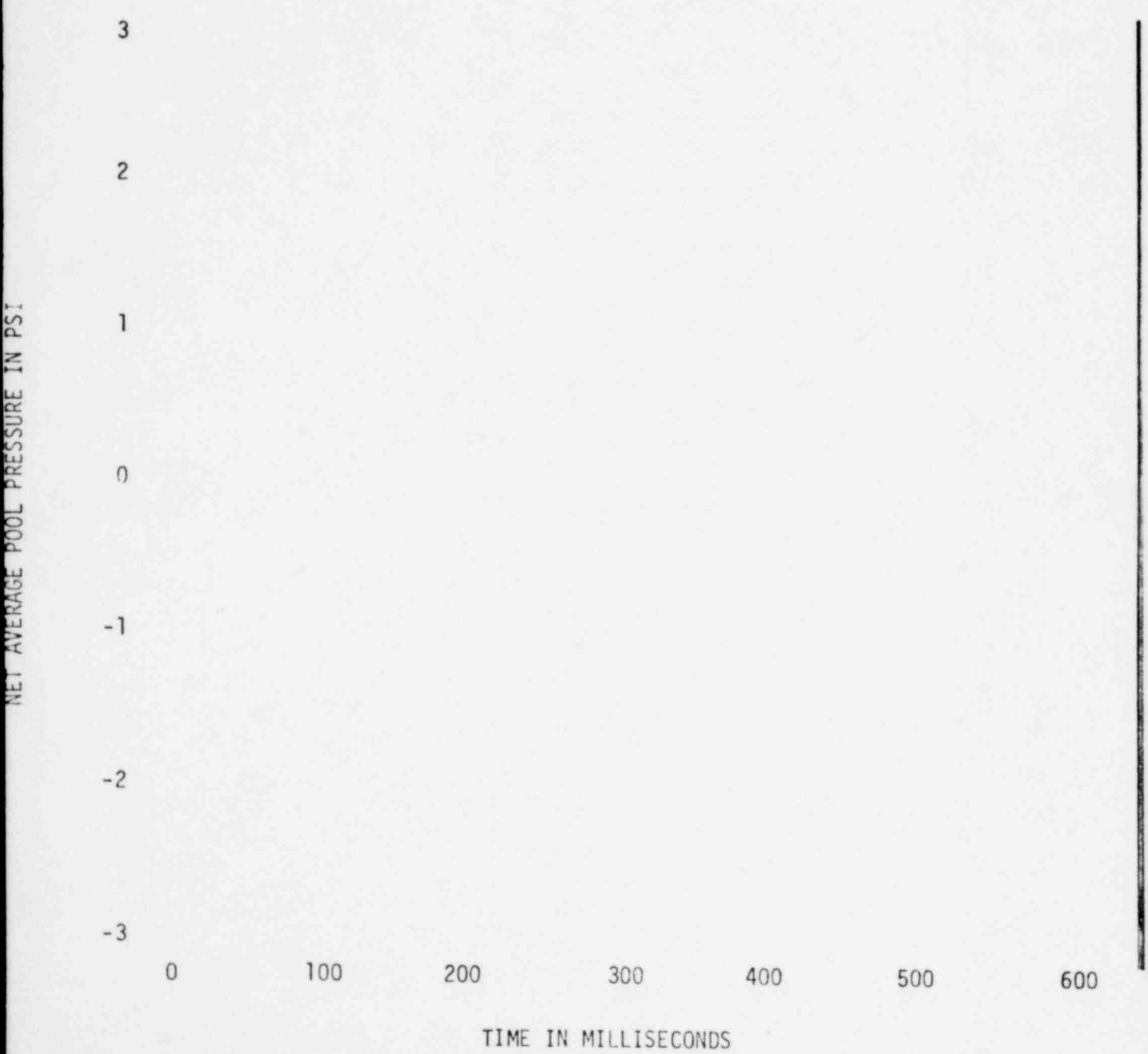
Task 5.5.3-2 Fermi 2 Test 7

1348 282

FIGURE A-129

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

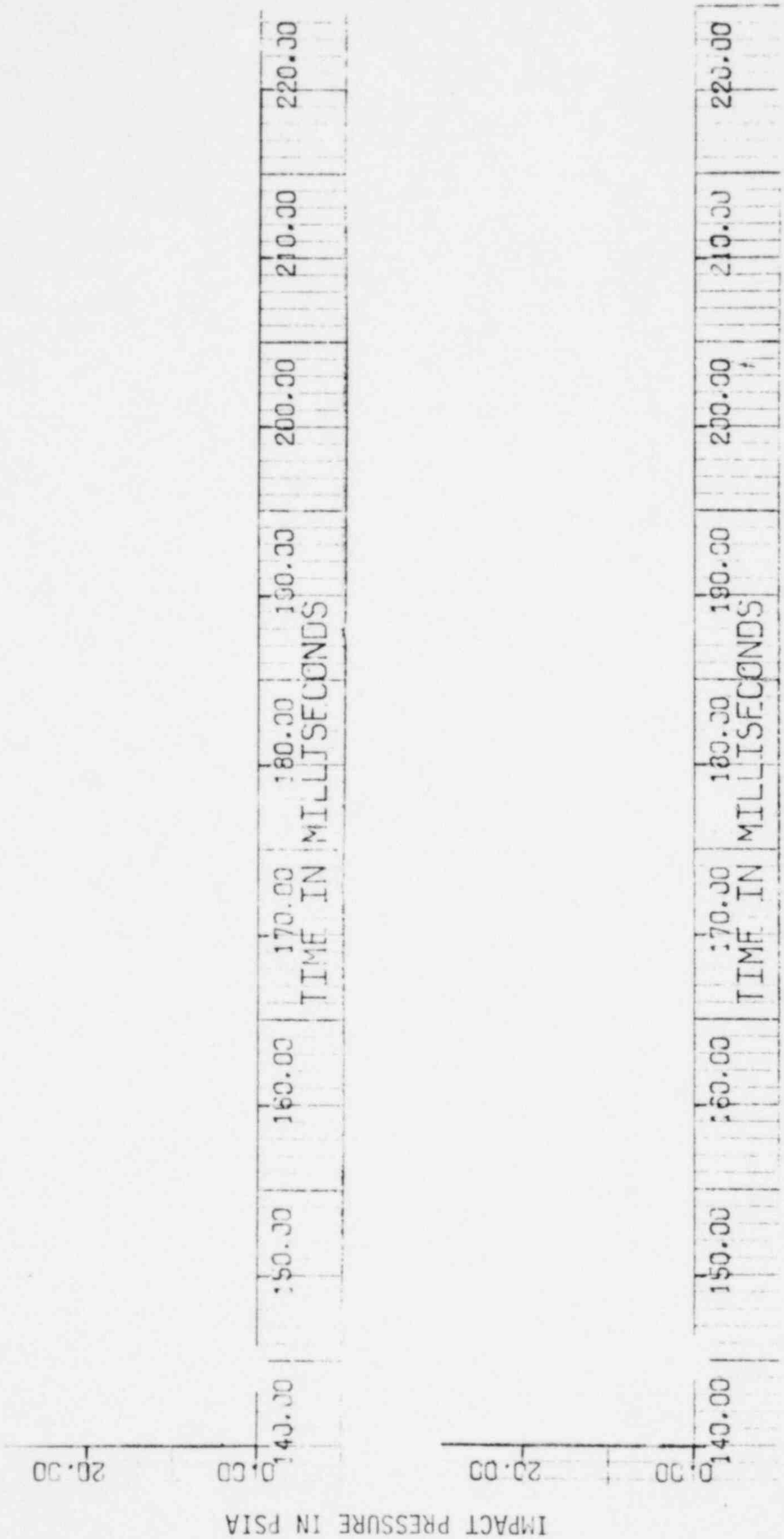
Task 5.5.3-2 Fermi 2 Test 7



1348 283

FIGURE A-130 VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Fermi 2 Test 3



1348 284

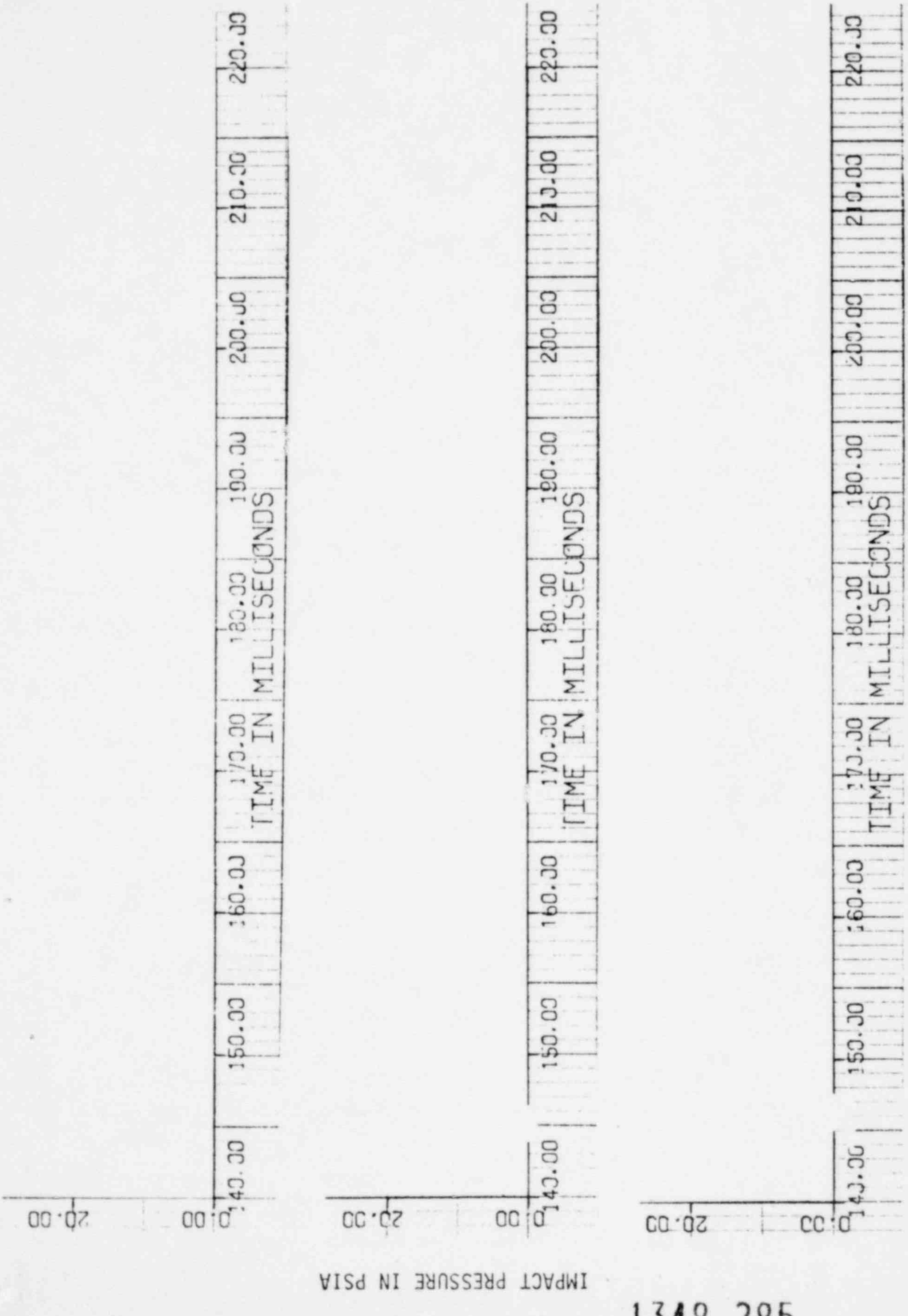
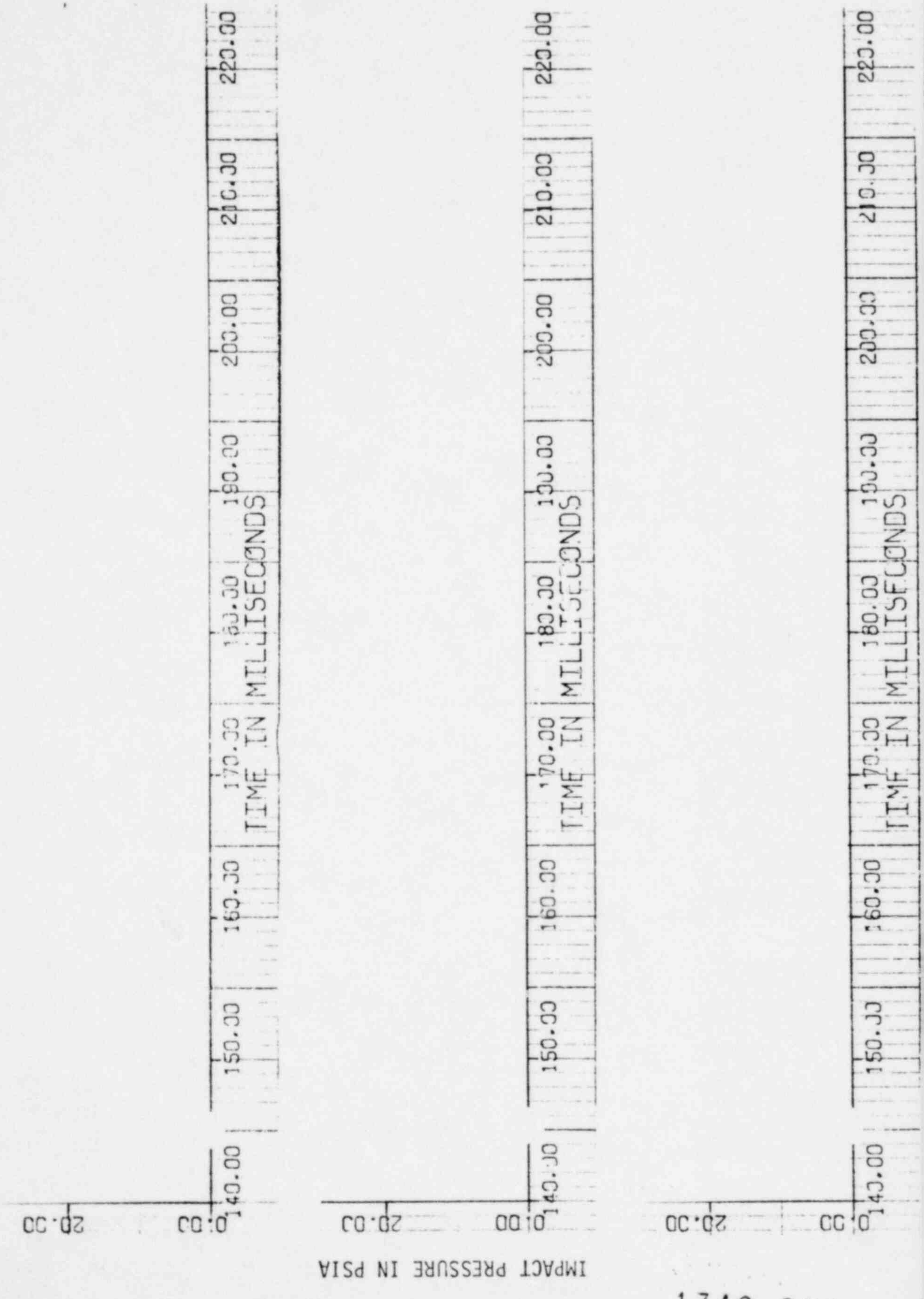


FIGURE A-131 VENT HEADER IMPACT PRESSURES
Task 5.5.3-2 Fermi 2 Test 3

1348 285

FIGURE A-132 VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Fermi 2 Test 3



1348 286

FIGURE A-133

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Fermi 2 Test 3

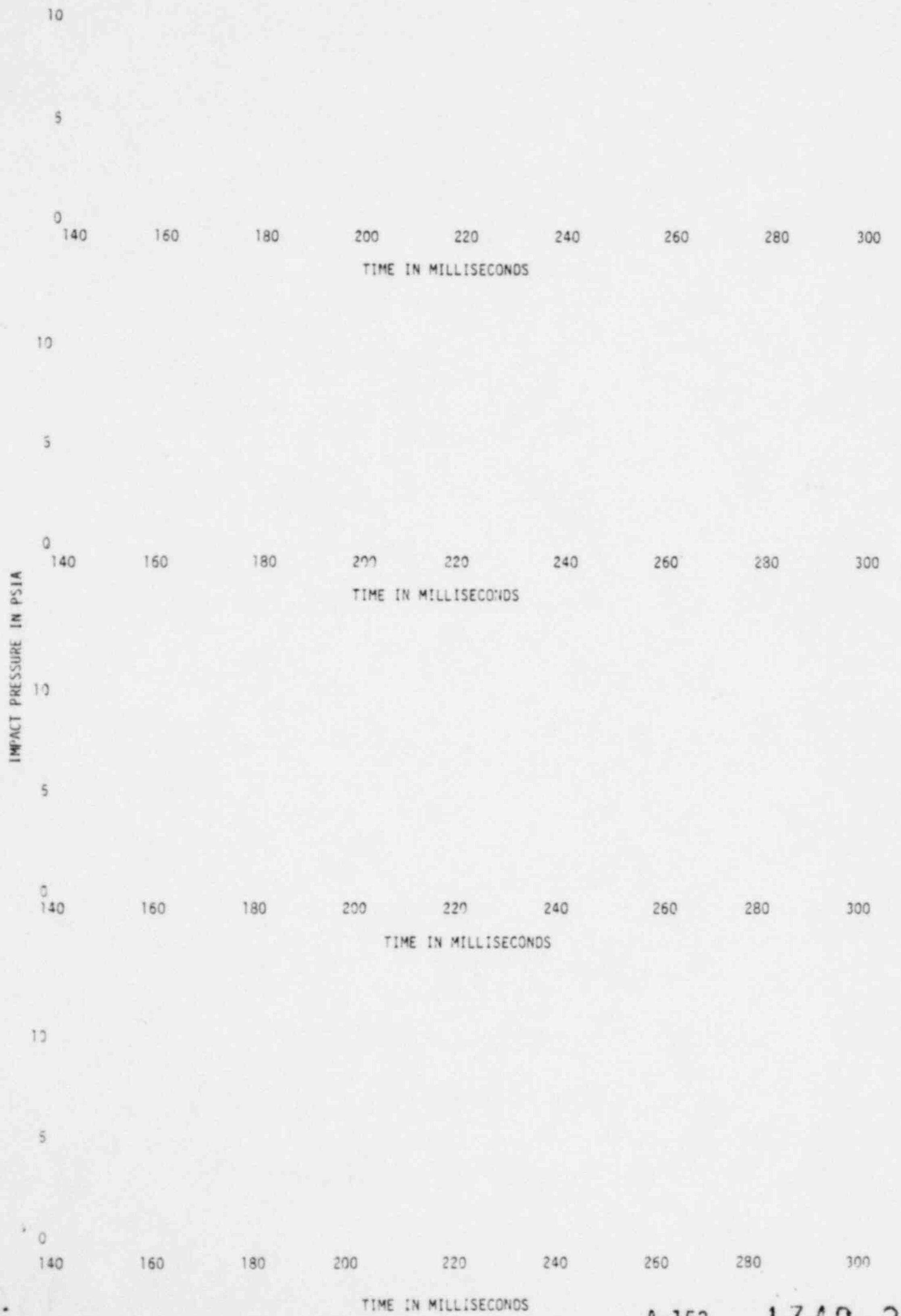


FIGURE A-134

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Fermi 2 Test 3

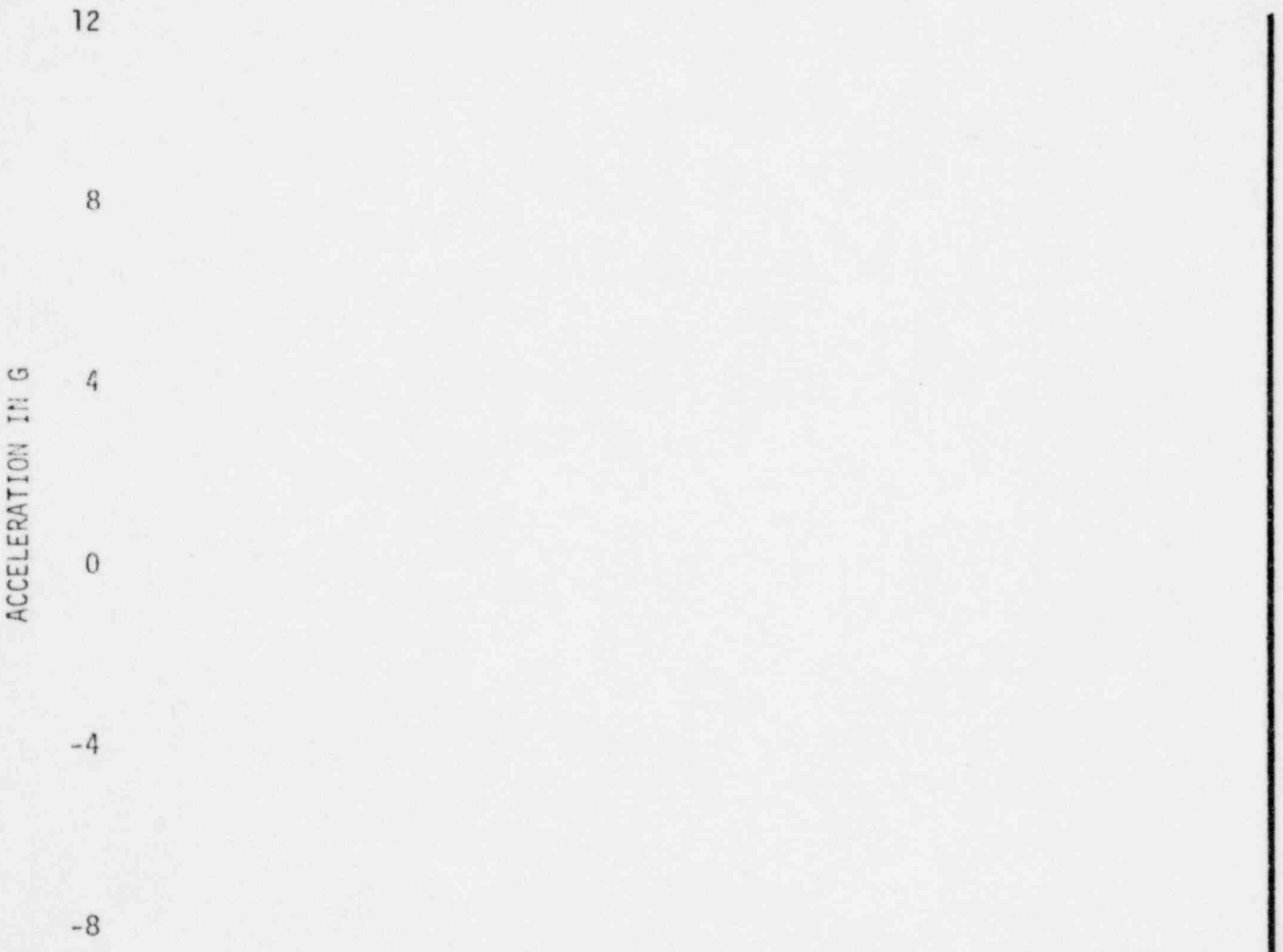
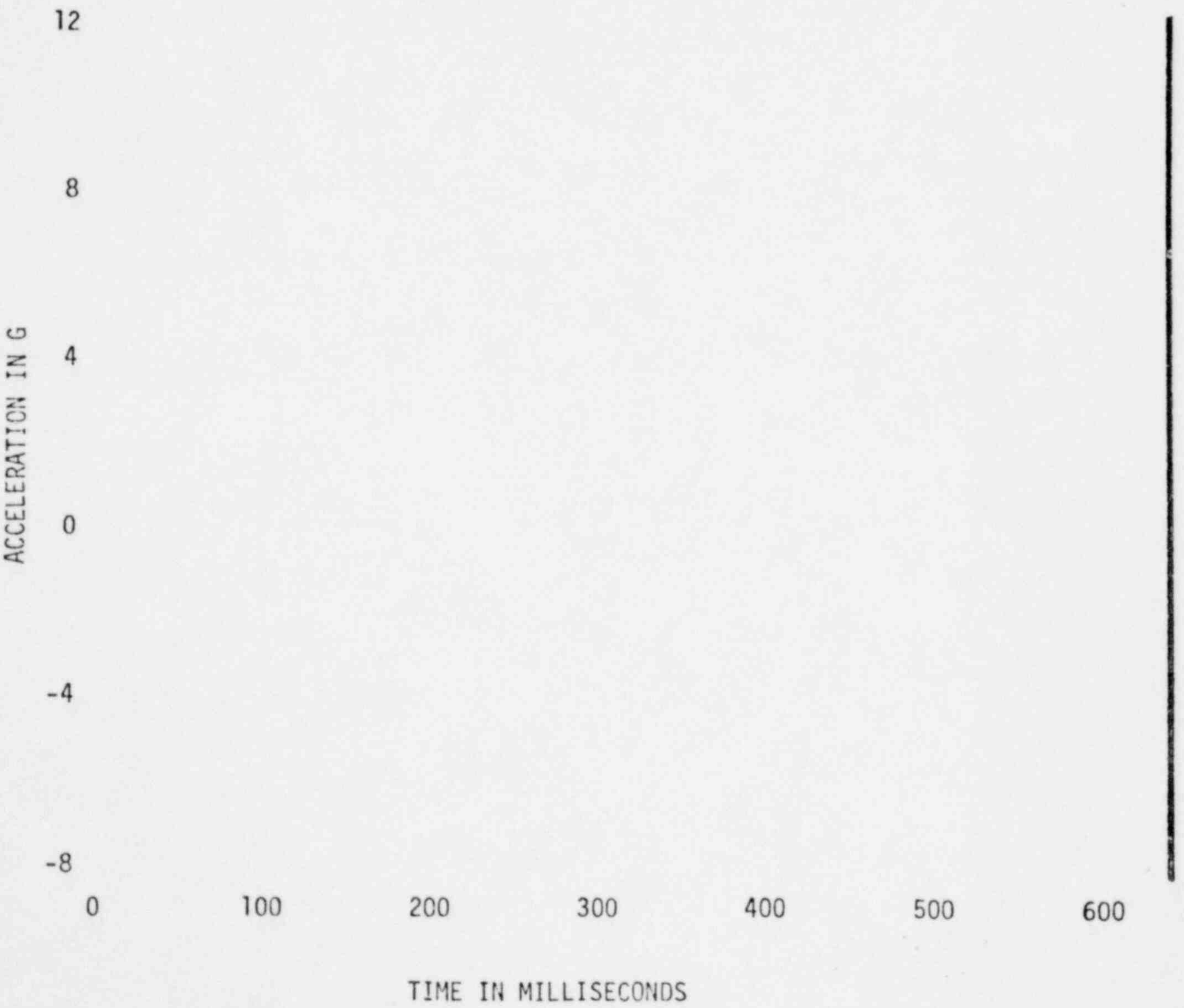


FIGURE A-135

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Fermi 2 Test 7



1348 289

FIGURE A-136

TIME HISTORY OF
POOL DISPLACEMENT

FERMI 2, TEST 1

Vertical Distance from Original Pool Water Level - inches

30

25

20

15

10

5

0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_0) - seconds

1348 290

FIGURE A-137

TIME HISTORY OF
POOL DISPLACEMENT

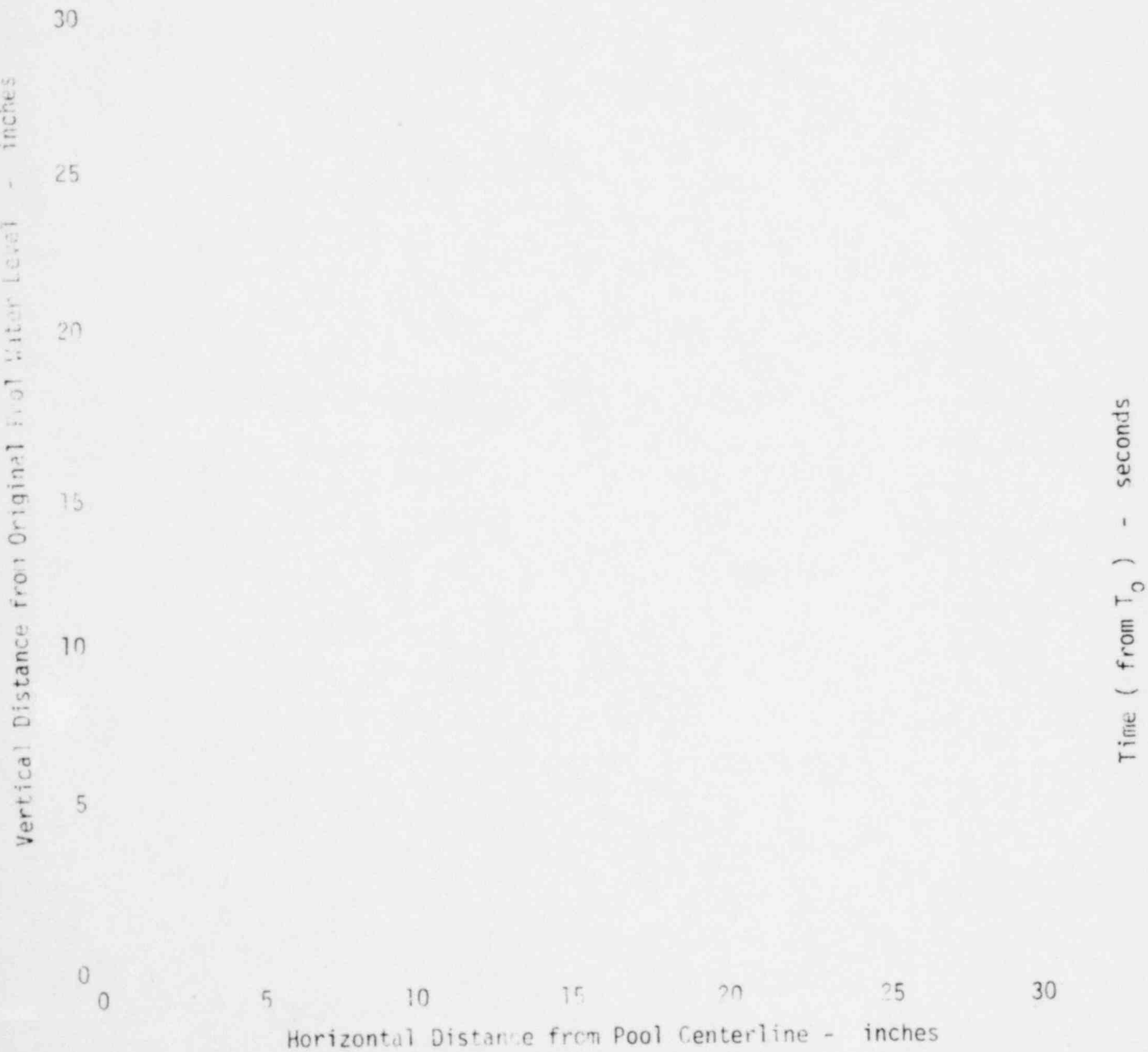
FERMI 2, TEST 2

1348 291

FIGURE A-138

TIME HISTORY OF
POOL DISPLACEMENT

FERMI 2, TEST 3

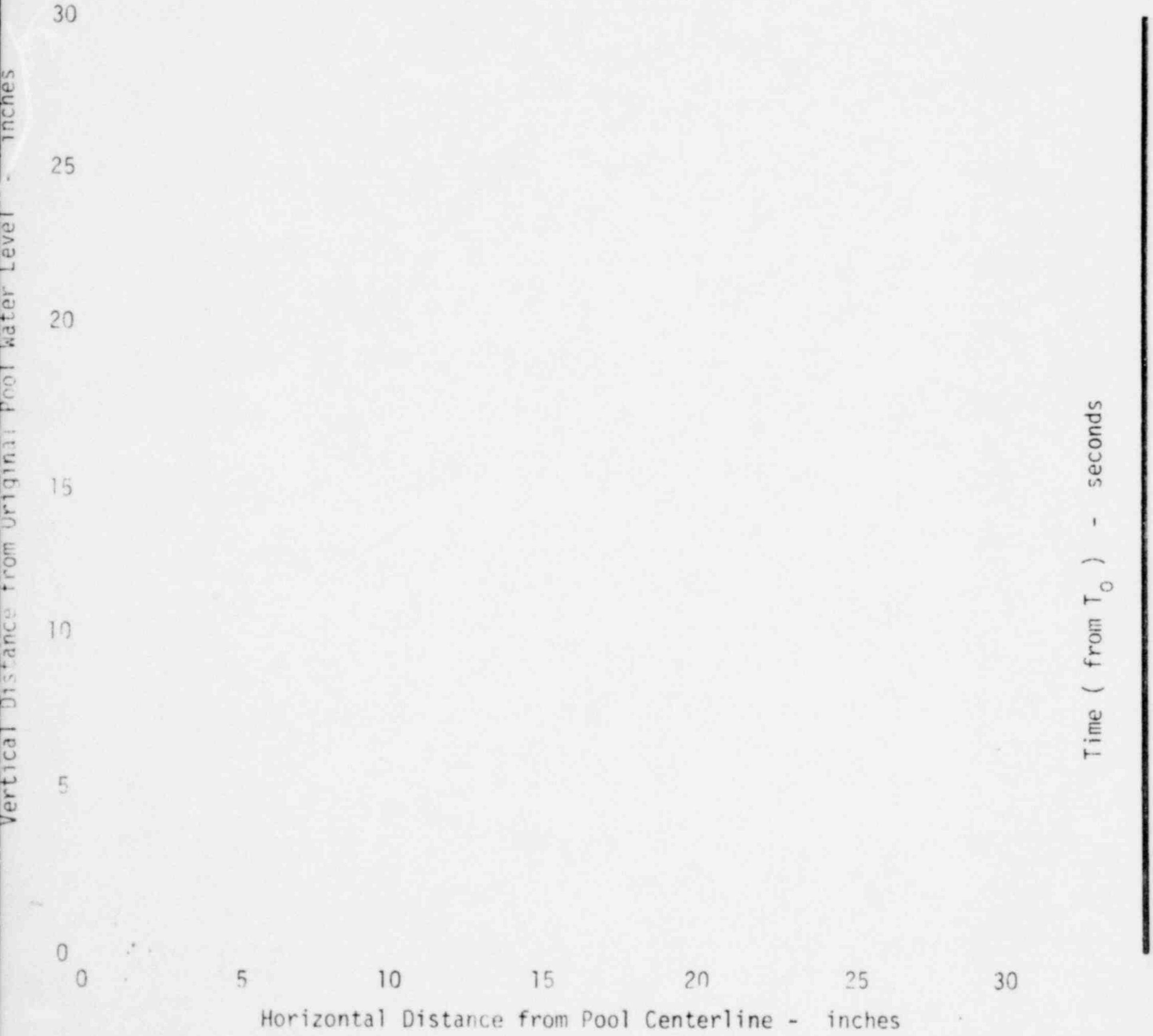


1348 292

FIGURE A-139

TIME HISTORY OF
POOL DISPLACEMENT

FERMI 2, TEST 5



1348 293

FIGURE A-140

POOL SURFACE DISPLACEMENT

FERMI, TESTS 1, 2, 3

1348 294

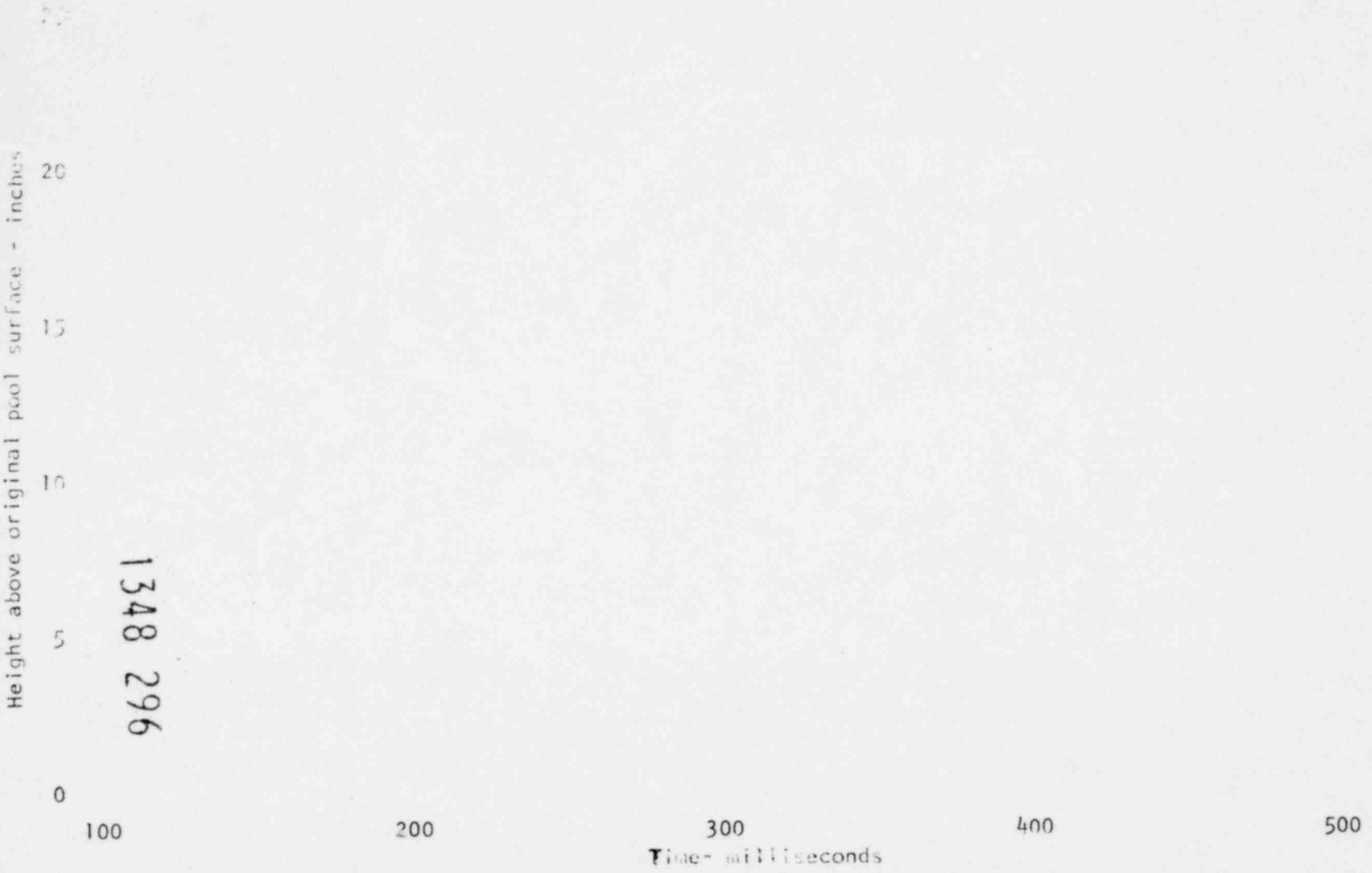
FIGURE A-141 POOL SURFACE VELOCITY PROFILES

FERMI, TESTS 1, 2, 3

1348 295

FIGURE A-142 POOL SURFACE DISPLACEMENT

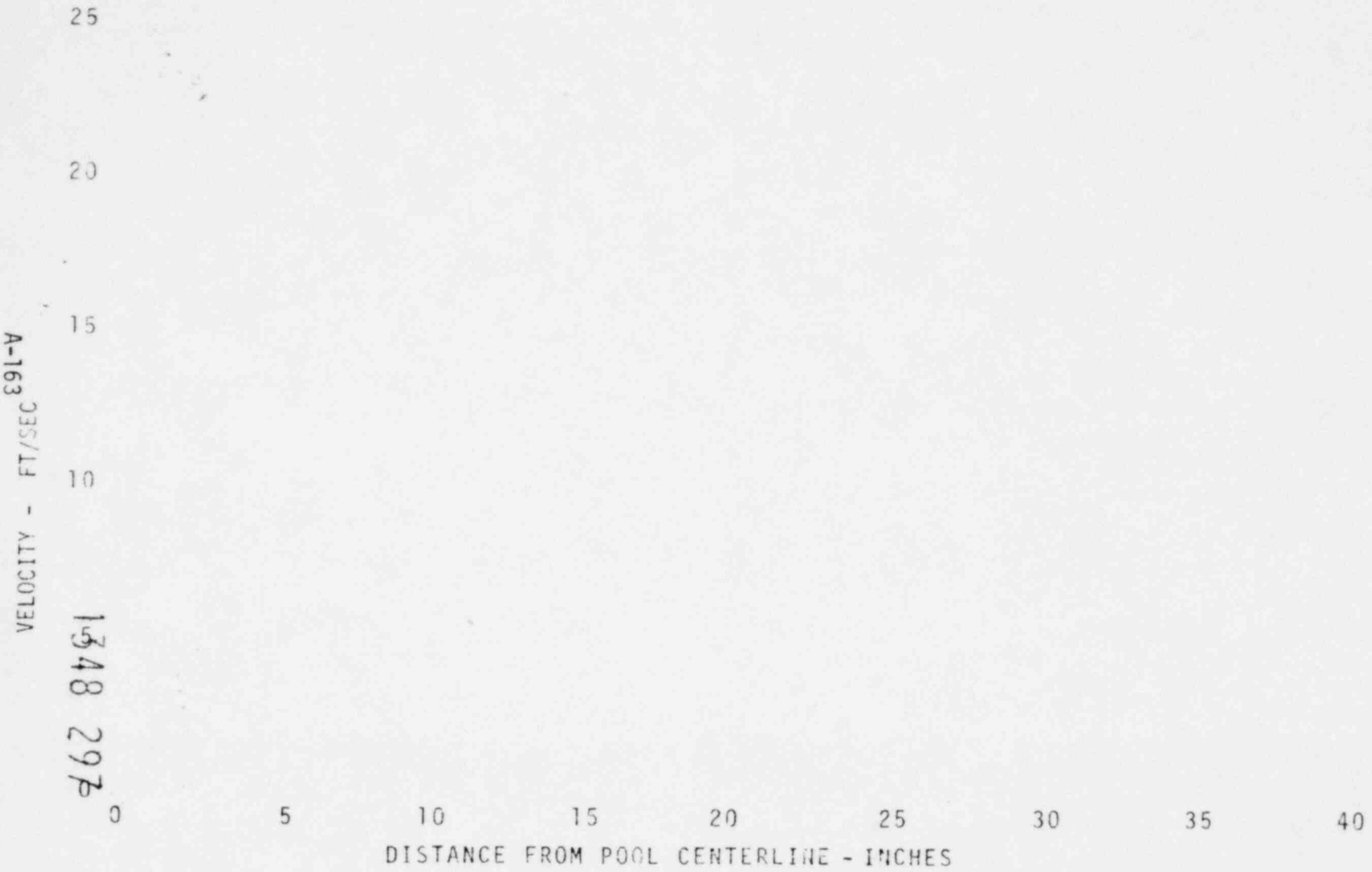
FERMI, TEST 5



1348 296

FIGURE A-143 POOL SURFACE VELOCITY PROFILES

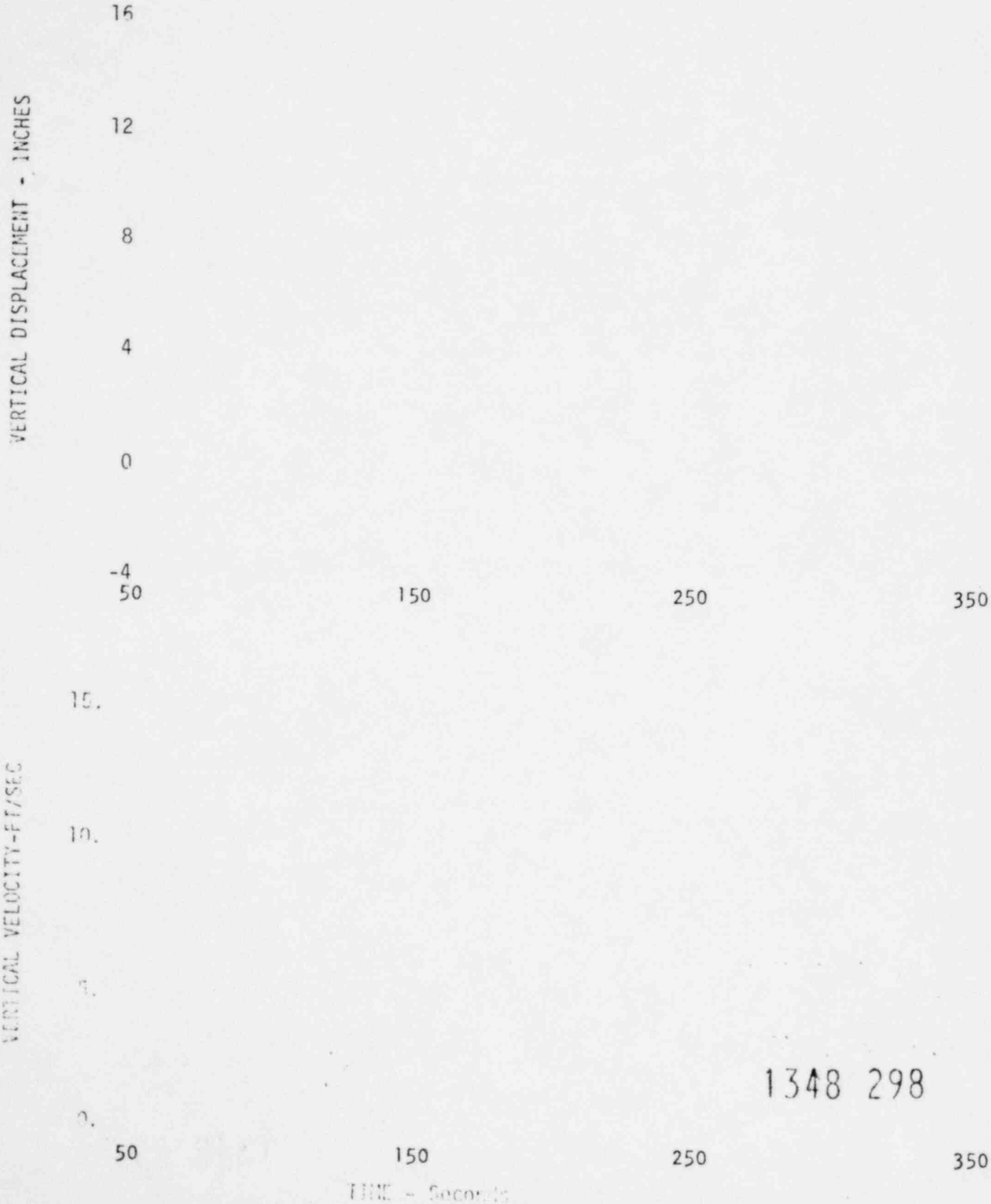
FERMI, TEST 5



1348 297

FIGURE A-144 SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

FERMI, TEST 4

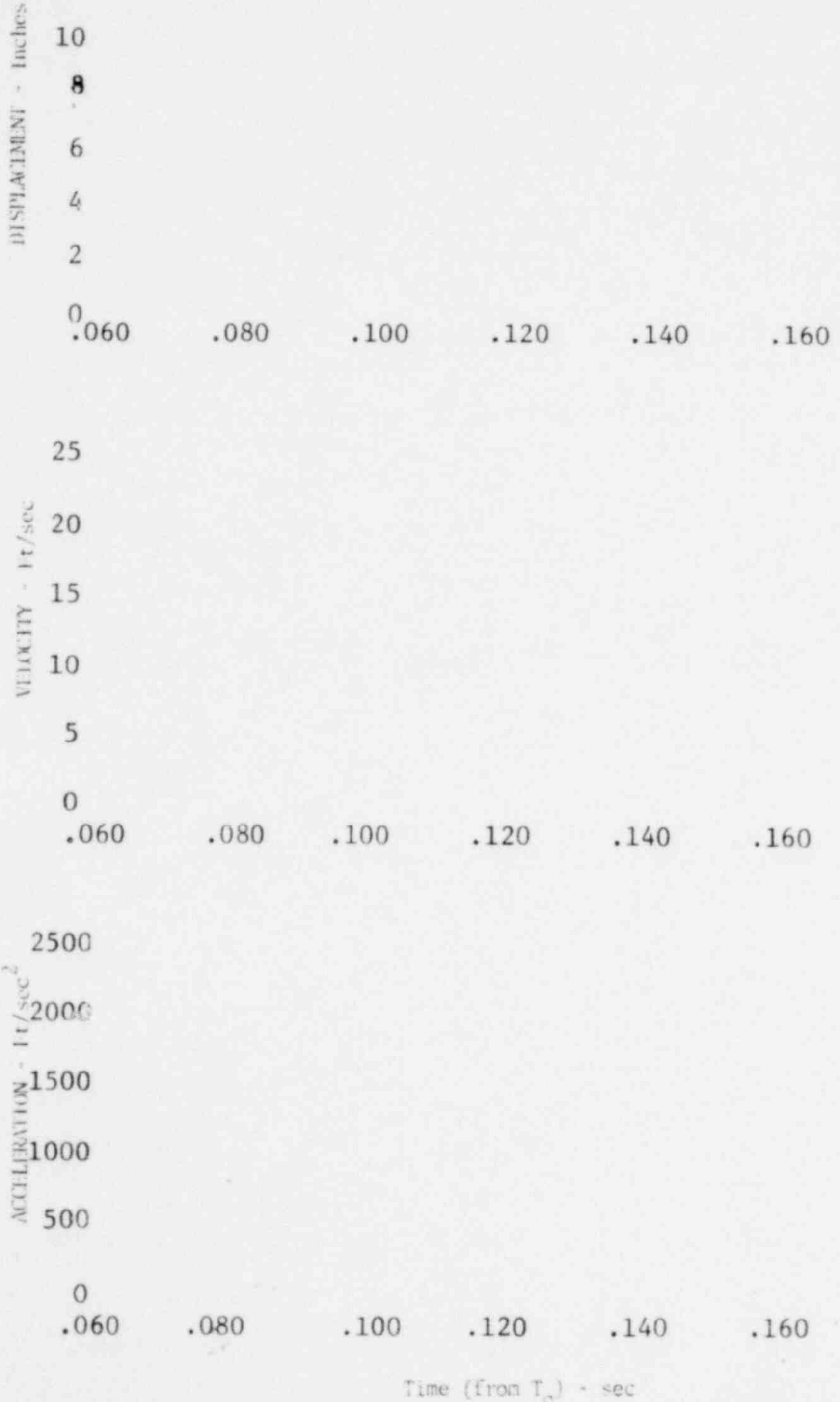


1348 298

FIGURE A-145

DOWNCOMER WATER SLUG EJECTION

FERMI, TEST 3

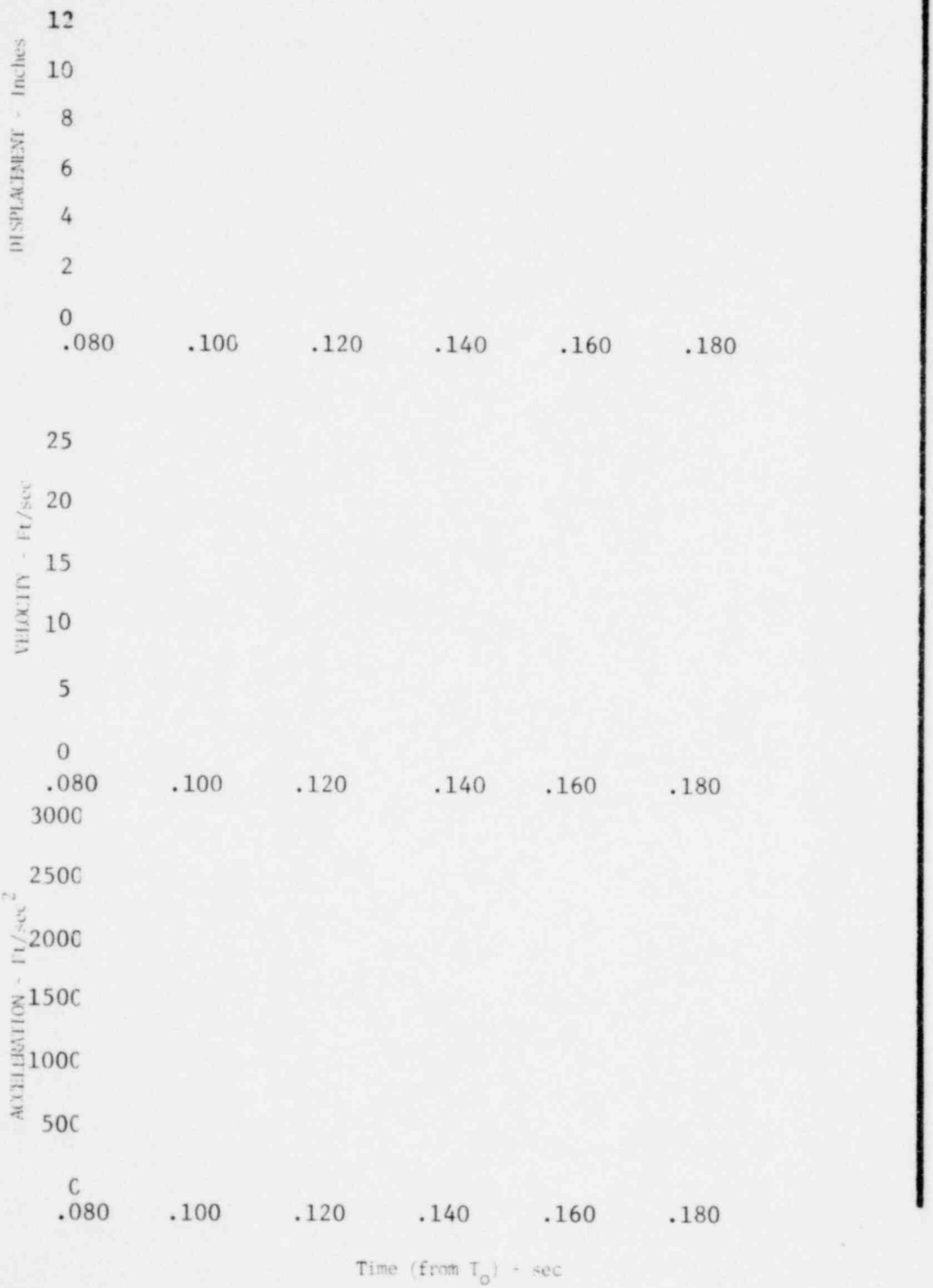


1348 299

FIGURE A-146

DOWNCOMER WATER SLUG EJECTION

FERMI, TEST 7



1348 300

FIGURE A-147

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Fermi 2 Tests

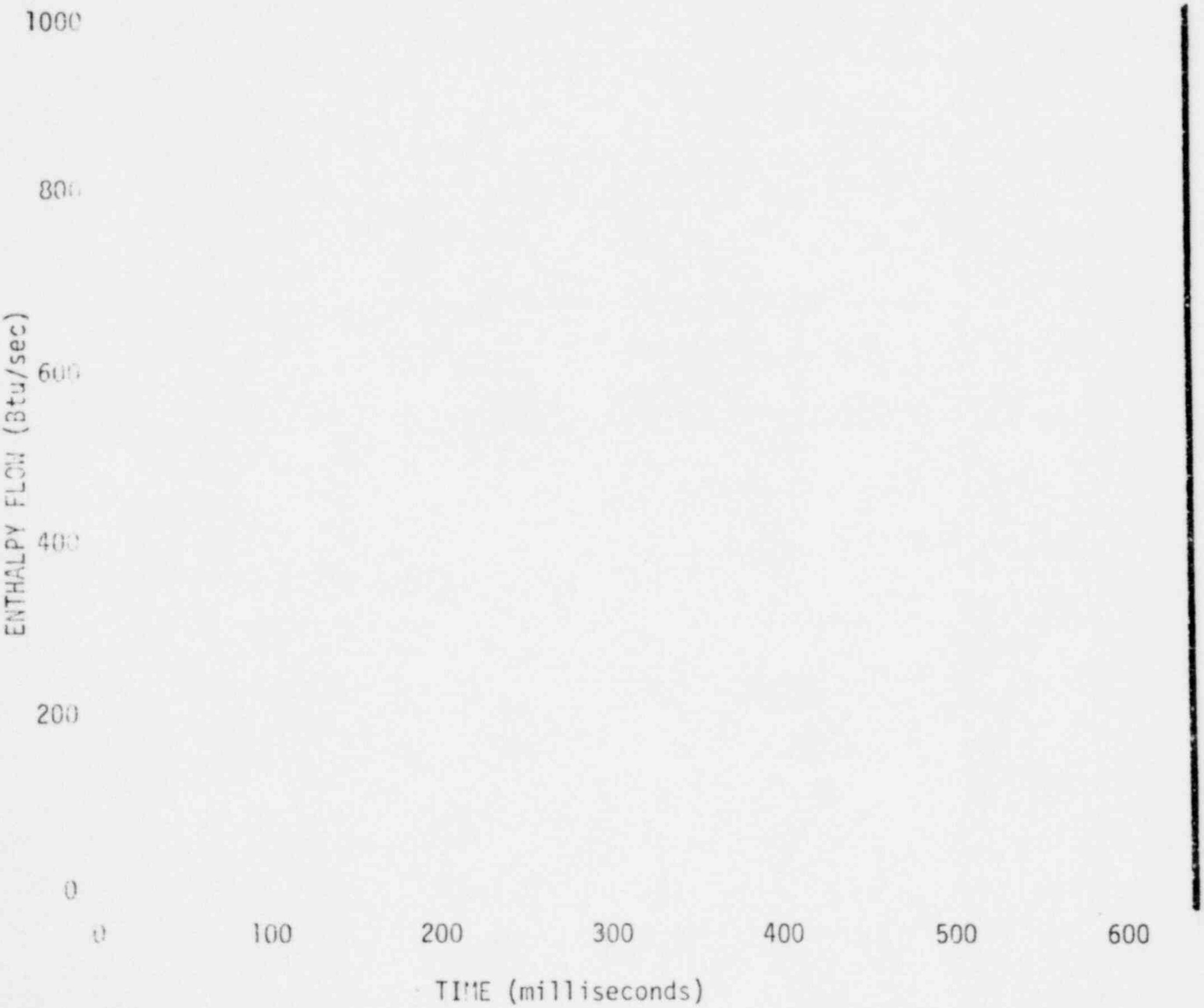
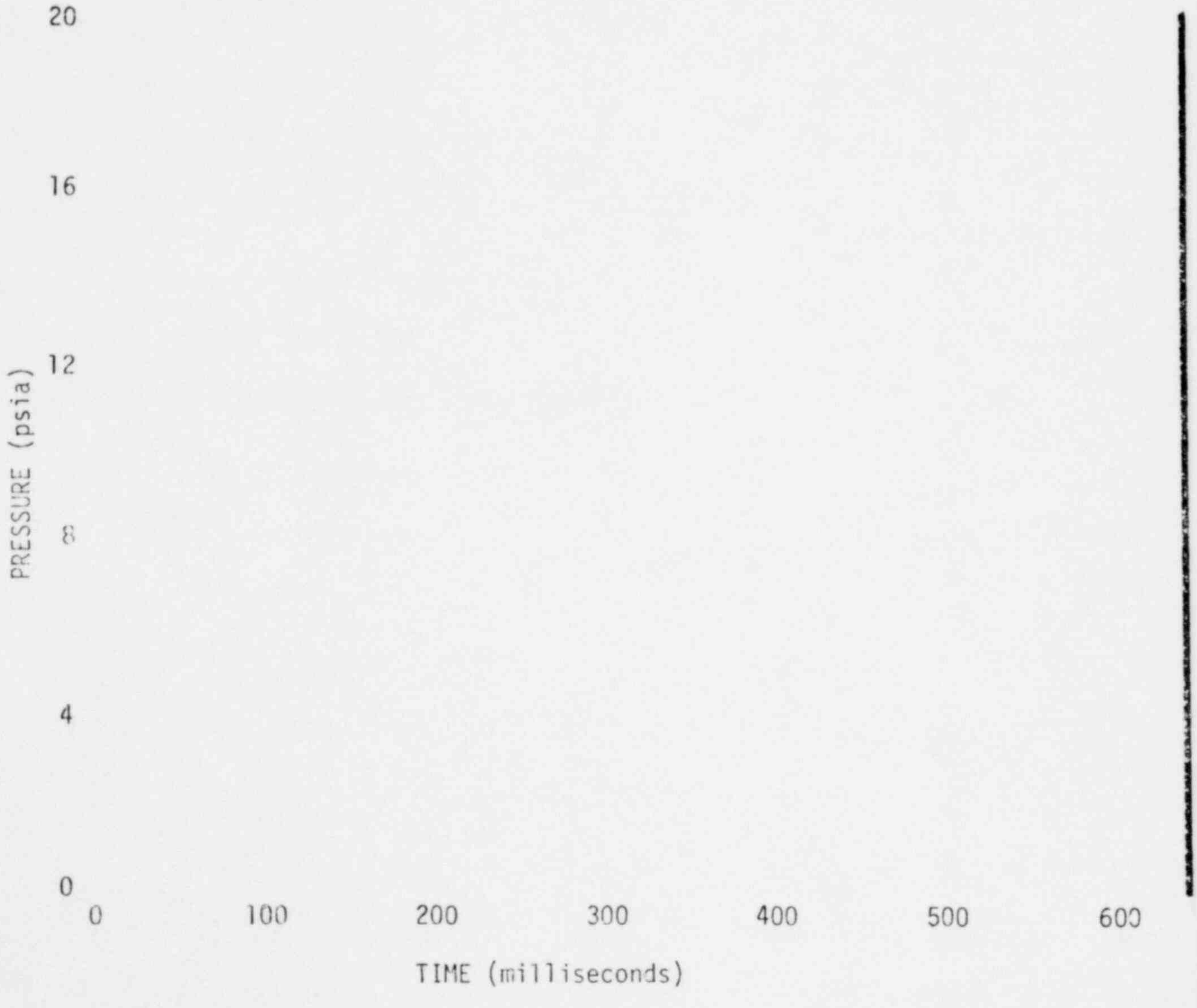


FIGURE A-148

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Fermi 2 Tests



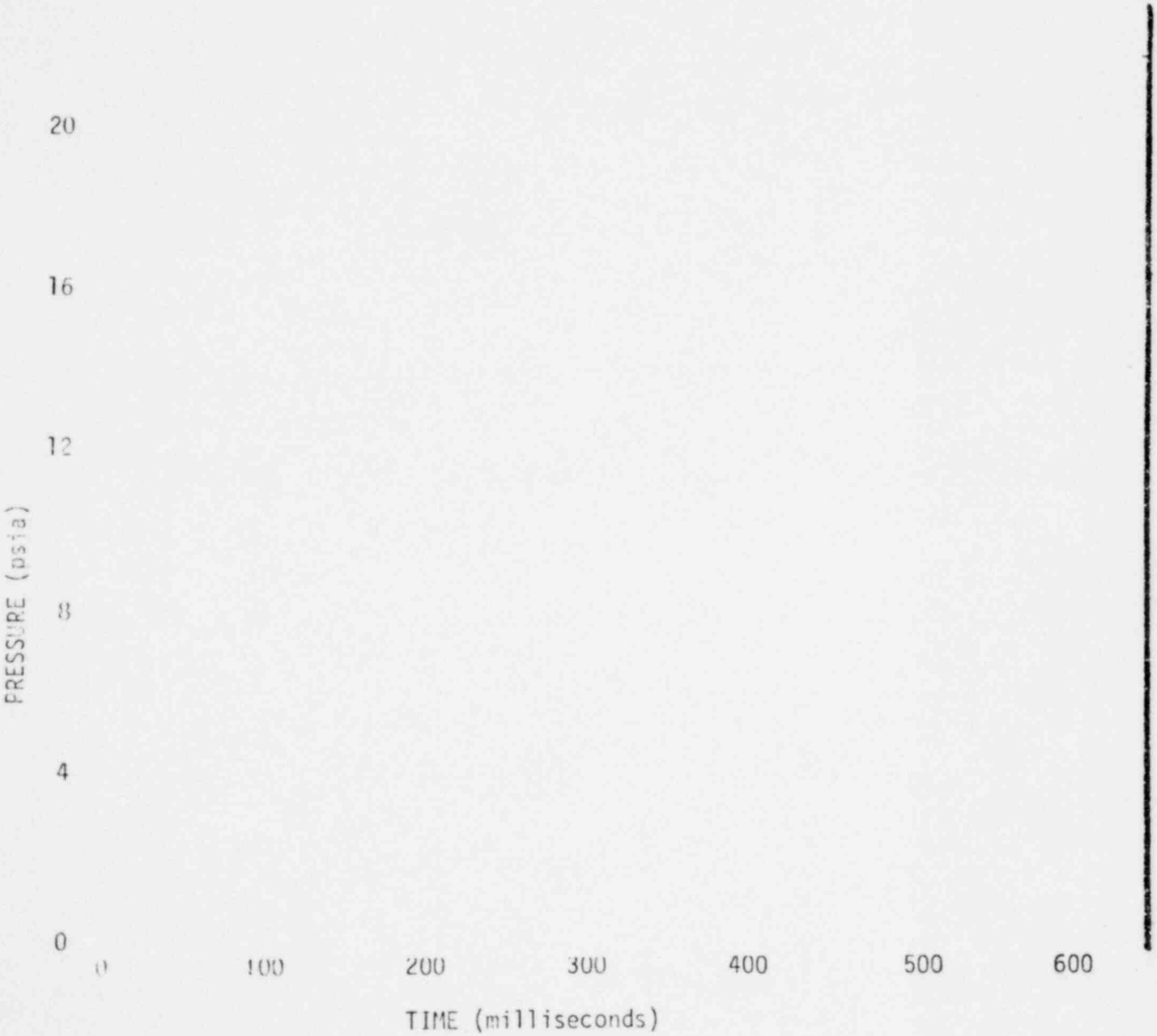
1348 302

FIGURE A-149

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Fermi 2 Tests



1348 303

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.
—No significant downforce valley or 2nd peak downforce.
*(1)Start-of-test reference time

TABLE A-6
DATA FOR WETWELL VERTICAL LOADS
Task 5.5.3-2 Fermi 2 Tests

Parameter \ Test No.		7.03" ΔP, 6.56-inch "T" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.
T_o *(1)	(sec)						
Vent Clearing Time*	(sec)						
Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Downforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
[Δt] Downforce Time**							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						
Downforce Impulse							
Pressure Integral:							
Impulse	(lb-sec)						

1348 304

*Time at force is zero (from T_o)

TABLE A-6 (Continued)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Fermi 2 Tests

Parameter \ Test No.		7.03" ΔP, 6.56-inch "T" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.
Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Upforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Zero Force Time*							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						

1348 305

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.
—No significant downforce valley or 2nd peak downforce.
*(1)Start-of-test reference time

TABLE A-7
DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Fermi 2 Tests

Parameter \ Test No.		0" ΔP, 6.56-inch "T" Deflector (5)	(6)	(7)	(8)	Mean	Std. Dev.
T_o *(1)	(sec)						
Vent Clearing Time*	(sec)						
Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Downforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Downforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
[Δt] Downforce Time**							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						
Downforce Impulse							
Pressure Integral:							
Impulse	(lb-sec)						

1348 306

*Time at force is zero (from T_o)
—No significant 2nd peak upforce

TABLE A-7 (Continued)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Fermi 2 Tests

Parameter / Test No.		0" ΔP, 6.56-inch "T" Deflector (5)	(6)	(7)	(8)	Mean	Std. Dev.
Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Upforce Valley							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
2nd Peak Upforce							
Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Pressure Integral:							
Force	(lb)						
Time (from T_o)	(sec)						
Corrected Load Cell:							
Force	(lb)						
Time (from T_o)	(sec)						
Zero Force Time*							
Pressure Integral	(sec)						
Corrected Pressure Integral	(sec)						
Corrected Load Cell	(sec)						

1348 307

TABLE A-8

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Fermi Tests

Parameter \ Test No.		7.03" ΔP, 6.56 inch "T" Deflector						0" ΔP, 6.56 inch "T" Deflector
		(1)	(2)	(3)	(4)	Mean	Std. Dev.	(5)
T_o	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

* Based on impact pressure measurements

** At start of the first impact pressure recorded

1348 308

A.4 Duane Arnold Tests

A.4.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Duane Arnold Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 9.19" H_2O ΔP and with no deflector. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with no deflector.

A.4.1.1 Driving Conditions

Driving conditions for Duane Arnold Test 3 are presented in Figures A-150 through A-154. Similar plots for Test 5 are shown in Figures A-155 through A-159. Duane Arnold driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.4.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Duane Arnold Tests 3 and 5 are presented in Figures A-160 through A-161 and A-162 through A-163, respectively. Net torus force from the pressure integral (Figures A-164 and A-165) shows some oscillations in downforce as well as in upforce. Net torus force that is determined from the torus load cell (Figures A-166 and A-168) by applying inertial correction with the torus accelerometer (Figures A-167 and A-169) is shown in Figures A-170 and A-171 and compared with net torus force determined from the pressure integral. Figures A-172 and A-173 present the net torus force based on the torus pressure integral, corrected for inertia.

1348 309

The "average" pool pressures for Duane Arnold Tests 3 and 5 are shown in Figures A-174 and A-176. Figure A-175 and A-177 are the same as Figures A-172 and A-173 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Duane Arnold Test 3 are presented in Figures A-178 through A-180. Vent header pressures for Test 5 are presented in Figures A-181 through A-183. These figures illustrate that, for the Duane Arnold single downcomer with unprotected vent header, the impact pressures are higher on the center row and decrease rapidly in the lateral direction. The maximum vent header force from the corrected load cell is somewhat lower than the maximum force from the pressure integral (Figure A-184).

The vent header impact force is not very sensitive to drywell/wetwell ΔP for the Duane Arnold tests. Vent header impact mitigation from ΔP may be primarily due to a reduction in the slug thickness at impact, since velocity is typically insensitive to ΔP. Based on the review of the Duane Arnold movies, the minimum slug thickness at zero ΔP appears to be no thicker than for partial ΔP condition due to the presence of small bubbles (thought to originate at vent clearing) on top of the main bubble at zero ΔP. In a two downcomer geometry these small bubbles are not directly underneath the vent header.

Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-185 and A-186, respectively.

A.4.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-187 through A-190 for Duane Arnold Tests 1, 2, 3, and 5. Pool surface displacement curves are shown in Figures A-191 and A-193. The pool surface velocity profiles are shown in Figures A-192 and A-194.

1348 310

The pool surface displacement and velocity profile viewed from the side window during Test 4 are shown in Figure A-195. The downcomer water slug displacement, velocity, and acceleration versus time for Test 3 are presented in Figure A-196. Similar plots are shown in Figure A-197 for Test 5.

The movies show that the pool swell is more concentrated under the header for a single downcomer. Therefore, although the total pool momentum is reduced, the vent impact velocity is relatively high. In addition, the pool appears to be quite flat along the header centerline. This pool swell configuration gives nearly simultaneous impact along the bottom of the header which produces peak pressures comparable to reference plant values.

A.4.3 Data Summaries

Table A-9 presents the Duane Arnold test data for wetwell vertical forces.

Table A-10 presents the Duane Arnold test data for vent header impact forces.

A.4.4 Discussion and Analysis

Figure A-198 presents the effect of drywell/wetwell ΔP on the enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressures is shown in Figure A-199. Figure A-200 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. This data for Duane Arnold parallels that for the "typical" plant in Section 3.0.

1348 311

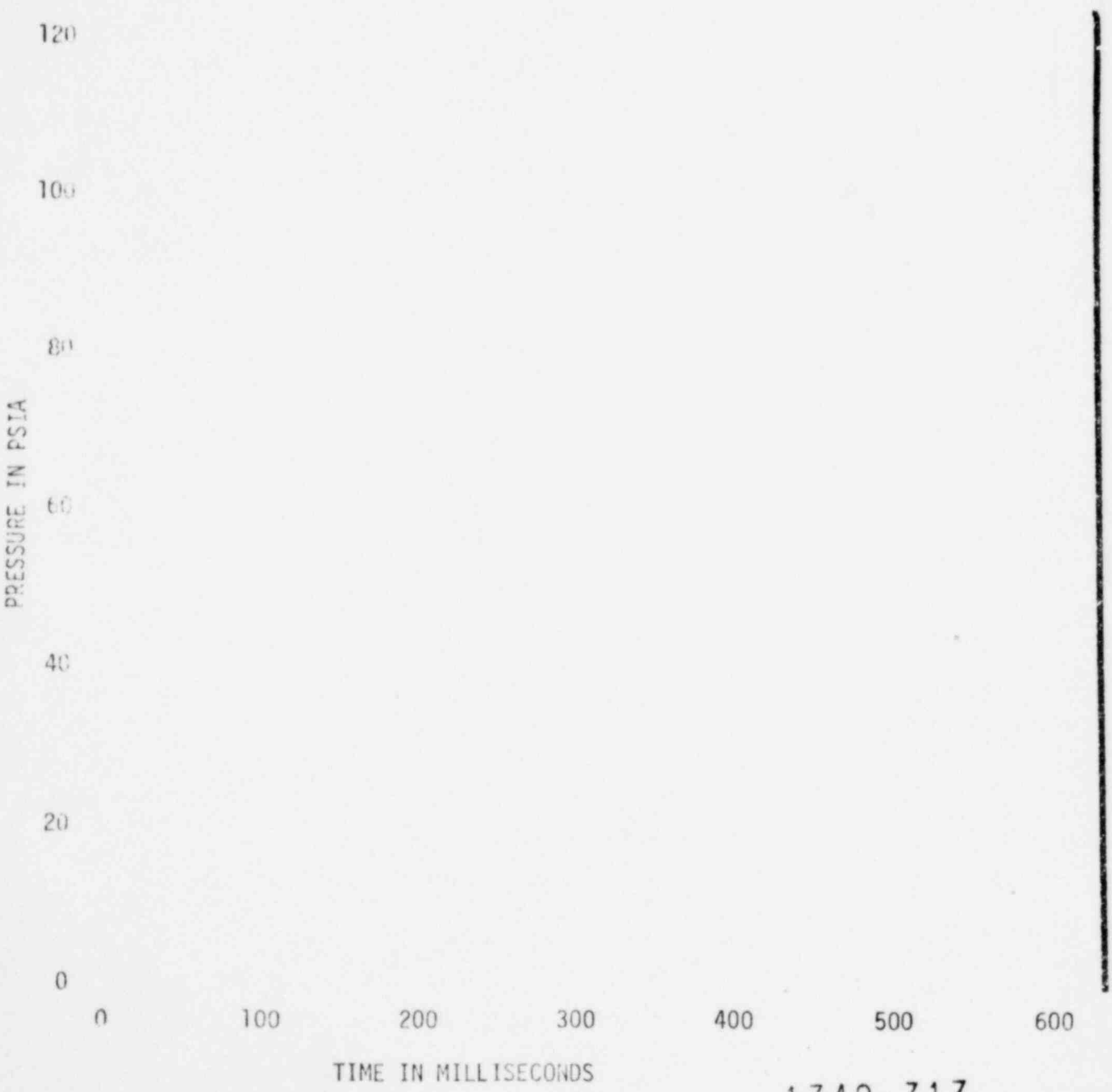
The Duane Arnold load definition tests were conducted at 9.19" H_2O ΔP with no deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. The upforce as well as downforce had minor oscillations. The vent header impact force was significantly higher than for plants using deflectors.

