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MARK I CONTAINMENT PROGRAM
QUARTER SCALE PLANT UNIQUE TESTS

TASK NUMBER 5.5.3, SERIES 2

VOLUME 3

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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 3, Appendix A (con't)

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1349 221

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TABLE OF CONTENTS - APPENDICES

1349 223

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 in flight 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 (con't)

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.

A.9 Browns Ferry Tests

A.9.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Browns Ferry Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 7.61" ΔP and with no deflector. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with no deflector.

A.9.1.1 Driving Conditions

Driving conditions for Browns Ferry Test 3 are presented in Figures A-387 through A-391. Similar plots for Browns Ferry Test 5 are shown in Figures A-392 through A-396. The thermocouple gave an erroneous reading due to the condensate wetting the thermocouple. The corrected vent air temperature is shown by dash line (Figures A-390 and A-395). Browns Ferry's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.9.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Browns Ferry Tests 3 and 5 are presented in Figures A-397 through A-398 and A-399 through A-400, respectively.

Figures A-401 and A-402 present net torus force based on the torus pressure integral for Browns Ferry Tests 3 and 5, respectively. Some downforce oscillations are present, but the upforce is relatively smooth.

1349 227

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-404 and A-408) to the torus load cell (Figures A-403 and A-405) is compared with the torus force obtained from the torus pressure integral in Figures A-407 and A-408. Residual oscillations are present in the corrected load cell. Figures A-409 and A-410 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 Browns Ferry Tests 3 and 5 are shown in Figures A-411 and A-413. Figures A-412 and A-414 are the same as Figures A-409 and A-410 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Browns Ferry Test 3 are presented in Figures A-415 through A-417. Vent header pressures for Browns Ferry Test 5 are presented in Figures A-418 through A-420. These figures illustrate that the impact pressures on an unprotected vend header are higher on the center row and decrease rapidly in the lateral direction.

Figure A-421 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-422 and A-423, respectively.

A.9.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-424 through A-427 for Browns Ferry Tests 1, 2, 3, and 5.

1349 228

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-428. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-429. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-430 and A-431, respectively.

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-432. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-433 and A-434.

A.9.3 Data Summaries

Table A-19 presents the Browns Ferry test data for wetwell vertical forces.

Table A-20 presents the Browns Ferry test data for vent header impact forces.

A.9.4 Discussion and Analysis

Figure A-435 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-436. Figure A-437 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The pool and freespace pressures show no oscillation during the upforce period.

The Browns Ferry load definition tests were conducted at 7.61" H_2O ΔP and with no deflector. A ΔP sensitivity test at 0" H_2O ΔP was also conducted. Some downforce oscillations were evident. The upforce was relatively smooth. The vent header impact force was significantly higher than the plants using deflectors.

FIGURE A-387

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Browns Ferry Test 3

PRESSURE IN PSIA

120

100

80

60

40

20

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

*Proprietary information deleted.

1349 230

FIGURE A-388

DRYWELL PRESSURE

Task 5.5.3-2 Browns Ferry Test 3

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

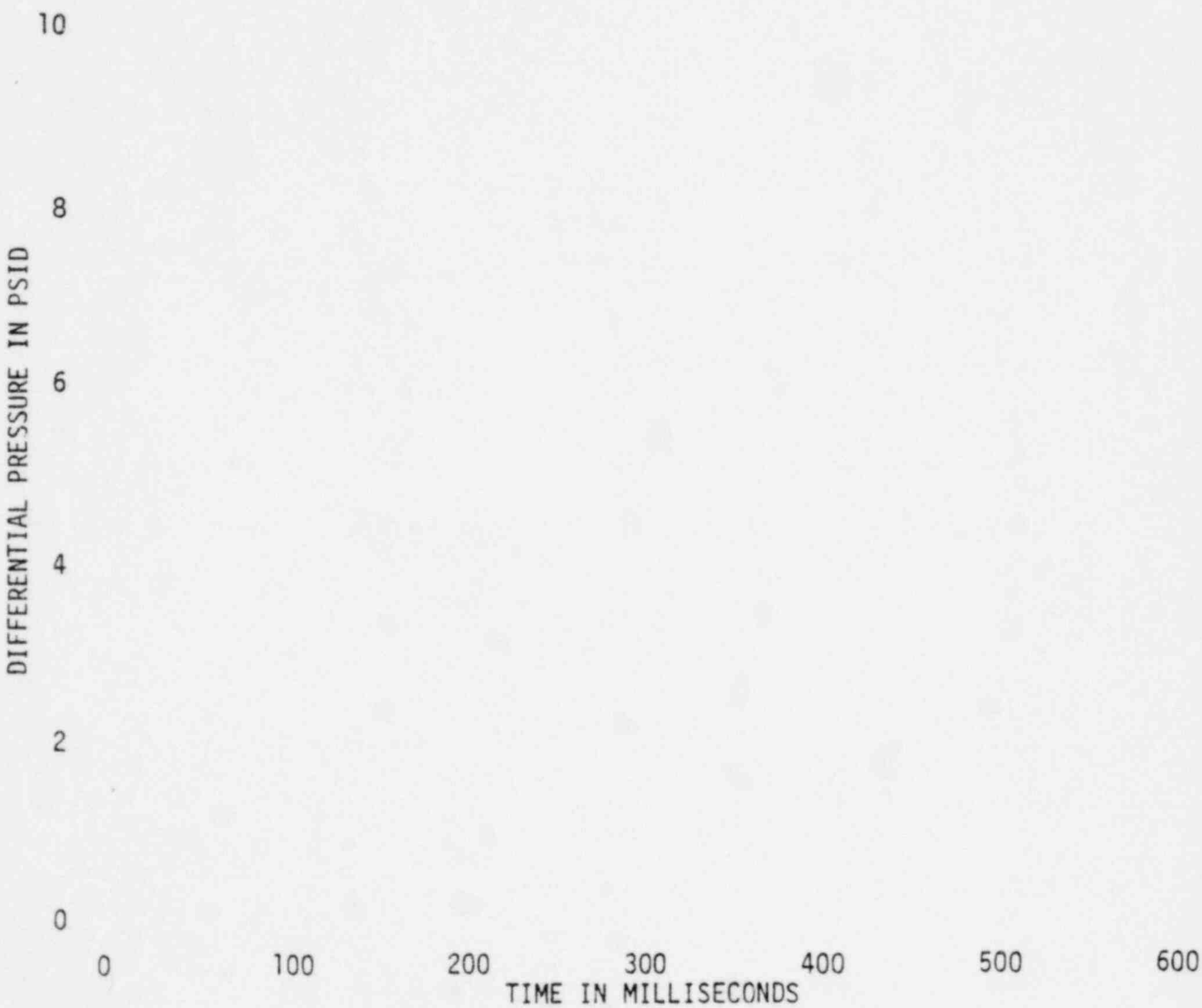
TIME IN MILLISECONDS

1349 231

FIGURE . A-389

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Browns Ferry Test 3

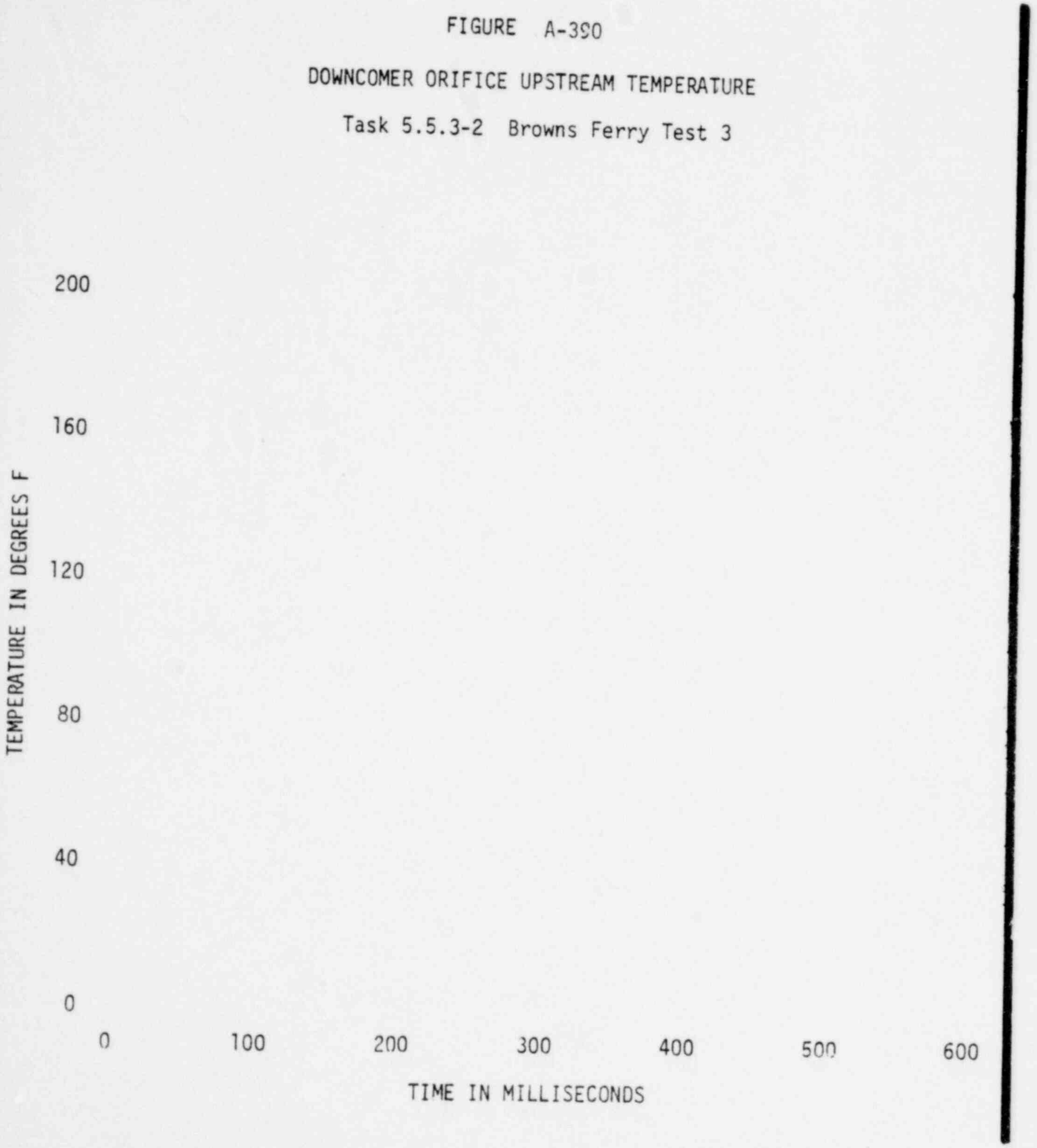


1349 232

FIGURE A-390

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Browns Ferry Test 3

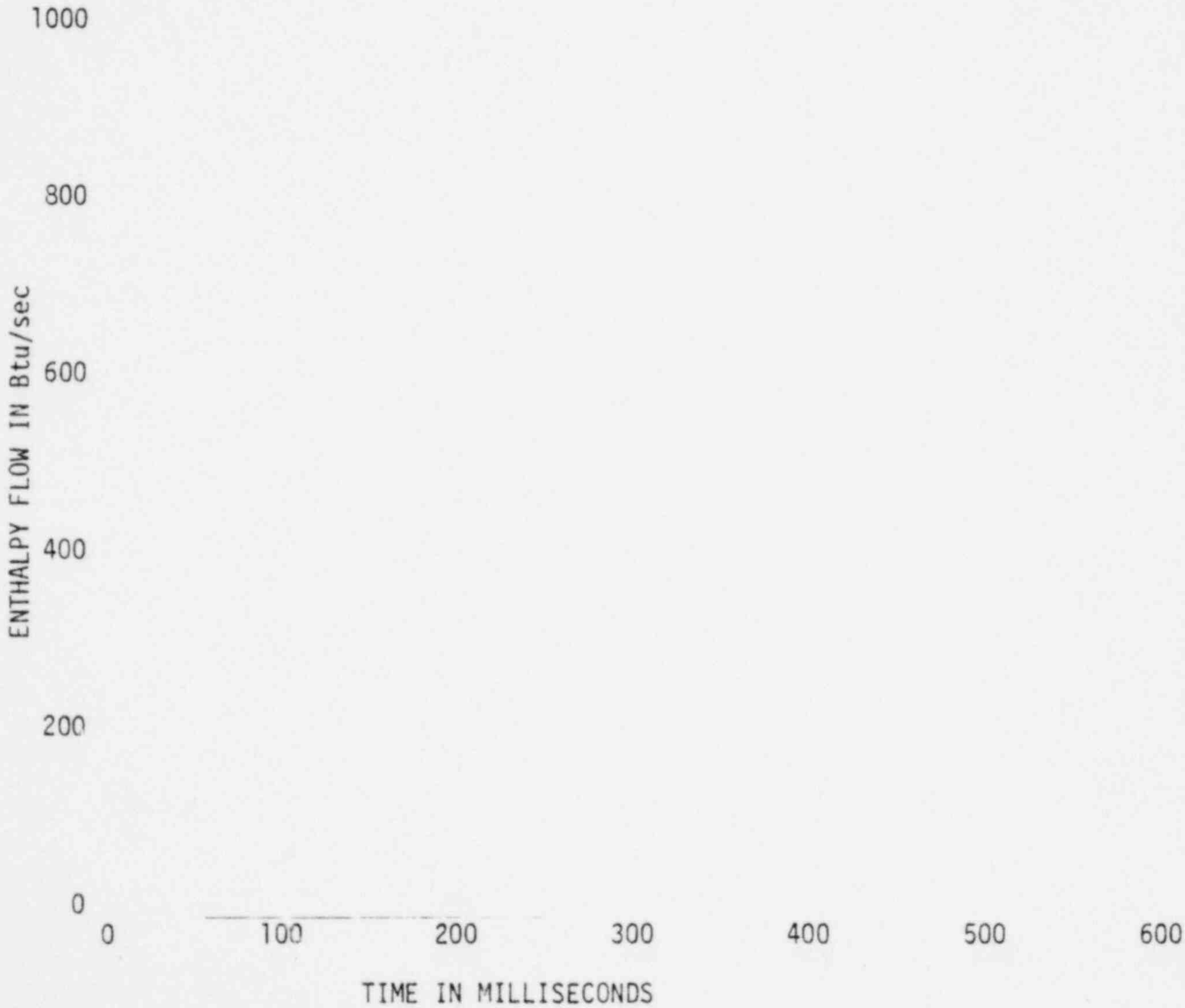


1349 233

FIGURE A-391

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Browns Ferry Test 3

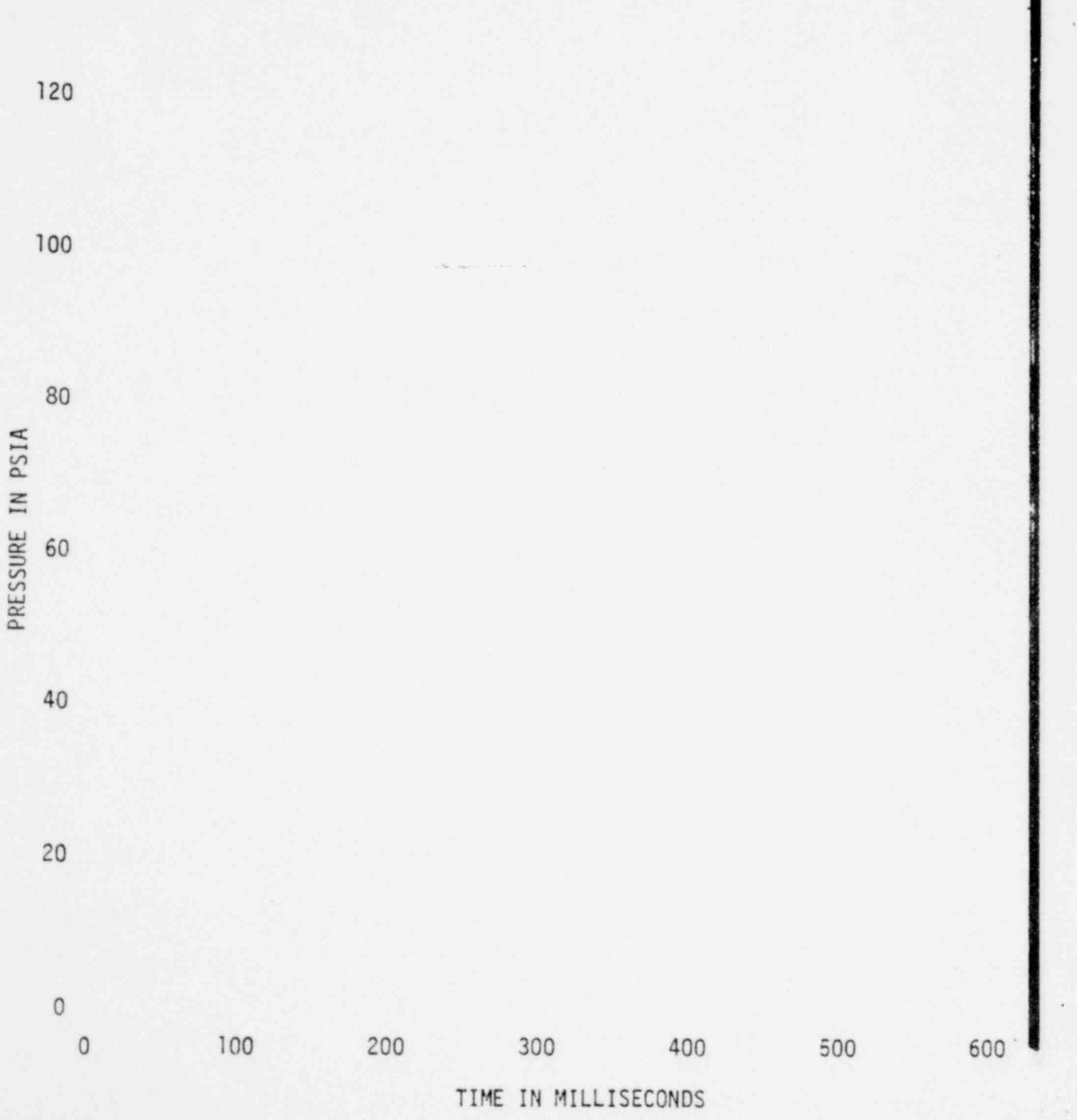


1349 234

FIGURE A-392

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Browns Ferry Test 5

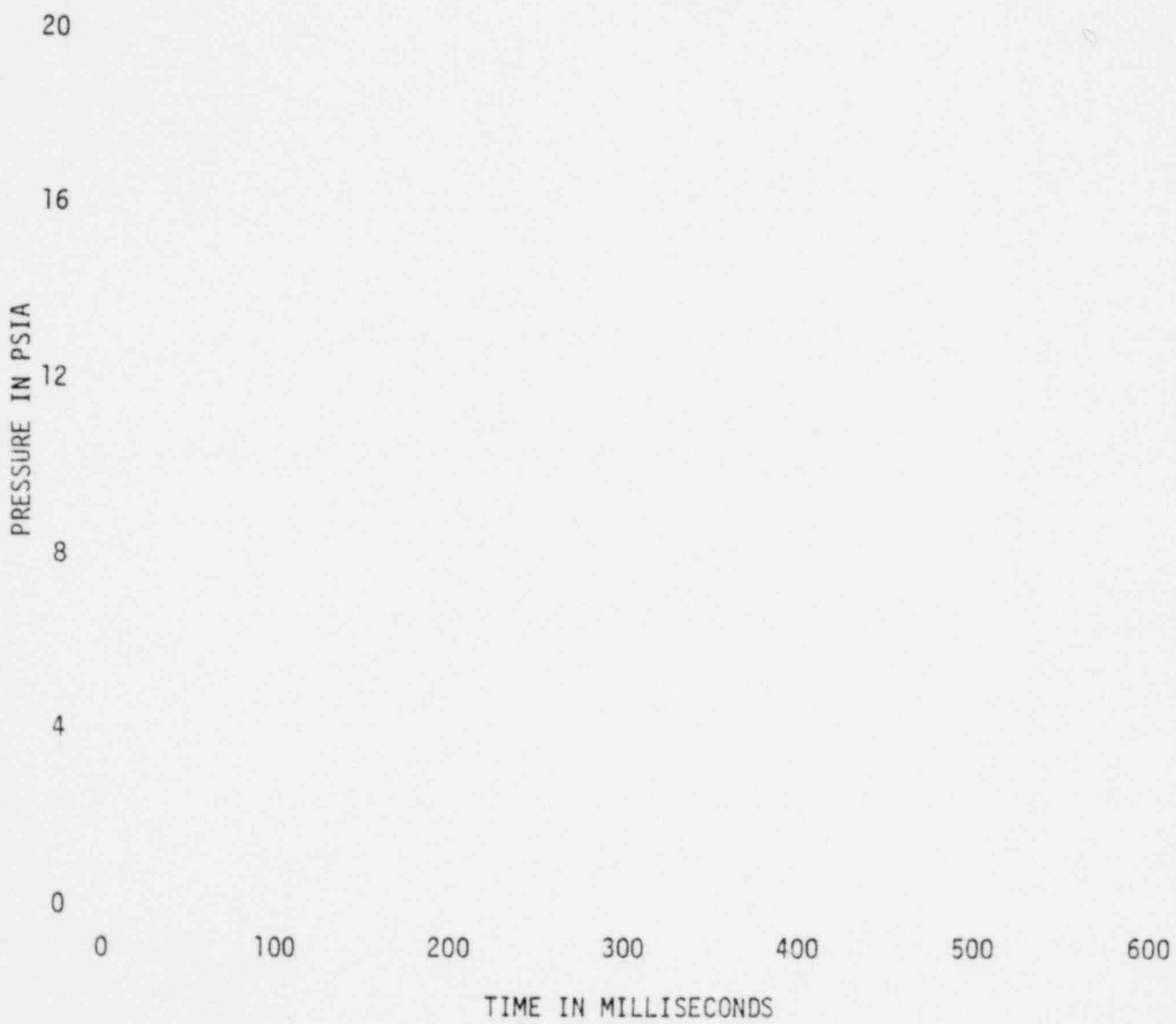


1349 235

FIGURE A-393

DRYWELL PRESSURE

Task 5.5.3-2 Browns Ferry Test 5



1349 236

FIGURE A-394

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Browns Ferry Test 5

DIFFERENTIAL PRESSURE IN PSID

10

8

6

4

2

0

0 100 200 300 400 500 600

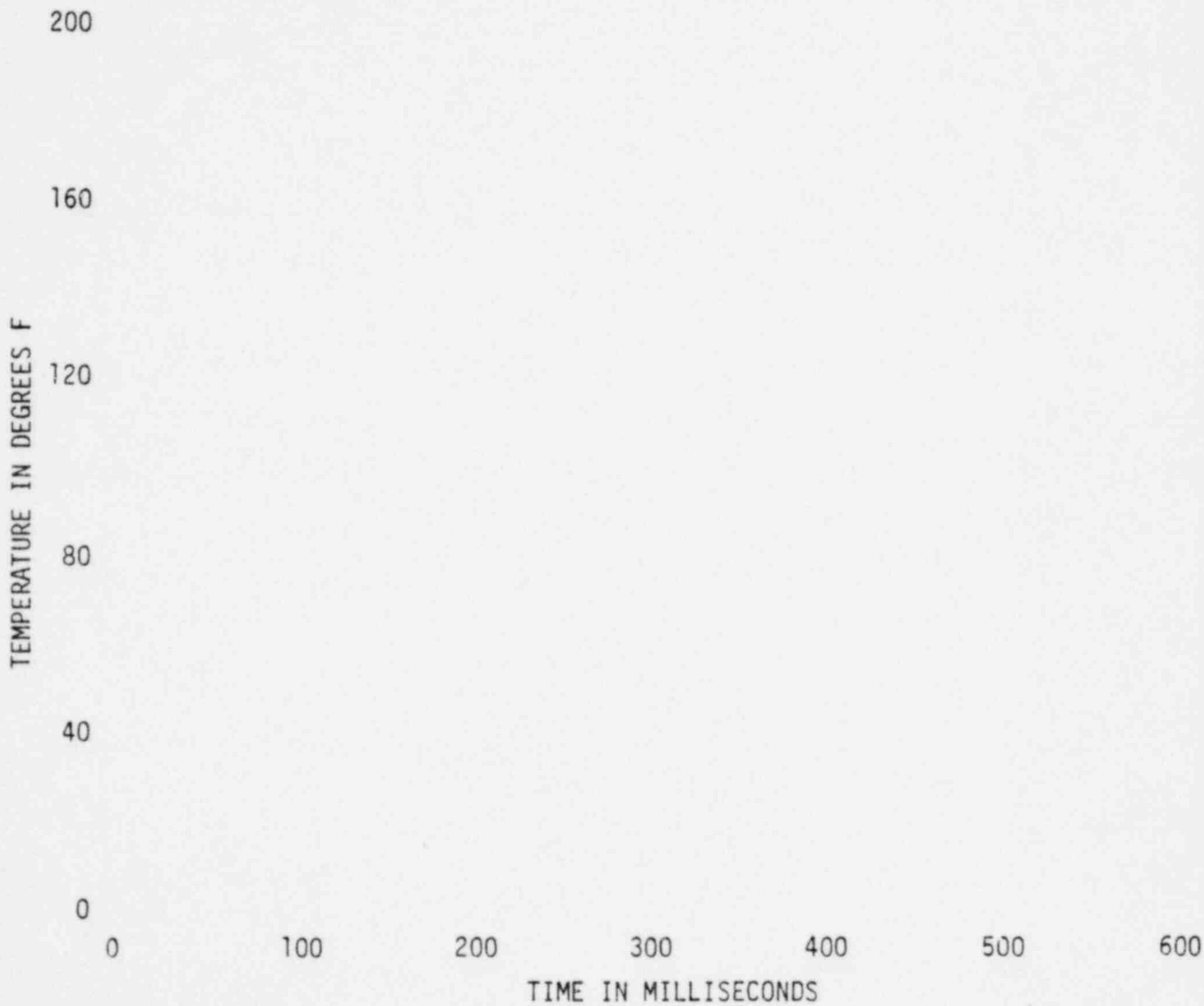
TIME IN MILLISECONDS

1349 237

FIGURE A-395

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Browns Ferry Test 5

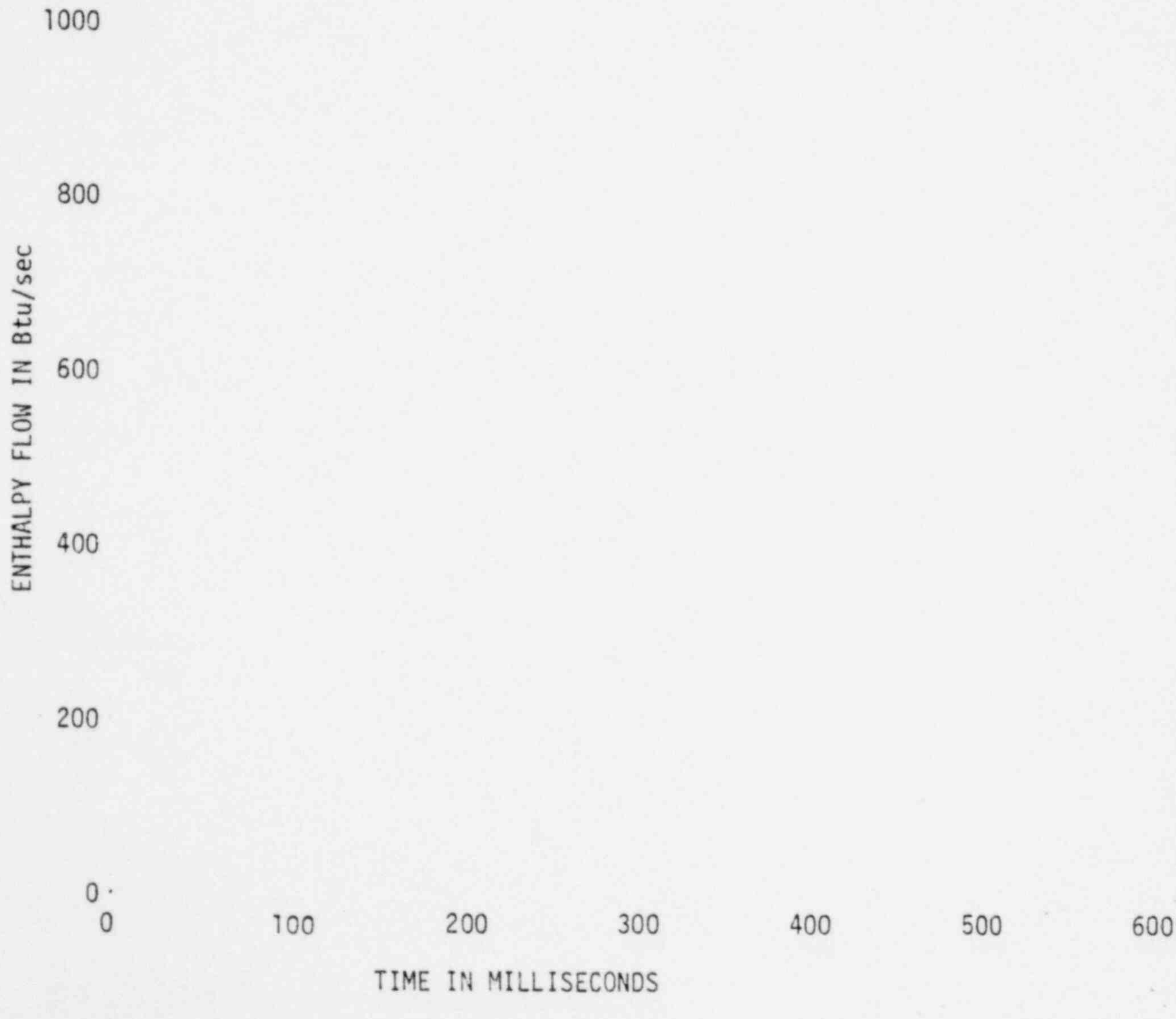


1349 238

FIGURE A-396

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Browns Ferry Test 5

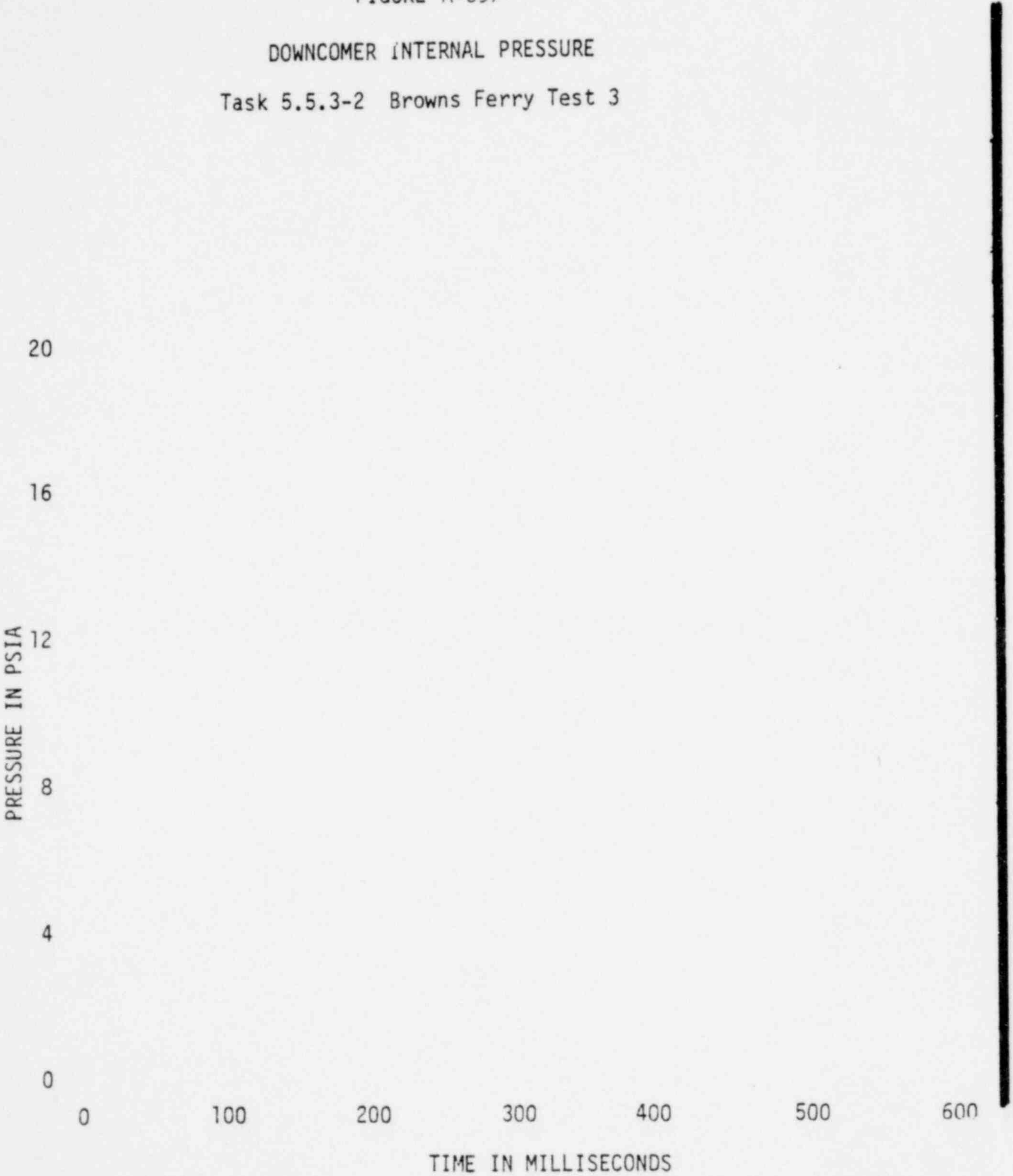


1349 239

FIGURE A-397

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Browns Ferry Test 3

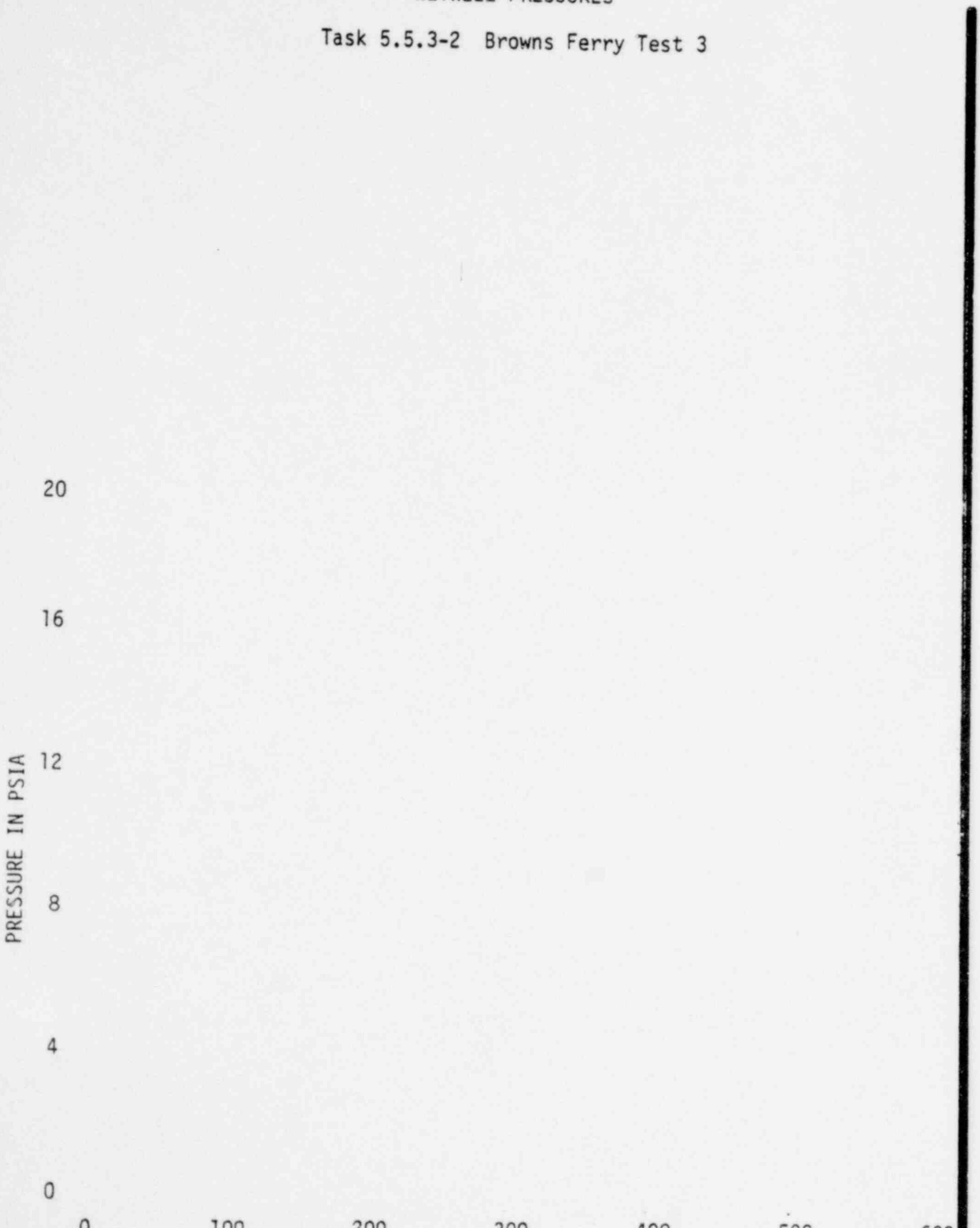


1349 240

FIGURE A-398

WETWELL PRESSURES

Task 5.5.3-2 Browns Ferry Test 3



1349 241

FIGURE A-399

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3-2 Browns Ferry Test 5

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1349 242

FIGURE A-400

WETWELL PRESSURES

Task 5.5.3-2 Browns Ferry Test 5

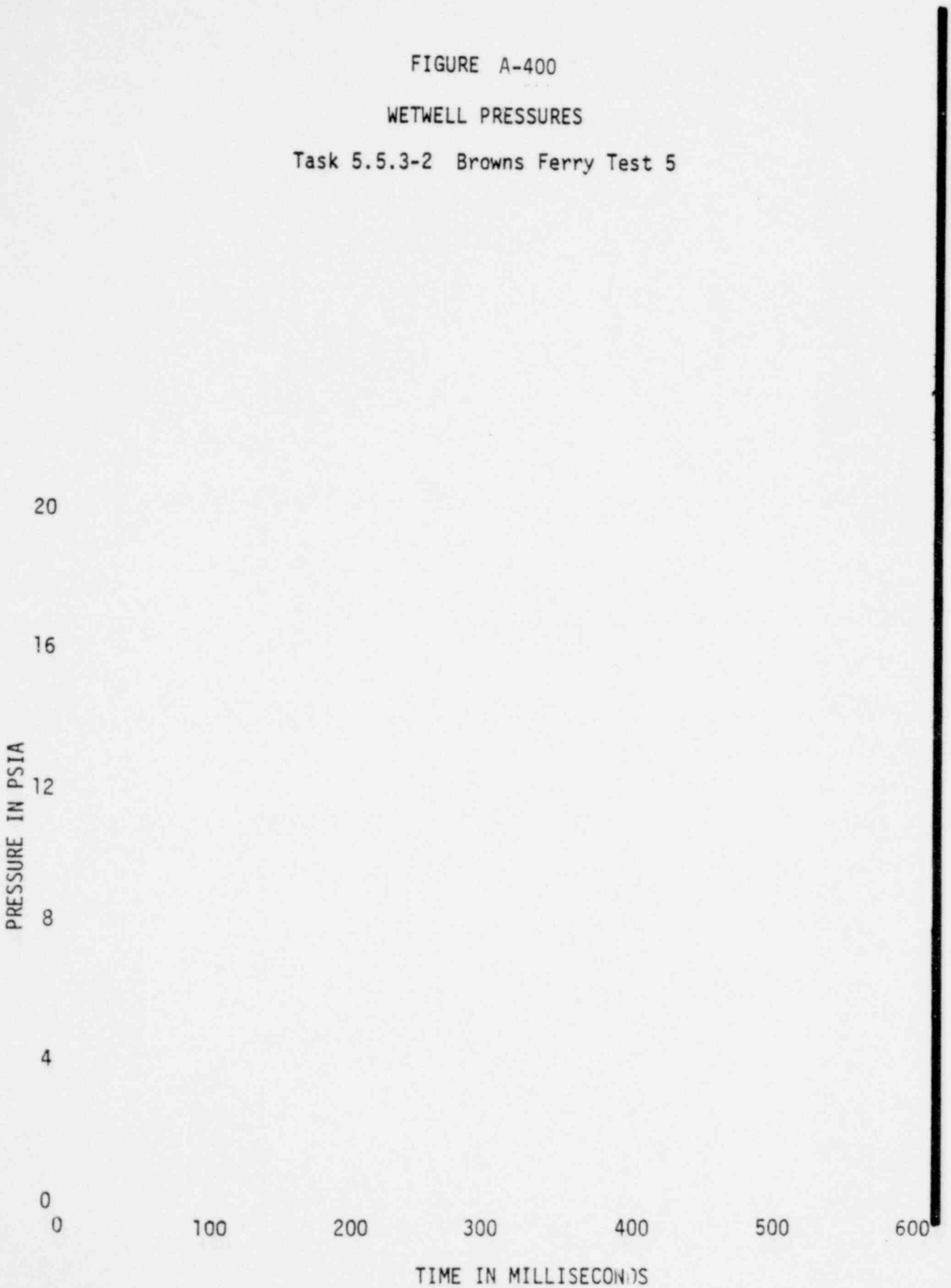
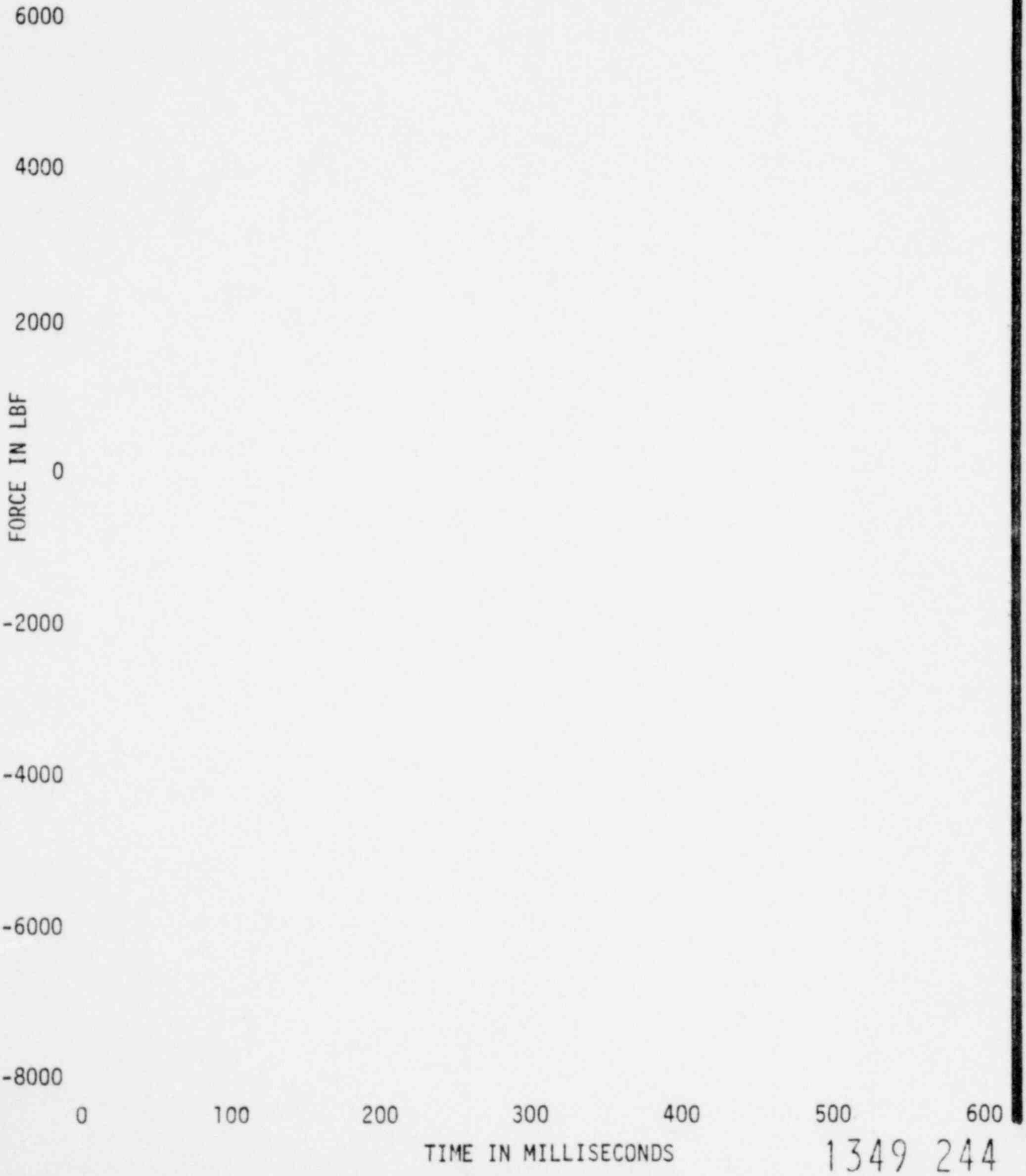