1348 312

FIGURE A-150

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Duane Arnold Test 3

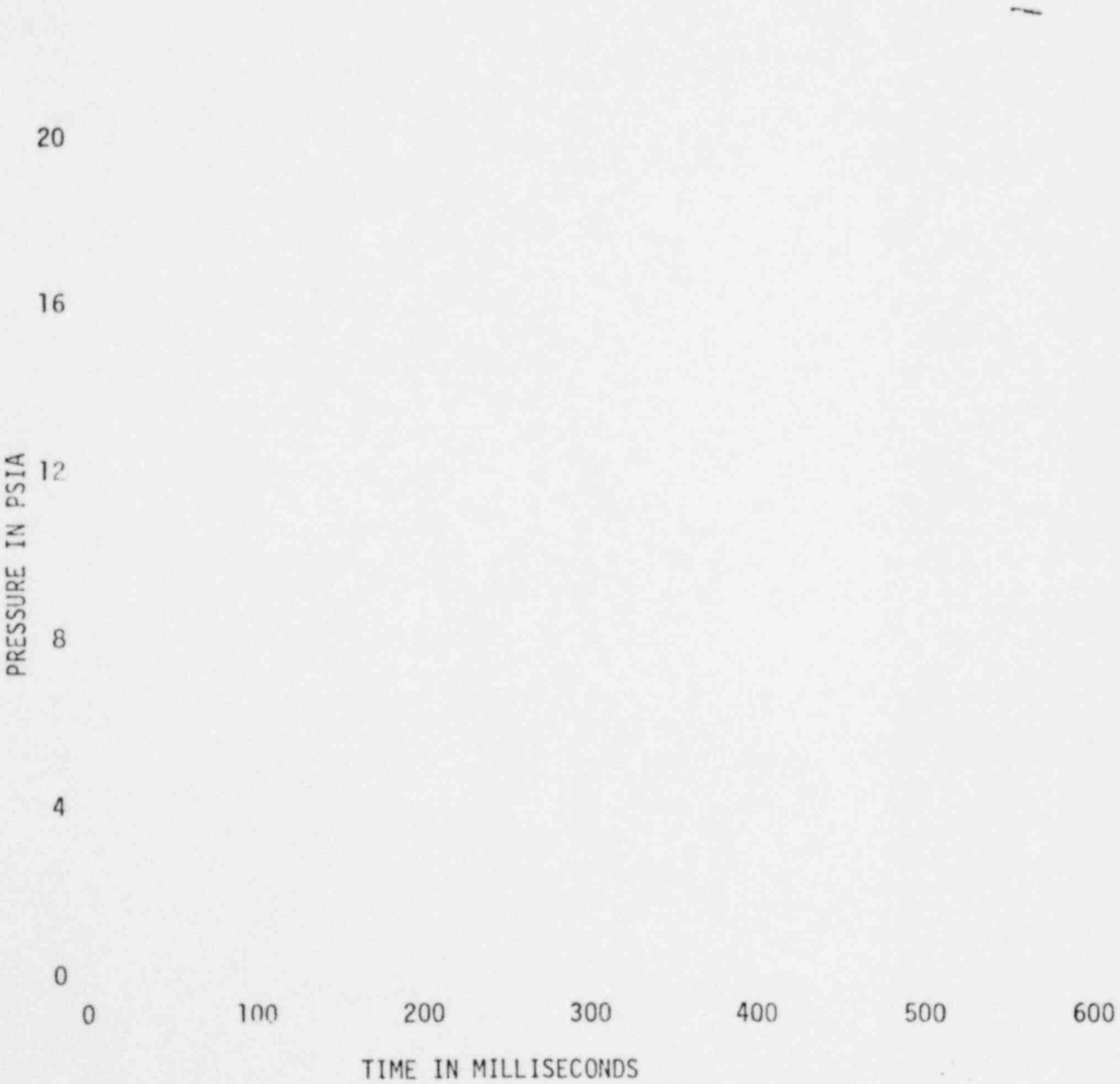


1348 313

FIGURE A-151

DRYWELL PRESSURE

Task 5.5.3-2 Duane Arnold Test 3



1348 314

FIGURE A-152

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Duane Arnold Test 3

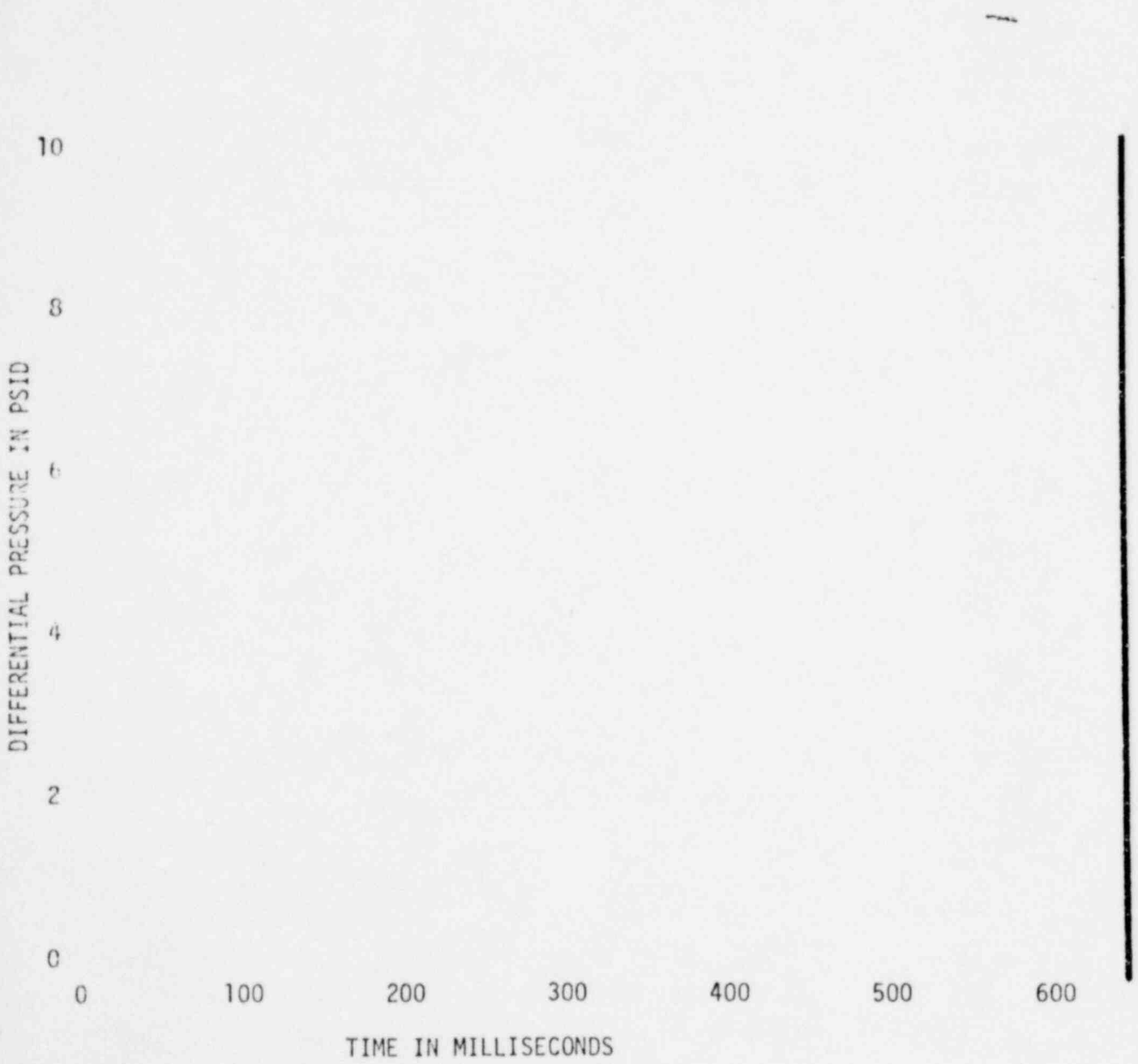
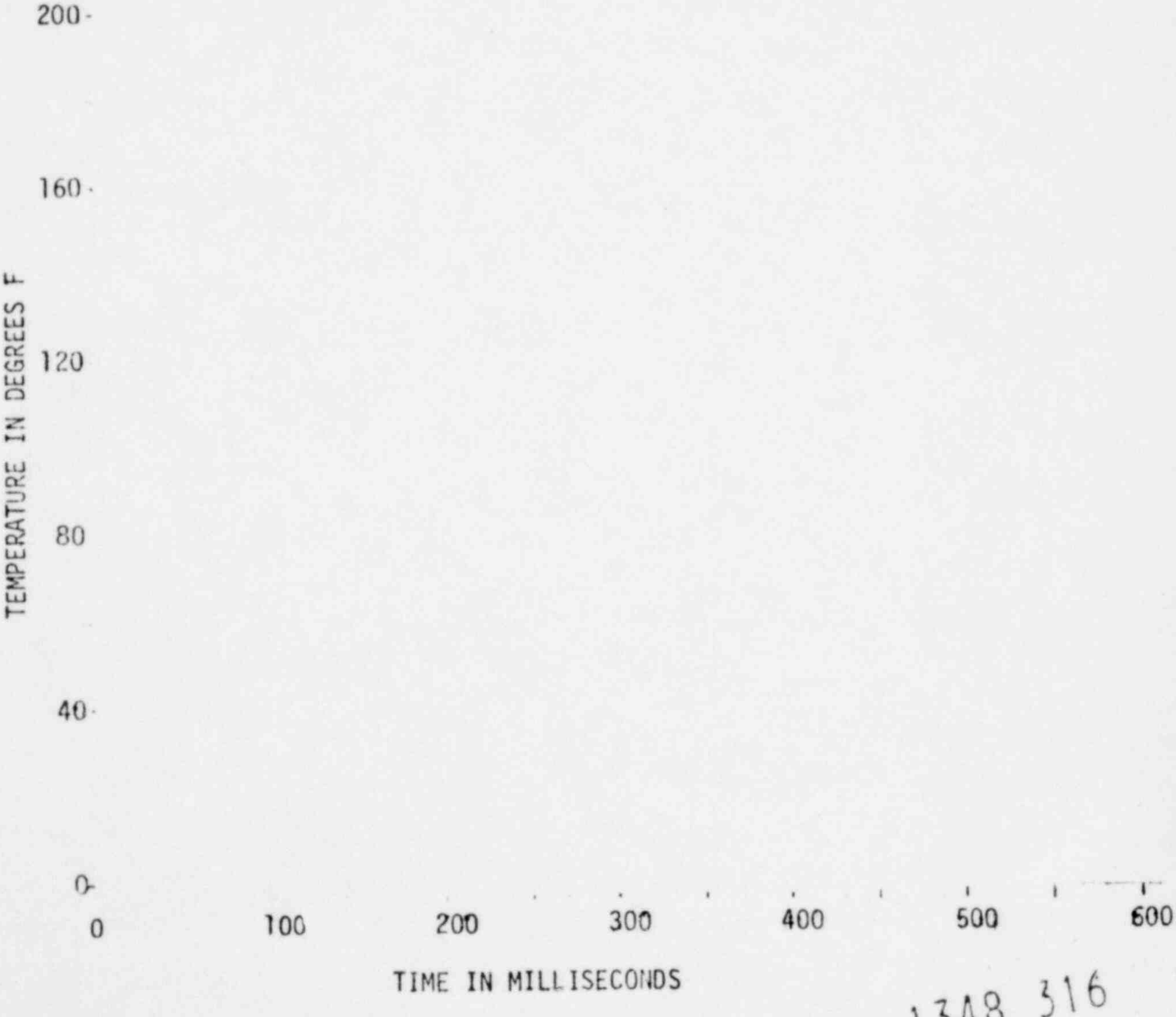


FIGURE A-153

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Duane Arnold Test 3



1348 316

FIGURE A-154

ENTHALPY FLOW INTO POOL

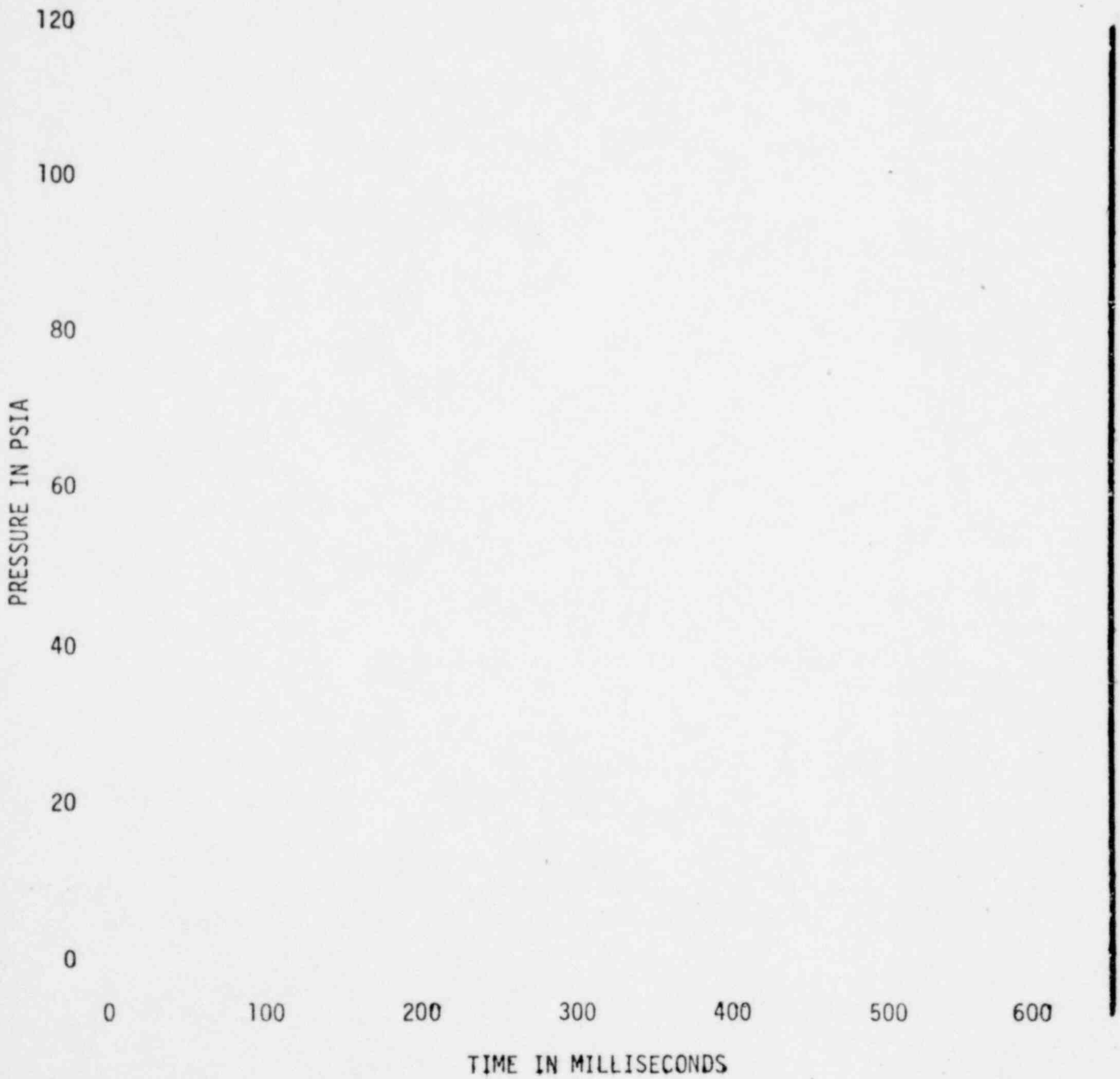
Task 5.5.3-2 Duane Arnold Test 3

1348 317

FIGURE A-155

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Duane Arnold Test 5

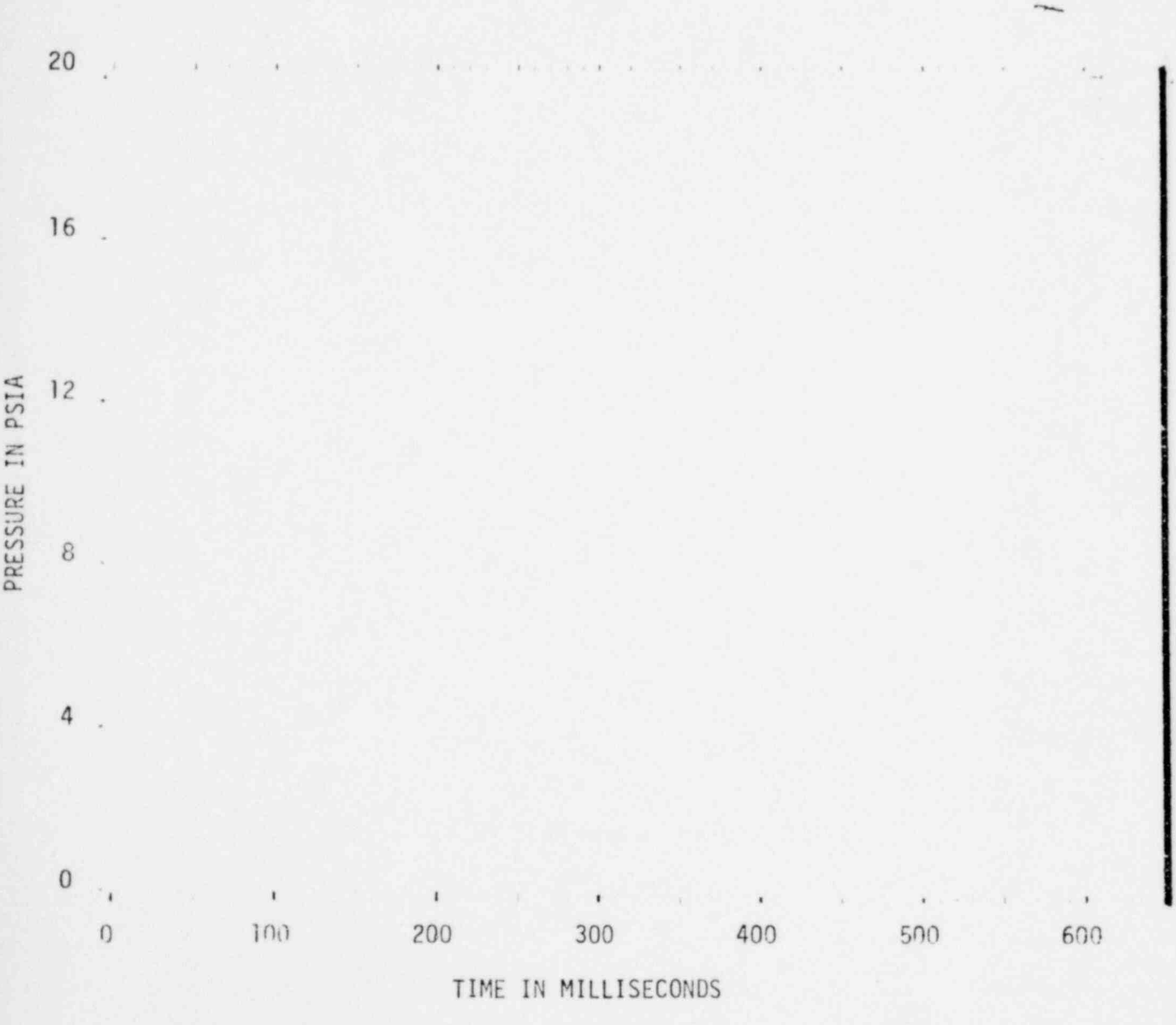


1348 318

FIGURE A-156

DRYWELL PRESSURE

Task 5.5.3-2 Duane Arnold Test 5

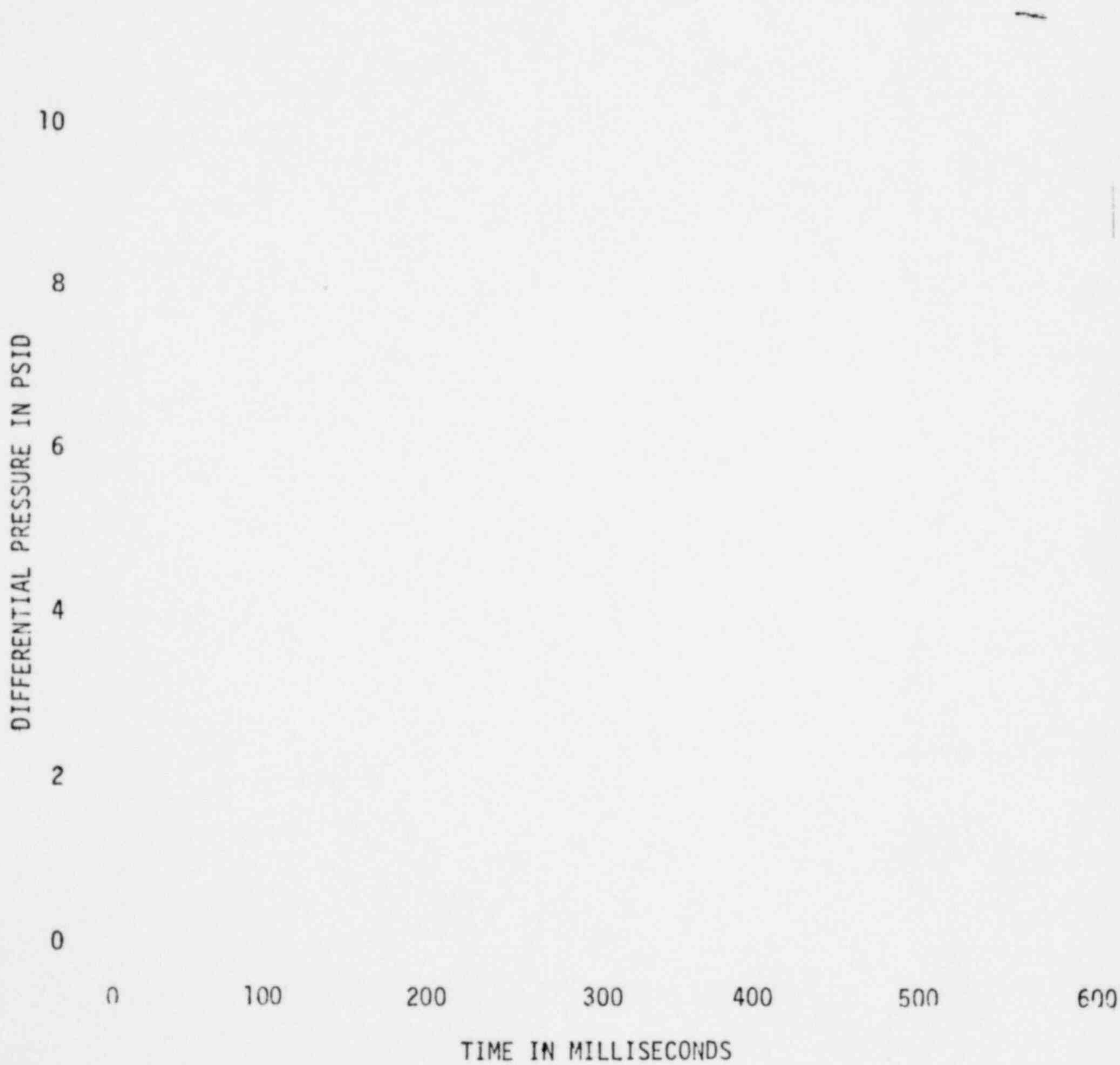


1348 319

FIGURE A-157

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Duane Arnold Test 5

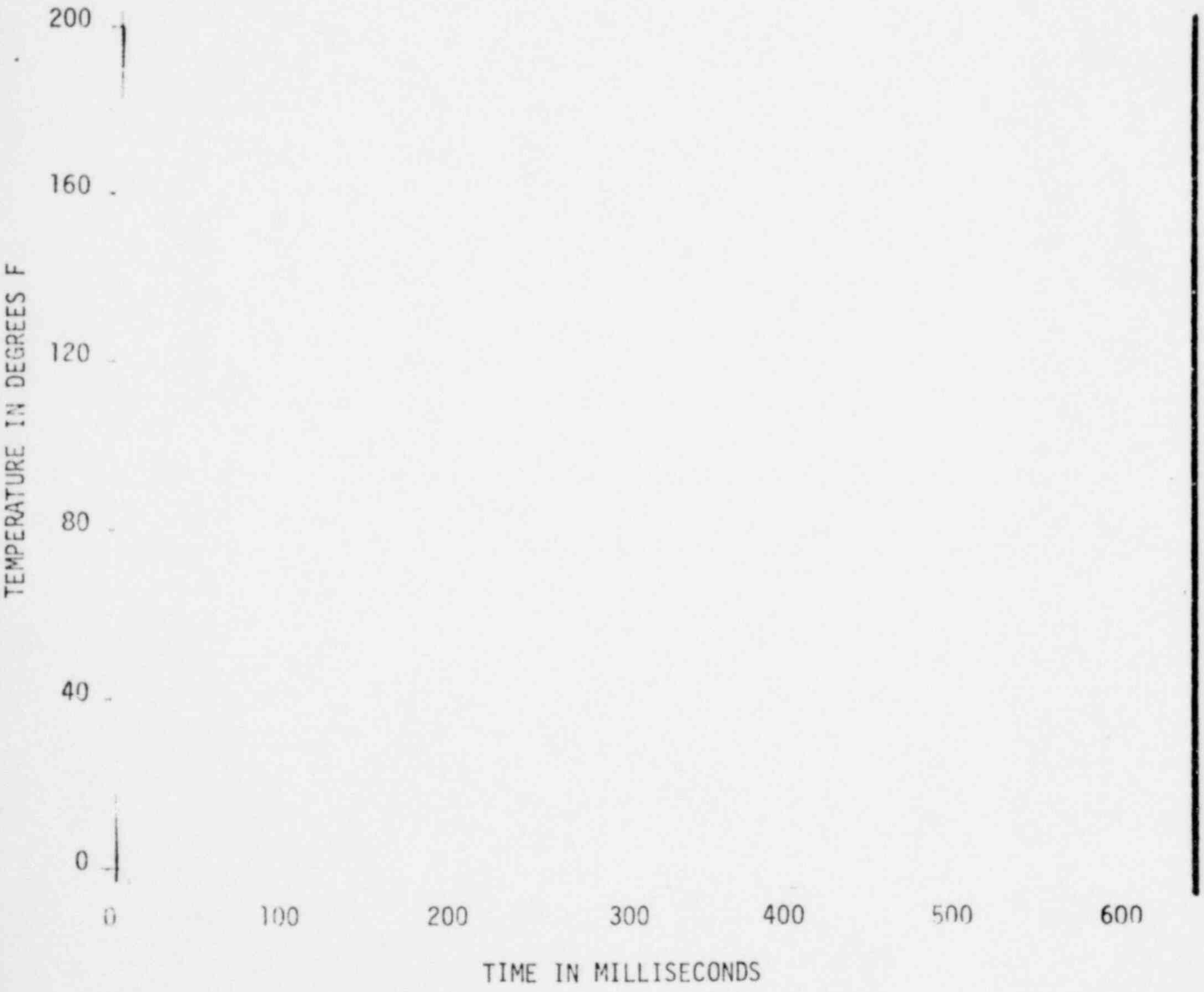


1348 320

FIGURE A-158

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Duane Arnold Test 5

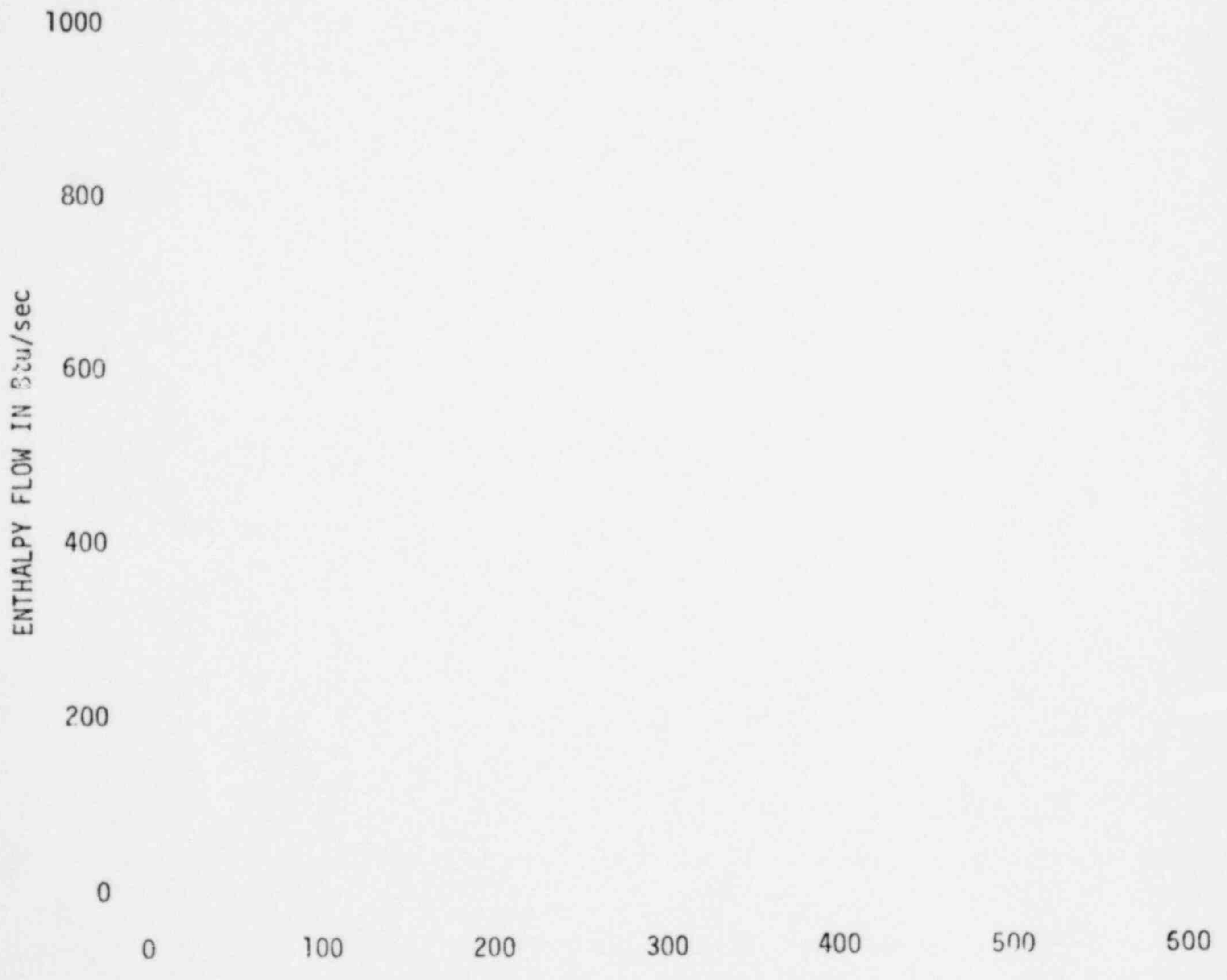


1348 321

FIGURE A-159

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Duane Arnold Test 5

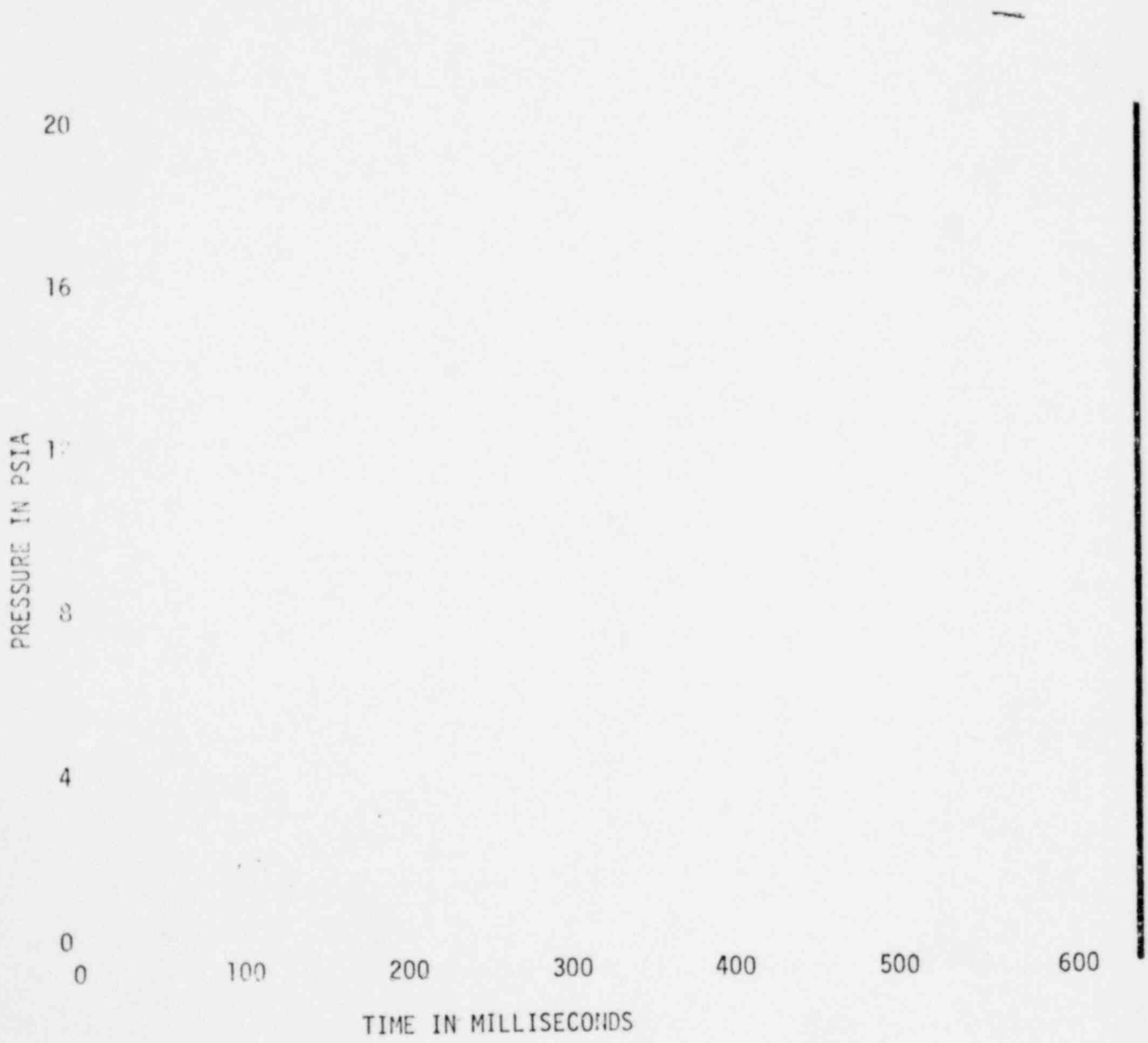


1348 322

FIGURE A-160

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Duane Arnold Test 3



1348 323

FIGURE A-161

WETWELL PRESSURES

Task 5.5.3-2 Duane Arnold Test 3

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

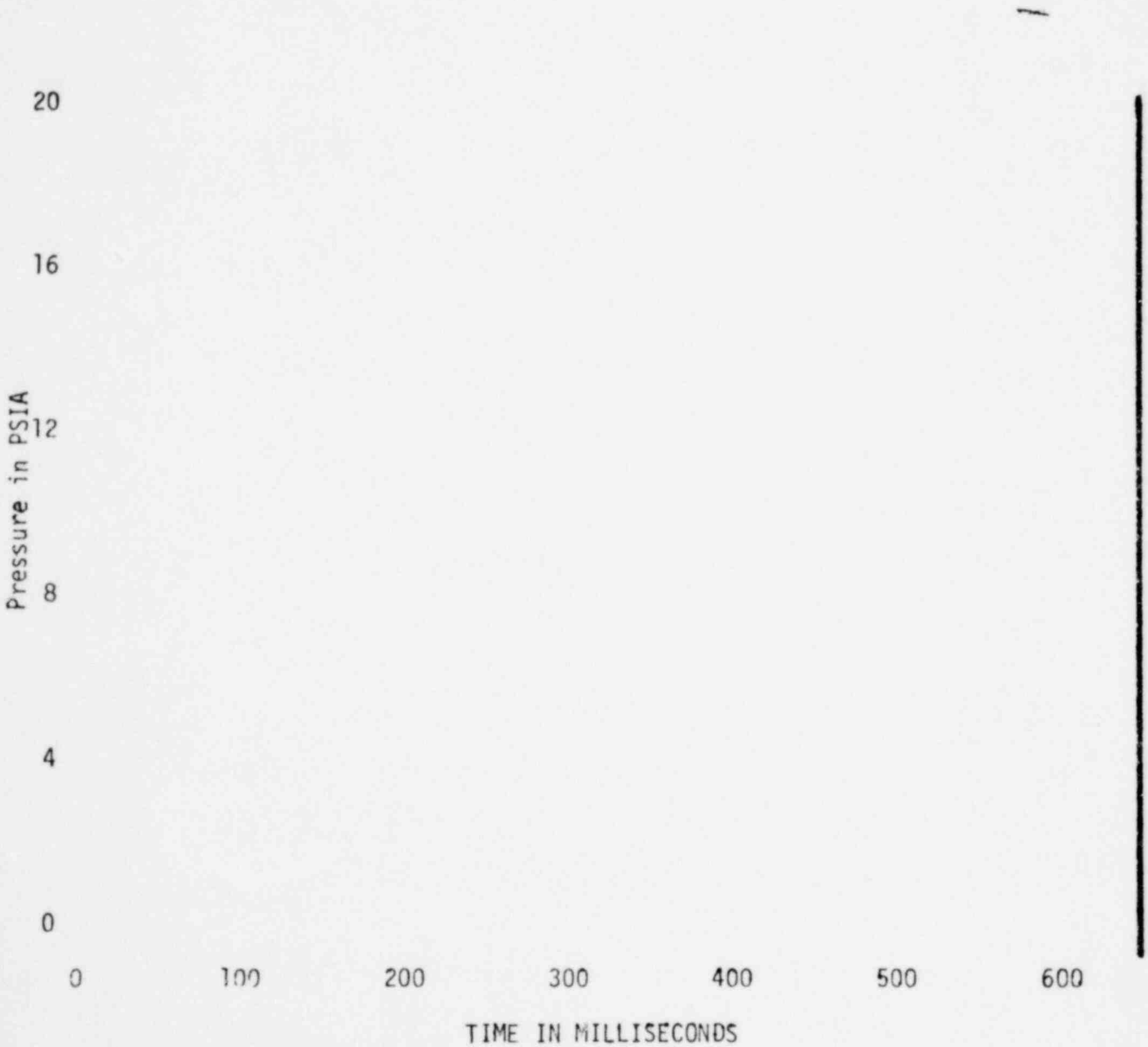
TIME IN MILLISECONDS

1348 324

FIGURE A-162

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Duane Arnold Test 5



1348 325

FIGURE A-163

WETWELL PRESSURES

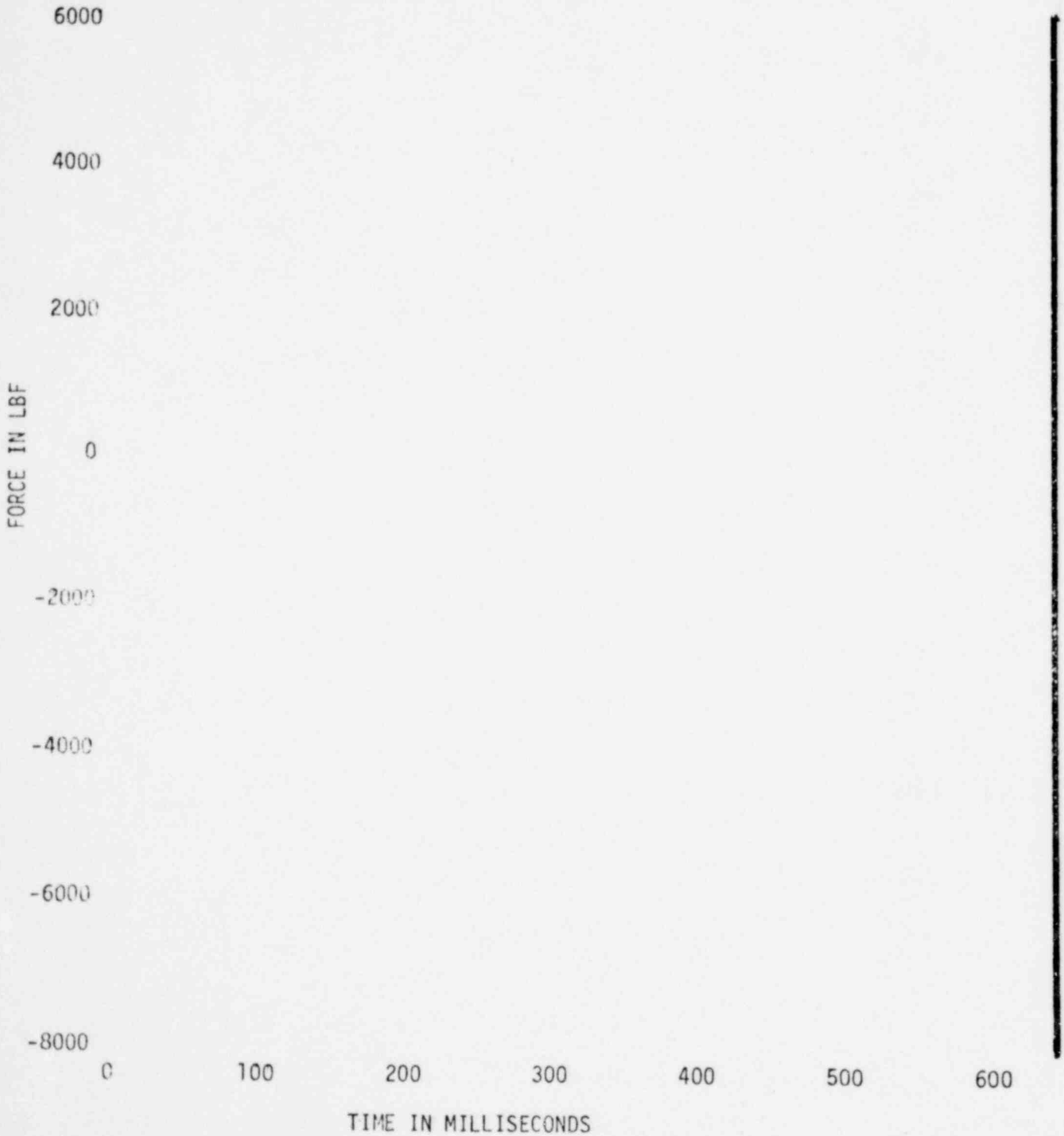
Task 5.5.3-2 Duane Arnold Test 5

1348 326

FIGURE A-164

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Duane Arnold Test 3

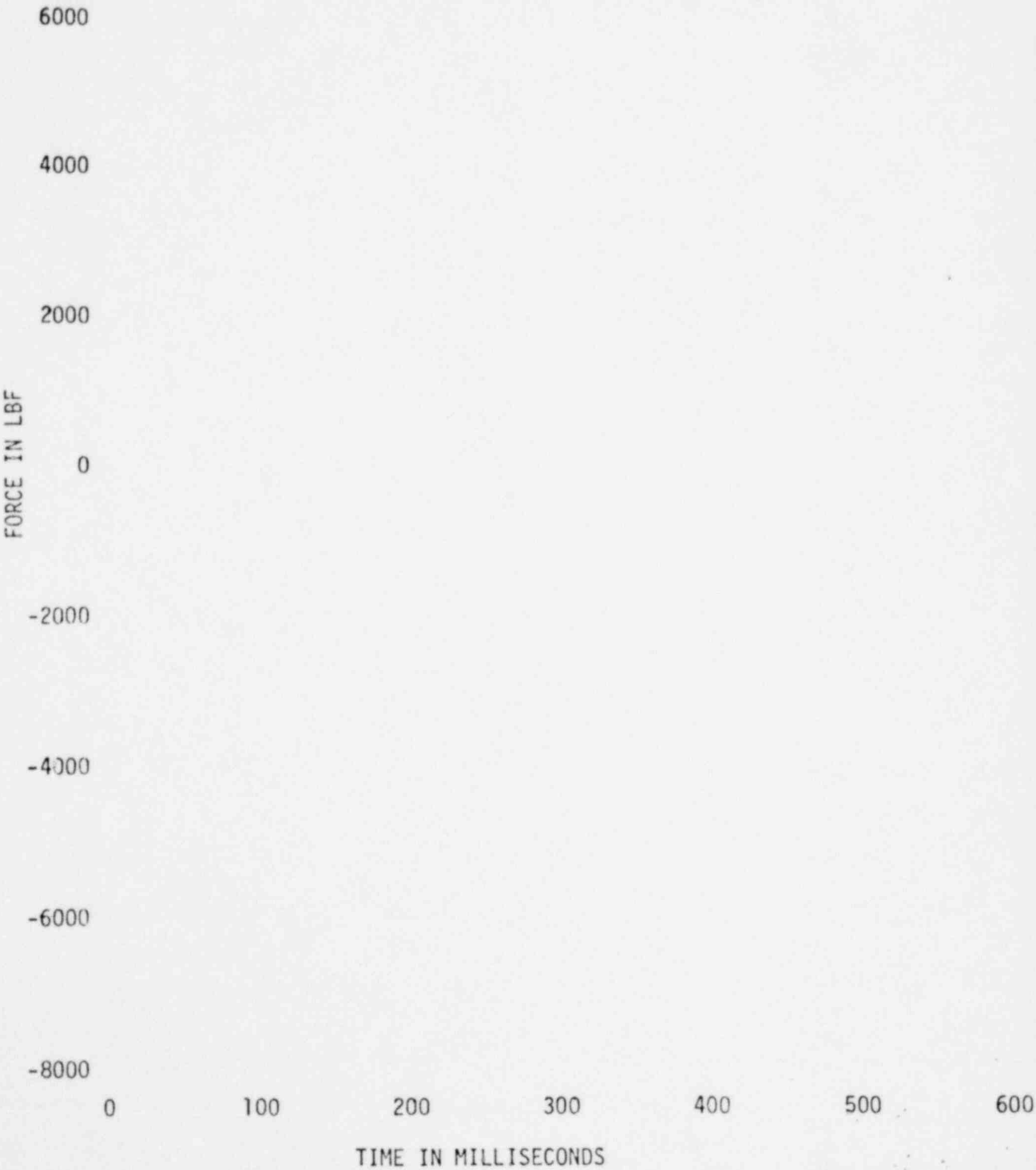


1348 327

FIGURE A-165

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Duane Arnold Test 5

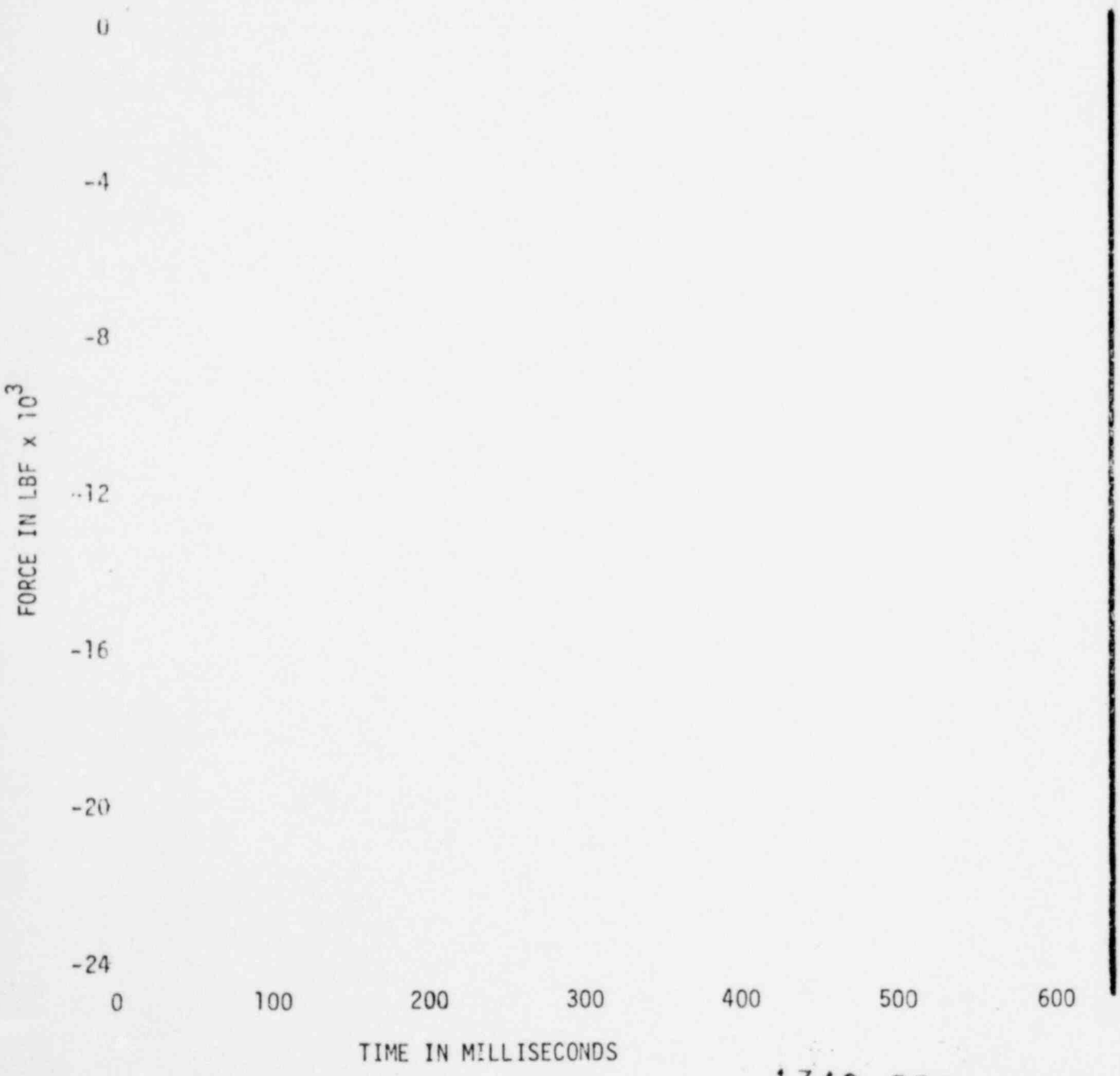


1348 328

FIGURE A-166

TORUS LOAD CELL

Task 5.5.3-2 Duane Arnold Test 3

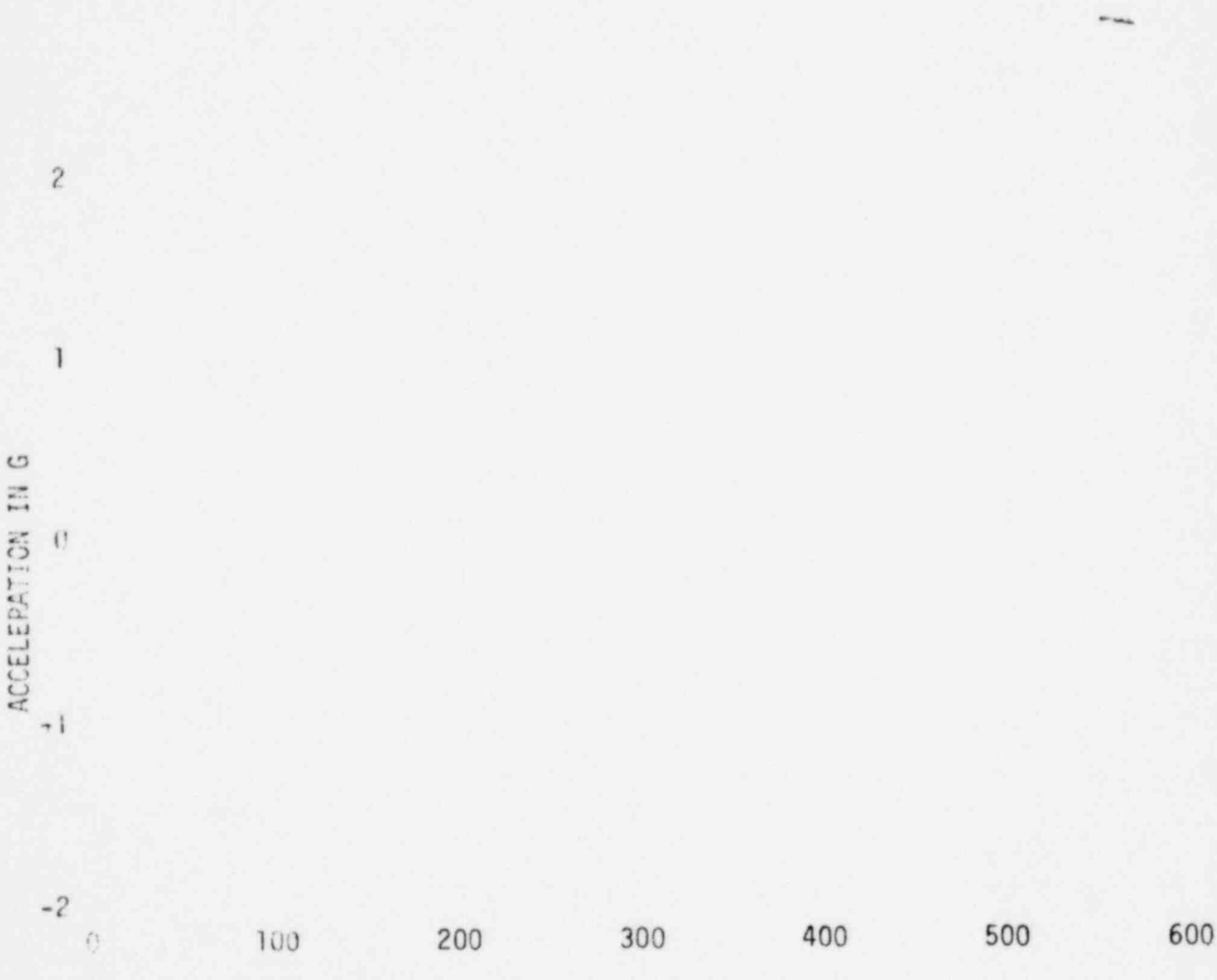


1348 329

FIGURE A-167

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Duane Arnold Test 3

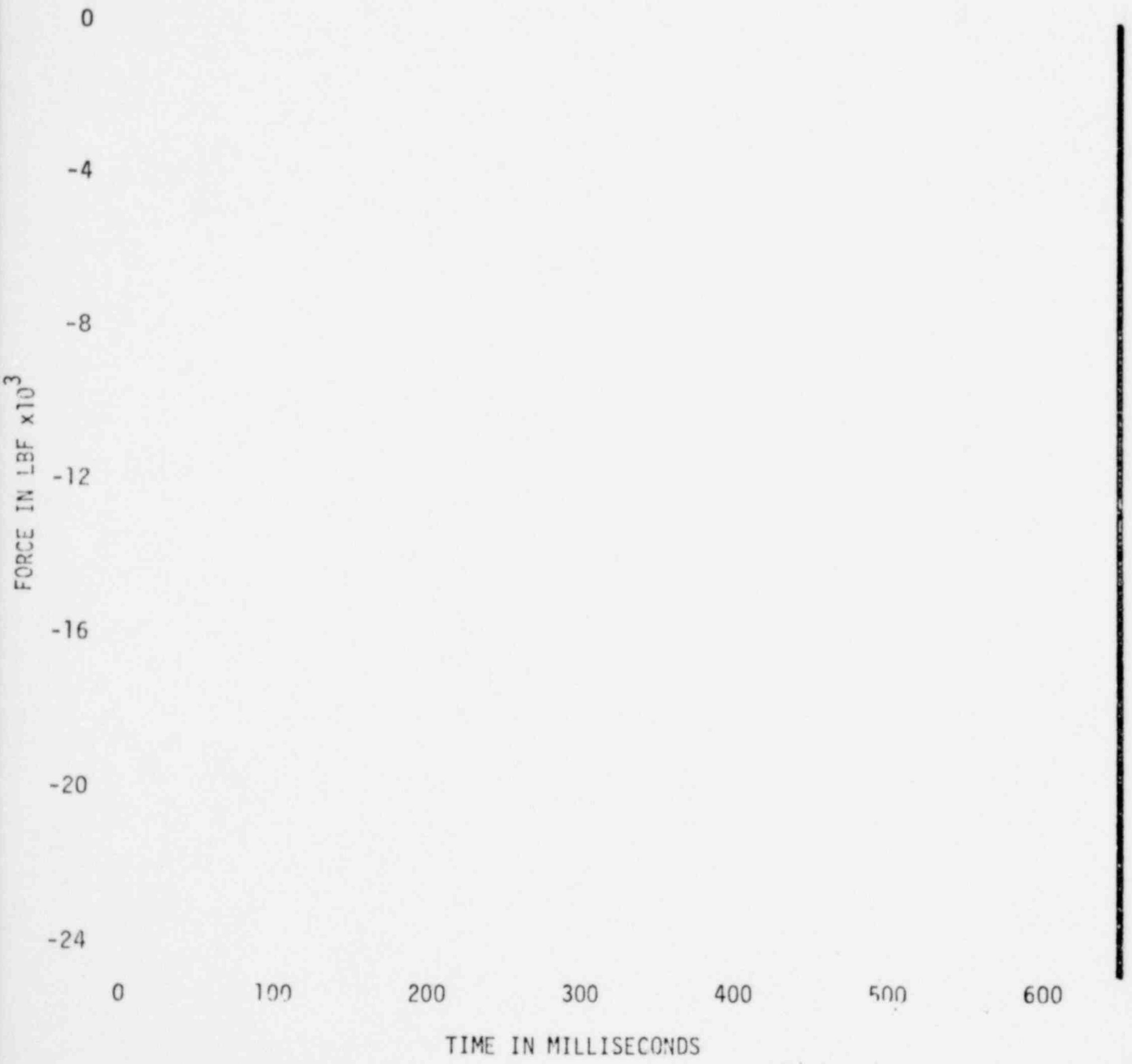


1348 330

FIGURE A-168

TORUS LOAD CELL

Task 5.5.3-2 Duane Arnold Test 5



1348 331

FIGURE A-169

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Duane Arnold Test 5

2

1

ACCELERATION IN G 0

-1

-2

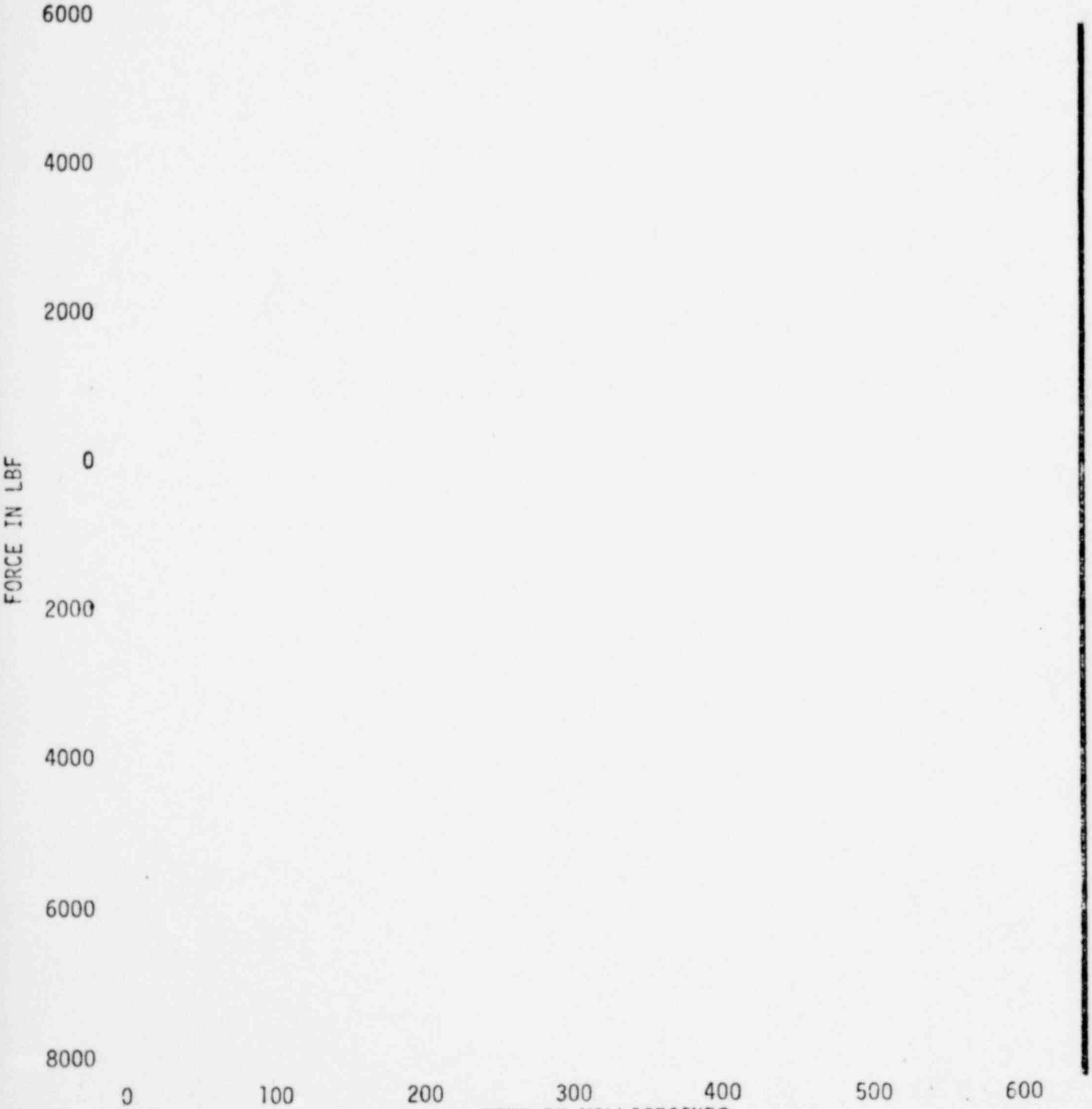
0 100 200 300 400 500 600

TIME IN MILLISECONDS

1348 332

FIGURE A-170

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL
WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA
Task 5.5.3-2 Duane Arnold Test 3



1348 333

FIGURE A-171

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL
WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Duane Arnold Test 5