FIGURE A-401

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Browns Ferry Test 3

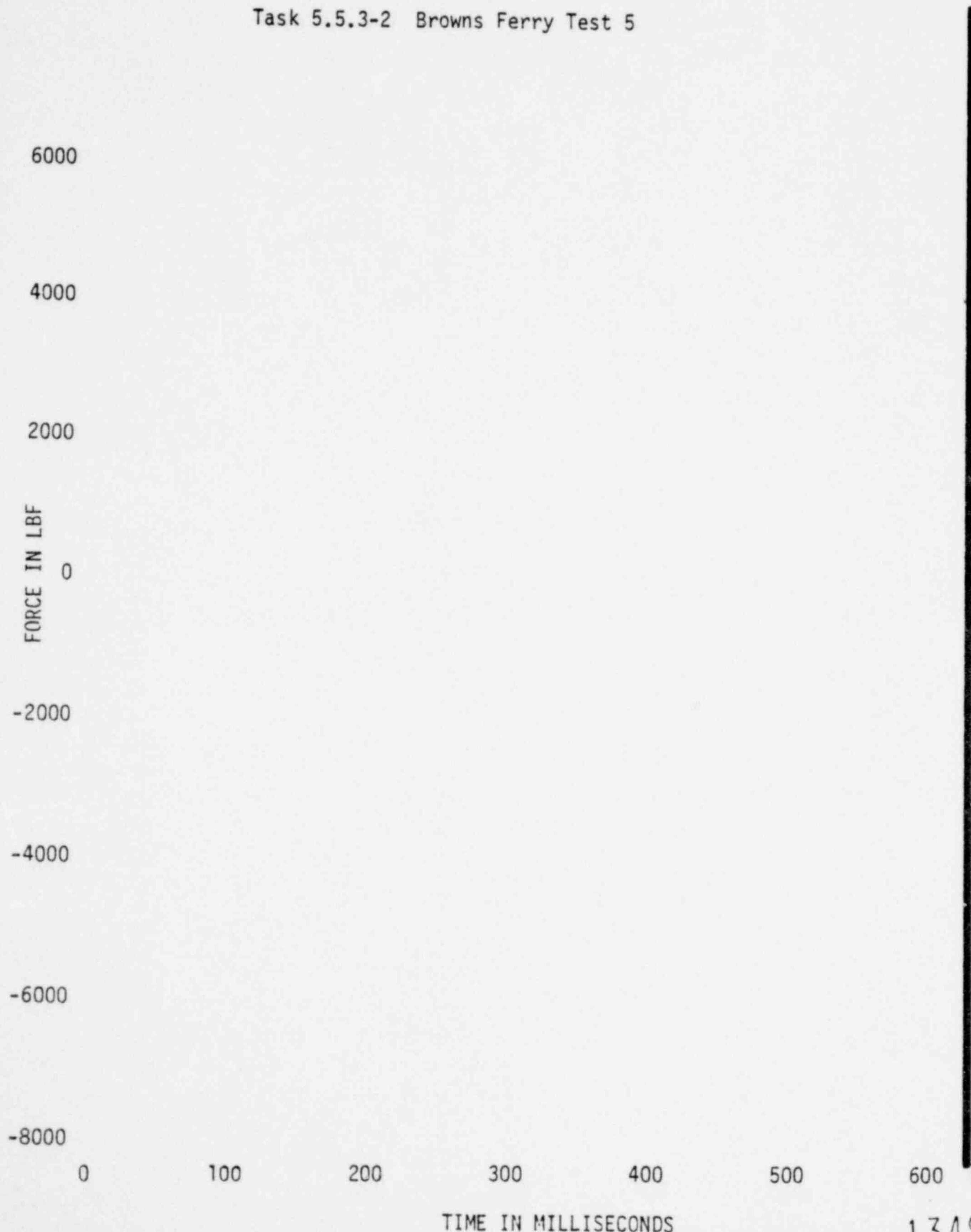


1349 244

FIGURE A-402

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Browns Ferry Test 5

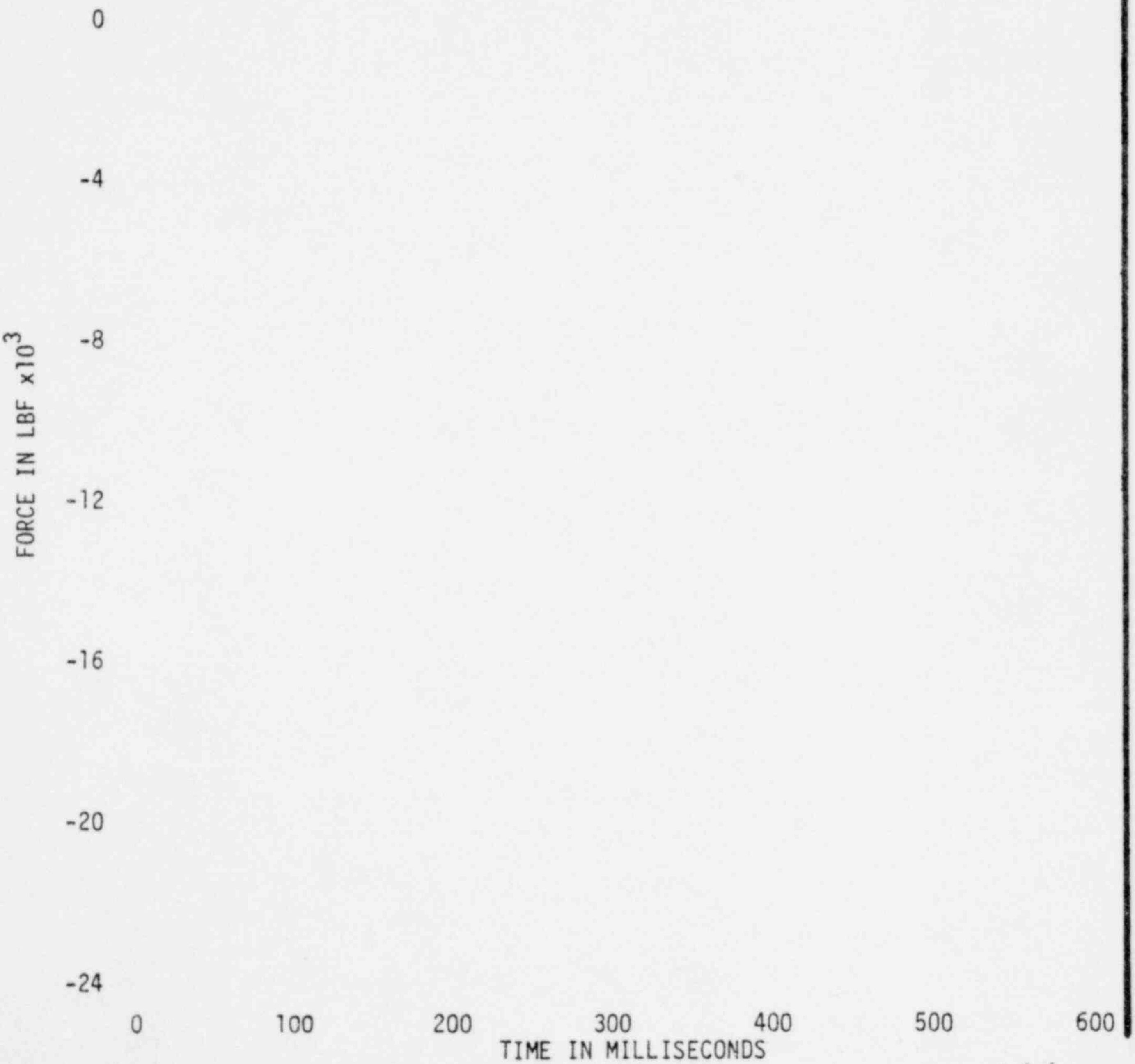


1349 24

FIGURE A-403

TORUS LOAD CELL

Task 5.5.3-2 Browns Ferry Test 3



1349 246

FIGURE A-404

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Browns Ferry Test 3

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

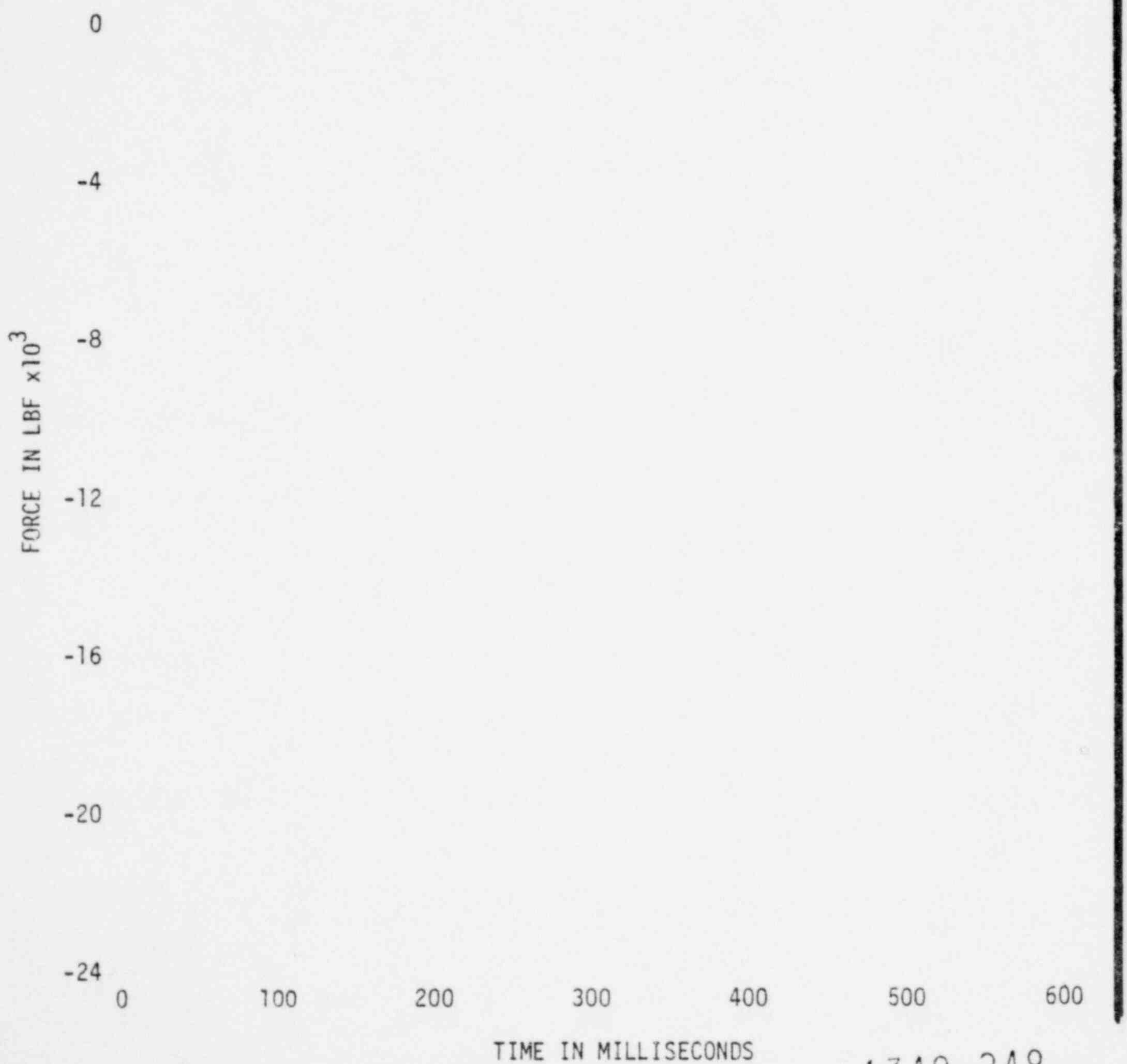
TIME IN MILLISECONDS

1349 247

FIGURE A-405

TORUS LOAD CELL

Task 5.5.3-2 Browns Ferry Test 5



1349 248

FIGURE A-406

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Browns Ferry Test 5

ACCELERATION IN G

2

1

0

-1

-2

0 100 200 300 400 500 600

TIME IN MILLISECONDS

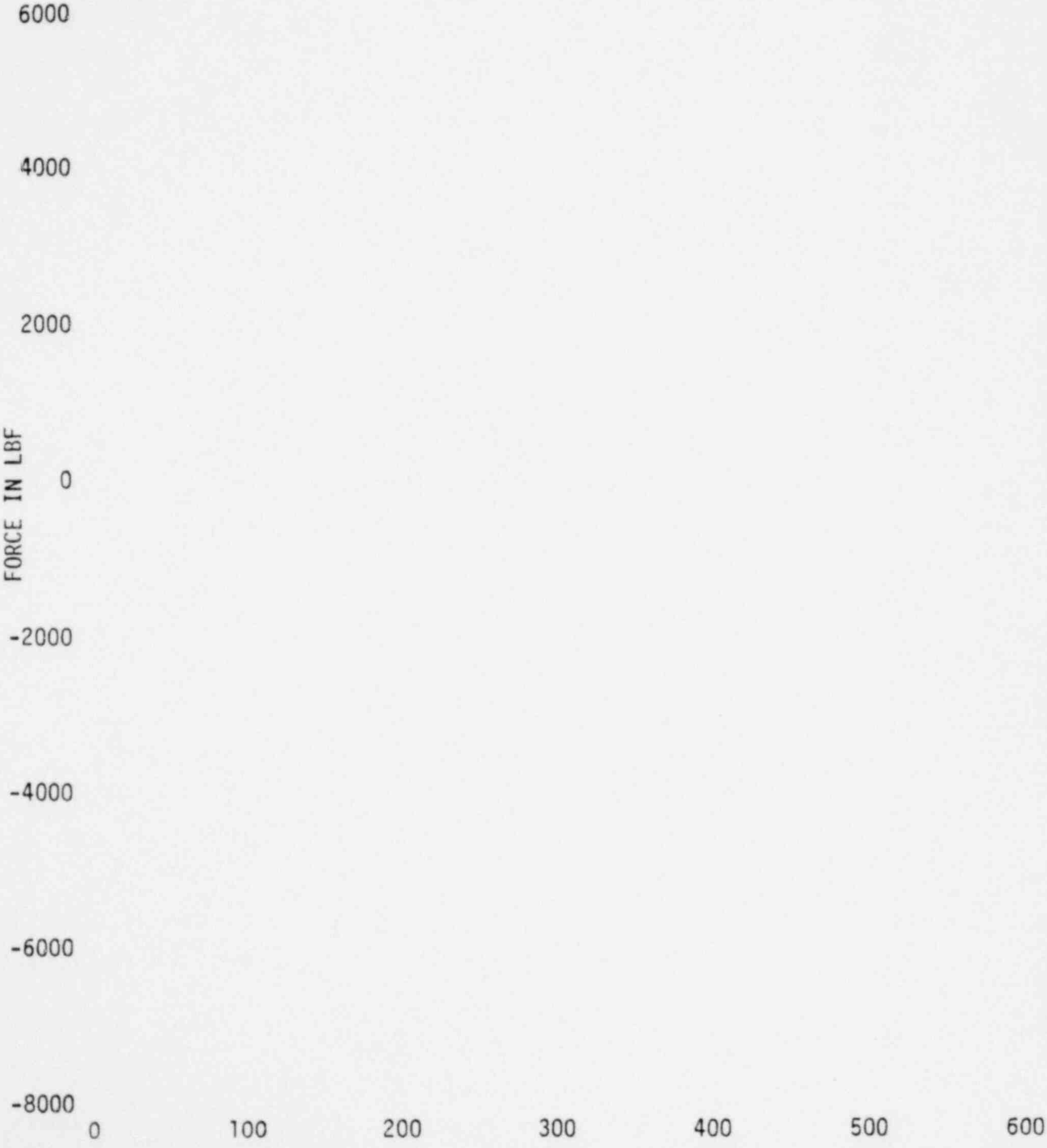
1349 249

FIGURE A-407

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Browns Ferry Test 3



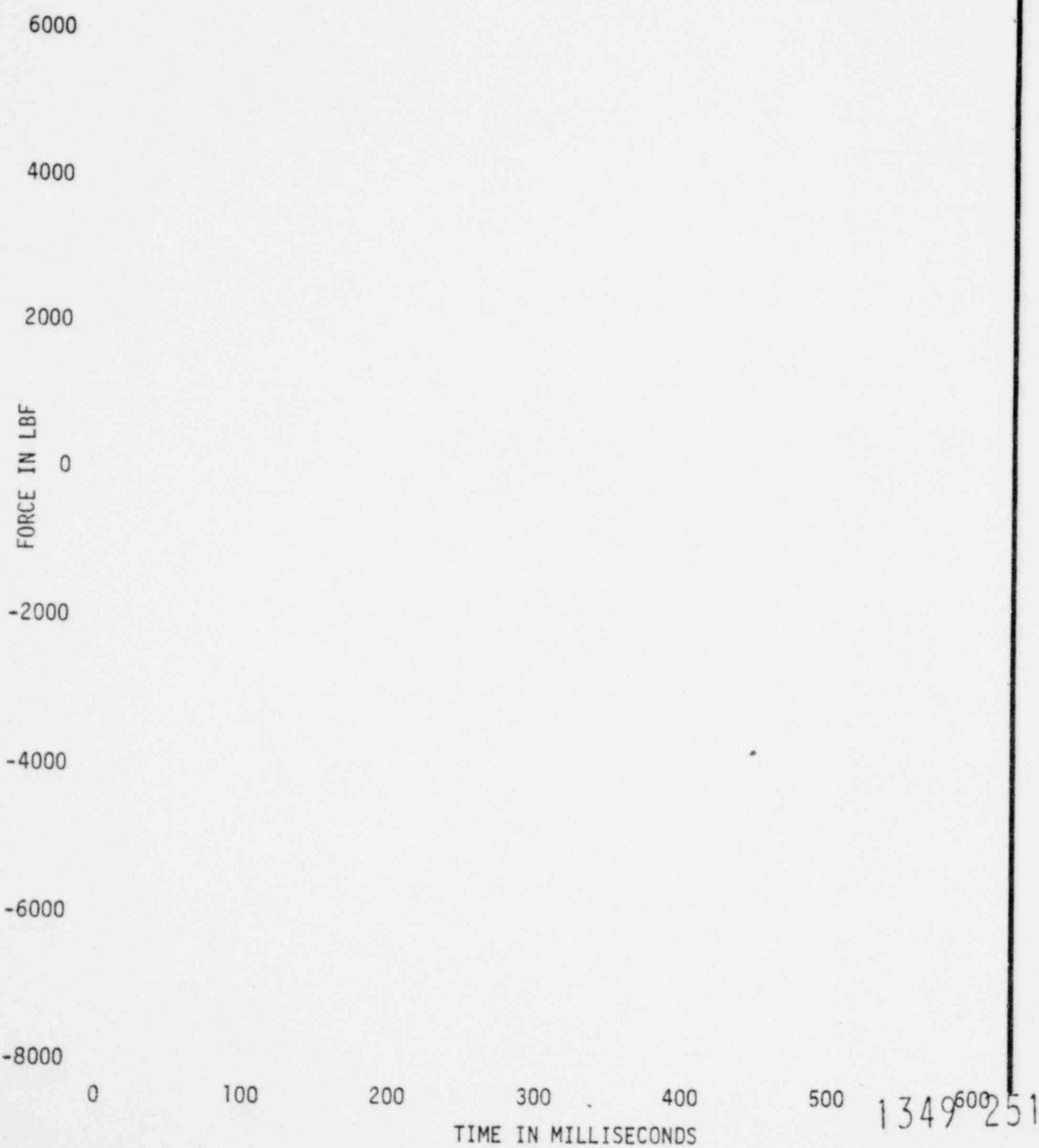
1349 250

FIGURE A-408

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Browns Ferry Test 5

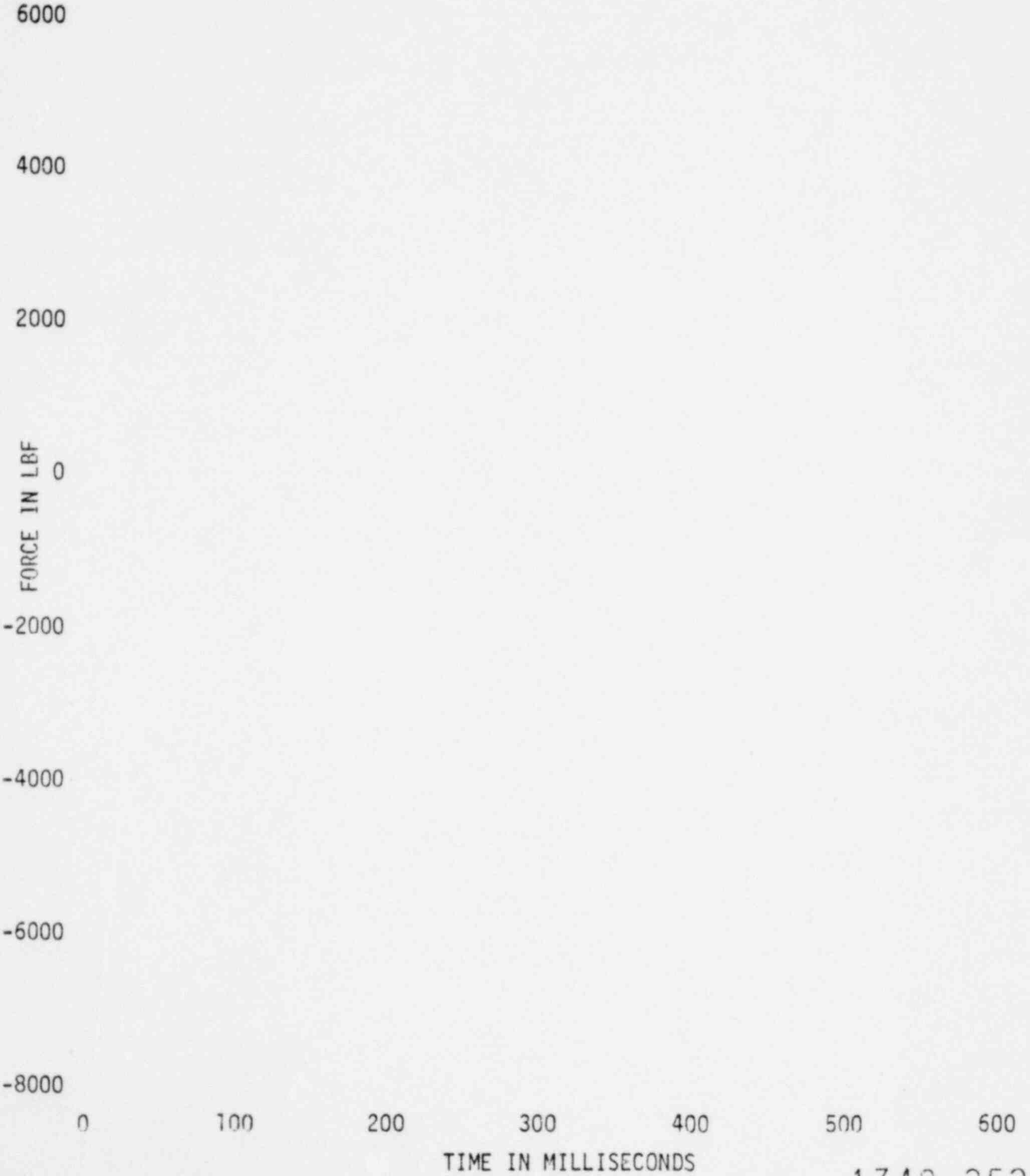


1349 251

FIGURE A-409

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 3

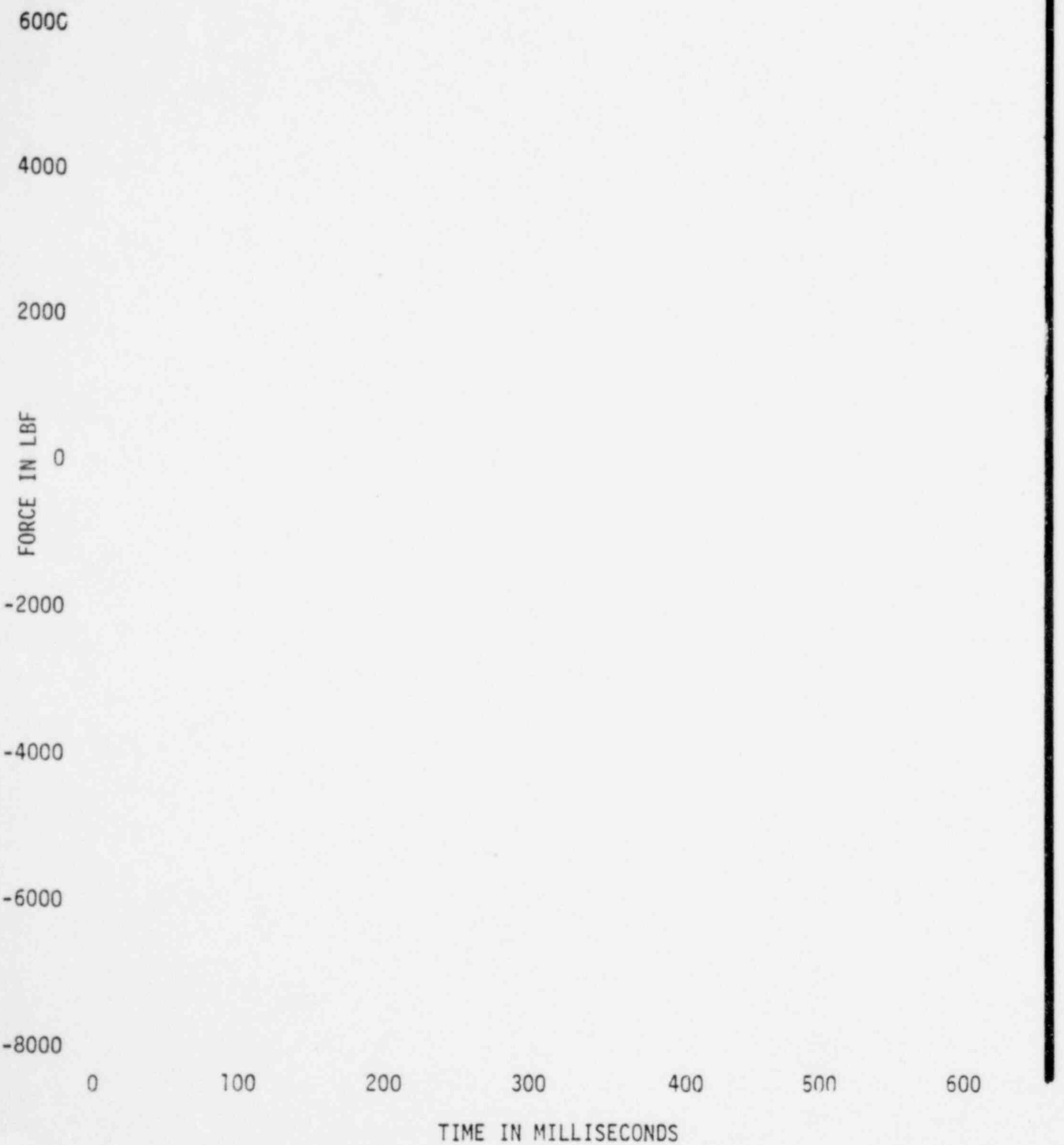


1349 252

FIGURE A-410

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 5



1349 253

FIGURE A-411

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 3

1349 254

FIGURE A-412

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 3

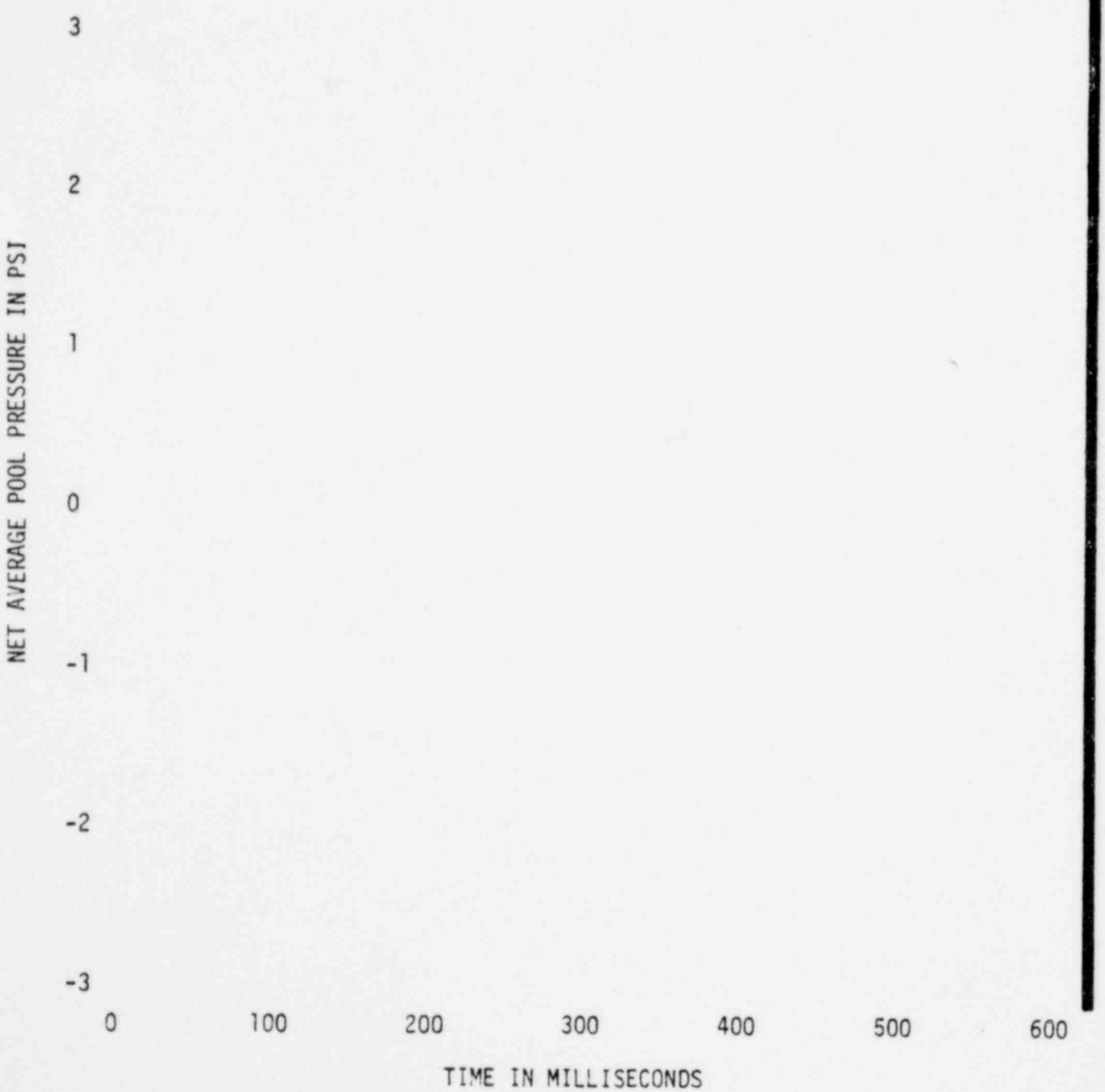
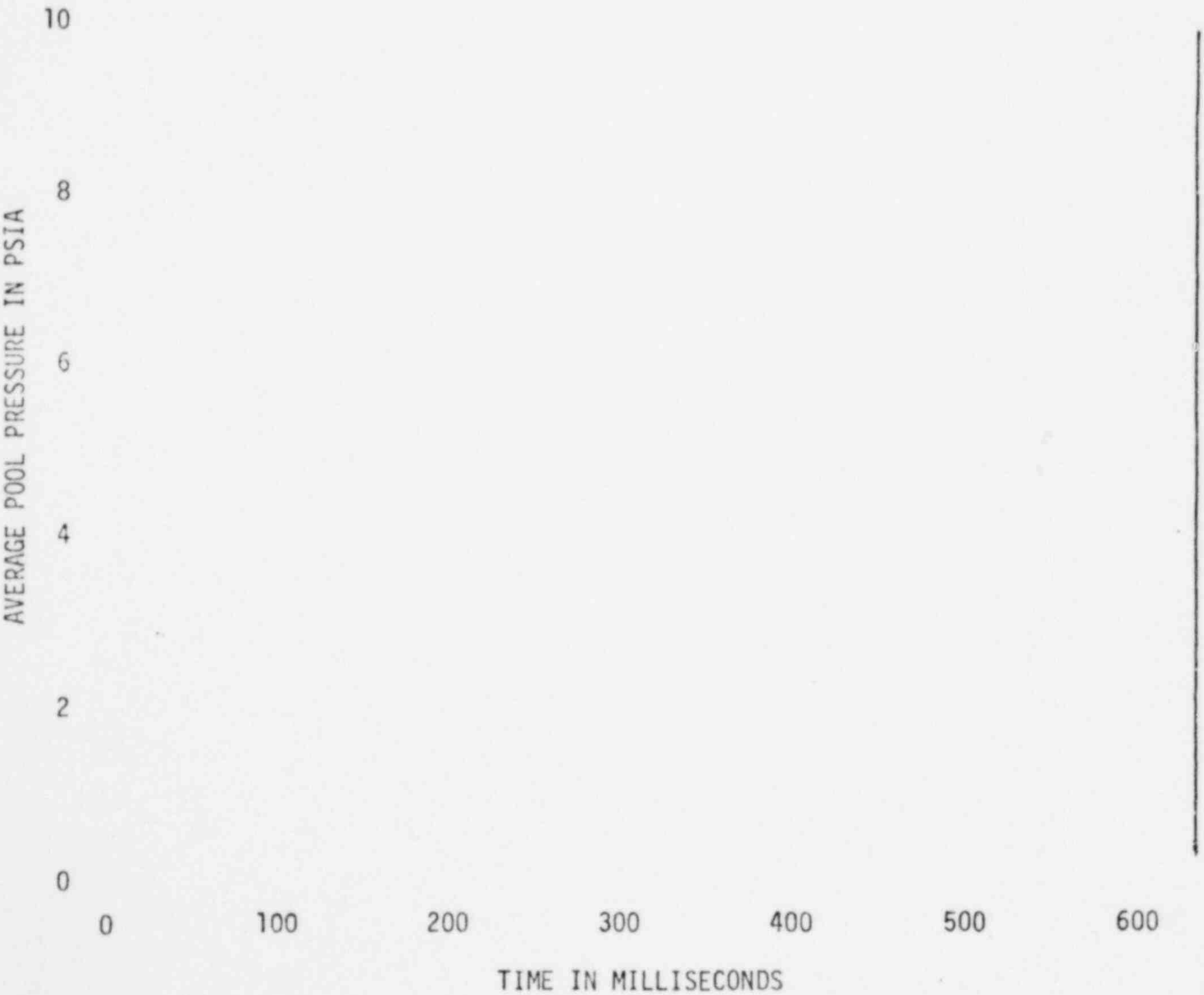


FIGURE A-413

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 5

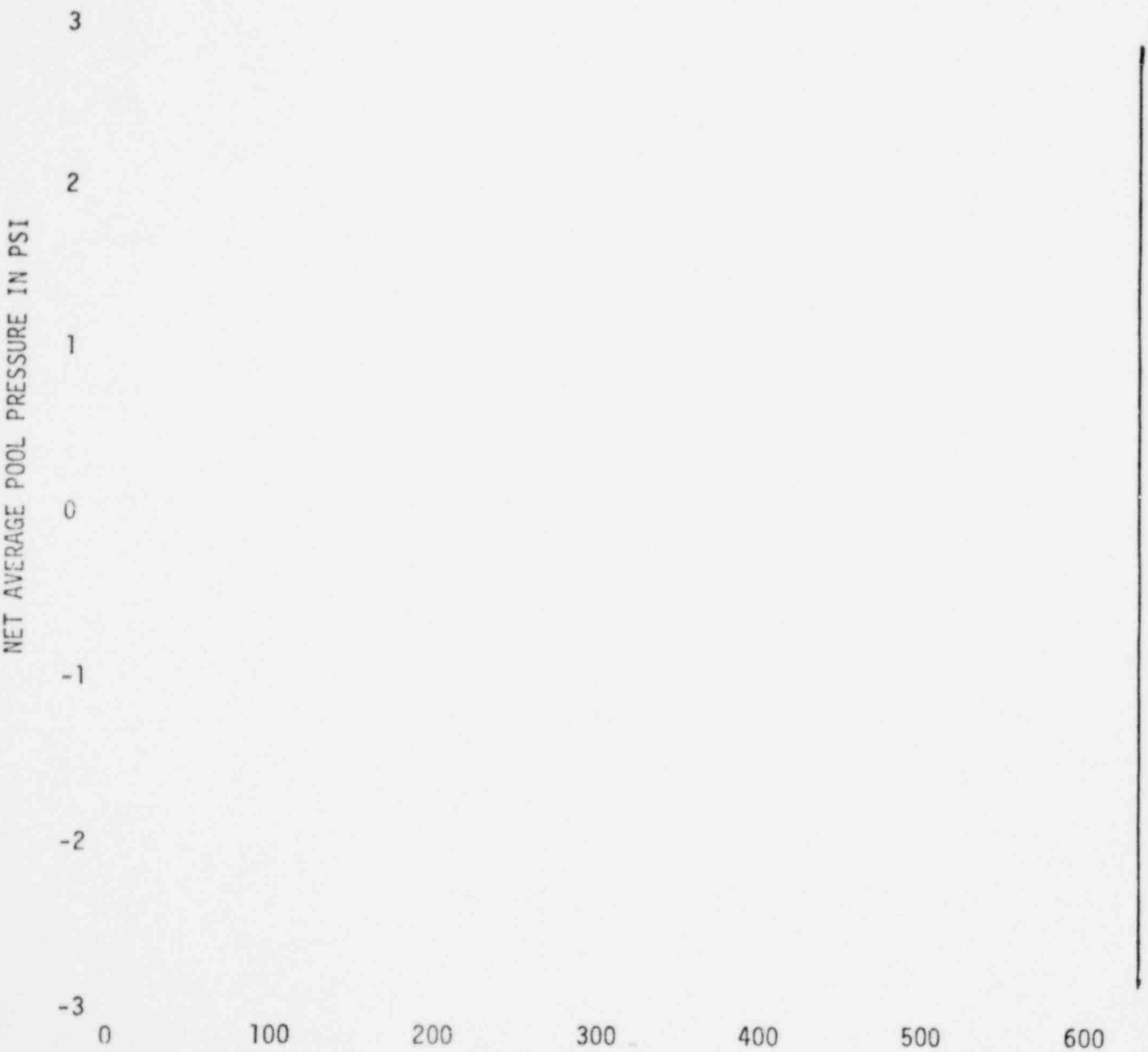


1349 256

FIGURE A-414

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Browns Ferry Test 5



1349 257

FIGURE A-415

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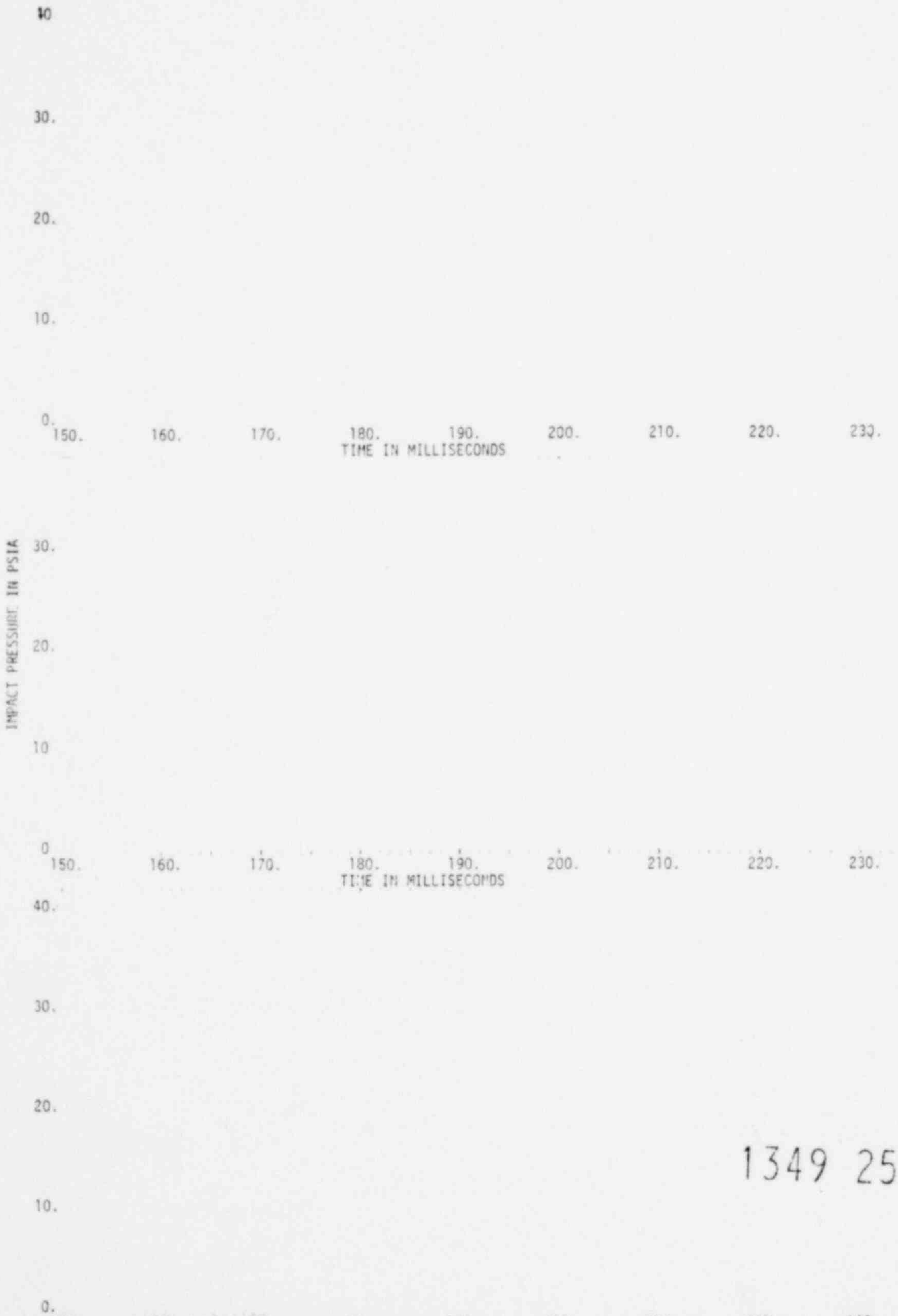
VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 3



1349 258

FIGURE A-416

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 3

30.

20.

10.

0.

150. 160. 170. 180. 190. 200. 210. 220. 230.

TIME IN MILLISECONDS

40.

30.

20.

10.

0.

IMPACT PRESSURE IN PSIA

150. 160. 170. 180. 190. 200. 210. 220. 230.

TIME IN MILLISECONDS

30

20

10

0

150. 160. 170. 180. 190. 200. 210. 220. 230.