6000

4000

2000

FORCE IN LBF 0

-2000

-4000

-6000

-8000

0 100 200 300 400 500 600

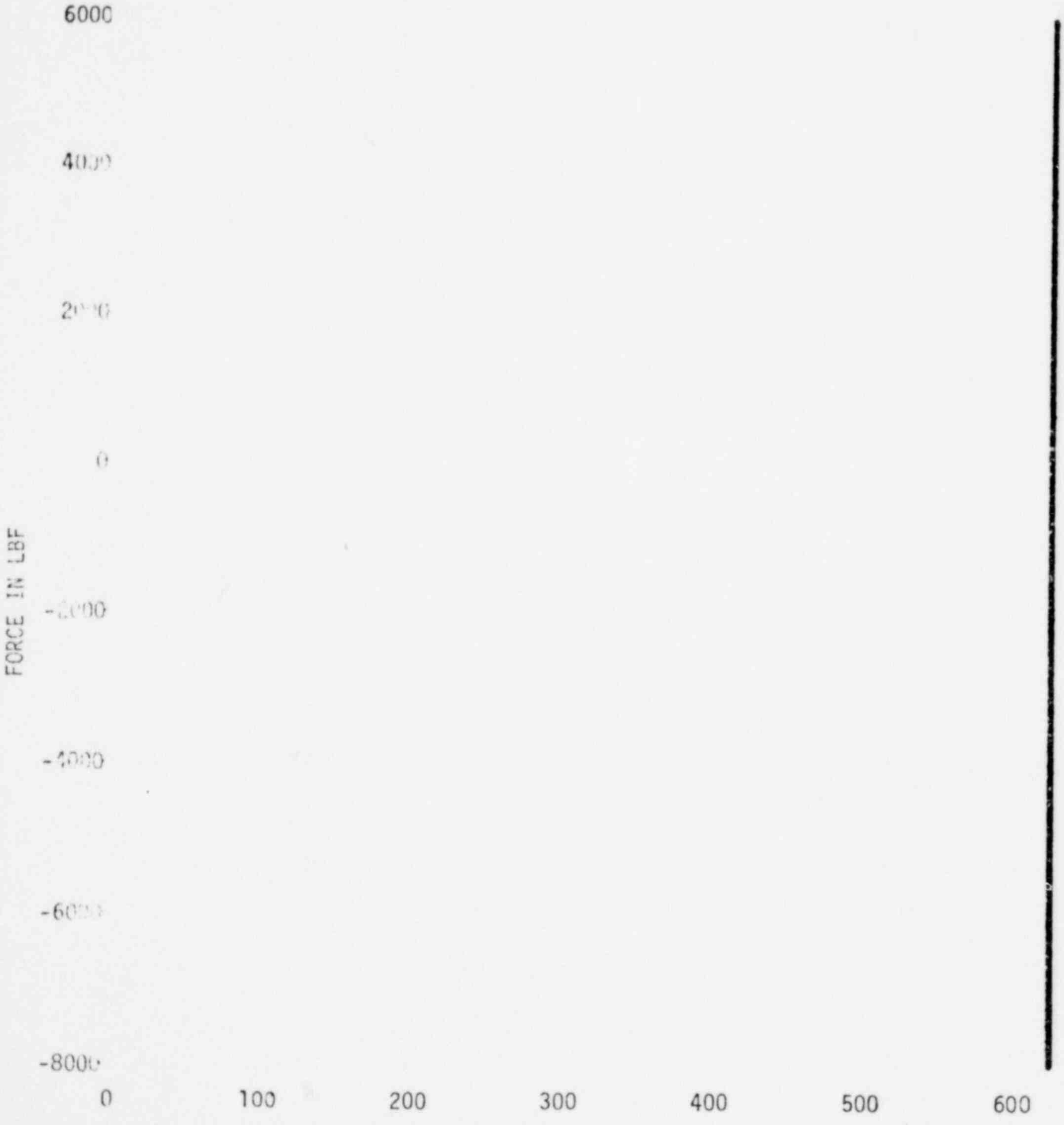
TIME IN MILLISECONDS

1348 334

FIGURE A-172

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Duane Arnold Test 3

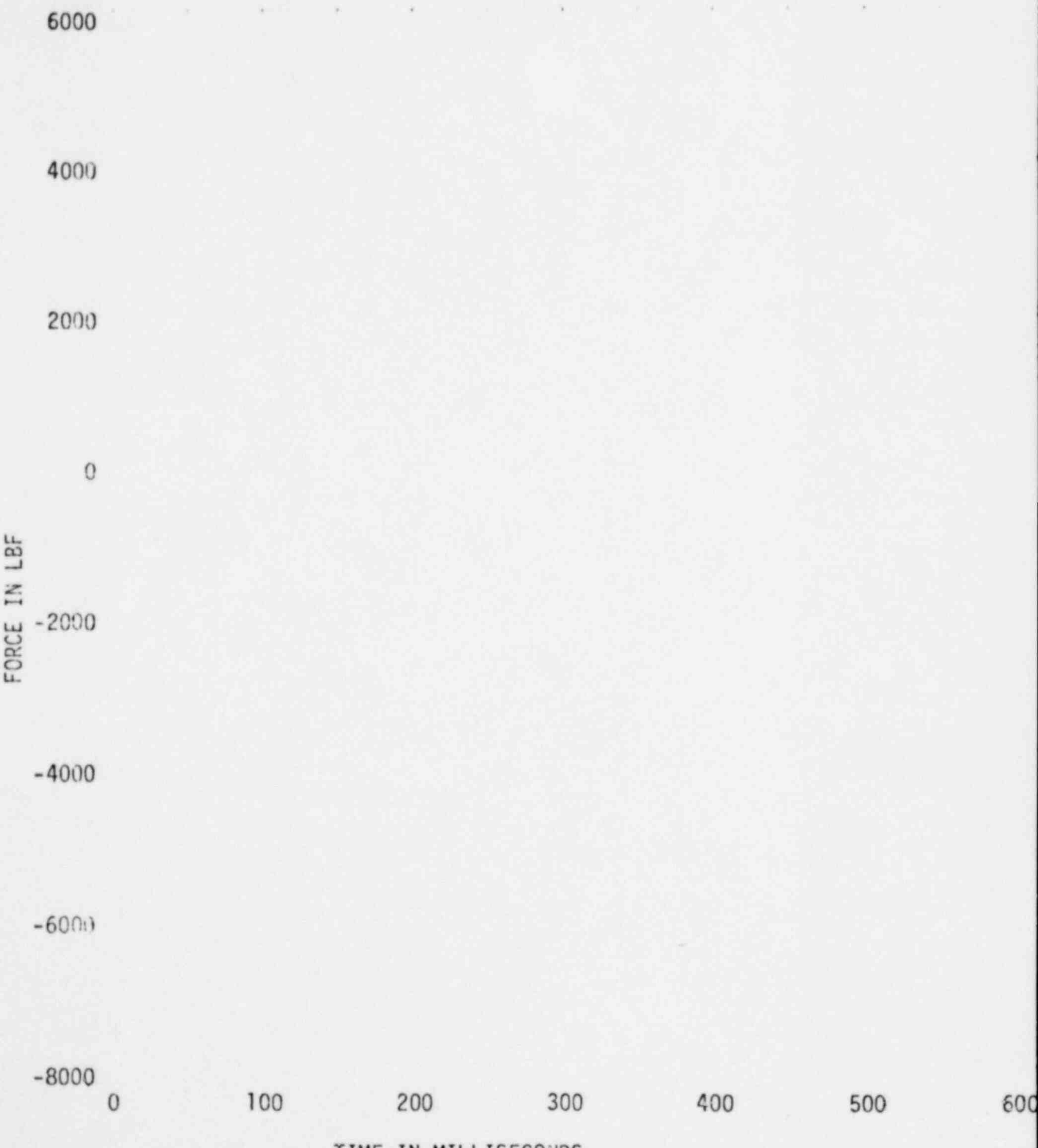


1348 335

FIGURE A-173

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Duane Arnold Test 5

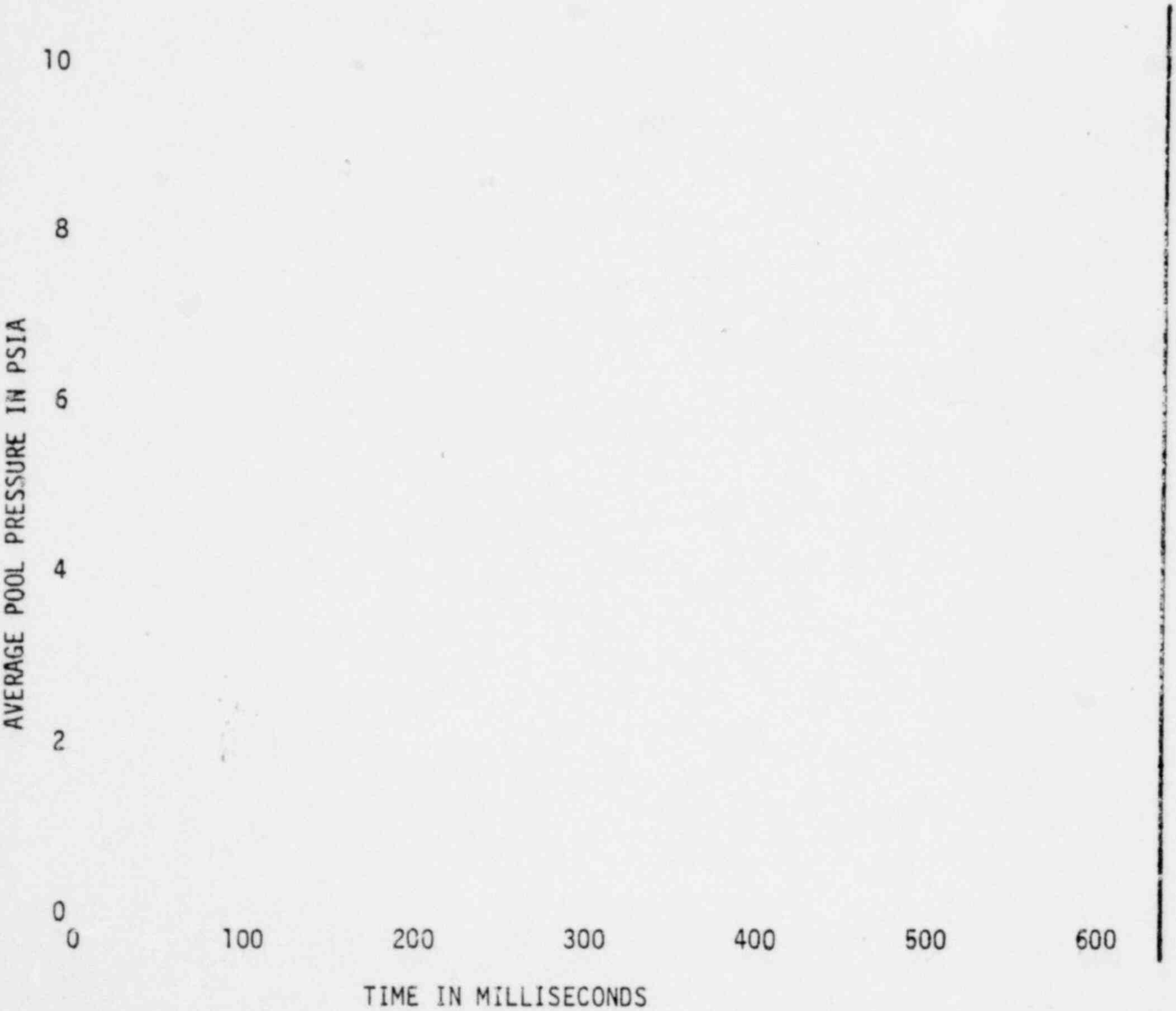


1348 336

FIGURE A-174

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Duane Arnold Test 3



1348 337

FIGURE A-175

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Duane Arnold Test 3

NET AVERAGE POOL PRESSURE IN PSI

3

2

1

0

-1

-2

-3

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1348 338

FIGURE A-176

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

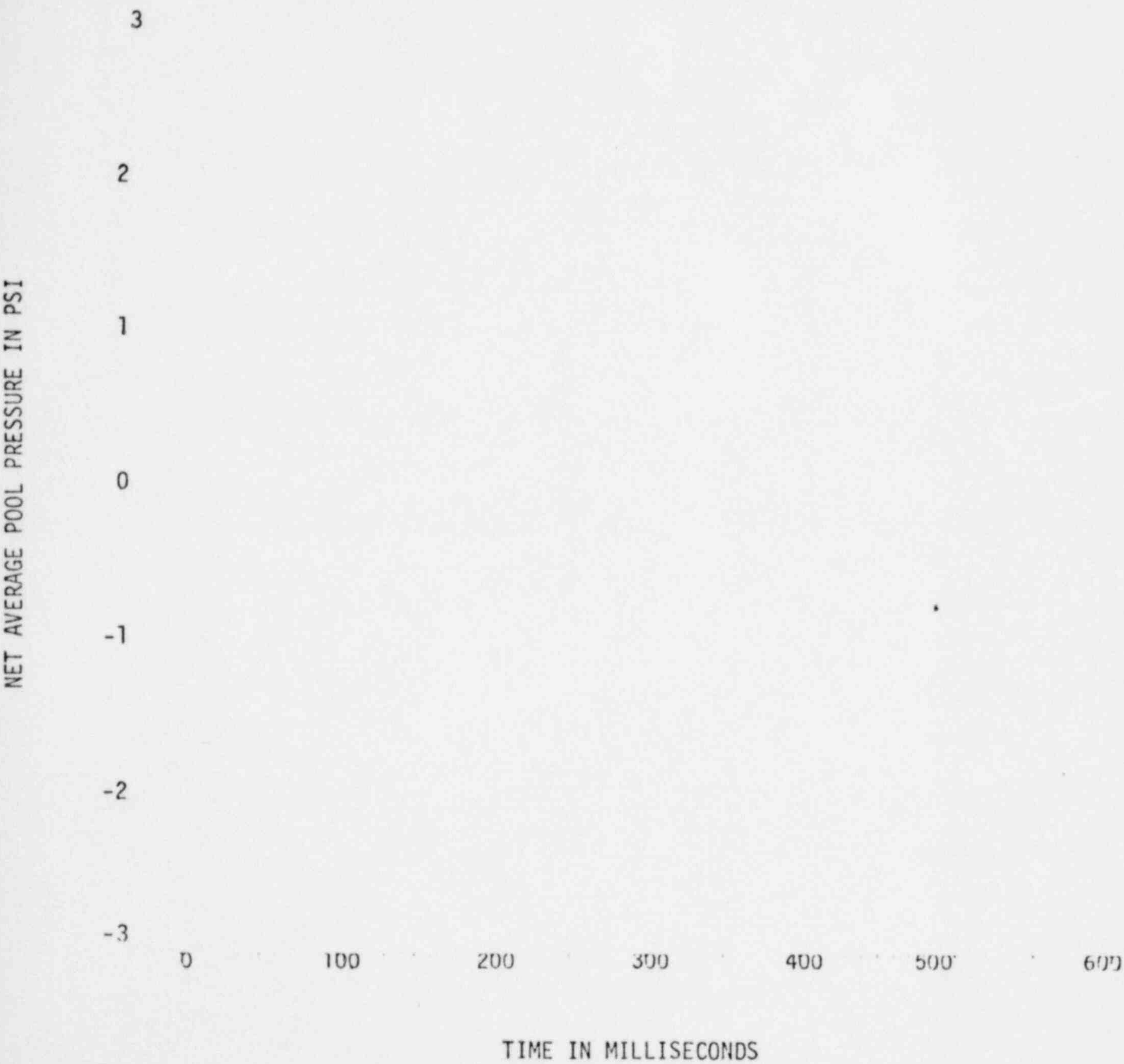
Task 5.5.3-2 Duane Arnold Test 5

1348 339

FIGURE A-177

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Duane Arnold Test 5

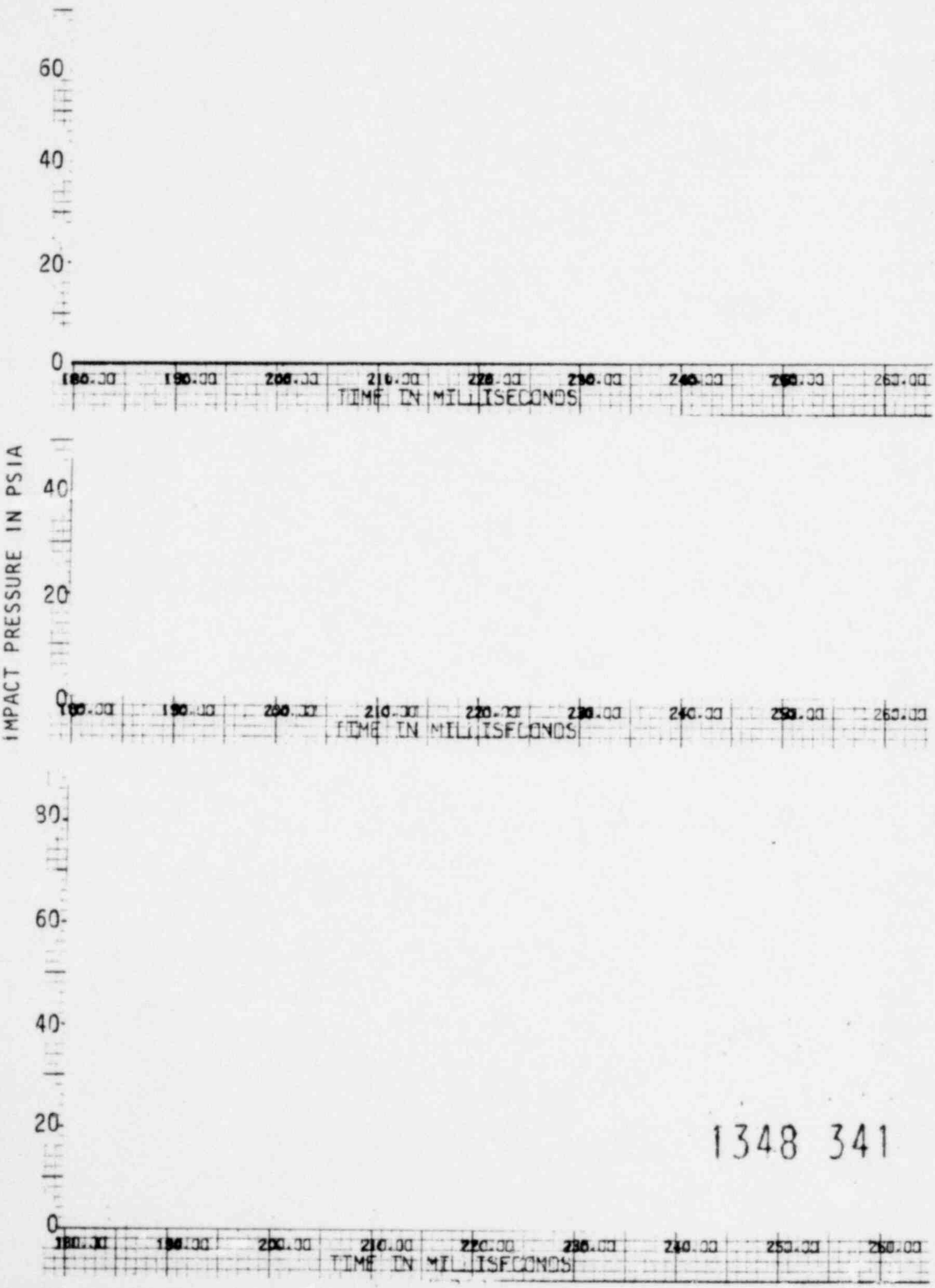


1348 340

FIGURE A-178

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 3

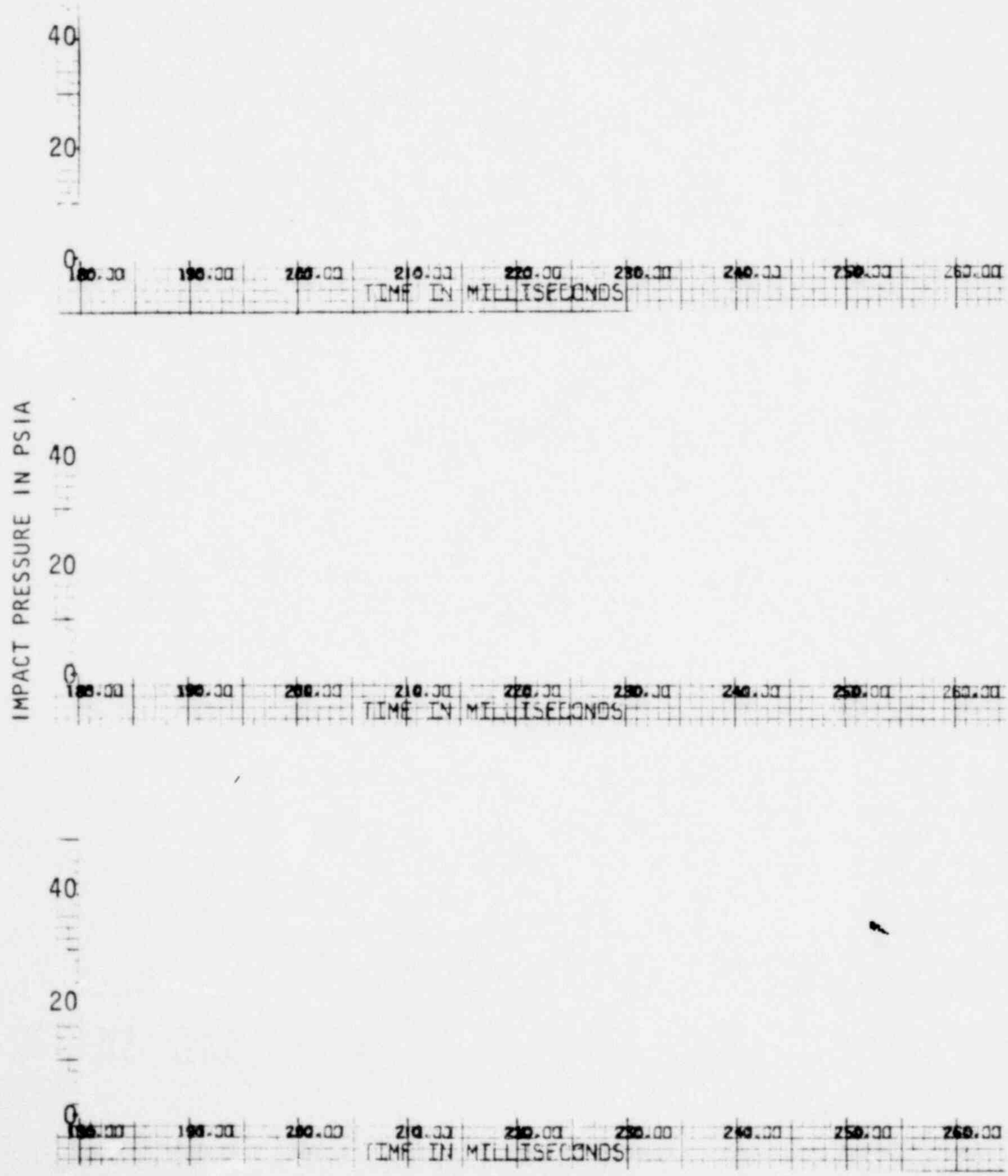


1348 341

FIGURE A-179

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 3

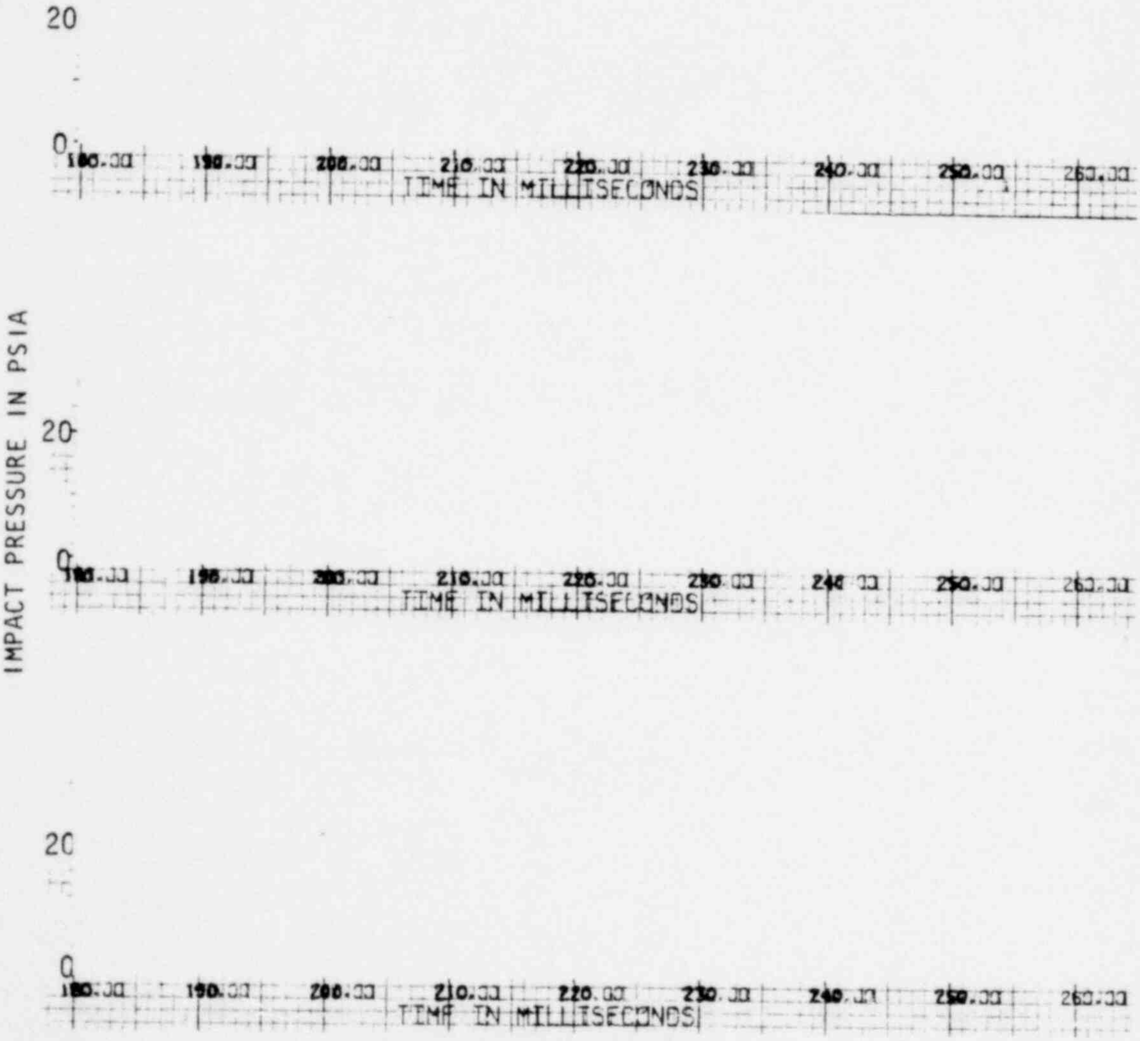


1348 342

FIGURE A-180

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 3

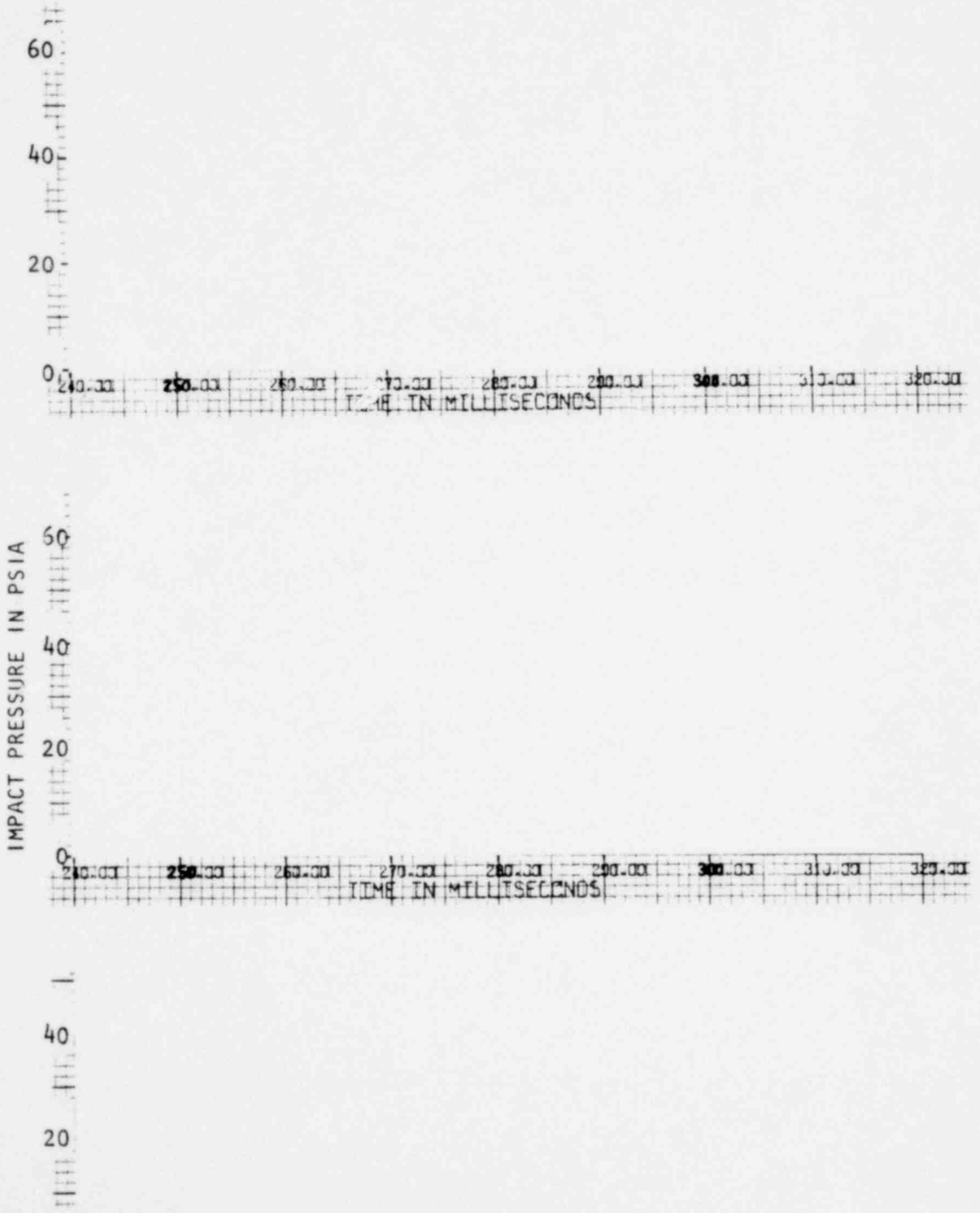


1348 343

FIGURE A-181

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 5



1348 344

FIGURE A-182

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 5

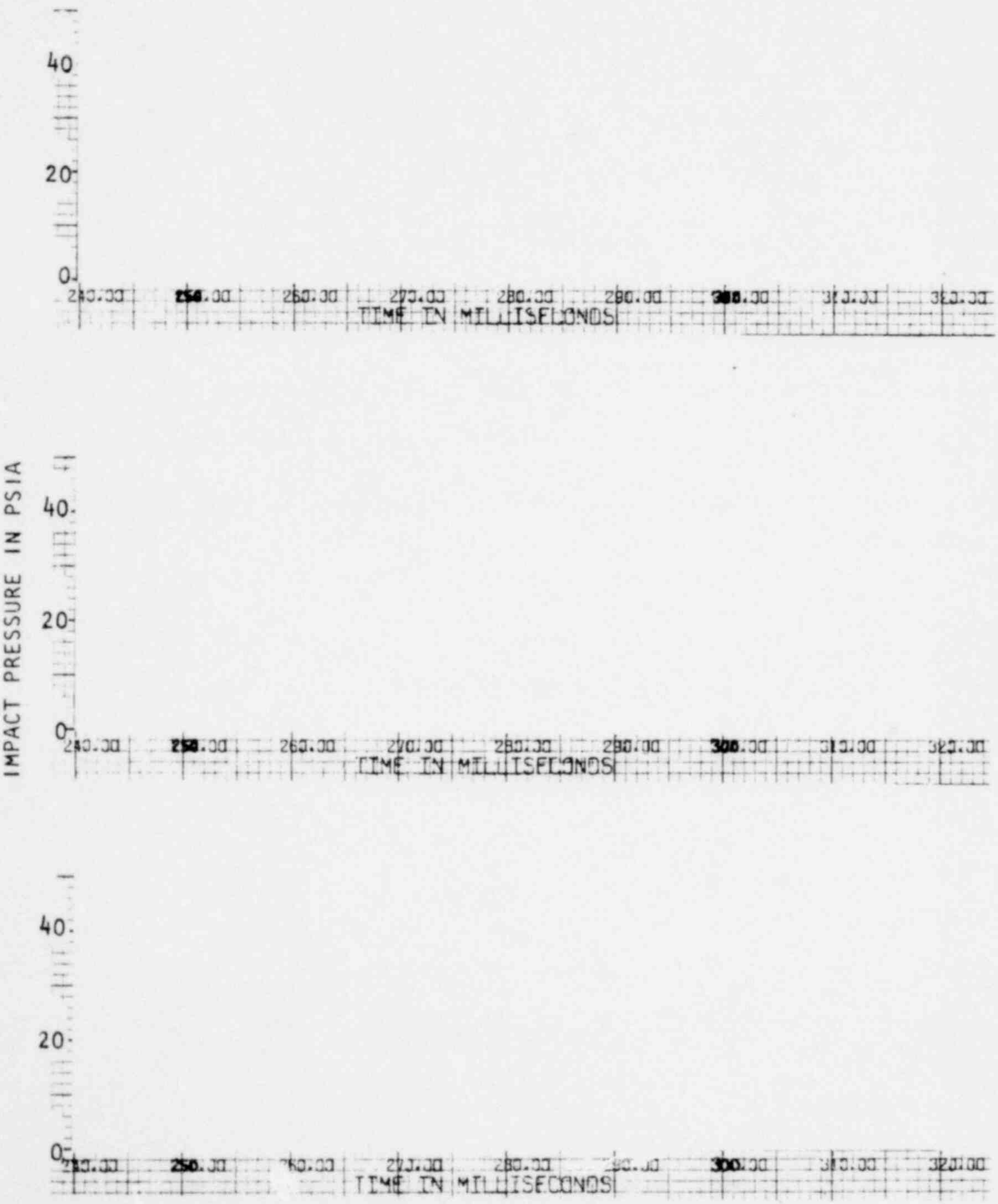
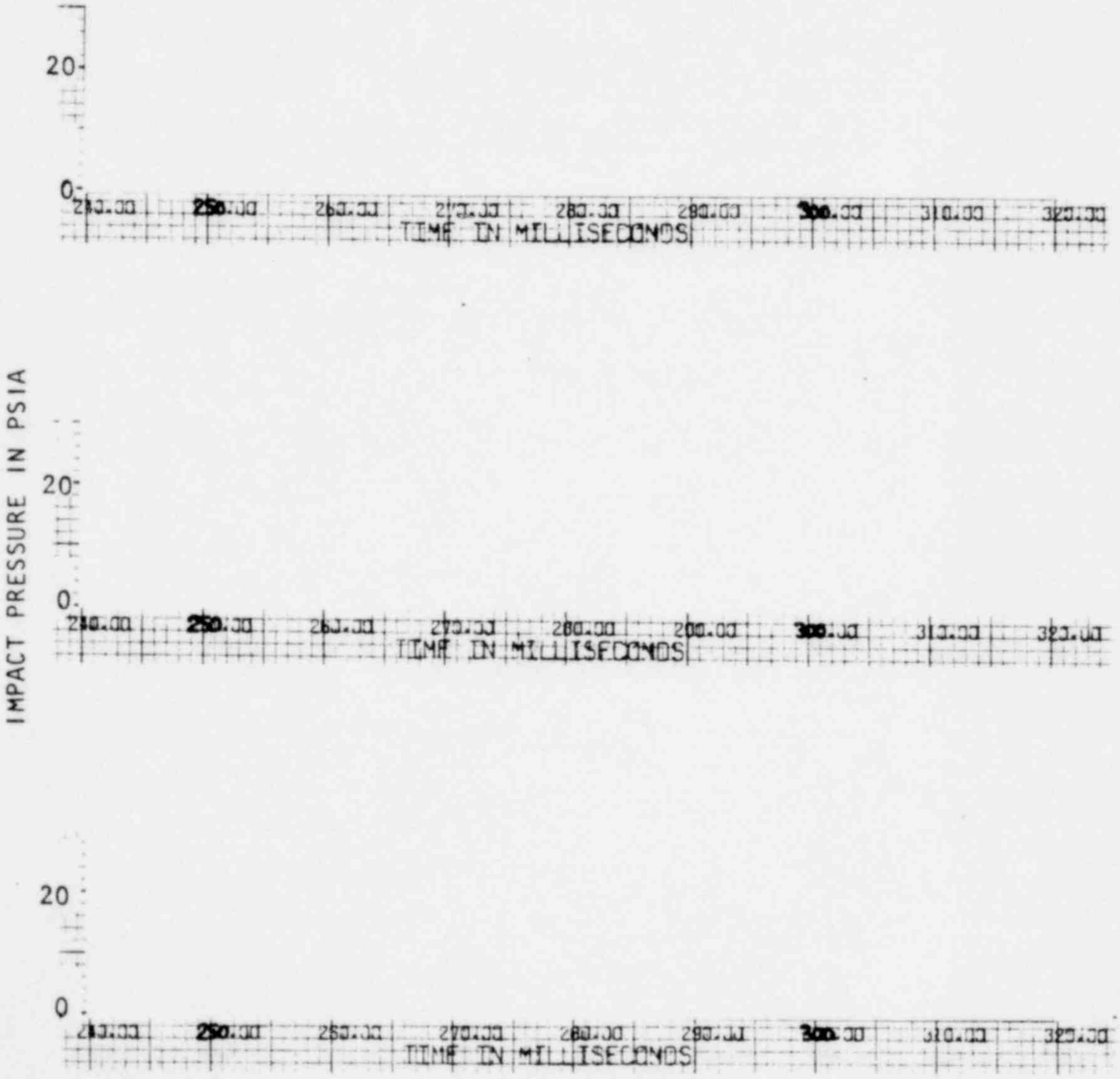


FIGURE A-183

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Duane Arnold Test 5



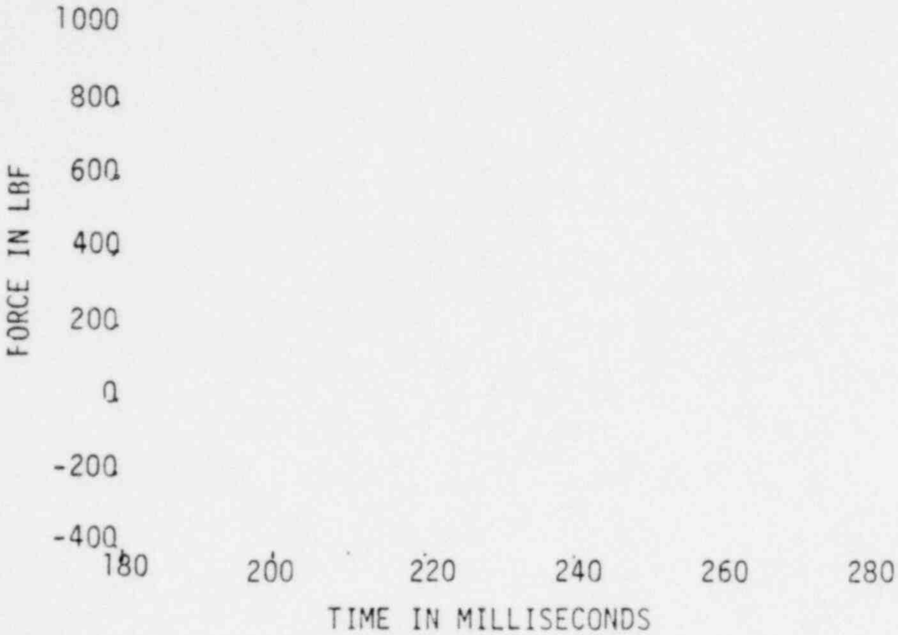
1348 346

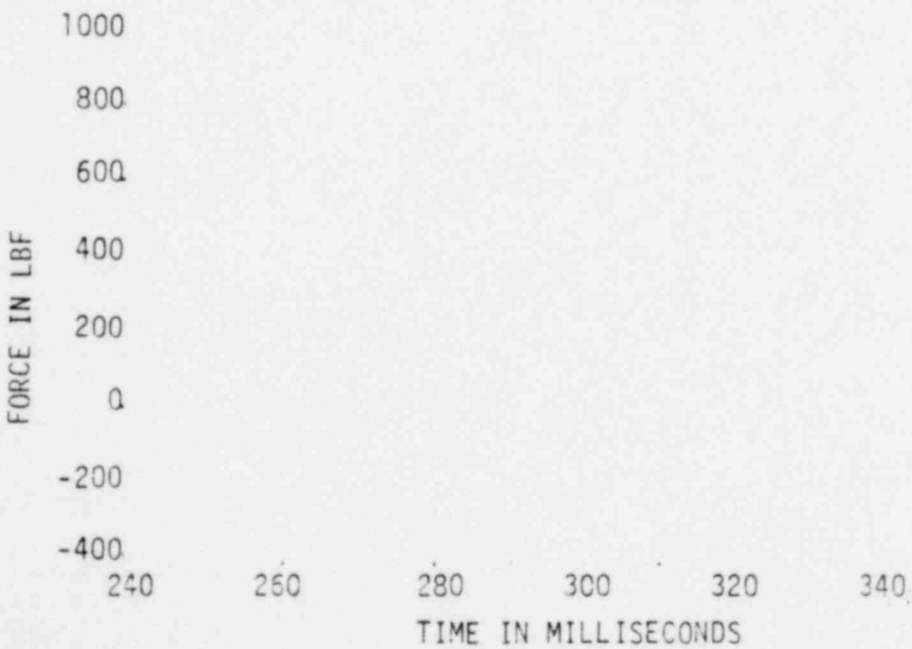
FIGURE A-184

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Duane Arnold Tests 3, 5



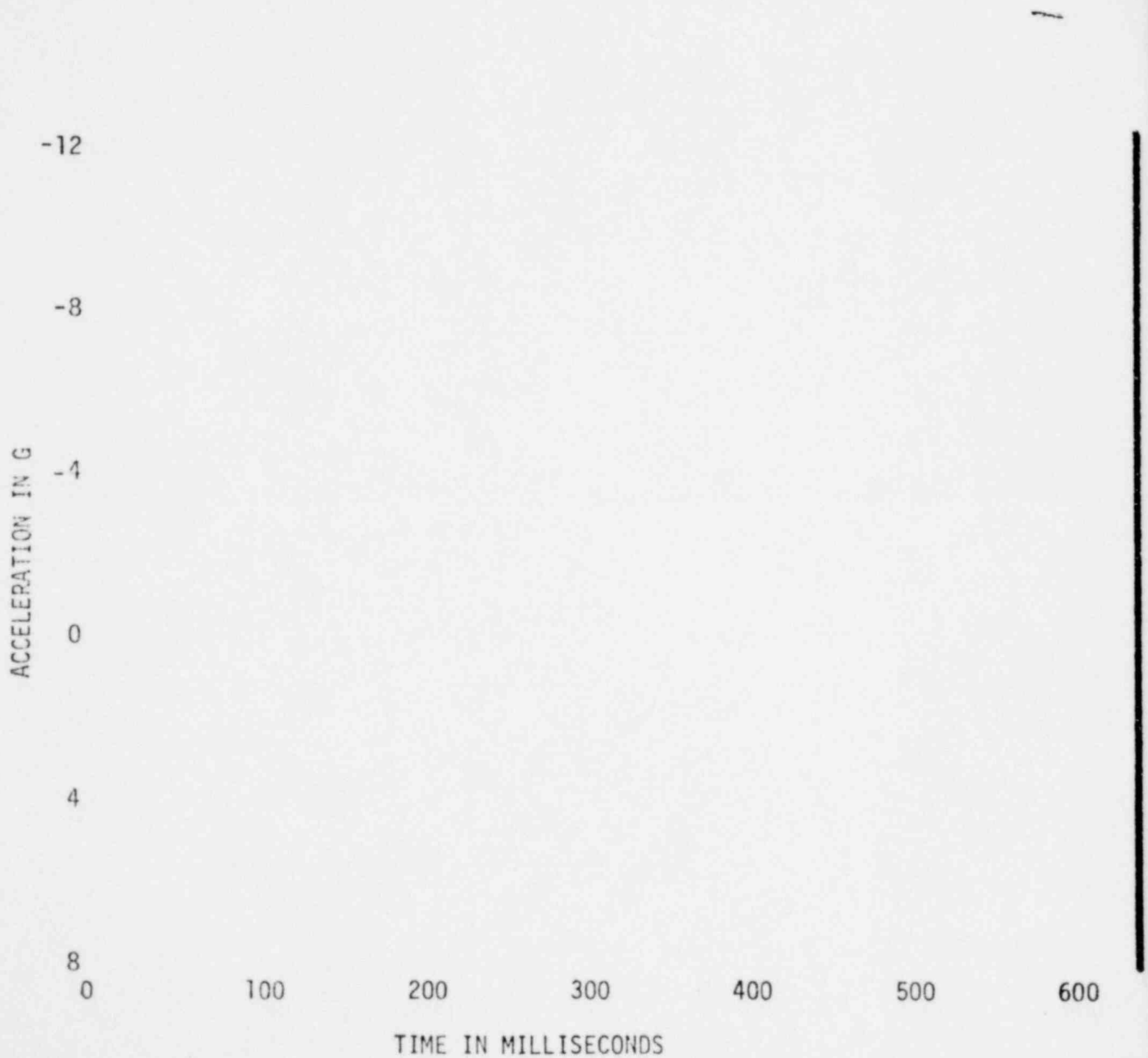


1348 347

FIGURE A-185

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Duane Arnold Test 3

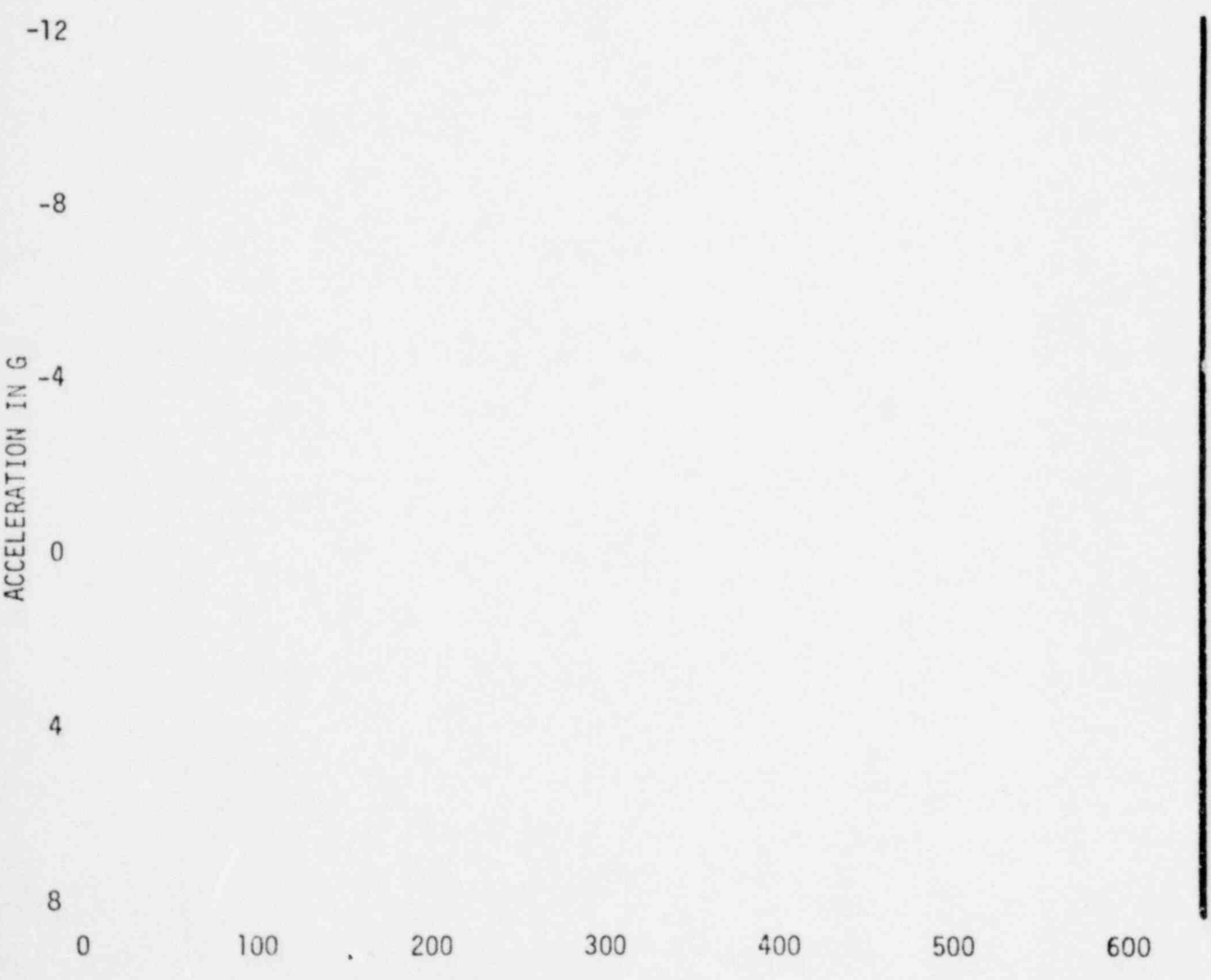


1348 348

FIGURE A-186

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Duane Arnold Test 5

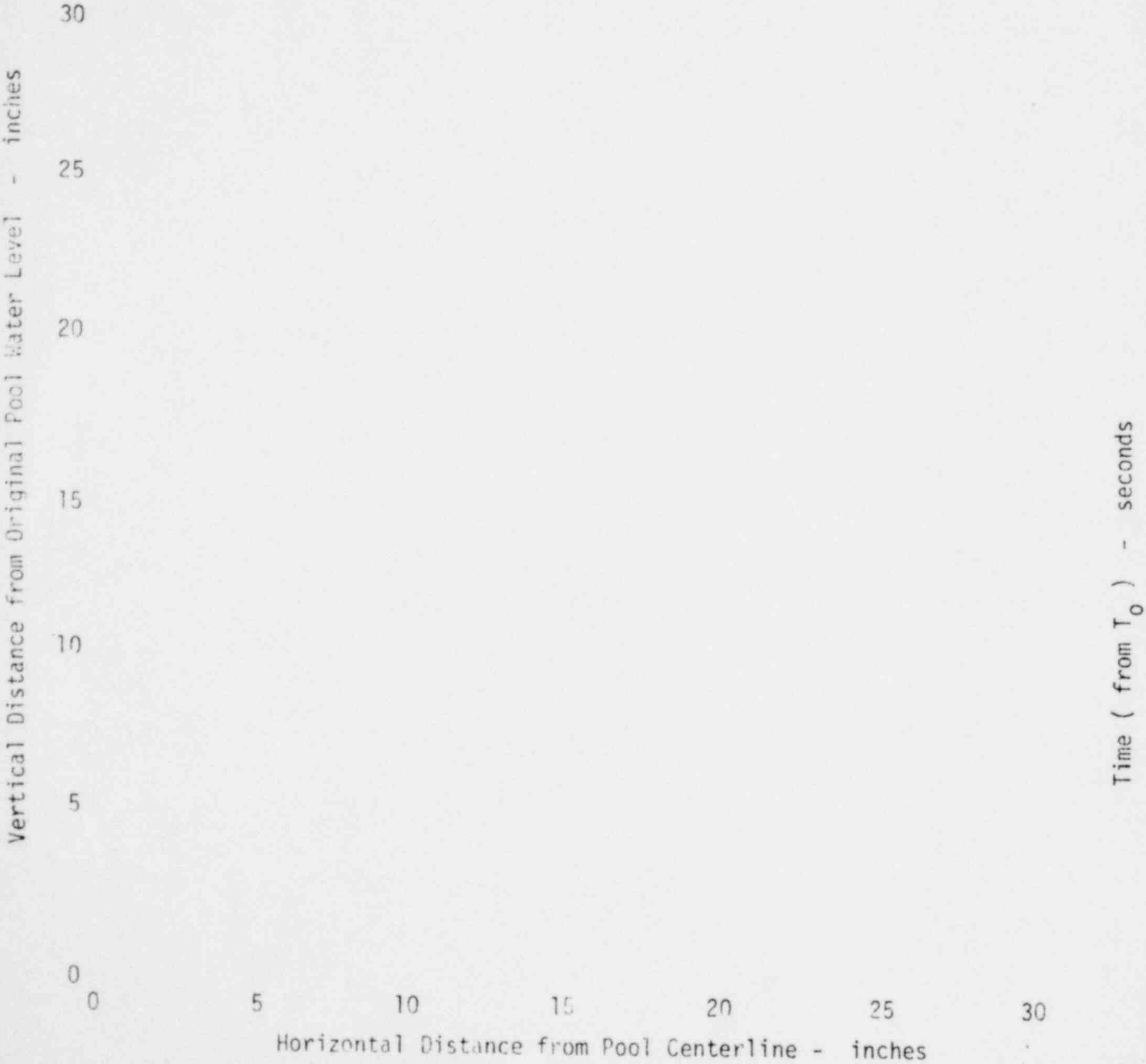


1348 349

FIGURE A-1[illegible]7

TIME HISTORY OF
POOL DISPLACEMENT

DUANE ARNOLD, TEST 1



1348 350

FIGURE A-188

TIME HISTORY OF
POOL DISPLACEMENT

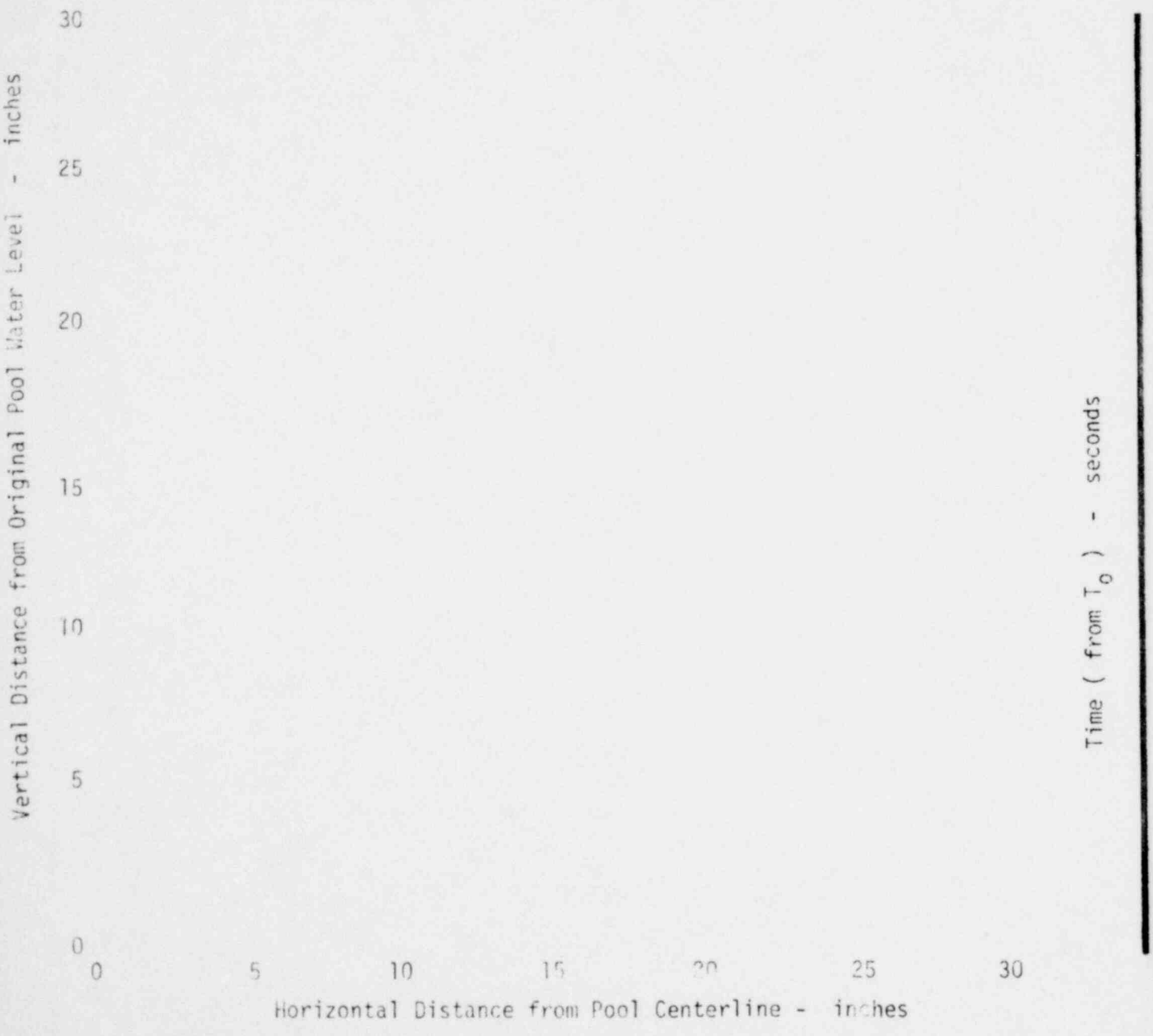
DUANE ARNOLD, TEST 2

1348 351

FIGURE A-189

TIME HISTORY OF
POOL DISPLACEMENT

DUANE ARNOLD, TEST 3

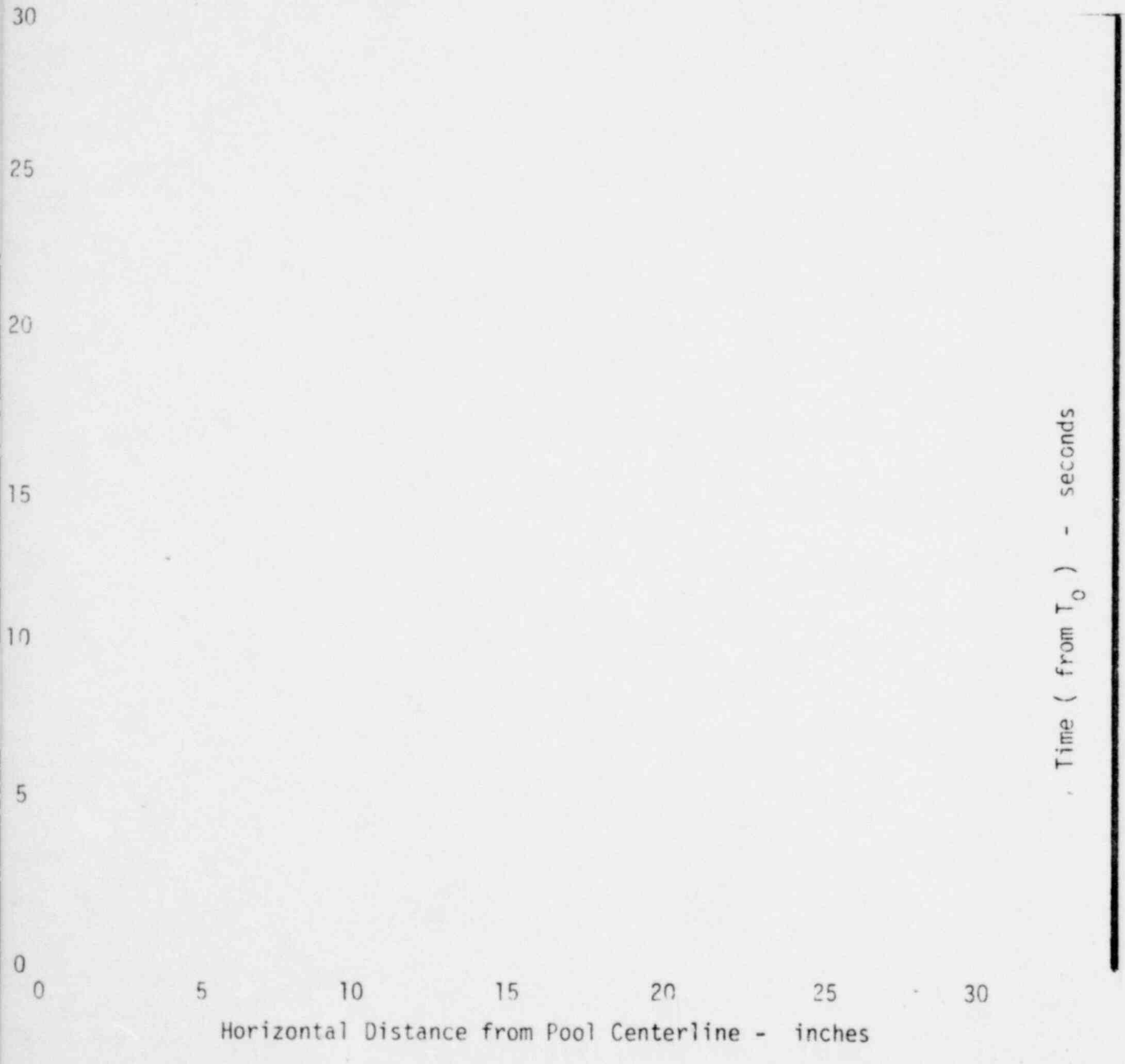


1348 352

FIGURE A-190

TIME HISTORY OF
POOL DISPLACEMENT

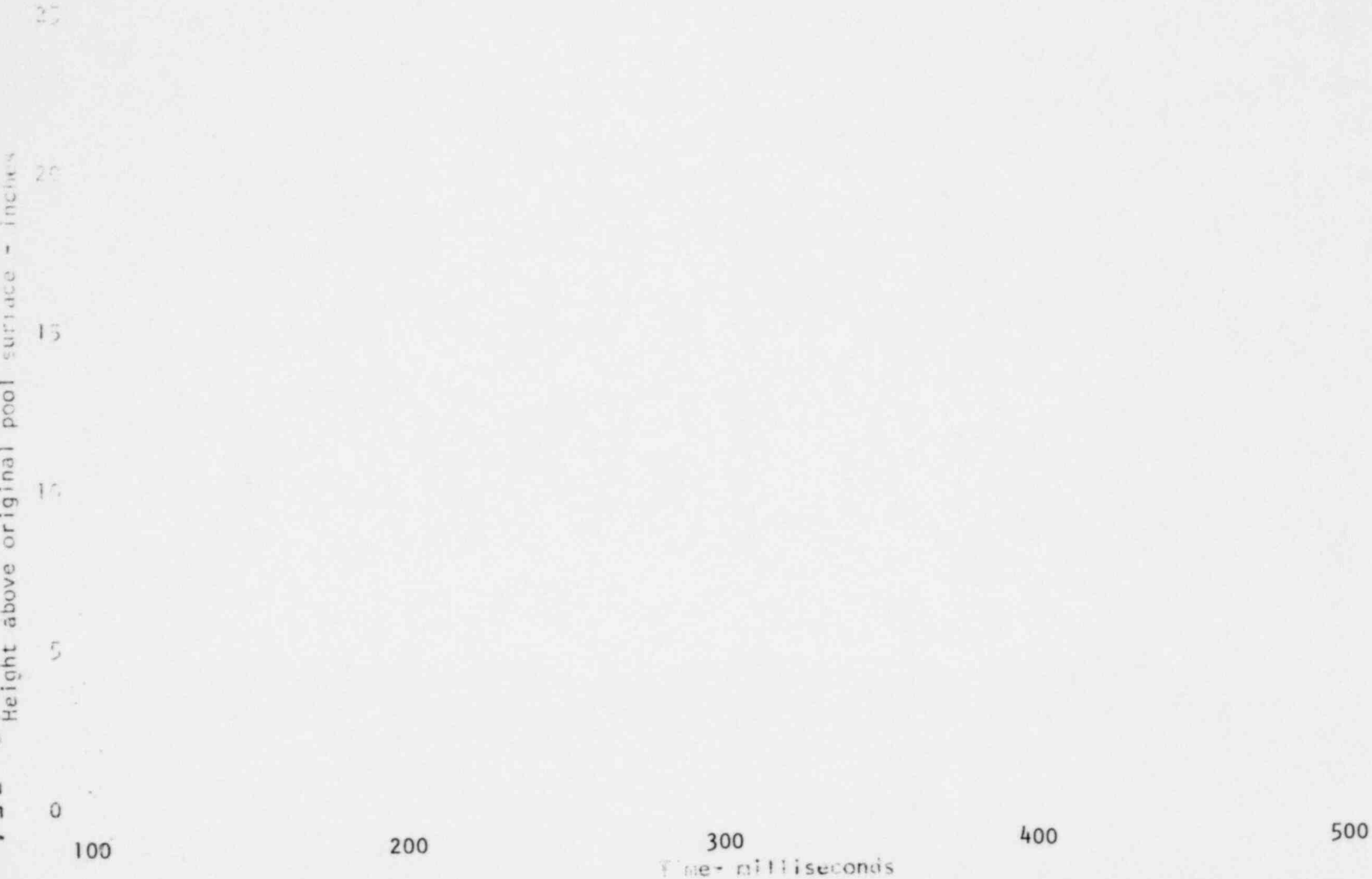
DUANE ARNOLD, TEST 5



1348 353

FIGURE A-191 POOL SURFACE DISPLACEMENT

DUANE ARNOLD, TESTS 1, 2, 3



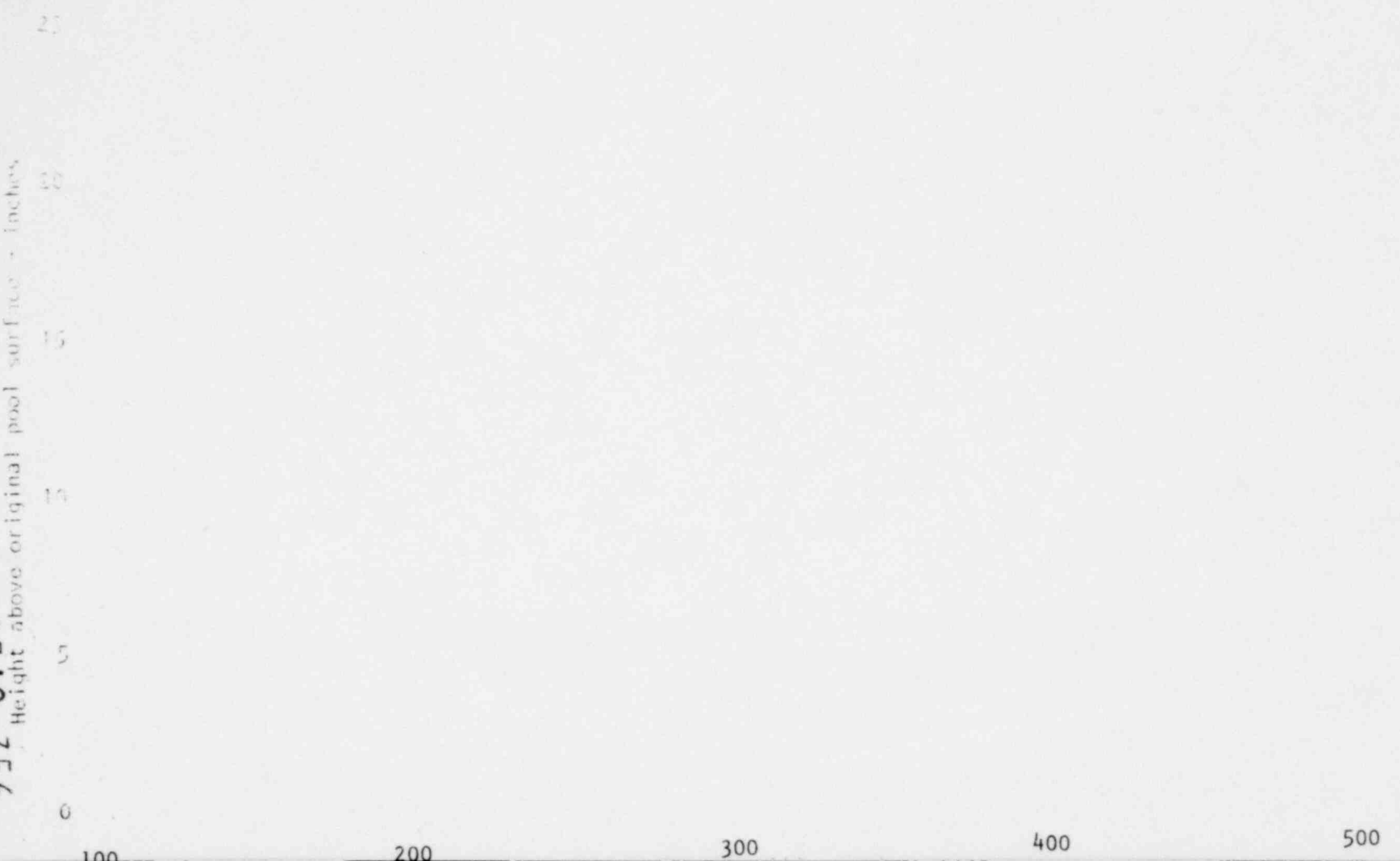
1348 354

DUANE ARNOLD, TESTS 1, 2, 3

1348 355

FIGURE A-193 POOL SURFACE DISPLACEMENT

DUANE ARNOLD, TEST 5



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1348 356

DUANE ARNOLD, TEST 5

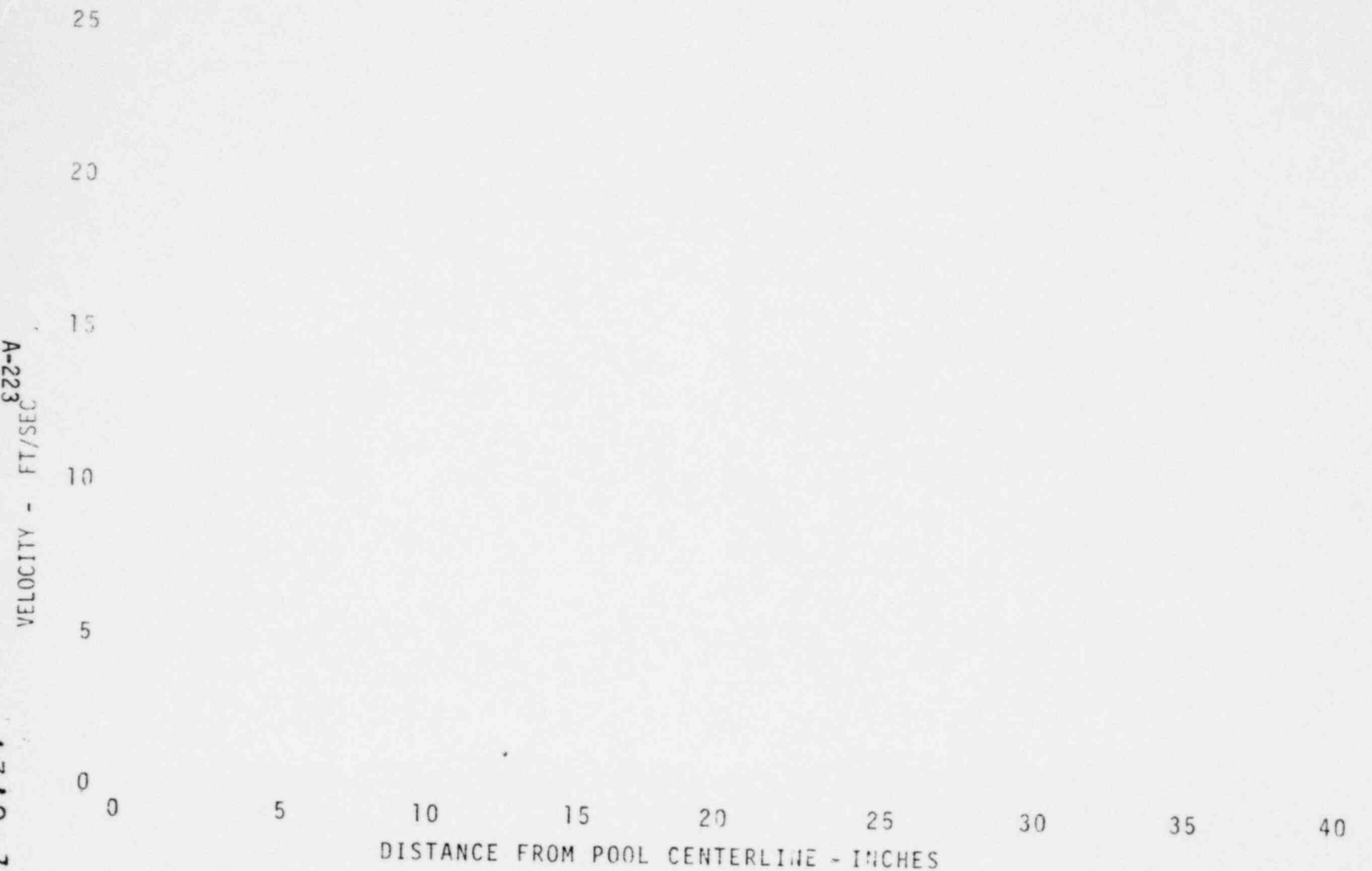


FIGURE A-195 SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

DUANE ARNOLD, TEST 4

VERTICAL DISPLACEMENT - INCHES

8

4

0

-4

-8

150 250 350 450

VERTICAL VELOCITY -FT/SEC

15.

10.

5.

0.

150 250 350 450

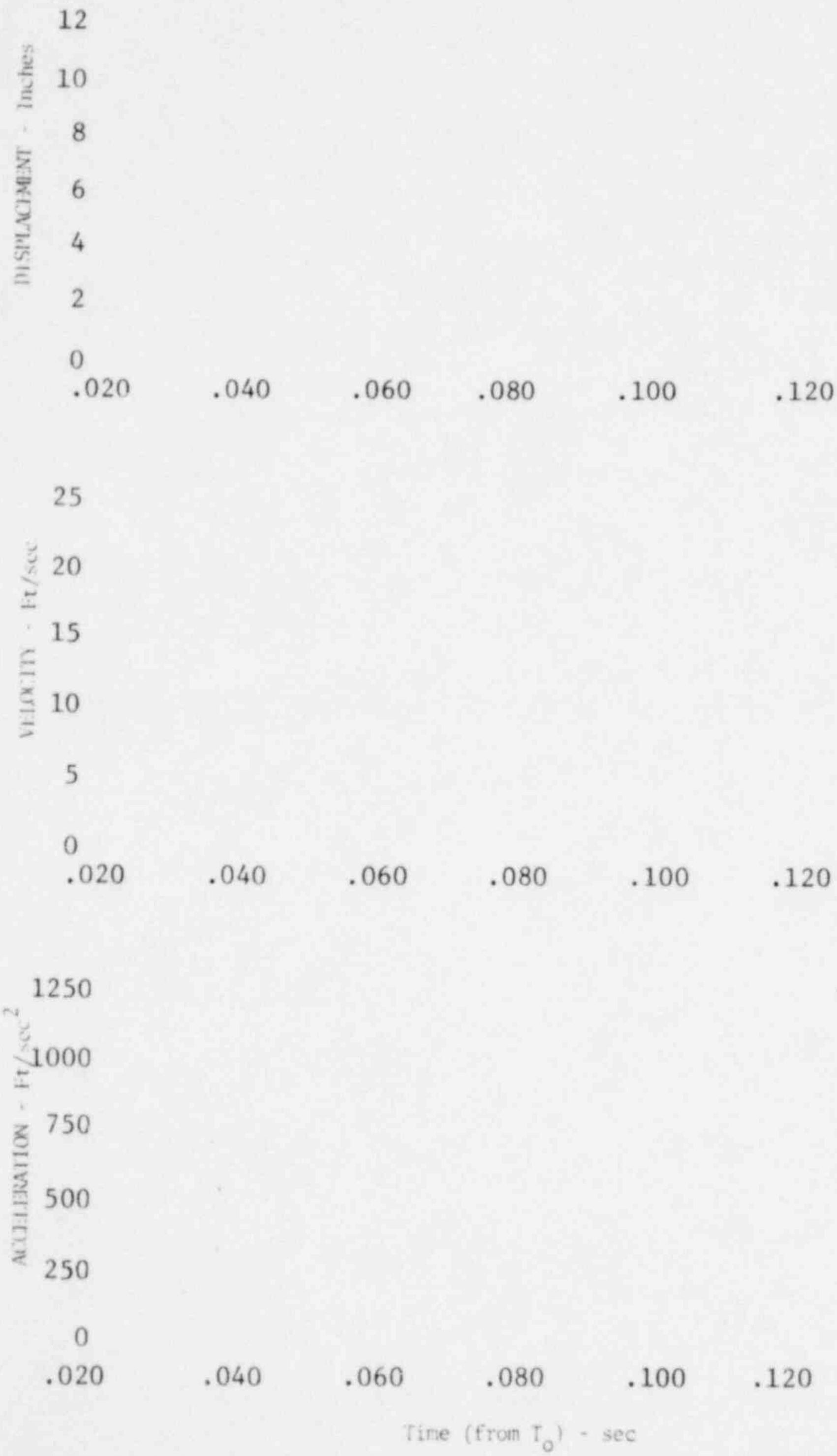
TIME - Seconds

1348 358

FIGURE A-196

DOWNCOMER WATER SLUG EJECTION

DUANE ARNOLD, TEST 3



1348 359

FIGURE A-197

DOWNCOMER WATER SLUG EJECTION

DUANE ARNOLD, TEST 5

DISPLACEMENT - Inches

12
10
8
6
4
2
0

.080 .100 .120 .140 .160 .180

VELOCITY - Ft/sec

25
20
15
10
5
0

.080 .100 .120 .140 .160 .180

ACCELERATION - Ft/sec^2

1250
1000
750
500
250
0

.080 .100 .120 .140 .160 .180

Time (from T_o) - sec

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

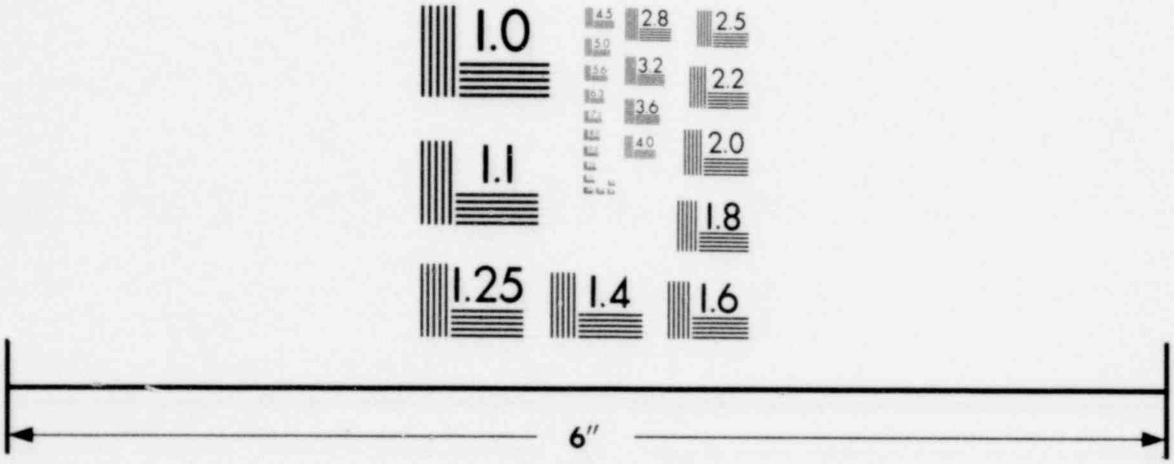
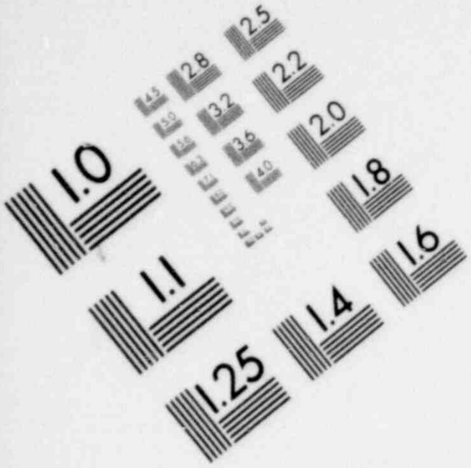


IMAGE EVALUATION
TEST TARGET (MT-3)

6″



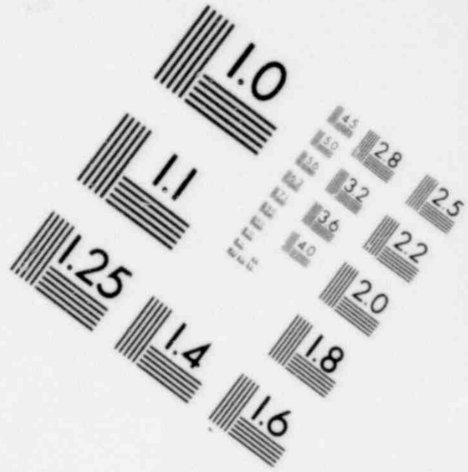
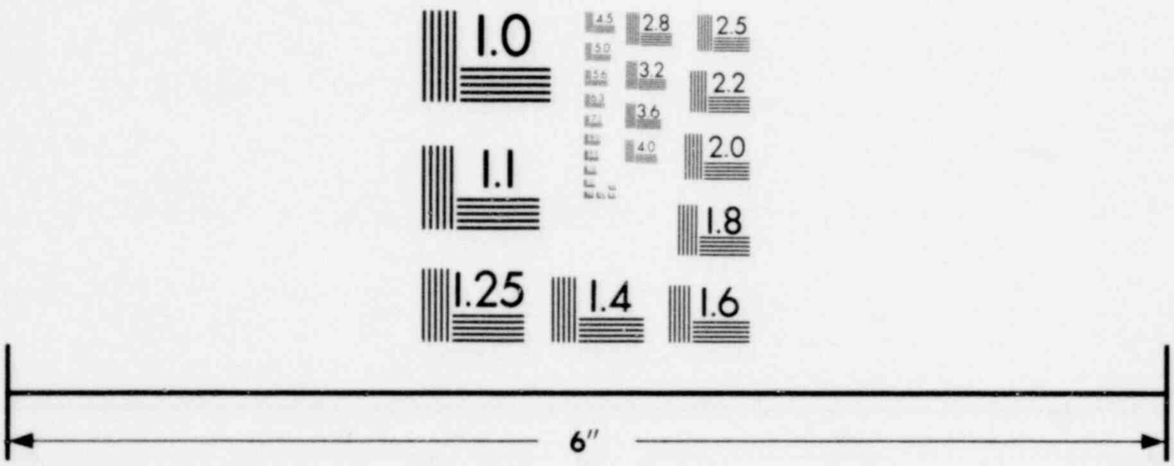
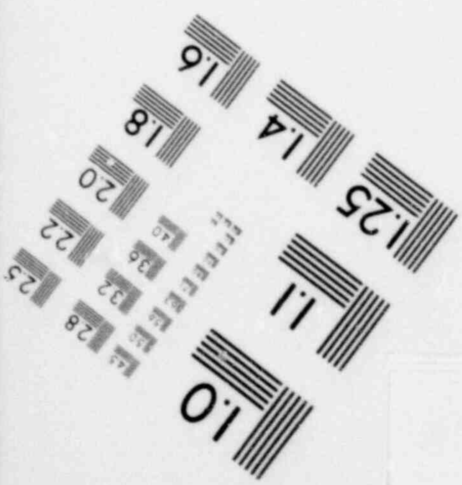


**IMAGE EVALUATION
TEST TARGET (MT-3)**





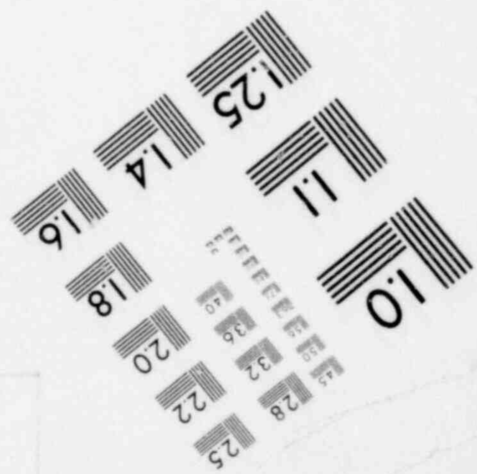
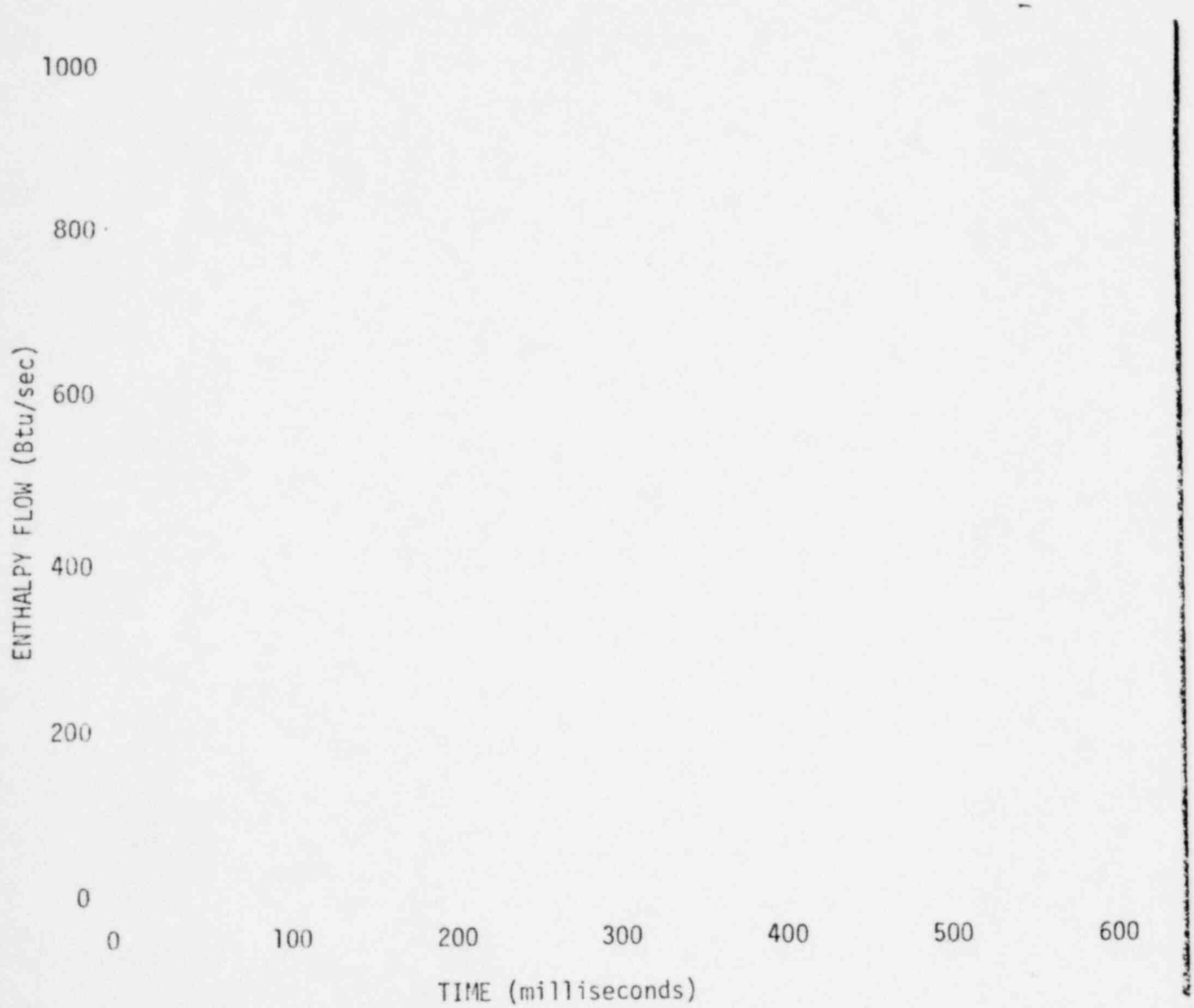


FIGURE A-198

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Duane Arnold Tests



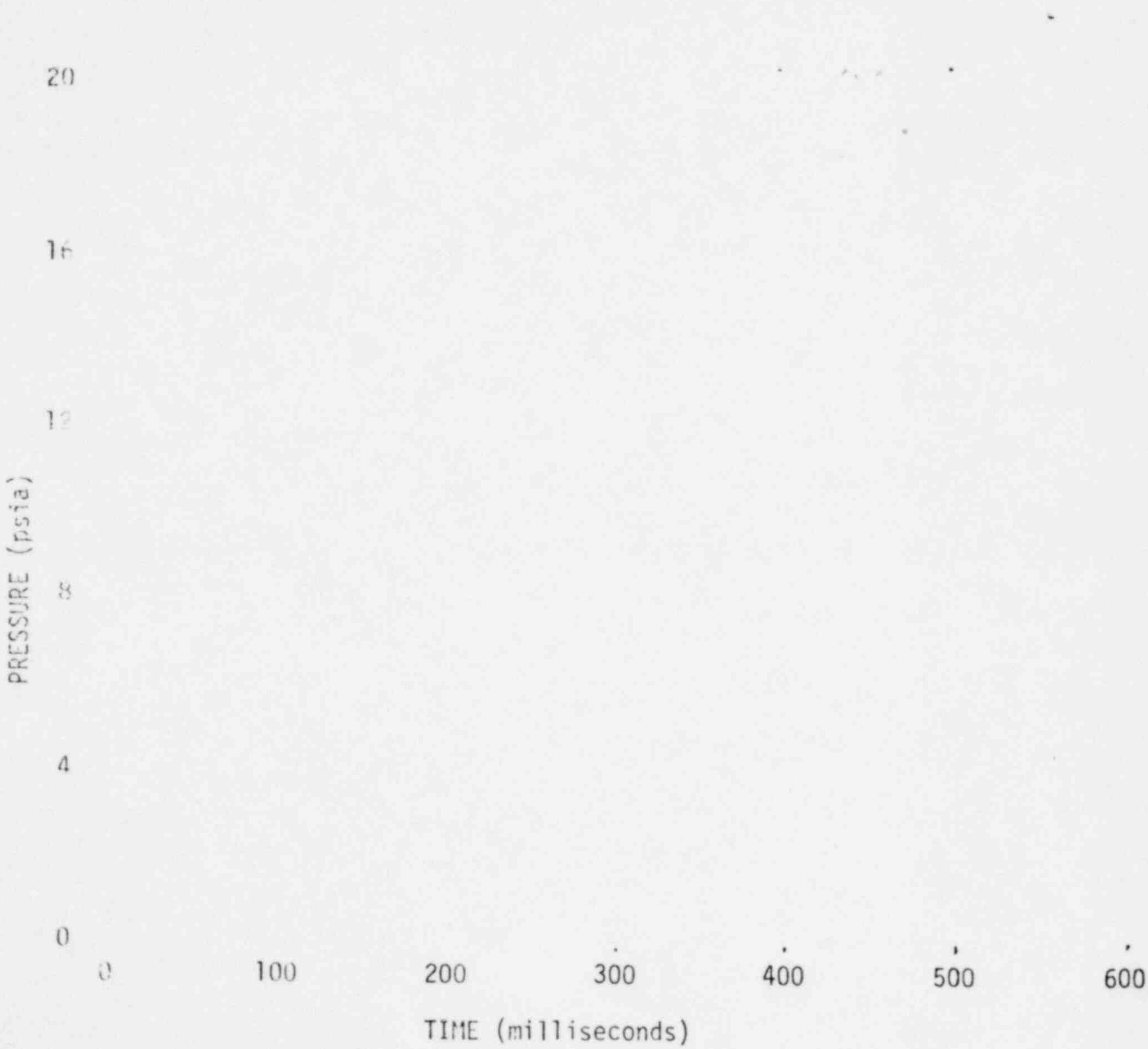
1349 001

FIGURE A-199

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Duane Arnold Tests



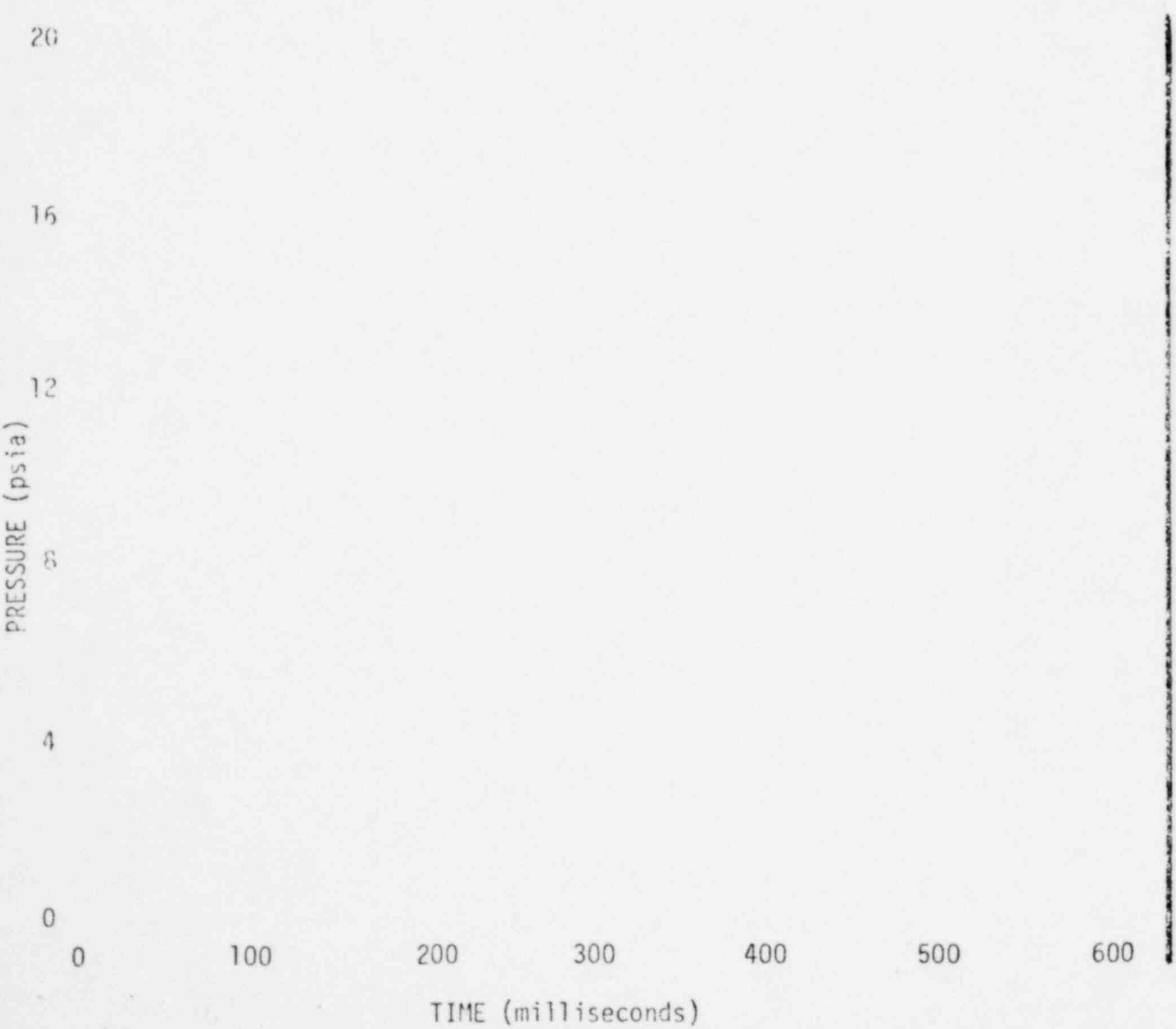
1349 002

FIGURE A-200

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Duane Arnold Tests



1349 003

*Vent clearing time (from T_o) determin from the movie films.
**Time difference from T_o to time of zero downforce.
- No significant downforce valley or 2nd peak downforce
*(1)Start-of-test reference time

TABLE A-9
DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Duane Arnold Tests

Parameter \ Test No.		9.19" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o *(1)	(sec)							
Vent Clearing Time*	(sec)							
Peak Downforce								
Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
Downforce Valley								
Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
2nd Peak Downforce								
Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
Corrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
[Δt] Downforce Time**								
Pressure Integral	(sec)							
Corrected Pressure Integral	(sec)							
Corrected Load Cell	(sec)							
Downforce Impulse								
Pressure Integral:								
Impulse	(lb-sec)							

1349 004

*Time at force is zero (from T_o)

TABLE A-9 (continued)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Duane Arnold Tests

Parameter \ Test No.	9.19" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Upforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Zero Force Time*							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							

1349 005

TABLE A-10

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Duane Arnold Tests

Parameter \ Test No.		9.19" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o †	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected: ††								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*(2) Offset 6" from pool centerline
* Based on impact pressure measurements
** At start of the first impact pressure recorded
† Start of reference time
†† represents peak of very noisy data (acceleration corrected); mean value would be lower

1349 006

A.5 Nine Mile Point Tests

A.5.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Nine Mile Point Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 7.94" ΔP and with a 4.59 inch pipe deflector (16 inch full scale). Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 4.59 inch pipe deflector.

A.5.1.1 Driving Conditions

Driving conditions for Nine Mile Point Test 3 are presented in Figures A-201 through A-205. Similar plots for Nine Mile Point Test 5 are shown in Figures A-206 through A-210. Nine Mile Point's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

It can be seen that the downcomer orifice upstream temperature starts to drop at about 200 milliseconds in Figure A-204 and about 185 milliseconds in Figure A-209. This is the result of the condensate, which formed in the drywell during the pretest pump-down period, dripping into the downcomer and wetting the thermocouple. The corrected vent air temperature, which was based on the normal temperature runs, is shown by dash line (Figures A-204 and A-209). Correction of the air temperature on enthalpy flow into pool is negligibly small. Before the last series of the plant unique tests were conducted (August to October 1978), the thermocouple was moved up into the vent header and near the downcomer inlet. This resulted in good vent air temperature measurement.

1349 007

A.5.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Nine Mile Point Tests 3 and 5 are presented in Figures A-211 through A-212 and A-213 through A-214, respectively. Several spikes can be observed in one of the freespace pressures at about 400 and 565 milliseconds (Figure A-212). These spikes were caused by water splashing on the transducer, which is mounted on the top of the torus (airspace).

Figures A-215 and A-216 present net torus force based on the torus pressure integral for Nine Mile Point Tests 3 and 5, respectively. Some downforce oscillations are present, but they dampen out rapidly after the first oscillation. During the Nine Mile Point Test 3, one of the two freespace pressure transducers was splashed with water. When the outputs of both the freespace transducers are used with the pool transducer outputs to obtain net torus force, an erroneous force peak is produced at the time splashing occurs. When only that transducer which was not splashed is used to obtain net torus force, a much smoother and more accurate force-time history is obtained (Figure A-215).

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-218 and A-220) to the torus load cell (Figures A-217 and A-219) is compared with the torus force obtained from the torus pressure integral in Figures A-221 and A-222. Residual oscillations are present in the corrected load cell. Figures A-223 and A-224 present the net torus force based on the torus pressure integral corrected for inertia.

The "average" pool pressures for Nine Mile Point Tests 3 and 5 are shown in Figures A-225 and A-227. Figures A-226 and A-228 are the same as Figures A-223 and A-224 with force replaced by average pressure (force/torus projected area).

1349 008

The vent header impact pressures for Nine Mile Point Test 3 are presented in Figures A-229 through A-232. Vent header pressures for Nine Mile Point Test 5 are presented in Figures A-233 through A-236. These figures indicate that the deflector was effective in reducing the peak local vent header impact pressure.

Figure A-237 presents a comparison of the vent header impact force derived from the pressure integral with that derived from the corrected load cell. Vent header vertical accelerations from Tests 3 and 5 are shown in Figures A-238 and A-239, respectively.

A.5.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-240 through A-243 for Nine Mile Point Tests 1, 2, 3, and 5.

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-244. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-245. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-246 and A-247, respectively.

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-248. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-249 and 250.

A.5.3 Data Summaries

Table A-11 presents the Nine Mile Point Test Data for wetwell vertical forces.

Table A-12 presents the Nine Mile Point test data for vent header impact forces.

1349 009

A.5.4 Discussion and Analysis

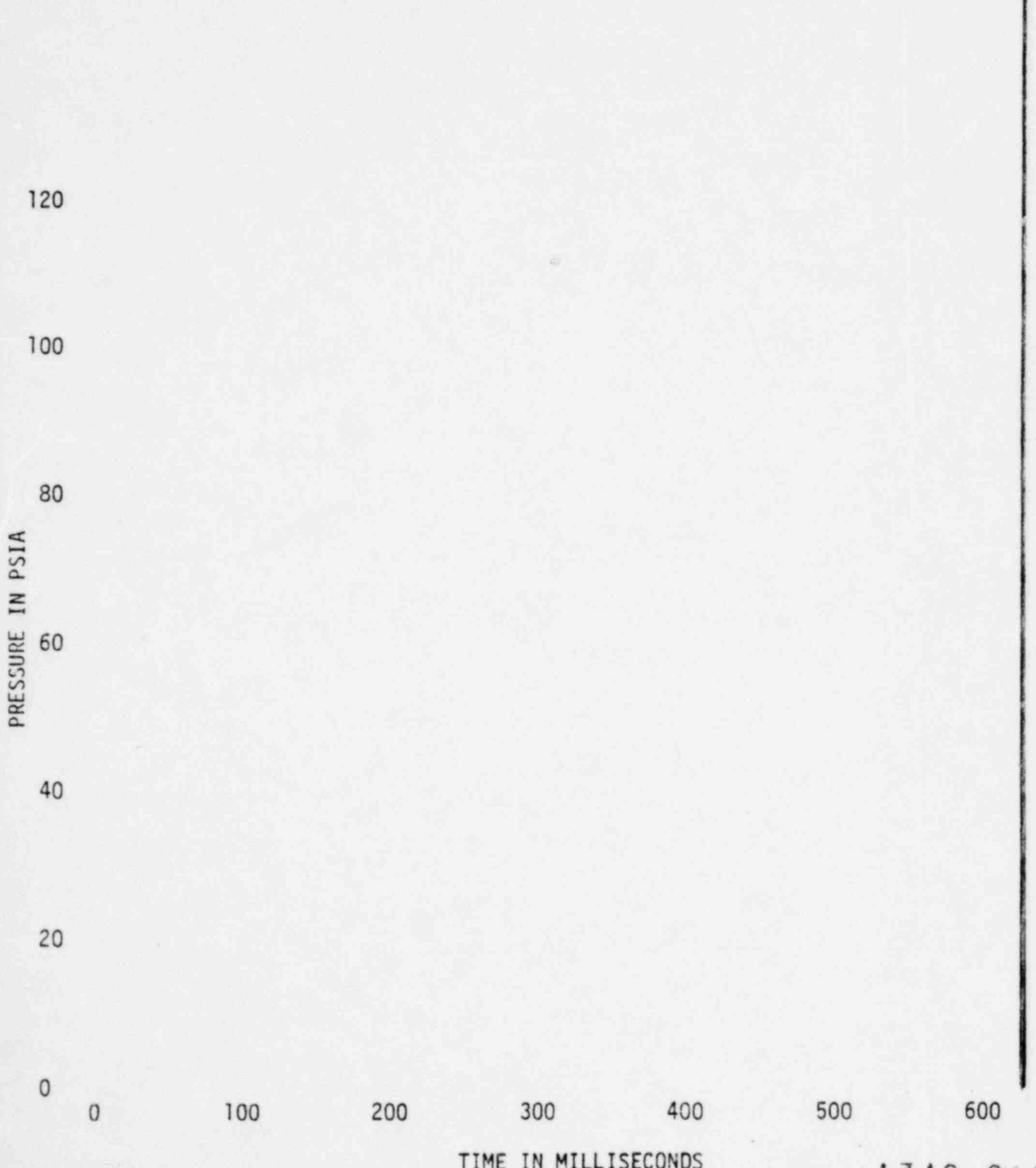
Figure A-251 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-252. Figure A-253 presents the effect of drywell/wetwell on pool and freespace pressures. The data for Nine Mile Point parallels that for the "typical" plant in Section 3.0.

The Nine Mile Point load definition tests were conducted at 7.94" H_2O ΔP and with a pipe deflector installed below the vent header. A ΔP sensitivity test at 0" H_2O ΔP was also conducted. Some downforce oscillations were evident. The upforce was relatively smooth. Since the pipe deflector was close to the pool water level, the deflector was less effective in reducing the vent header impact force.

FIGURE A-201

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Nine Mile Point Test 3

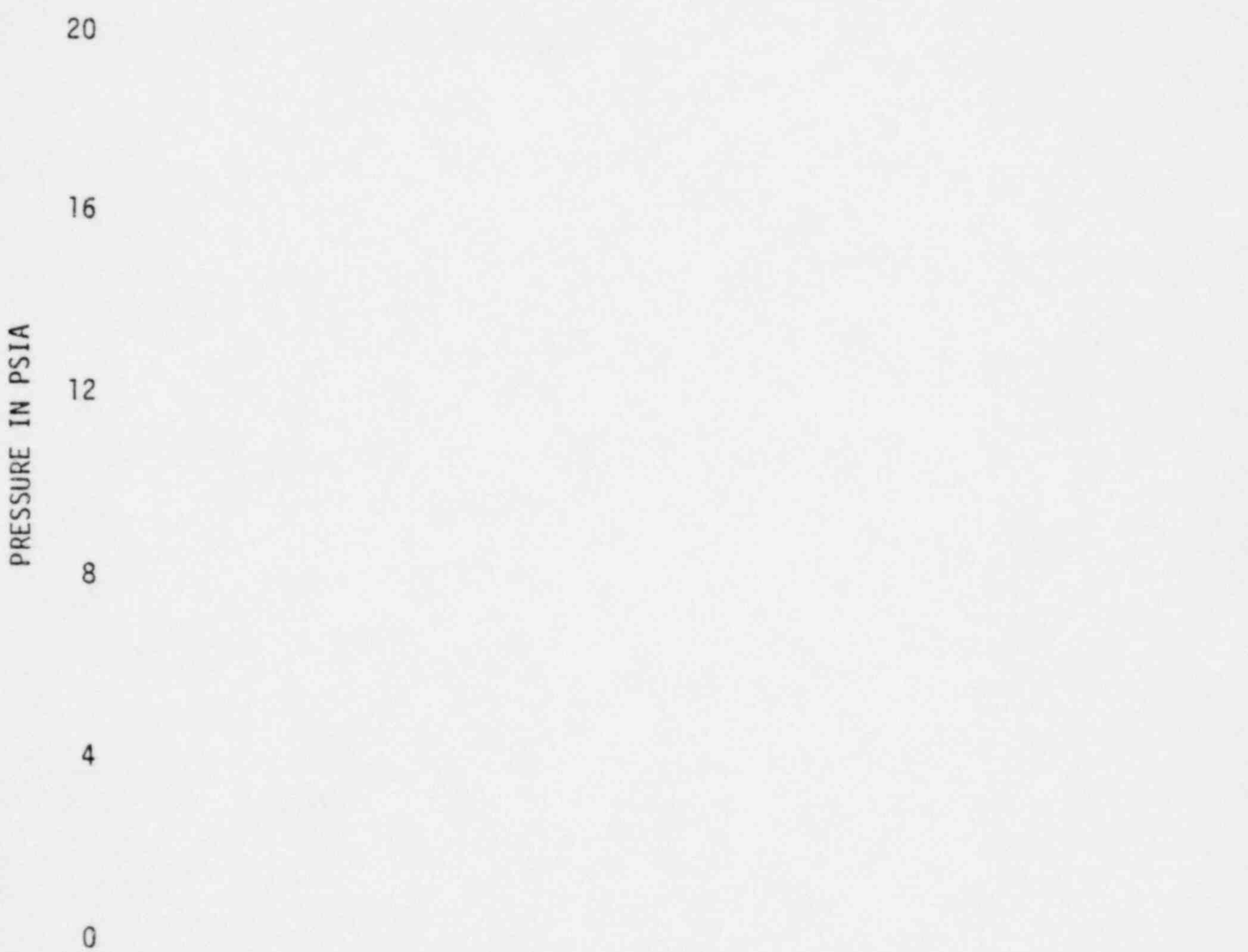


1349 011

FIGURE A-202

DRYWELL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 3

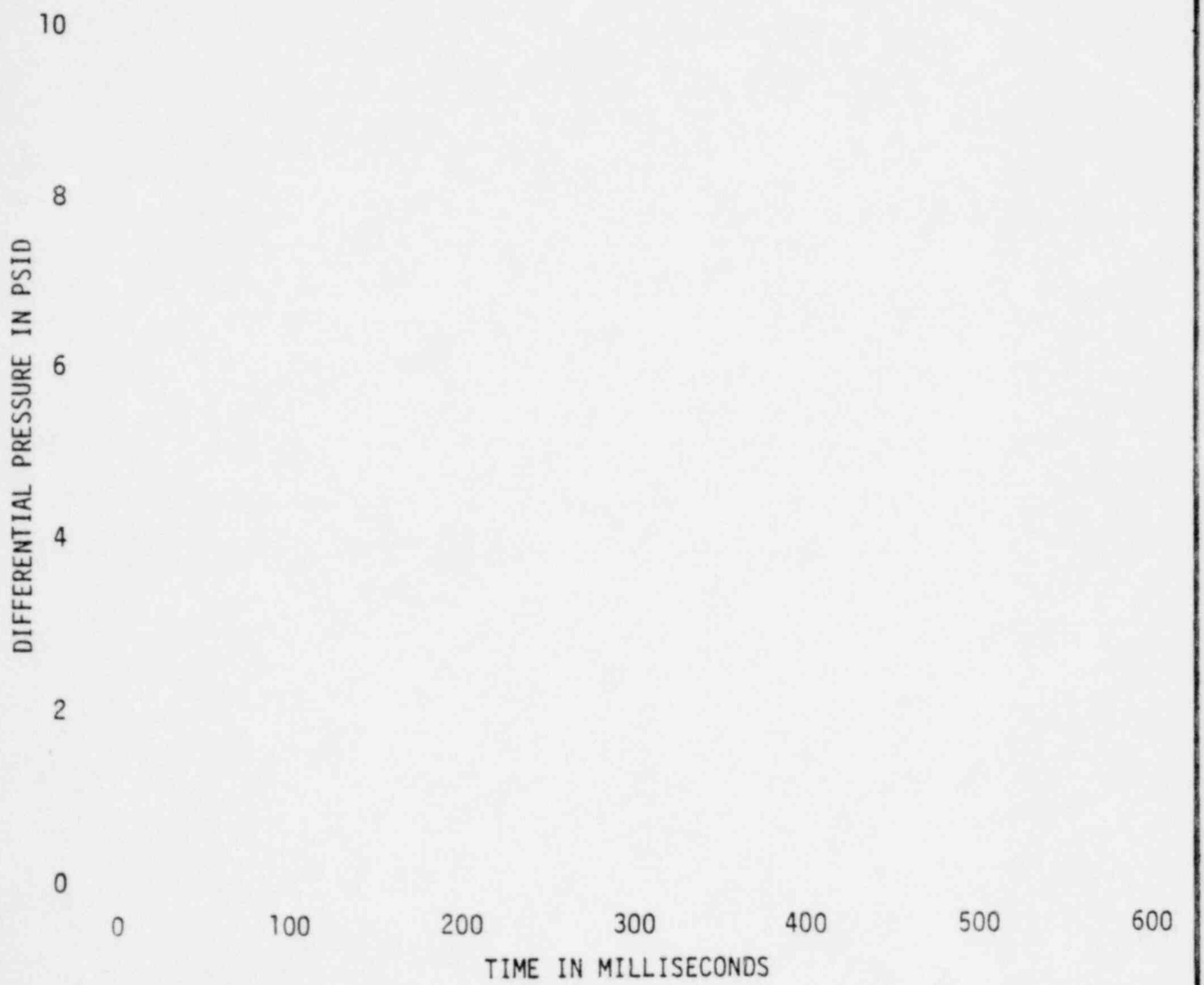


1349 012

FIGURE A-203

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 3

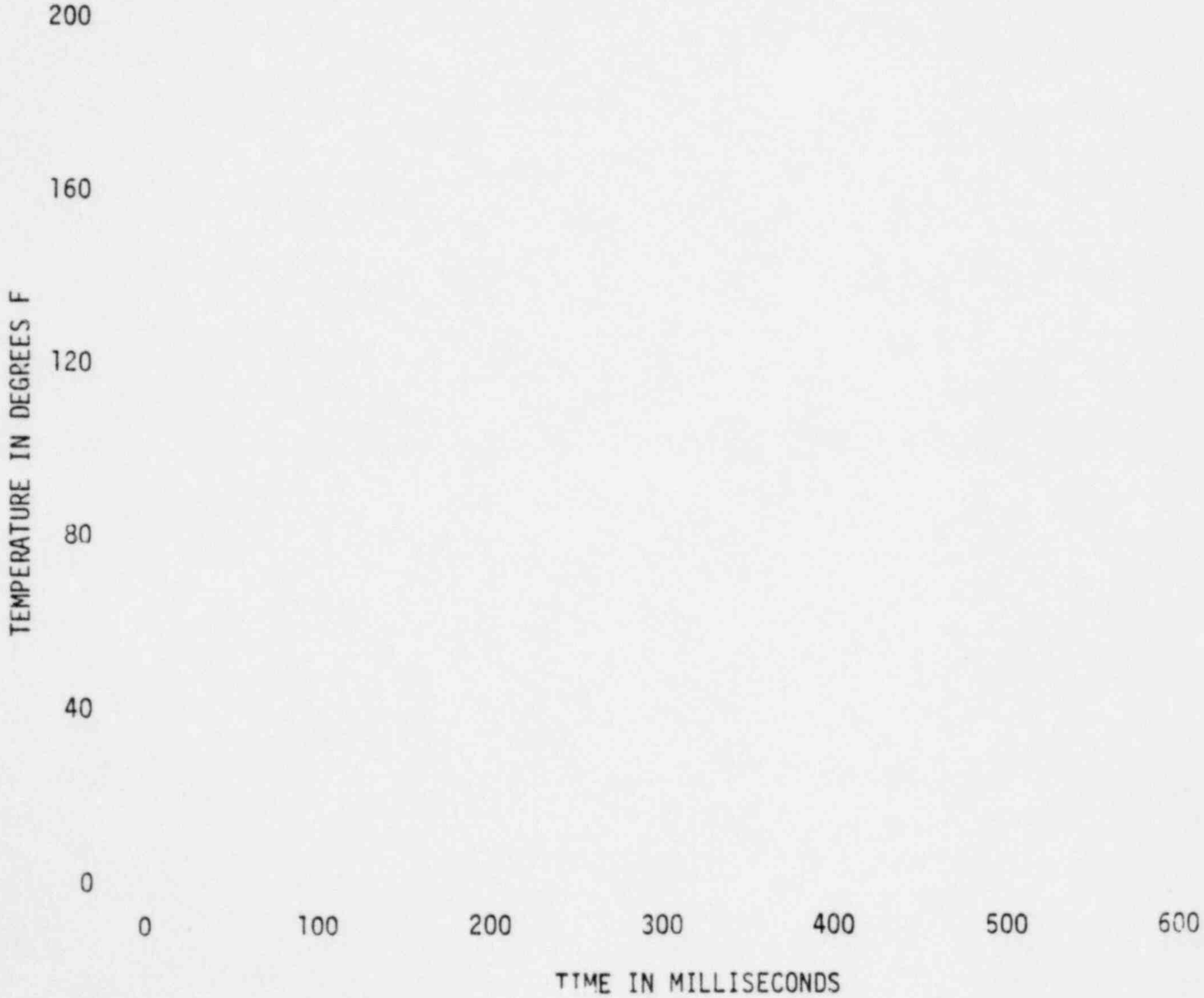


1349 013

FIGURE A-204

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Nine Mile Point Test 3

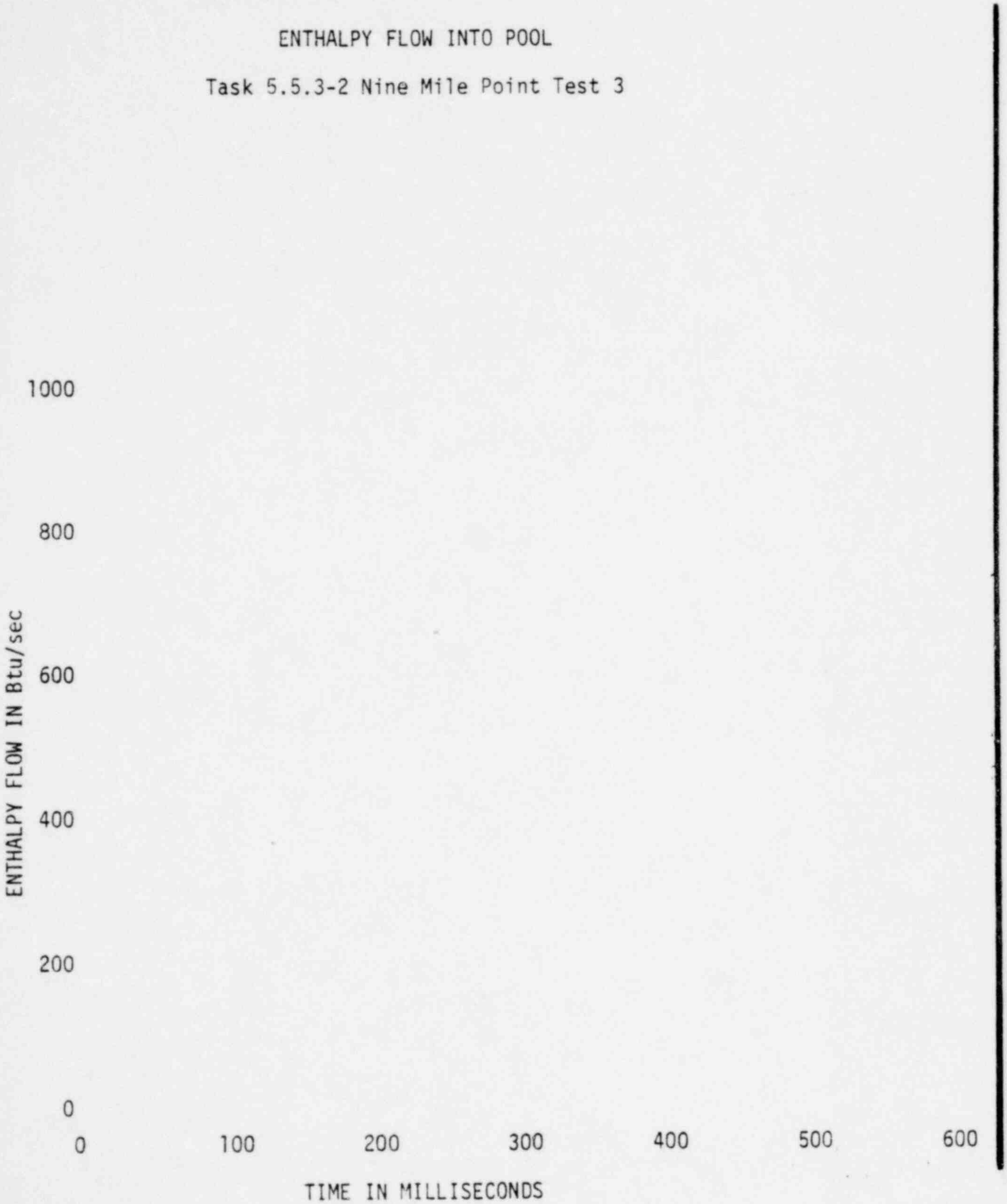


1349 014

FIGURE A-205

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Nine Mile Point Test 3



1349 015

FIGURE A-206

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Nine Mile Point Test 5

PRESSURE IN PSIA

120

100

80

60

40

20

0

0 100 200 300 400 500 600

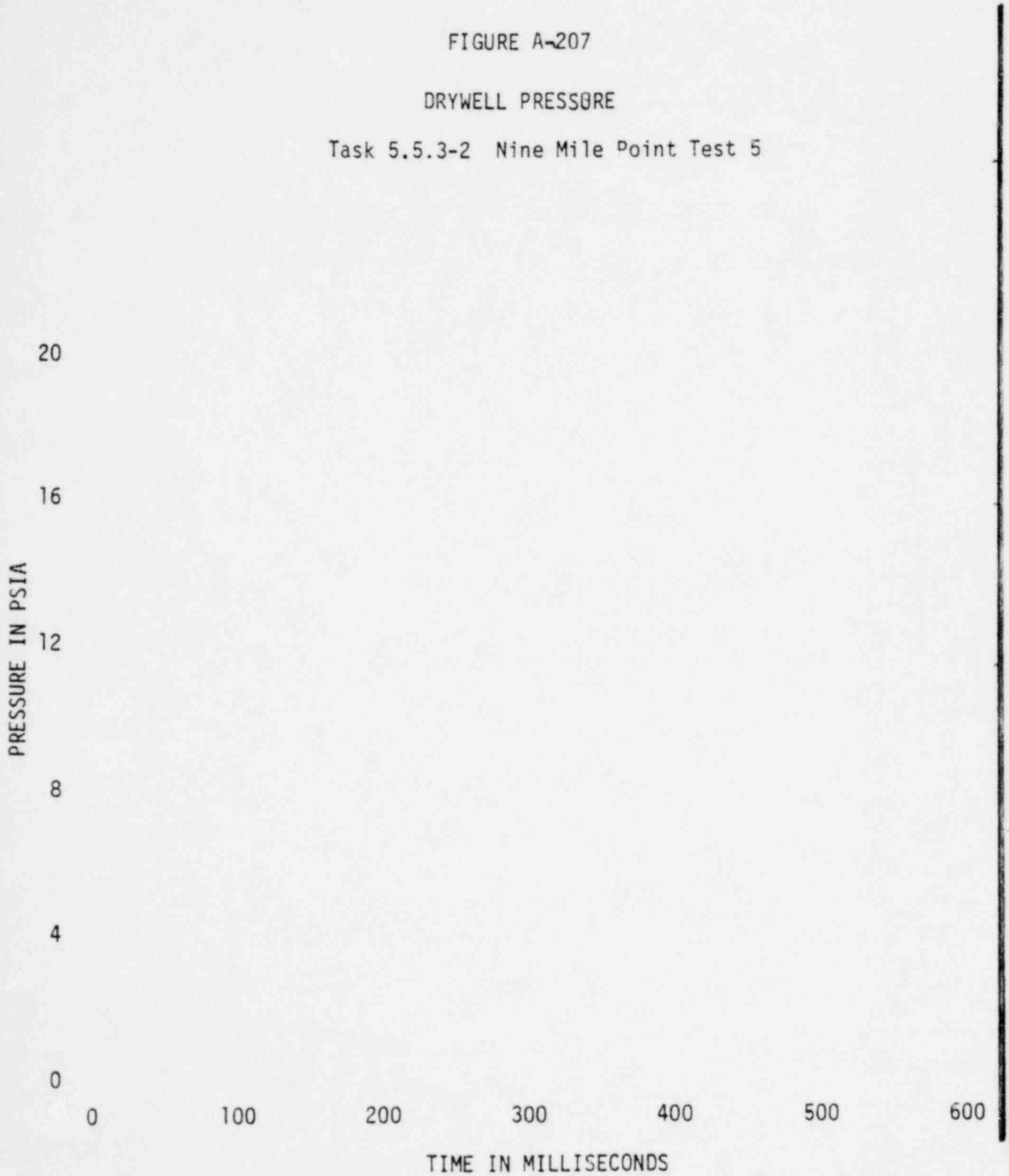
TIME IN MILLISECONDS

1349 016

FIGURE A-207

DRYWELL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 5



1349 017

FIGURE A-208

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 5

DIFFERENTIAL PRESSURE IN PSID

10

8

6

4

2

0

0 100 200 300 400 500 600

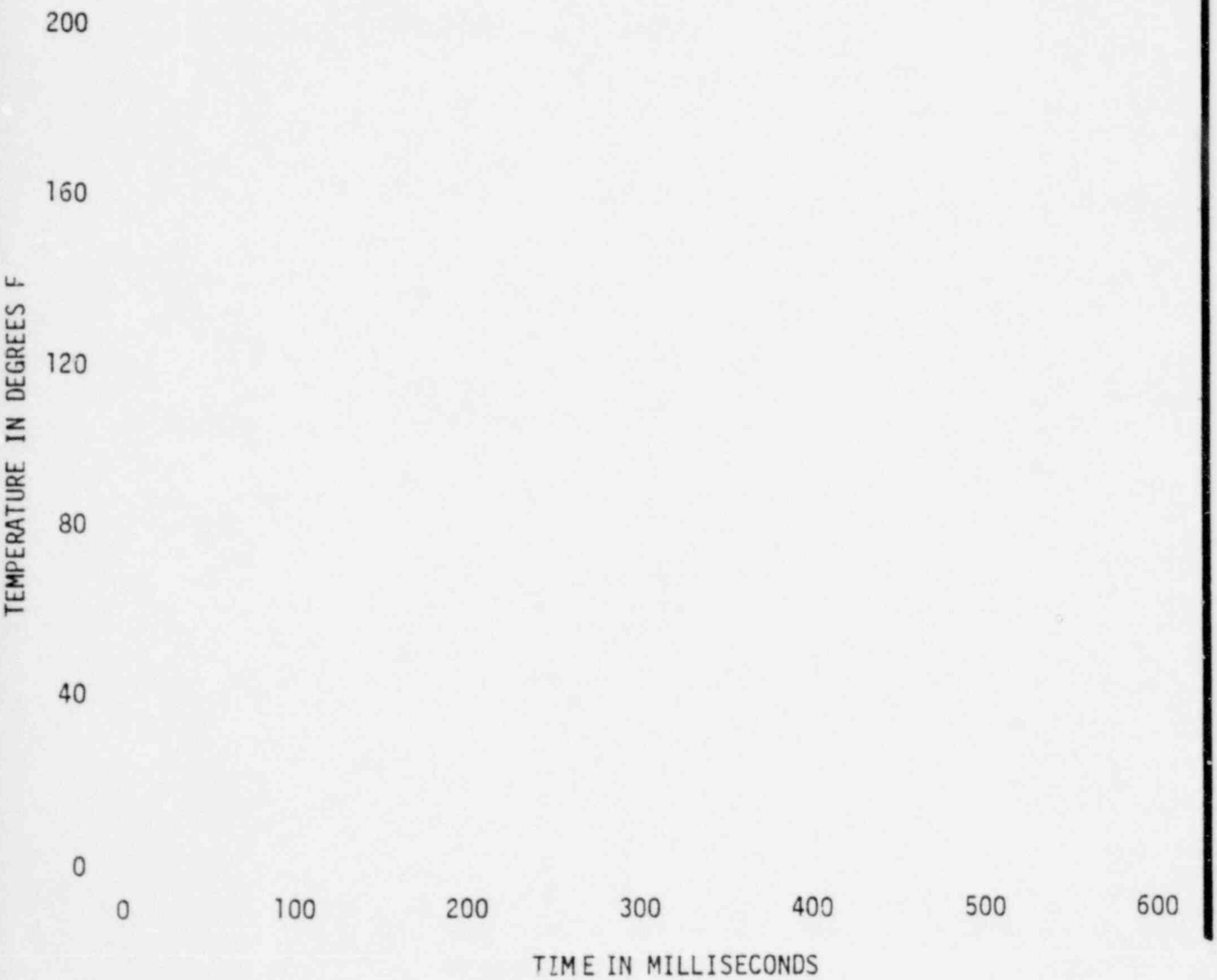
TIME IN MILLISECONDS

1349 018

FIGURE A-209

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Nine Mile Point Test 5



1349 019

FIGURE A-210

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Nine Mile Point Test 5

ENTHALPY FLOW IN Btu/sec

1000

800

600

400

200

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 020

FIGURE A-211

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 3

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 021

FIGURE A-212

WETWELL PRESSURES

Task 5.5.3-2 Nine Mile Point Test 3

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

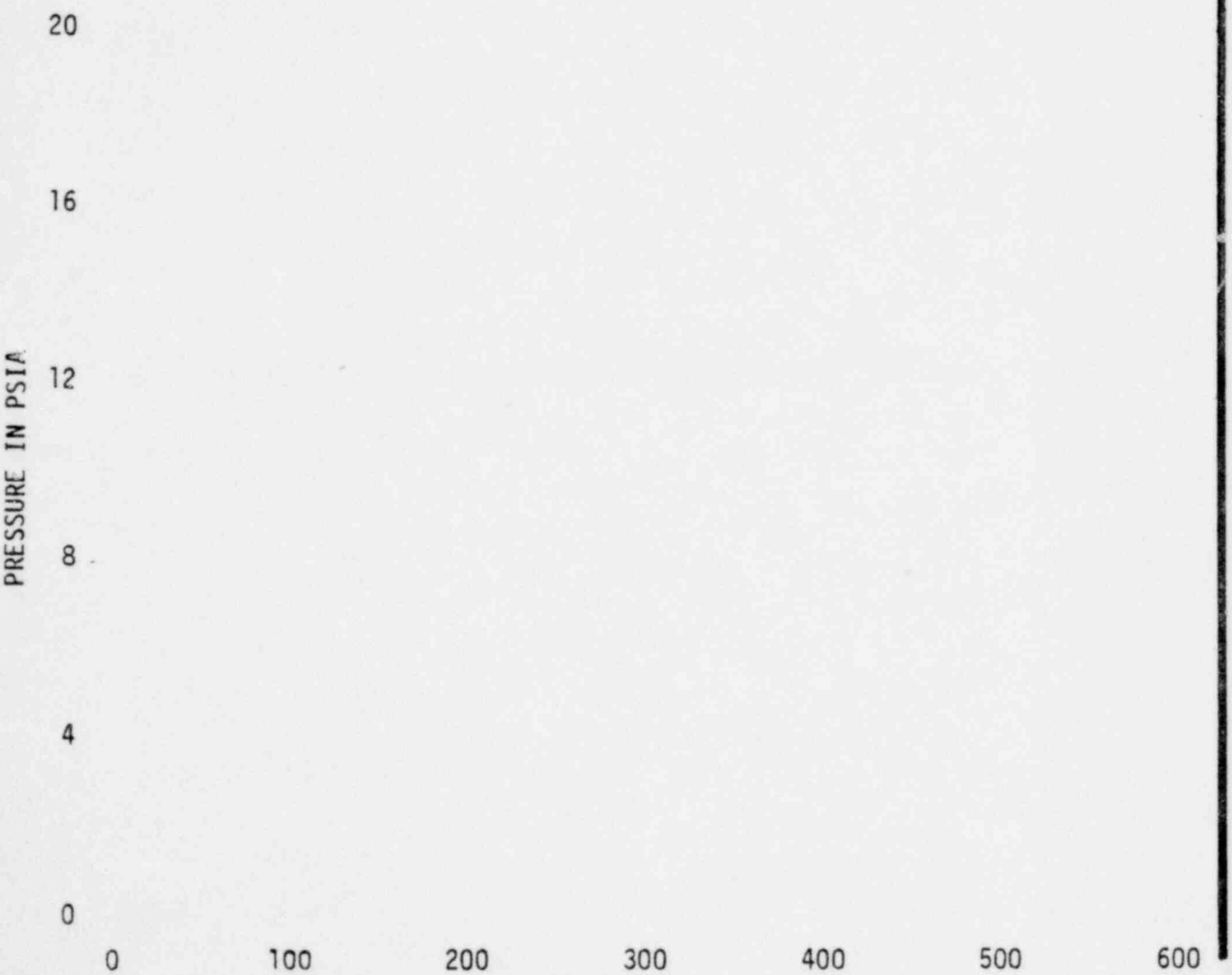
TIME IN MILLISECONDS

1349 022

FIGURE A-213

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Nine Mile Point Test 5

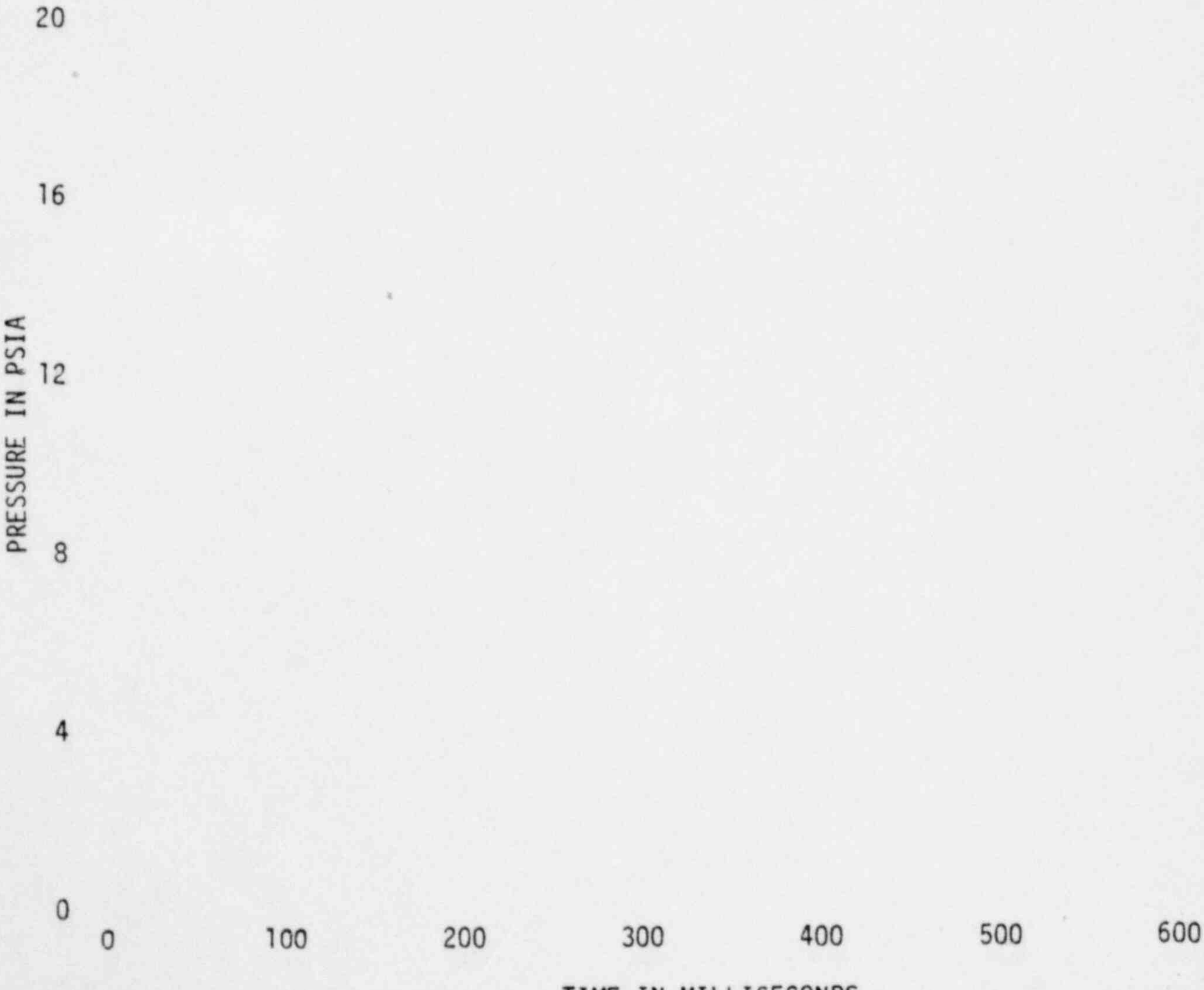


1349 023

FIGURE A-214

WETWELL PRESSURES

Task 5.5.3-2 Nine Mile Point Test 5

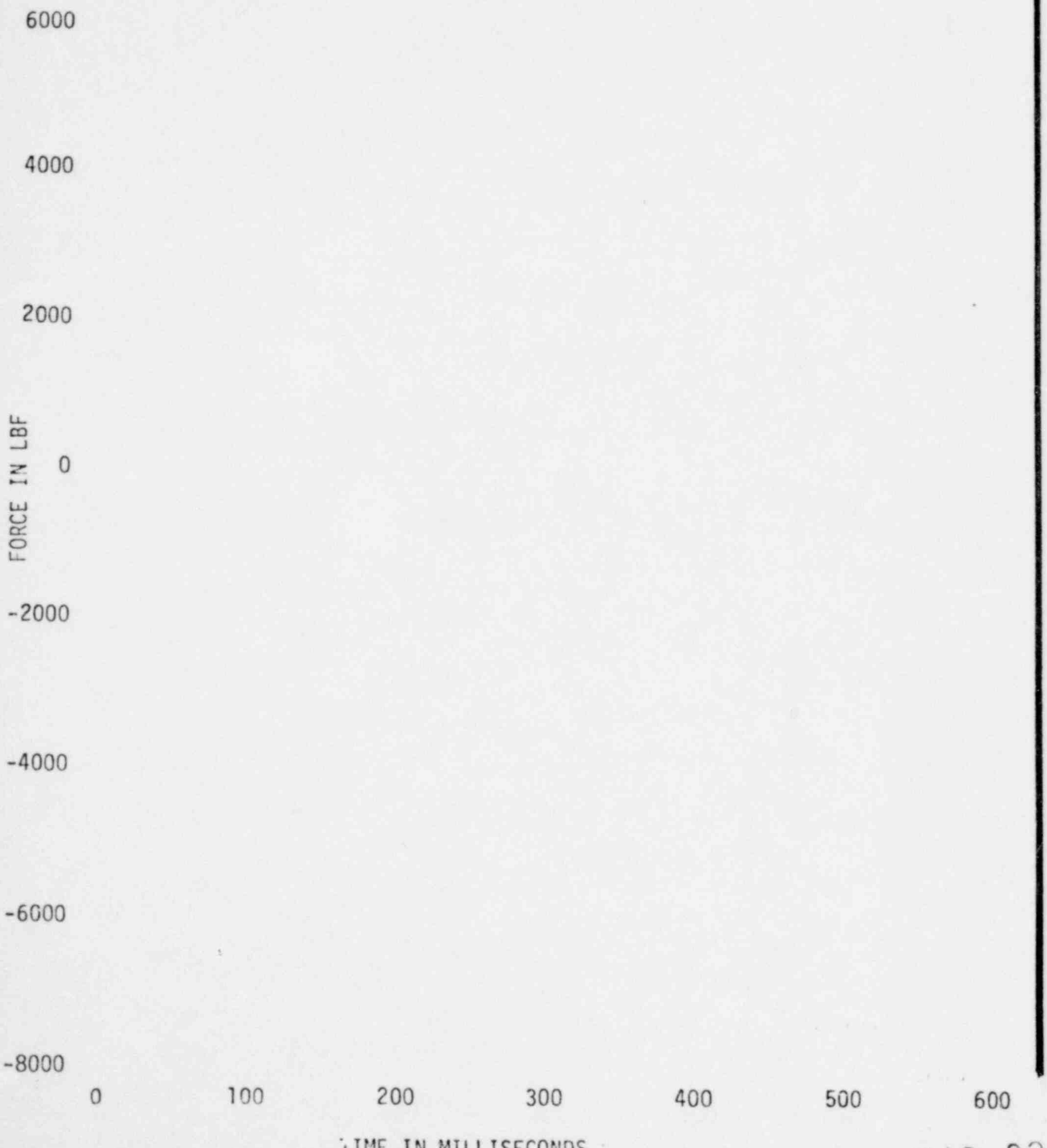


1349 024

FIGURE A-215

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Nine Mile Point Test 3



1349 025

FIGURE A-216

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Nine Mile Point Test 5

6000

4000

2000

FORCE IN LBF

0

-2000

-4000

-6000

-8000

0 100 200 300 400 500 600

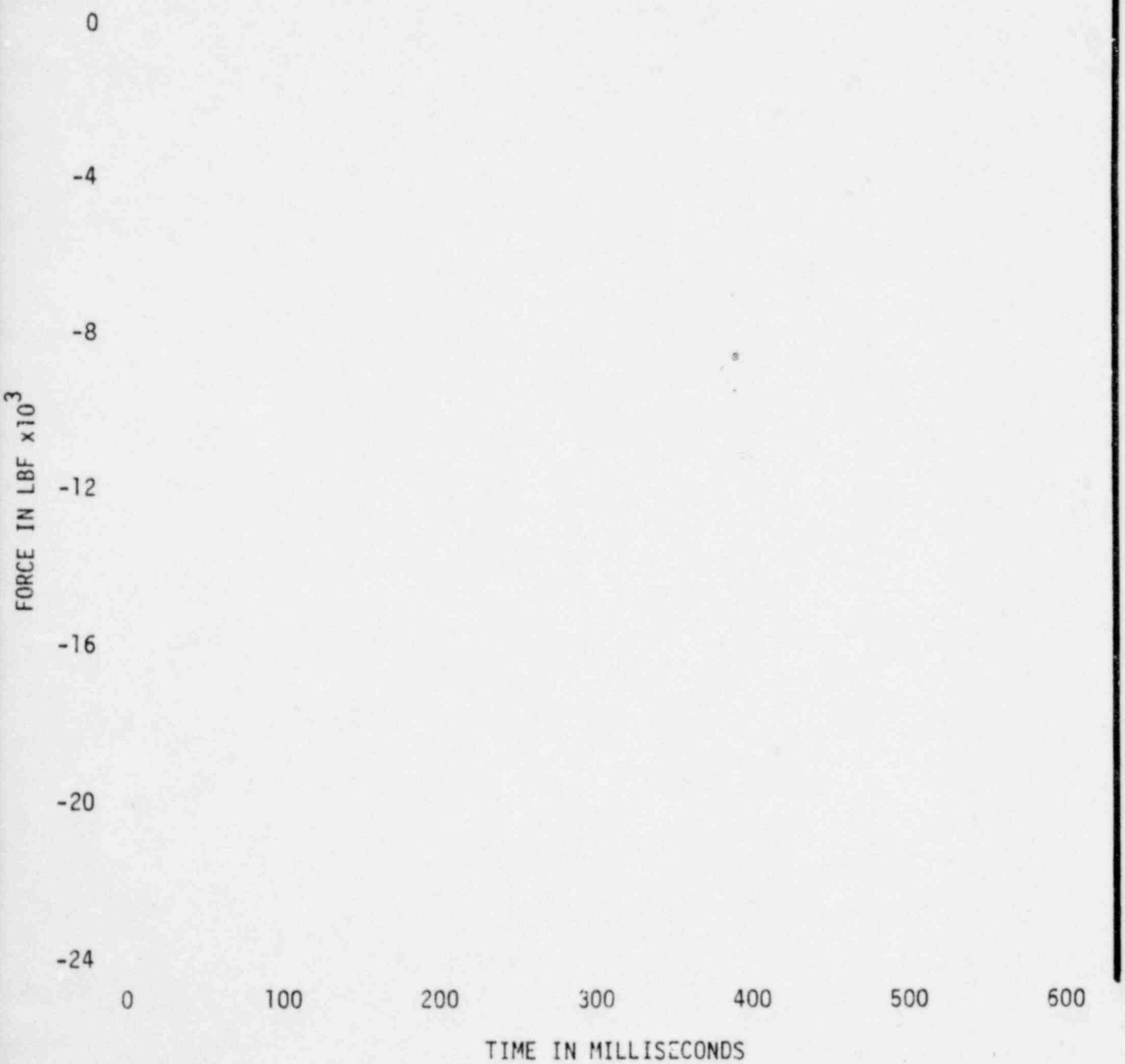
TIME IN MILLISECONDS

1349 026

FIGURE A-217

TORUS LOAD CELL

Task 5.5.3-2 Nine Mile Point Test 3



1349 027

FIGURE A-218

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Nine Mile Point Test 3

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

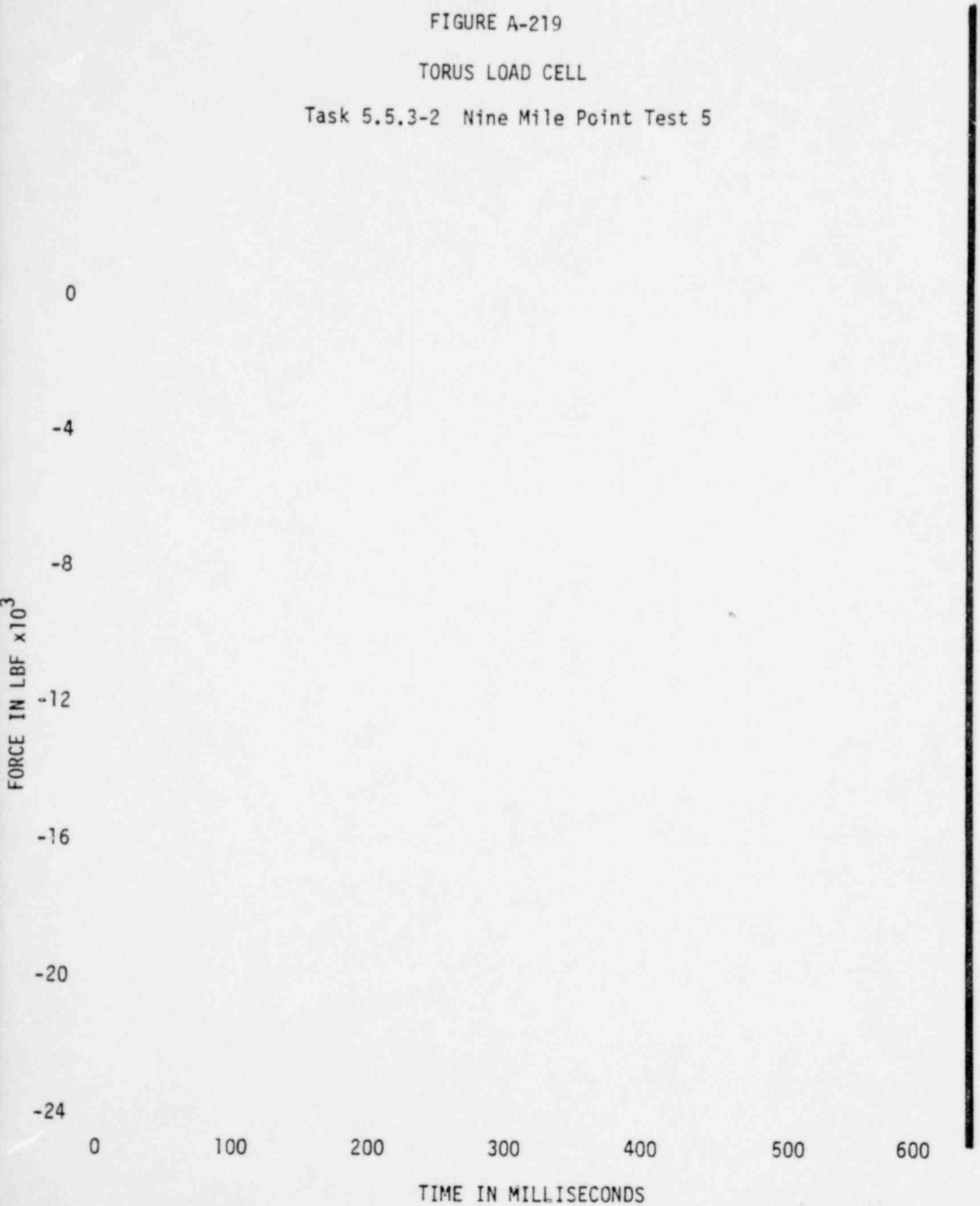
TIME IN MILLISECONDS

1349 028

FIGURE A-219

TORUS LOAD CELL

Task 5.5.3-2 Nine Mile Point Test 5



1349 029

FIGURE A-220

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Nine Mile Point Test 5

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

TIME IN MILLISECONDS

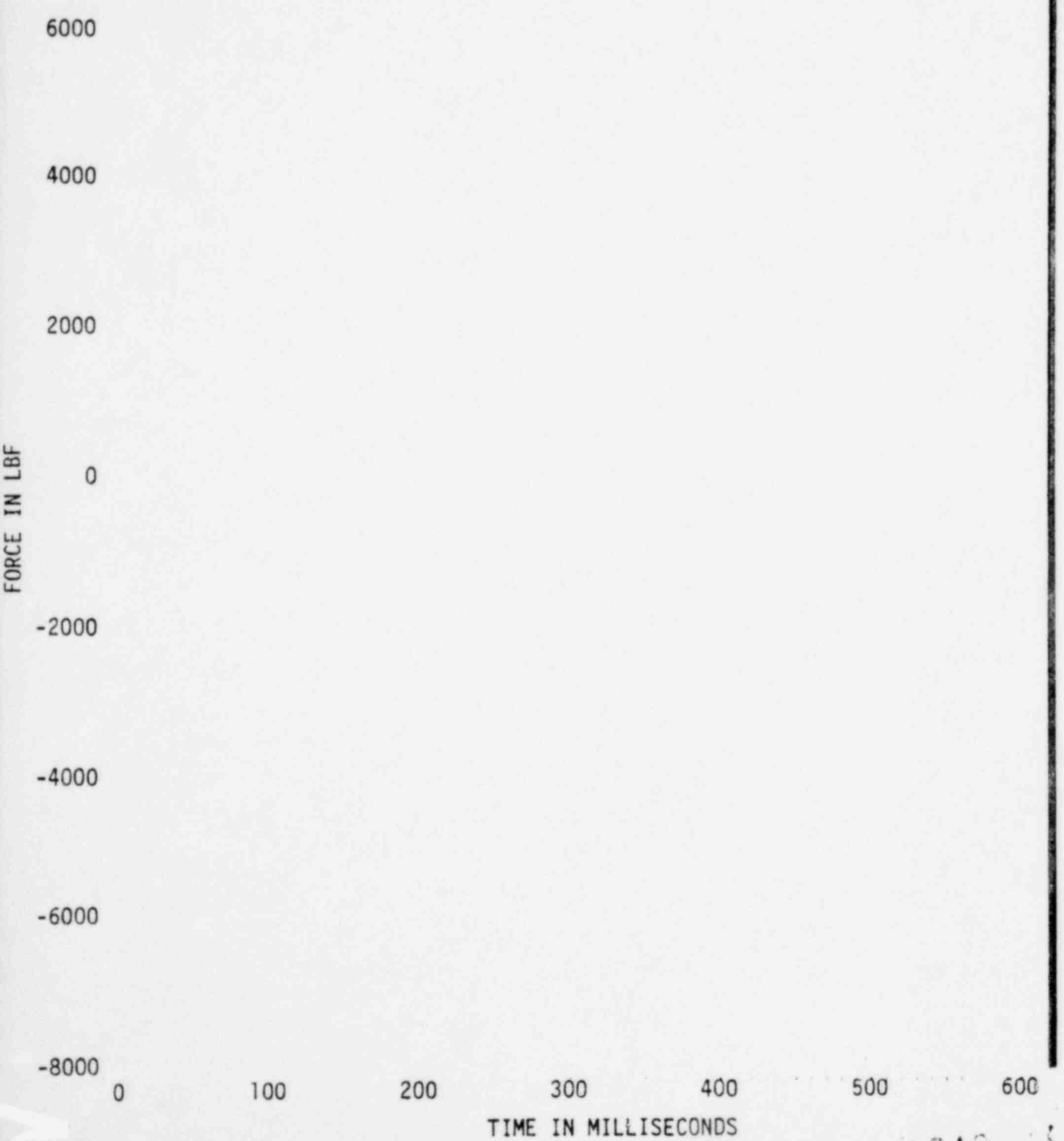
1349 030

FIGURE A-221

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Nine Mile Point Test 3



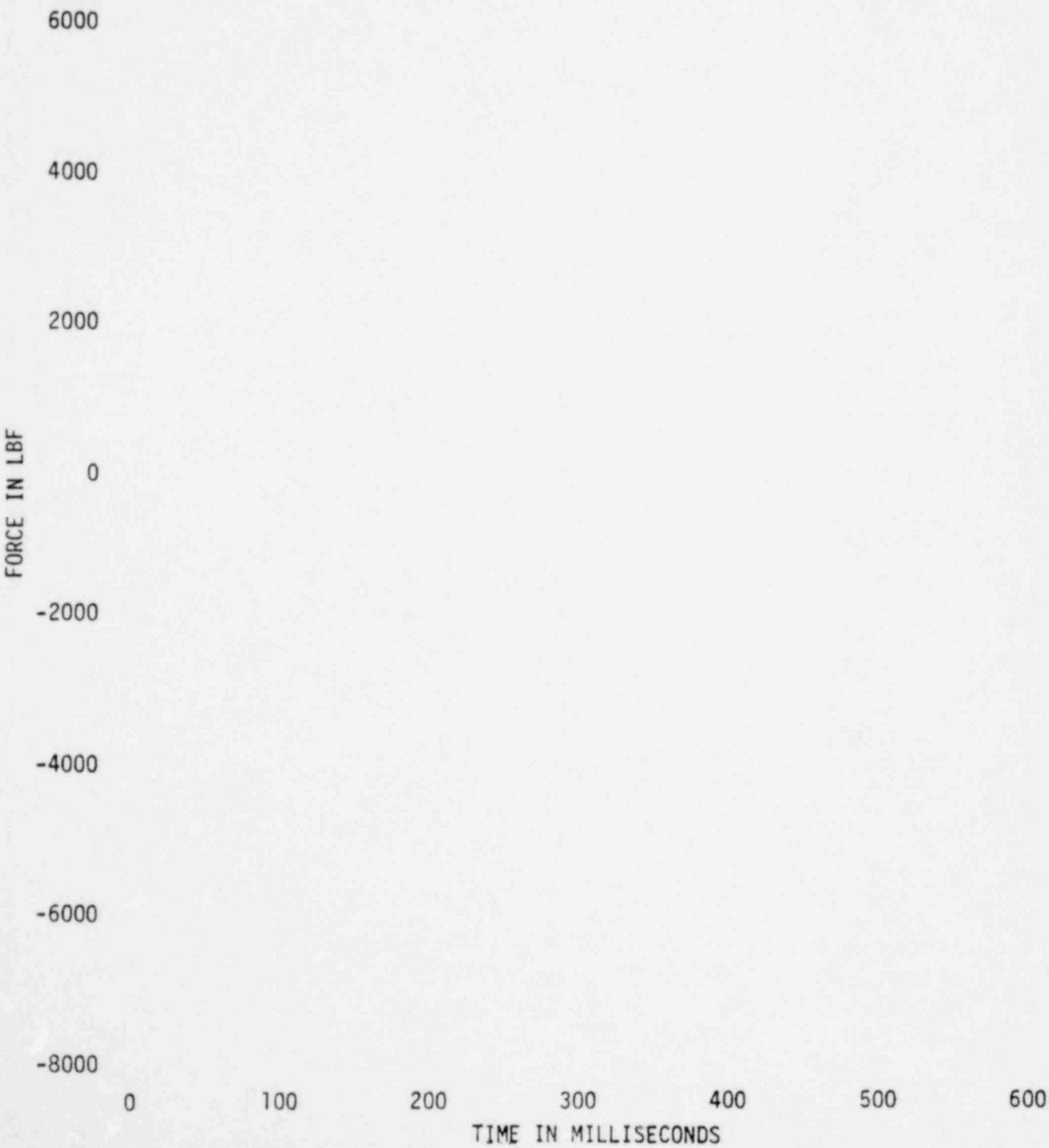
1349 051

FIGURE A-222

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Nine Mile Point Test 5

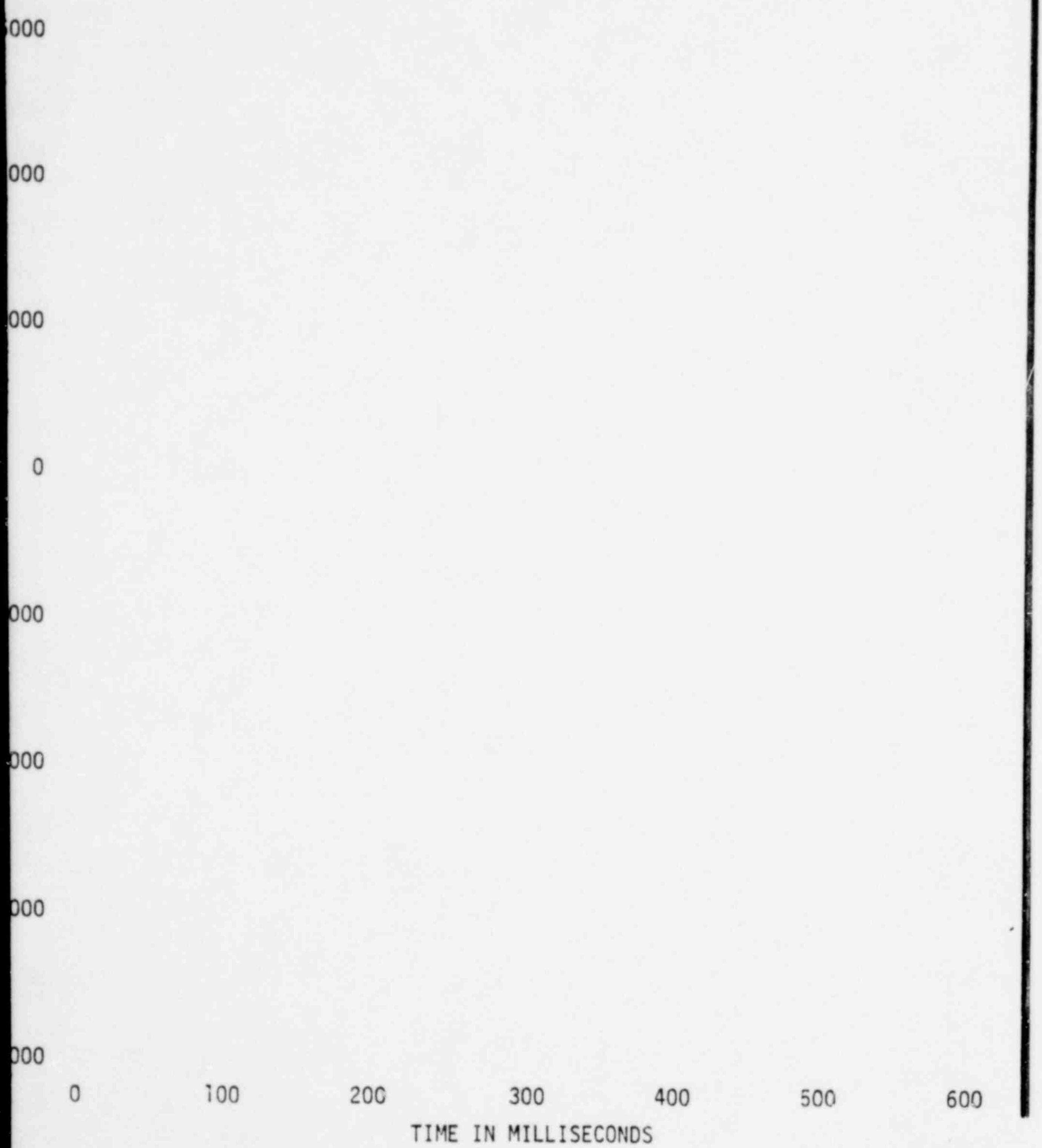


1349 032

FIGURE A-223

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 3



1349 033

FIGURE A-224

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 5

FORCE IN LBF

6000
4000
2000
0
-2000
-4000
-6000
-8000

0 100 200 300 400 500 600

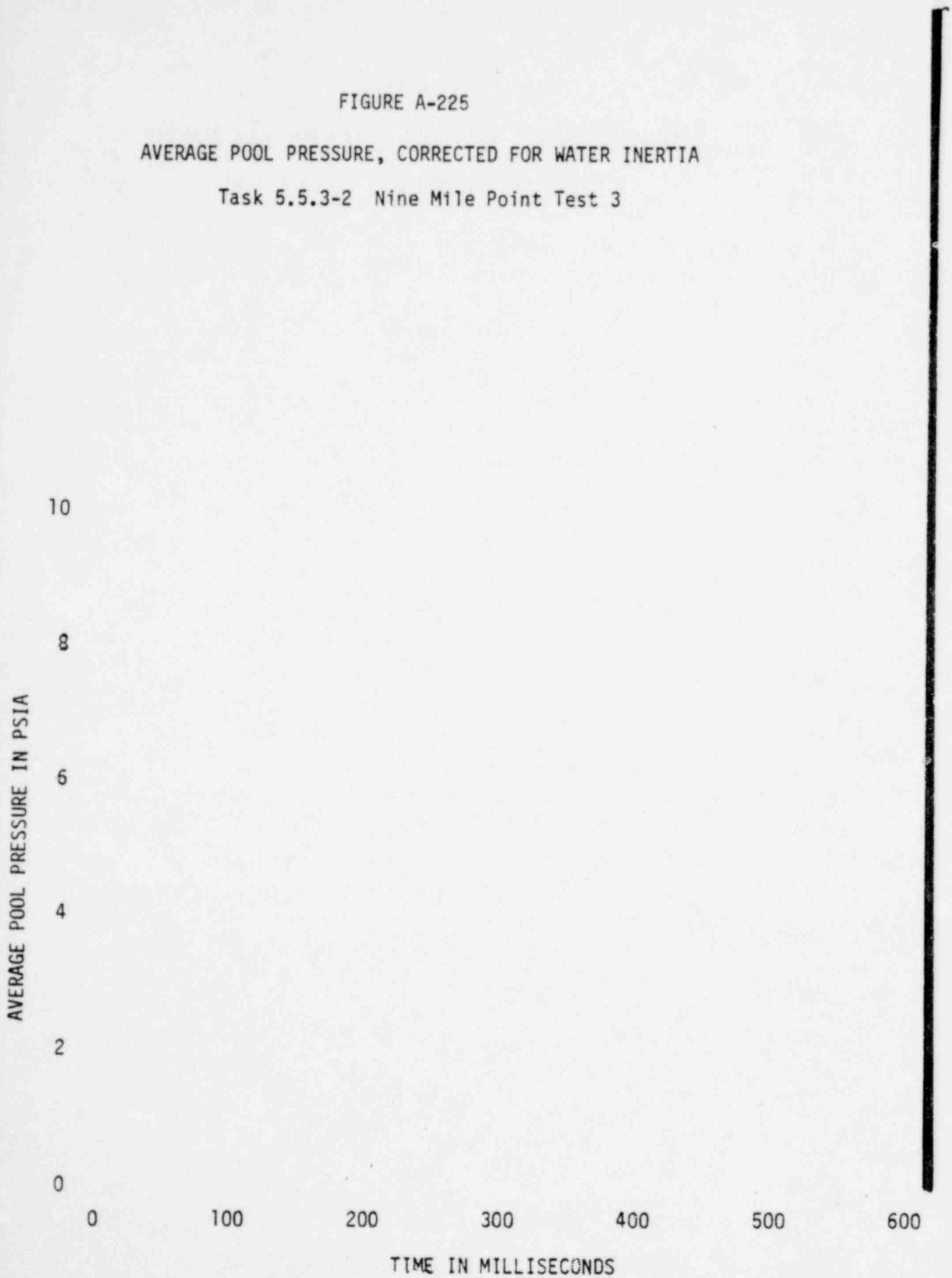
TIME IN MILLISECONDS

1349 034

FIGURE A-225

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 3



1349 035

FIGURE A-226

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 3

NET AVERAGE POOL PRESSURE IN PSI

3
2
1
0
-1
-2
-3

0 100 200 300 400 500 600

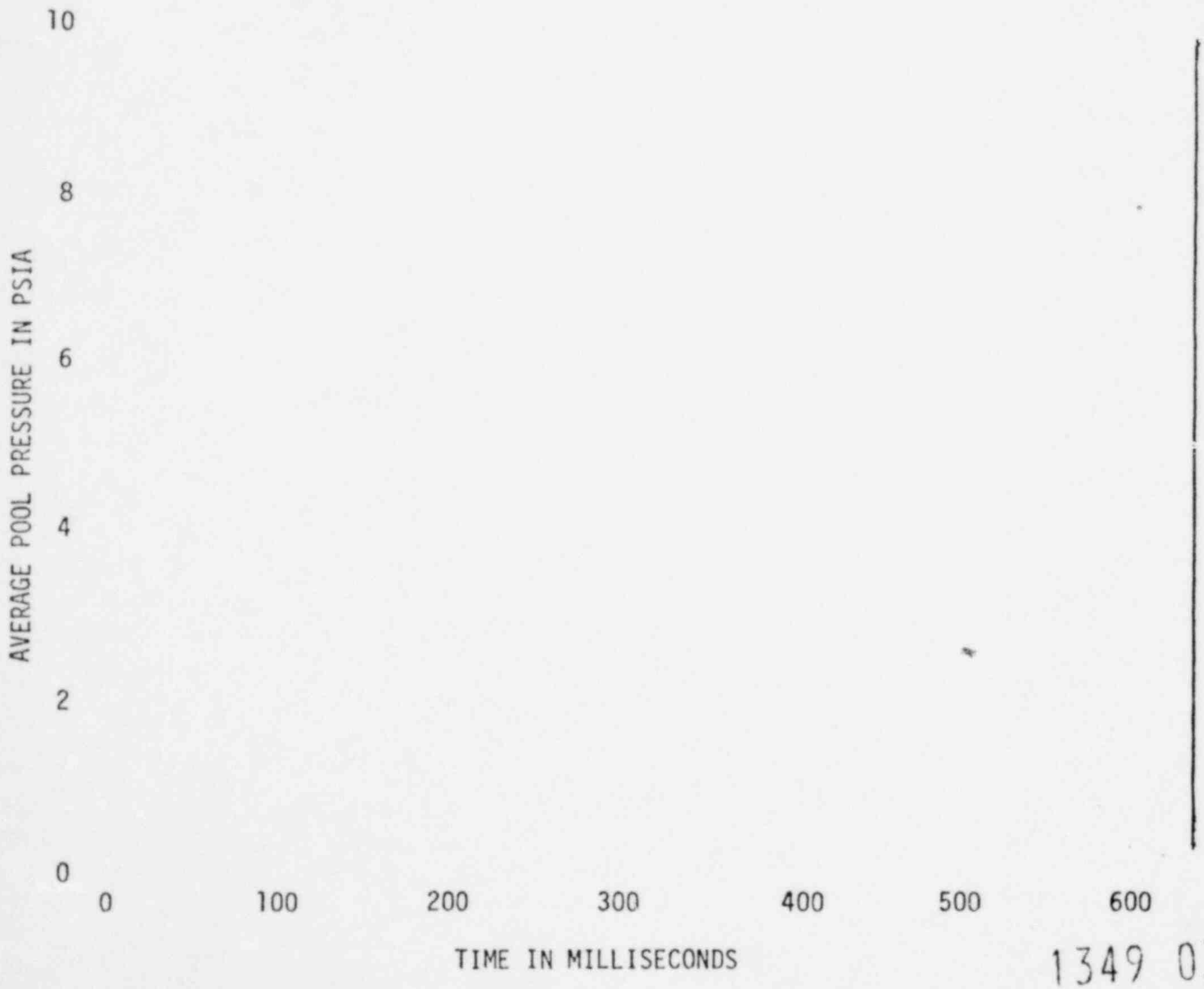
TIME IN MILLISECONDS

1349 036

FIGURE A-227

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 5



1349 037

FIGURE A-228

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Nine Mile Point Test 5

NET AVERAGE POOL PRESSURE IN PSI

3

2

1

0

-1

-2

-3

-4

-5

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 038

Task 5.5.3-2 Nine Mile Point Test 3

IMPACT PRESSURE IN PSIA

20

10

0

150 160 170 180 190 200 210 220 230

TIME IN MILLISECONDS

10

0

150 160 170 180 190 200 210 220 230

10

0

150 160 170 180 190 200 210 220 230

1349 03

FIGURE A-230

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 3

20

10

0

150 160 170 180 190 200 210 220 230

TIME IN MILLISECONDS

IMPACT PRESSURE IN PSIA

10

0

150 160 170 180 190 200 210 220 230

10

1349 040

VENT HEADER IMPACT PRESSURES

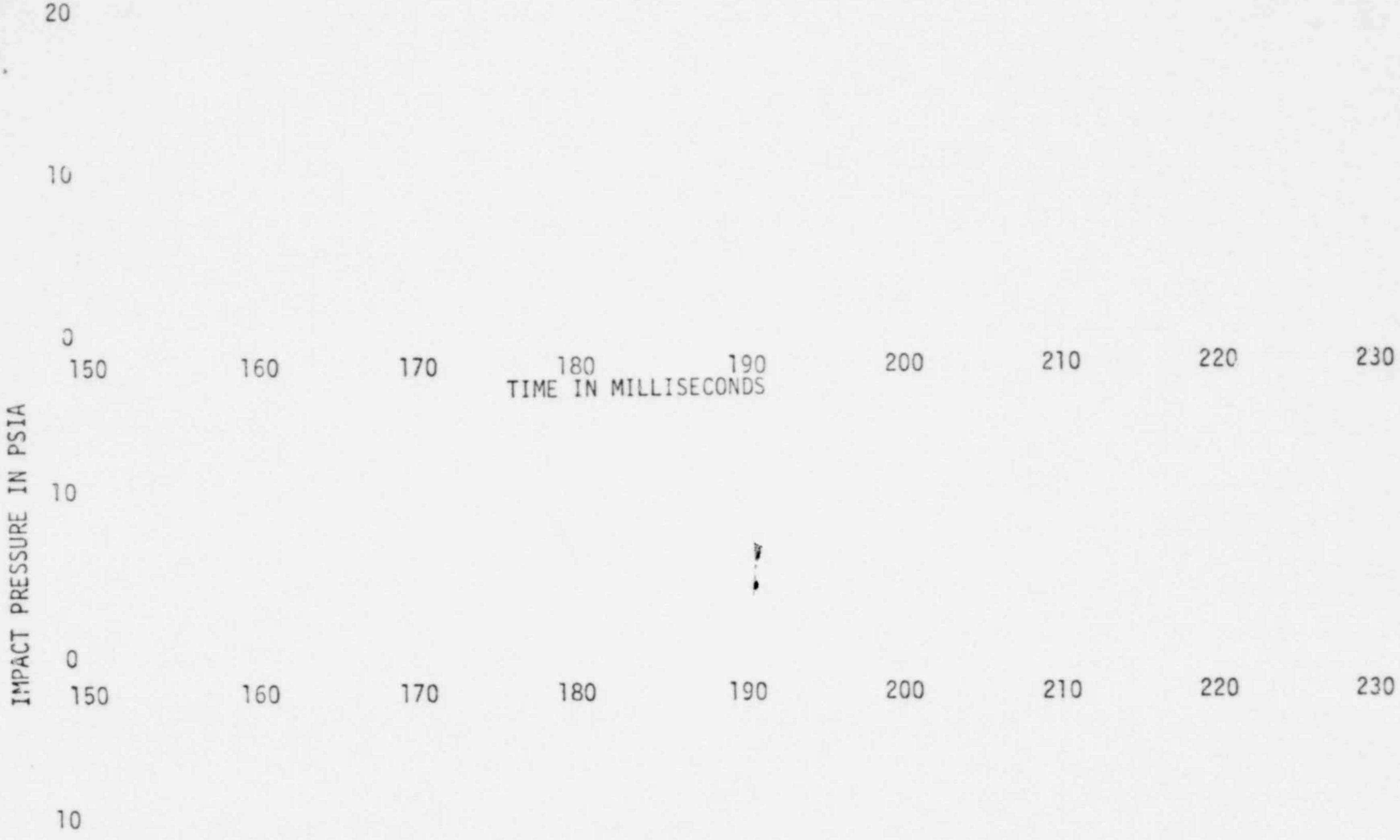
Task 5.5.3-2 Nine Mile Point Test 3

1349 041

FIGURE A-232

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 3



1349 042

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 5

IMPACT PRESSURE IN PSIA

1349 043

FIGURE A-234

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 5

IMPACT PRESSURE IN PSIA

1349 044

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 5

IMPACT PRESSURE IN PSIA

1349 045

FIGURE A-236

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Nine Mile Point Test 5

IMPACT PRESSURE IN PSIA

1349 046

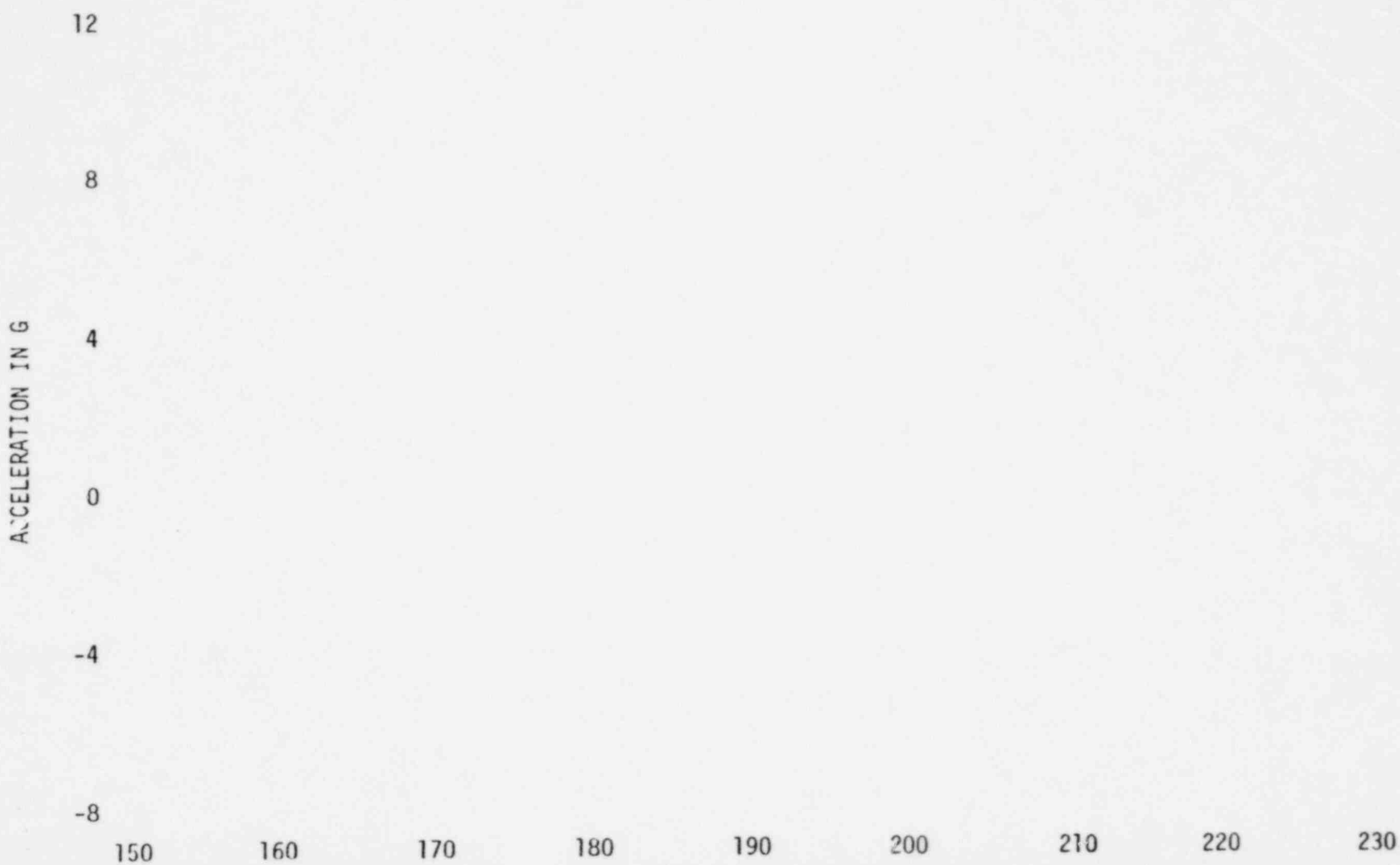
FIGURE A-237
COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3 Nine Mile Point Tests 3, 5

1349 047

FIGURE A-238

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Nine Mile Point Test 3



1349 048

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Nine Mile Point Test 5

ACCELERATION IN G

12

8

4

0

-4

-8

200 210 220 230 240 250 260 270 280

TIME IN MILLISECONDS

1349 049

FIGURE A-240

TIME HISTORY OF
POOL DISPLACEMENT

NINE MILE POINT, TEST 1

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_0) - seconds

1349 050

FIGURE A-241

TIME HISTORY OF
POOL DISPLACEMENT

NINE MILE POINT, TEST 2

Time (from T_o) - seconds

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

1342 051

FIGURE A-242

TIME HISTORY OF
POOL DISPLACEMENT

NINE MILE POINT, TEST 3

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_0) - seconds

1349 052

FIGURE A-243

TIME HISTORY OF
POOL DISPLACEMENT

NINE MILE POINT, TEST 5

Time (from T_o) - seconds

0 5 10 15 20 25 30

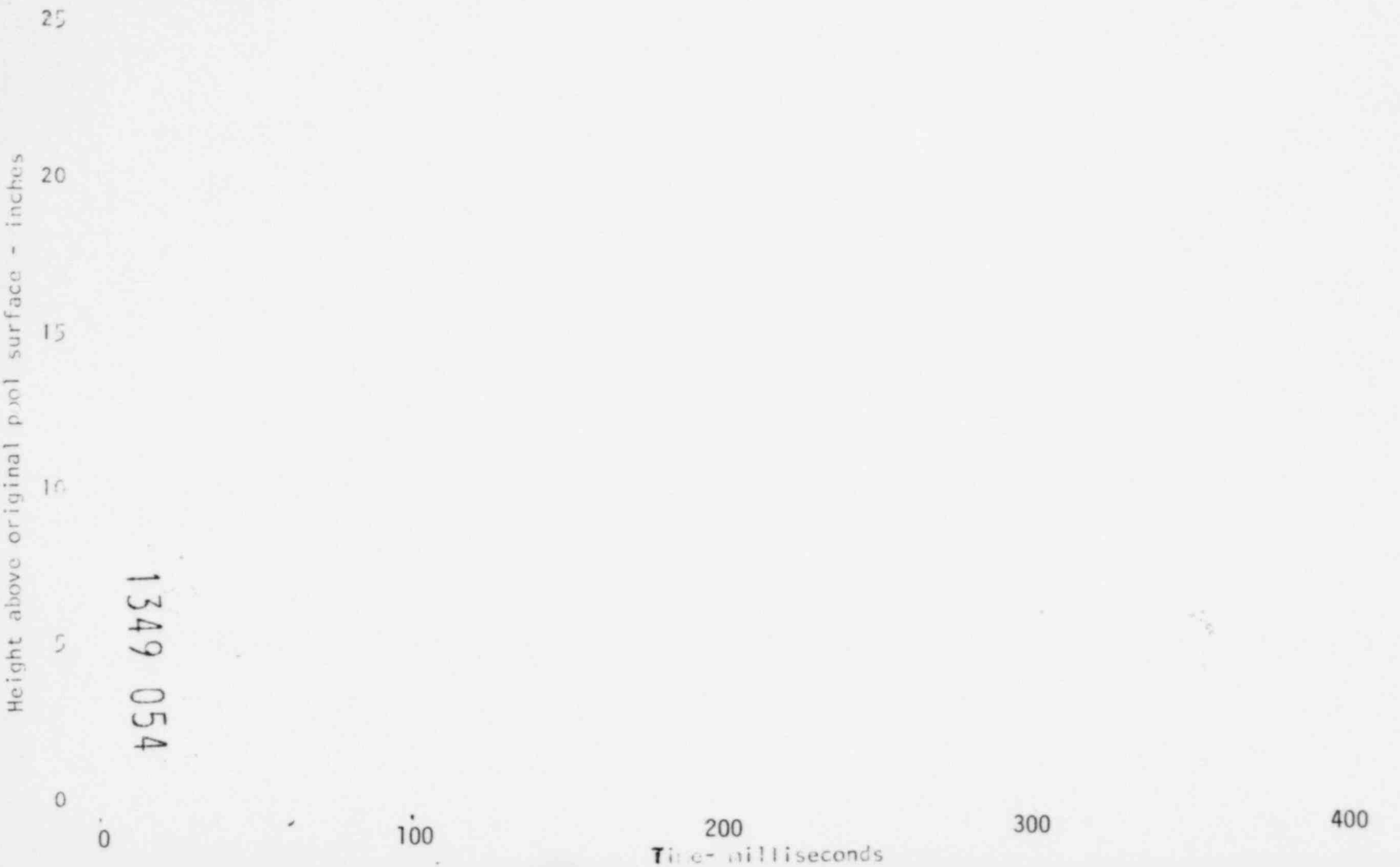
Horizontal Distance from Pool Centerline - inches

1349 053

FIGURE A-244

POOL SURFACE DISPLACEMENT

NINE MILE POINT, TESTS 1, 2, 3



1349 054

POOL SURFACE VELOCITY PROFILES

FIGURE A-245

NINE MILE POINT, TESTS 1, 2, 3

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

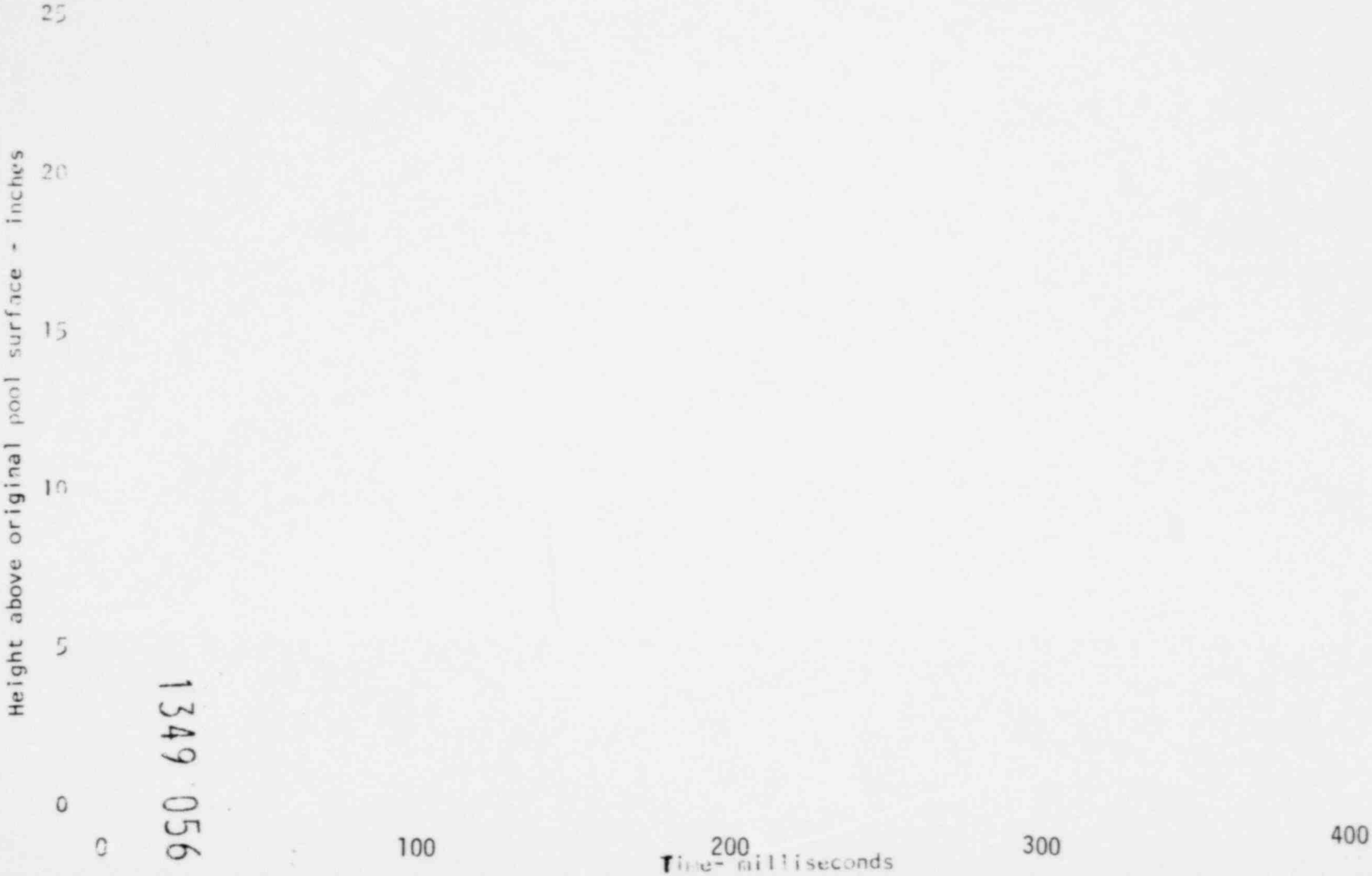
DISTANCE FROM POOL CENTERLINE - INCHES

1349 055

POOL SURFACE DISPLACEMENT

FIGURE A-246

NINE MILE POINT, TEST 5



1349 056

POOL SURFACE VELOCITY PROFILES

FIGURE A-247

NINE MILE POINT, TEST 5

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

DISTANCE FROM POOL CENTERLINE - INCHES

1349 057

FIGURE A-248

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

NINE MILE POINT, TEST 4

VERTICAL DISPLACEMENT - INCHES

8
6
4
2
0
-2
-4
-6
-8

.100 .150 .200 .250 .300 .350 .400

VERTICAL VELOCITY-FT/SEC

15.
10.
5.
0.