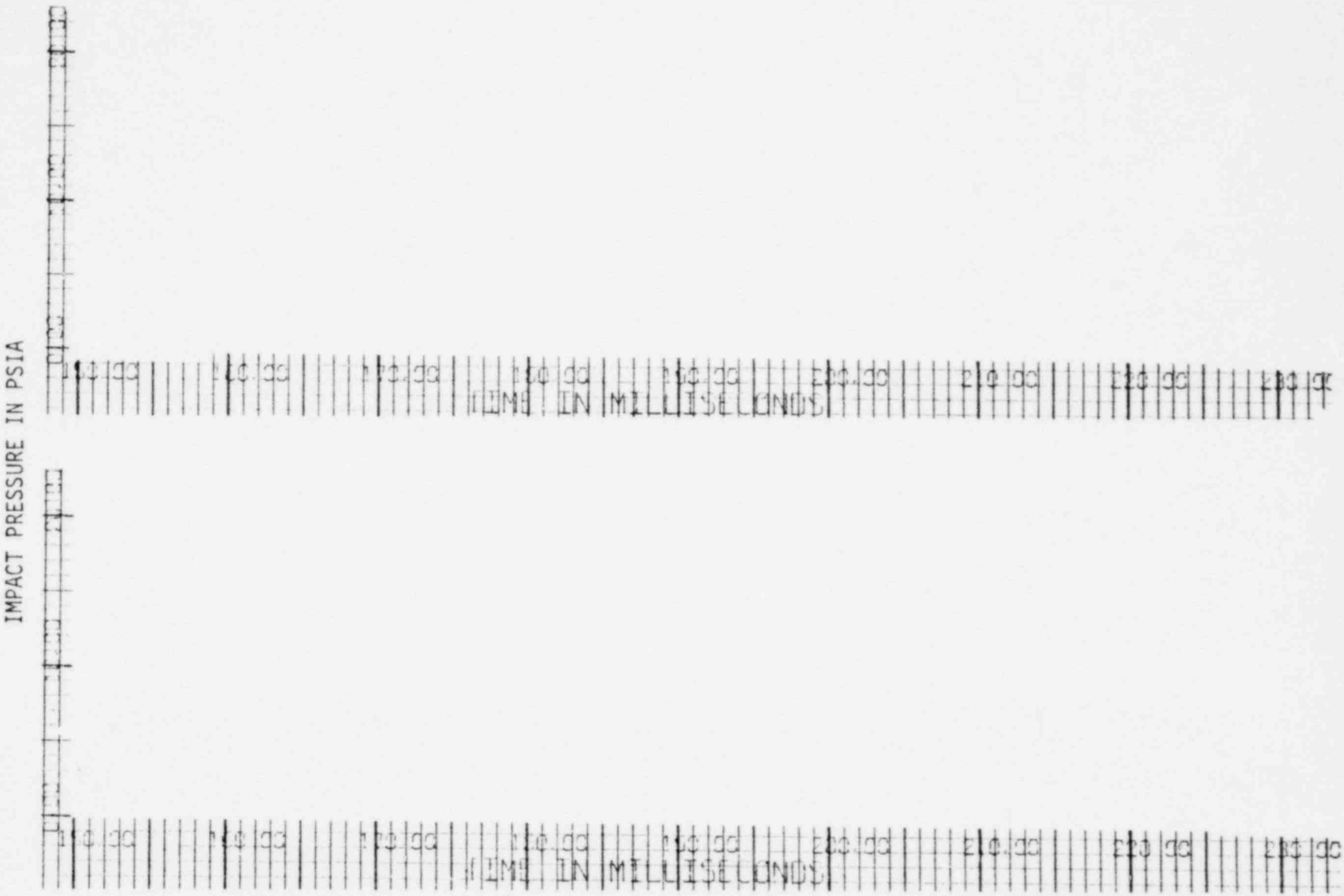
TIME IN MILLISECONDS

1349 259

FIGURE A-417

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 3



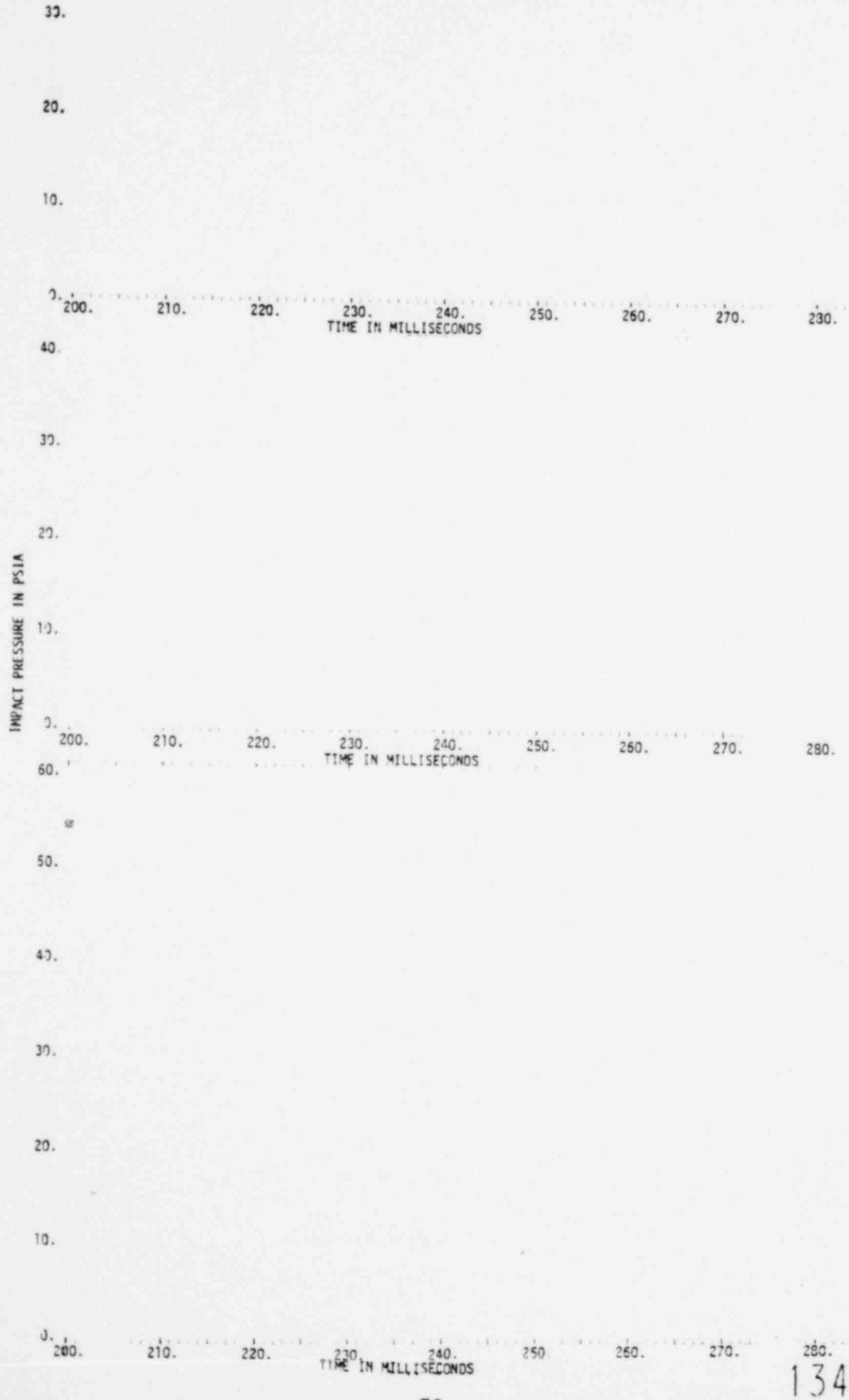
1349 260

FIGURE A-418

NEDO-21944

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 5



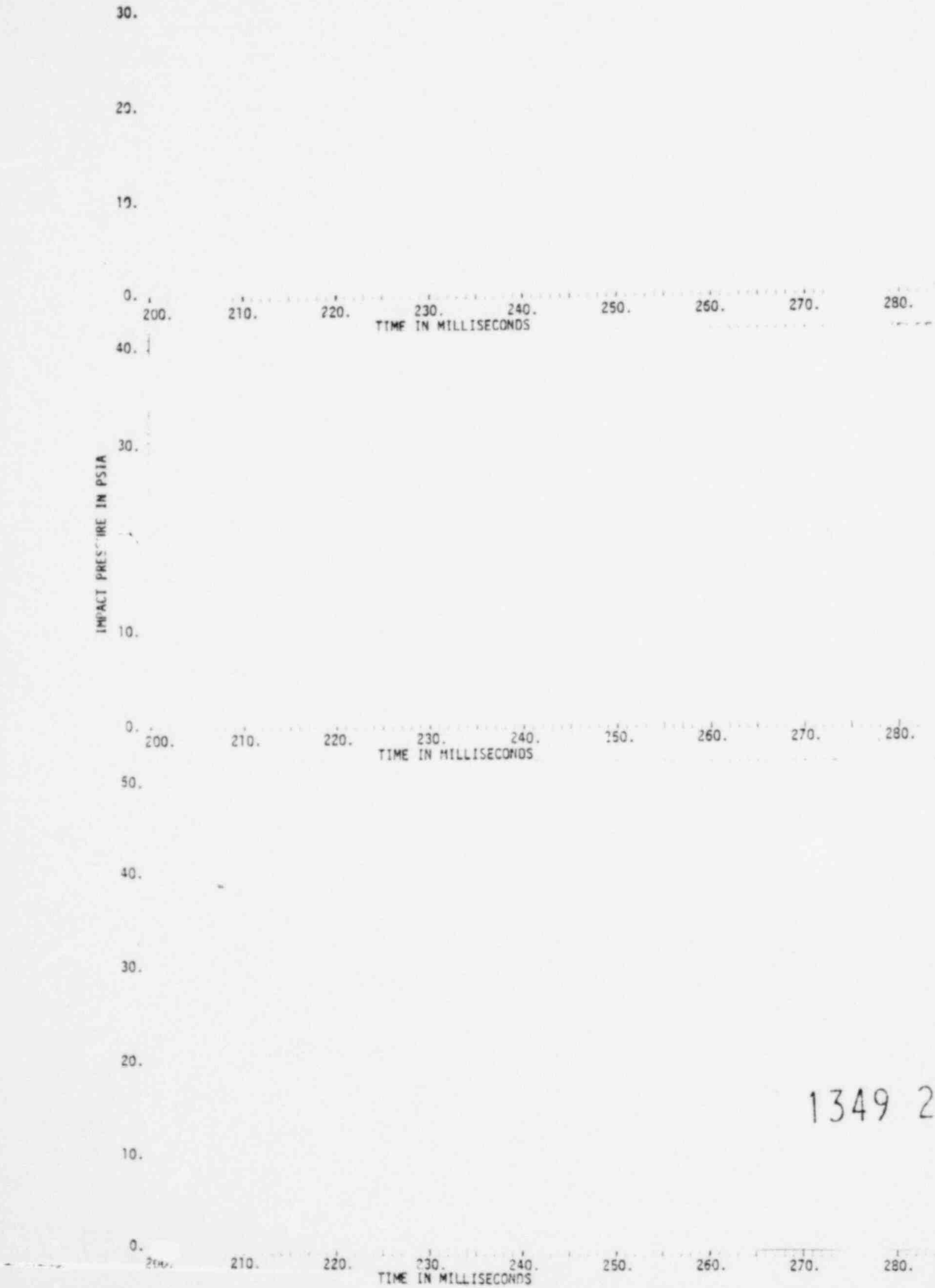
1349 261

FIGURE A-419

NEDO-21944

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 5

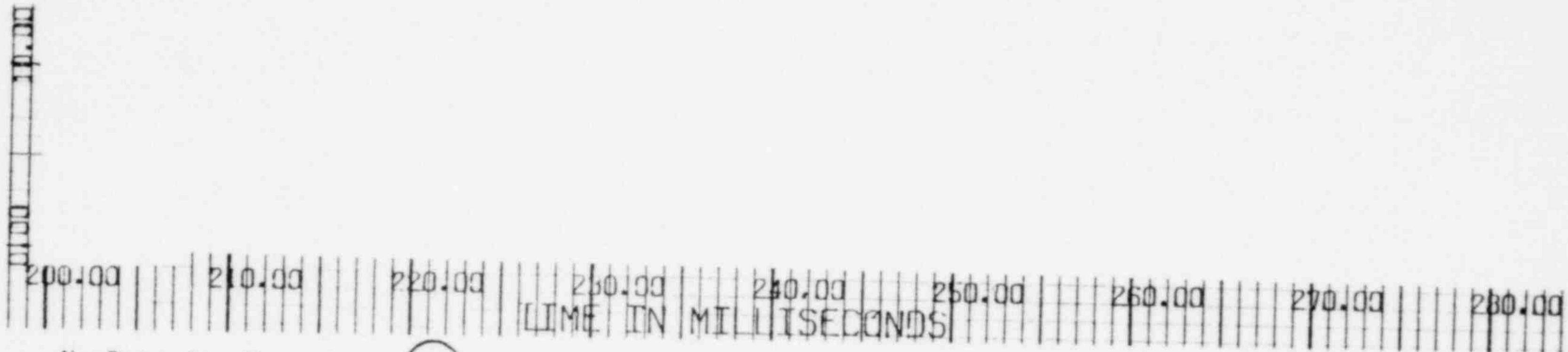


1349 262

FIGURE A-420

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Browns Ferry Test 5



No Data for Transducer T12

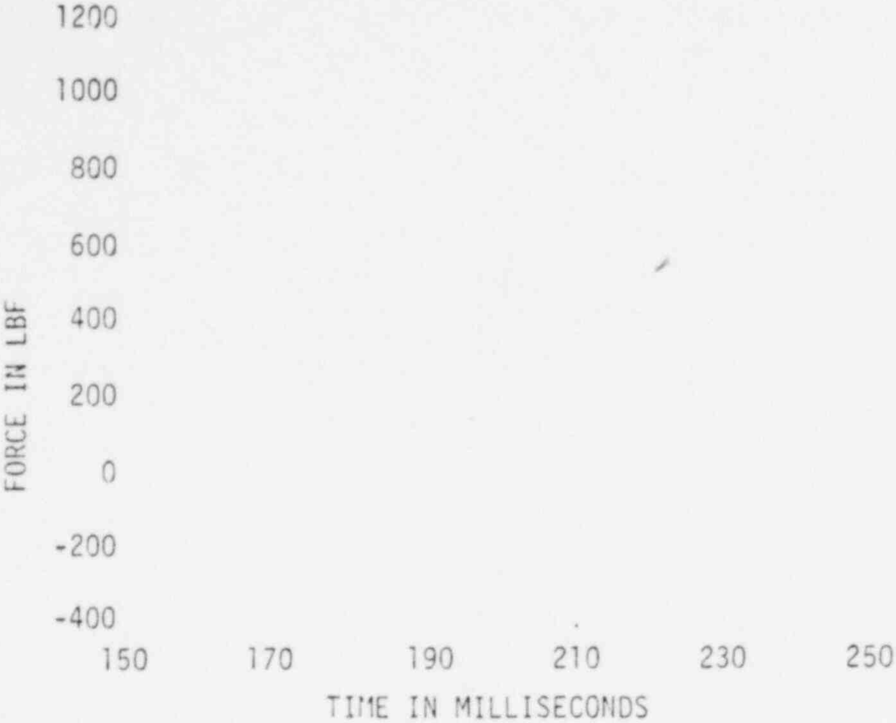
1349 263

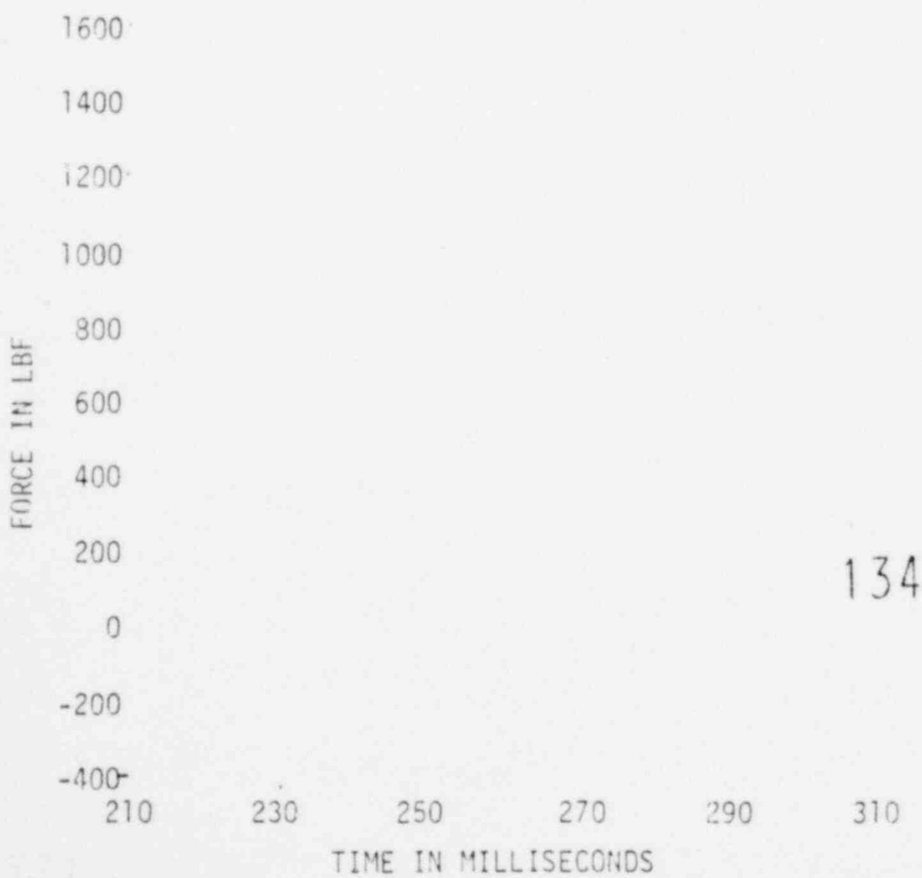
FIGURE A-421

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Browns Ferry Tests 3, 5



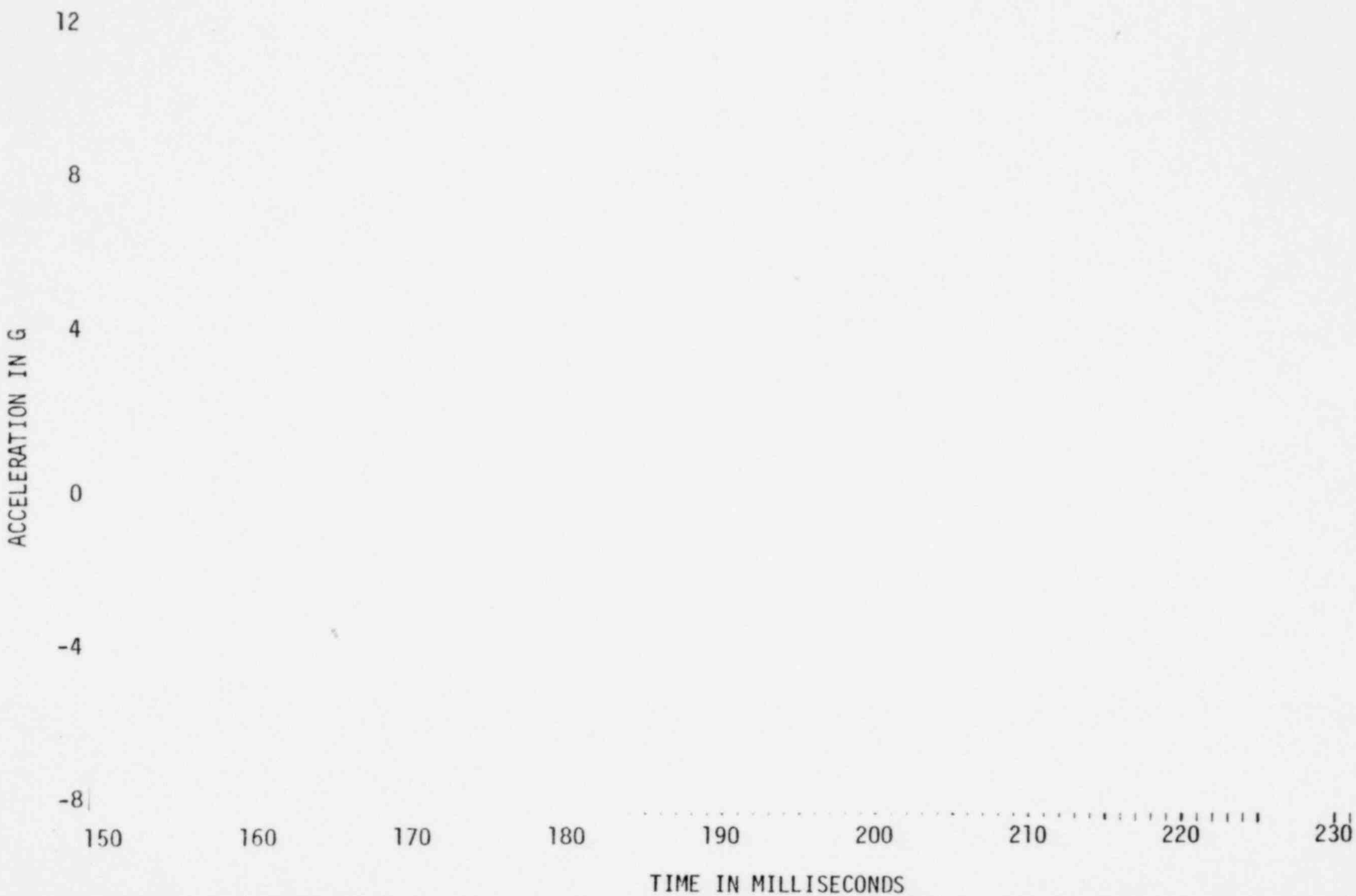


1349 264

FIGURE A-422

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Browns Ferry Test 3



1349 265

FIGURE A-423

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Browns Ferry Test 5

ACCELERATION IN G

12

8

4

0

-4

-8

210 220 230 240 250 260 270 280 290

TIME IN MILLISECONDS

1349 266

FIGURE A-424

NEDO-21944

TIME HISTORY OF

POOL DISPLACEMENT

BROWNS FERRY, TEST 1

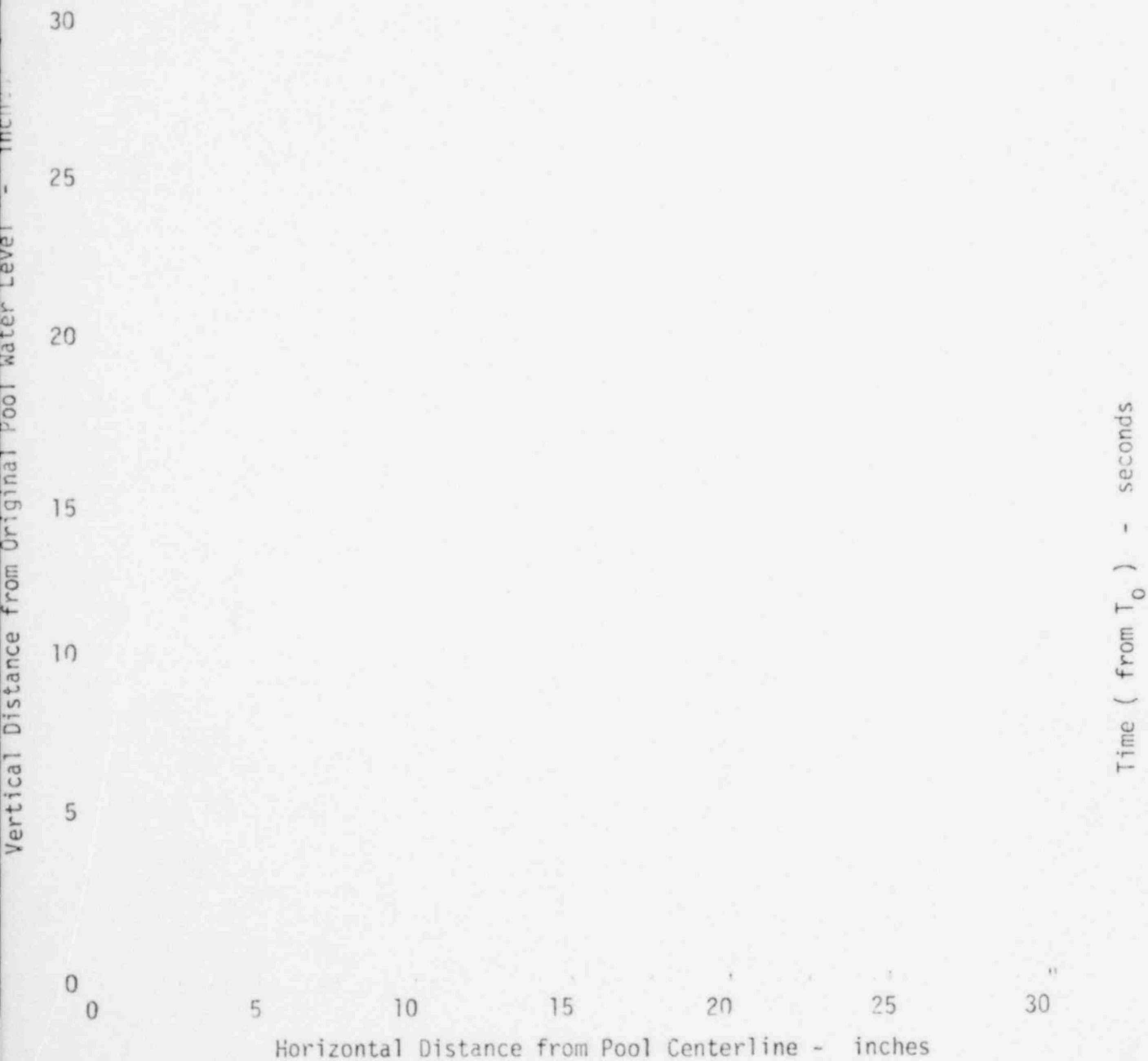
1349 267

FIGURE A-425

NEDO-21944

TIME HISTORY OF
POOL DISPLACMENT

BROWNS FERRY, TEST 2



1349 268

FIGURE A-426

TIME HISTORY OF

POOL DISPLACEMENT

BROWNS FERRY, TEST 3

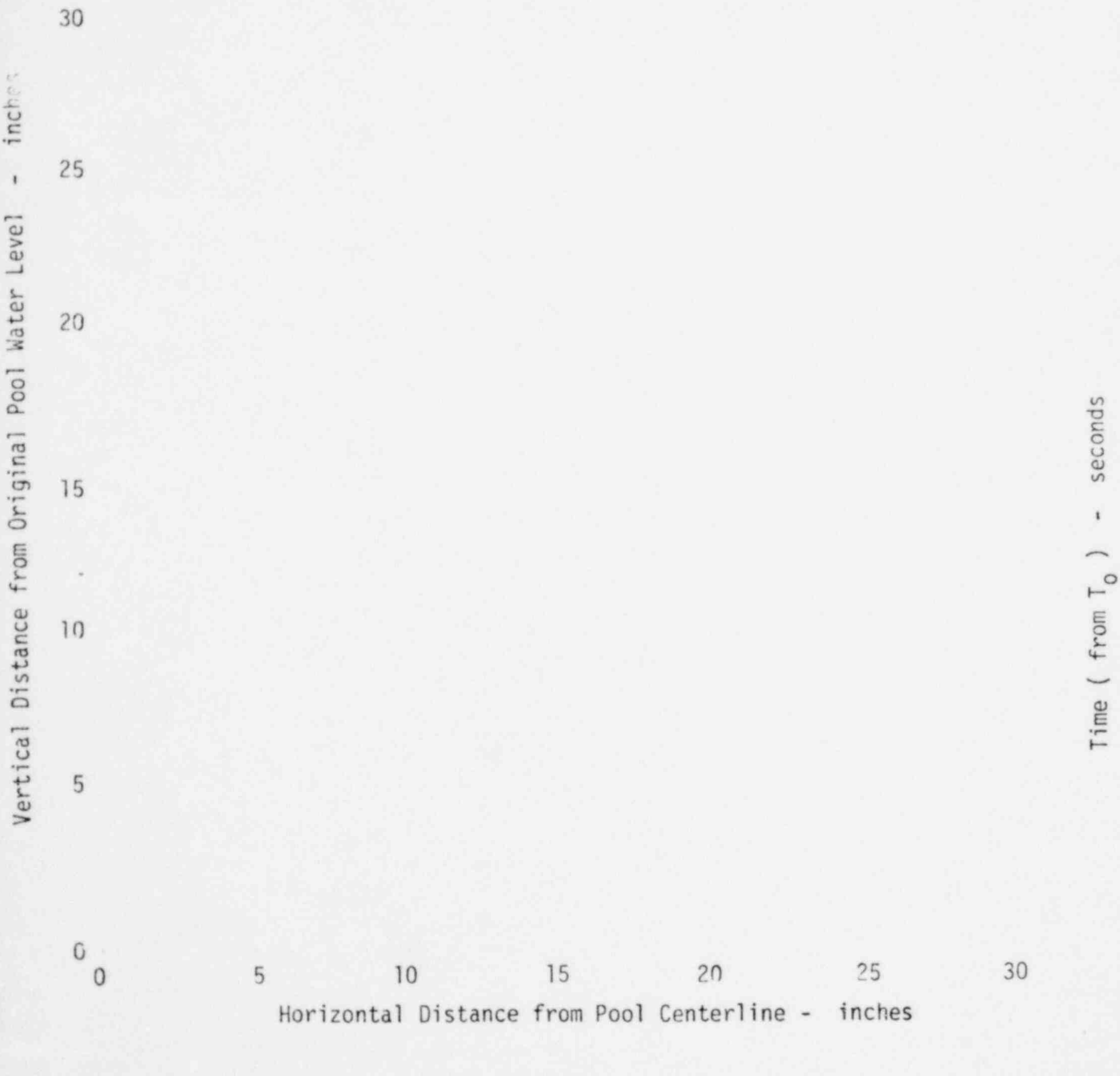
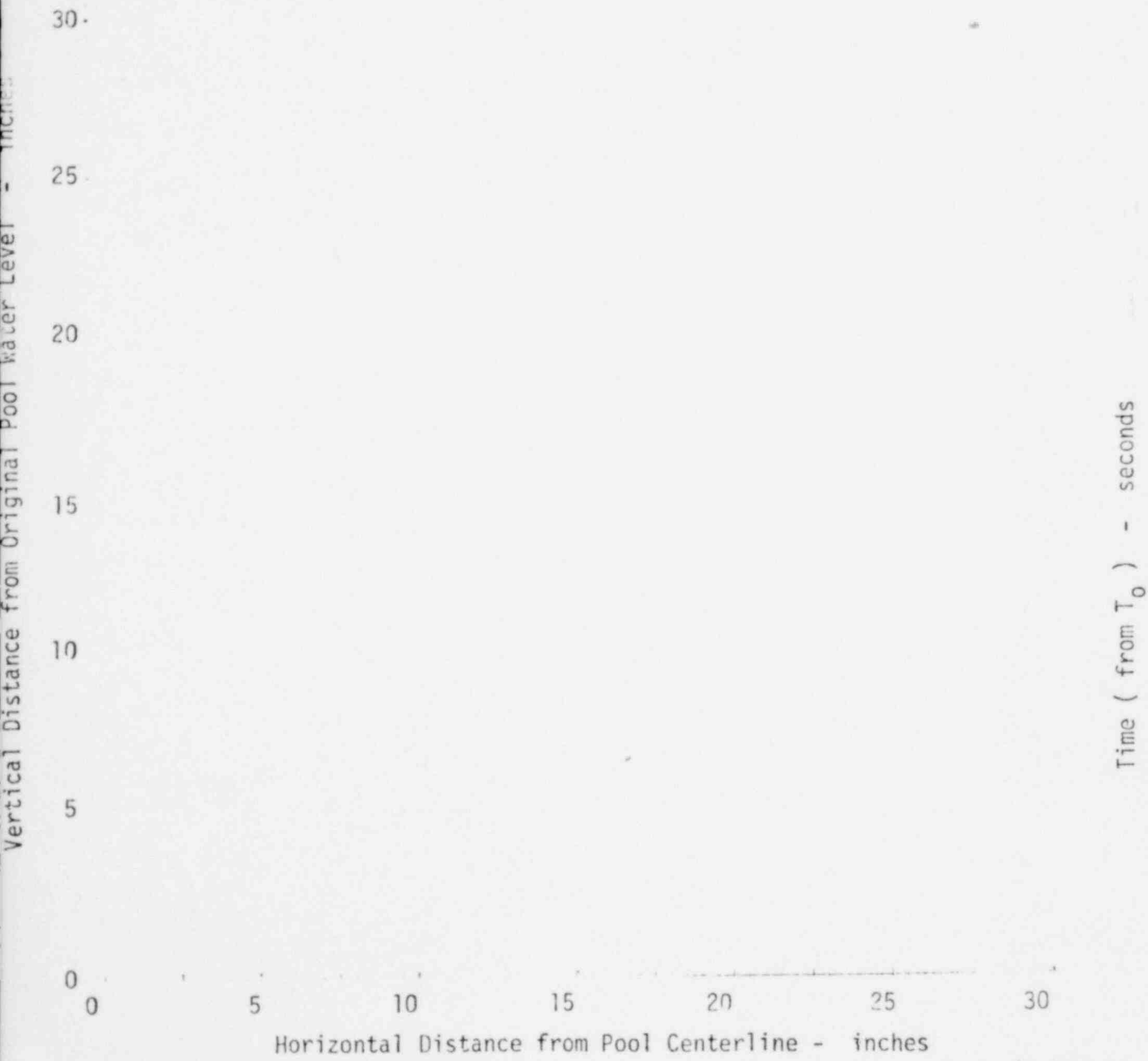