.100 .150 .200 .250 .300 .350 .400

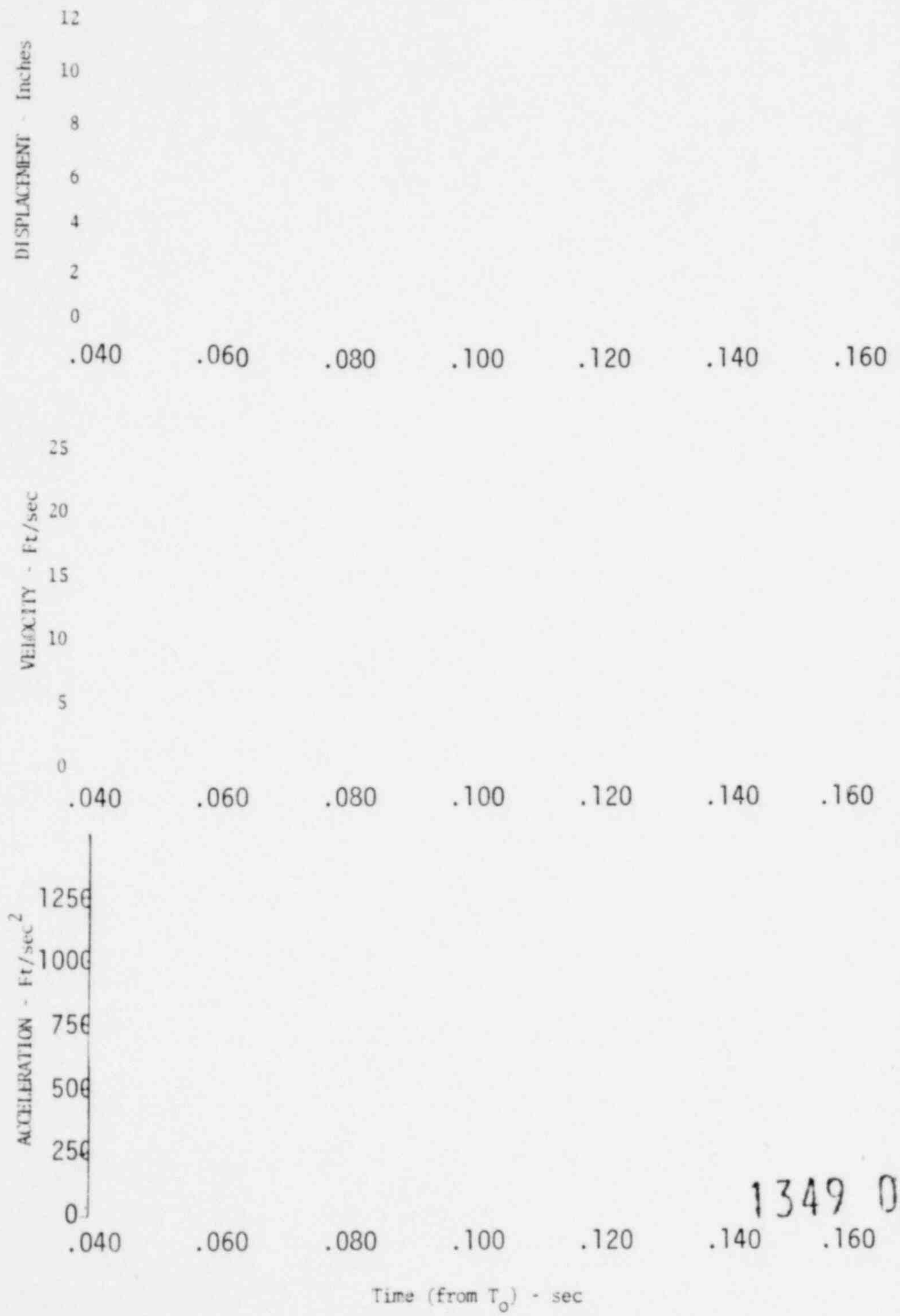
TIME - Seconds

1349 058

FIGURE A-249

DOWNCOMER WATER SLUG EJECTION

NINE MILE POINT, TEST 3

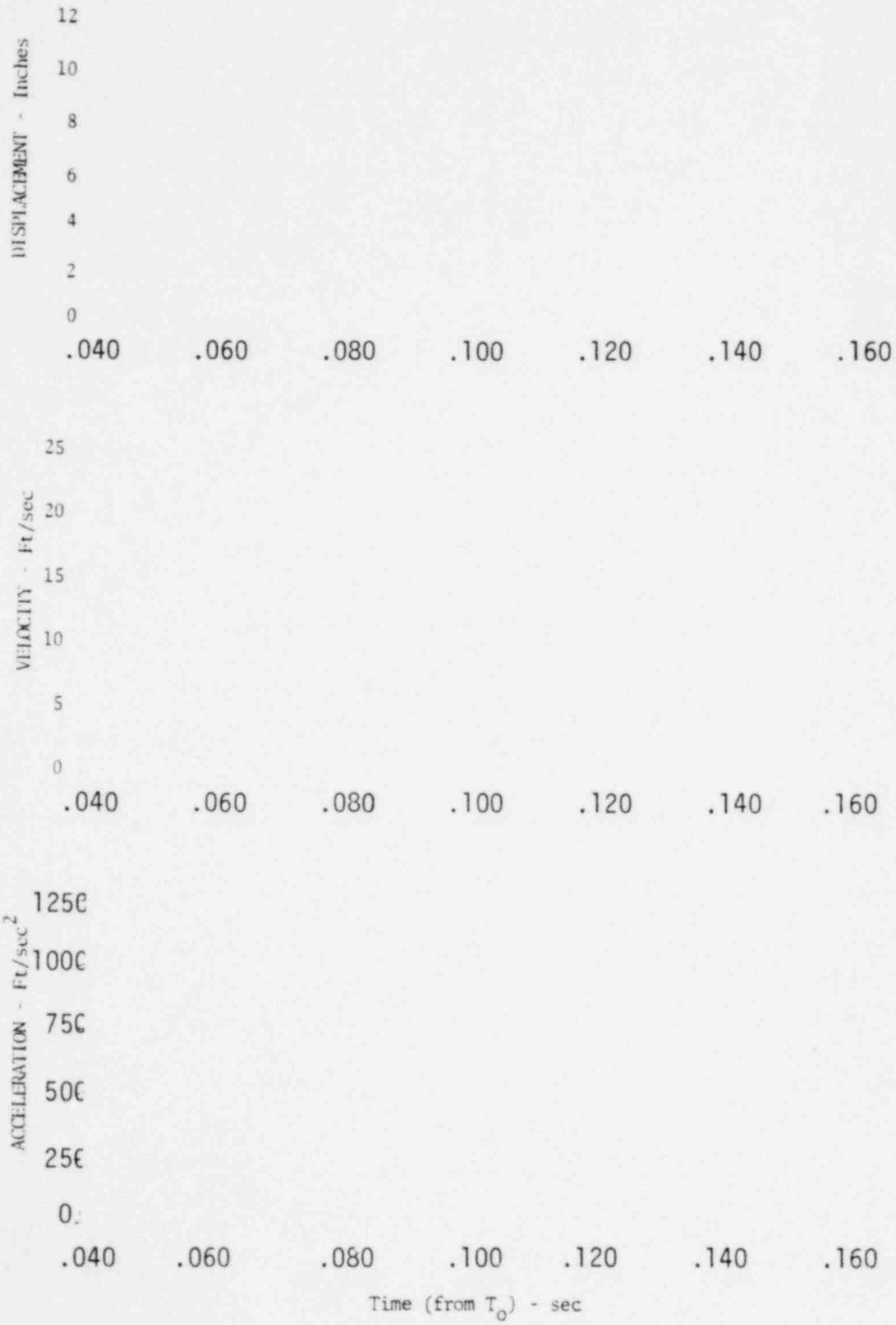


1349 059

FIGURE A-250

DOWNCOMER WATER SLUG EJECTION

NINE MILE POINT, TEST 5



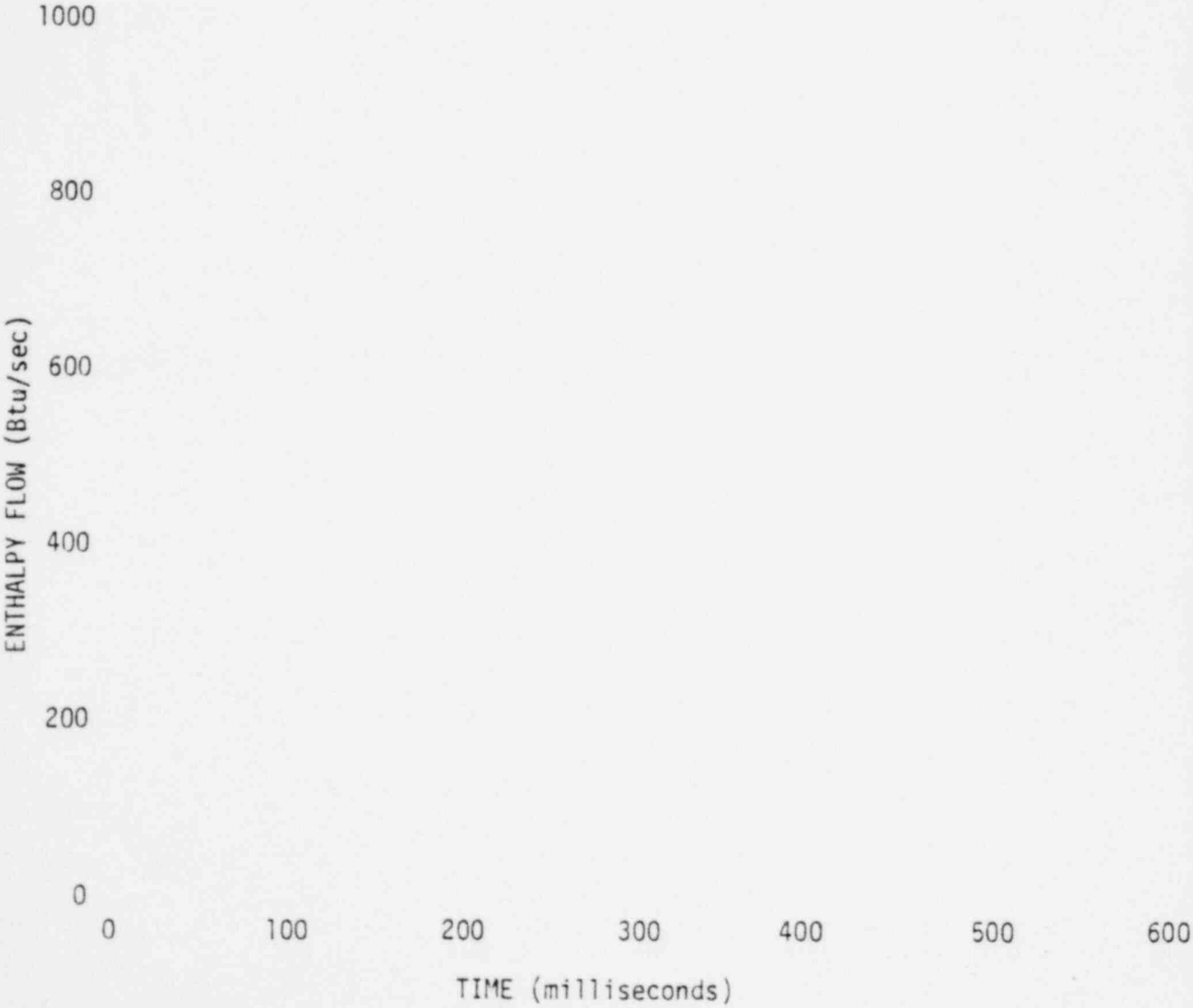
1349 060

FIGURE A-251

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Nine Mile Point Tests



1349 061

FIGURE A-252

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Nine Mile Point Tests

PRESSURE (psia)

20

16

12

8

4

0

0 100 200 300 400 500 600

TIME (milliseconds)

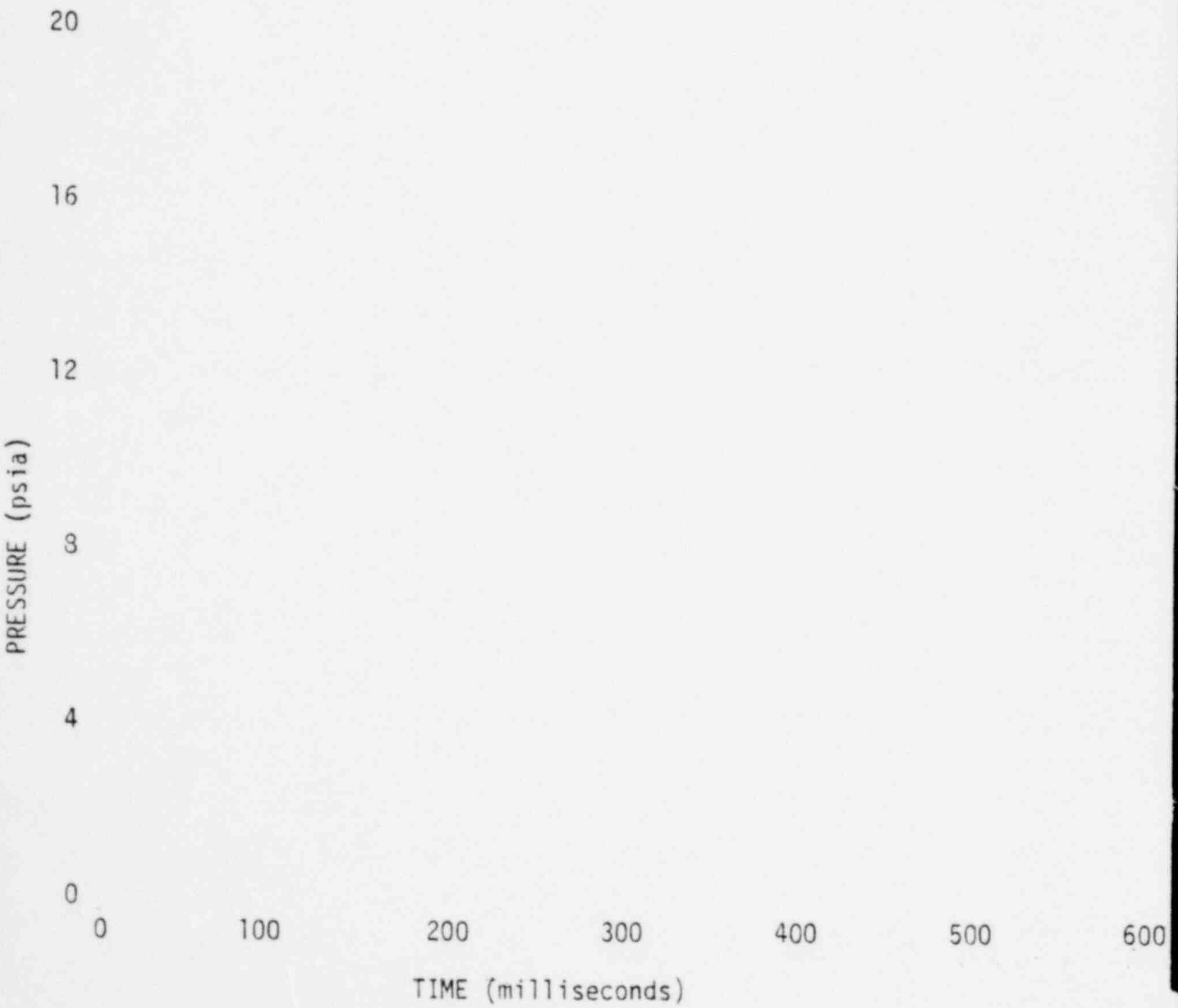
1349 062

FIGURE A-253

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Nine Mile Point Tests



1349 063

*Vent clearing time (from T_o) determine from the movie films.
**Time difference from T_o to time of zero downforce.
*(1)Start-of-test reference time

TABLE A-11

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Nine Mile Point Tests

Parameter / Test No.	7.94" ΔP, 4.59" Pipe Deflector (16" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o *(1) (sec)							
Vent Clearing Time* (sec)							
Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Downforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
[Δt] Downforce Time**							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							
Downforce Impulse							
Pressure Integral:							
Impulse (lb-sec)							

1349 064

TABLE A-11

*Time at force is zero (from T_o)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Nine Mile Point Tests

Parameter / Test No.	7.94" ΔP, 4.59" Pipe Deflector (16" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Upforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Zero Force Time*							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							

1349 065

TABLE A-12

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Nine Mile Point Tests

Test No. / Parameter		7.94" ΔP, 4.60" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o†	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected:††								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*Based on impact pressure measurements
**At start of the first impact pressure recorded.

†Start of test reference time
††represents peak of very noisy data (acceleration corrected); mean value would be lower

1349 066

A.6 Brunswick Tests

A.6.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Brunswick Test 3. Test 3 was a load definition test, conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with a 5.34 inch pipe deflector (20 inch full scale). ΔP sensitivity test was not conducted for Brunswick.

A.6.1.1 Driving Conditions

Driving conditions for Brunswick Test 3 are presented in Figures A-254 through A-258. Brunswick's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.6.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Brunswick Test 3 are presented in Figures A-259 and A-260. These pressure plots have the same characteristics as the "typical" plant in Section 3.0.

Figure A-261 presents net torus force based on the torus pressure integral for Brunswick Test 3. The net torus force shows relatively smooth downforce except for the first oscillation and shows some upforce oscillation.

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figure A-262) to the torus load cell (Figure A-263) is compared with the torus force obtained from the torus pressure integral in Figure A-264. Figure A-265 presents the net torus force based on the torus pressure integral corrected for inertia.

C67

The "average" pool pressure for Brunswick Test 3 is shown in Figure A-266. Figure A-267 is the same as Figure A-265 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Brunswick Test 3 are presented in Figures A-268 through A-271. These figures indicate that the deflector was effective in reducing the peak local vent header impact pressure.

Figure A-272 presents a comparison of the vent header impact force derived from the pressure integral with that derived from the corrected load cell. Vent header vertical acceleration is shown in Figure A-273.

A.6.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-274 through A-276 for Brunswick Tests 1, 2, and 3.

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-277. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-278.

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-279. The dow comer water slug displacement, velocity, and acceleration versus time for Test 3 are presented in Figure A-280.

Brunswick pool dynamics are similar to those of the "typical" plant discussed in Section 3.0.

1349 068

A.6.3 Data Summaries

Table A-13 presents the Brunswick Test Data for wetwell vertical forces.

Table A-14 presents the Nine Mile Point test data for vent header impact forces.

A.6.4 Discussion and Analysis

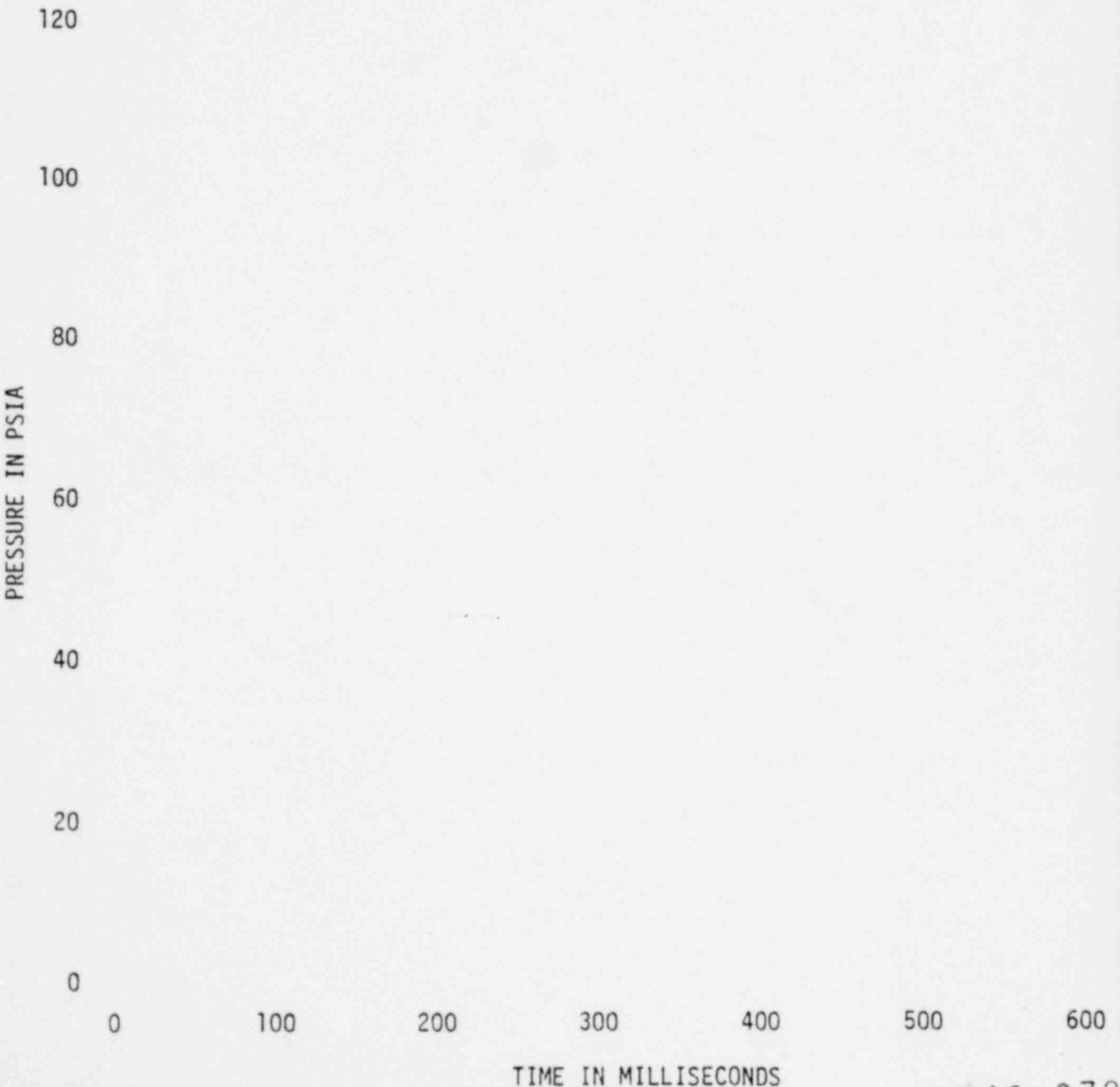
The load definition tests were conducted at zero ΔP and with a pipe deflector installed below the vent header. ΔP sensitivity test (at a partial or full ΔP) was not conducted for Brunswick. The down-force was relatively smooth except for the first oscillation. The upforce showed some oscillation, which is a characteristic of the type II (30° bend) downcomers. The pipe deflector (20 inch full scale) effectively reduced the vent header impact force.

1349 069

FIGURE A-254

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Brunswick Test 3

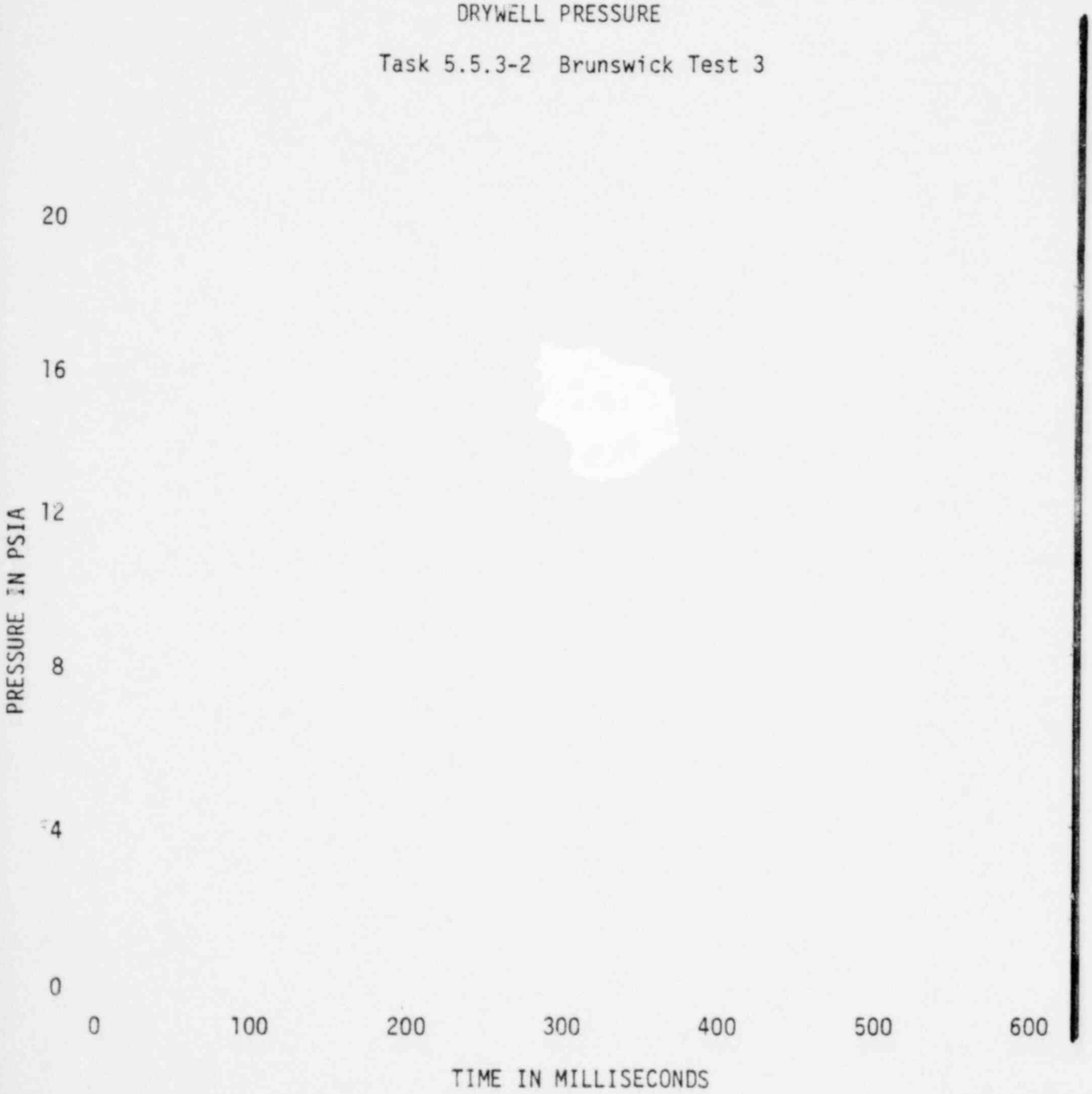


1349 070

FIGURE A-255

DRYWELL PRESSURE

Task 5.5.3-2 Brunswick Test 3



1349 071

FIGURE A-256

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Brunswick Test 3

DIFFERENTIAL PRESSURE IN PSID

10

8

6

4

2

0

0 100 200 300 400 500 600

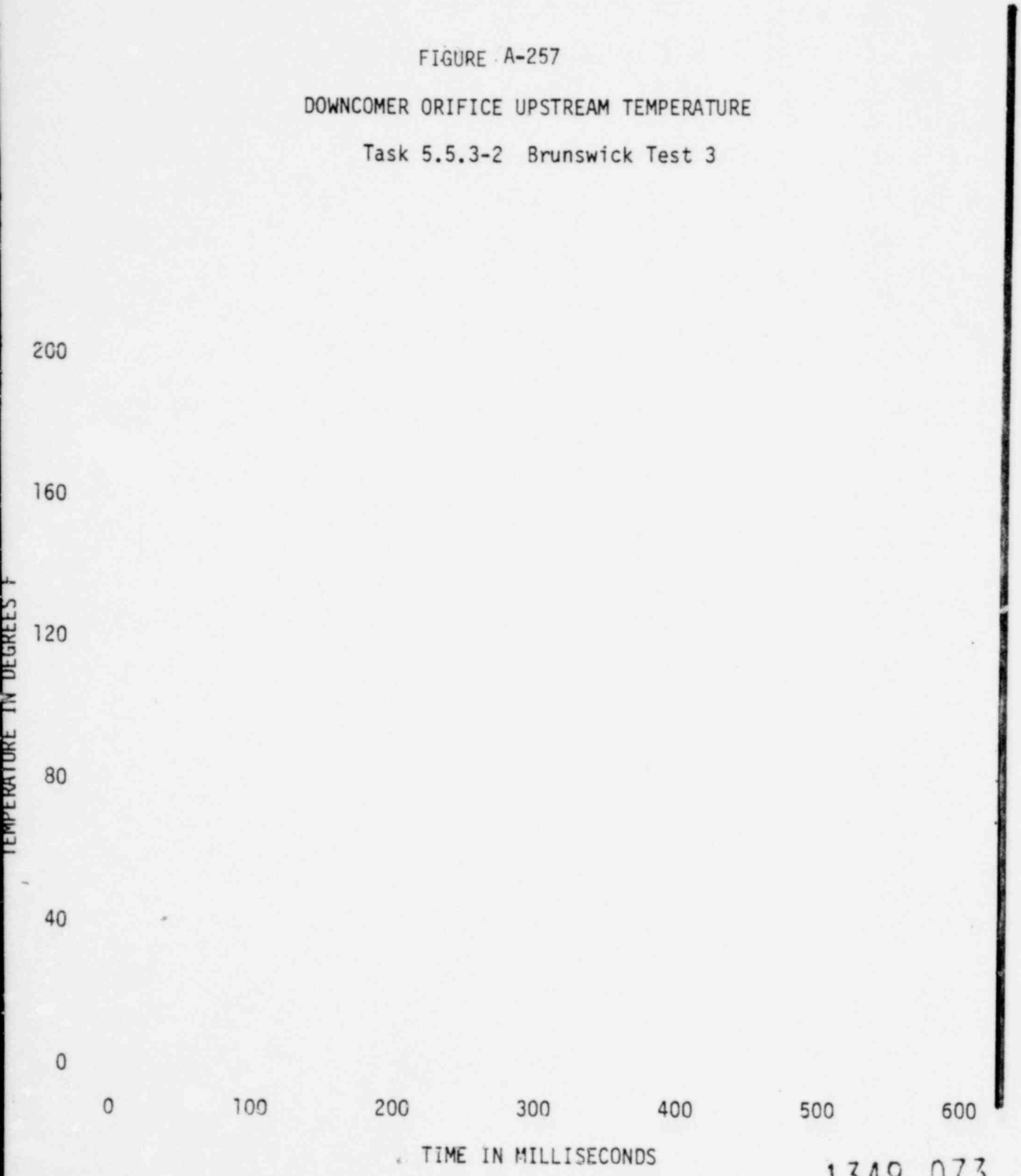
TIME IN MILLISECONDS

1349 072

FIGURE A-257

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Brunswick Test 3



1349 073

FIGURE A-258

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Brunswick Test 3

ENTHALPY FLOW IN Btu/sec

1000

800

600

400

200

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 074

FIGURE A-259

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Brunswick Test 3

1349 075

FIGURE A-260

WETWELL PRESSURES

Task 5.5.3-2 Brunswick Test 3

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

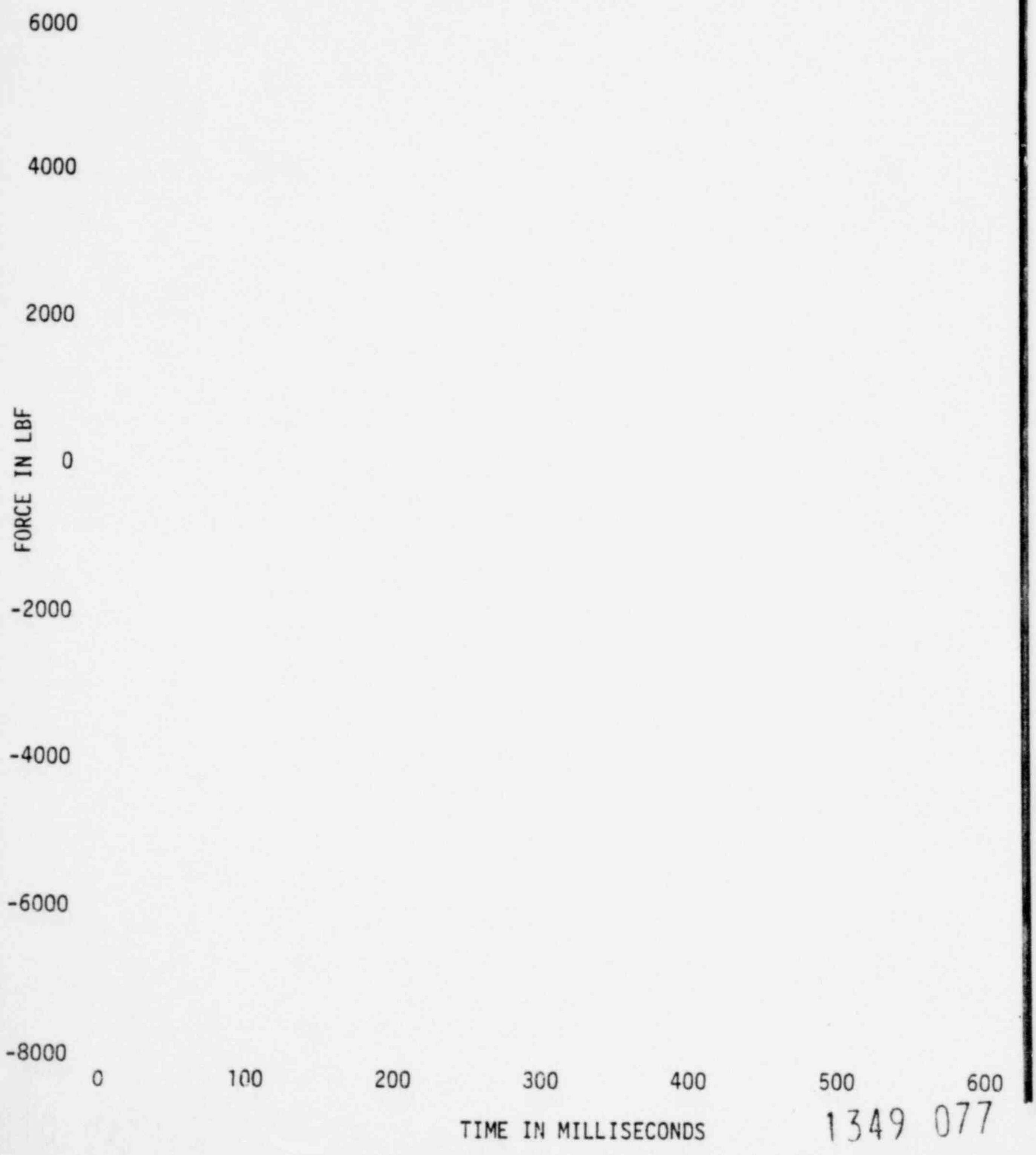
TIME IN MILLISECONDS

1349 076

FIGURE A-261

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Brunswick Test 3



1349 077

FIGURE A-262

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Brunswick Test 3

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 078

FIGURE A-263

TORUS LOAD CELL

Task 5.5.302 Brunswick Test 3

FORCE IN LBF $x10^3$

0

-4

-8

-12

-16

-20

-24

0 100 200 300 400 500 600

TIME IN MILLISECONDS

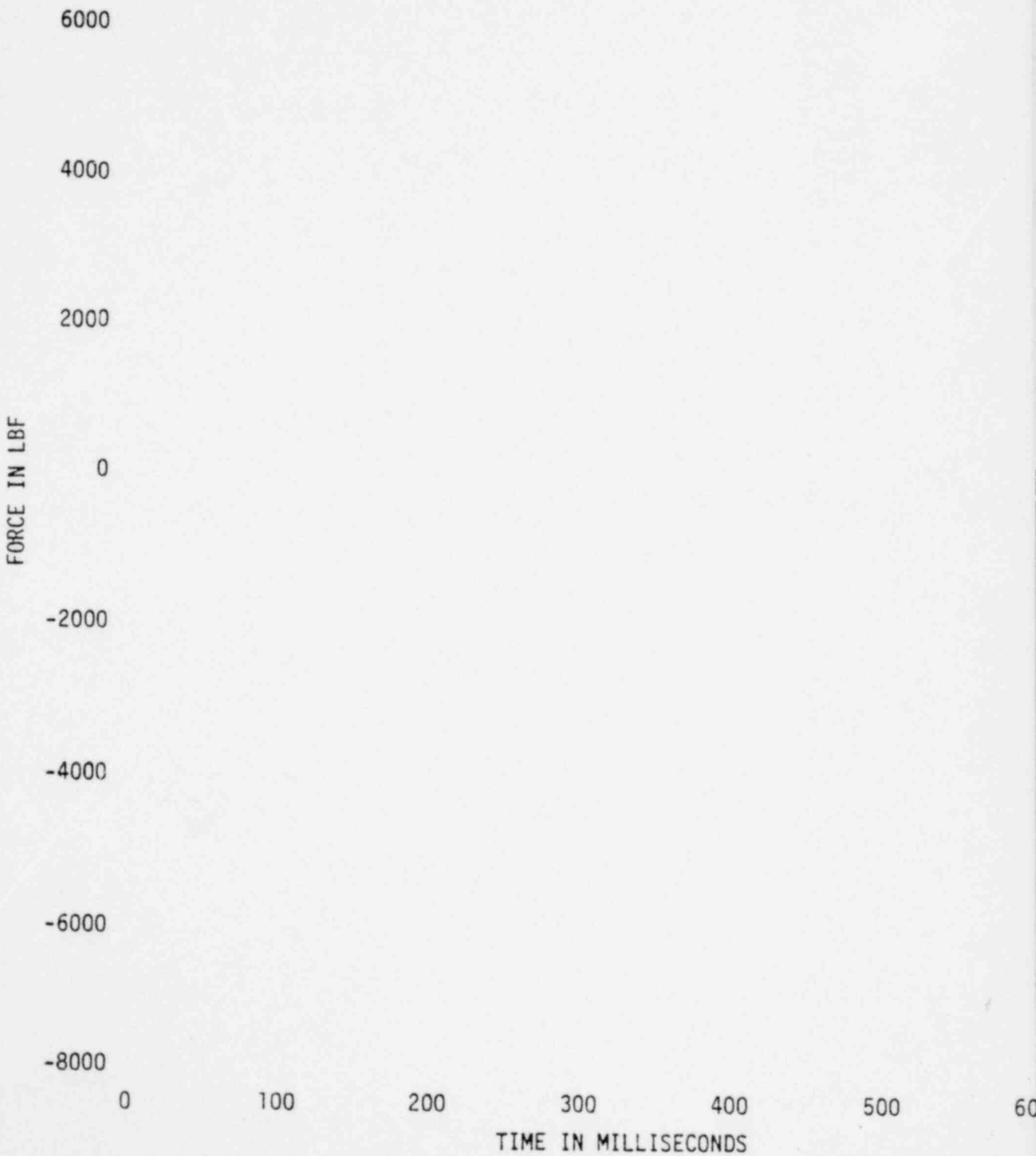
1349 079

FIGURE A-264

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Brunswick Test 3

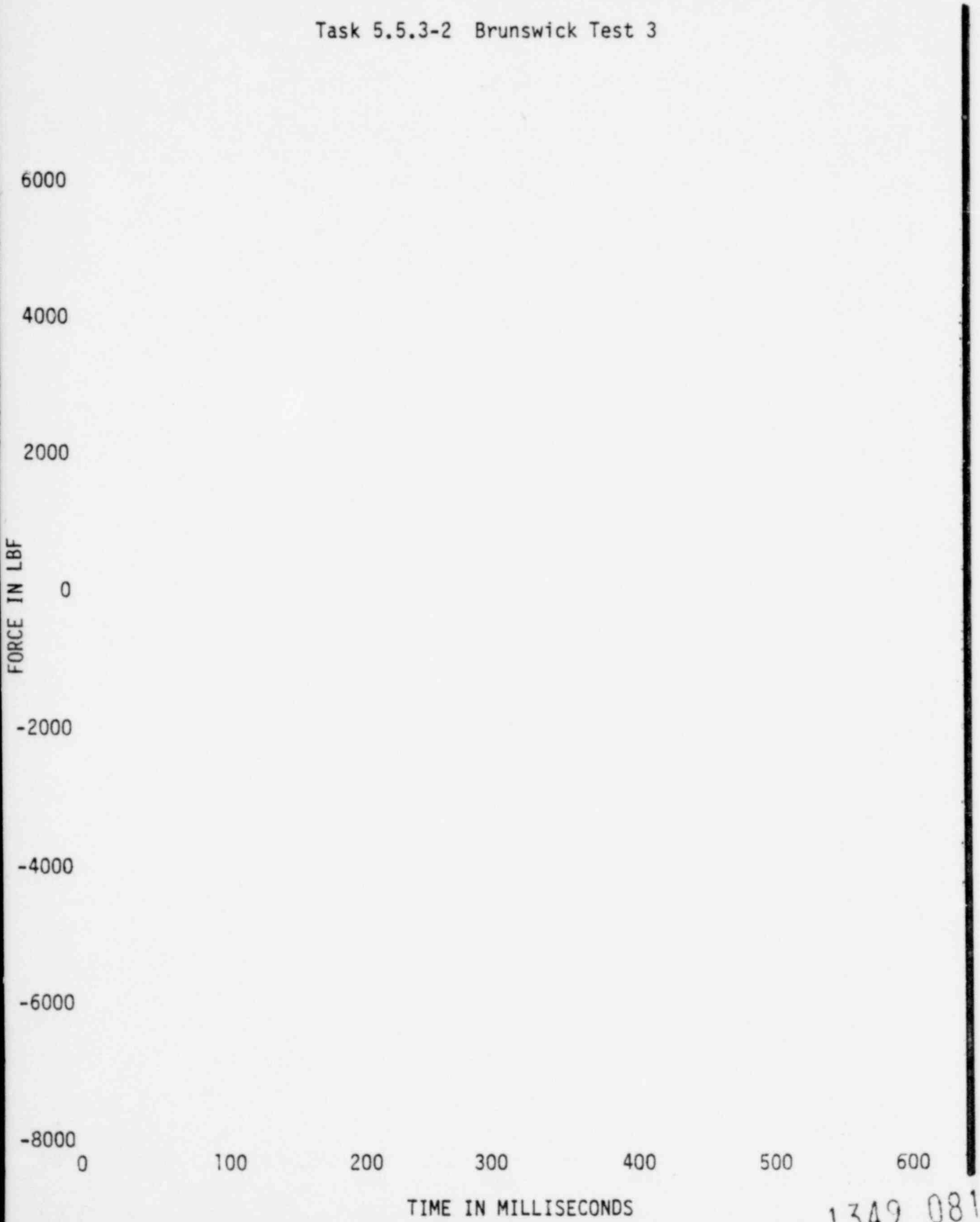


1349 080

FIGURE A-265

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Brunswick Test 3



1349 081

FIGURE A-266

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Brunswick Test 3

AVERAGE POOL PRESSURE IN PSIA

10

8

6

4

2

0

0 100 200 300 400 500 600

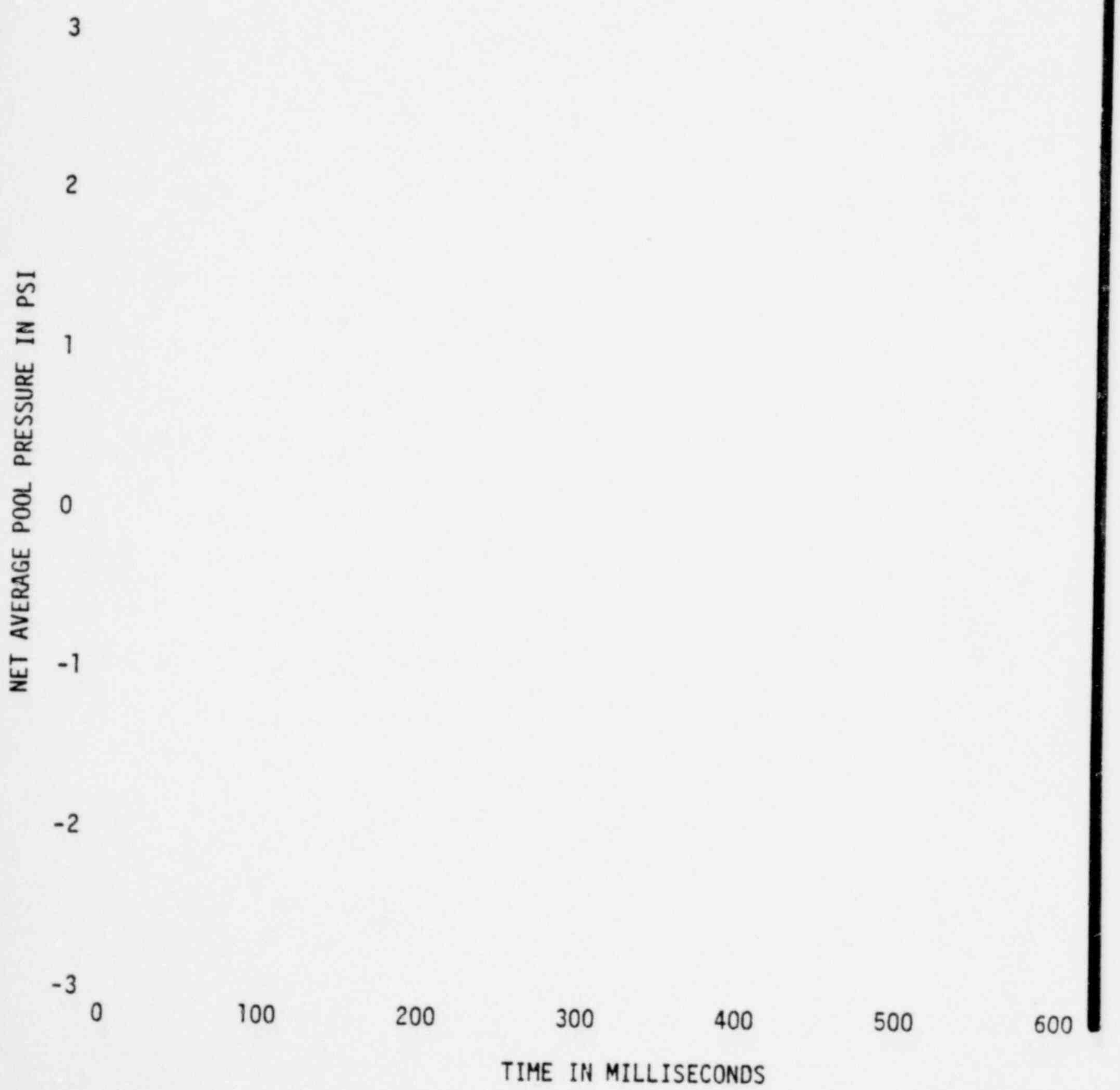
TIME IN MILLISECONDS

1349 082

FIGURE A-267

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Brunswick Test 3



1349 083

FIGURE A-268

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Brunswick Test 3

10

0

210 220 230 240 250 260 270 280 290

TIME IN MILLISECONDS

IMPACT PRESSURE IN PSIA

10

0

210 220 230 240 250 260 270 280 290

10

1349 084

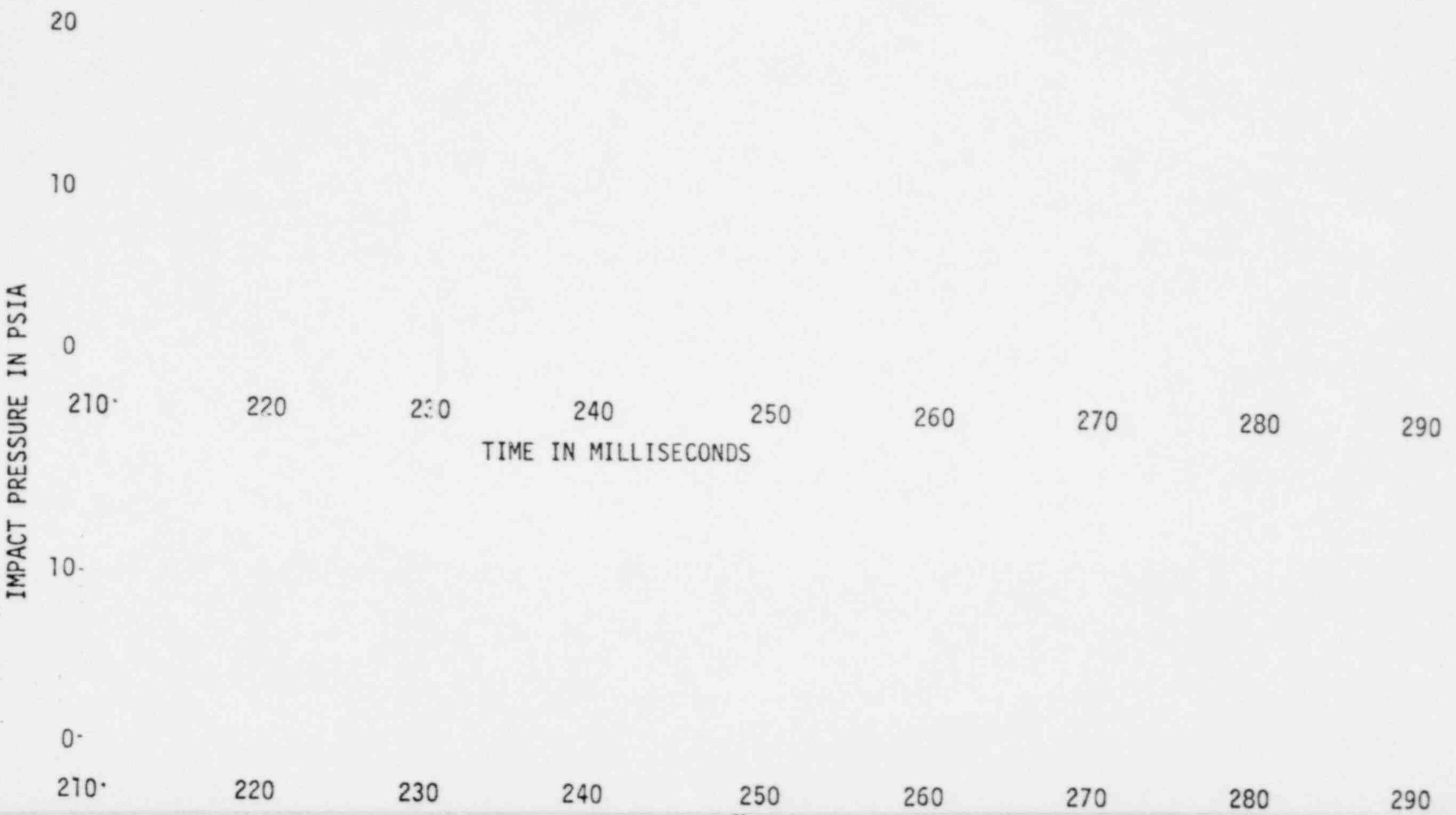
VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Brunswick Test 3

FIGURE A-270

VENT HEADER IMPACT PRESSURES

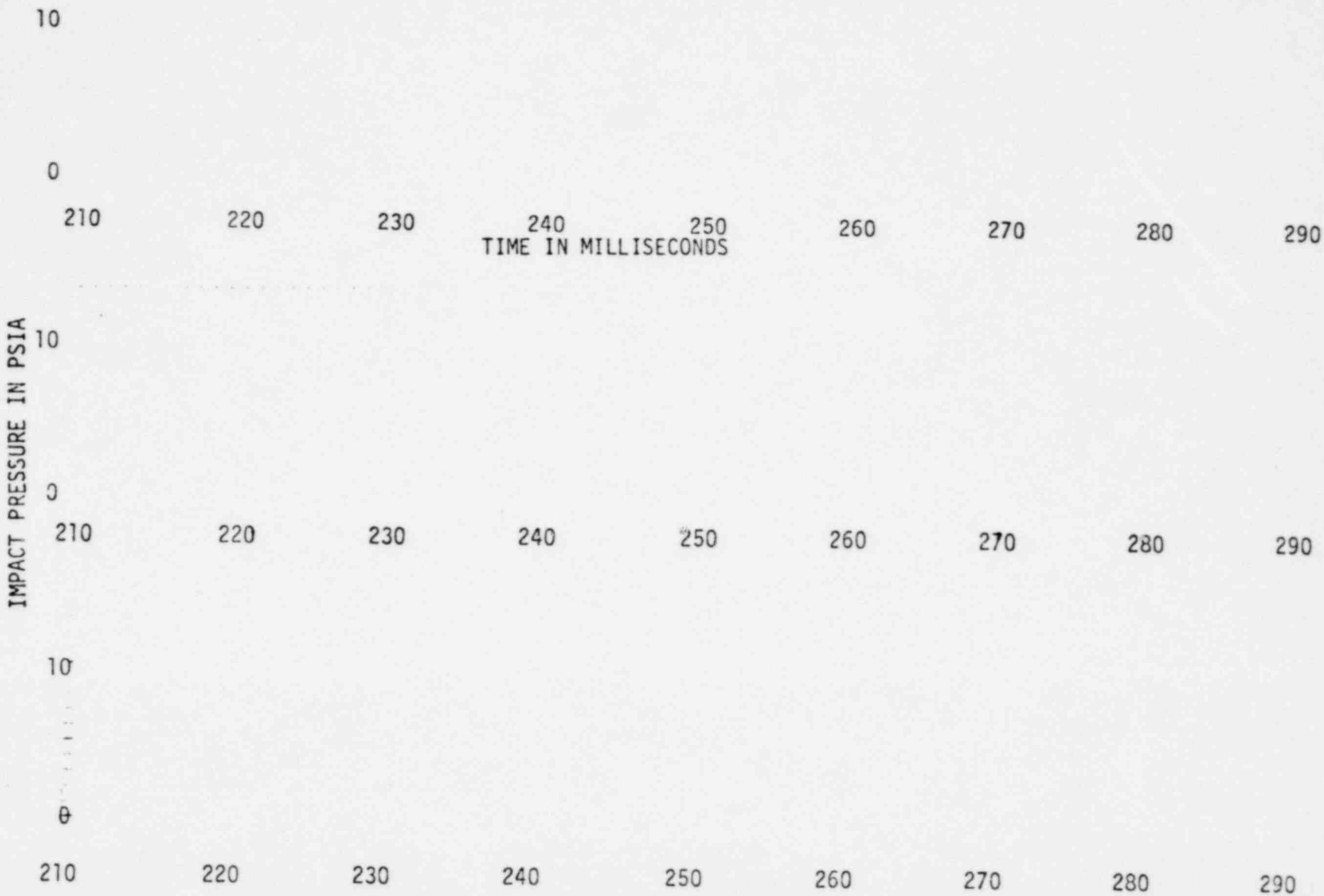
Task 5.5.3-2 Brunswick Test 3



1349 086

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Brunswick Test 3



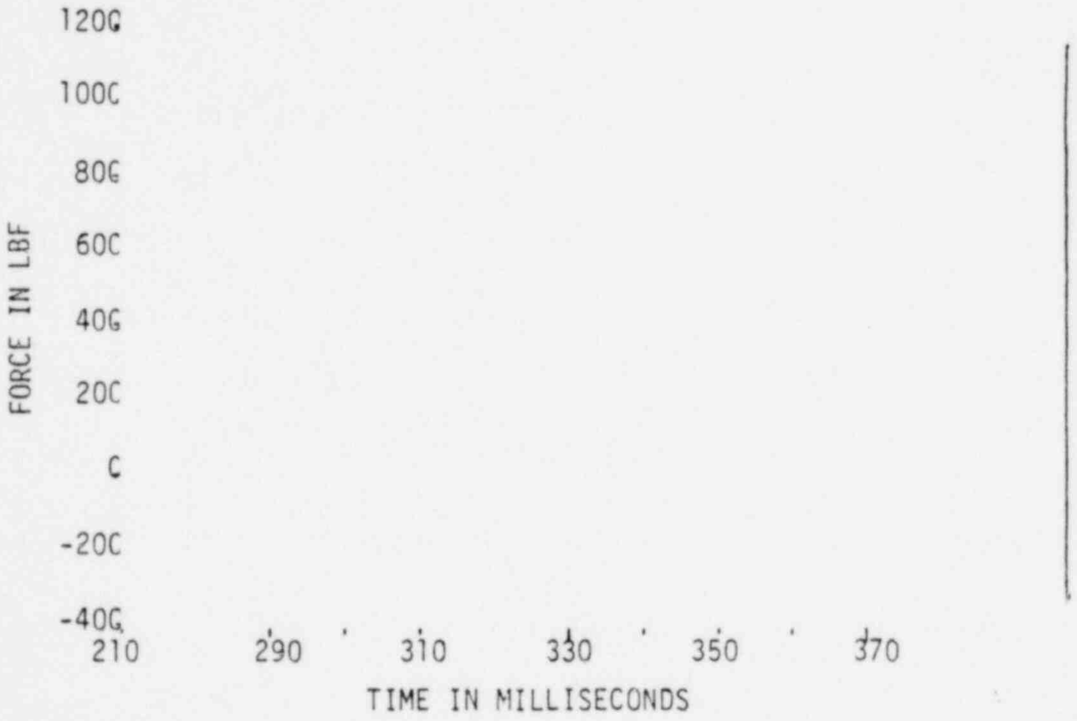
1349 087

FIGURE A-272

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Brunswick Test 3



1349 088

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Brunswick Test 3

1349 089

FIGURE A-274

TIME HISTORY OF
POOL DISPLACEMENT

BRUNSWICK, TEST 1

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_0) - seconds

1349 090

FIGURE A-275

TIME HISTORY OF
POOL DISPLACEMENT

BRUNSWICK, TEST 2

1349 091

FIGURE A-276

TIME HISTORY OF
POOL DISPLACEMENT

BRUNSWICK, TEST 3

Vertical Distance from Original Pool Water Level - inches

30

25

20

15

10

5

0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

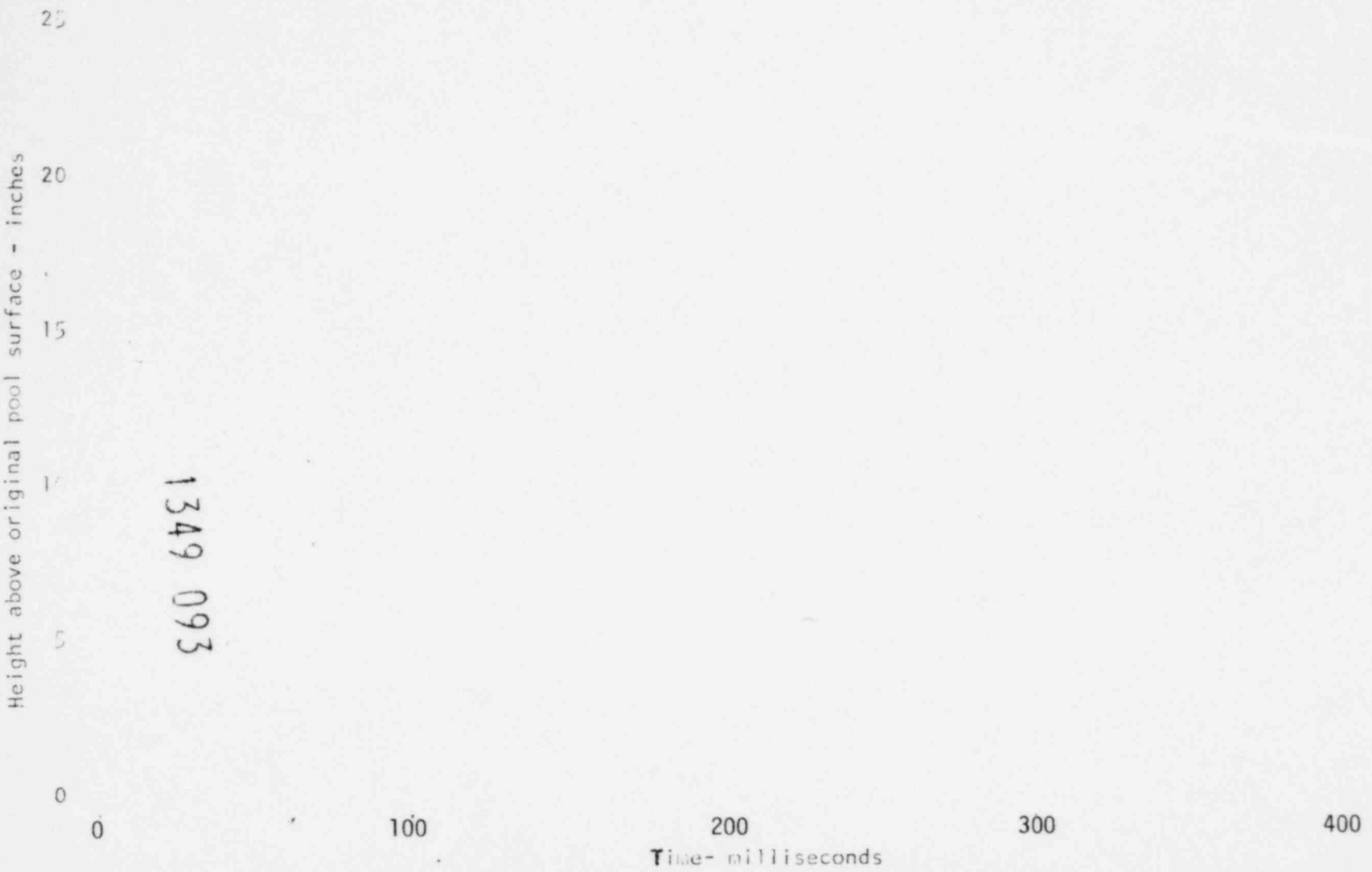
Time (from T_0) - seconds

1349 092

POOL SURFACE DISPLACEMENT

FIGURE A-277

BRUNSWICK, TESTS 1, 2, 3

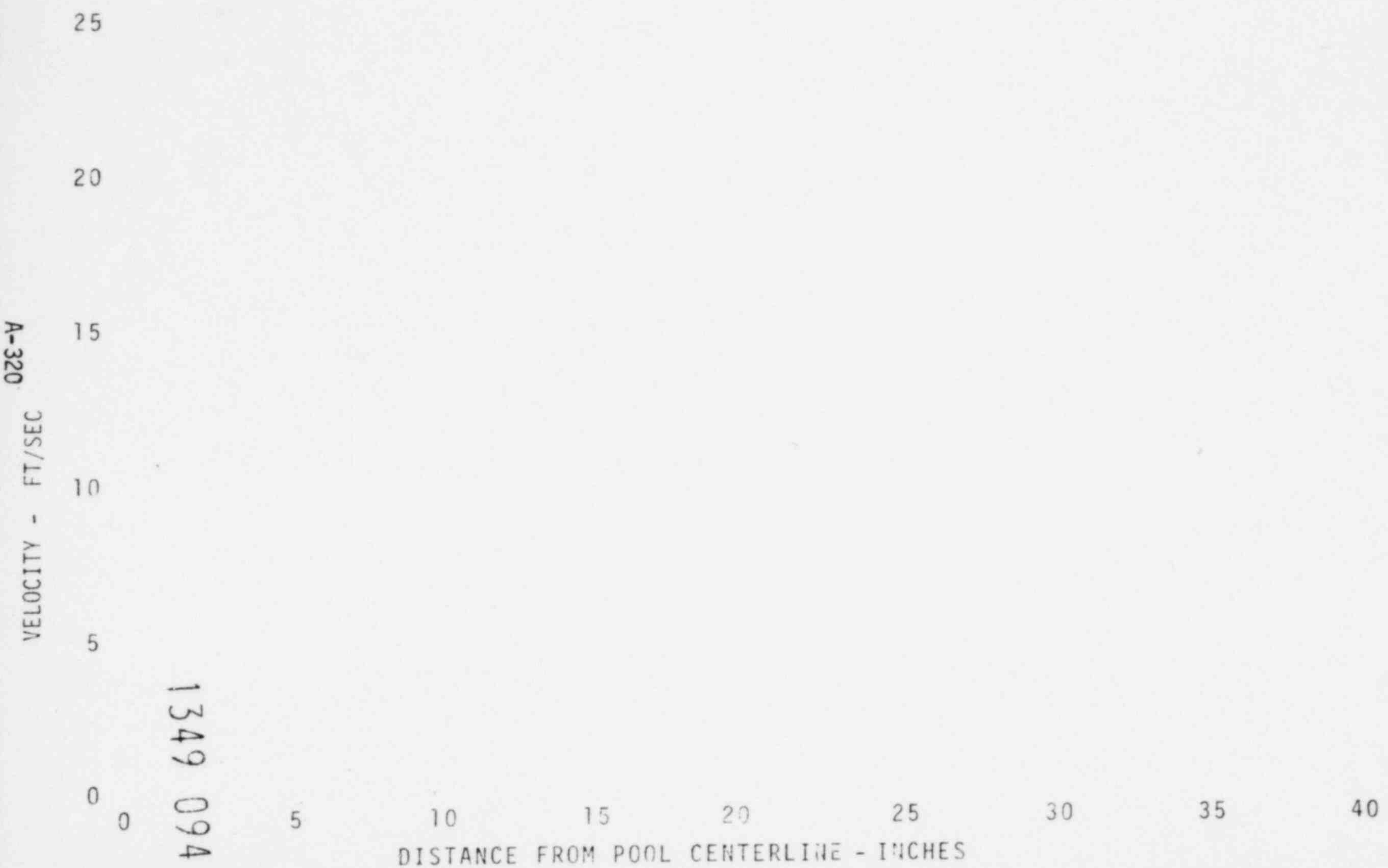


1349 093

FIGURE A-278

POOL SURFACE VELOCITY PROFILES

BRUNSWICK, TESTS 1, 2, 3

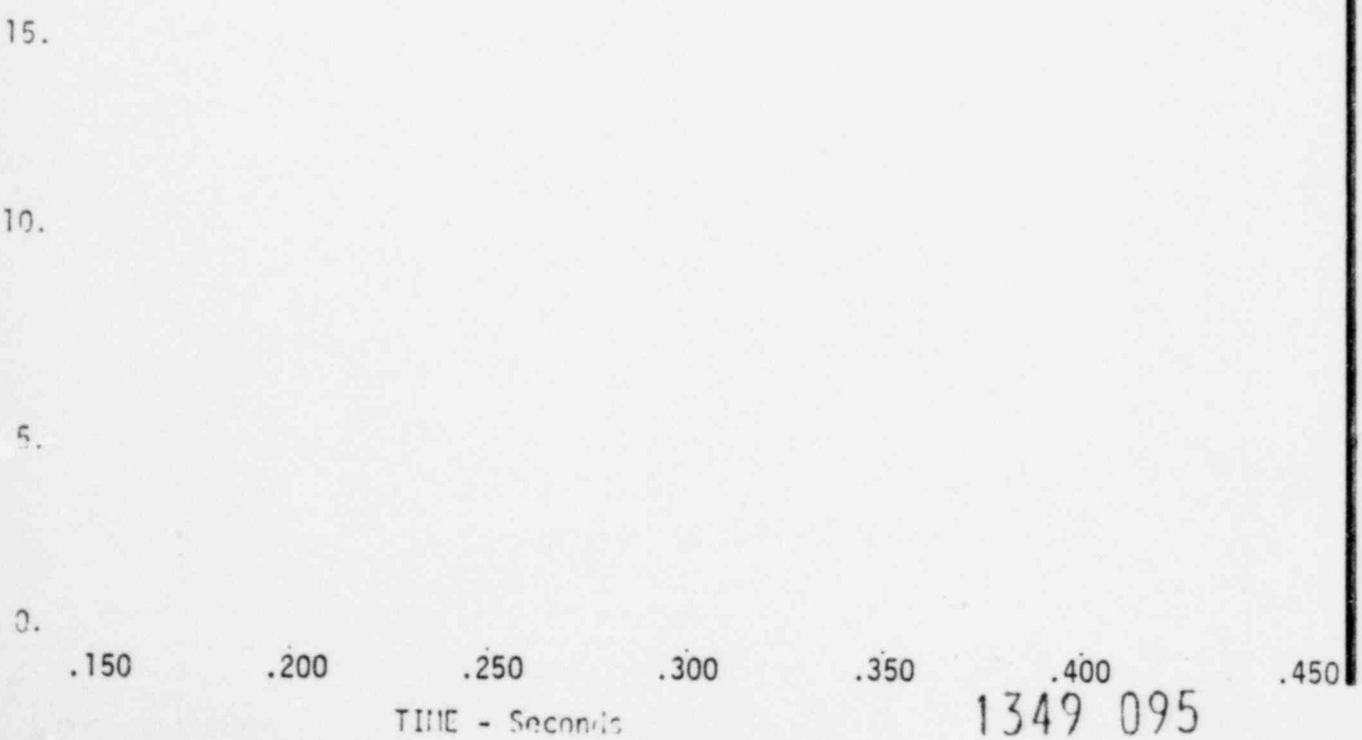


1349 094

FIGURE A-279

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

BRUNSWICK, TEST 4

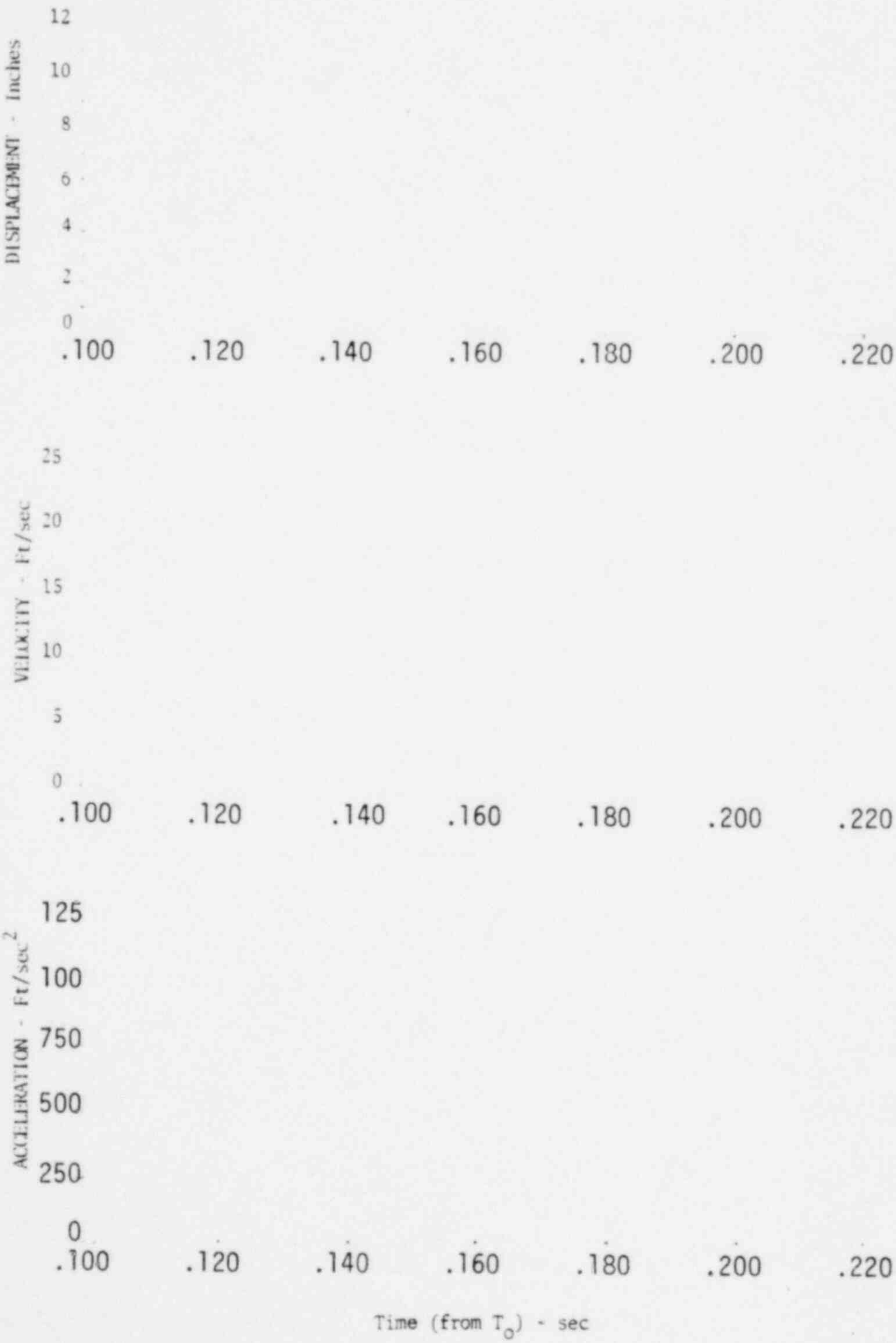


1349 095

FIGURE A-280

DOWNCOMER WATER SLUG EJECTION

BRUNSWICK, TEST 3



1349 096

TABLE A-13

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Brunswick Tests

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.

*(1)Start-of-test reference time

Parameter \ Test No.	0" ΔP, 5.34" Pipe Deflector (20" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.
T_o *(1) (sec)						
Vent Clearing Time* (sec)						
Peak Downforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Downforce Valley						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
2nd Peak Downforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
[Δt] Downforce Time**						
Pressure Integral (sec)						
Corrected Pressure Integral (sec)						
Corrected Load Cell (sec)						
Downforce Impulse						
Pressure Integral:						
Impulse (lb-sec)						

1349 097

TABLE A-13

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Brunswick Tests

Parameter \ Test No.	0"ΔP,5.34" Pipe Deflector (20" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.
Peak Upforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Upforce Valley						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
2nd Peak Upforce						
Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Pressure Integral:						
Force (lb)						
Time (from T_o) (sec)						
Corrected Load Cell:						
Force (lb)						
Time (from T_o) (sec)						
Zero Force Time*						
Pressure Integral (sec)						
Corrected Pressure Integral (sec)						
Corrected Load Cell (sec)						

*Time at force is zero (from T_o)

1349 098

TABLE A-14

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Brunswick Tests

Parameter \ Test No.		0" ΔP, 5.34" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	(5)
T_o†	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected:††								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*Based on impact pressure measurements.
**At start of the first impact pressure recorded.
***Only the mean velocity (for tests 1, 2, 3) at a position 6" off the facility centerline is calculate.
†Start of reference time
††represents peak of very noisy data (acceleration corrected); mean value would be lower

1349 099

A.7 Cooper Station Tests

A.7.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Cooper Station Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 7.46" ΔP. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP). The Cooper Station tests were conducted with no vent header deflector.

A.7.1.1 Driving Conditions

Driving conditions for Cooper Station Test 3 are presented in Figures A-281 through A-285. Similar plots for Cooper Station Test 5 are shown in Figures A-286 through A-290. Cooper Station's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.7.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Cooper Station Tests 3 and 5 are presented in Figures A-291 through A-292 and A-293 through A-294, respectively. These pressure plots have the same characteristics as the "typical" plant in Section 3.0.

Figures A-295 and A-296 present net torus force based on the torus pressure integral for Cooper Station Tests 3 and 5, respectively. Some downforce oscillations are present, but they dampen out rapidly after the first oscillation. The upforce also shows some oscillation.

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-298 and A-300) to the torus load cell (Figures A-297 and A-299) is compared with

1349 100

the torus force obtained from the torus pressure integral in Figures A-301 and A-302. Figures A-303 and A-304 present the net torus force based on the torus pressure integral corrected for inertia.

The "average" pool pressures for Cooper Station Tests 3 and 5 are shown in Figures A-305 and A-307. Figures A-306 and A-308 are the same as Figures A-303 and A-304 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Cooper Station Test 3 are presented in Figures A-309 through A-312. Vent header pressures for Cooper Station Test 5 are presented in Figures A-313 through A-316.

Figure A-317 presents a comparison of the vent header impact force derived from the pressure integral with that derived from the corrected load cell. Vent header vertical accelerations from Tests 3 and 5 are shown in Figures A-318 and A-319, respectively.

A.7.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-320 through A-323 for Cooper Station Tests 1, 2, 3, and 5.

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-324. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-325. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-326 and A-327, respectively.

1349 101

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-328. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-329 and A-330.

A.7.3 Data Summaries

Table A-15 presents the Cooper Station test data for wetwell vertical forces.

Table A-16 presents the Cooper Station test data for vent header impact forces.

A.7.4 Discussion and Analysis

Figure A-331 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-332. Figure A-333 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The data for Cooper Station parallels that for the "typical" plant in Section 3.0.

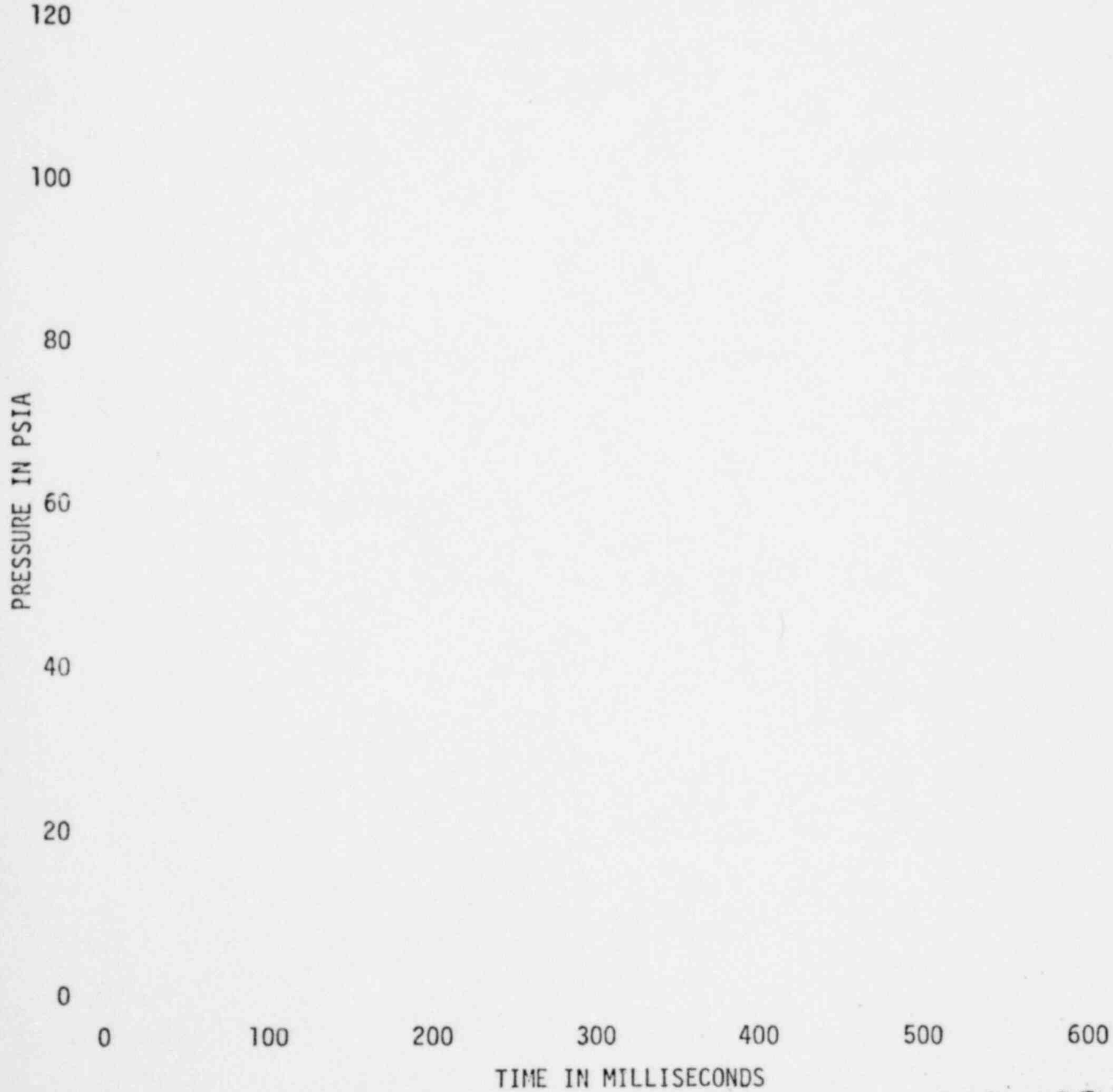
The Cooper Station load definition tests were conducted at 7.46" H_2O ΔP and with no vent header deflector. A ΔP sensitivity test at 0" H_2O ΔP was also conducted. Some downforce oscillations were evident. The upforce also showed oscillation. The vent header impact force was significantly higher than for plants using deflectors.