FIGURE A-427

TIME HISTORY OF

POOL DISPLACEMENT

BROWNS FERRY, TEST 5



1349 270

POOL SURFACE DISPLACEMENT

FIGURE A-428

BROWNS FERRY, TESTS 1, 2, 3

Height above original pool surface - inches

25
20
15
10
5
0

0 100 200 300 400

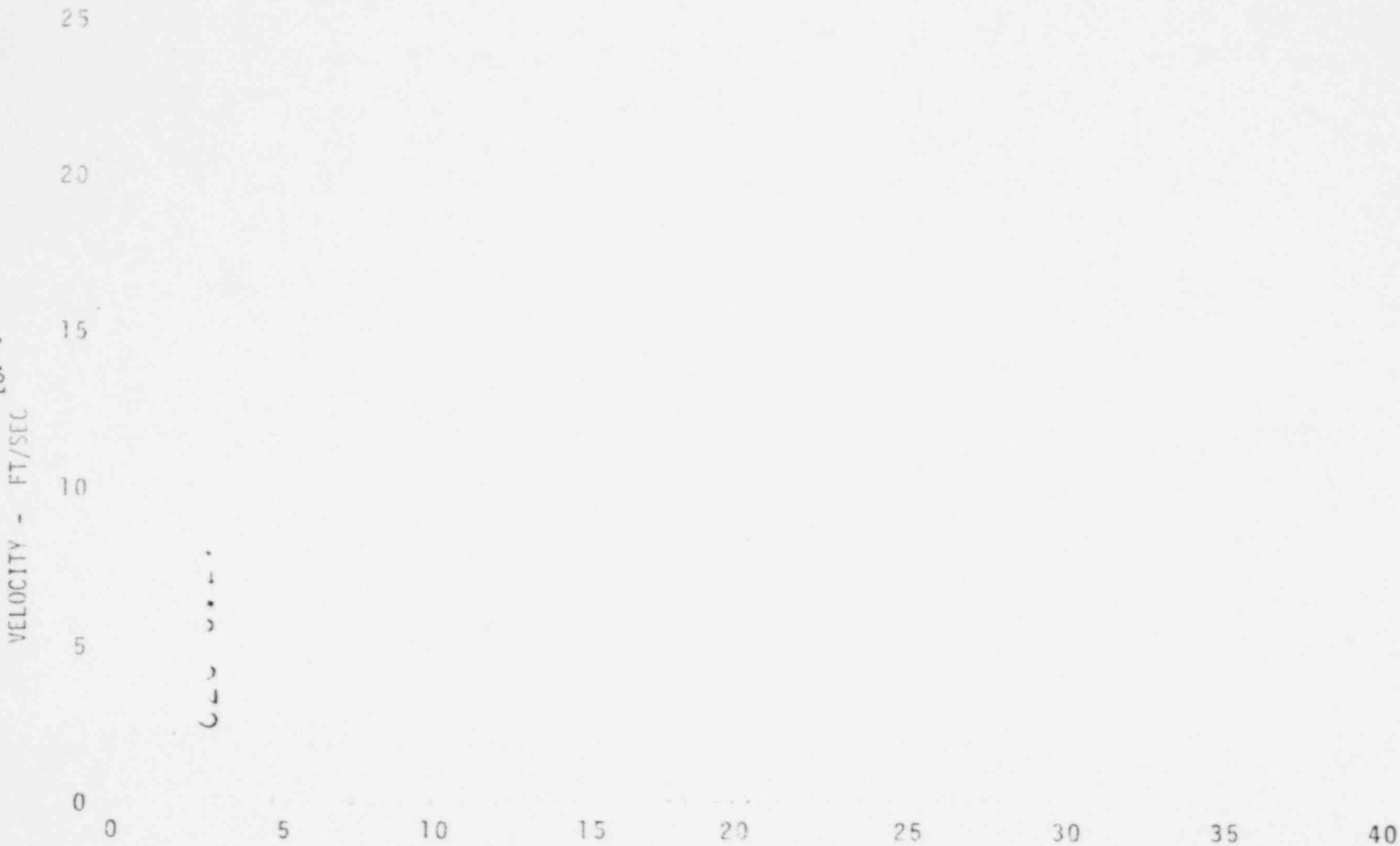
Time- milliseconds

1349 271

POOL SURFACE VELOCITY PROFILES

FIGURE A-429

BROWNS FERRY, TESTS 1, 2, 3



POOL SURFACE DISPLACEMENT

BROWNS FERRY, TEST 5

1349 273

POOL SURFACE VELOCITY PROFILES

FIGURE A-431

BROWNS FERRY, TEST 5

1349 274

FIGURE A-432

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

BROWNS FERRY, TEST 4

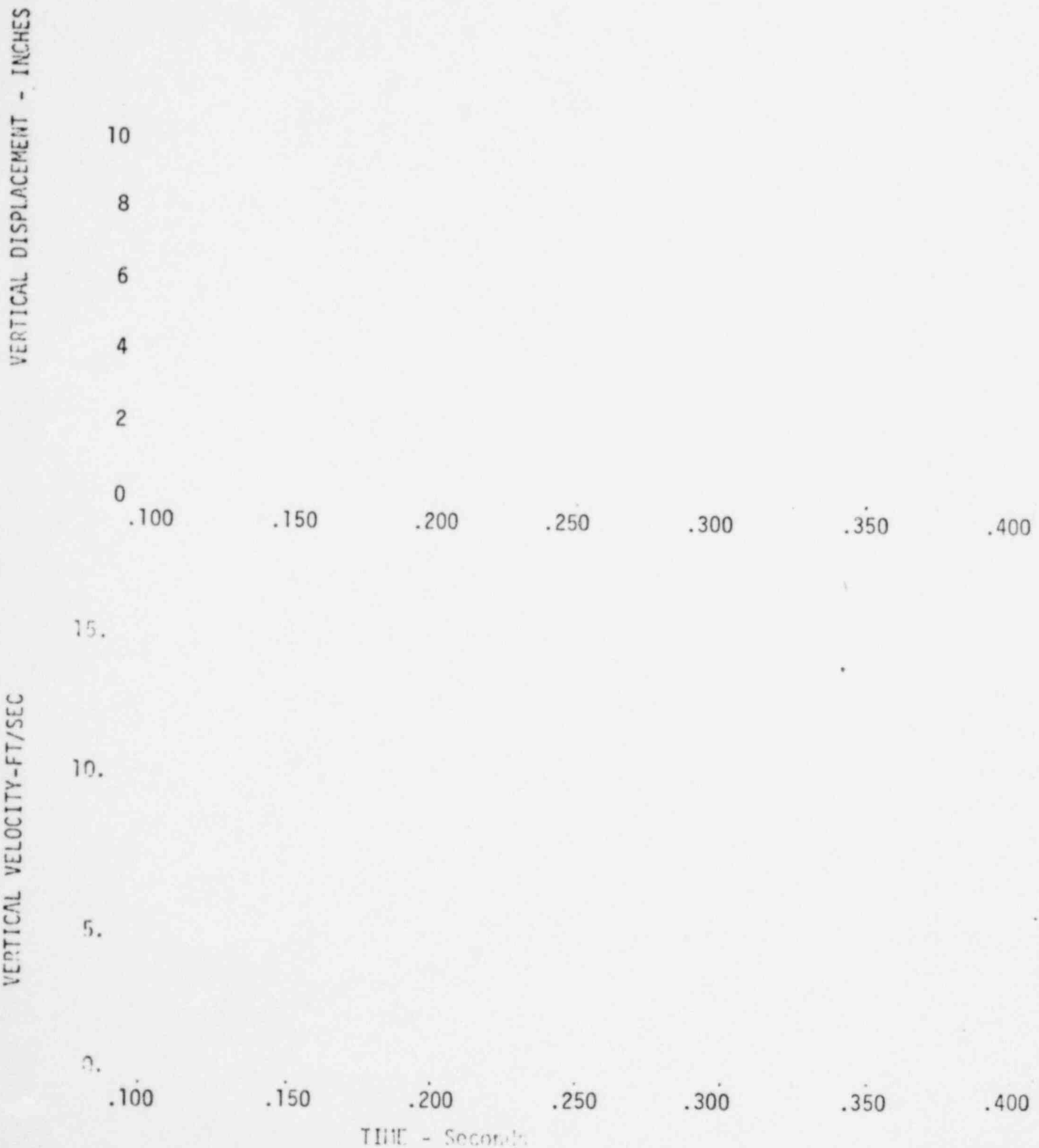
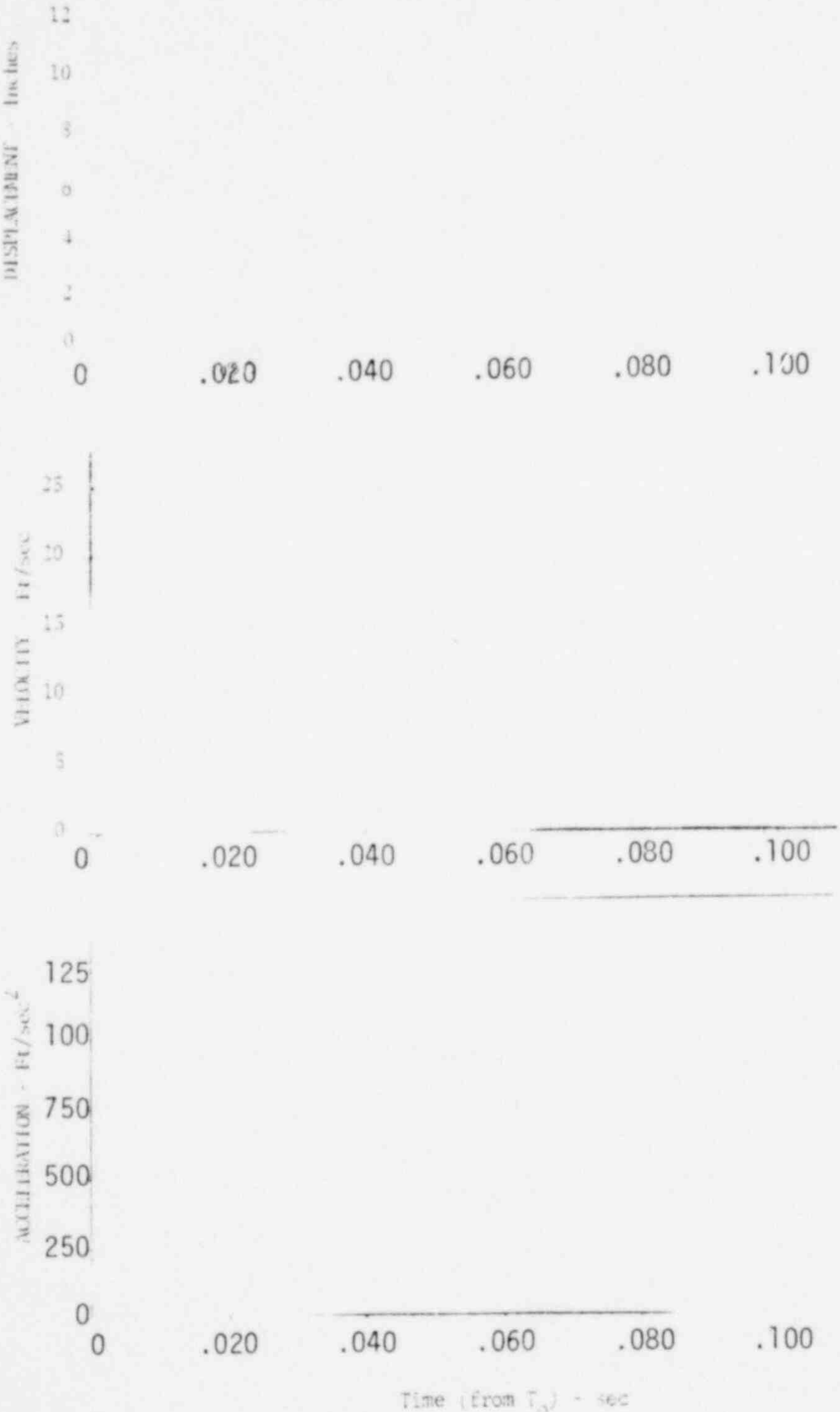


FIGURE A-433

DOWNCOMER WATER SLUG EJECTION

BROWNS FERRY, TEST 3



1349 276

FIGURE A-434

DOWNCOMER WATER SLUG EJECTION

BROWNS FERRY, TEST 5

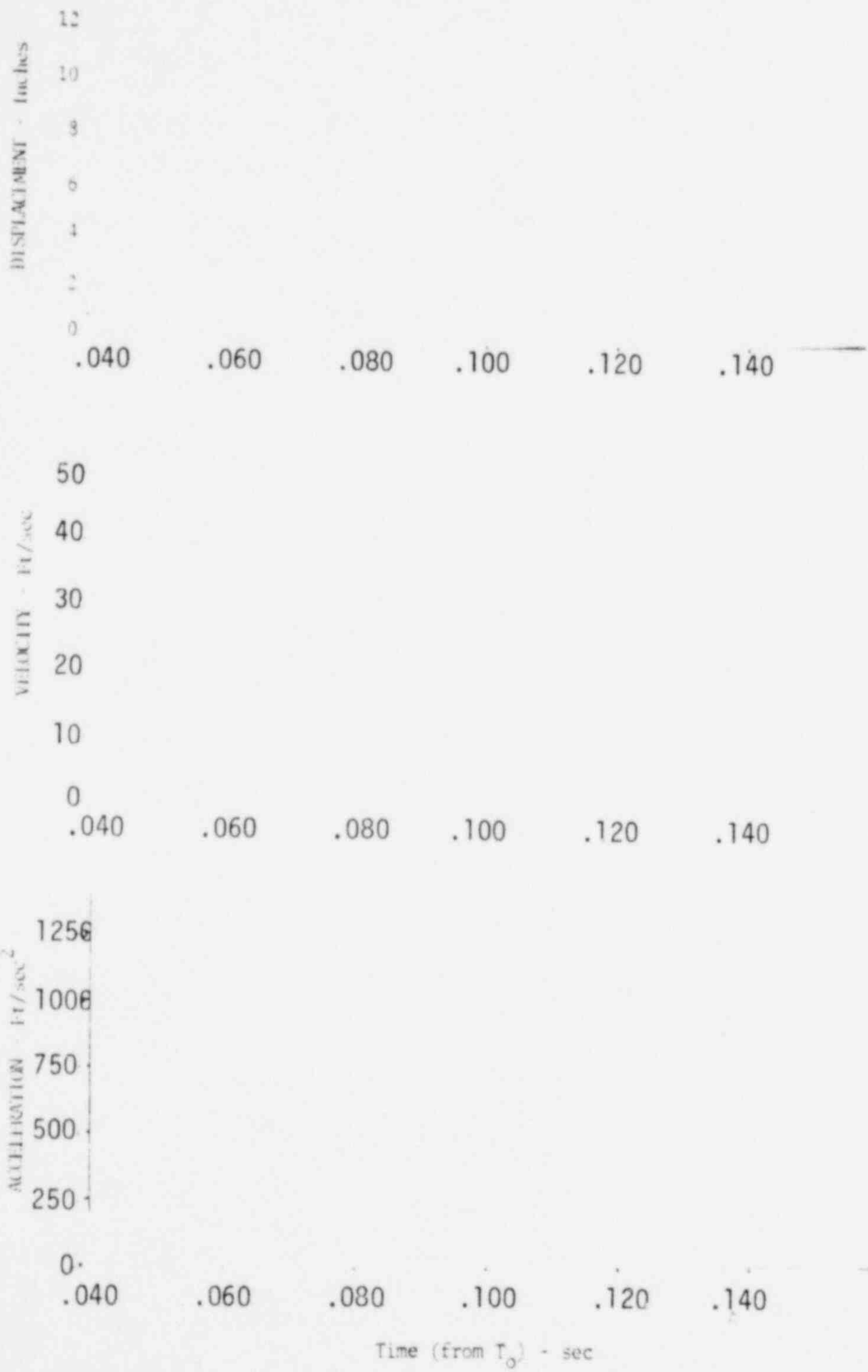
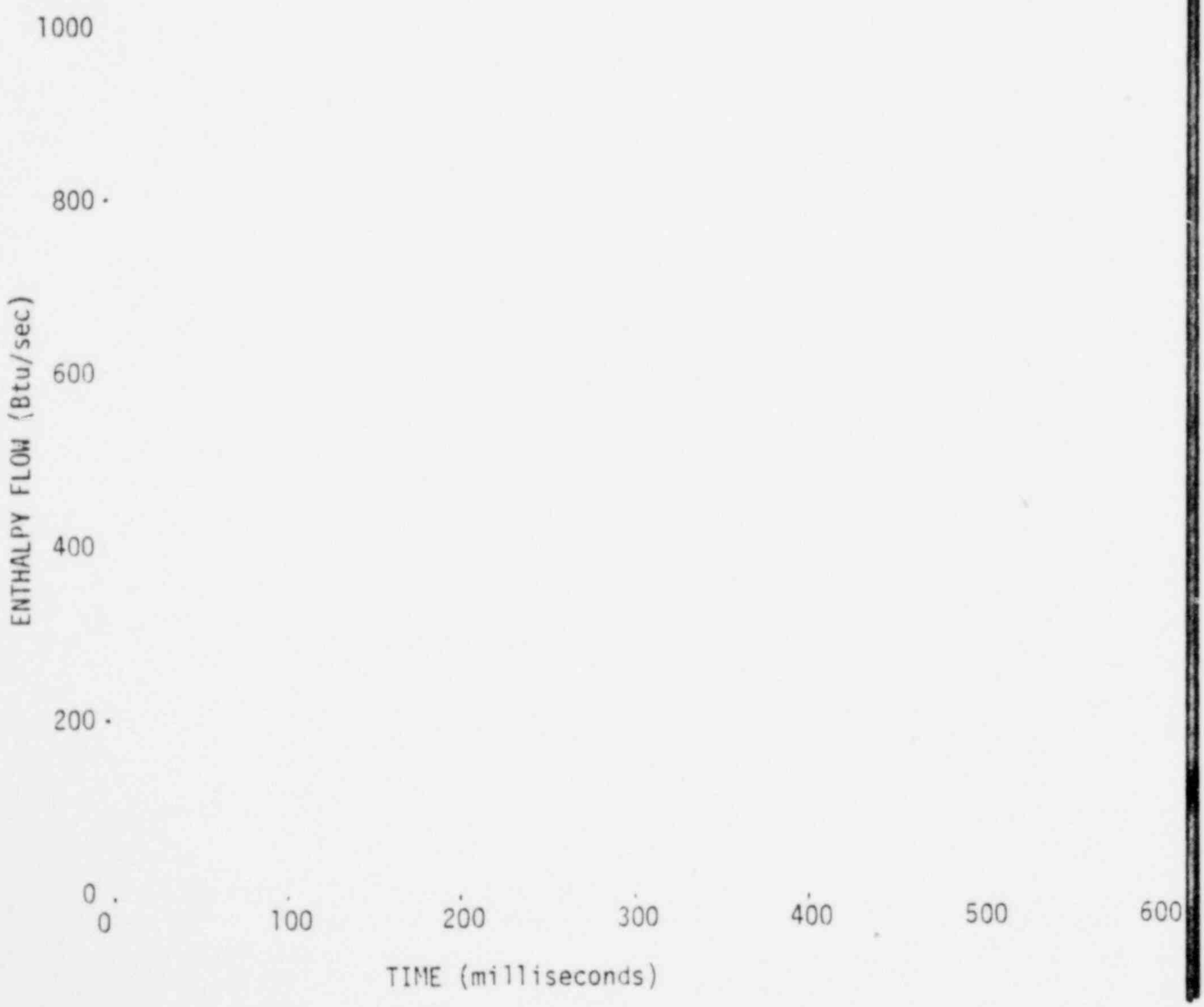


FIGURE A-435

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Brown's Ferry Tests



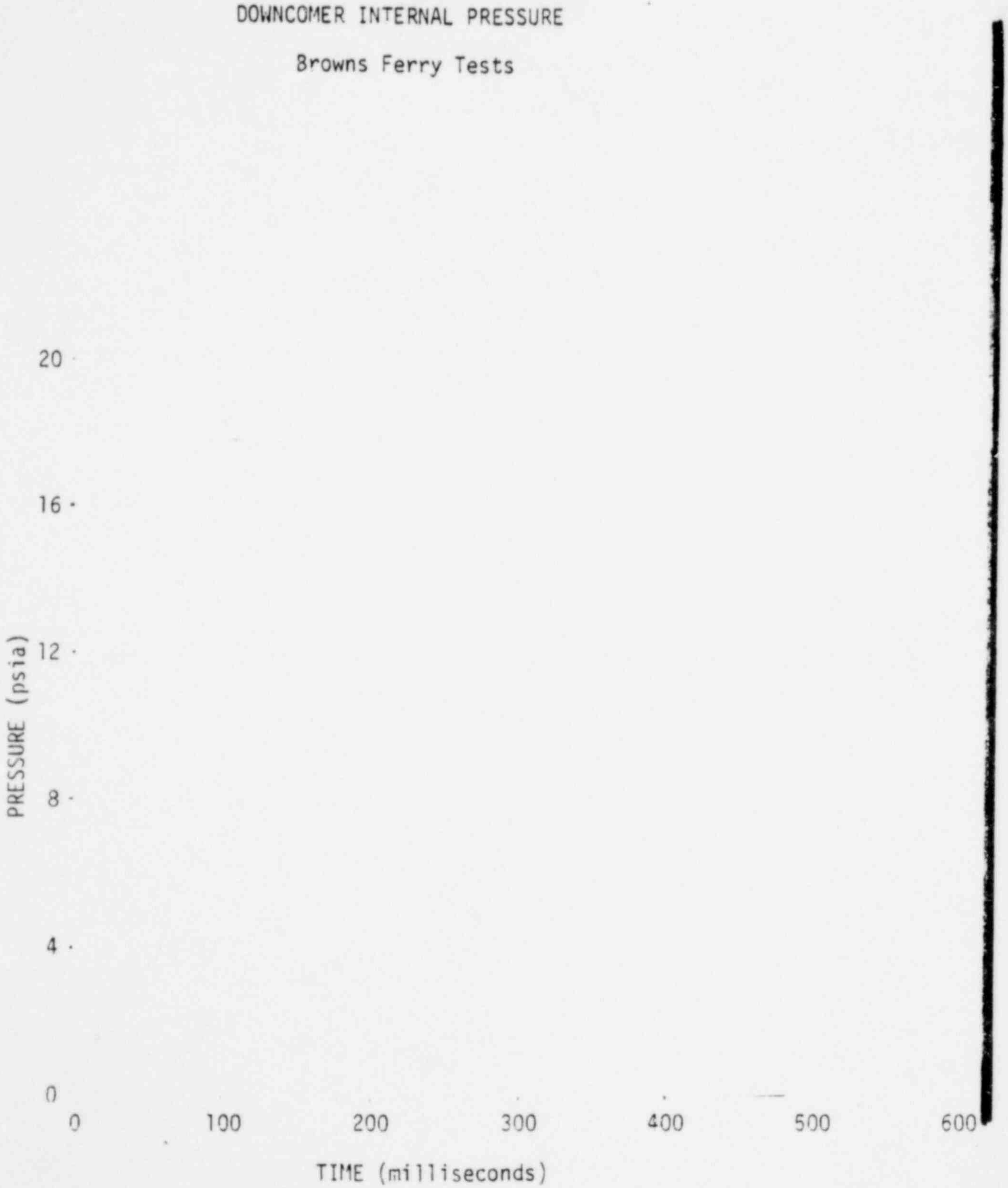
1349 278

FIGURE A-436

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Browns Ferry Tests



1349 279

FIGURE A-437

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Browns Ferry Tests

1349 280

TABLE A-19

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Browns Ferry 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.	7.61" 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)							

1349 281

TABLE A-19

*Time at force is zero (from T_o)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Browns Ferry Tests

Parameter \ Test No.	7.61" ΔP (No 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)							

1349 282

TABLE A-20

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Browns Ferry Tests

Parameter \ Test No.		7.61" ΔP (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
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)							

*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 283

A.10 Peach Bottom Tests

A.10.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Peach Bottom Tests 3 and 5. Test 3 was a load definition test, which was conducted at a partial drywell/wetwell differential pressure of 7.61" H_2O ΔP and with a 6.5 inch winged deflector (26 inch full-scale)*. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 6.5 inch winged deflector.

A.10.1.1 Driving Conditions

Driving conditions for Peach Bottom Test 3 are presented in Figures A-438 through A-442. Similar plots for Test 5 are shown in Figures A-443 through A-447. The thermocouple gave an erroneous reading due to the condensate wetting the thermocopule. The corrected vent air temperature is shown by dash line (Figure A-441). Peach Bottom driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.10.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Peach Bottom Tests 3 and 5 are presented in Figures A-448 through A-449 and A-450 through A-451, respectively. Figures A-452 and A-453 present net torus force based on the torus pressure integral for Peach Bottom Tests 3 and 5, respectively. Some downforce oscillations are present in Test 3. Upforce oscillation is evident in both Tests 3 and 5. Net torus force that is determined from the load cell (Figures A-454 and A-456) by applying inertial correction with the torus accelerometer (Figures A-455 and 457) is shown in Figures A-458 and A-459 and compared to net torus force determined from the

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* Winged deflector is a pipe with structural angles.

1349 284

pressure integral. Figures A-460 and A-461 present the net torus force based on the torus pressure integral, corrected for inertia. Smoothed downforce is also shown in the 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 Peach Bottom Tests 3 and 5 are shown in Figures A-462 and A-464. Figures A-463 and A-465 are the same as Figures A-460 and A-461 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Peach Bottom Test 3 are presented in Figures A-466 through A-469. Vent header pressures for Test 5 are presented in Figures A-470 through A-473. These figures indicate that the winged deflector was very effective in mitigating the vent header impact.

Figure A-474 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 measurements from Tests 3 and 5 are shown in Figures A-475 and A-476, respectively.

A.10.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-477 through A-480 for Peach Bottom Tests 1, 2, 3, and 5. Pool surface displacement curves for Tests 1, 2, and 3 are shown in Figure A-481. The pool surface velocity profiles for Tests 1, 2, and 3 are shown in Figure A-482. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-483 and A-484, respectively.

The pool surface displacement and velocity profile viewed from the side window during Test 4 are shown in Figure A-485. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are shown in Figures A-486 and A-487, respectively.

A.10.3 Data Summaries

Table A-21 presents the Peach Bottom test data for wetwell vertical forces.

Table A-22 presents the Peach Bottom test data for vent header impact forces.

A.10.4 Discussion and Analysis

Figure A-488 presents the effect of drywell/wetwell ΔP on the enthalpy flow into the bubbles. The effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-489. Figure A-490 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The data for Peach Bottom parallels that for the "typical" plant in Section 3.0.

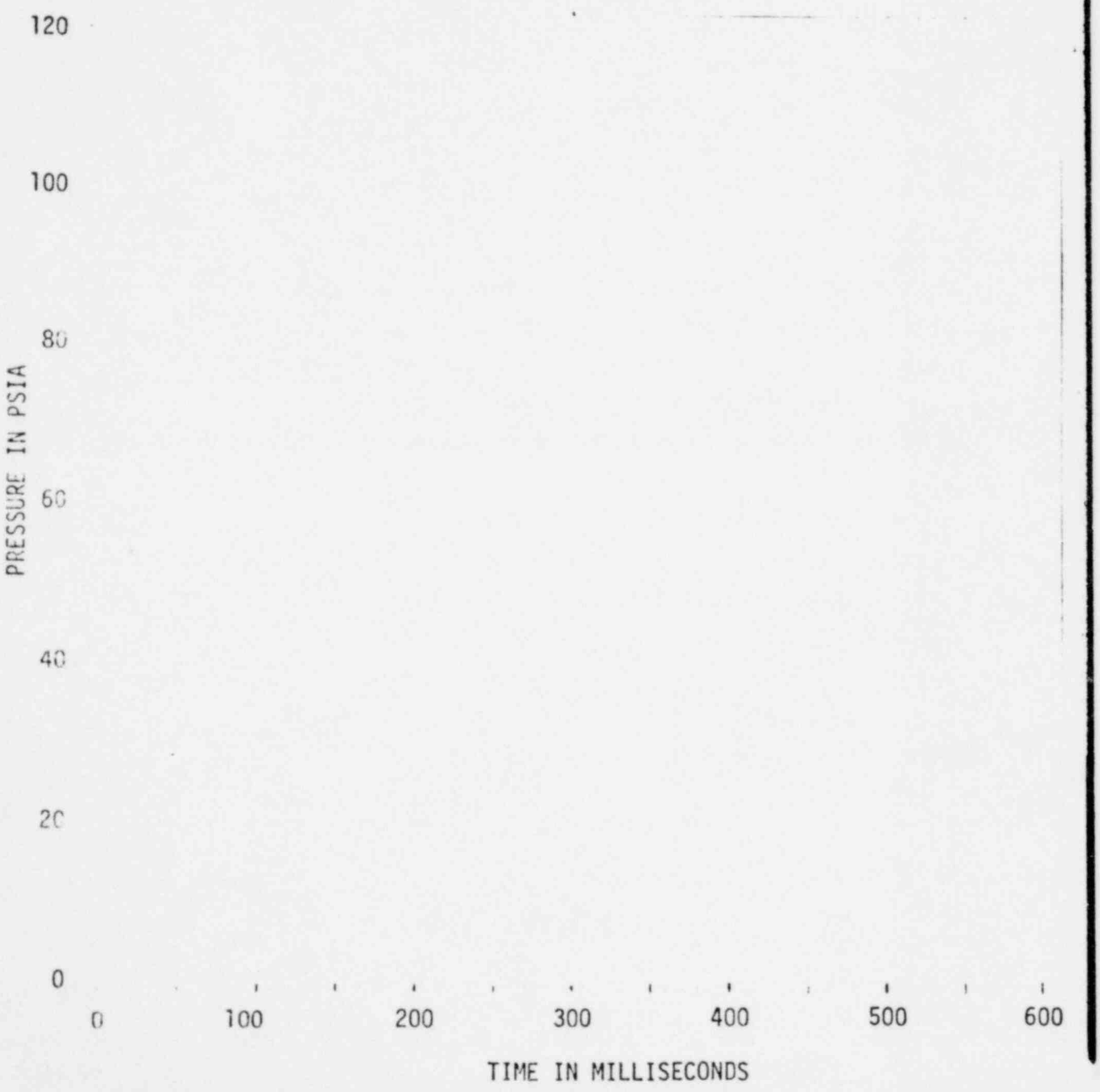
The Peach Bottom load definition tests were conducted at 7.61" H_2O ΔP with a 6.5 inch winged deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. Some downforce oscillations were present in Test 3. Upforce oscillation was evident in both Tests 3 and 5. The deflector (26 inch full-scale) effectively mitigated vent header impact.

1349 286

FIGURE A-438

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Peach Bottom Test 3



1349 287

FIGURE A-439

DRYWELL PRESSURE

Task 5.5.3-2 Peach Bottom Test 3

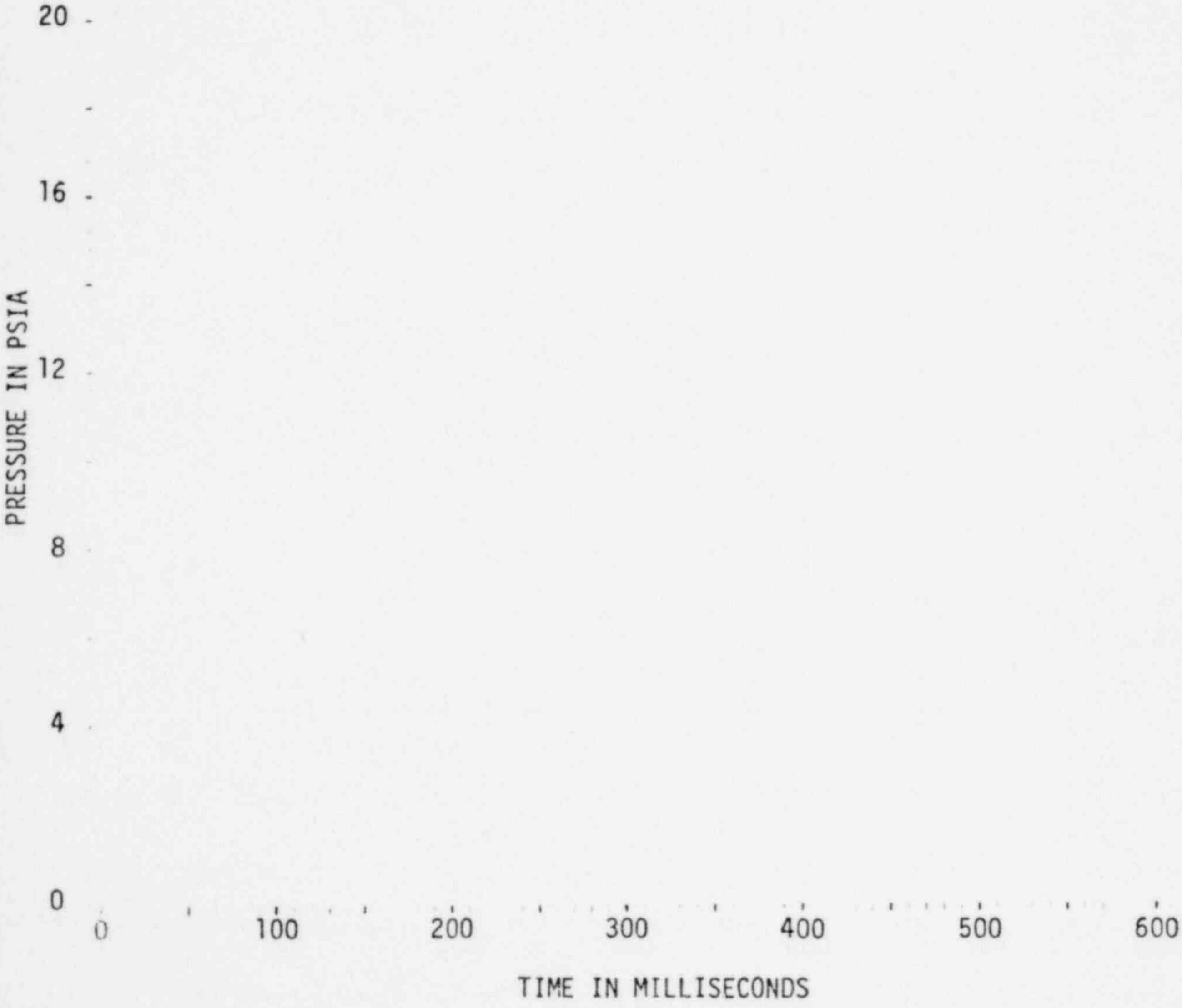


FIGURE A-440

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Peach Bottom Test 3

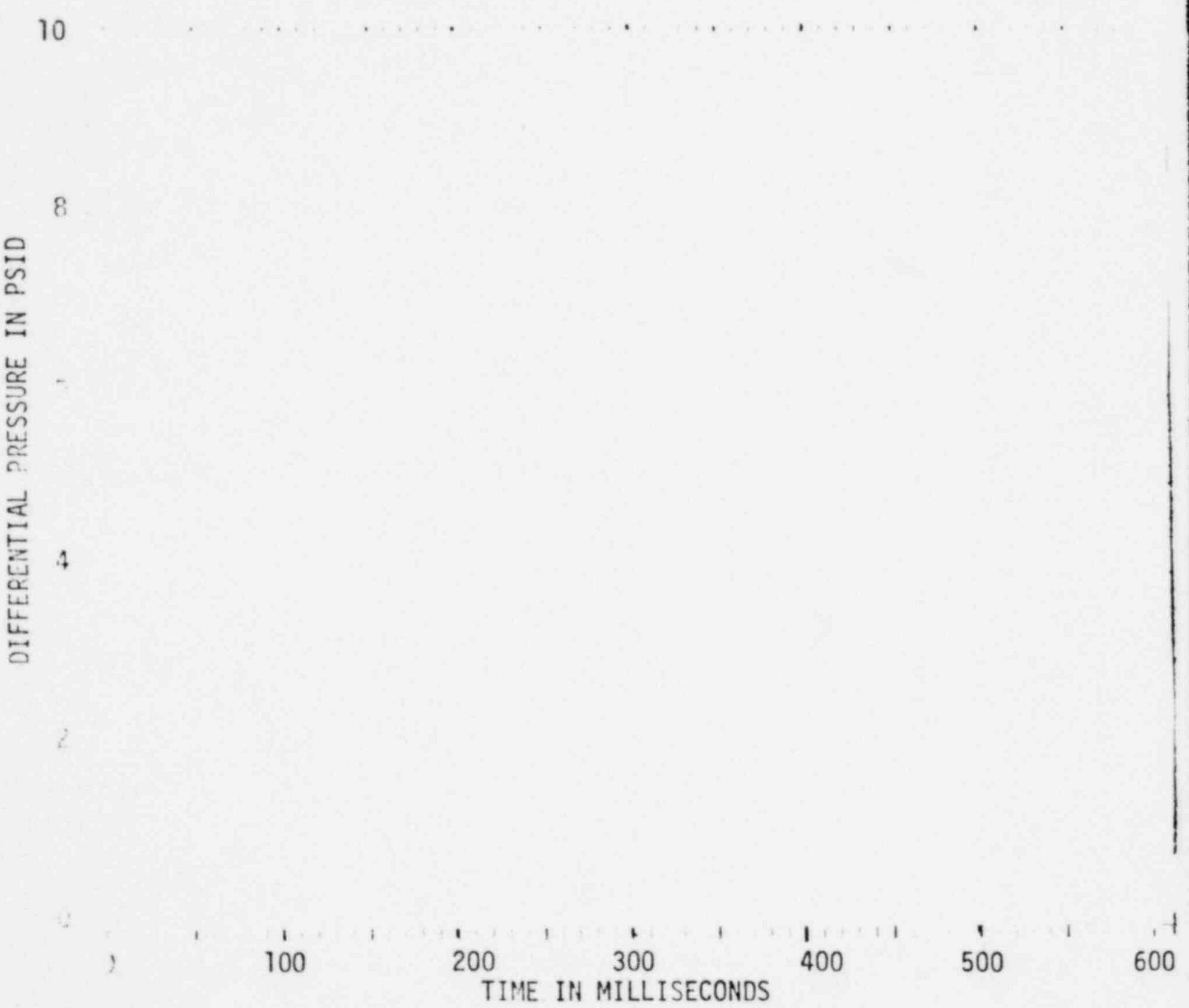
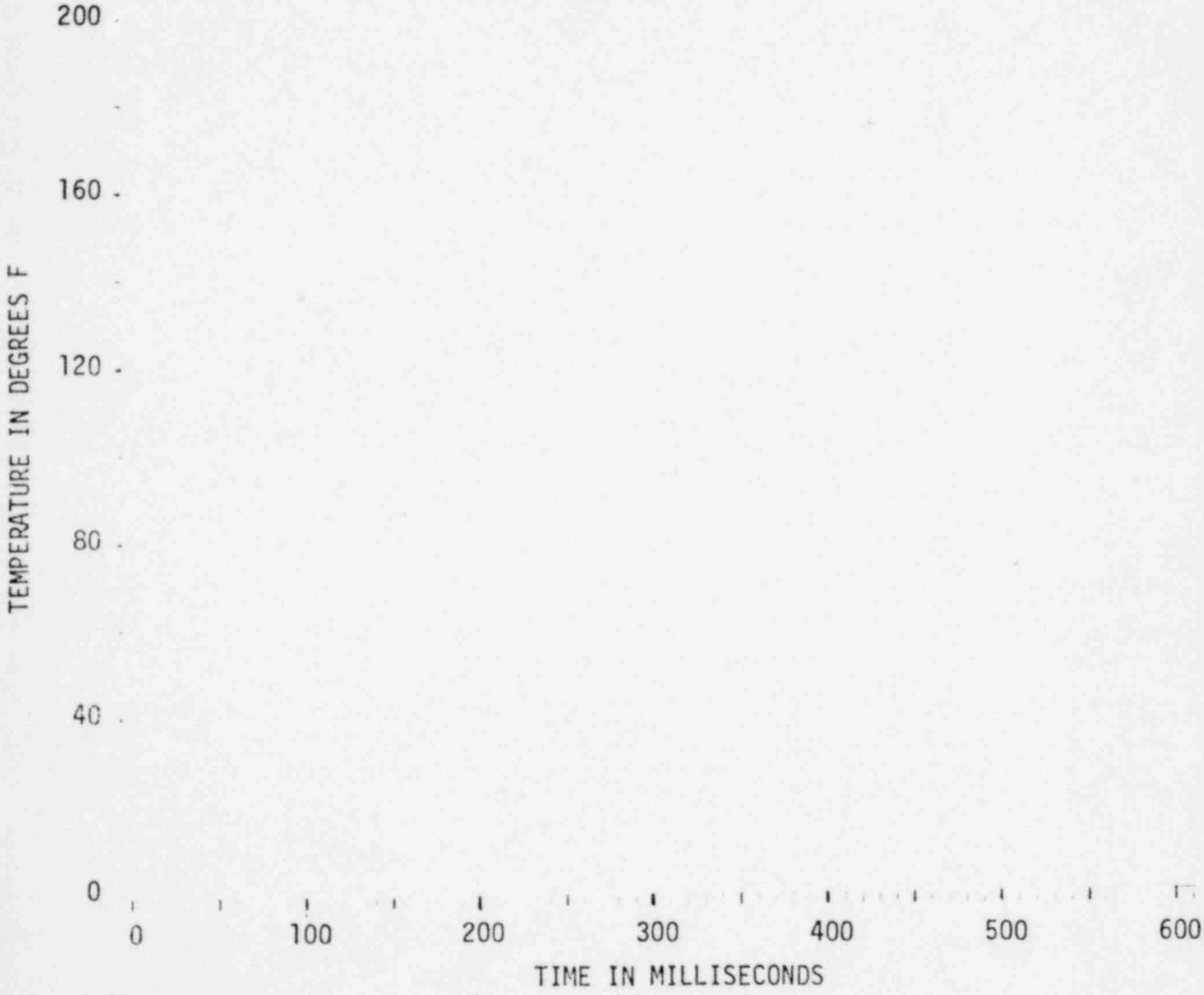