1349 102

FIGURE A-281

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Cooper Station Test 3



1349 103

FIGURE A-282

DRYWELL PRESSURE

Task 5.5.3-2 Cooper Station Test 3

20

16

PRESSURE IN PSIA

12

8

4

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 104

FIGURE A-283

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

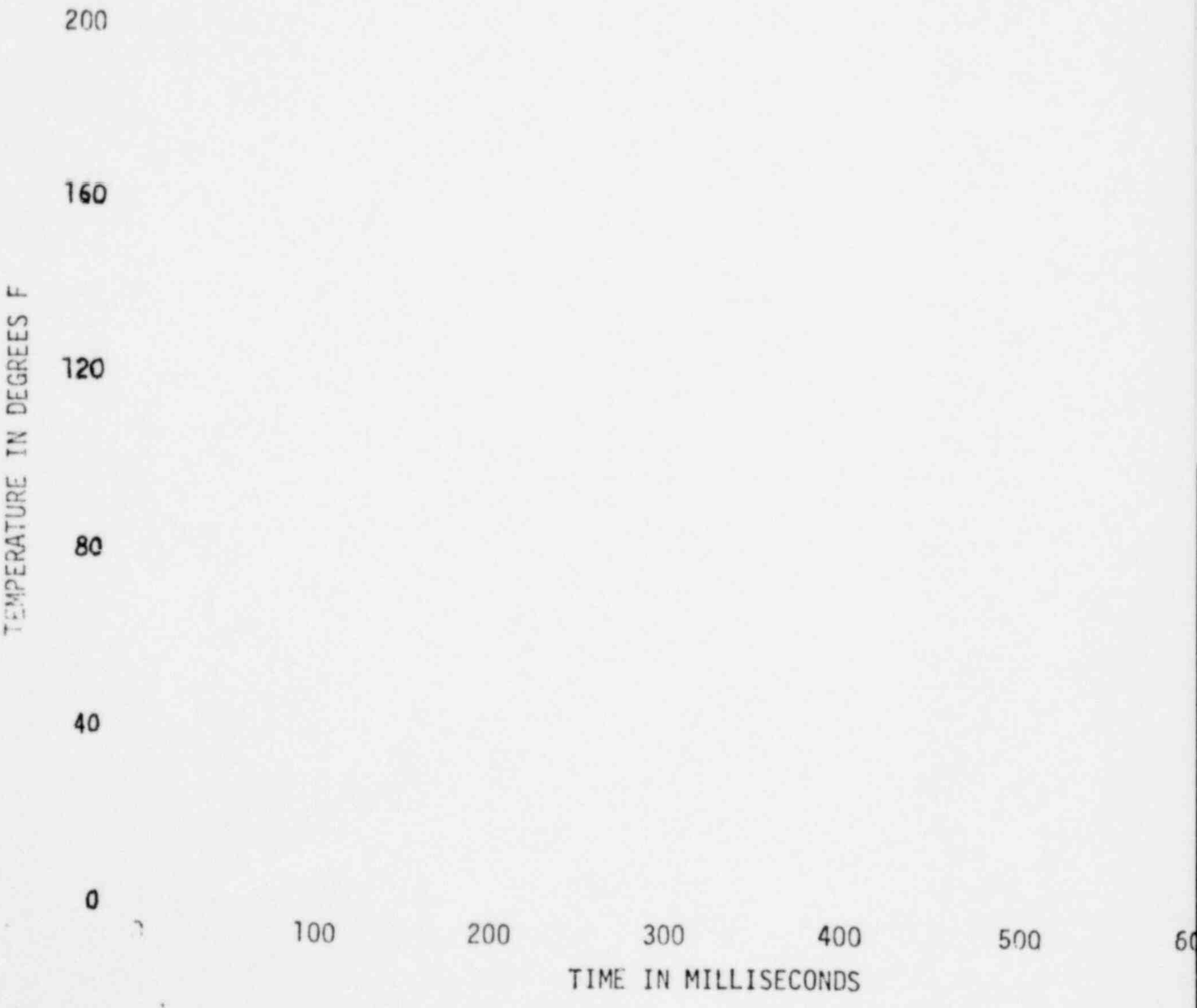
Task 5.5.3-2 Cooper Station Test 3

1349 105

FIGURE A-284

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Cooper Station Test 3

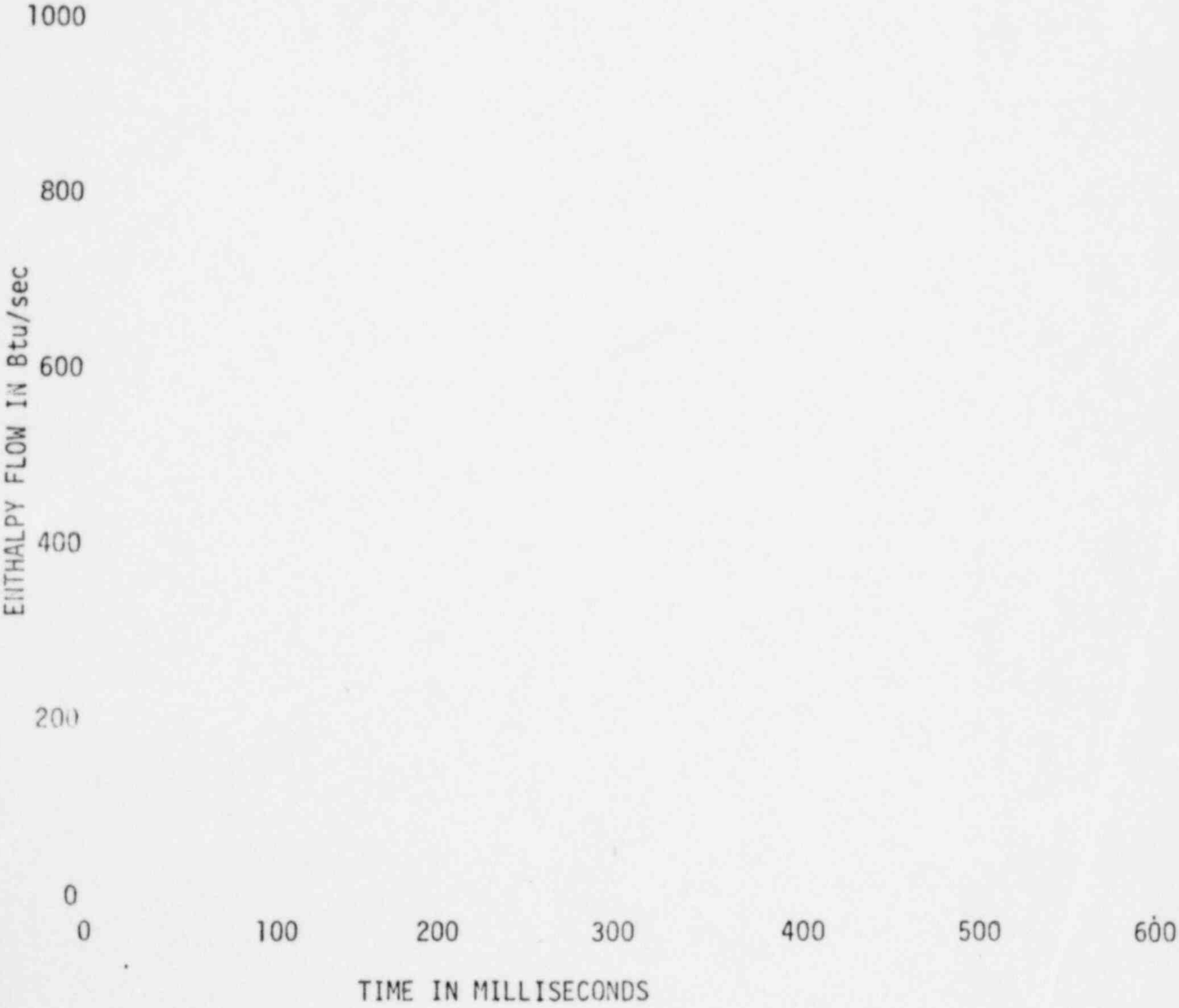


1349 106

FIGURE A-285

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Cooper Station Test 3



1349 107

FIGURE A-286

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Cooper Station Test 5

PRESSURE IN PSIA

120
100
80
60
40
20
0

0 100 200 300 400 500 600

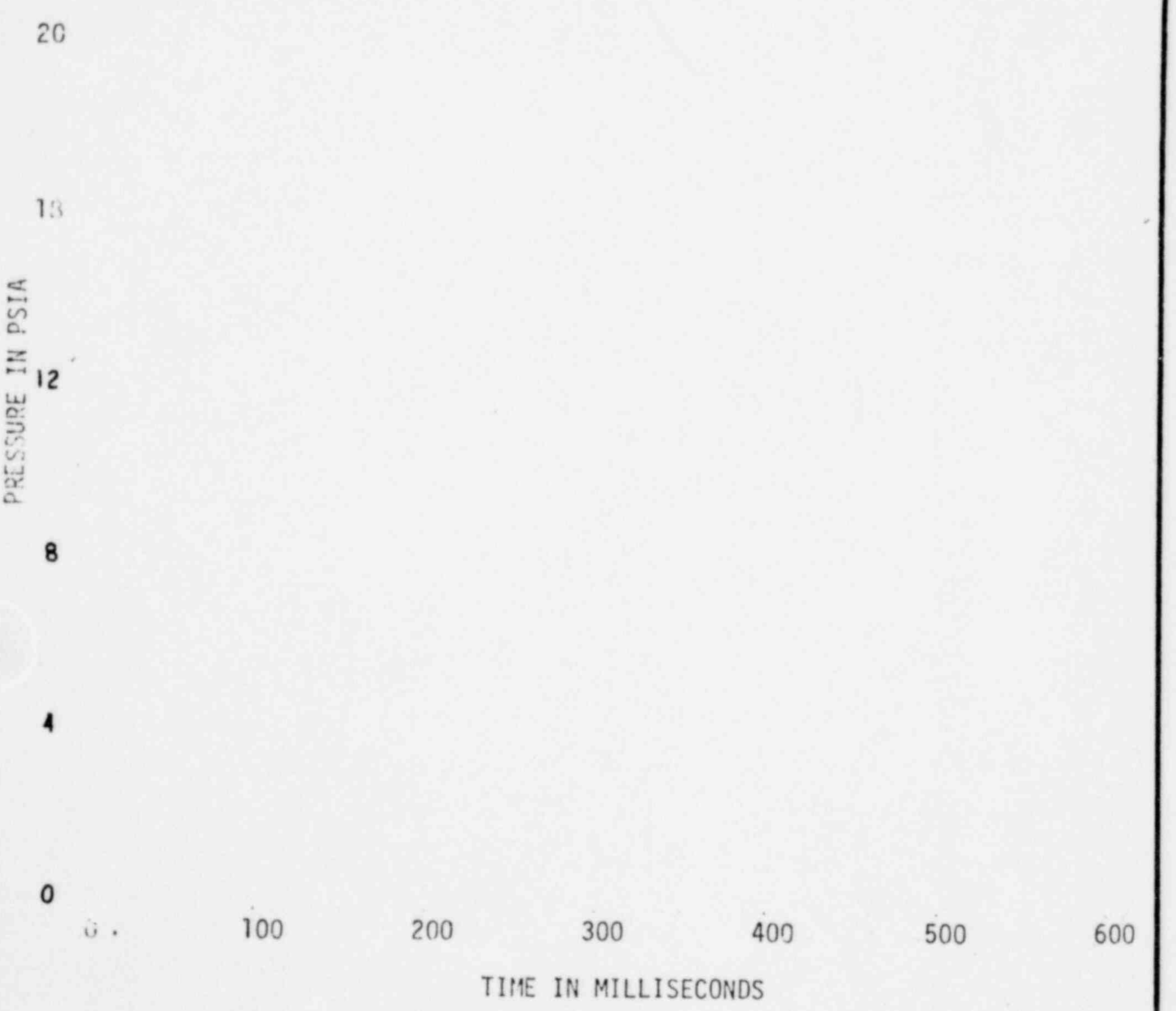
TIME IN MILLISECONDS

1349 108

FIGURE A-287

DRYWELL PRESSURE

Task 5.5.3-2 Cooper Station Test 5



1349 109

FIGURE A-288

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Cooper Station Test 5

DIFFERENTIAL PRESSURE IN PSID

10

8

6

4

2

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 110

FIGURE A-289

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Cooper Station Test 5

200

160

120

80

40

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 111

FIGURE A-290

ENTHALPY FLOW INTO POOL

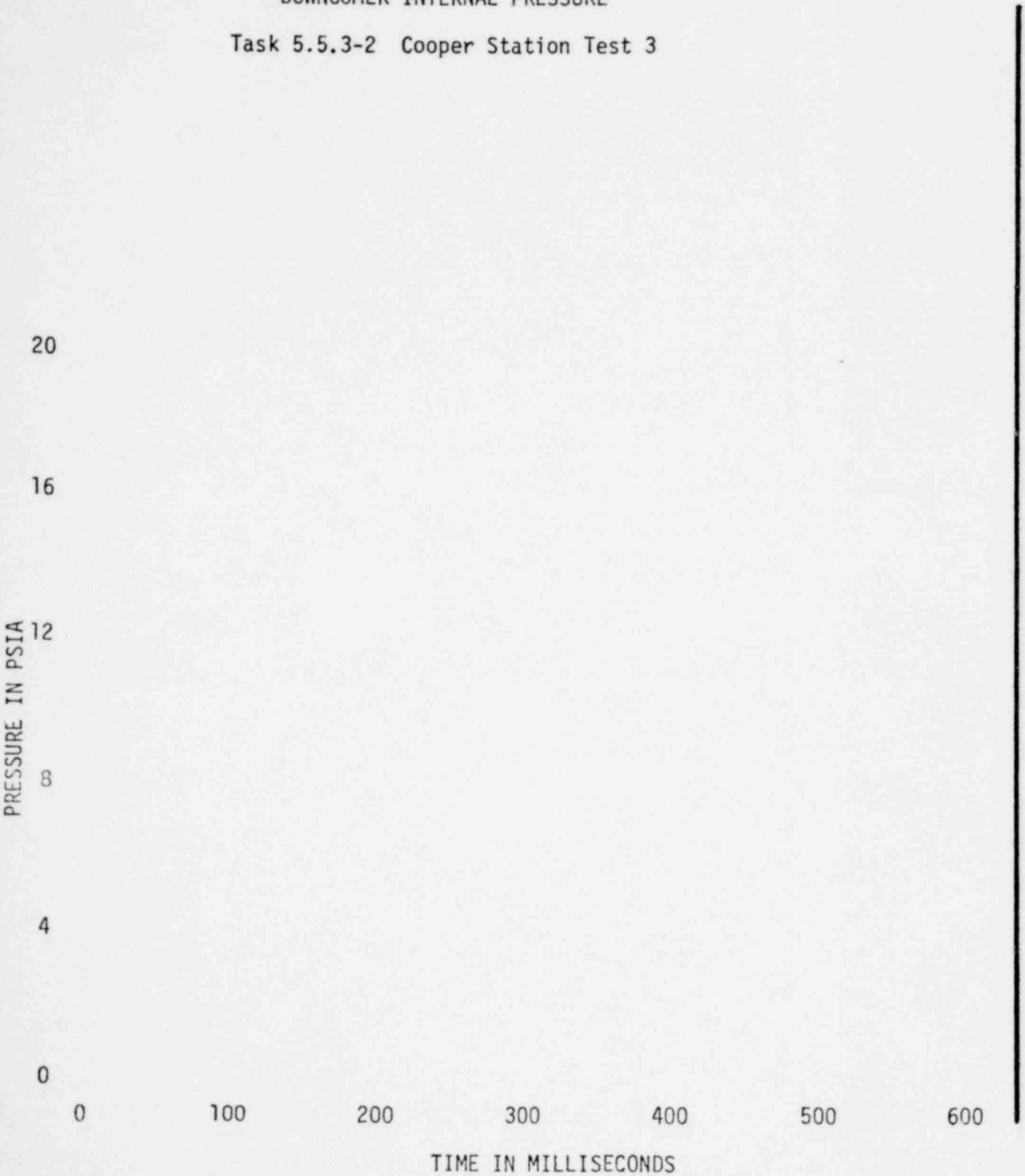
Task 5.5.3-2 Cooper Station Test 5

1349 112

FIGURE A-291

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Cooper Station Test 3

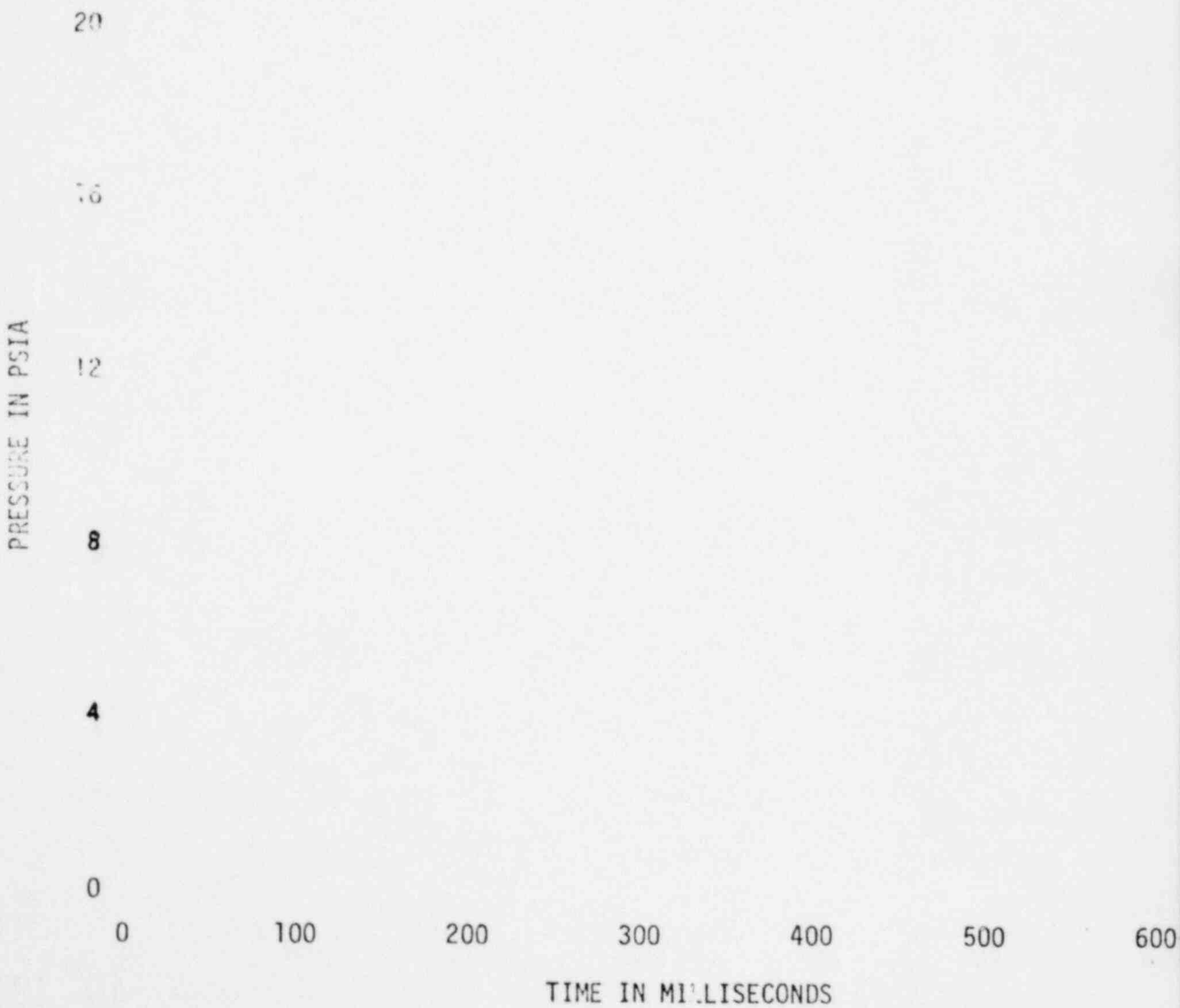


1749 113

FIGURE A-292

WETWELL PRESSURES

Task 5.5.3-2 Cooper Station Test 3

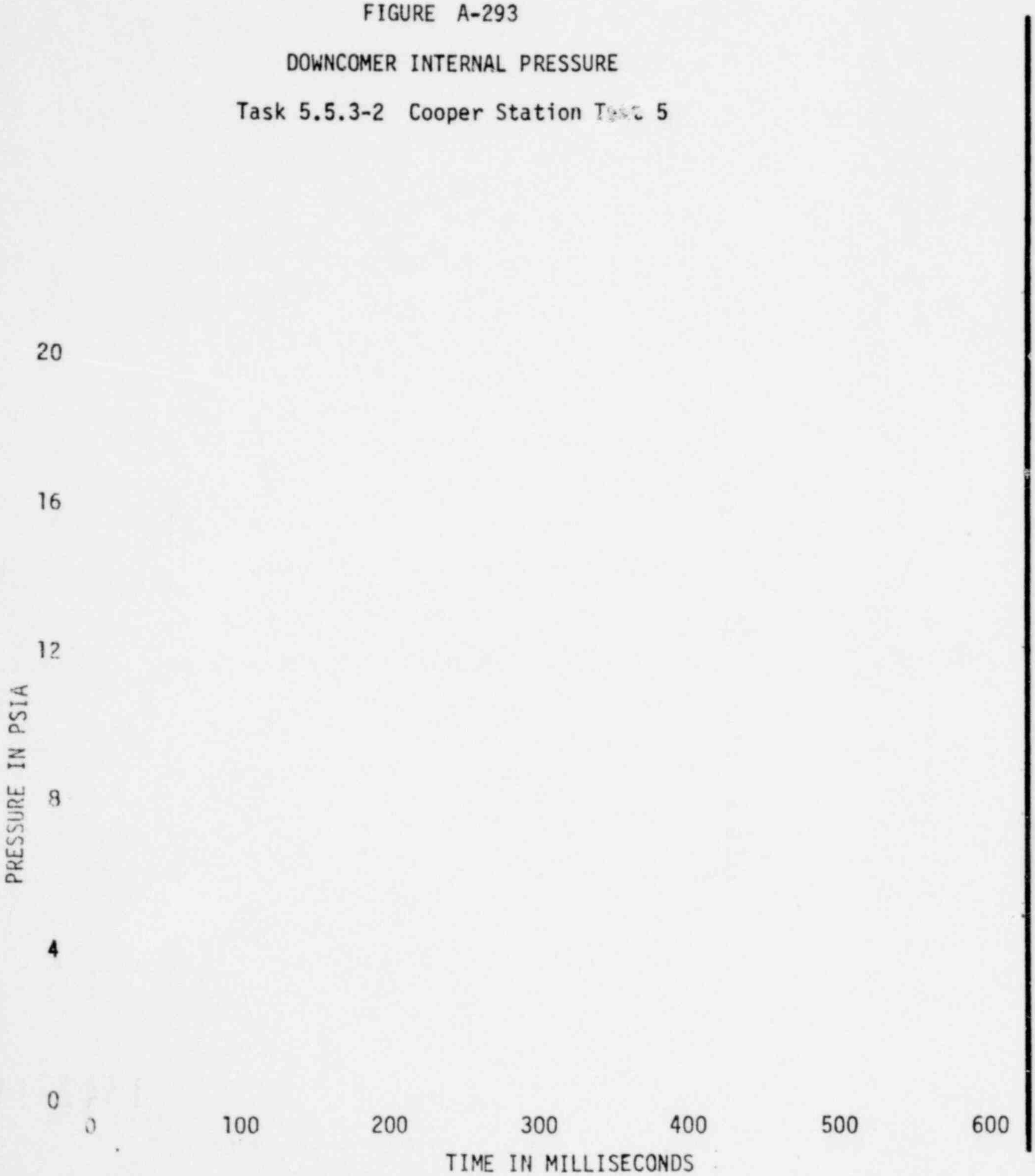


1349 114

FIGURE A-293

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Cooper Station Test 5



1349 115

FIGURE A-294

WETWELL PRESSURES

Task 5.5.3-2 Cooper Station Test 5

PRESSURE IN PSIA

20

16

12

8

4

1349 116

0

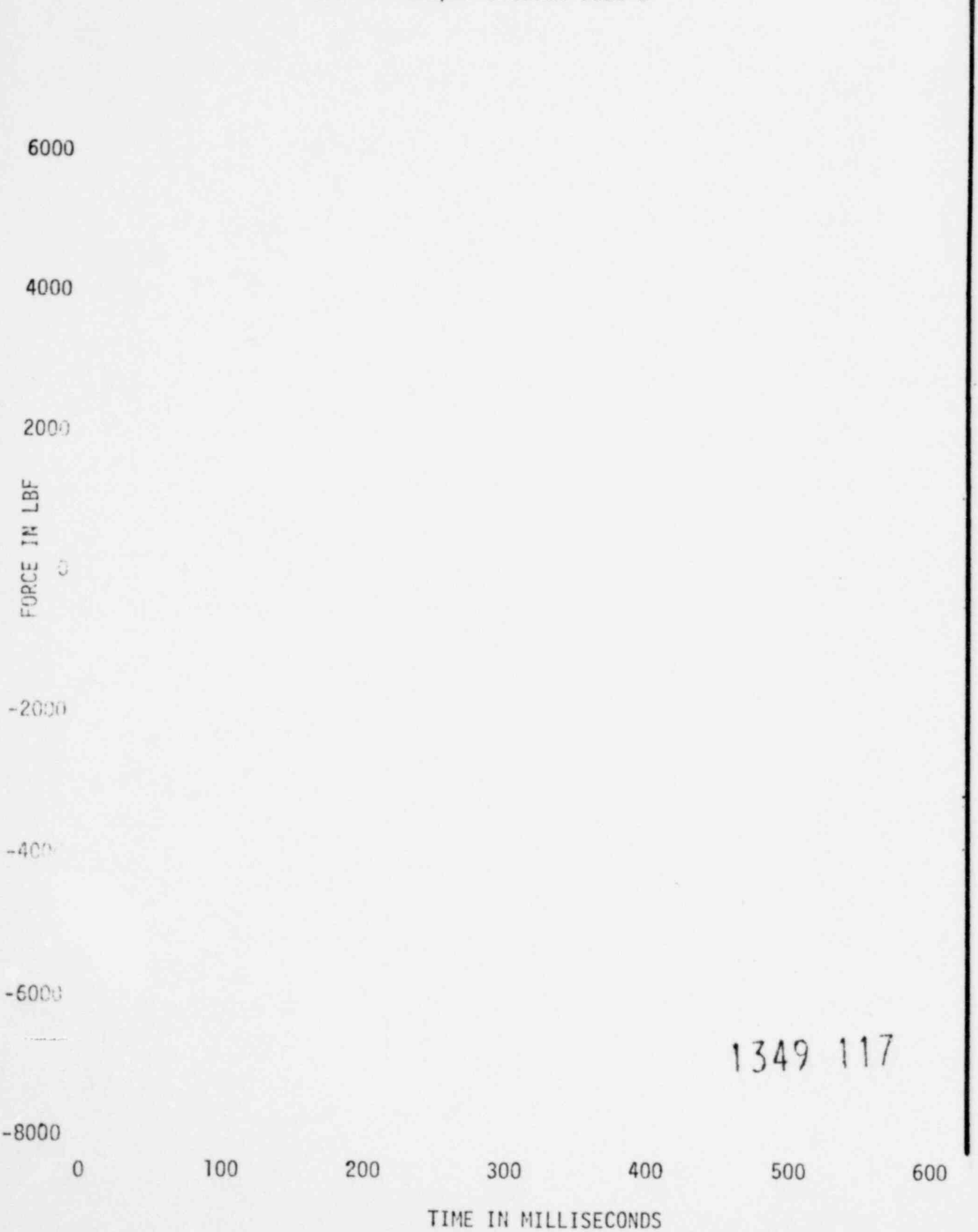
0 100 200 300 400 500 6

TIME IN MILLISECONDS

FIGURE A-295

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Cooper Station Test 3



1349 117

FIGURE A-296

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Cooper Station Test 5

6000

4000

2000

FORCE IN LBF 0

-2000

-4000

-6000

-8000

-10,000

0 100 200 300 400 500 6

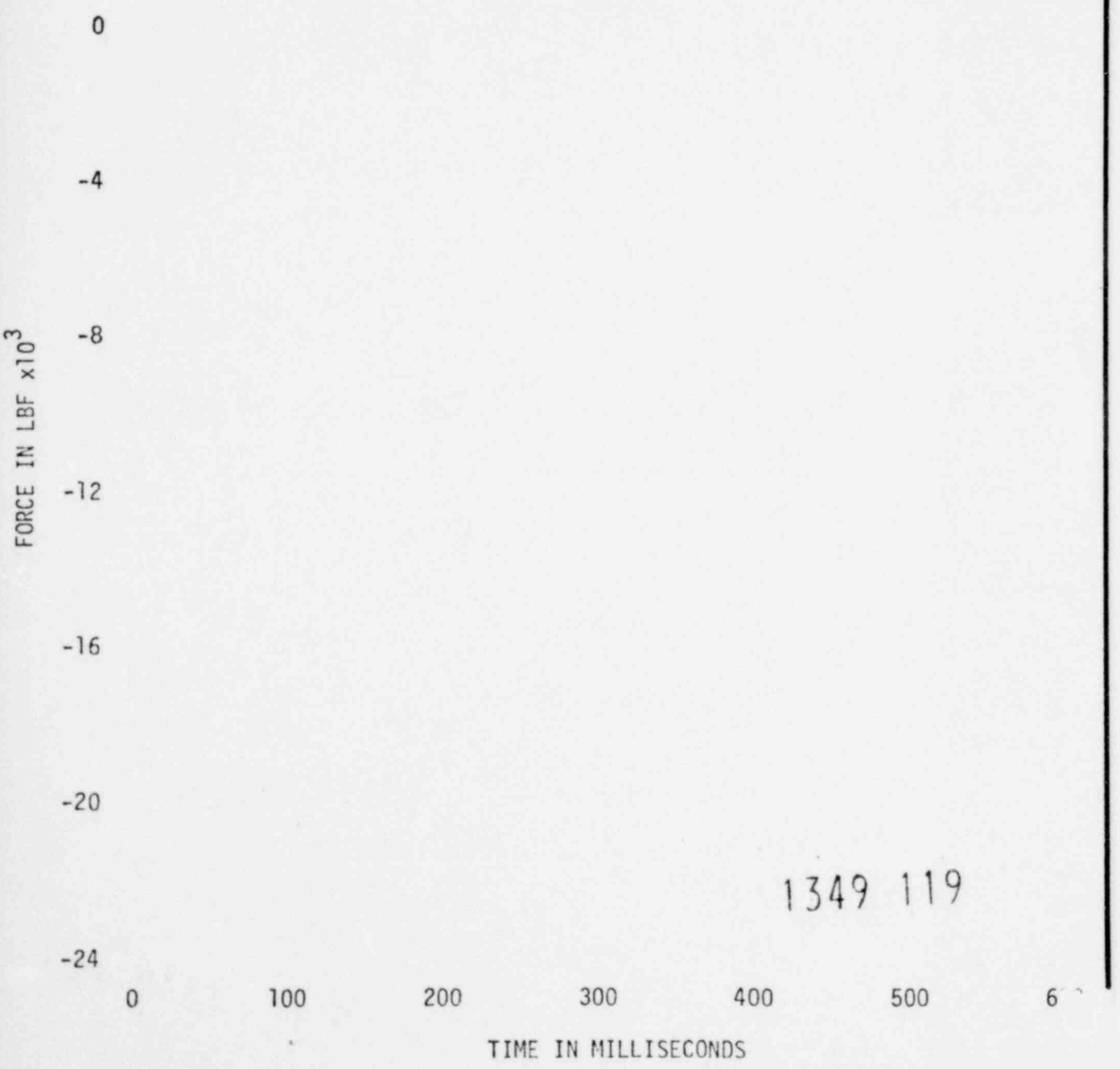
TIME IN MILLISECONDS

1349 118

FIGURE A-297

TORUS LOAD CELL

Task 5.5.3-2 Cooper Station Test 3

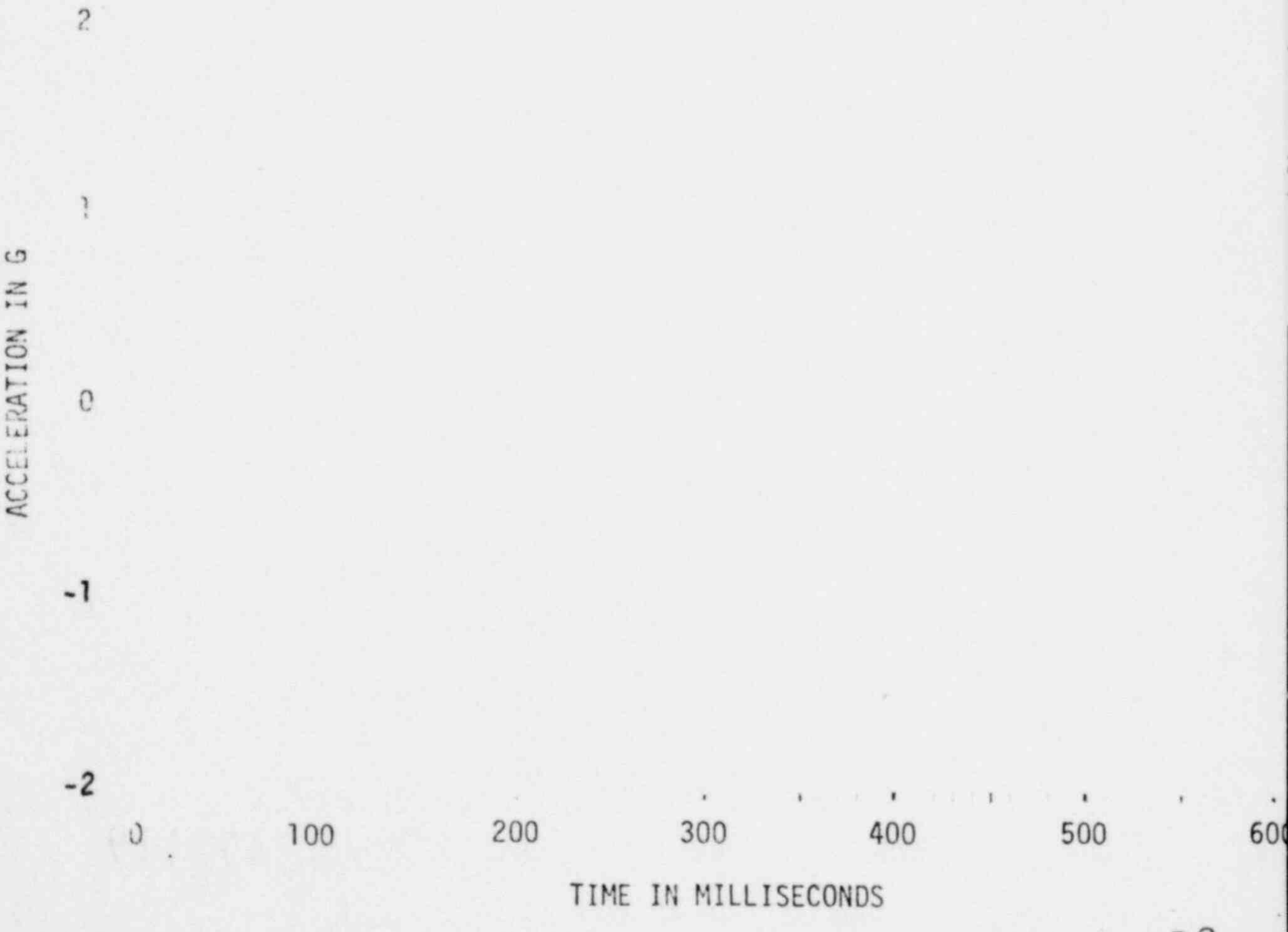


1349 119

FIGURE A-298

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Cooper Station Test 3



1349 120

FIGURE A-299

TORUS LOAD CELL

Task 5.5.3-2 Cooper Station Test 5

FORCE IN LBF $\times 10^3$

0

-4

-8

-12

-16

-20

-24

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 121

FIGURE A-300

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Cooper Station Test 5

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

TIME IN MILLISECONDS

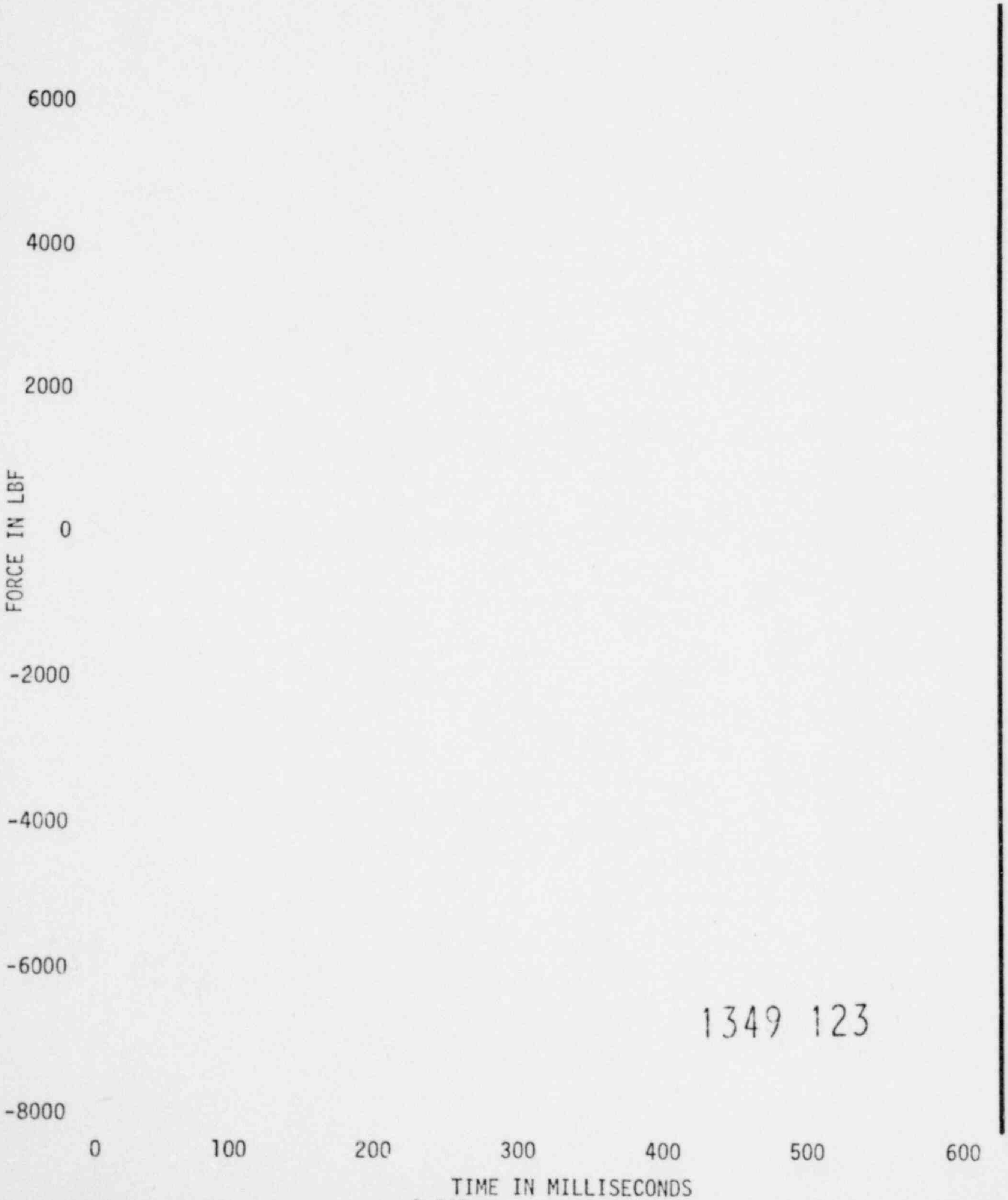
1349 122

FIGURE A-301

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Cooper Station Test 3



1349 123

FIGURE A-302

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

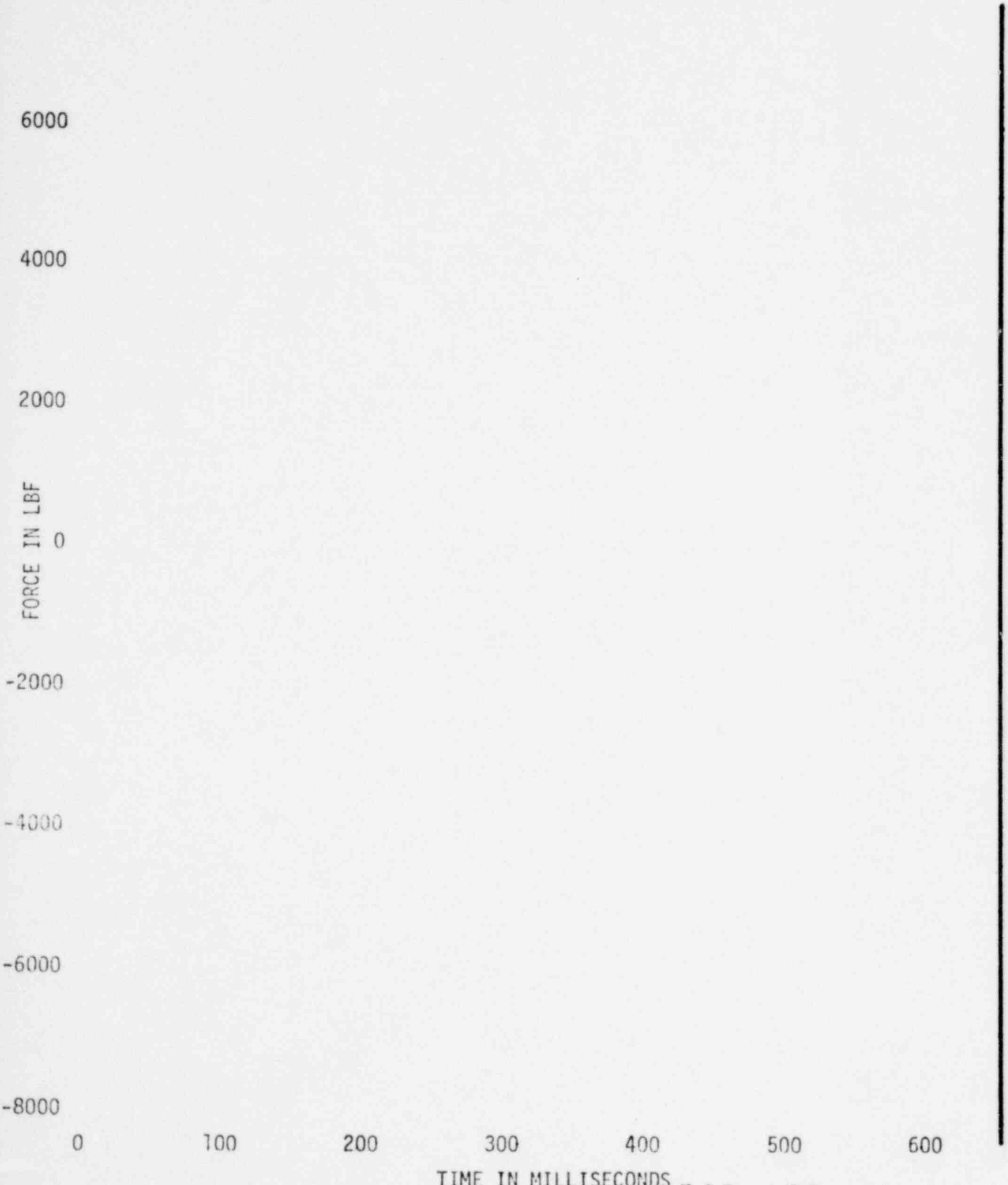
Task 5.5.3-2 Cooper Station Test 5

1349 124

FIGURE A-303

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 3

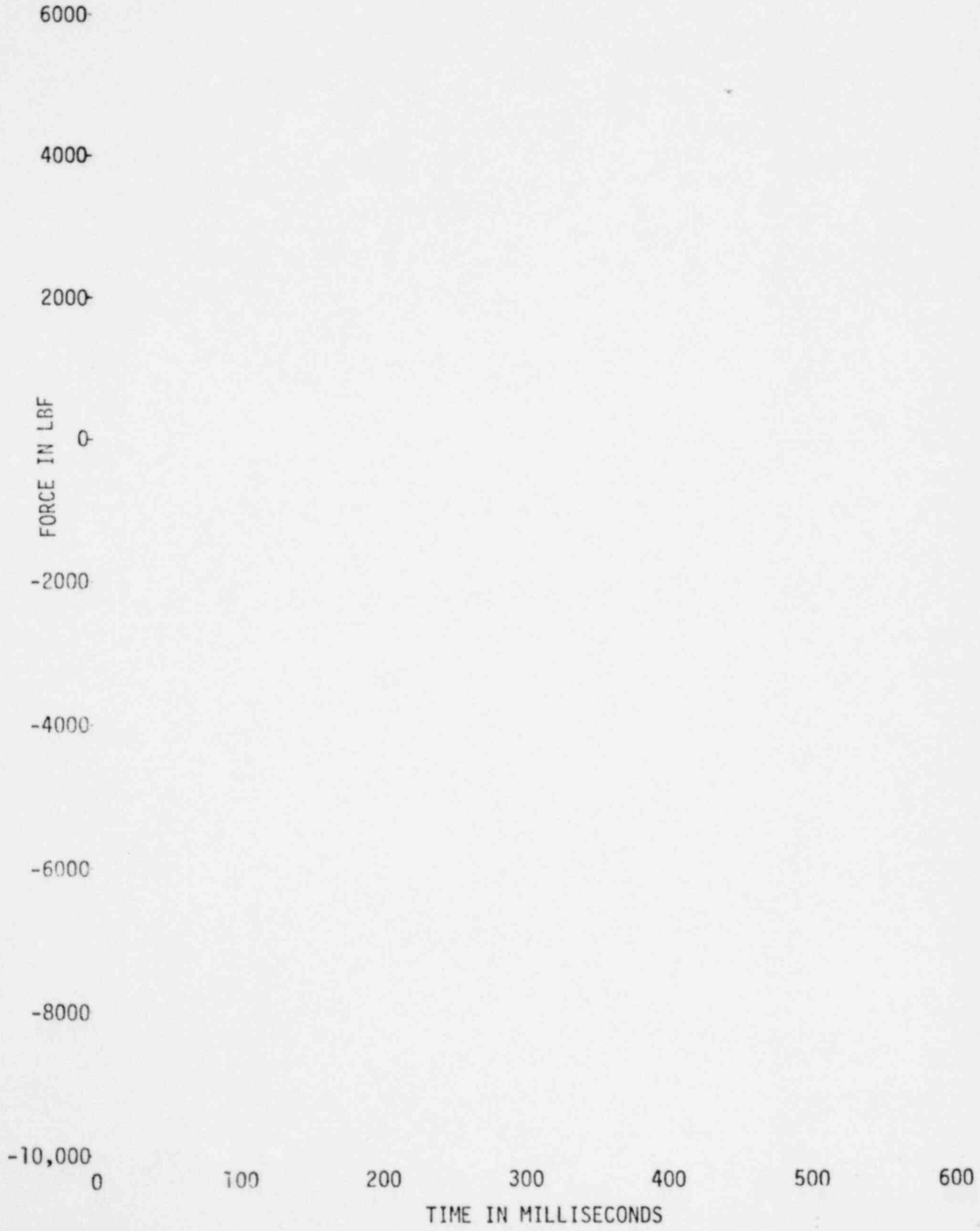


1349 125

FIGURE A-304

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 5

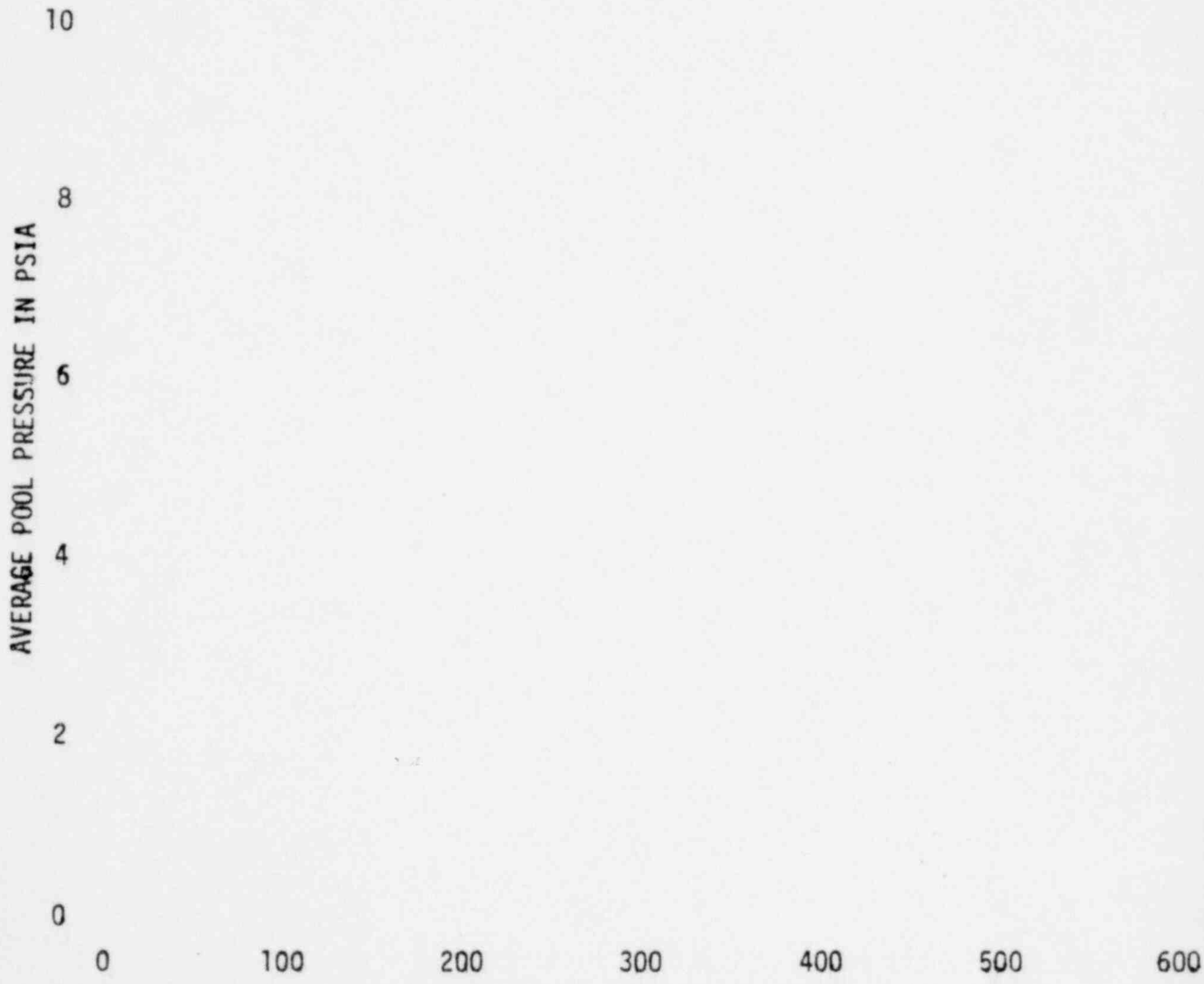


1349 126

FIGURE A-305

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 3

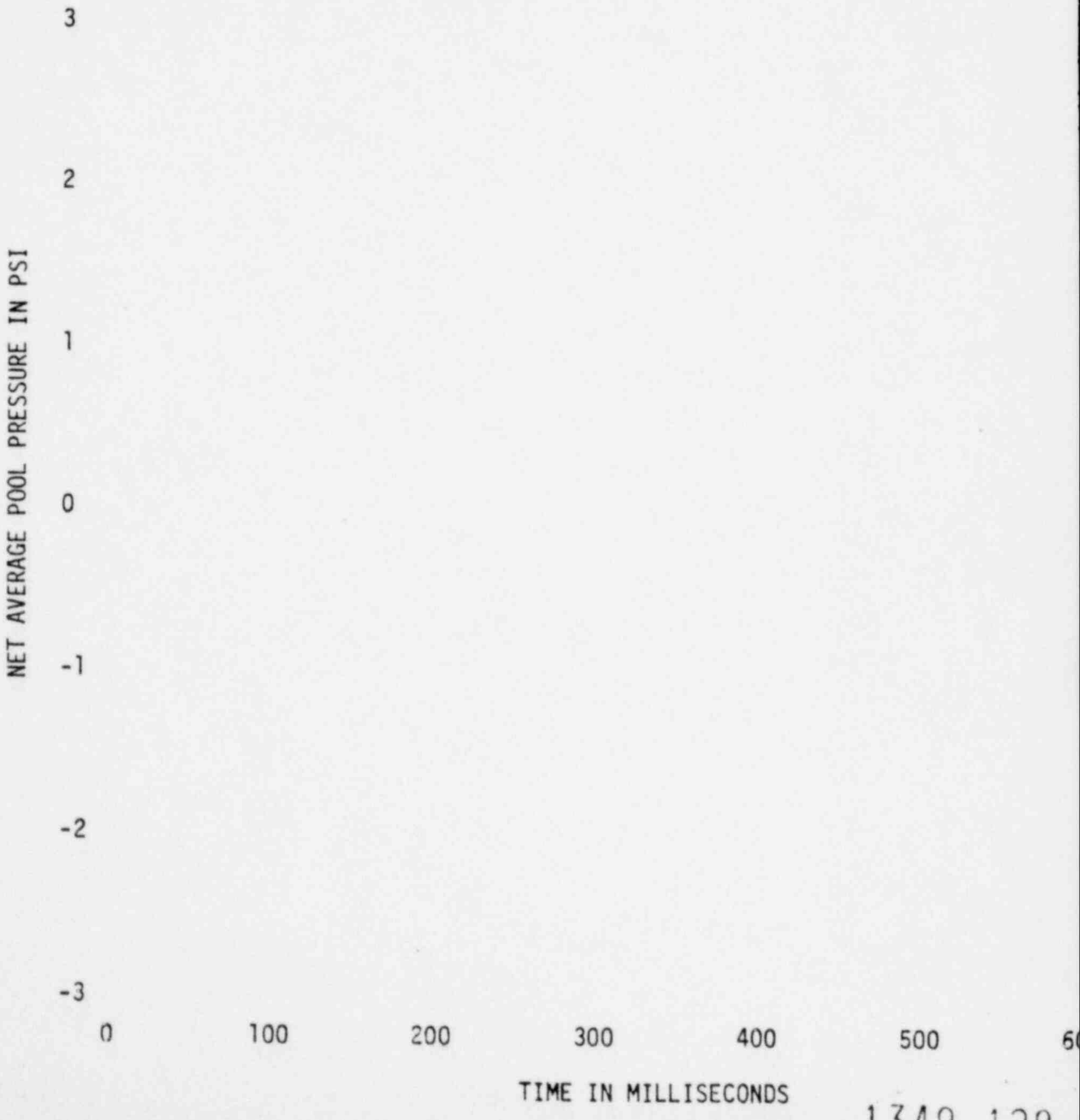


1349 127

FIGURE A-306

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 3

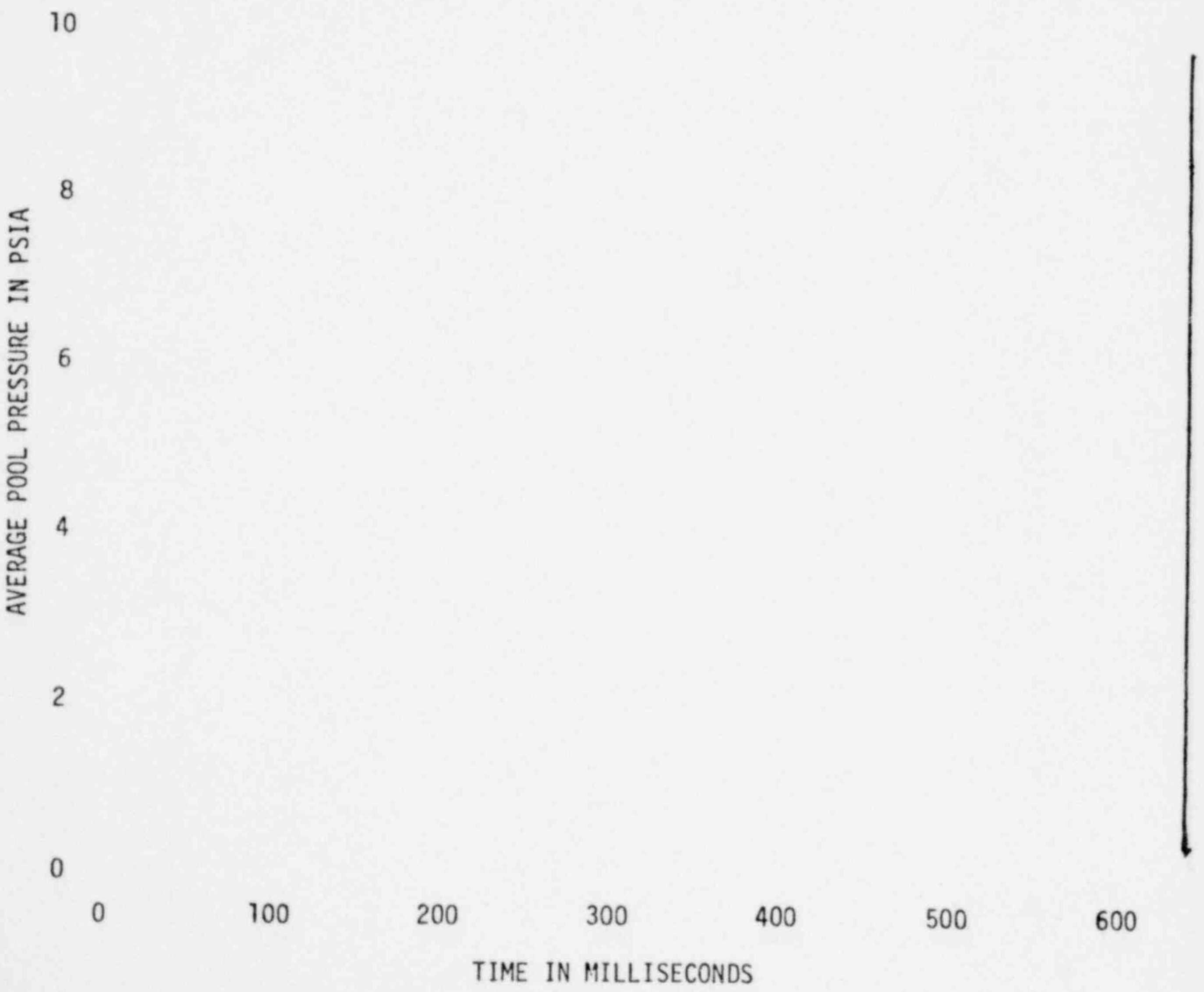


1349 128

FIGURE A-307

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 5



1349 129

FIGURE A-308

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Cooper Station Test 5

NET AVERAGE POOL PRESSURE IN PSI

3

2

1

0

-1

-2

-3

-4

-5

0 100 200 300 400 500 6-

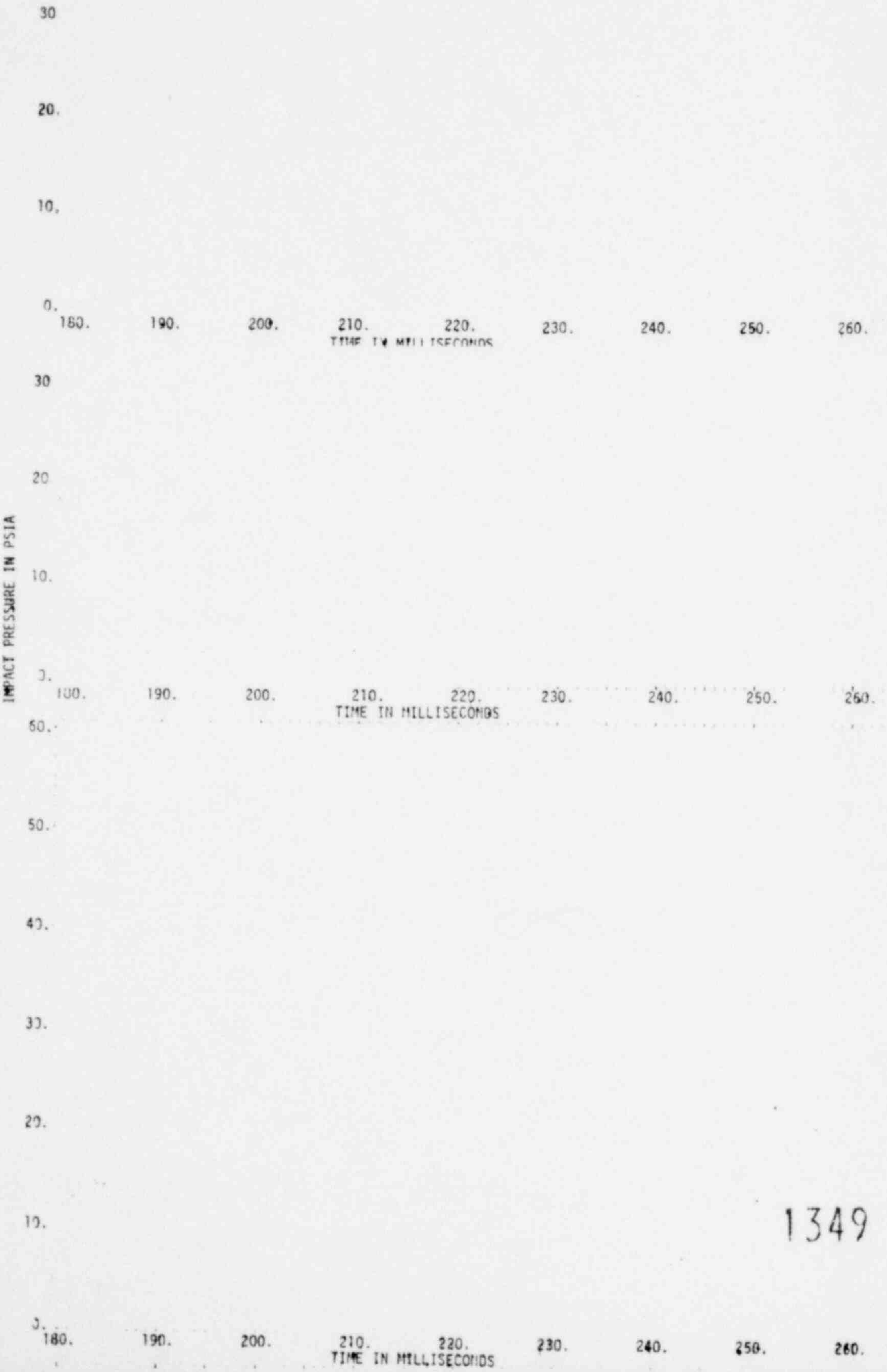
TIME IN MILLISECONDS

1349 130

FIGURE A-309

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 3

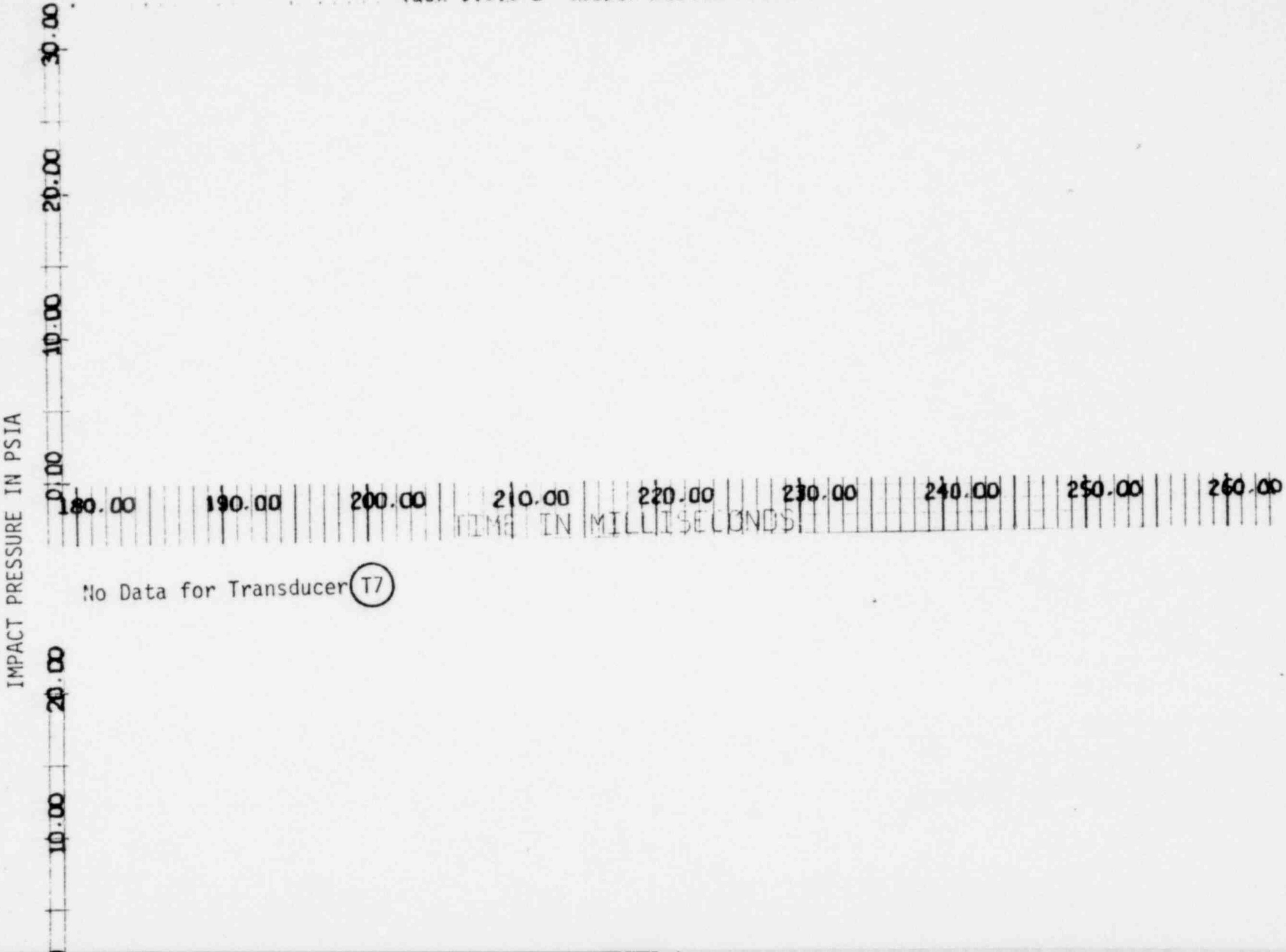


1349 131

FIGURE A-310

VENT HEADER IMPACT PRESSURES

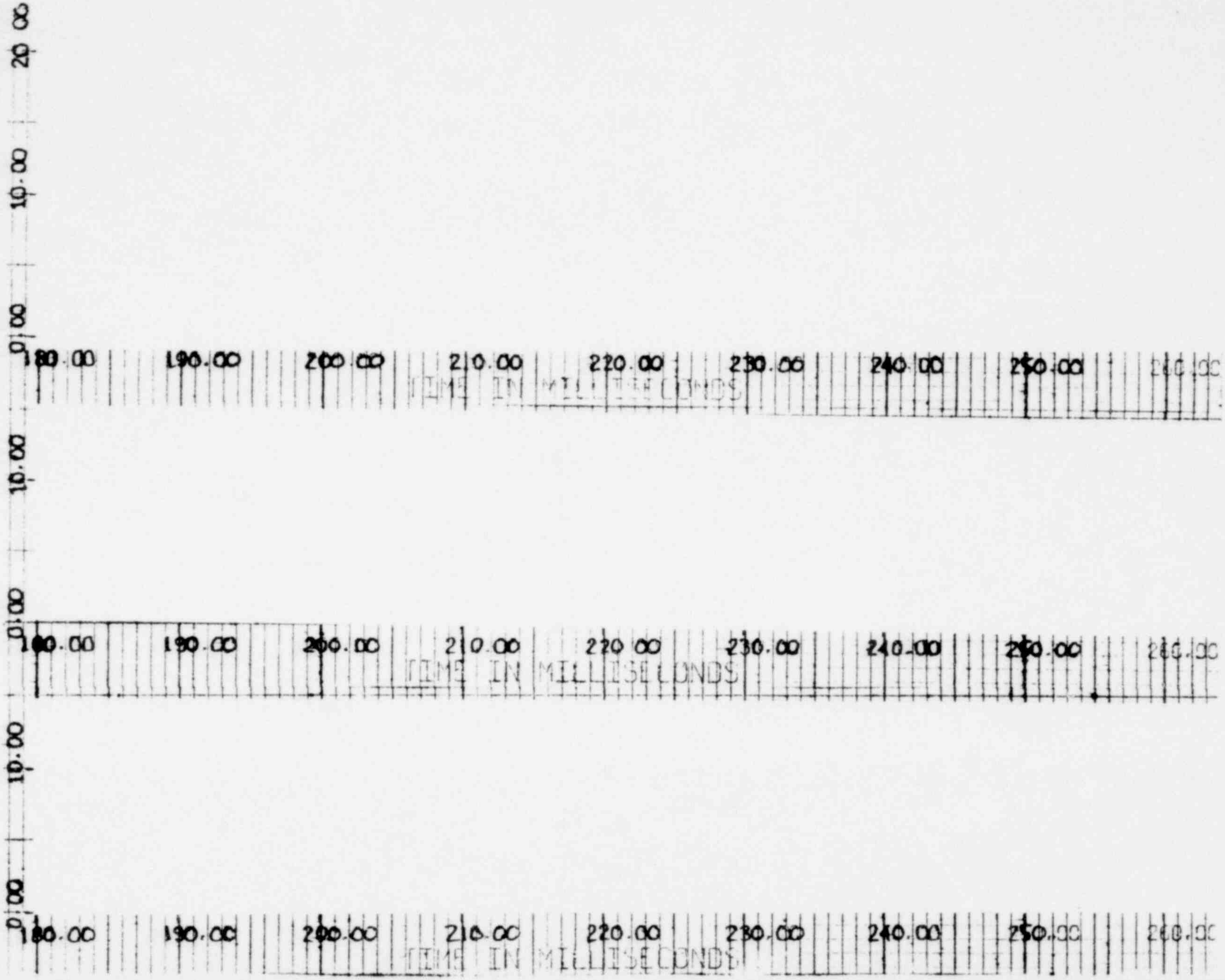
Task 5.5.3-2 Cooper Station Test 3



1349 132

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 3

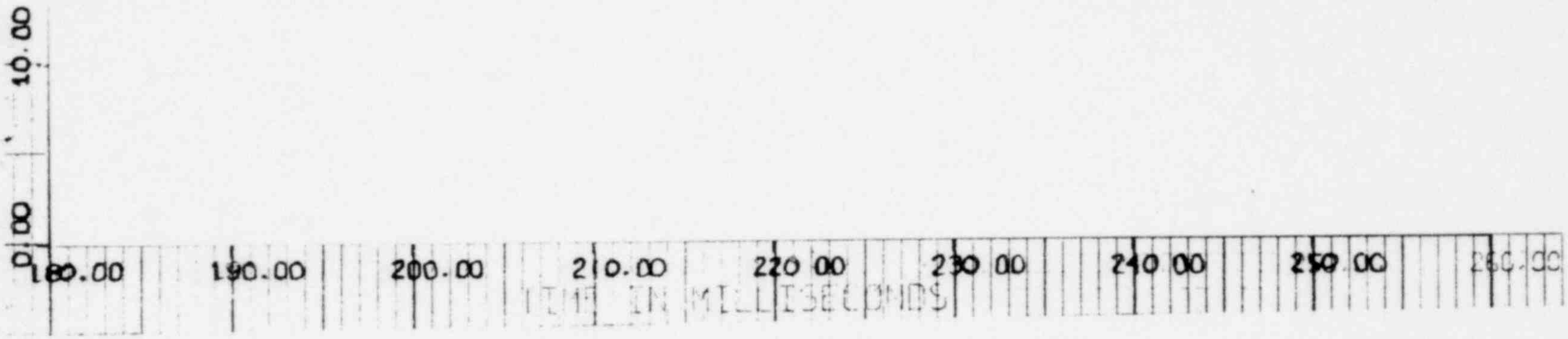


1349 133

FIGURE A-312

VENT HEADER IMPACT PRESSURES

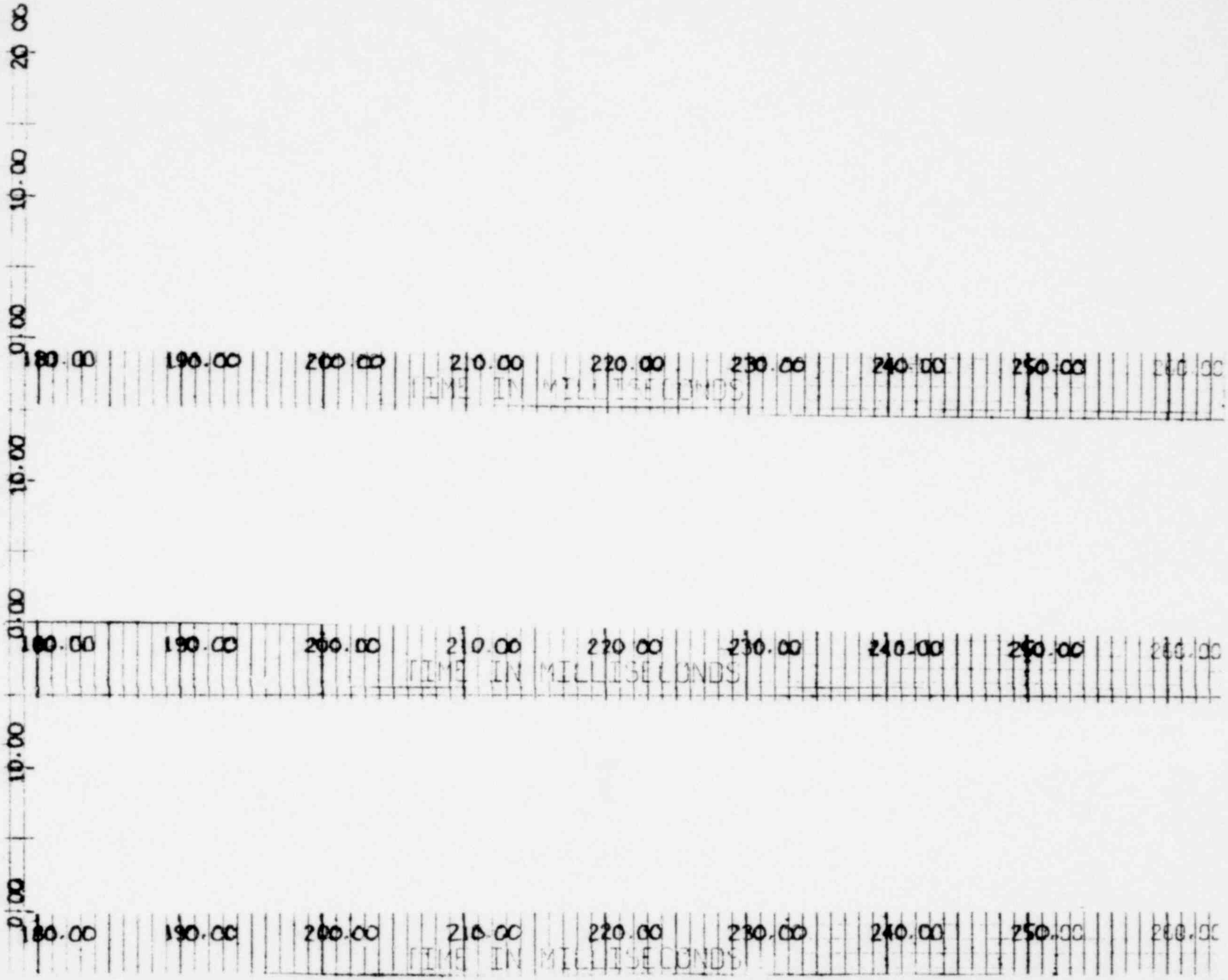
Task 5.5.3-2 Cooper Station Test 3



1349 134

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 3

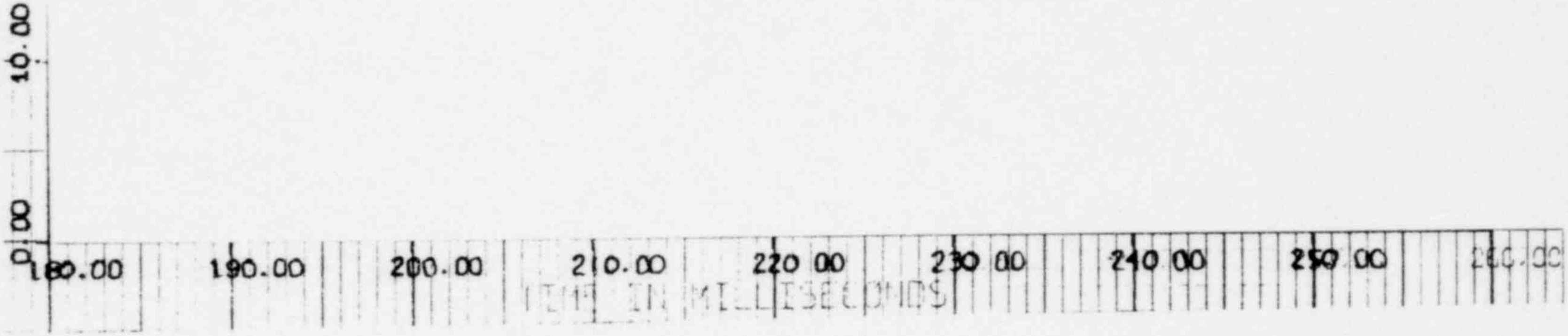


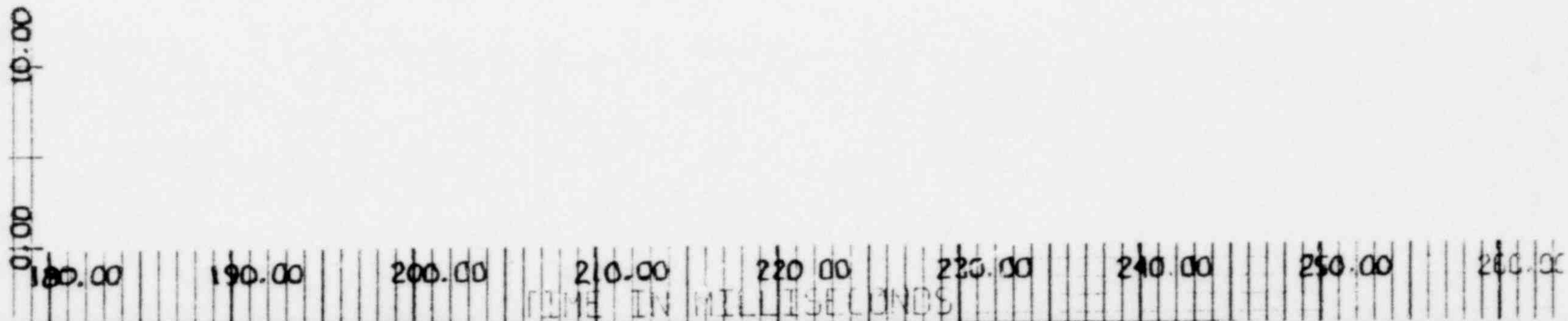
1349 135

FIGURE A-312

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 3



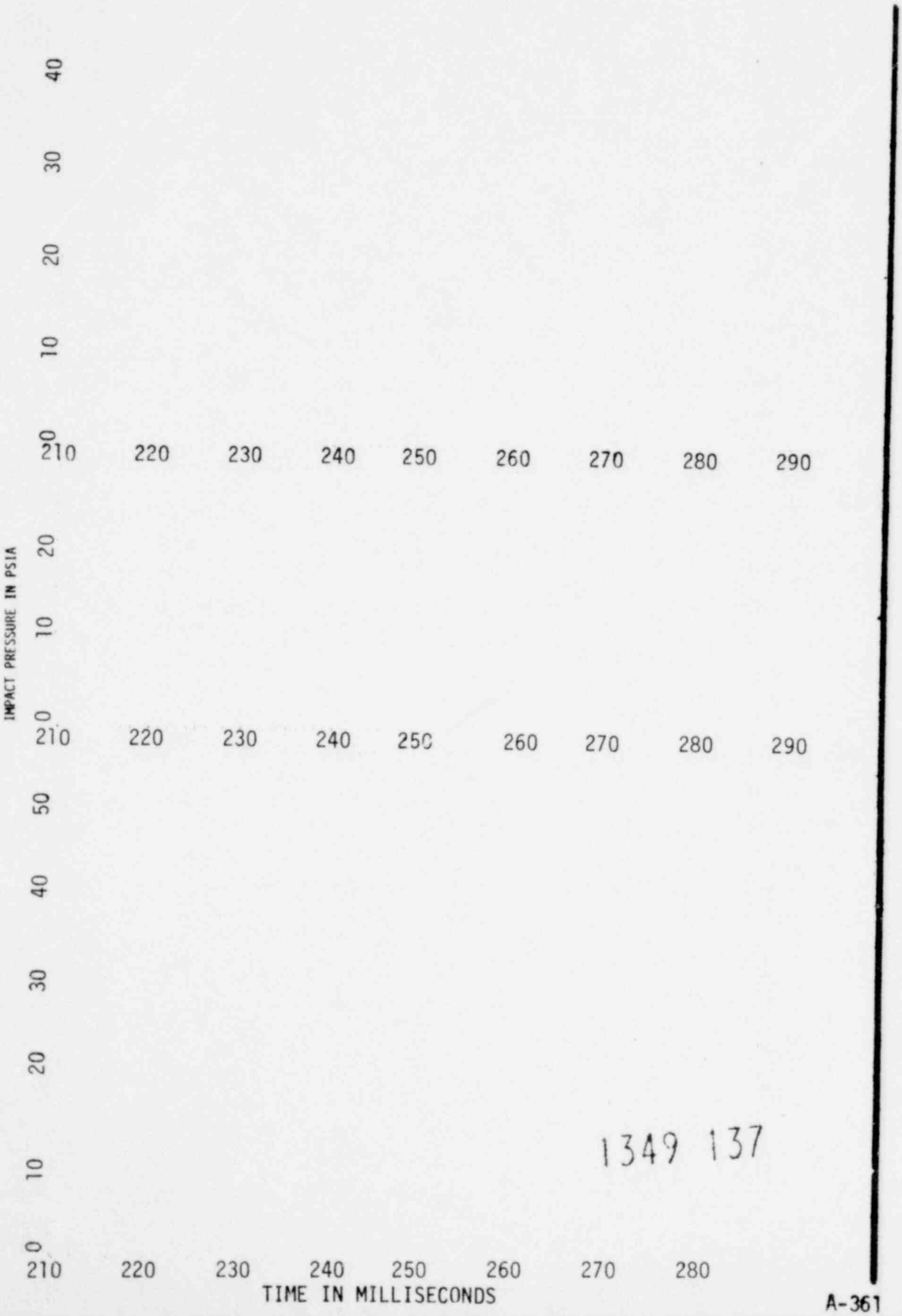


1349 136

FIGURE A-313

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 5

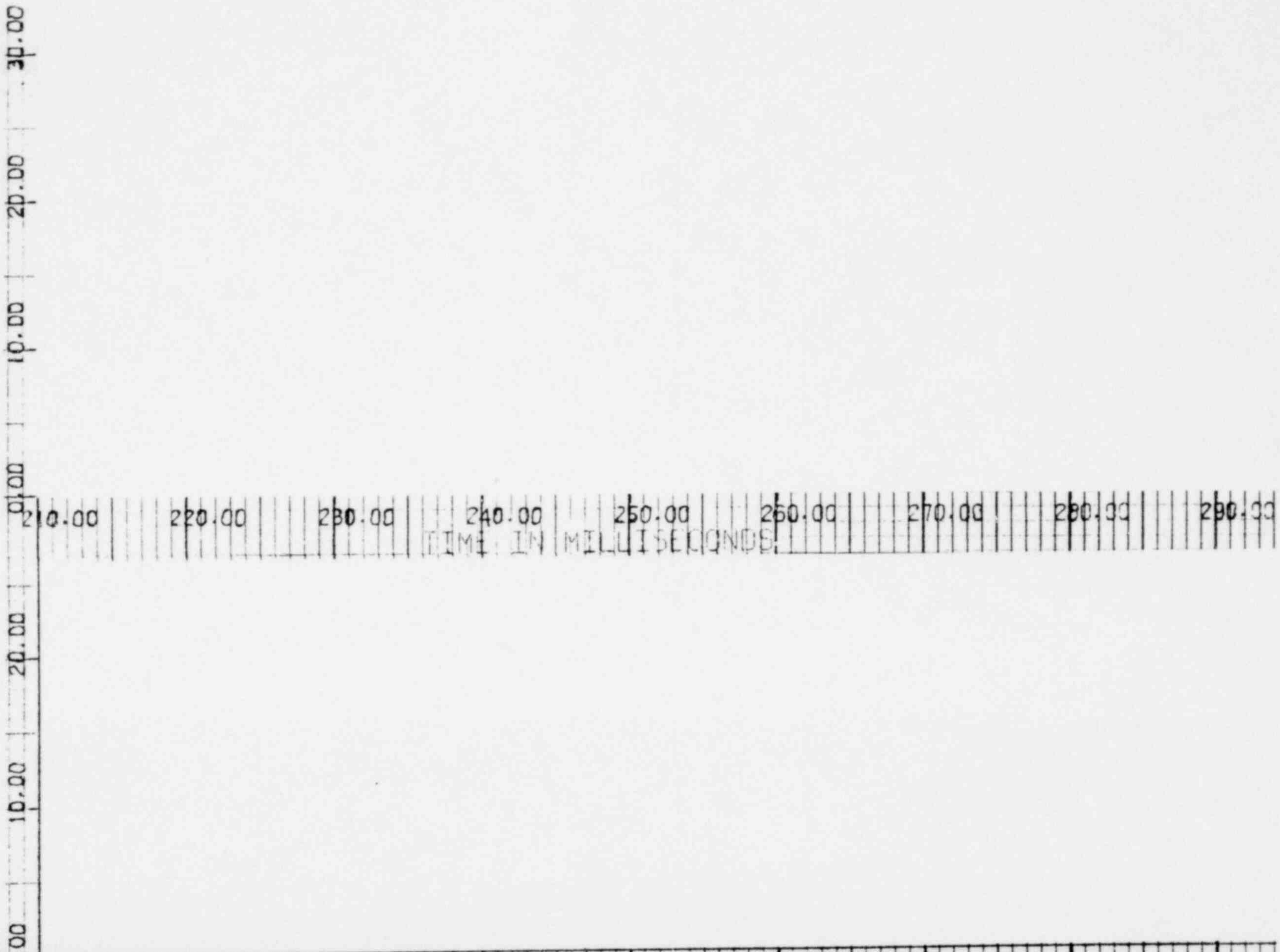


1349 137

FIGURE A-314

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 5



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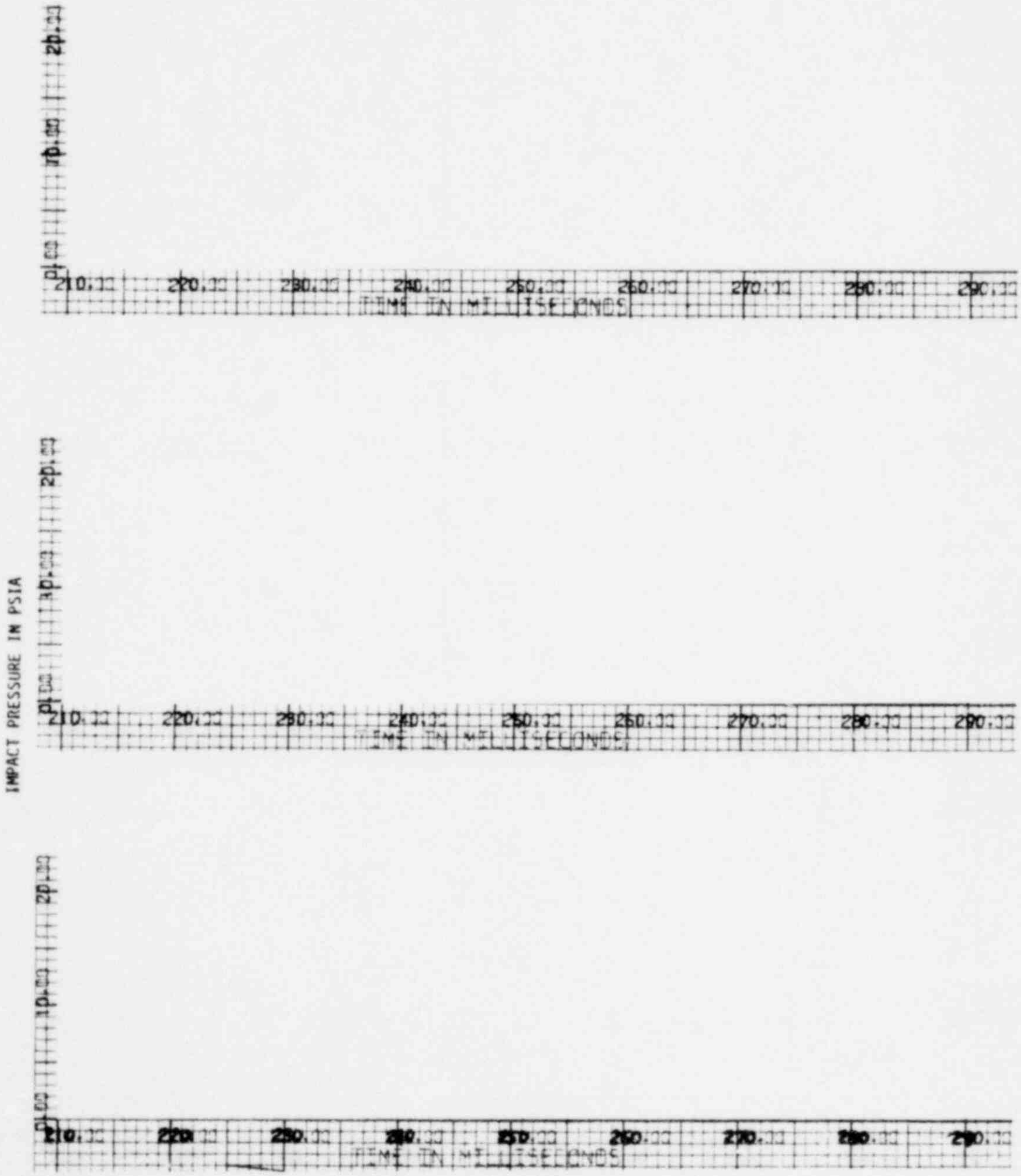
1349 138