FIGURE A-441

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Peach Bottom Test 3

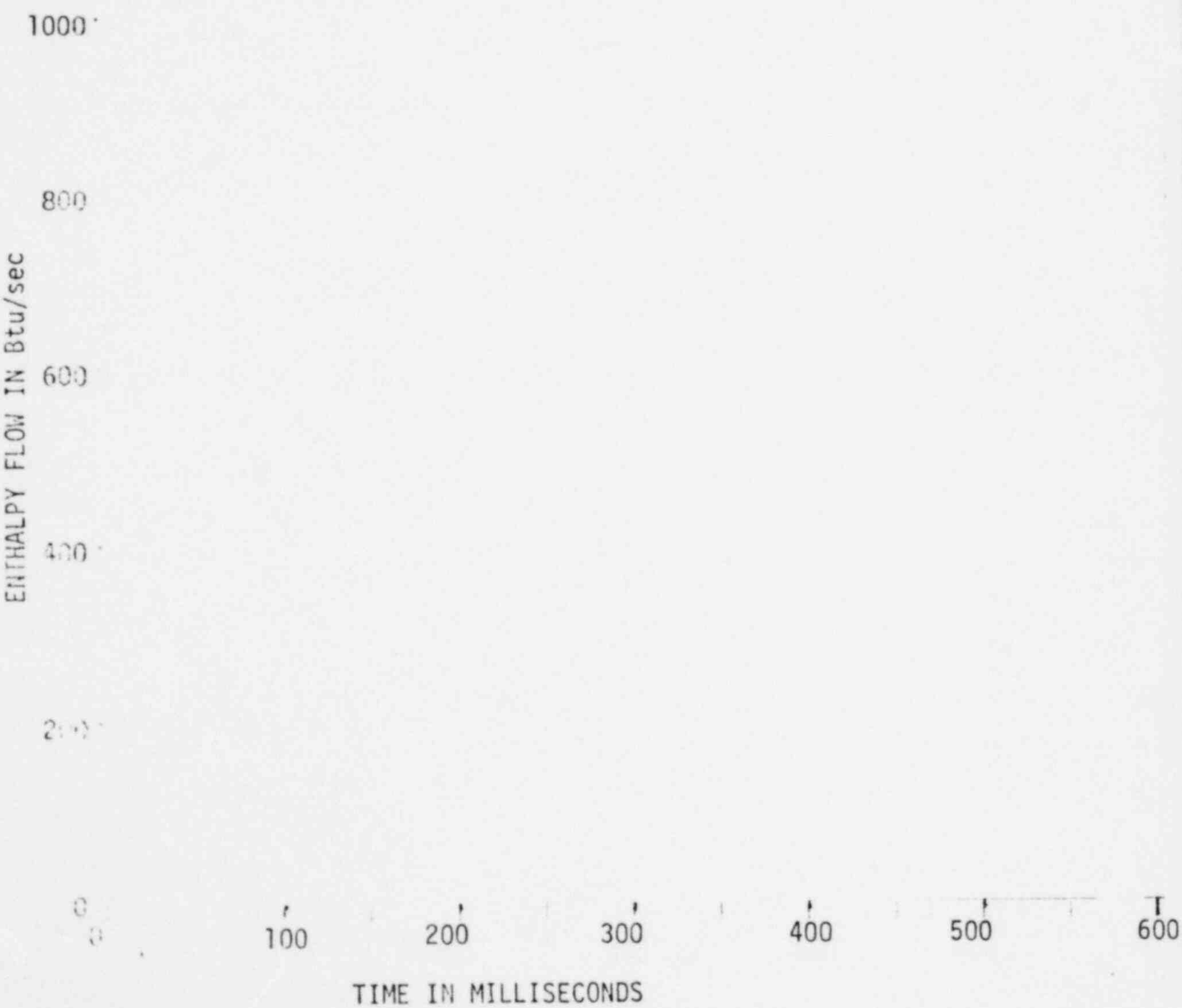


1349 290

FIGURE A-442

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Peach Bottom Test 3

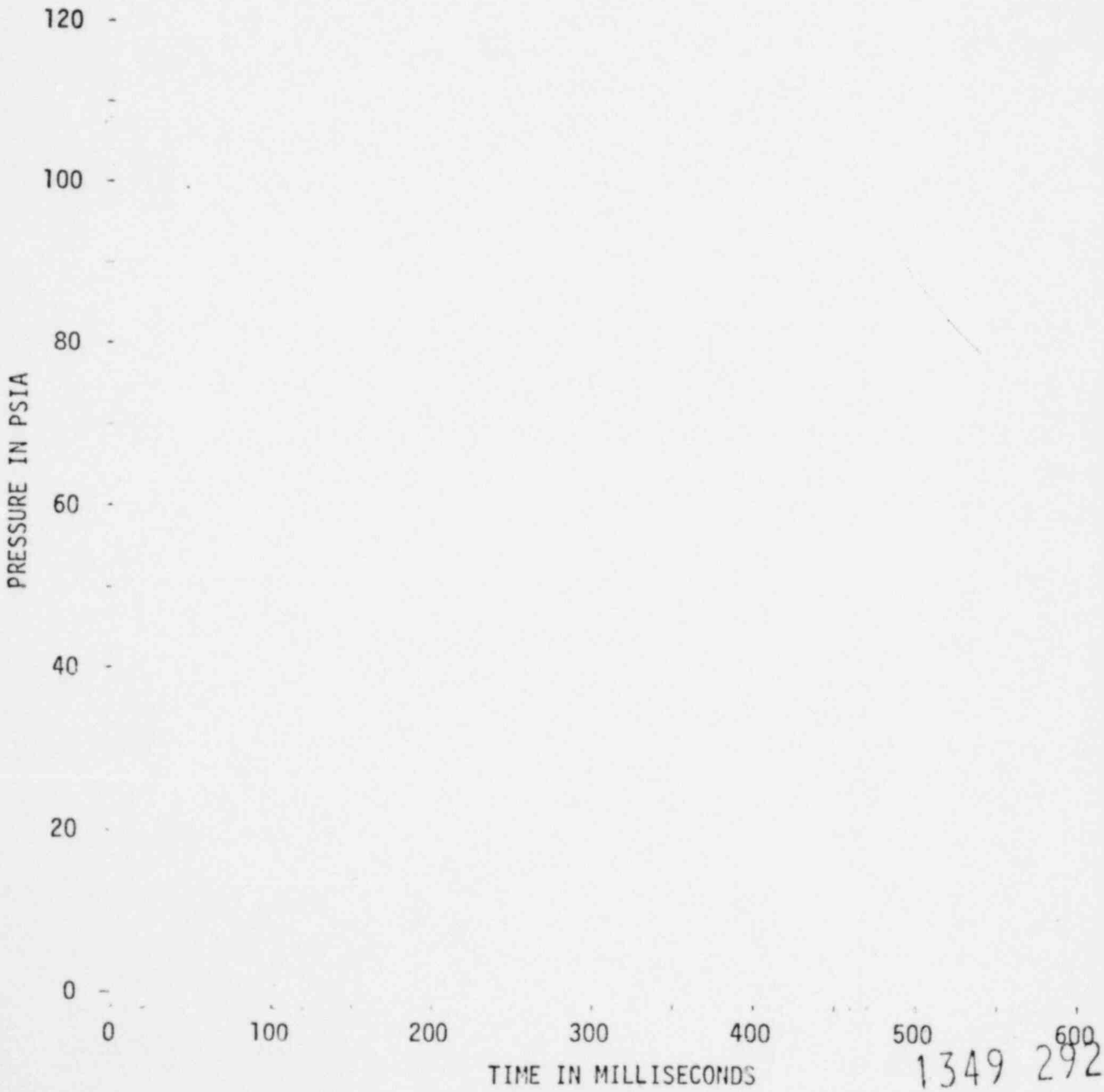


1349 291

FIGURE A-443

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3-2 Peach Bottom Test 5



1349 292

FIGURE A-444

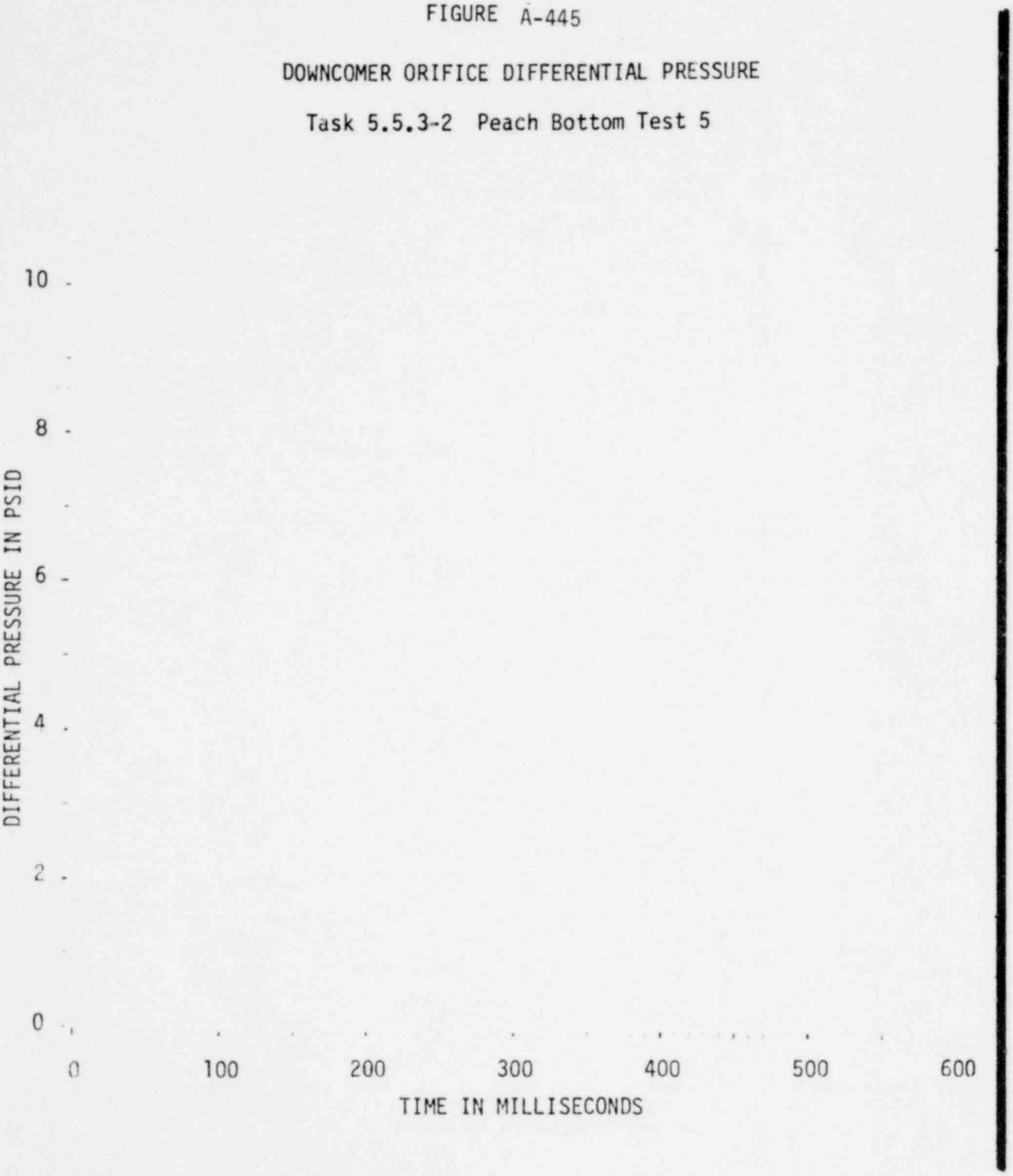
DRYWELL PRESSURE

Task 5.5.3-2 Peach Bottom Test 5

FIGURE A-445

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3-2 Peach Bottom Test 5

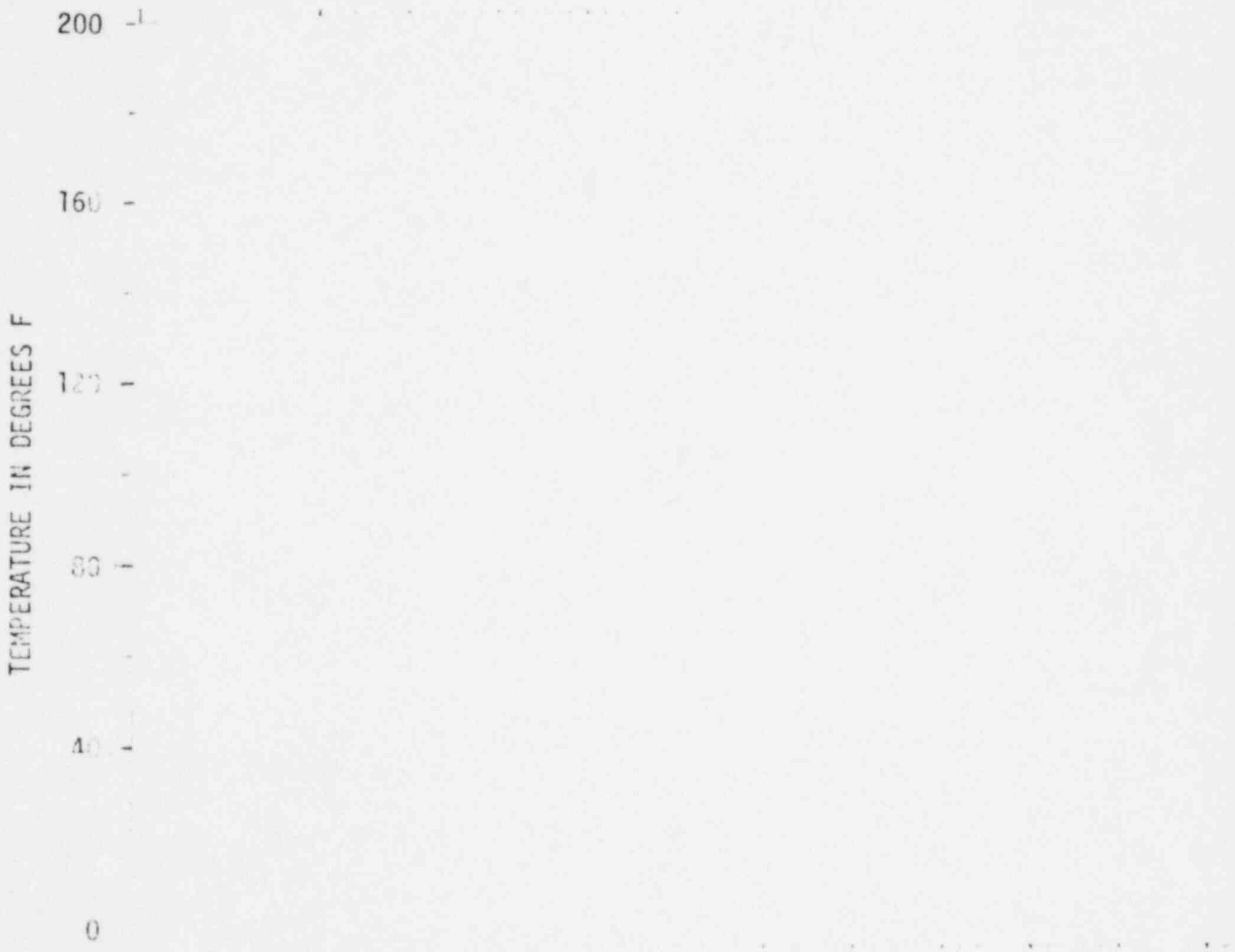


1349 294

FIGURE A-446

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3-2 Peach Bottom Test 5

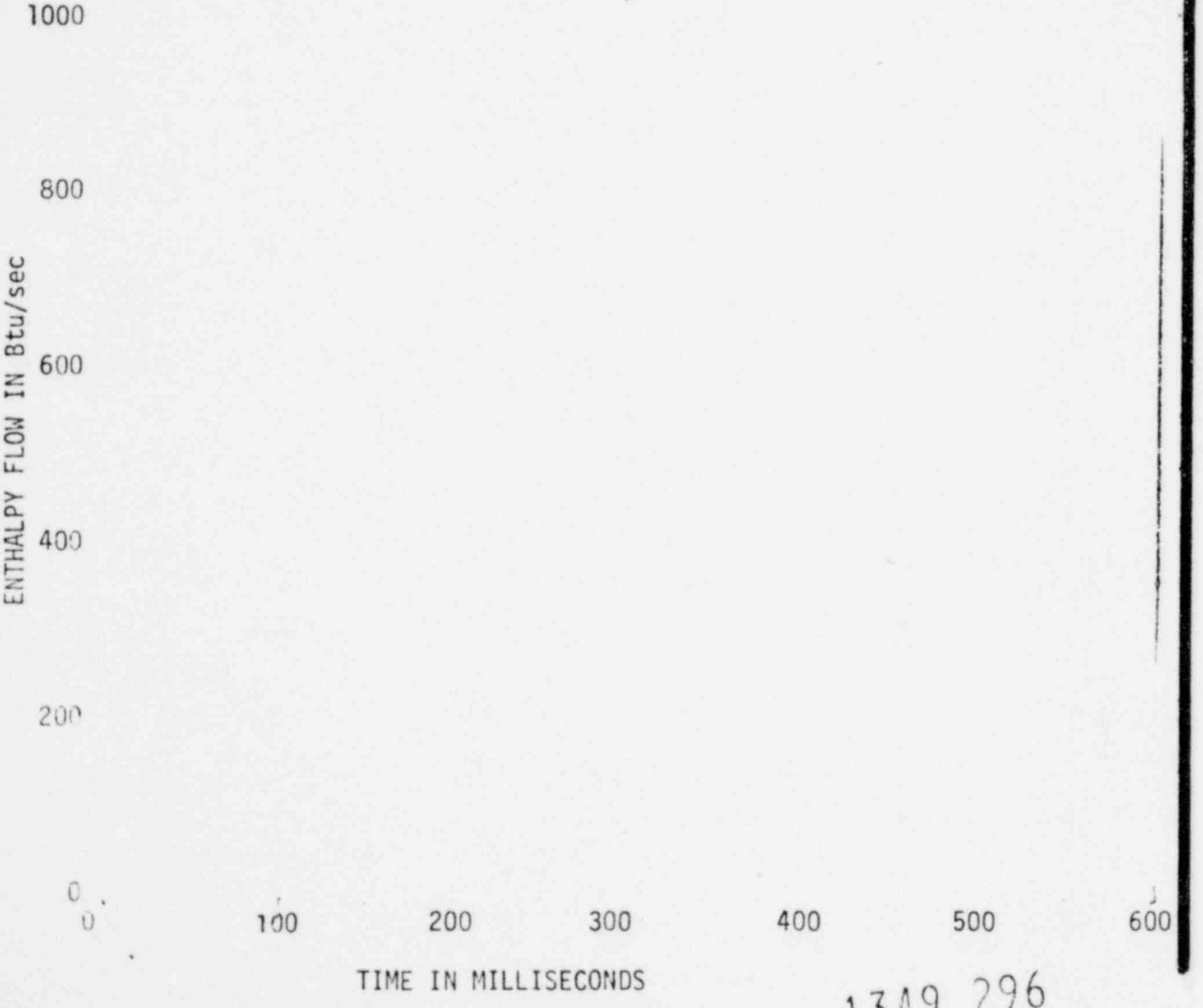


1349 295

FIGURE A-447

ENTHALPY FLOW INTO POOL

Task 5.5.3-2 Peach Bottom Test 5



1349 296

FIGURE A-448

DOWNCOMER INTERNAL PRESSURE

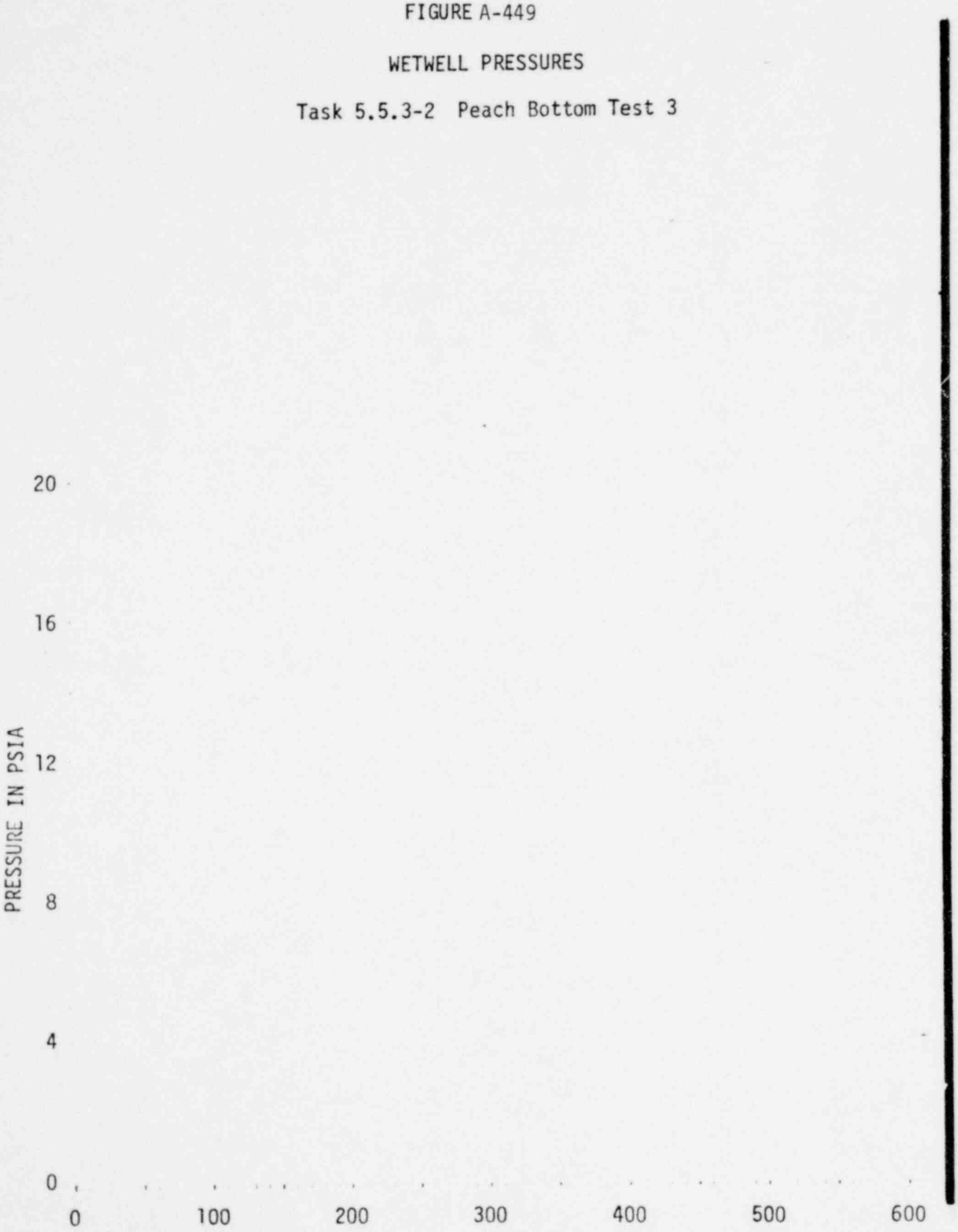
Task 5.5.3-2 Peach Bottom Test 3

1349 297

FIGURE A-449

WETWELL PRESSURES

Task 5.5.3-2 Peach Bottom Test 3



1349 298

FIGURE A-450

DOWNCOMER INTERNAL PRESSURE

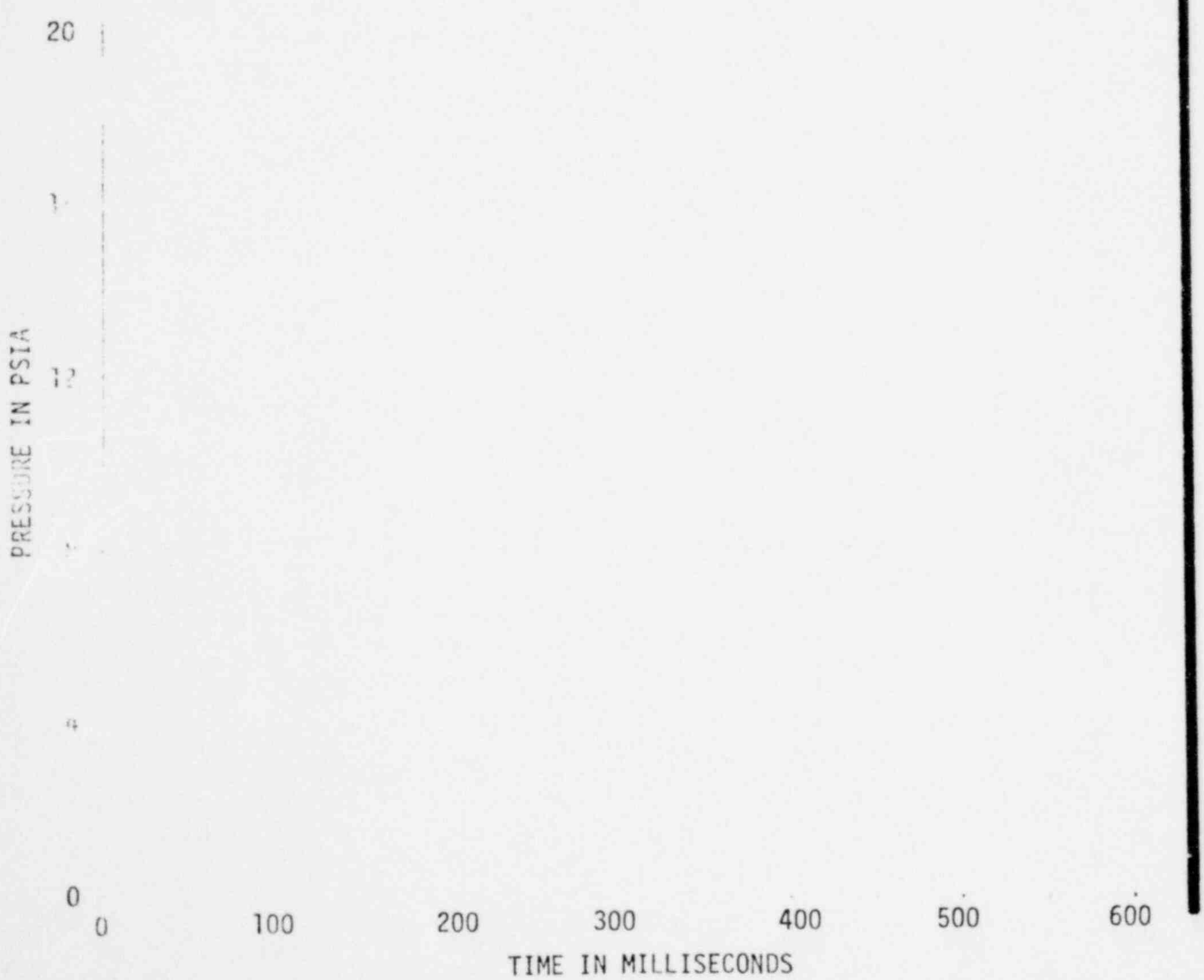
Task 5.5.3-2 Peach Bottom Test 5

1349 299

FIGURE A-451

WETWELL PRESSURES

Task 5.5.3-2 Peach Bottom Test 5

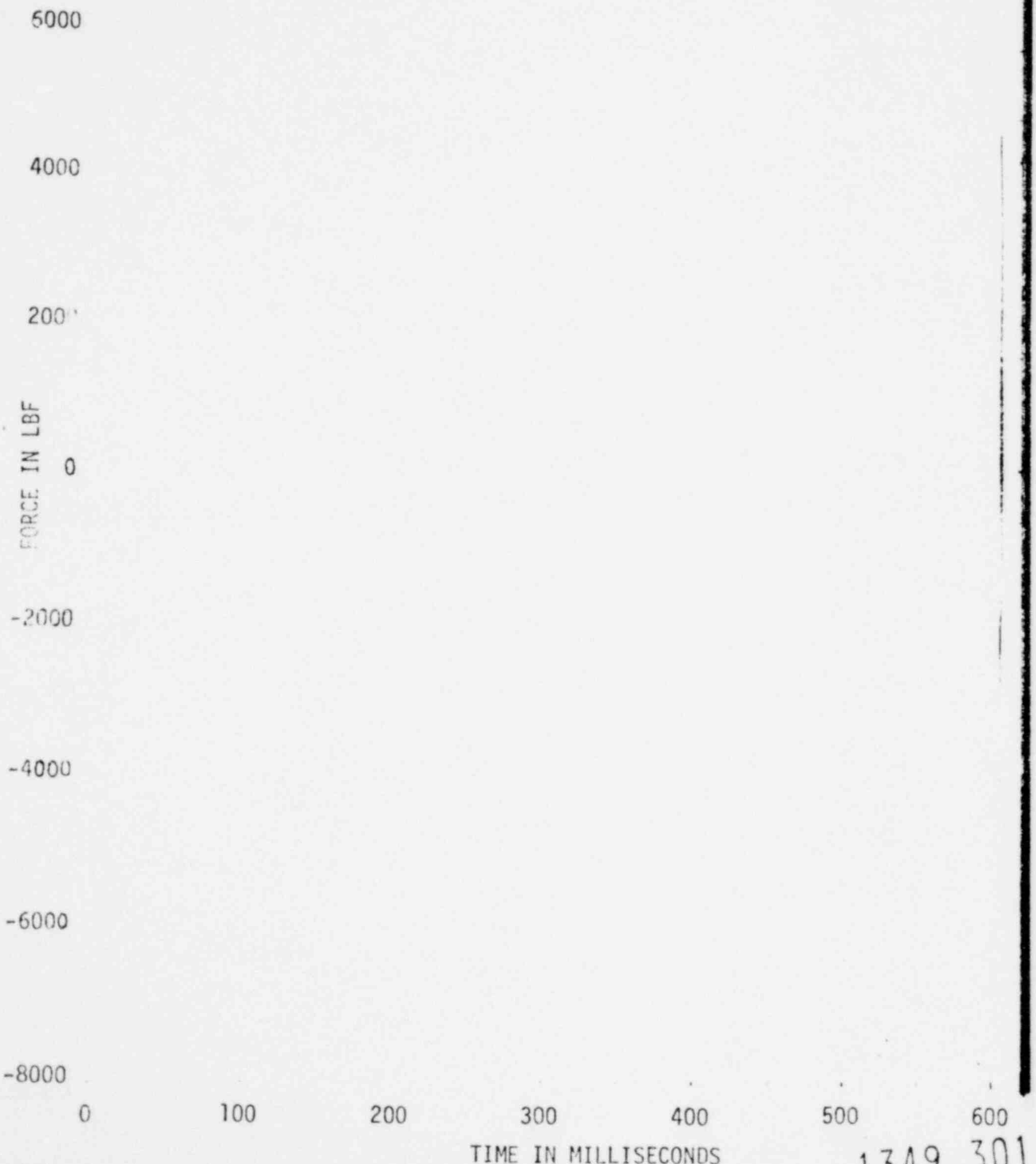


1349 300

FIGURE A-452

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Peach Bottom Test 3

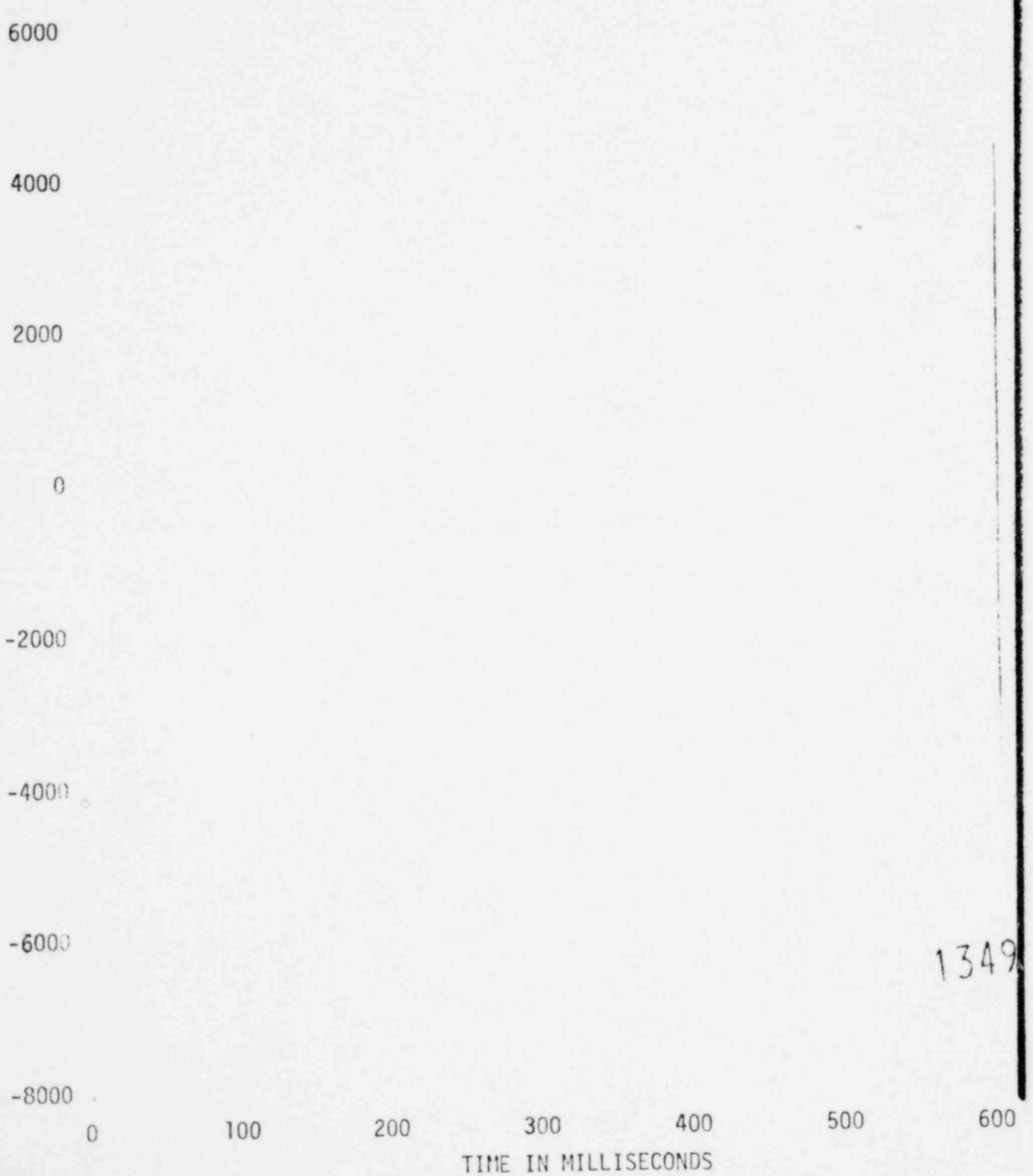


1349 301

FIGURE A-453

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3-2 Peach Bottom Test 5

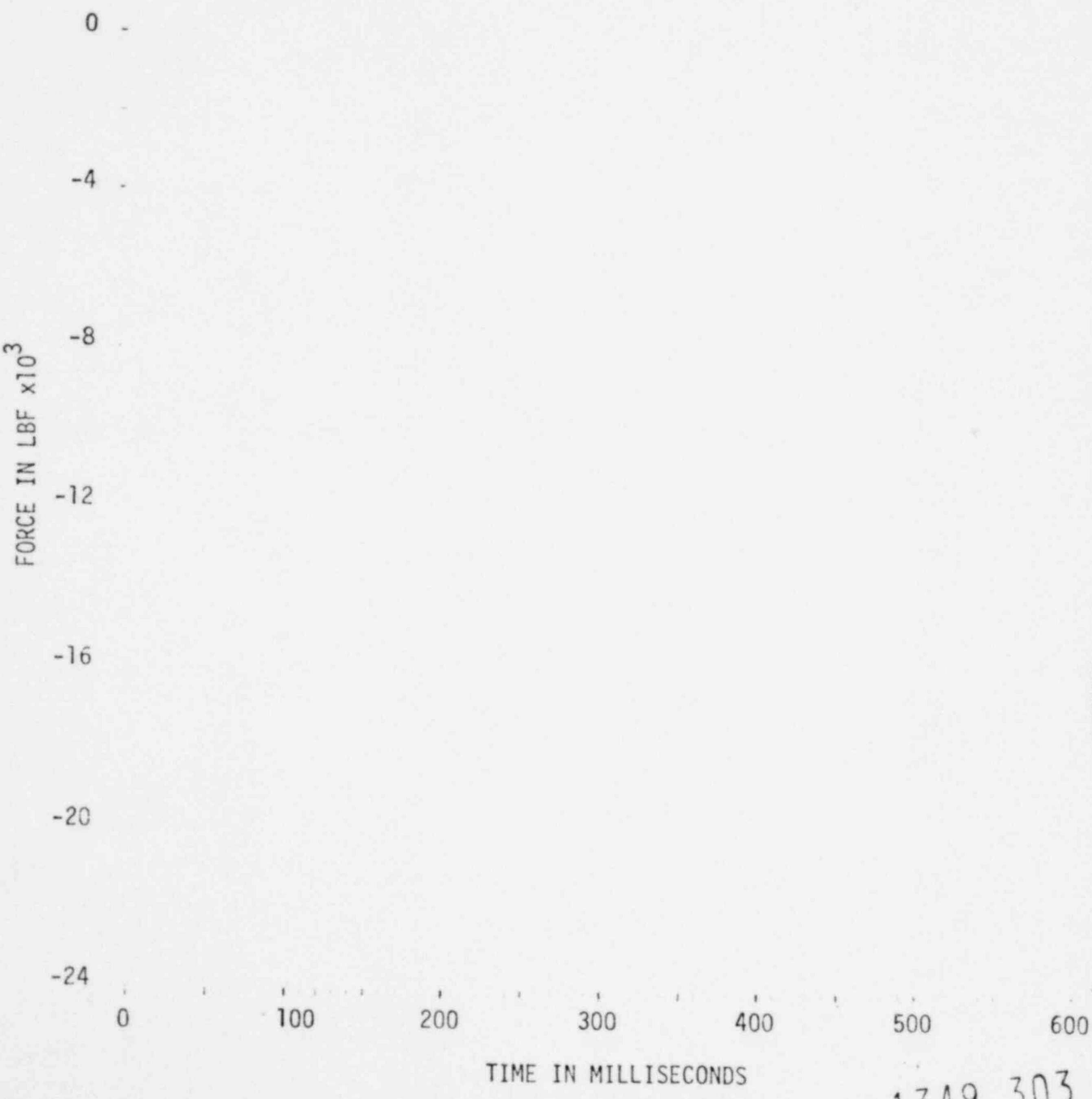


1349 302

FIGURE A-454

TORUS LOAD CELL

Task 5.5.3-2 Peach Bottom Test 3

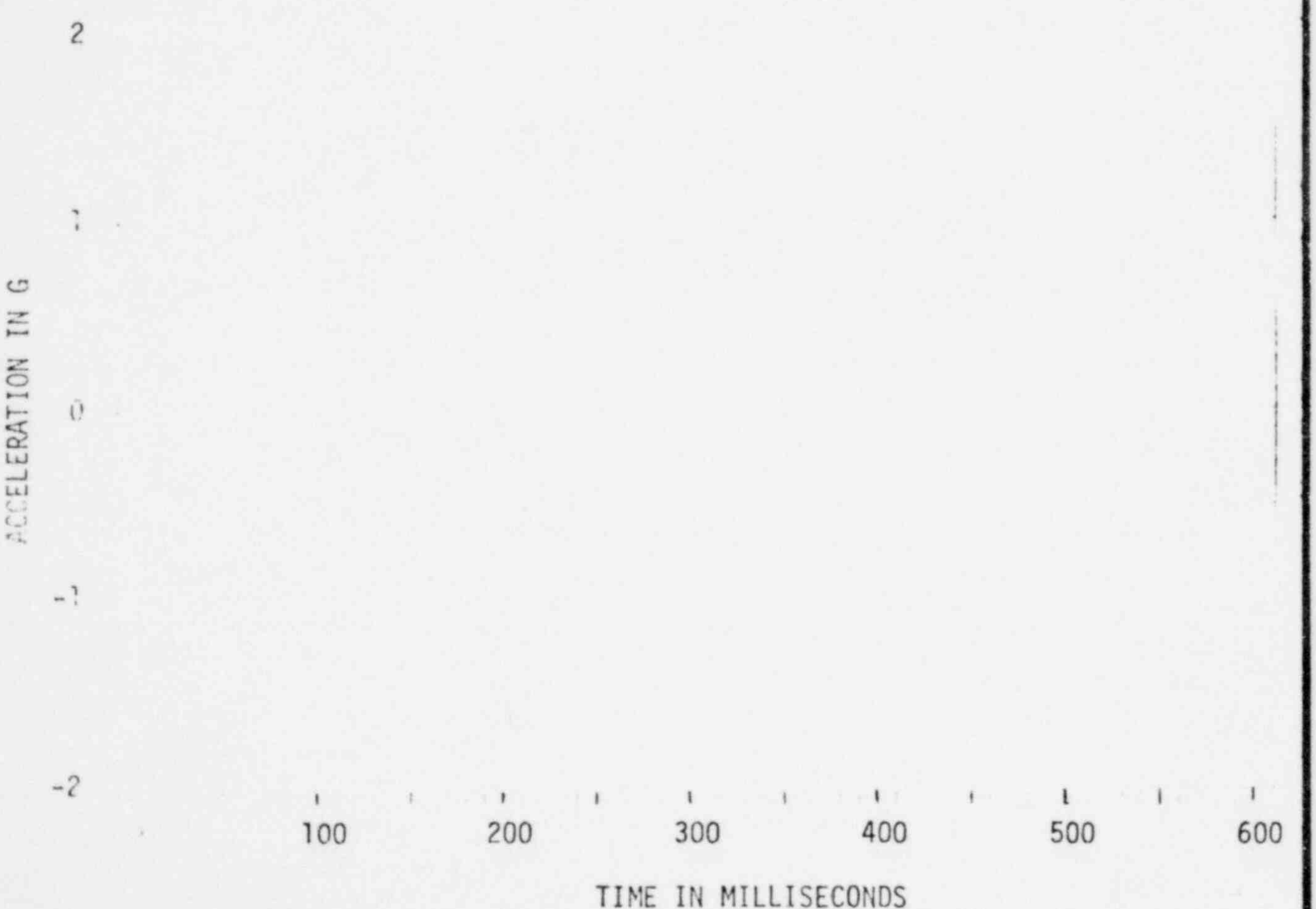


1349 303

FIGURE A-455

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Peach Bottom Test 3



1349 304

FIGURE A-456

TORUS LOAD CELL

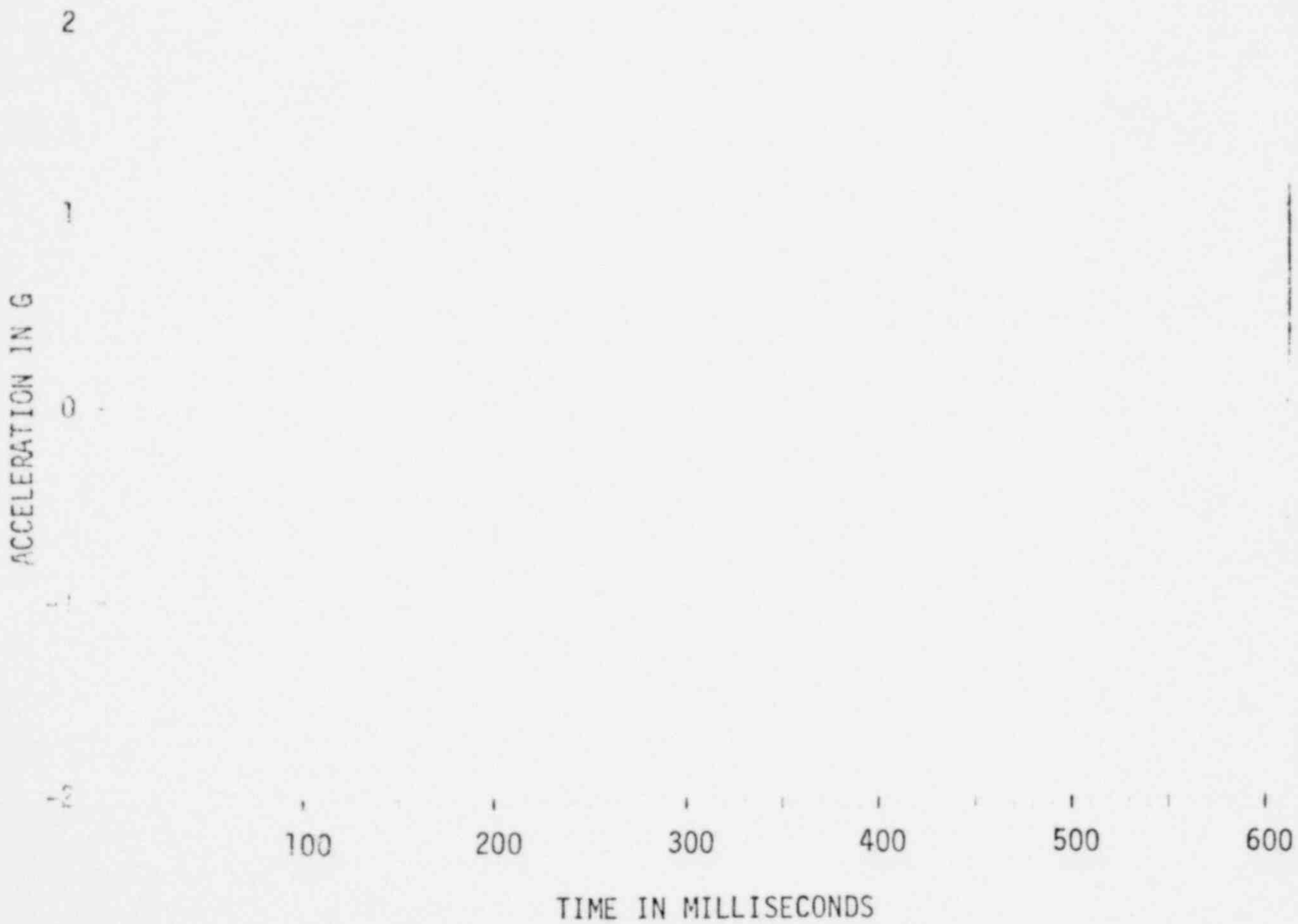
Task 5.5.3-2 Peach Bottom Test 5

1349 30

FIGURE A-457

TORUS VERTICAL ACCELERATION

Task 5.5.3-2 Peach Bottom Test 5



1349 306

FIGURE A-458

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Peach Bottom Test 3

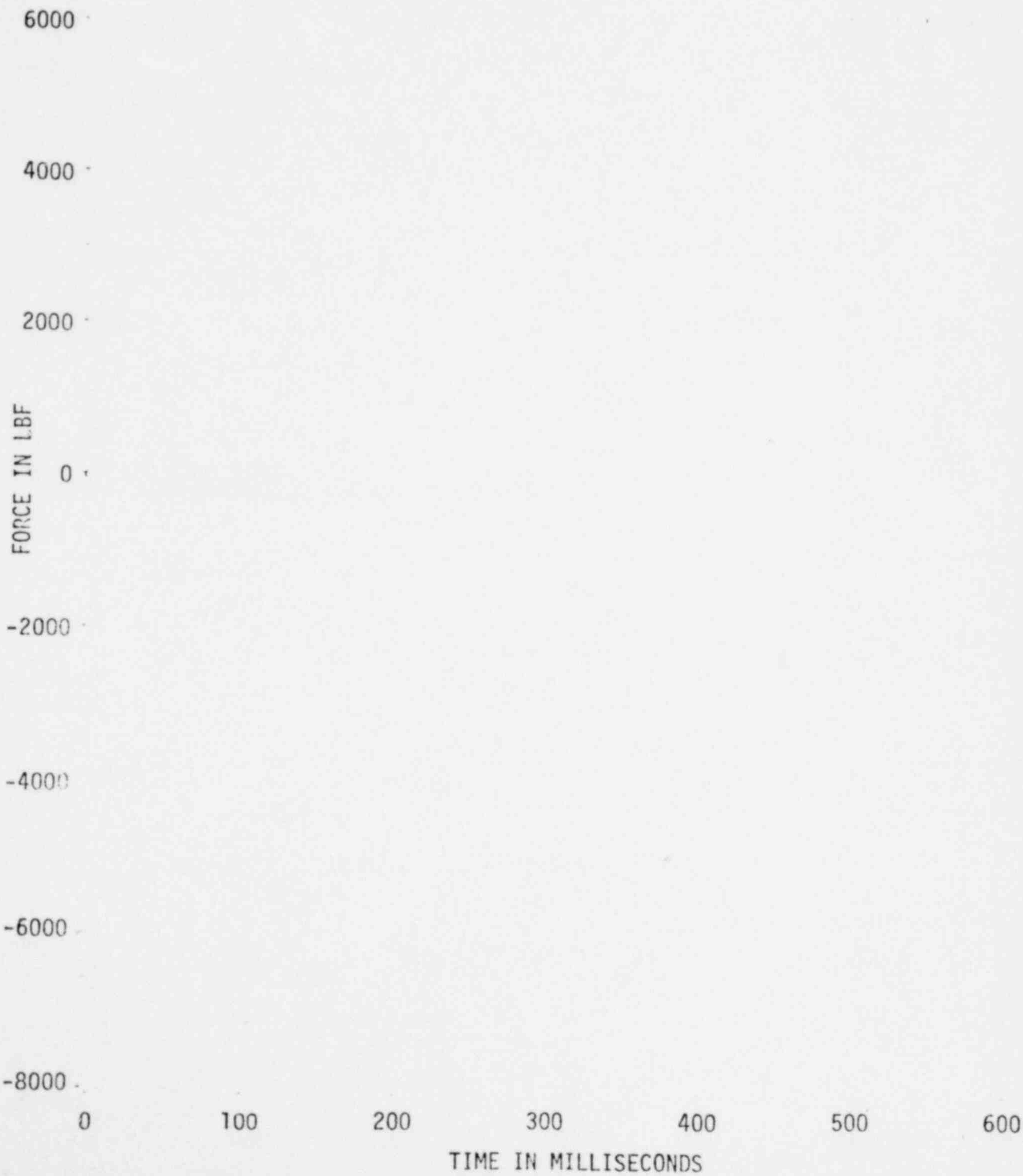
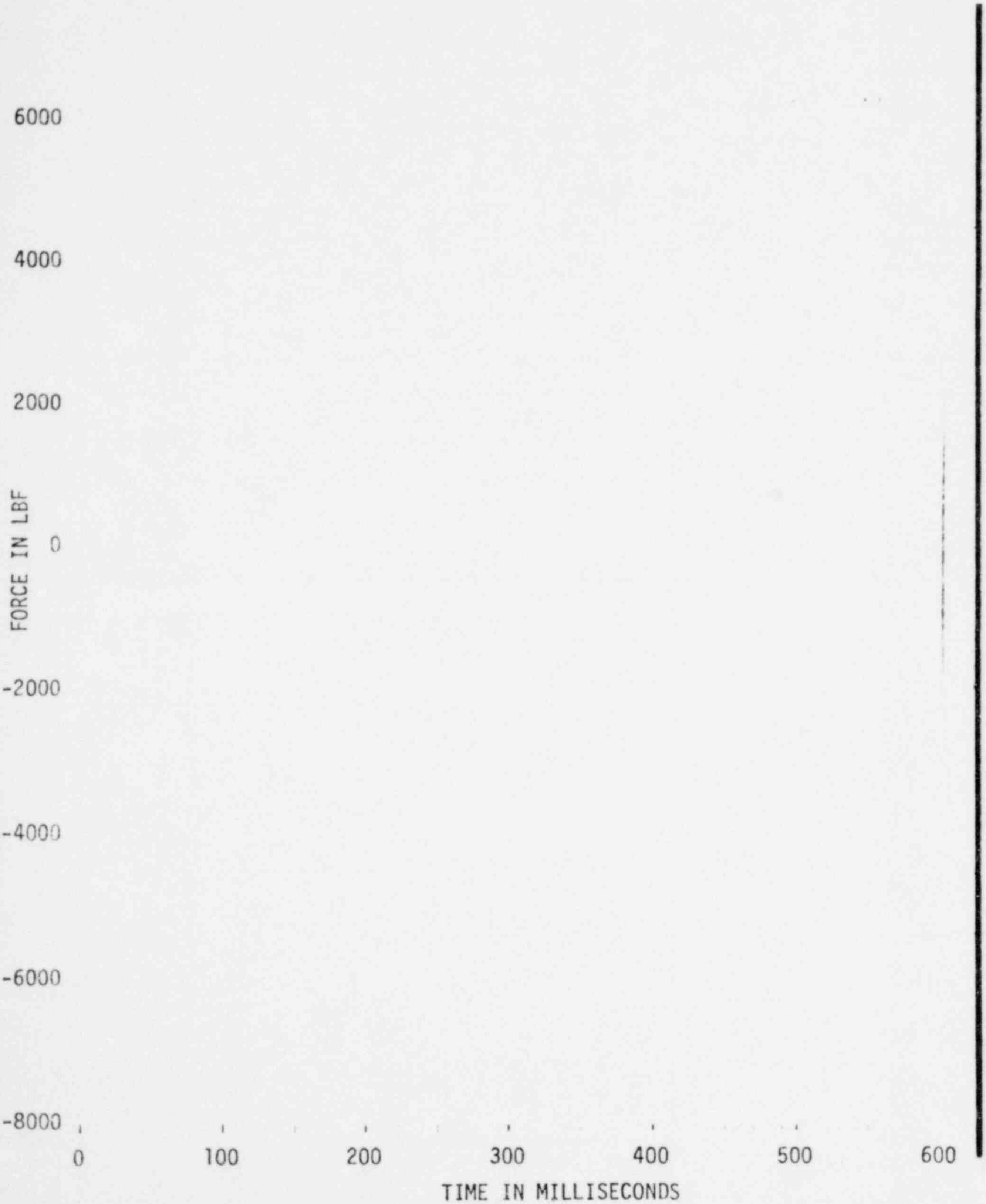