FIGURE A-315

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Cooper Station Test 5

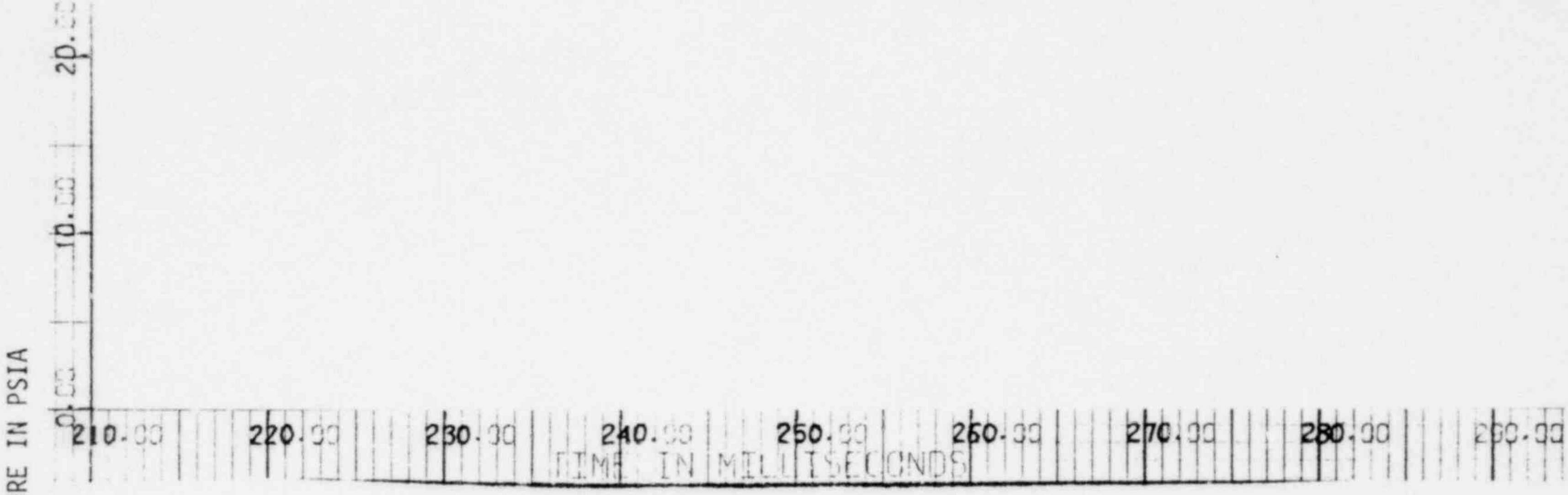


1349 139

FIGURE A-316

VENT HEADER IMPACT PRESSURES

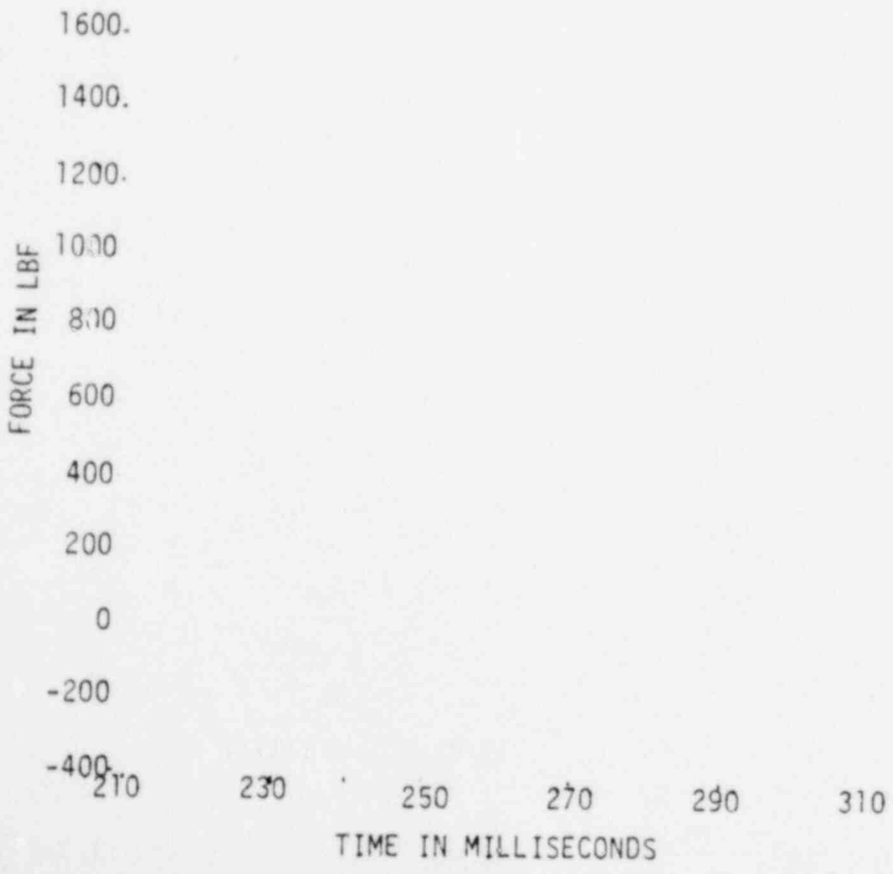
Task 5.5.3-2 Cooper Station Test 5



1349 140

FIGURE A-317

COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3 Cooper Station Tests 3, 5



1349 141

FIGURE A-318

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Cooper Station Test 3

1349 142

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Cooper Station Test 5

1349 143

FIGURE A-320

TIME HISTORY OF
POOL REPLACEMENT

COOPER STATION, TEST 1

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

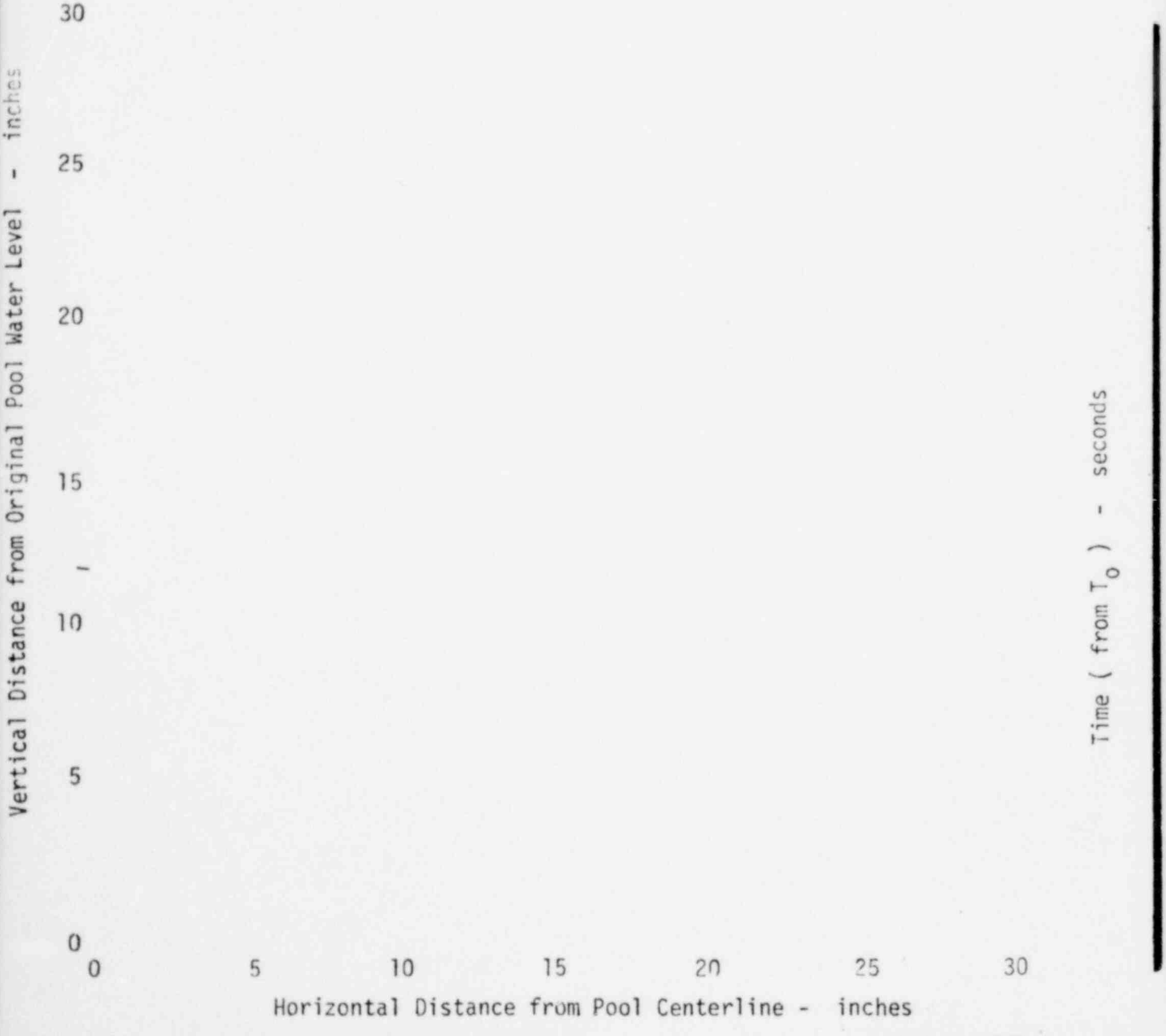
Time (from T_o) - seconds

1349 144

FIGURE A-321

TIME HISTORY OF
POOL DISPLACEMENT

COOPER STATION, TEST 2



1349 145

FIGURE A-322

TIME HISTORY OF
POOL DISPLACEMENT

COOPER STATION, TEST 3

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

Time (from T_o) - seconds

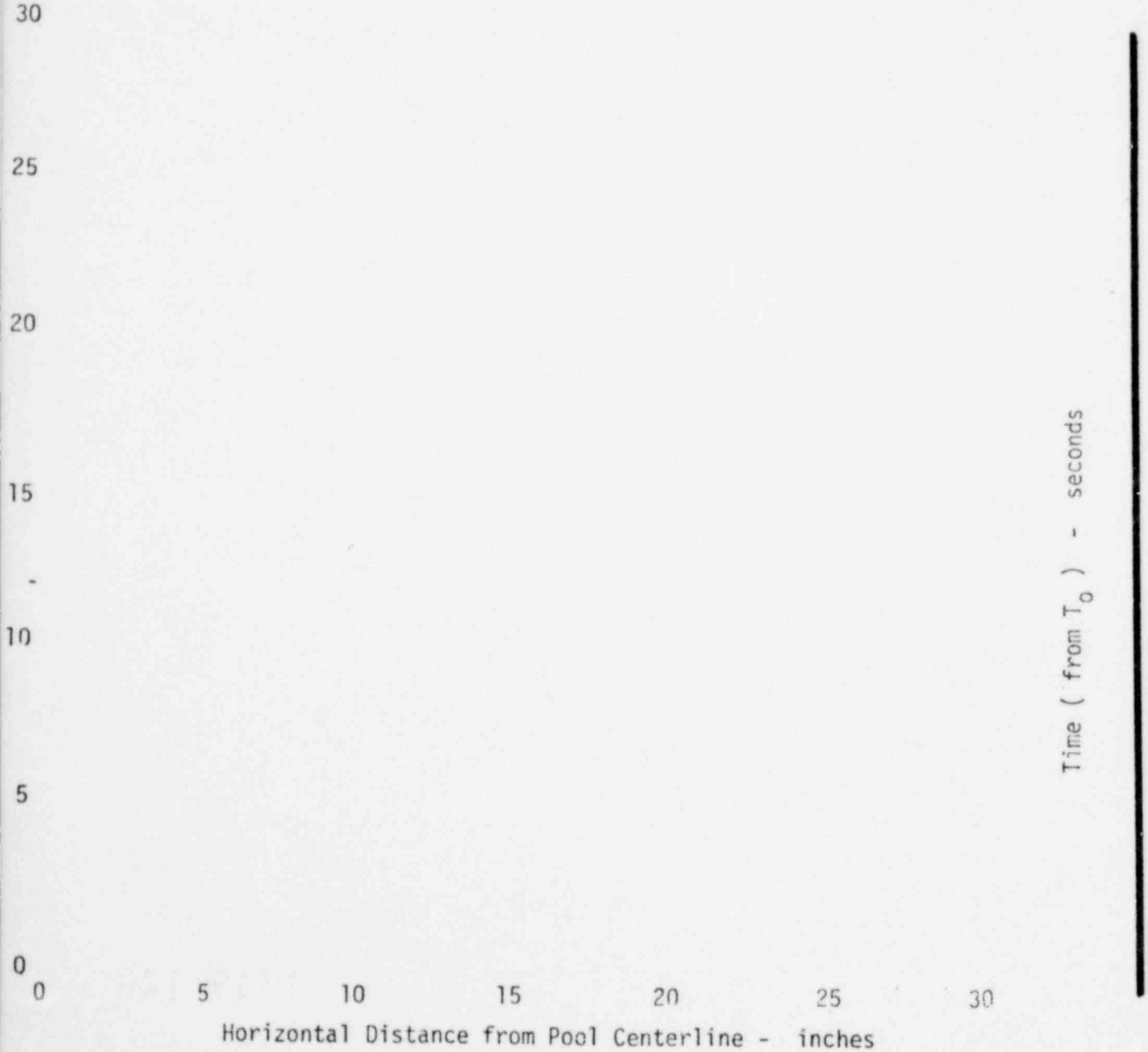
0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

FIGURE A-323

TIME HISTORY OF
POOL DISPLACEMENT

COOPER STATION, TEST 5



1349 147

POOL SURFACE DISPLACEMENT

FIGURE A-324

COOPER STATION, TESTS 1, 2, 3

Height above original pool surface - inches

25

20

15

10

5

0

0 100 200 300 400

Time- milliseconds

1349 148

POOL SURFACE VELOCITY PROFILES

FIGURE A-325

COOPER STATION TESTS 1, 2, 3

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

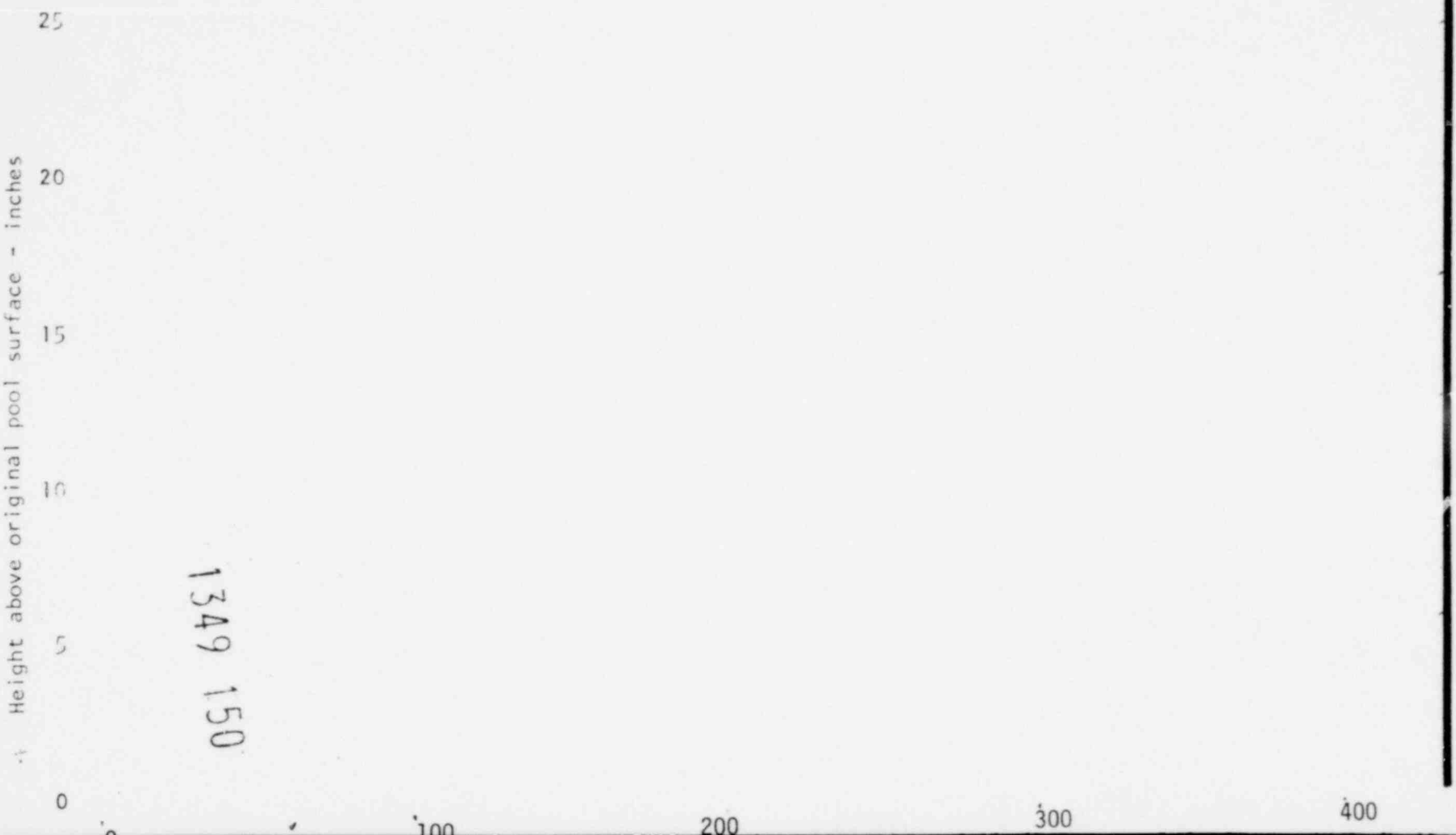
DISTANCE FROM POOL CENTERLINE - INCHES

1349 149

POOL SURFACE DISPLACEMENT

FIGURE A-326

COOPER STATION, TEST 5



1349 150

POOL SURFACE VELOCITY PROFILES

FIGURE A-327

COOPER STATION, TEST 5

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

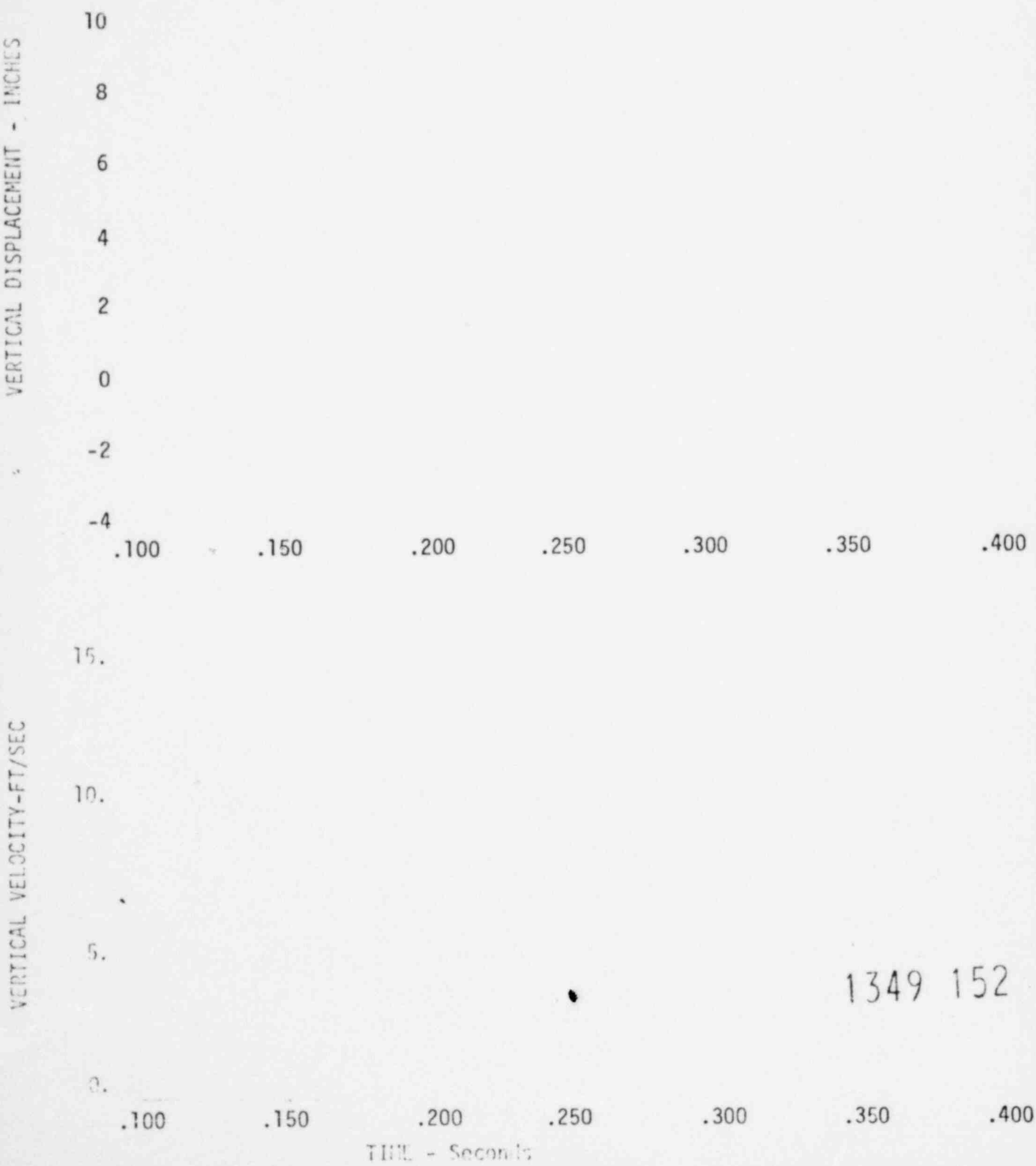
DISTANCE FROM POOL CENTERLINE - INCHES

1349 151

FIGURE A-328

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

COOPER STATION, TEST 4

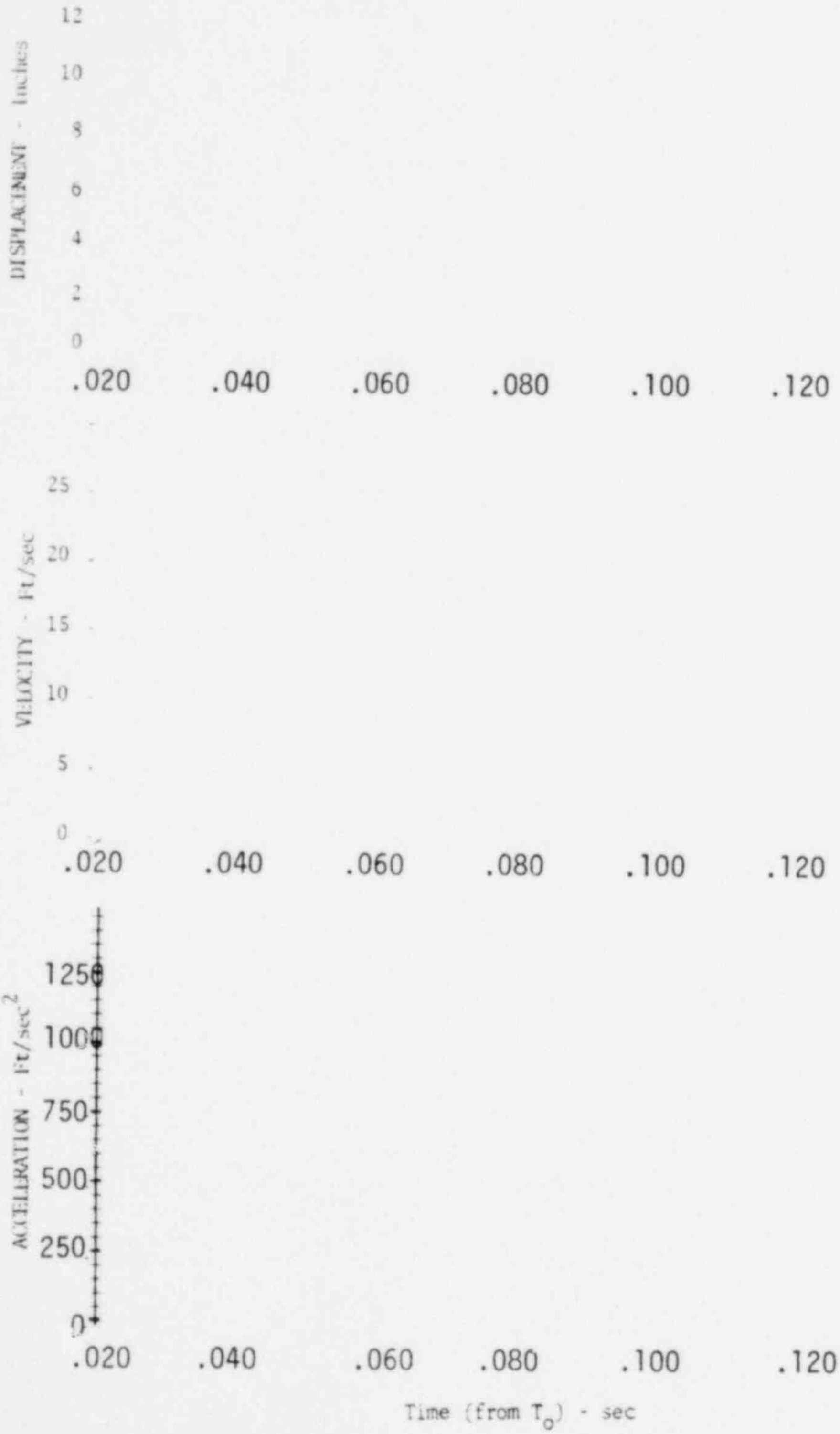


1349 152

FIGURE A-329

DOWNCOMER WATER SLUG EJECTION

COOPER STATION, TEST 3

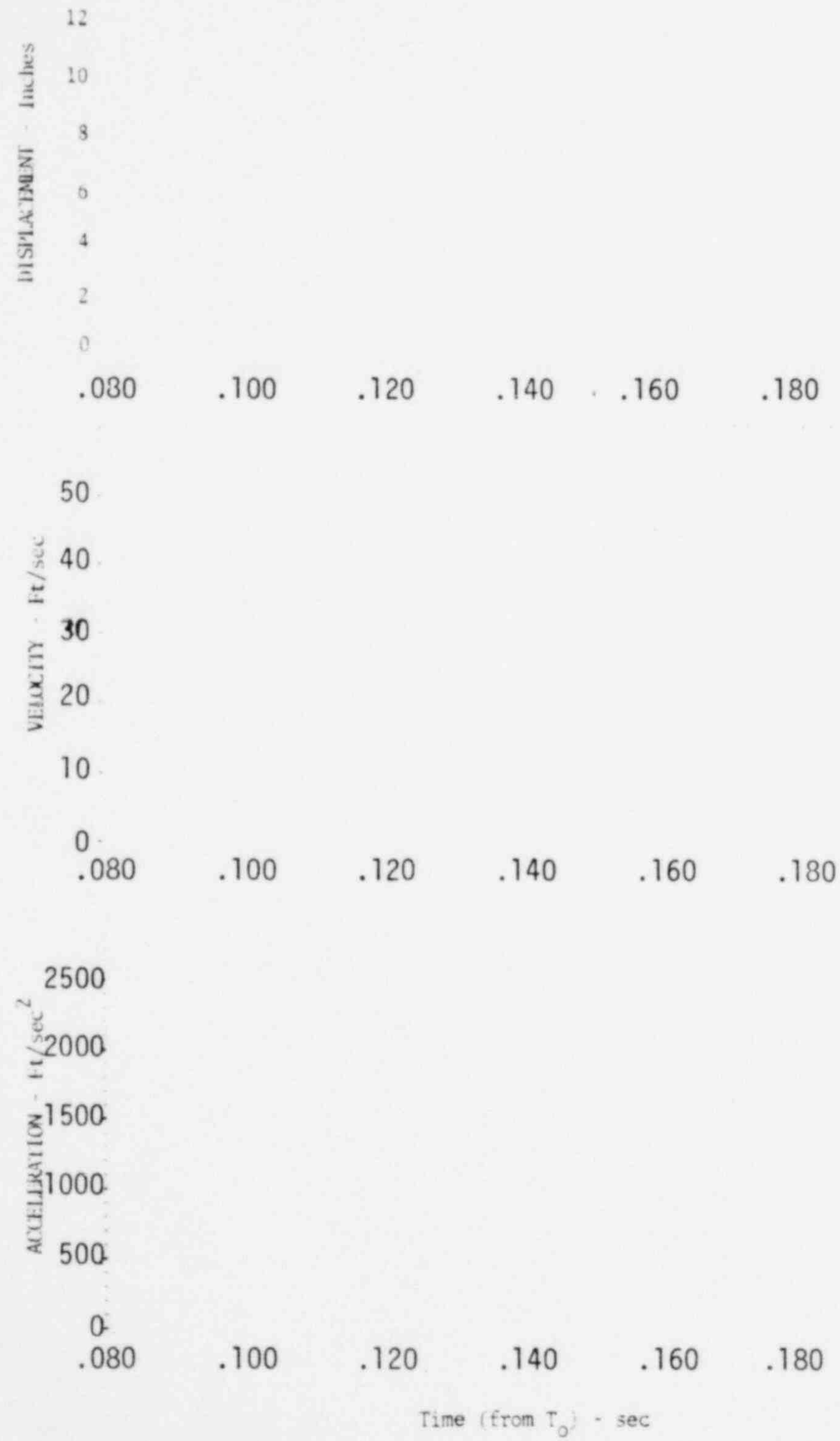


1349 153

FIGURE A-330

DOWNCOMER WATER SLUG EJECTION

COOPER STATION, TEST 5



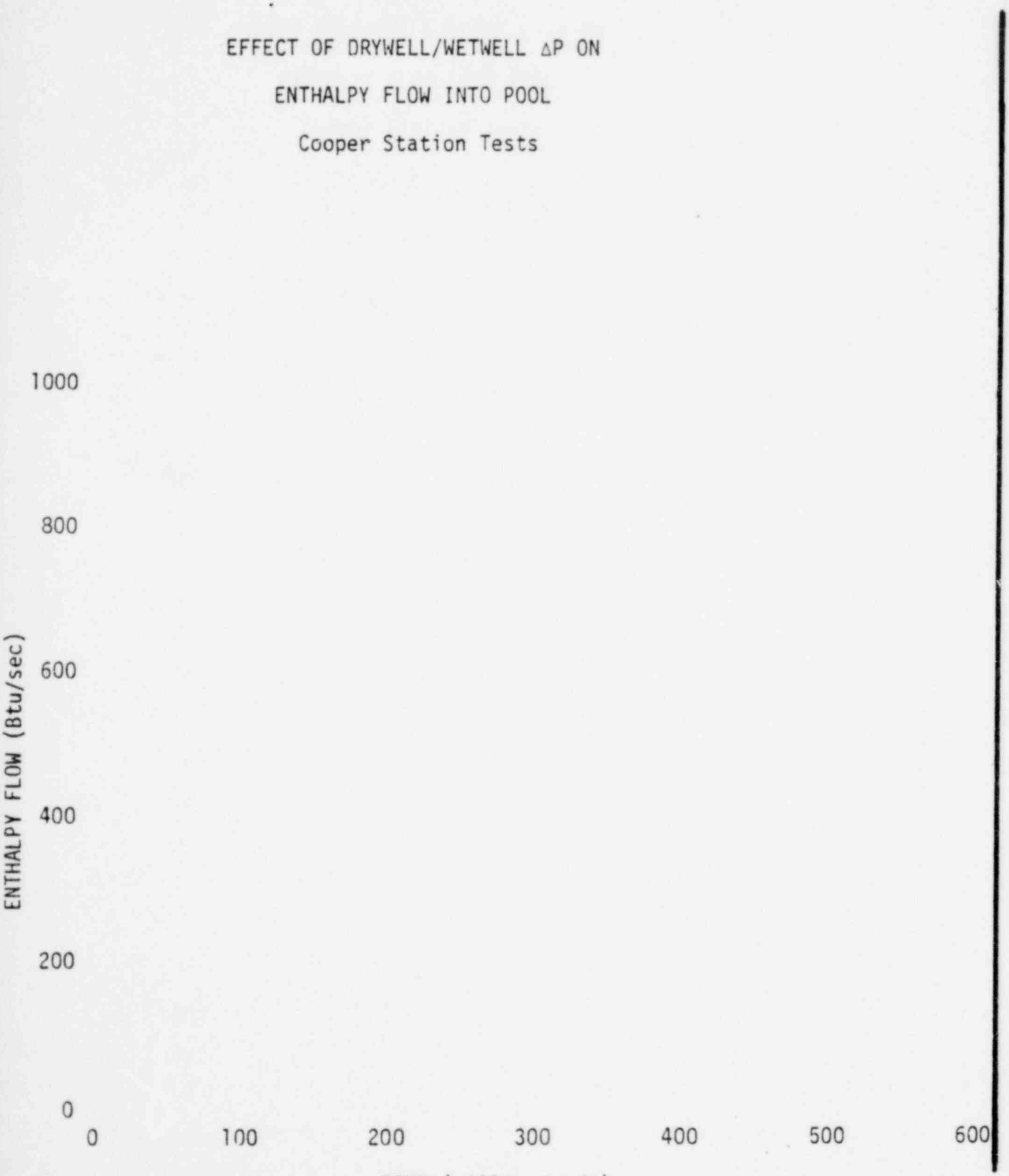
1349 154

FIGURE A-331

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Cooper Station Tests



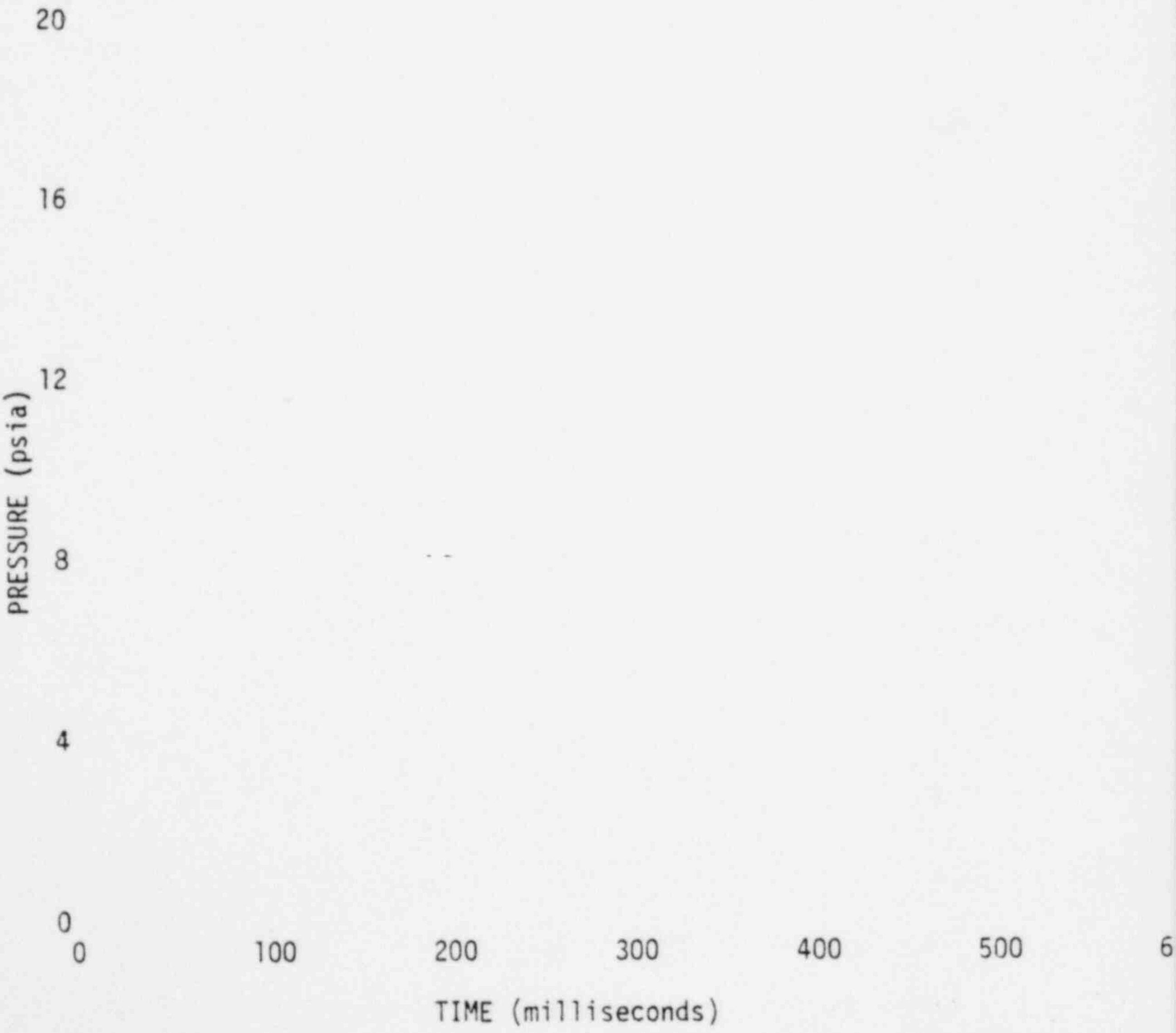
1349 155

FIGURE A-332

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Cooper Station Tests



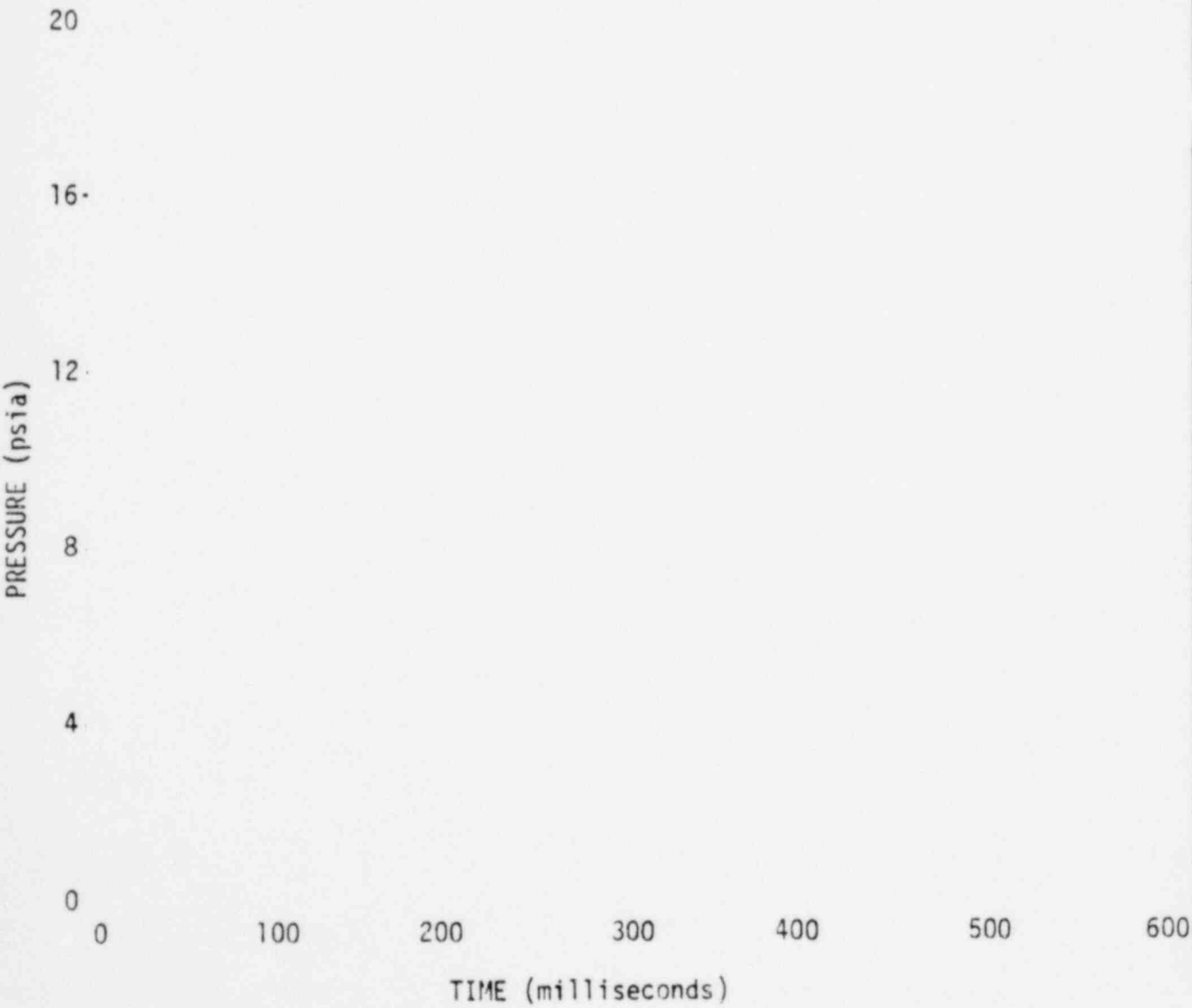
1349 156

FIGURE A -333

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Cooper Station Tests



1349 157

TABLE A-15

*Vent clearing time (from T_o) determined from the movie films.
**Time difference from T_o to time of zero downforce.
*(1)Start-of-test reference time

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Cooper Station Test.

Parameter \ Test No.	7.46" ΔP (No Deflector) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o *(1) (sec)							
Vent Clearing Time* (sec)							
Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Downforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
[Δt] Downforce Time**							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							
Downforce Impulse							
Pressure Integral:							
Impulse (lb-sec)							

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Table A-15

*Time at force is zero (from T_o)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Cooper Station Tests

Test No. / rameter		7.46" ΔP (No Deflector) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
ak Upforce								
essure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
rrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
rrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
force Valley								
essure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
rrected Pressure Integral:								
orce	(lb)							
ime (from T_o)	(sec)							
rrected Load Cell:								
orce	(lb)							
ime (from T_o)	(sec)							
Peak Upforce								
ssure Integral:								
orce	(lb)							
ime (from T_o)	(sec)							
rected Pressure Integral:								
orce	(lb)							
ime (from T_o)	(sec)							
rected Load Cell:								
orce	(lb)							
ime (from T_o)	(sec)							
o Force Time*								
ressure Integral	(sec)							
orrected Pressure Integral	(sec)							
orrected Load Cell	(sec)							

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TABLE A-16

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Cooper Station Tests

Parameter \ Test No.		7.46" ΔP (1)	7.46" ΔP (2)	7.46" ΔP (3)	7.46" ΔP (4)	Mean	Std. Dev.	0" ΔP (5)
T_o+	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected: ††								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*Based on impact pressure measurements.
**At start of the first impact pressure recorded.

+Start-of-test reference time.
††represents peak of very noisy data (acceleration corrected); mean value would be lower.

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A.8 Dresden Tests

The plant input for Dresden and Quad Cities showed that with the same deflector geometry both plants had identical QSTF test parameters except that Dresden had a slightly higher (0.8%) drywell pressurization rate. Therefore the Dresden test data is applicable to Quad Cities.

A.8.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Dresden Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 7.15" ΔP and with a 5.17 inch pipe deflector (20 inch full scale). Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 5.17 inch pipe deflector.

A.8.1.1 Driving Conditions

Driving conditions for Dresden Test 3 are presented in Figures A-334 through A-338. Similar plots for Dresden Test 5 are shown in Figures A-339 through A-343. Dresden's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.8.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Dresden Tests 3 and 5 are presented in Figures A-344 through A-345 and A-346 through A-347, respectively. These pressure plots have the same characteristics as the "typical" plant in Section 3.0.

Figure A-348 and A-349 present net torus force based on the torus pressure integral for Dresden Tests 3 and 5, respectively. Some downforce oscillations are present.

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The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-351 and A-353) to the torus load cell (Figures A-350 and A-352) is compared with the torus force obtained from the torus pressure integral in Figures A-354 and A-355. Residual oscillations are present in the corrected load cell. Figures A-356 and A-357 present the net torus force based on the torus pressure integral corrected for inertia. Smoothed downforce is also shown in these figures, using the filtering technique described in Appendix I. Refer to Appendix H for detailed comparison of filtered and unfiltered downforce transients.

The "average" pool pressures for Dresden Tests 3 and 5 are shown in Figures A-358 and A-360. Figures A-359 and A-361 are the same as Figures A-356 and A-357 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Dresden Test 3 are presented in Figures A-362 through A-365. Vent header pressures for Dresden Test 5 are presented in Figures A-366 through A-369. These figures indicate that the deflector was effective in reducing the peak local vent header impact pressure.

Figure A-370 presents a comparison of the vent header impact force derived from the pressure integral with that derived from the corrected load cell. Vent header vertical accelerations from Tests 3 and 5 are shown in Figures A-371 and A-372, respectively.

A.8.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-373 through A-376 for Dresden Tests 1, 2, 3, and 5.

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-377. The pool surface velocities for Tests 1, 2,

1349 162

and 3 are shown on Figure A-378. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-379 and A-380, respectively.

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-381. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-382 and A-383.

A.8.3 Data Summaries

Table A-17 presents the Dresden test data for wetwell vertical forces.

Table A-18 presents the Dresden test data for vent header impact forces.

A.8.4 Discussion and Analysis

Figure A-384 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-385. Figure A-386 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The data for Dresden parallels that for the "typical" plant in Section 3.0.

The Dresden load definition tests were conducted at 7.15" H_2O ΔP and with a pipe deflector installed below the vent header. A ΔP sensitivity test at 0" H_2O ΔP was also conducted. Some downforce oscillations were evident. The upforce also showed some oscillation. The pipe deflector (20 inch full-scale) effectively reduced vent header impact force.

1349 163

FIGURE A-334

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Dresden Test 3

120

100

80

PRESSURE IN PSIA

60

40

20

0

0 100 200 300 400 500 600

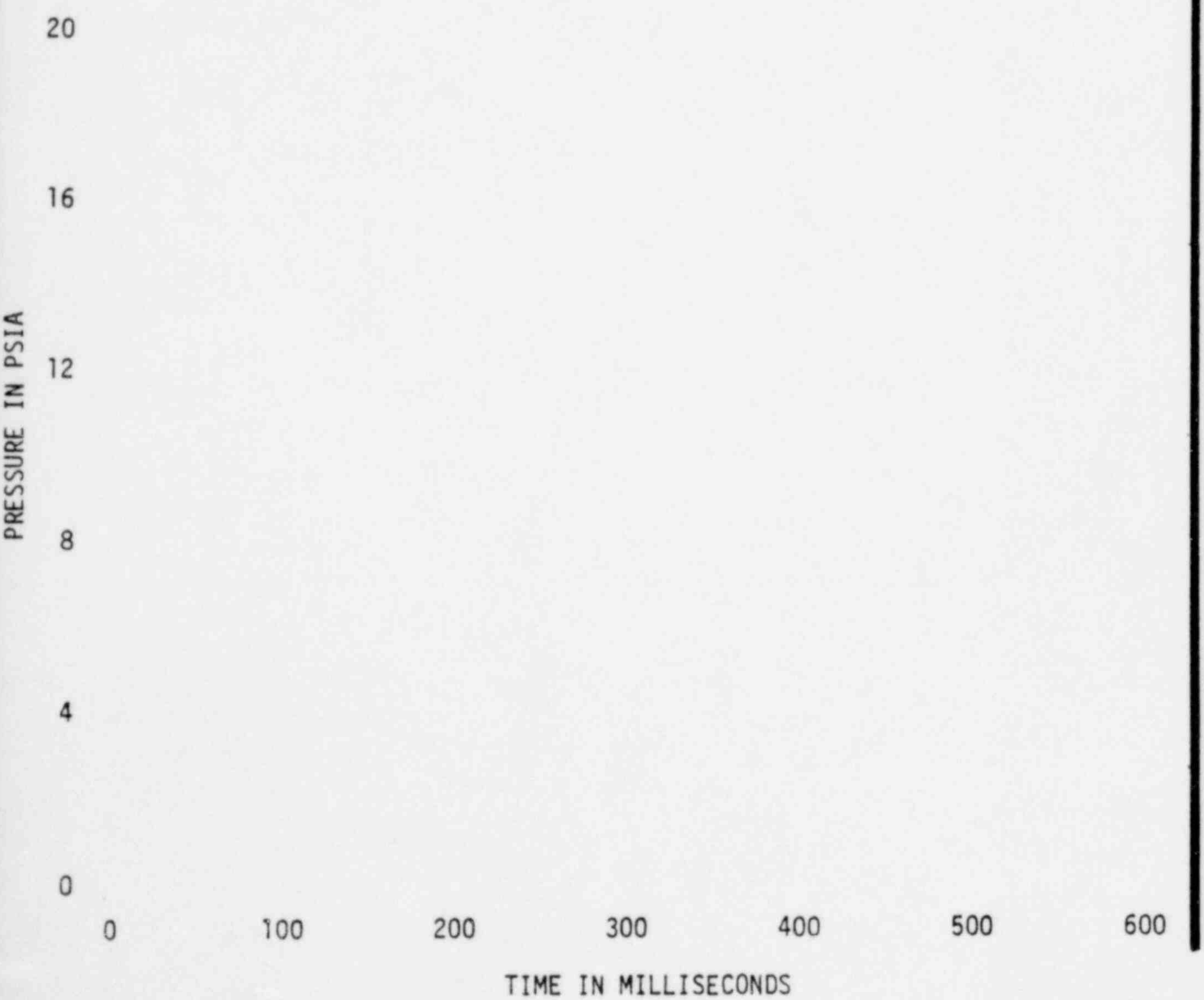
TIME IN MILLISECONDS

1349 16

FIGURE A-335

DRYWELL PRESSURE

Task 5.5.3-2 Dresden Test 3



4 1349 165

FIGURE A-336

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Dresden Test 3

DIFFERENTIAL PRESSURE IN PSID

10

8

6

4

2

0

0 100 200 300 400 500 60

TIME IN MILLISECONDS

1349 166

FIGURE A-337

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

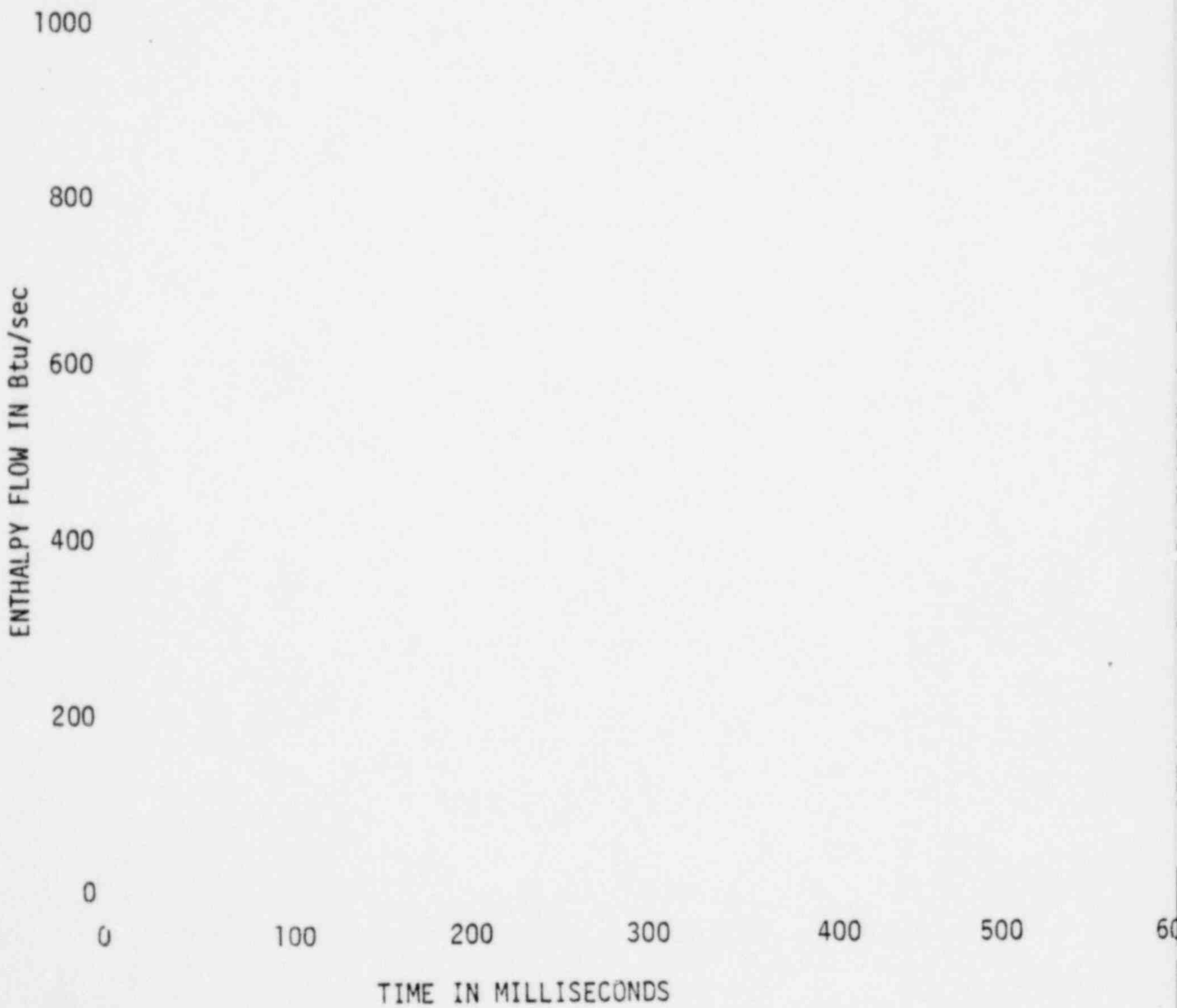
Task 5.5.3-2 Dresden Test 3

1349 167

FIGURE A-338

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Dresden Test 3

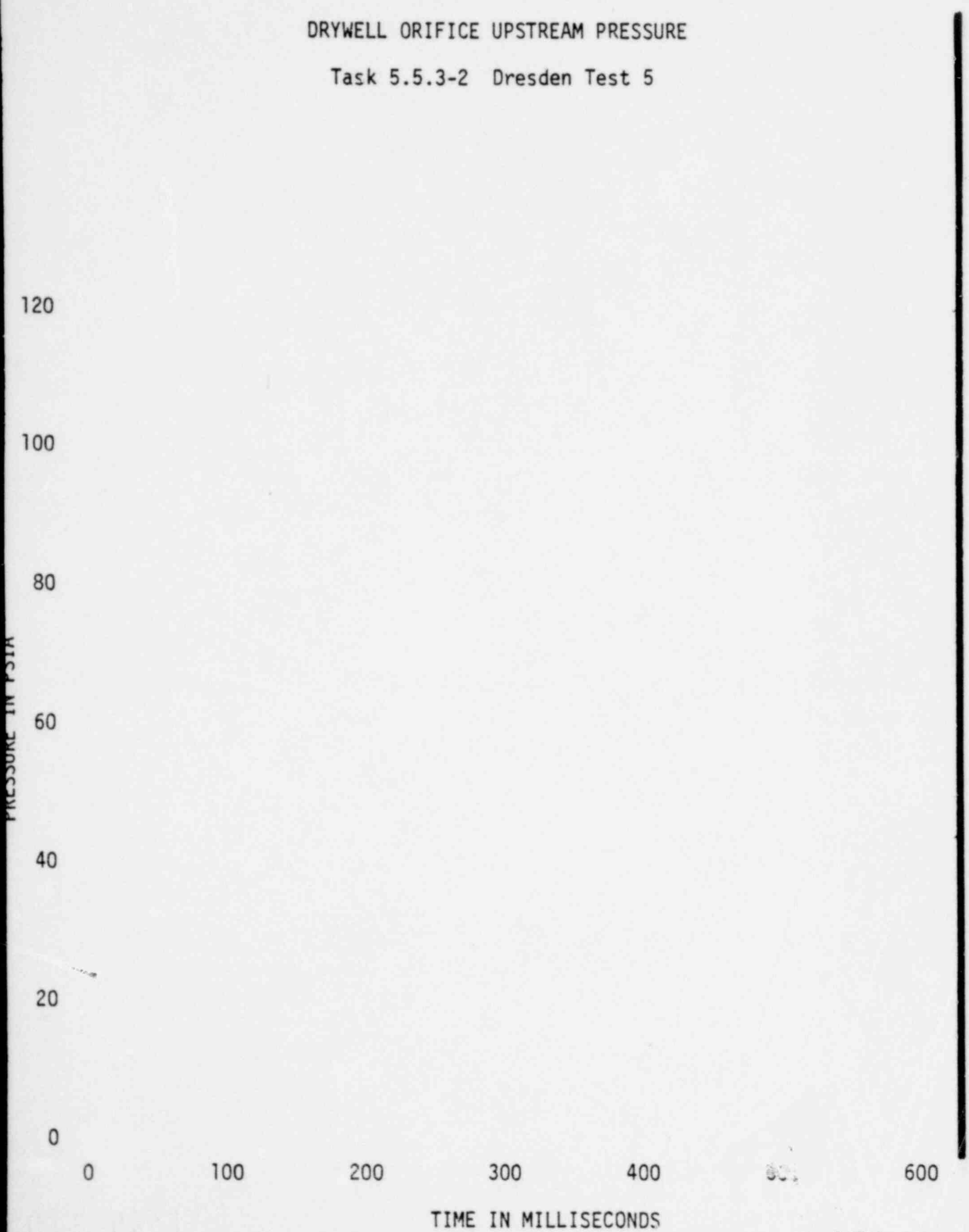


1349 168

FIGURE A-339

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Dresden Test 5

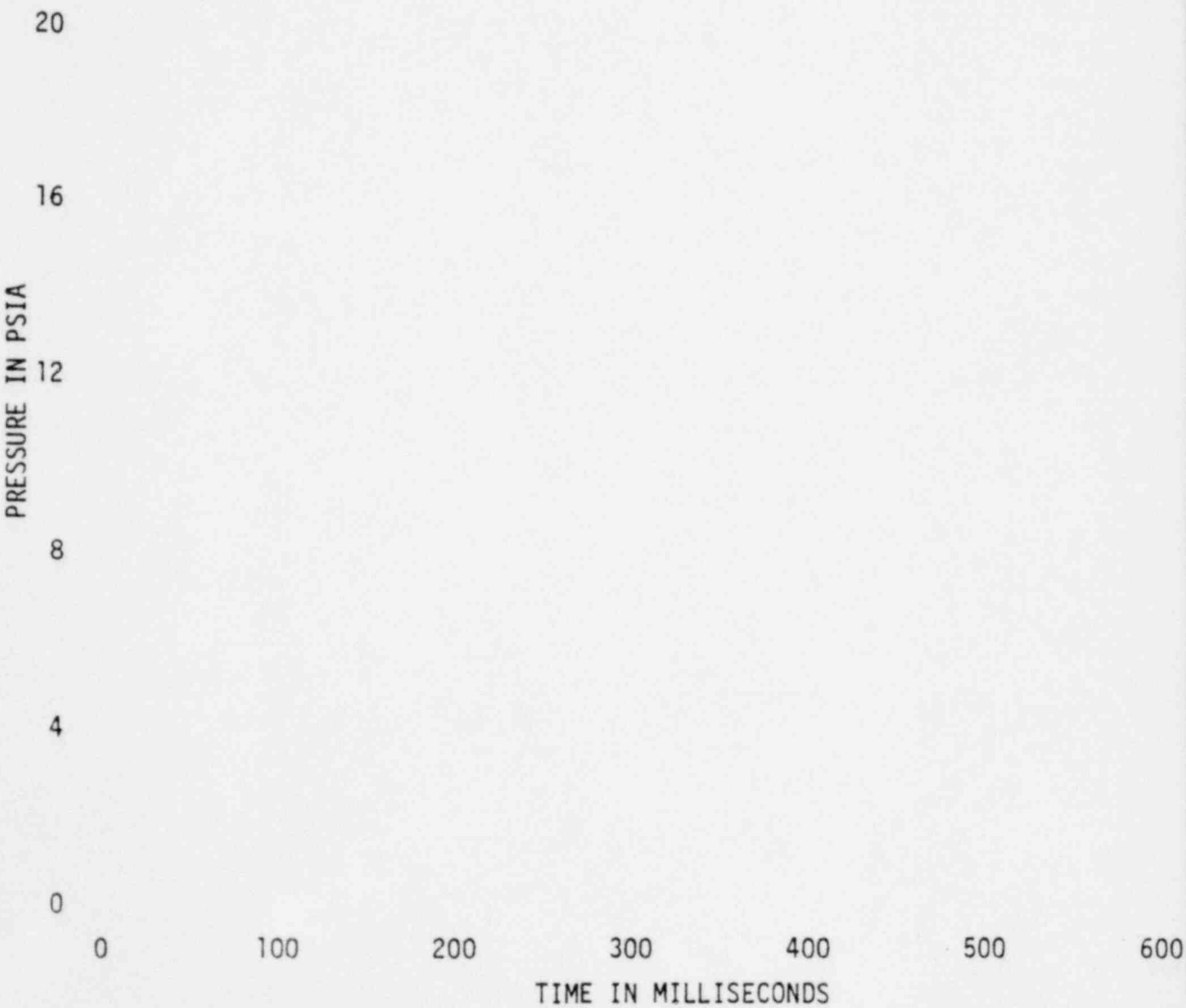


1349 169

FIGURE A-340

DRYWELL PRESSURE

Task 5.5.3-2 Dresden Test 5

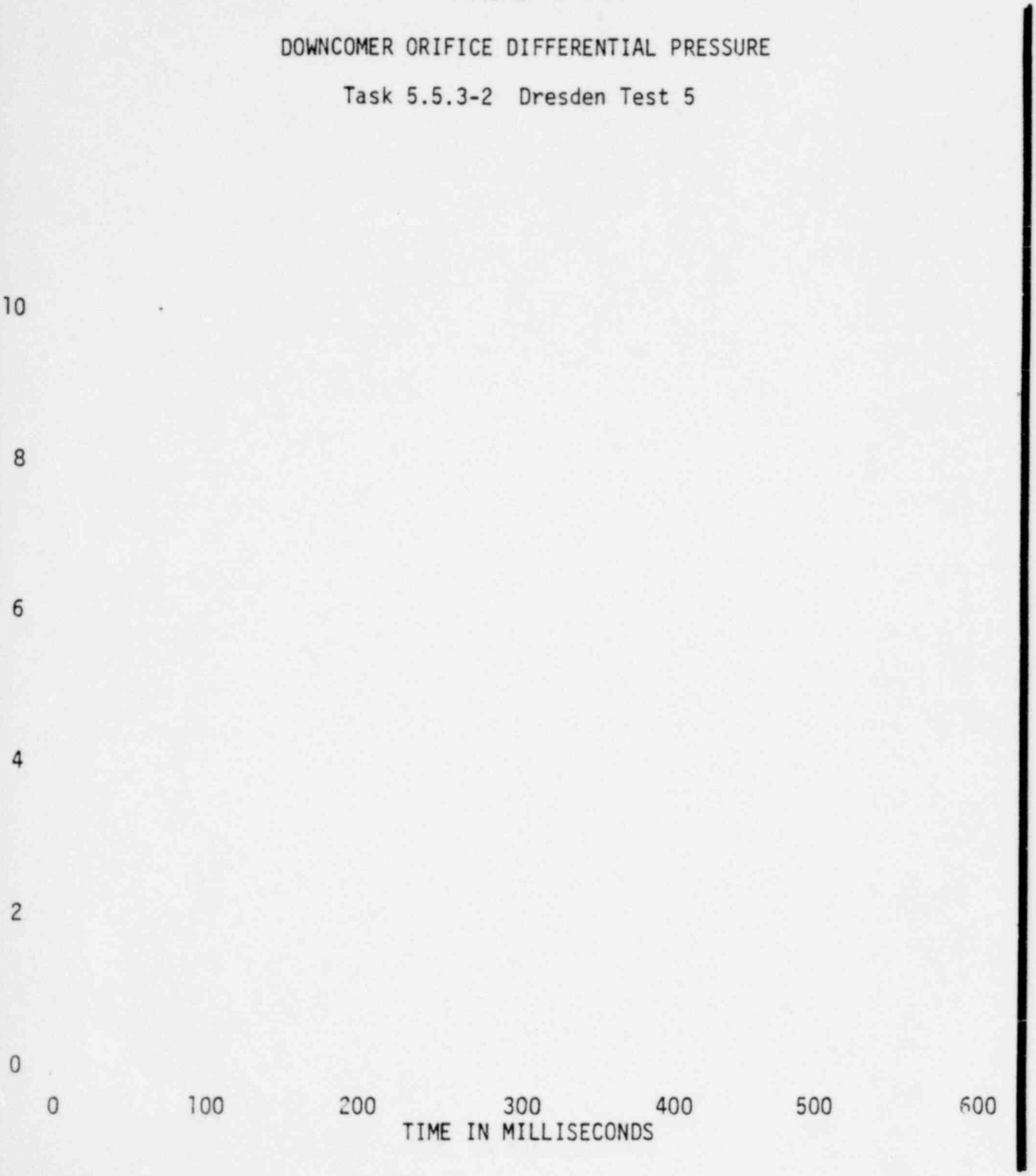


1349 170

FIGURE A-341

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Dresden Test 5



1349 171

FIGURE A-342

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Dresden Test 5

TEMPERATURE IN DEGREES F

200

160

120

80

40

0

0 100 200 300 400 500 60

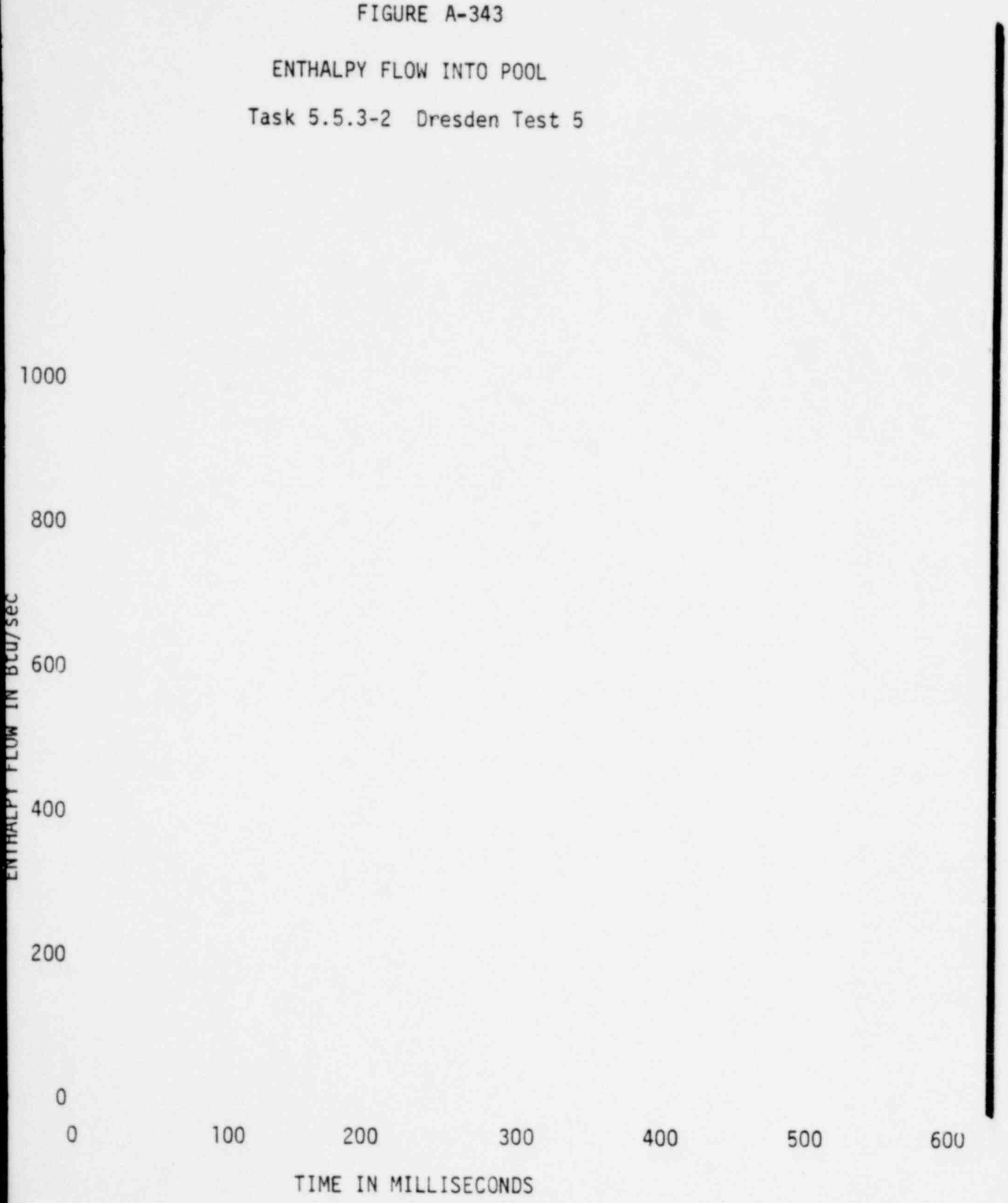
TIME IN MILLISECONDS

1349 172

FIGURE A-343

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Dresden Test 5

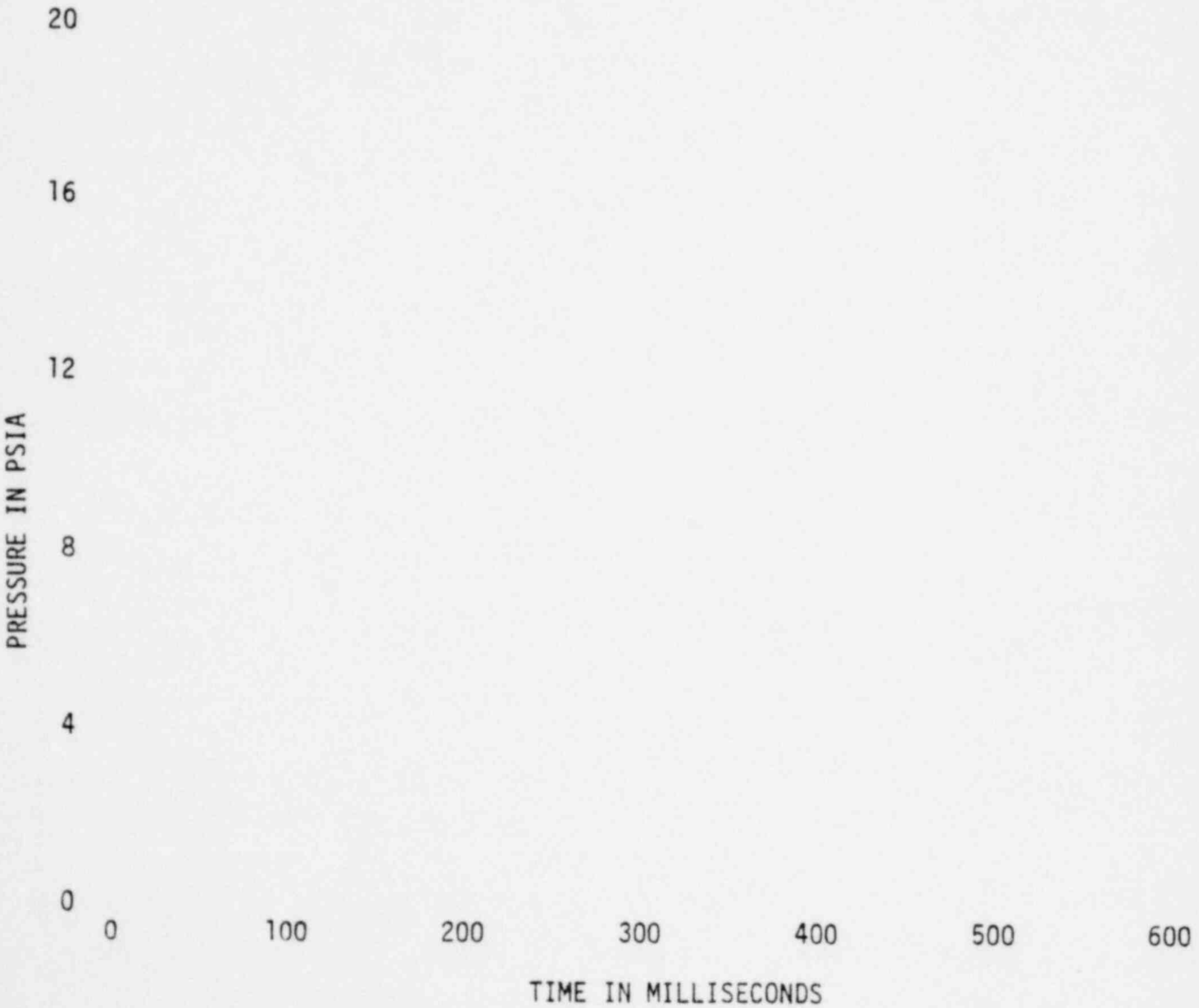


1349 173

FIGURE A-344

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Dresden Test 3

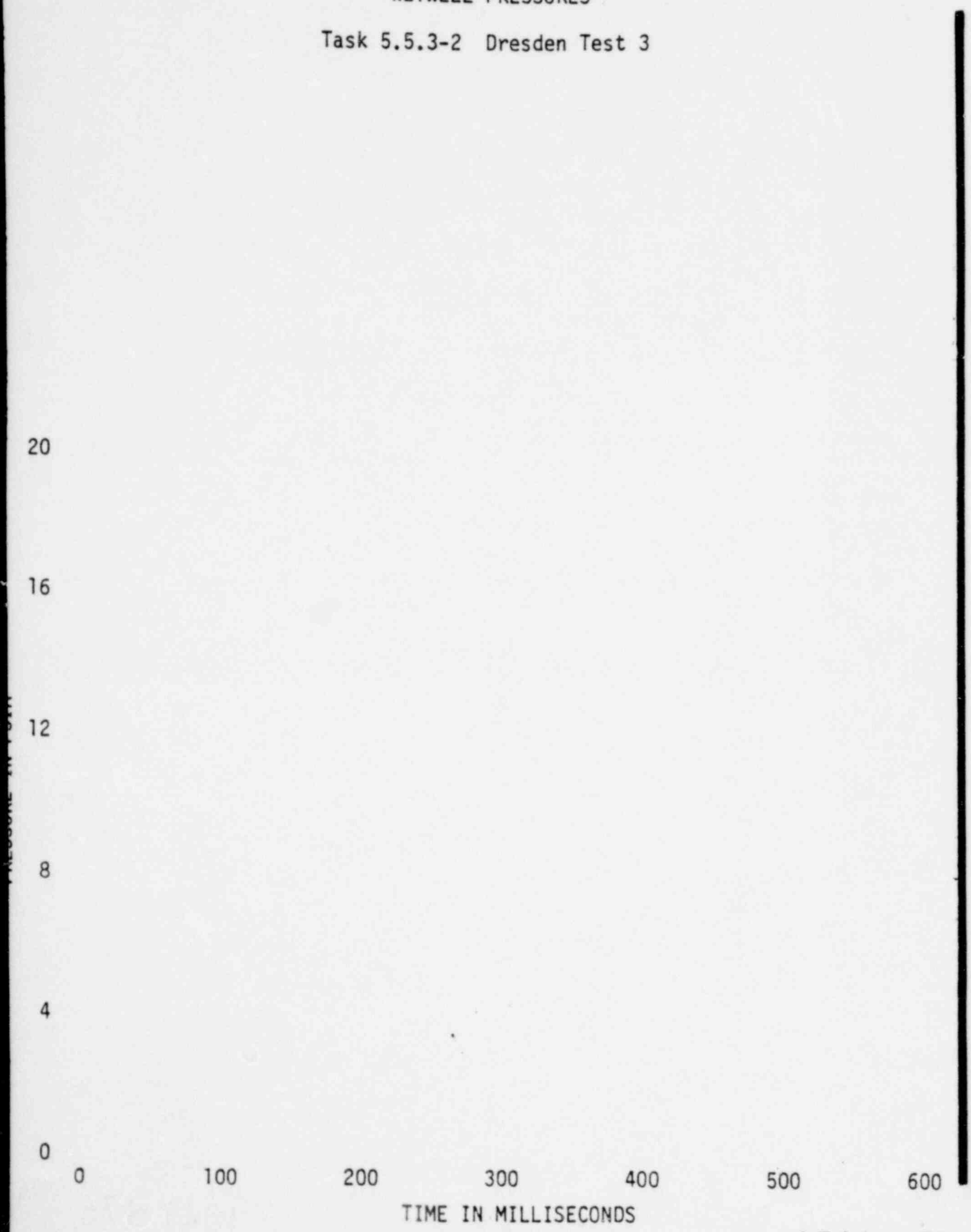


1349 174

FIGURE A-345

WETWELL PRESSURES

Task 5.5.3-2 Dresden Test 3



1349 175

FIGURE A-346

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Dresden Test 5

20

16

12

PRESSURE IN PSIA

8

4

0

0 100 200 300 400 500 600

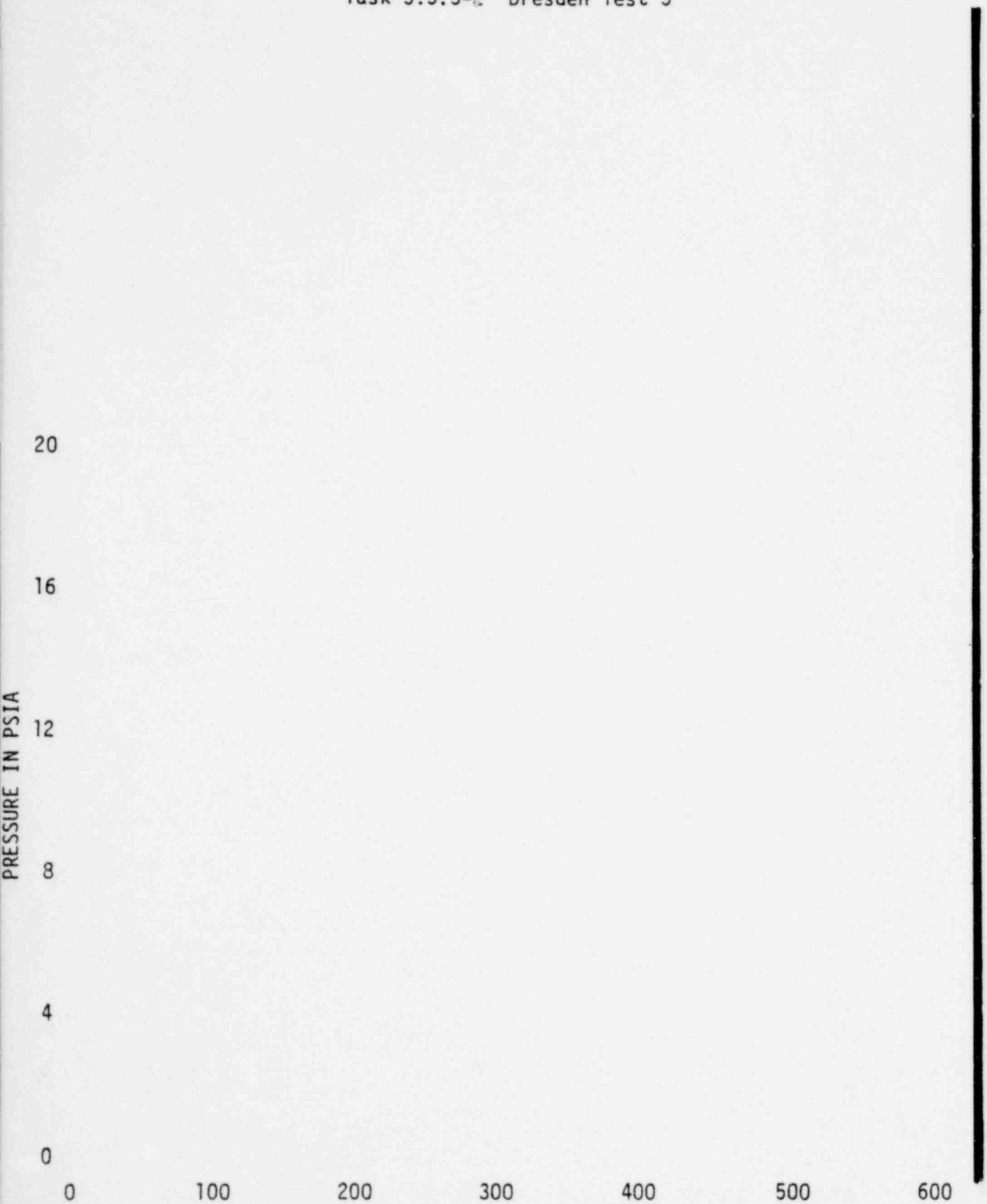
TIME IN MILLISECONDS

1349 176

FIGURE A-347

WETWELL PRESSURES

Task 5.5.3-2 Dresden Test 5



1349 177

FIGURE A-348

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Dresden Test 3

FORCE IN LBF

6000

4000

2000

0

-2000

-4000

-6000

1349 178

-8000

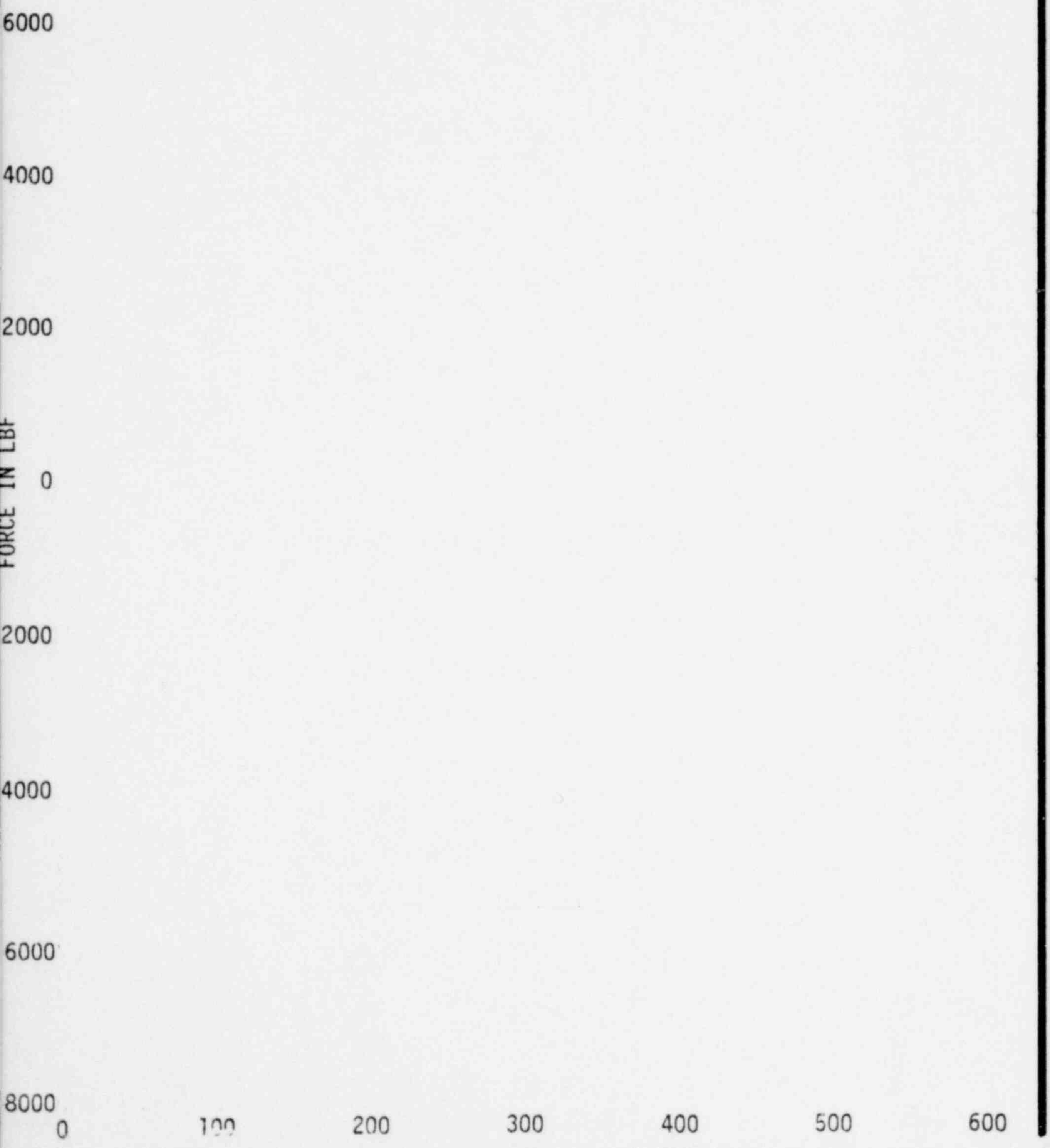
0 100 200 300 400 500 600

TIME IN MILLISECONDS

FIGURE A-349

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Dresden Test 5

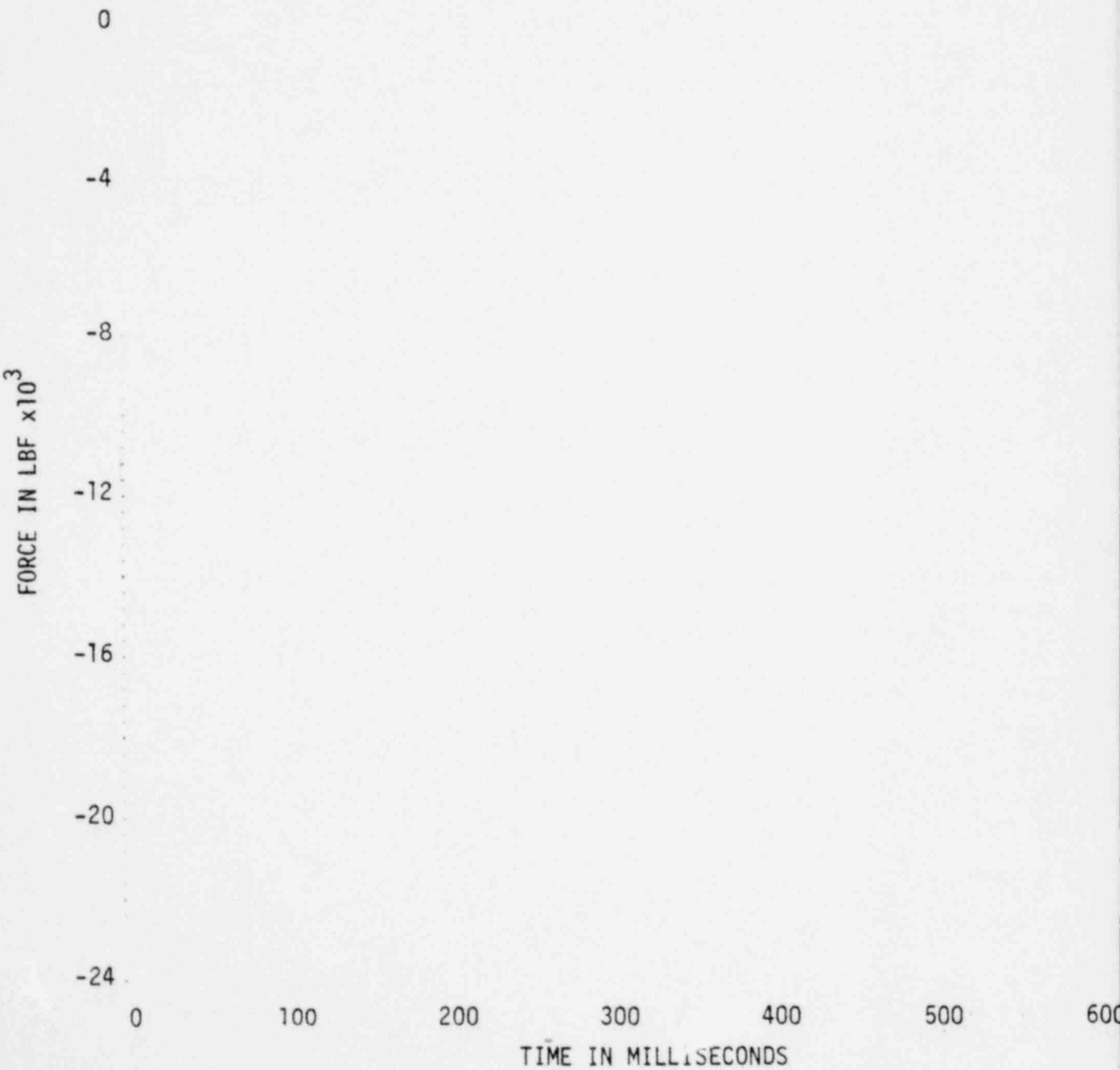


1349 179

FIGURE A-350

TORUS LOAD CELL

Task 5.5.3-2 Dresden Test 3

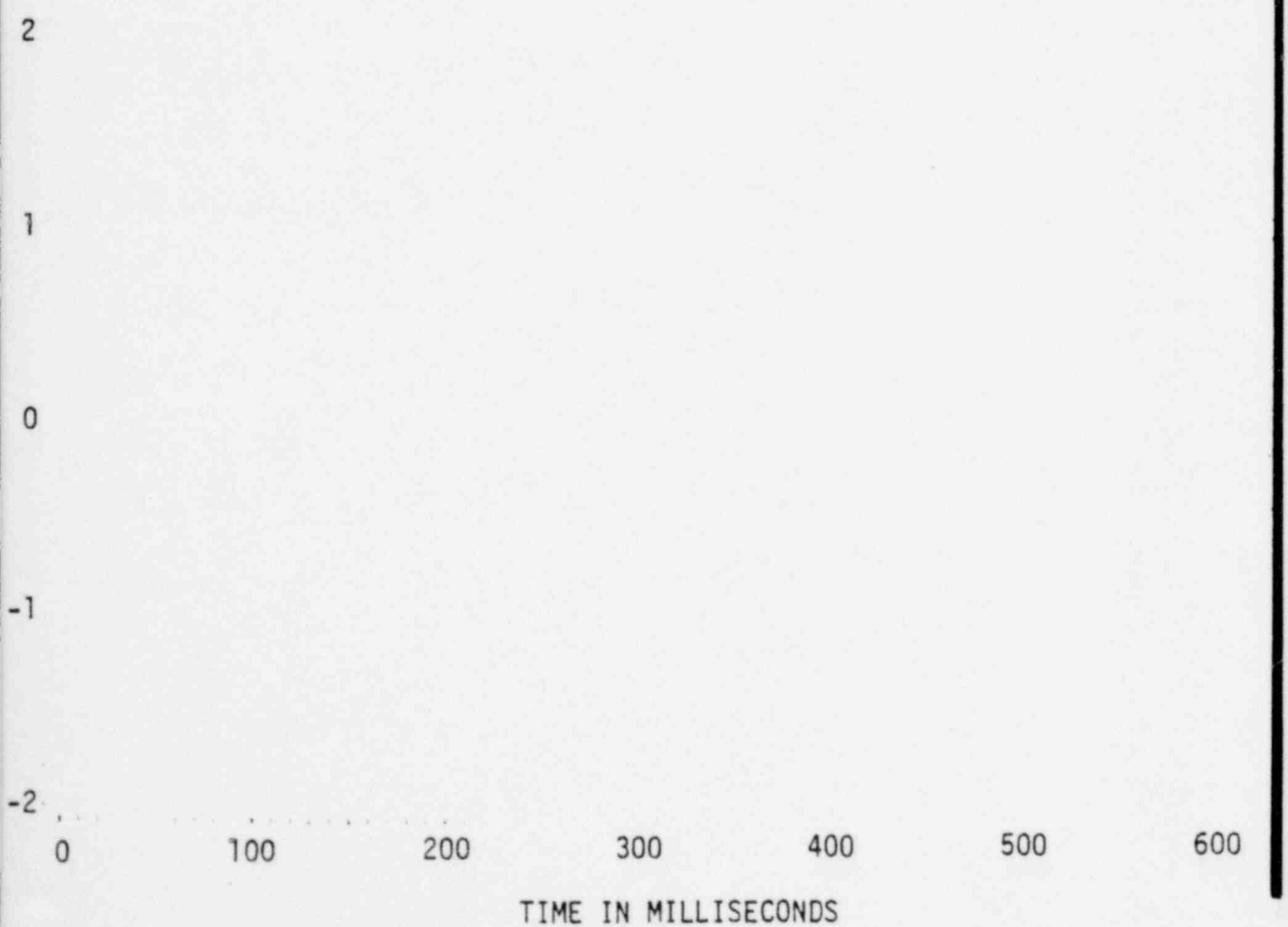


1349 180

FIGURE A-351

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Dresden Test 3

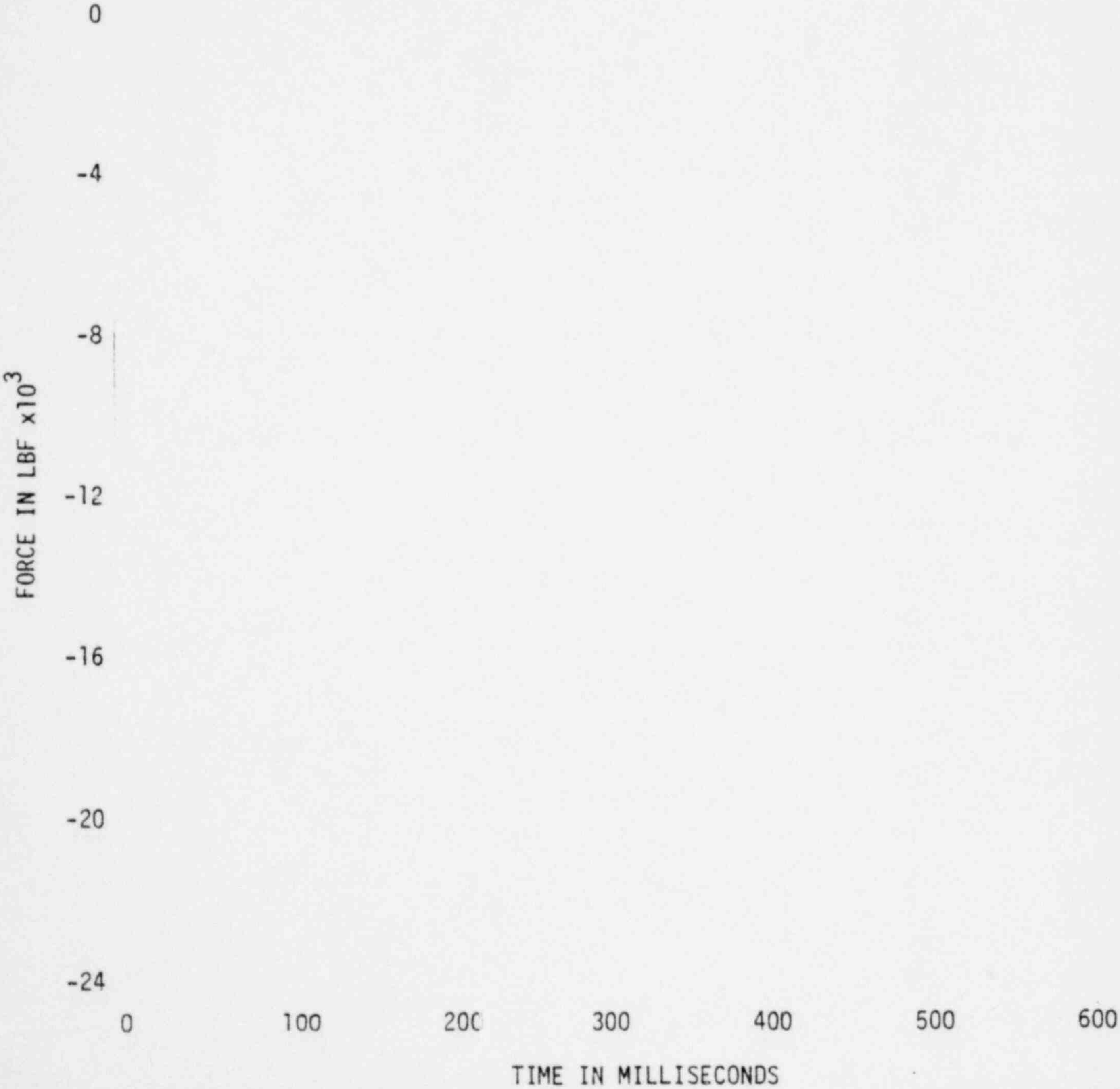


1349 181

FIGURE A-352

TORUS LOAD CELL

Task 5.5.3-2 Dresden Test 5



1349 182

FIGURE A-353

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Dresden Test 5

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 183

FIGURE A-354

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Dresden Test 3

6000

4000

2000

FORCE IN LBF 0

-2000

-4000

-6000

1349 184

-8000

0 100 200 300 400 500 6

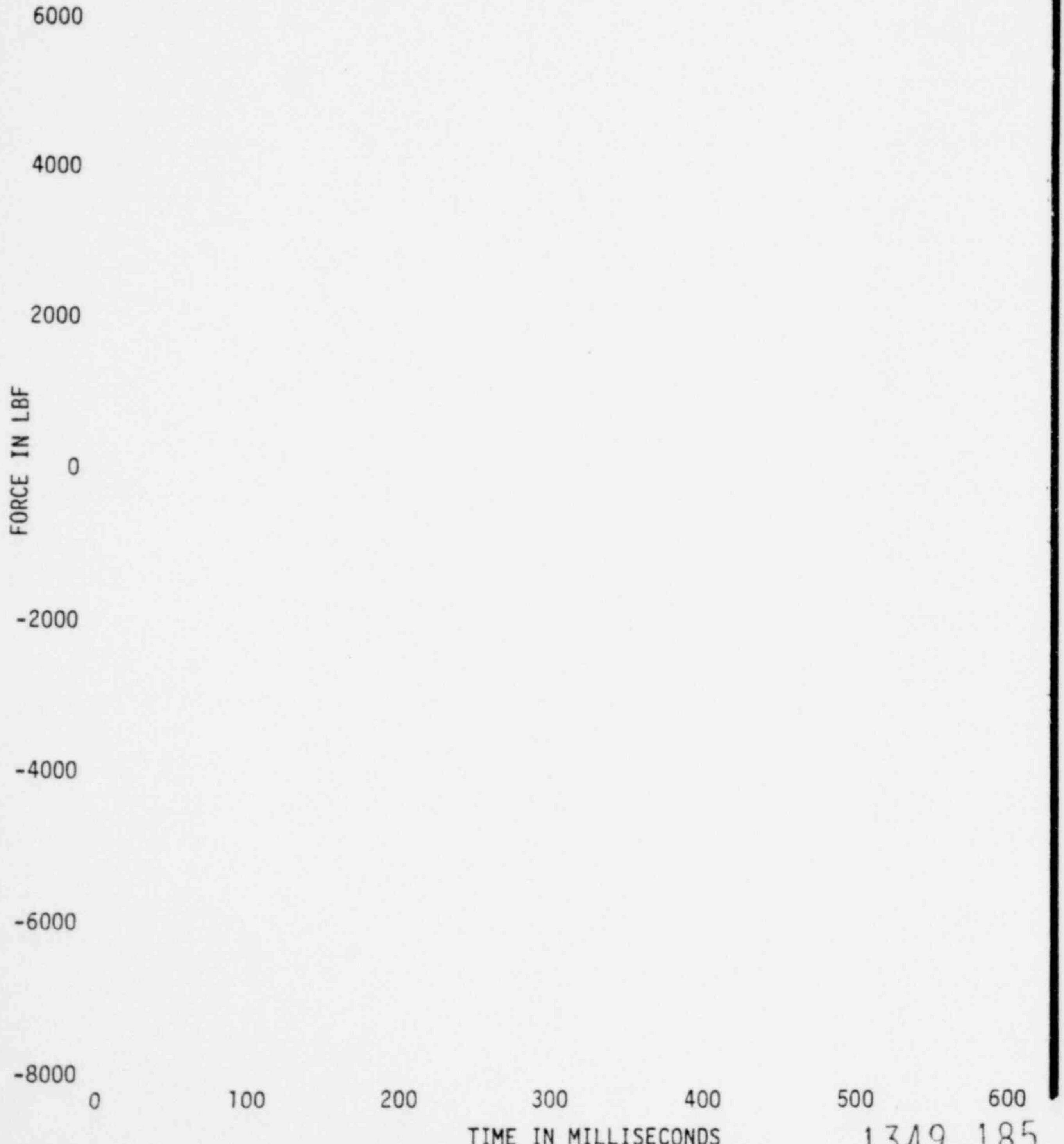
TIME IN MILLISECONDS

FIGURE A-355

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Dresden Test 5



1349 185

FIGURE A-356

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 3

1349 186

FIGURE A-357

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 5

5000

4000

2000

0

2000

4000

000

000

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 187

FIGURE A-358

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 3

AVERAGE POOL PRESSURE IN PSIA

10

8

6

4

2

0

0 100 200 300 400 500 600

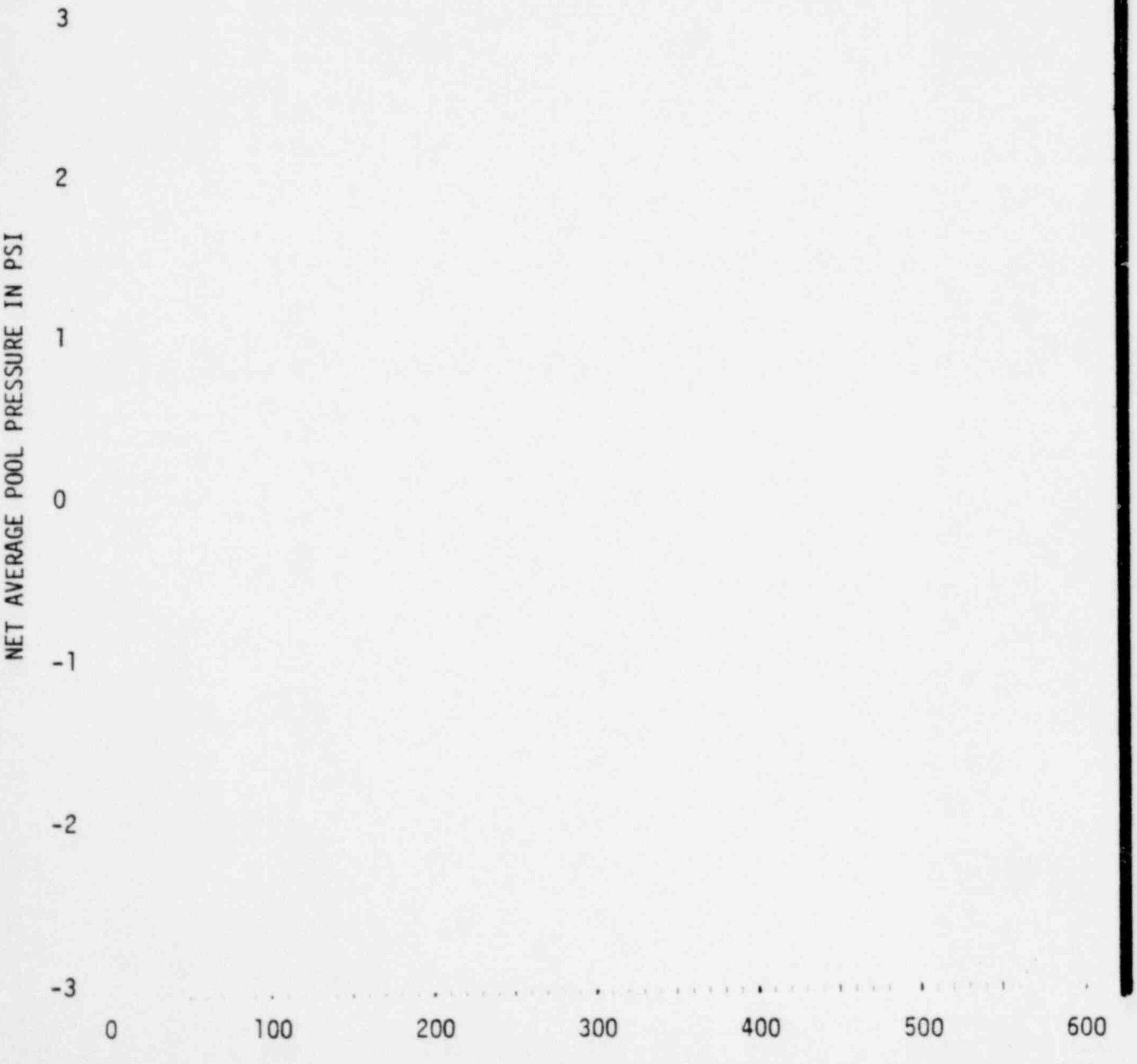
TIME IN MILLISECONDS

1349 188

FIGURE A-359

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 3



1349 189

FIGURE A-360

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 5

AVERAGE POOL PRESSURE IN PSIA

10

8

6

4

2

0

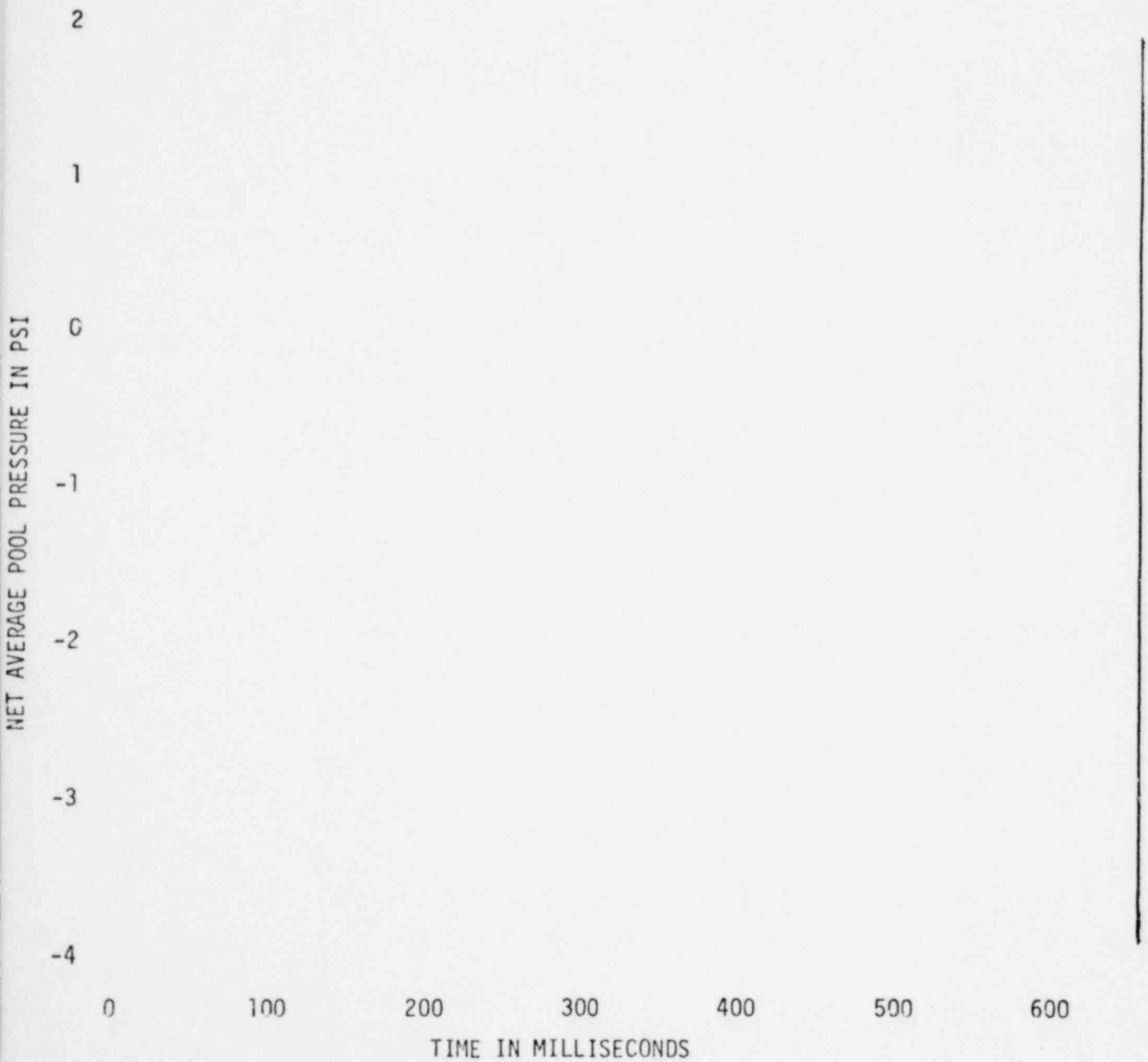
0 100 200 300 400 500 600

TIME IN MILLISECONDS

FIGURE A-361

NET AVERAGE PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Dresden Test 5

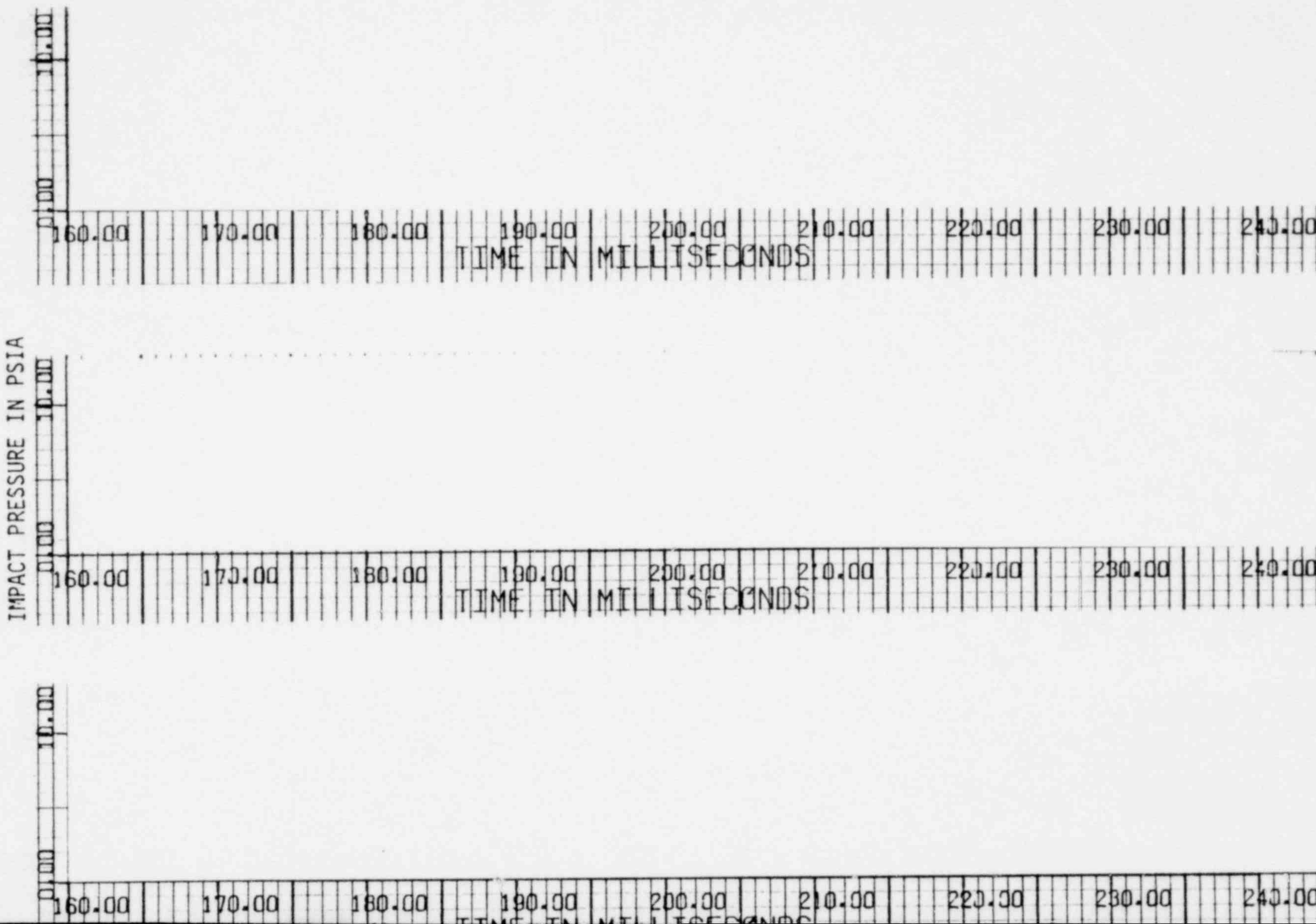


1349 191

FIGURE A-362

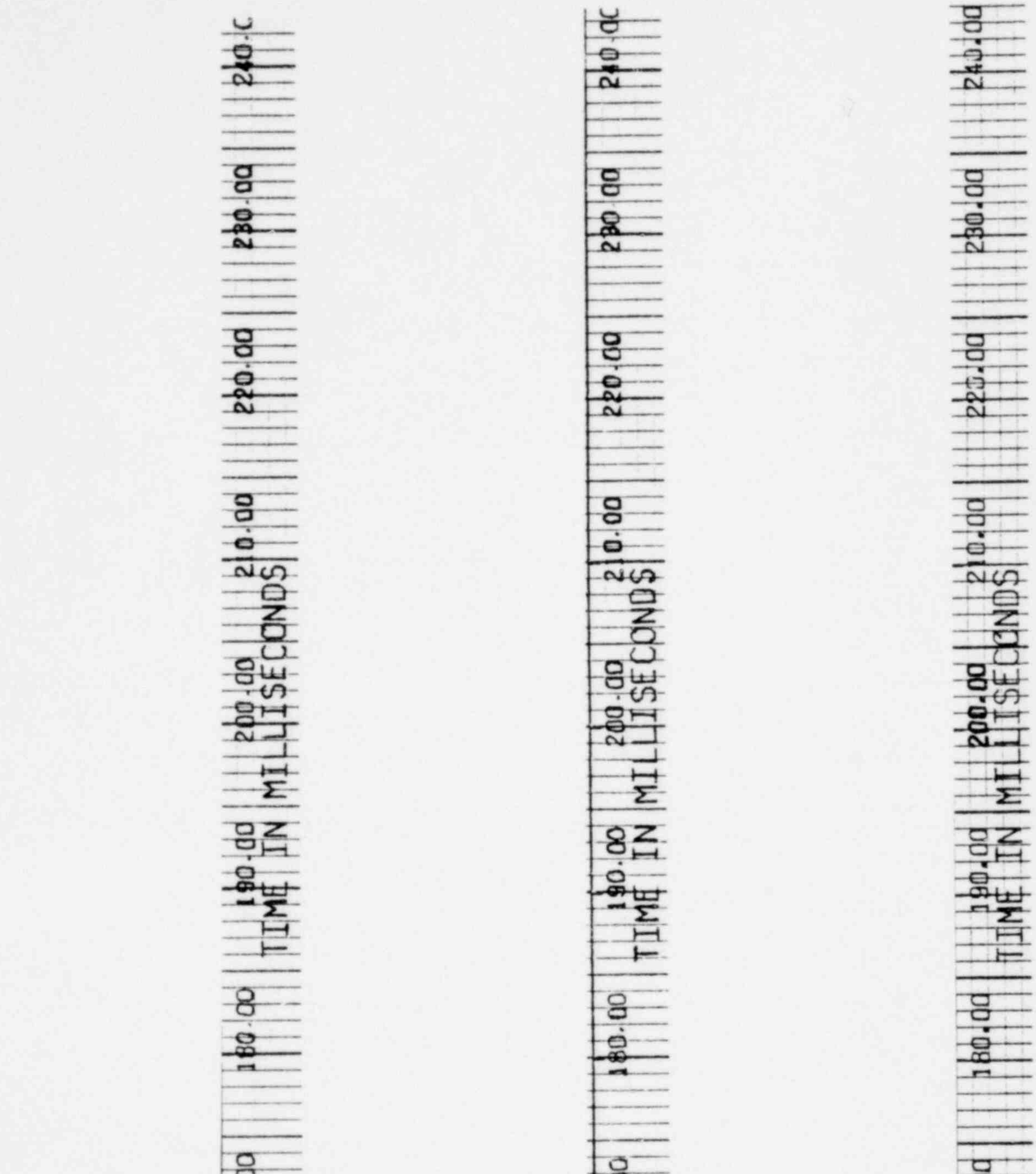
VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Dresden Test 3



1349 192

Task 5.5.3-2 Dresden Test 3



1349 193

FIGURE A-364

VENT HEADER IMPACT PRESSURES

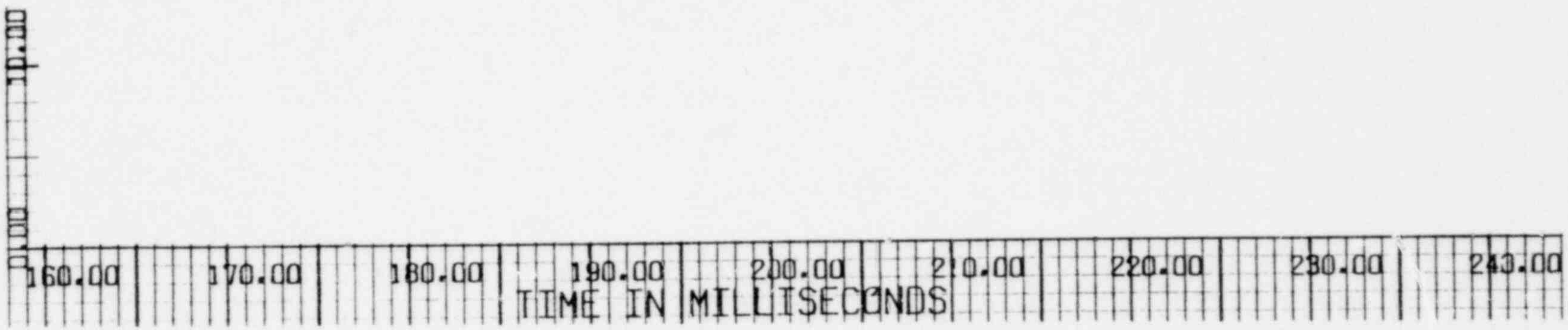
Task 5.5.3-2 Dresden Test 3

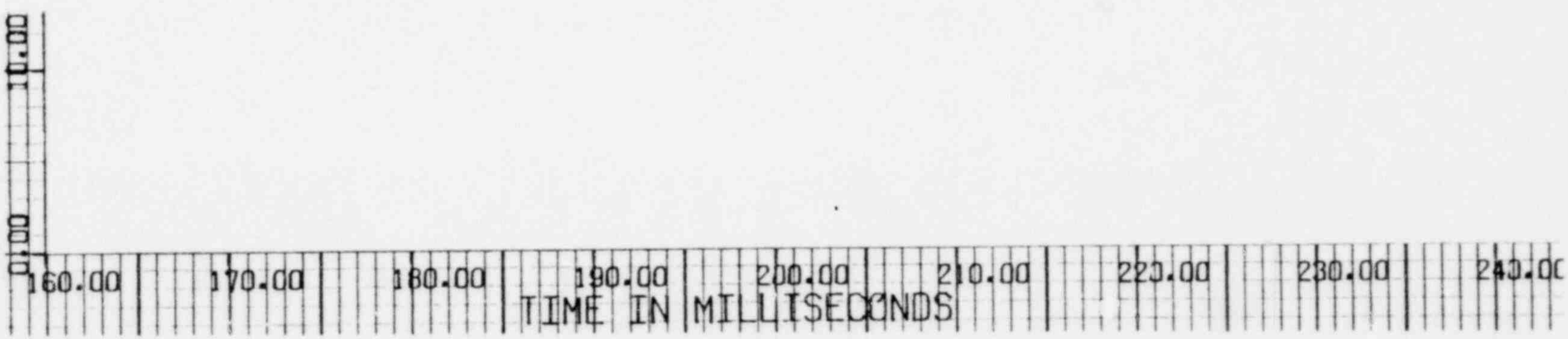
1349 194

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Dresden Test 3

No Data for Transducer T12



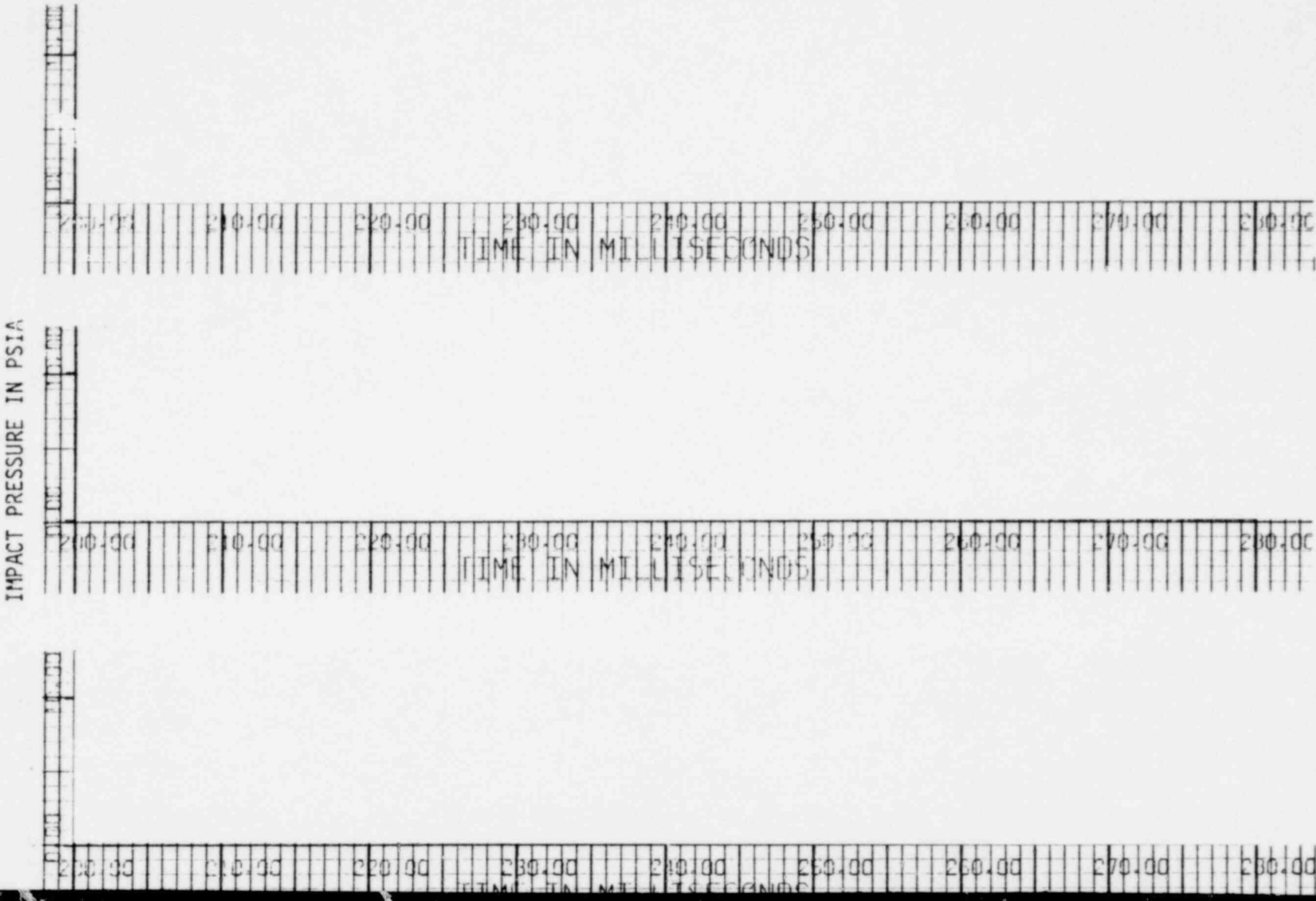


1349 195

FIGURE A-366

VENT HEADER IMPACT PRESSURES

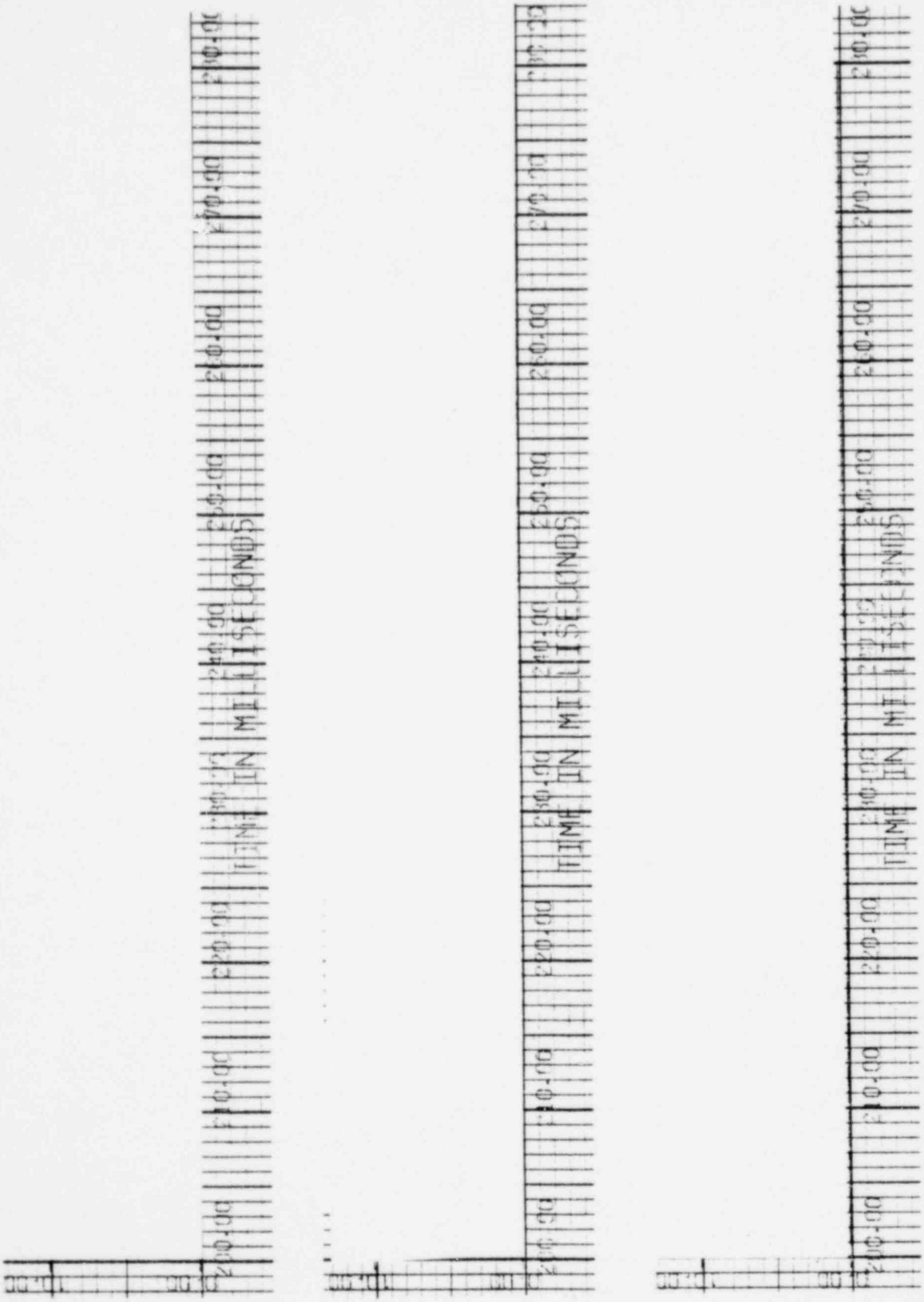
Task 5.5.3-2 Dresden Test 5



1349 196

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Dresden Test 5



1349 197

FIGURE A-368

VENT HEADER IMPACT PRESSURES

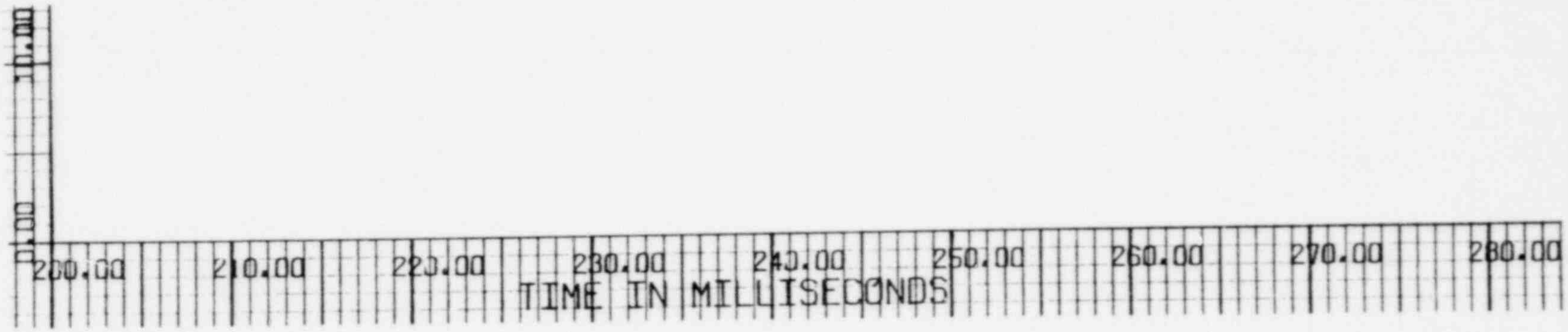
Task 5.5.3-2 Dresden Test 5

1349 198

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Dresdan Test 5

No Data for Transducer T12



1349 199

FIGURE A-370

COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3 Dresden Tests 3, 5

FORCE IN LBF

1200
1000
800
600
400
200
0
-200
-400

160 180 200 220 240 260

TIME IN MILLISECONDS

FORCE IN LBF

1200
1000
800
600
400
200
0
-200
-400

200 220 240 260 280 300

TIME IN MILLISECONDS

1349 200

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Dresden Test 3

○ Lower Accelerometer

△ Upper Accelerometer

ACCELERATION IN G

12
8
4
0
-4
-8

160 170 180 190 200 210 220 230 240

TIME IN MILLISECONDS

1349 201

FIGURE A-372

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Dresden Test 5

○ Lower Accelerometer

△ Upper Accelerometer

ACCELERATION IN G

12

8

4

0

-4

-8

200 210 220 230 240 250 260 270 280

1349 202

FIGURE A-373

TIME HISTORY OF

POOL DISPLACEMENT

DRESDEN, TEST 1

1349 203

FIGURE A-374

TIME HISTORY OF

POOL DISPLACEMENT

DRESDEN, TEST 2

Vertical Distance from Original Pool Water Level - inches

30
25
20
15
10
5
0

0 5 10 15 20 25 30

Horizontal Distance from Pool Centerline - inches

Time (from T_o) - seconds

1349 204

FIGURE A-375

TIME HISTORY OF POOL DISPLACEMENT

DRESDEN, TEST 3

Time (from T_0) - seconds

0 5 10 15 20 2 30

Horizontal Distance from Pool Centerline - inches

1349 205

FIGURE A-376

TIME HISTORY OF
POOL DISPLACEMENT

DRESDEN, TEST 5

Vertical Distance from Original Pool Water Level - inches

3(
25
2(
15
1(
5
C

0 5 10 15 20 25 30

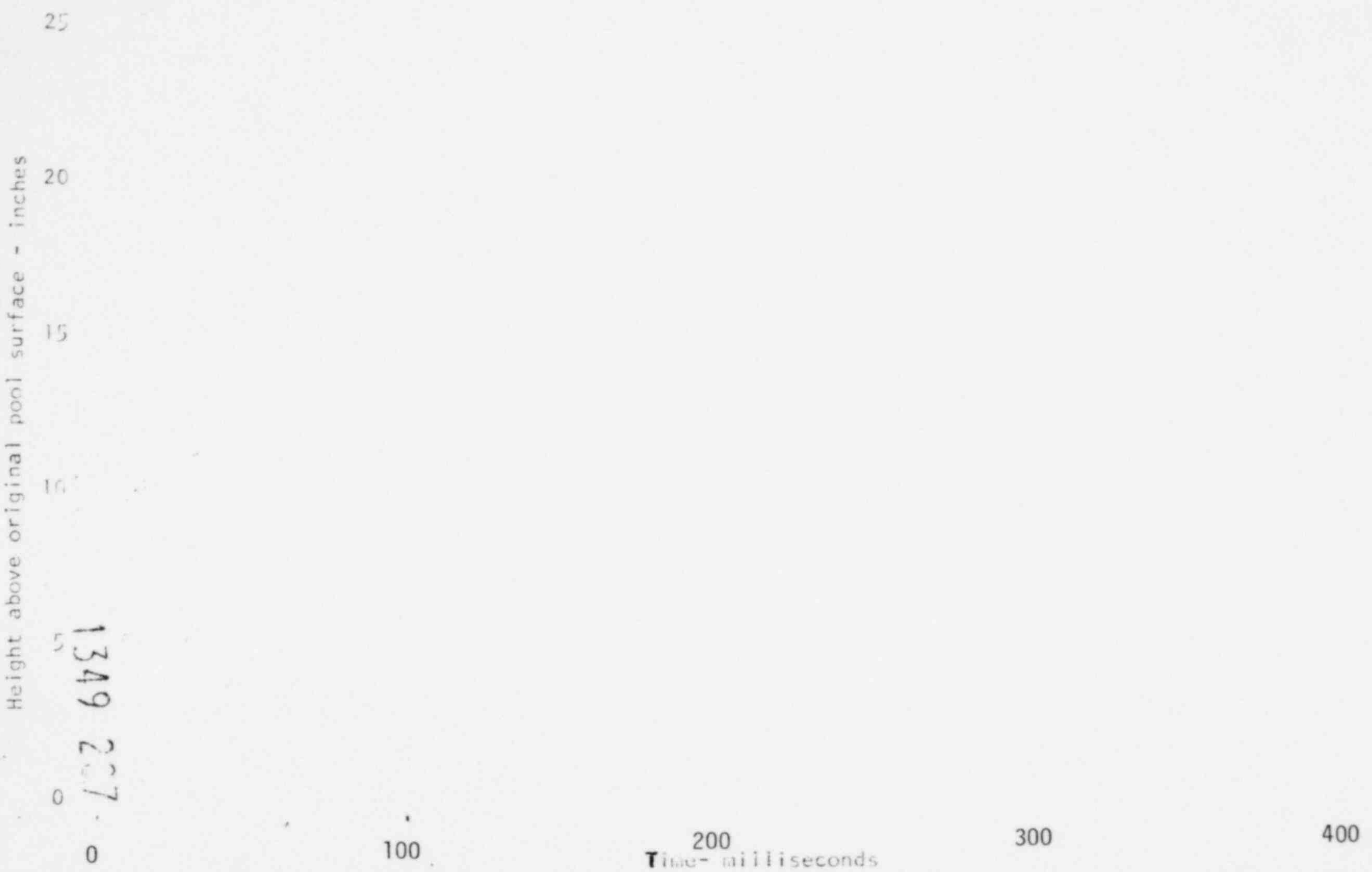
Horizontal Distance from Pool Centerline - inches

Time (from T_0) - seconds

1349 206

POOL SURFACE DISPLACEMENT

DRESDEN, TESTS 1, 2, 3



1349 227

FIGURE A-378

POOL SURFACE VELOCITY PROFILES

DRESDEN, TESTS 1, 2, 3

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

DISTANCE FROM POOL CENTERLINE - INCHES

1349 208

POOL SURFACE DISPLACEMENT

FIGURE A-379

DRESDEN, TEST 5

Height above original pool surface - inches

25

20

15

10

5

0

1349 209

0 100 200 300 400

Time- milliseconds

FIGURE A-380

POOL SURFACE VELOCITY PROFILES

DRESDEN, TEST 5

VELOCITY - FT/SEC

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

DISTANCE FROM POOL CENTERLINE - INCHES

1349 210

FIGURE A-381

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

DRESDEN, TEST 4

12
10
8
6
4
2
0

.100 .150 .200 .250 .300 .350 .400

15.

10.

5.

1349 211

0.

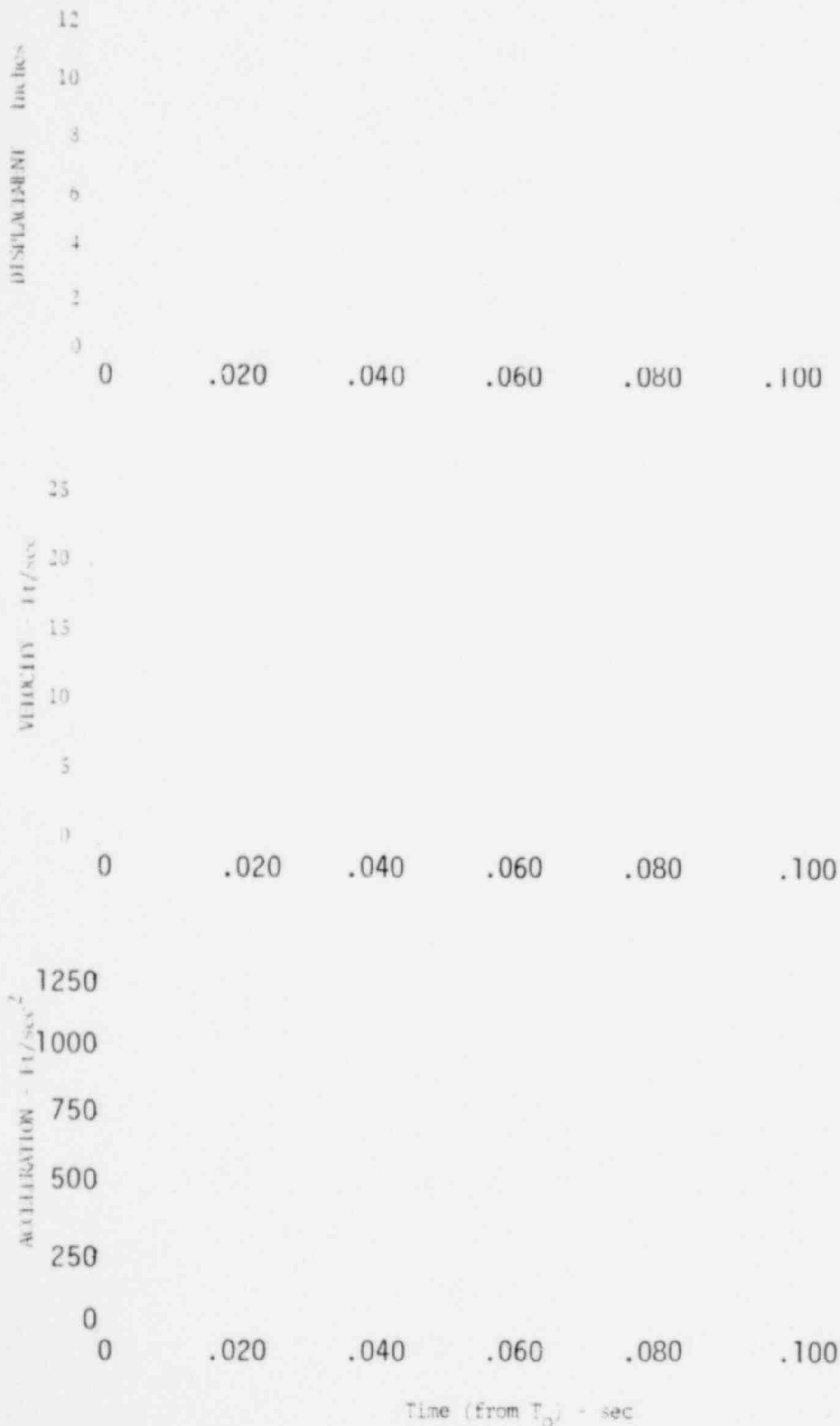
.100 .150 .200 .250 .300 .350 .400

TIME - Seconds

FIGURE A-382

DOWNCOMER WATER SLUG EJECTION

DRESDEN, TEST 3

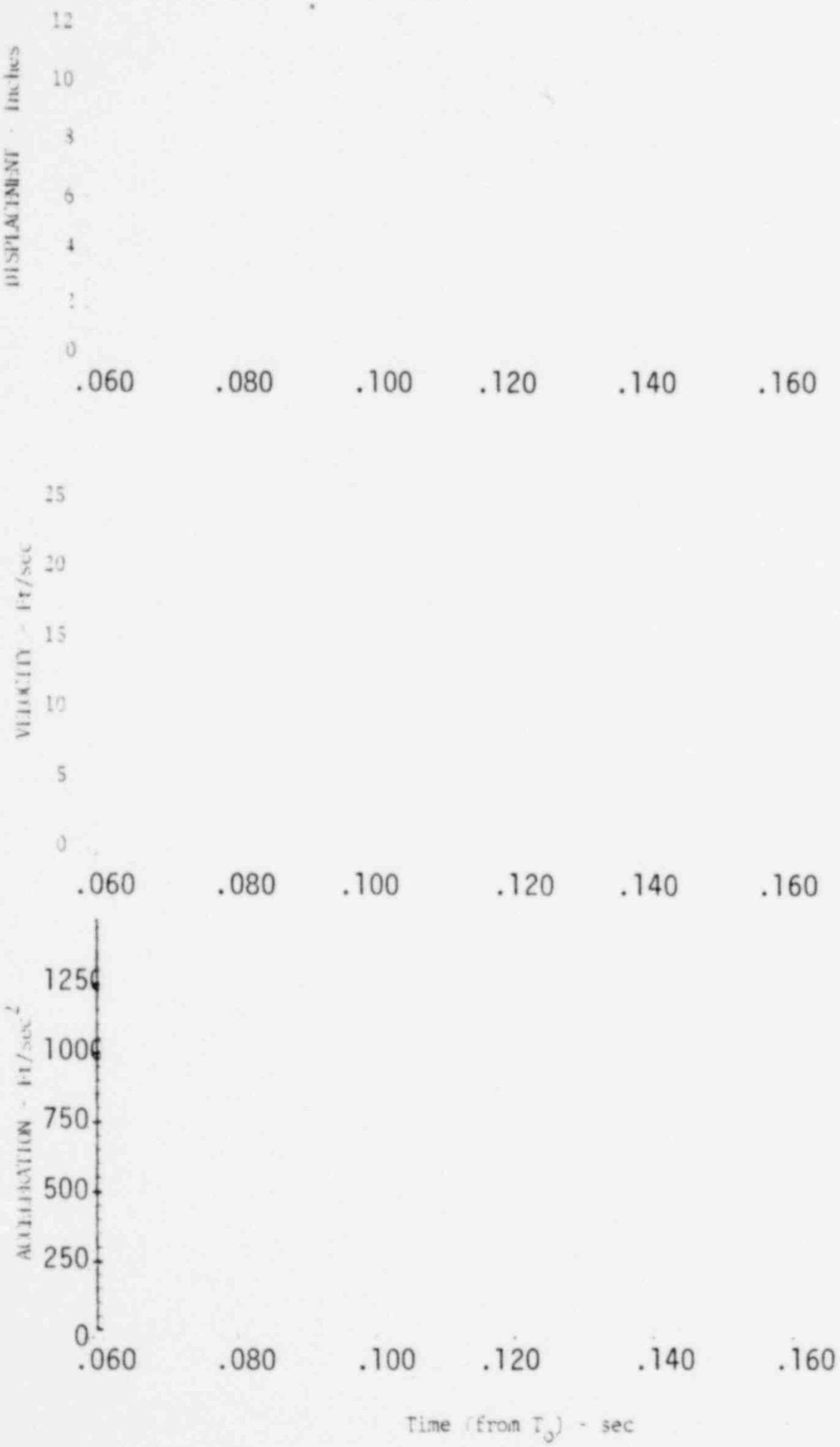


1349 212

FIGURE A-383

DOWNCOMER WATER SLUG EJECTION

DRESDEN, TEST 5



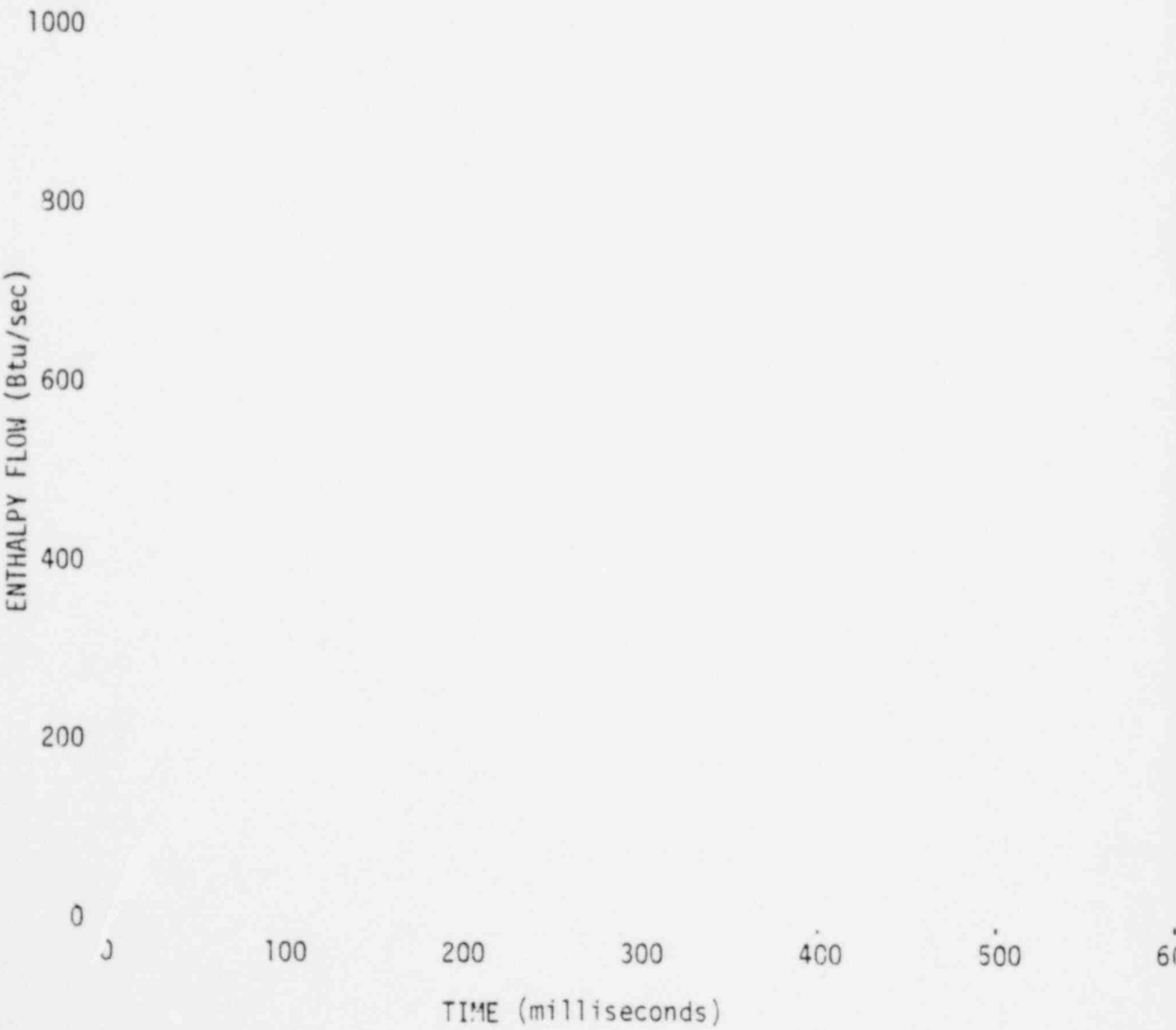
1349 213

FIGURE A-384

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Dresden Tests



1349 214

FIGURE A-385

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Dresden Tests

PRESSURE (psia)

20

16

12

8

4

0

0 100 200 300 400 500 600

TIME (milliseconds)

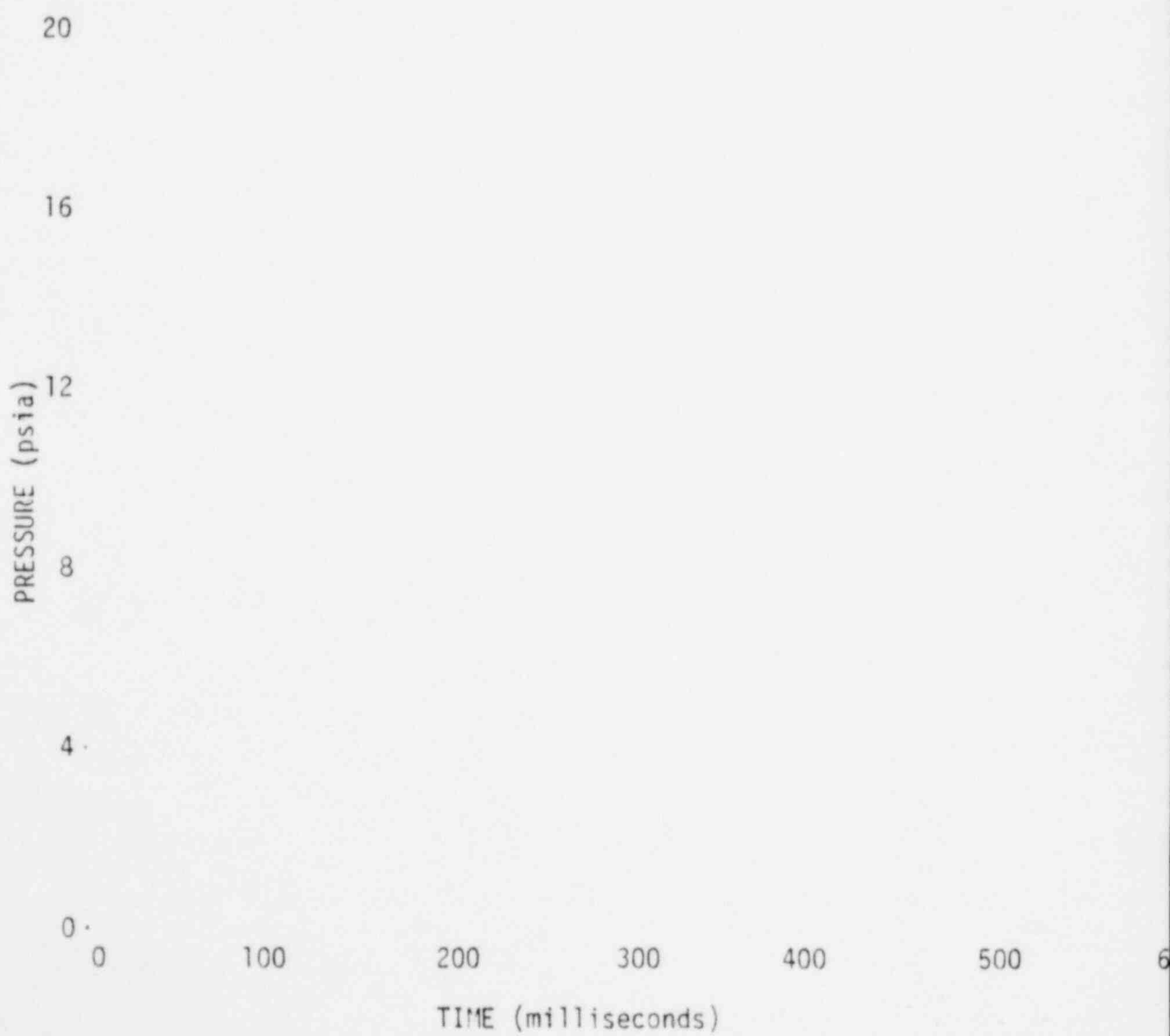
1349 215

FIGURE A-386

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Dresden Tests



1349 216

TABLE A-17

*Time at force is zero (from T_o)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Dresden Tests

Test No. / rameter	7.15" ΔP, 5.17" Pipe Deflector (20" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
ak Upforce							
essure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
force Valley							
essure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
d Peak Upforce							
essure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
rrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
ro Force Time*							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							

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TABLE A-17

*Vent clearing time (from T_o) determi[ned] from the movie films.
**Time difference from T_o to time of zero downforce.

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Dresden Tests

*(1) Start-of-test reference time

Parameter \ Test No.	7.15" ΔP, 5.17" Pipe Deflector (20" Full Scale) (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o *(1) (sec)							
Vent Clearing Time* (sec)							
Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
Downforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
2nd Peak Downforce							
Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_o) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_o) (sec)							
[Δt] Downforce Time**							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							
Downforce Impulse							
Pressure Integral:							
Impulse (lb-sec)		--					

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TABLE A-18

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Dresden Tests

Parameter \ Test No.		7.15" ΔP, 5.18" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o†	(sec)							
Vent Header Impact								
Pressure Integral:								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration*	(sec)							
Load Cell Corrected:††								
Maximum Force	(lb)							
Impulse	(lb-sec)							
Duration	(sec)							
Pool Surface Velocity	(ft/sec)							
Time (from T_o)**	(sec)							

*Based on impact pressure measurements
**At start of the first impact pressure recorded.

†Start of reference time
††represents peak of very noisy data (acceleration corrected); mean value would be lower

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