FIGURE A-459

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3-2 Peach Bottom Test 5



1349 308

FIGURE A-460

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 3

1349 309

FIGURE A-461

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 5

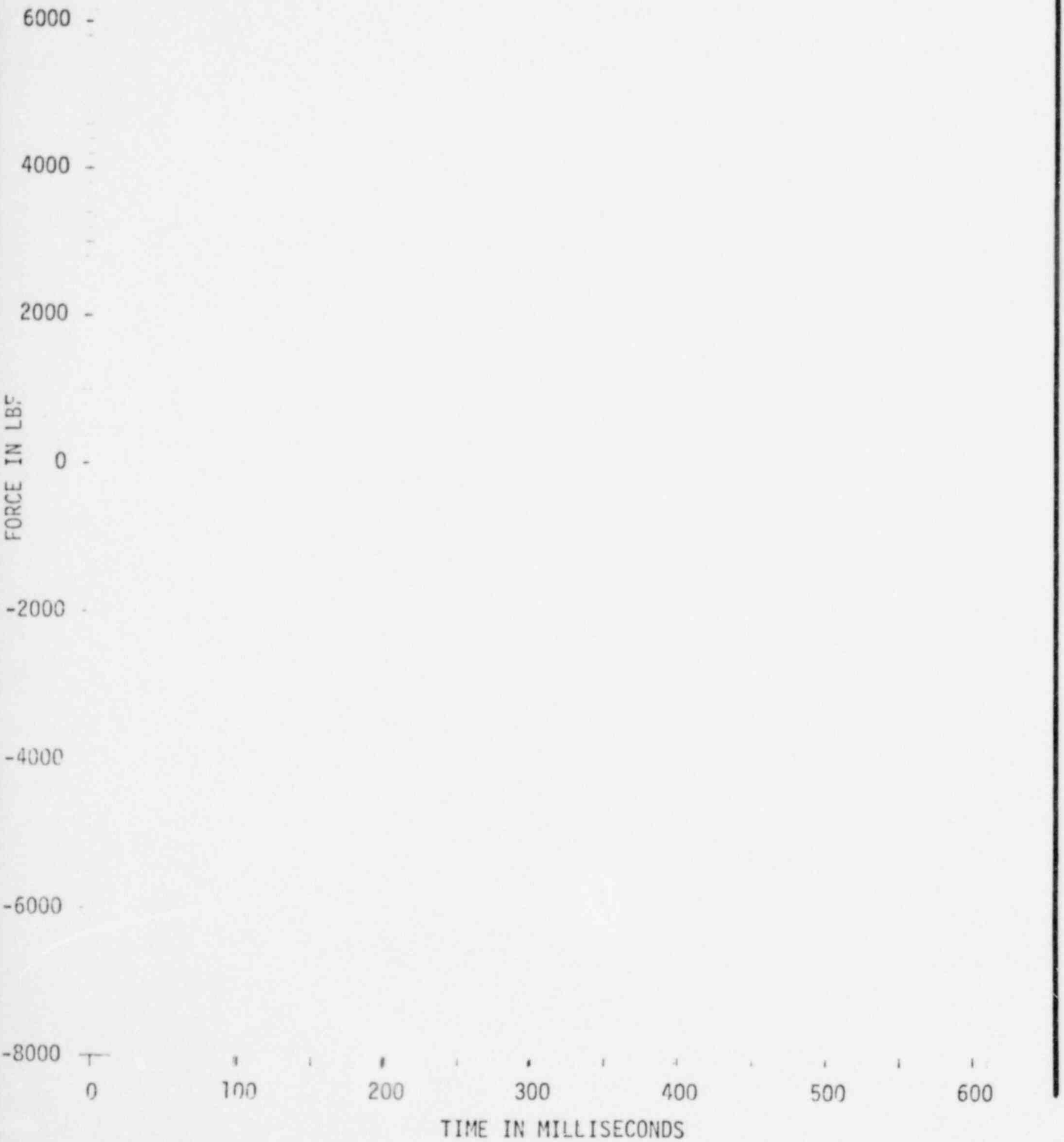
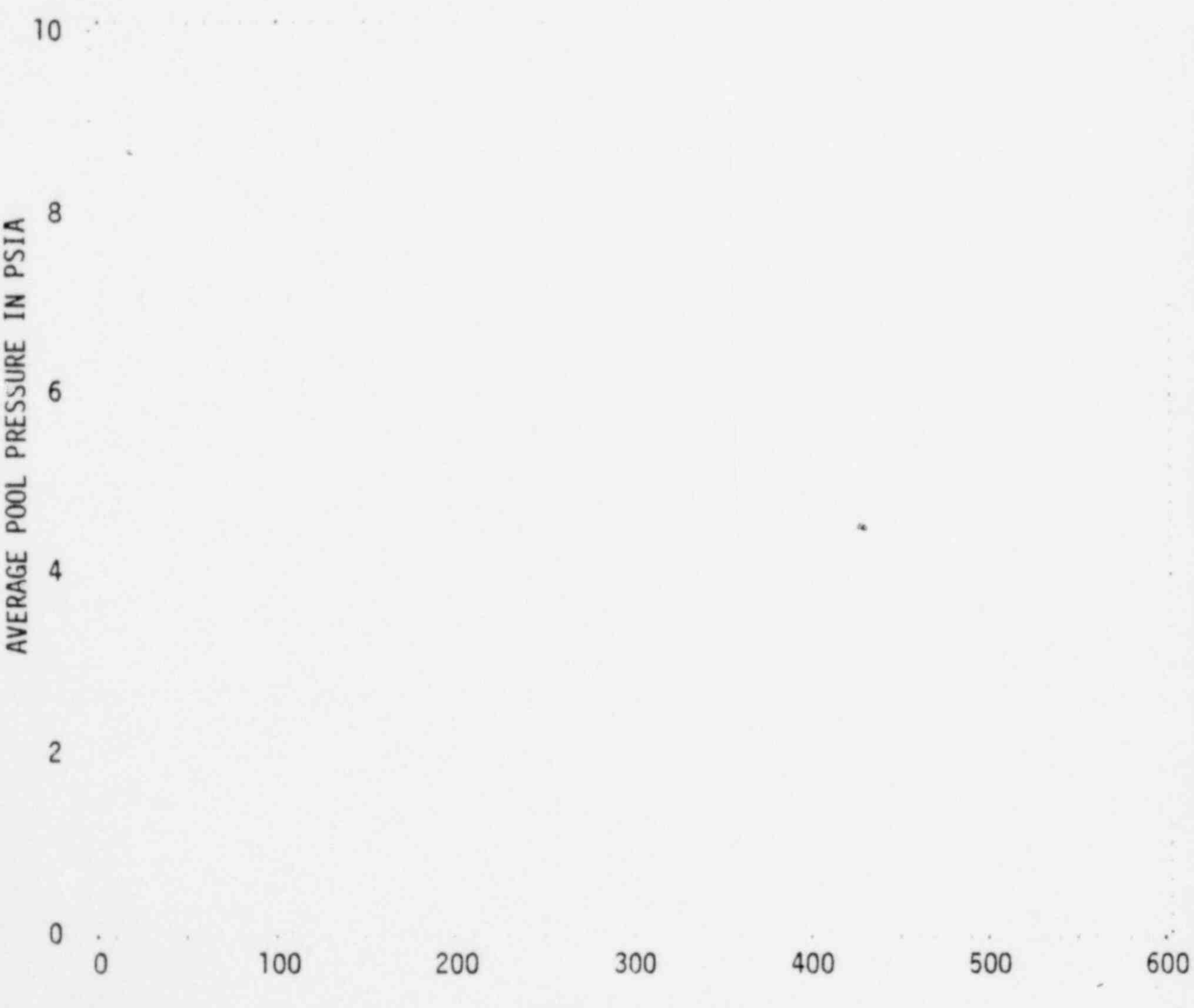


FIGURE A-462

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 3



1349 311

FIGURE A-463

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 3

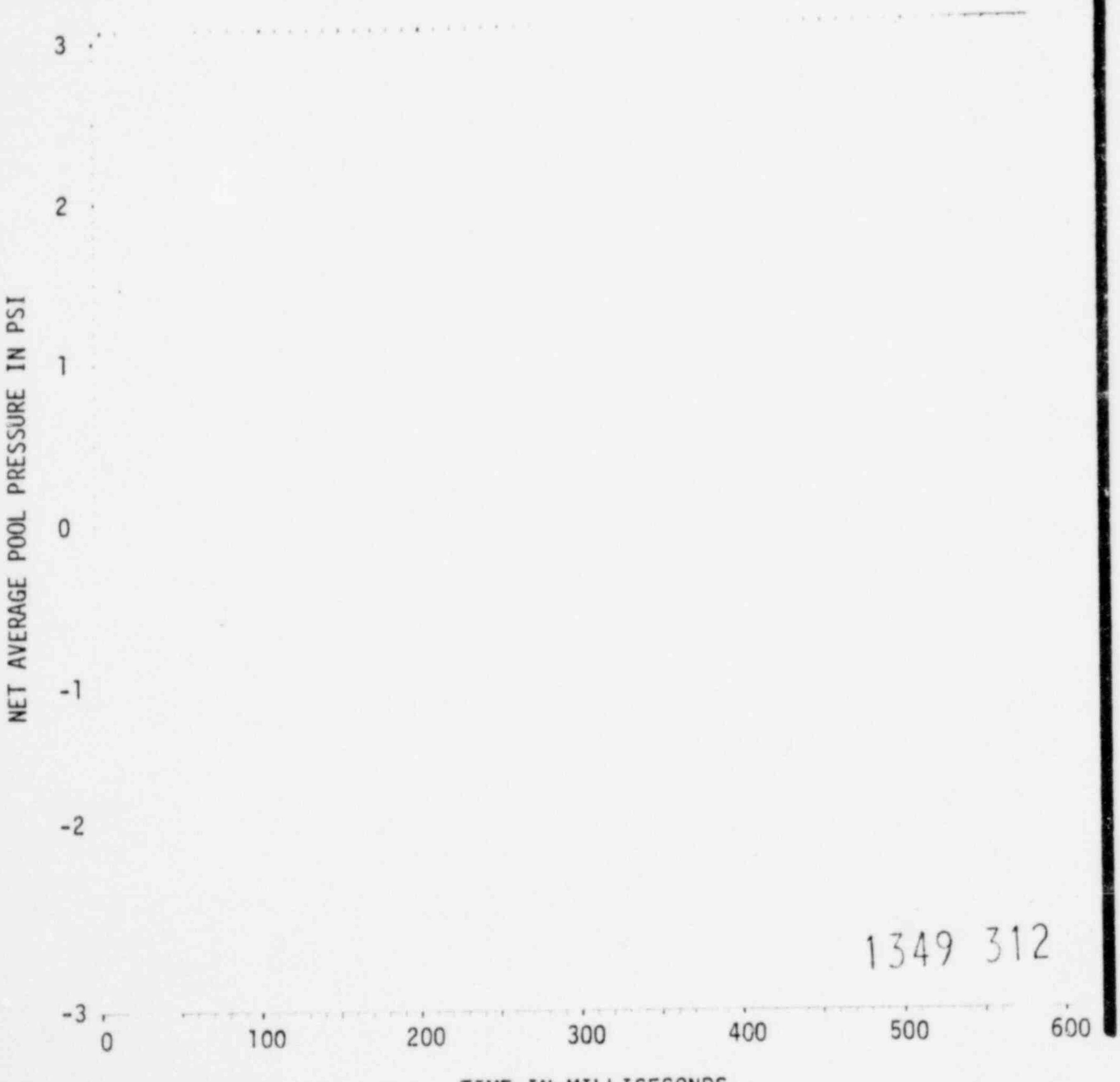
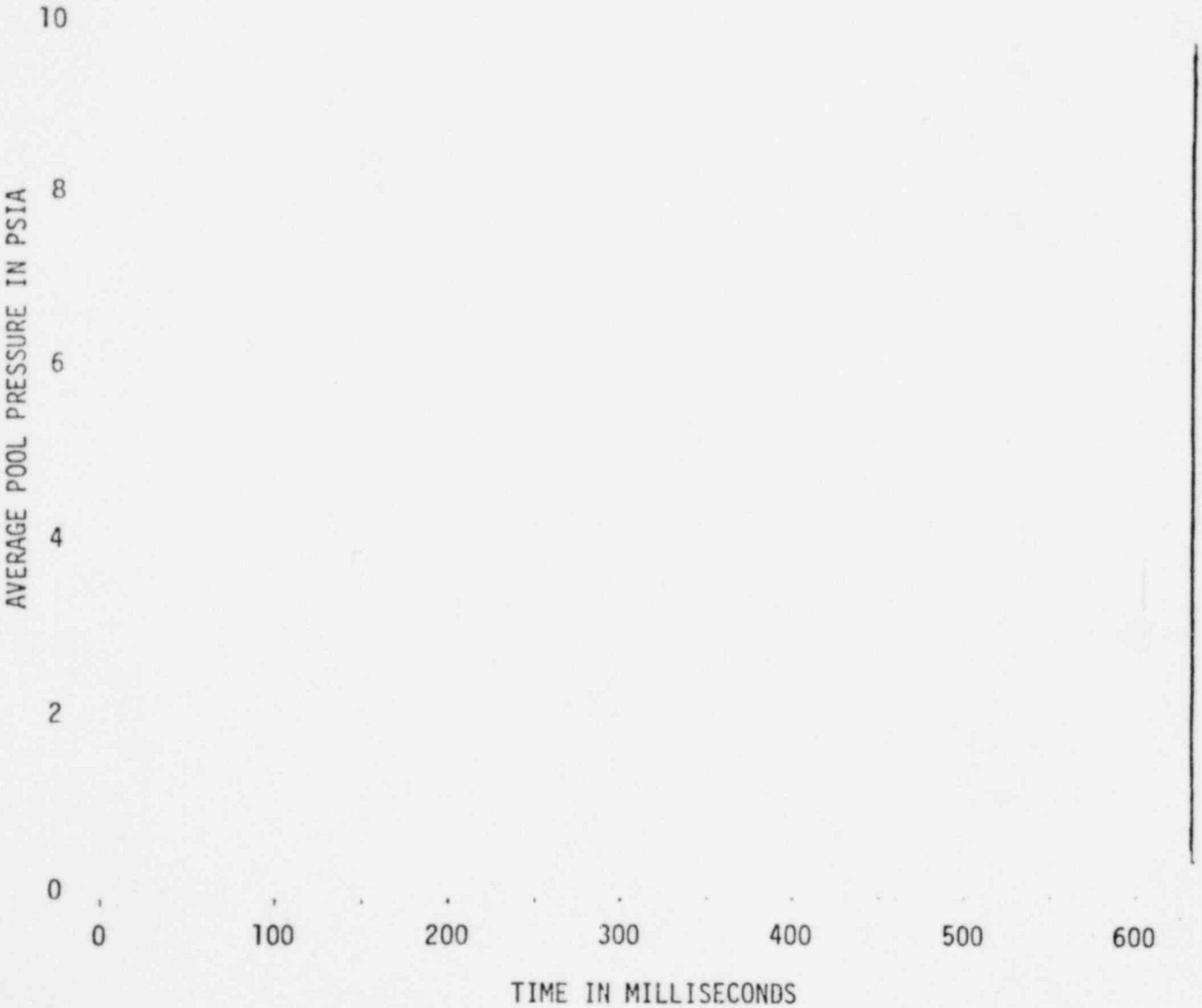


FIGURE A-464

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 5

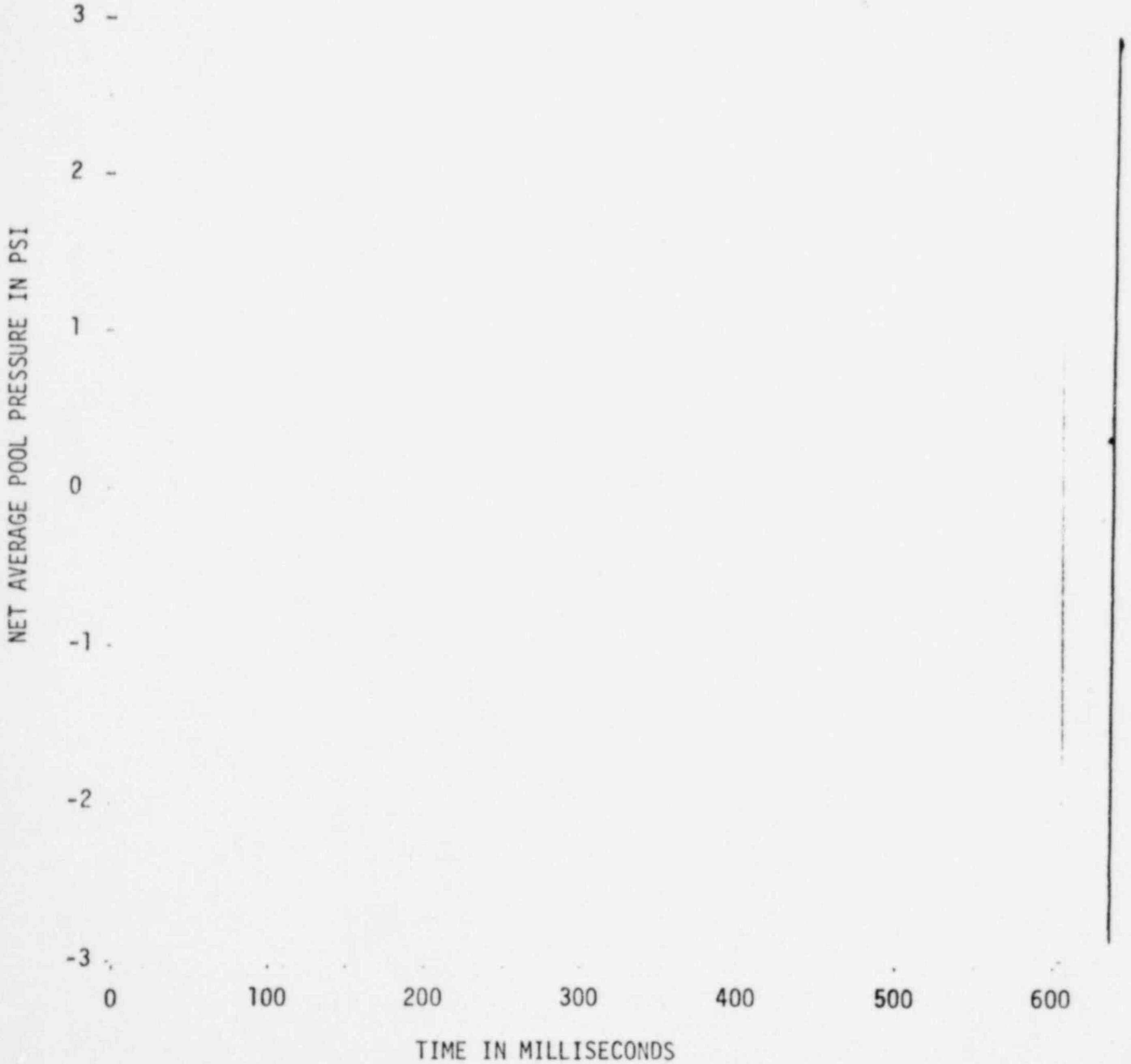


1349 313

FIGURE A-465

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3-2 Peach Bottom Test 5

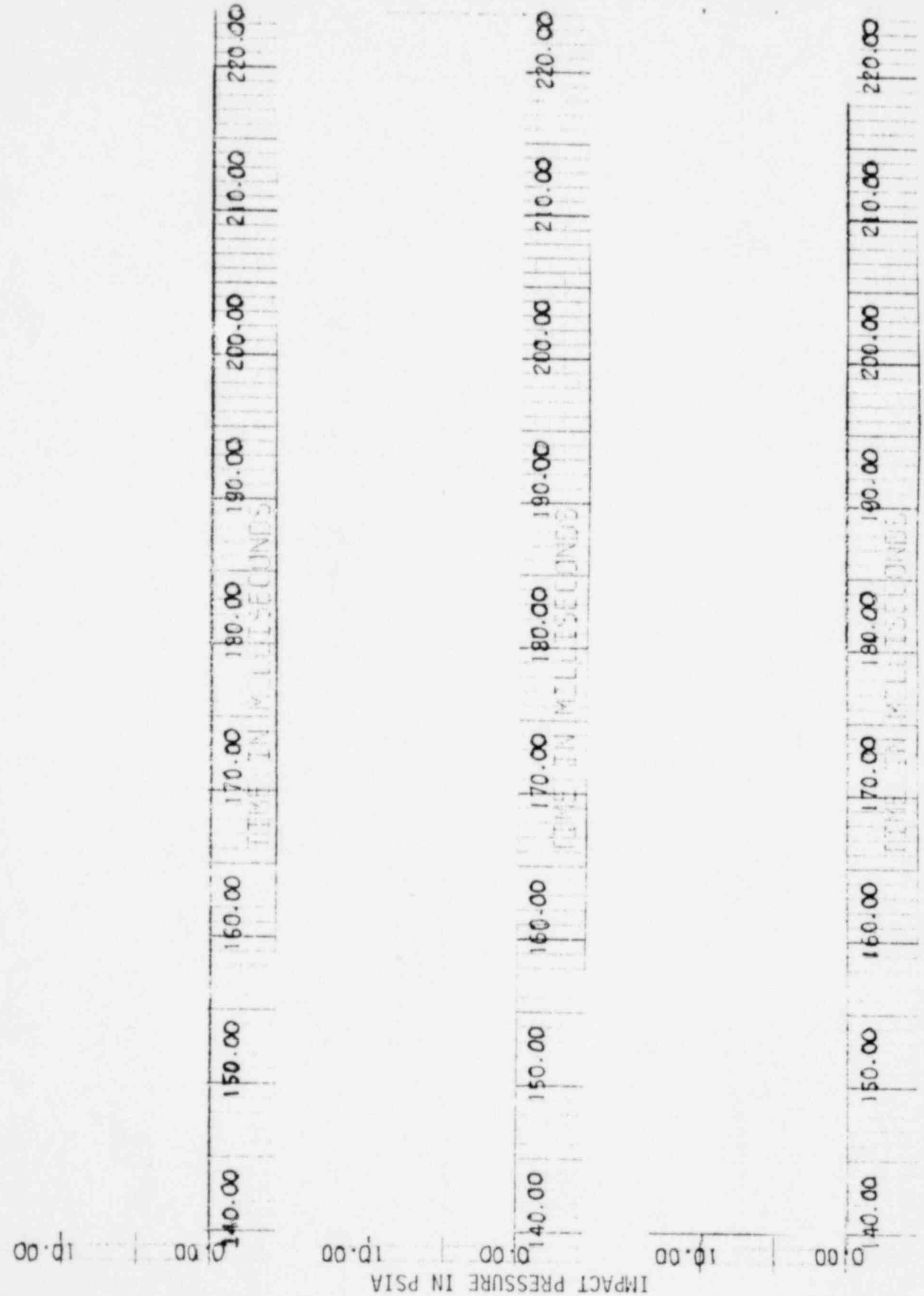


1349 314

FIGURE A-466

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Peach Bottom Test 3



1349 315

VENT HEADER IMPACT PRESSURES

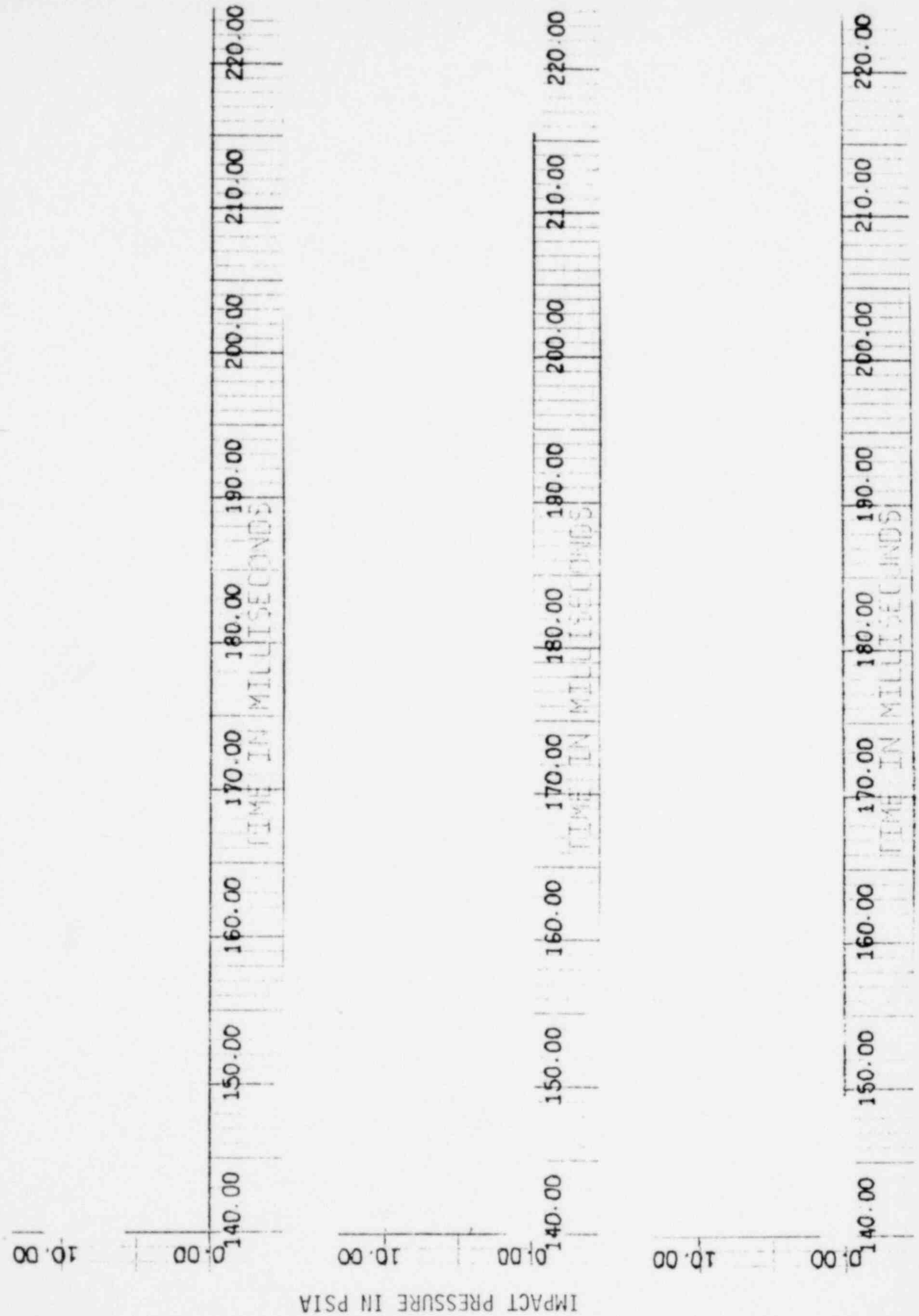
Task 5.5.3-2 Peach Bottom Test 3

1349 316

FIGURE A-468

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Peach Bottom Test 3

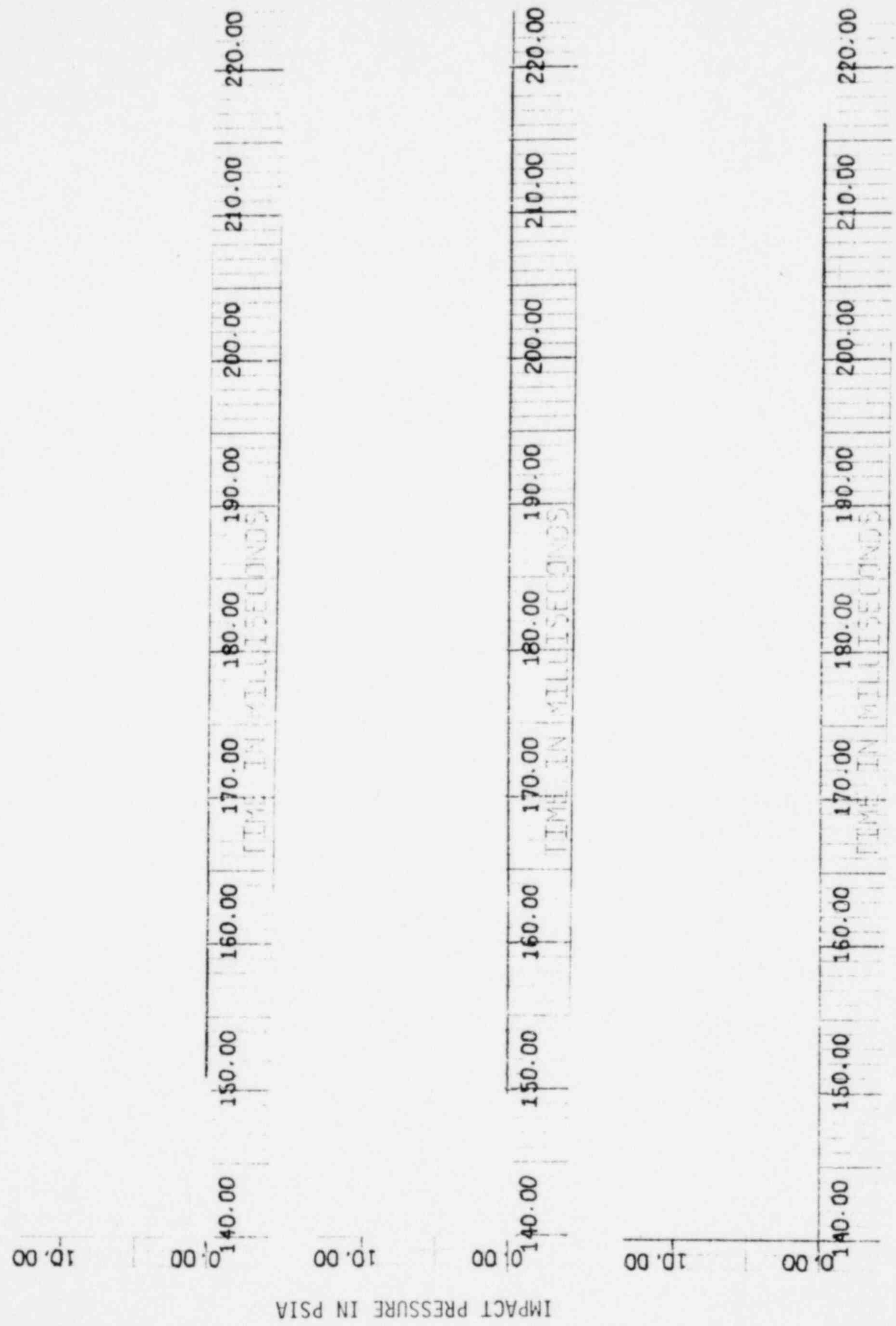


1349 317

FIGURE A-469

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Peach Bottom Test 3

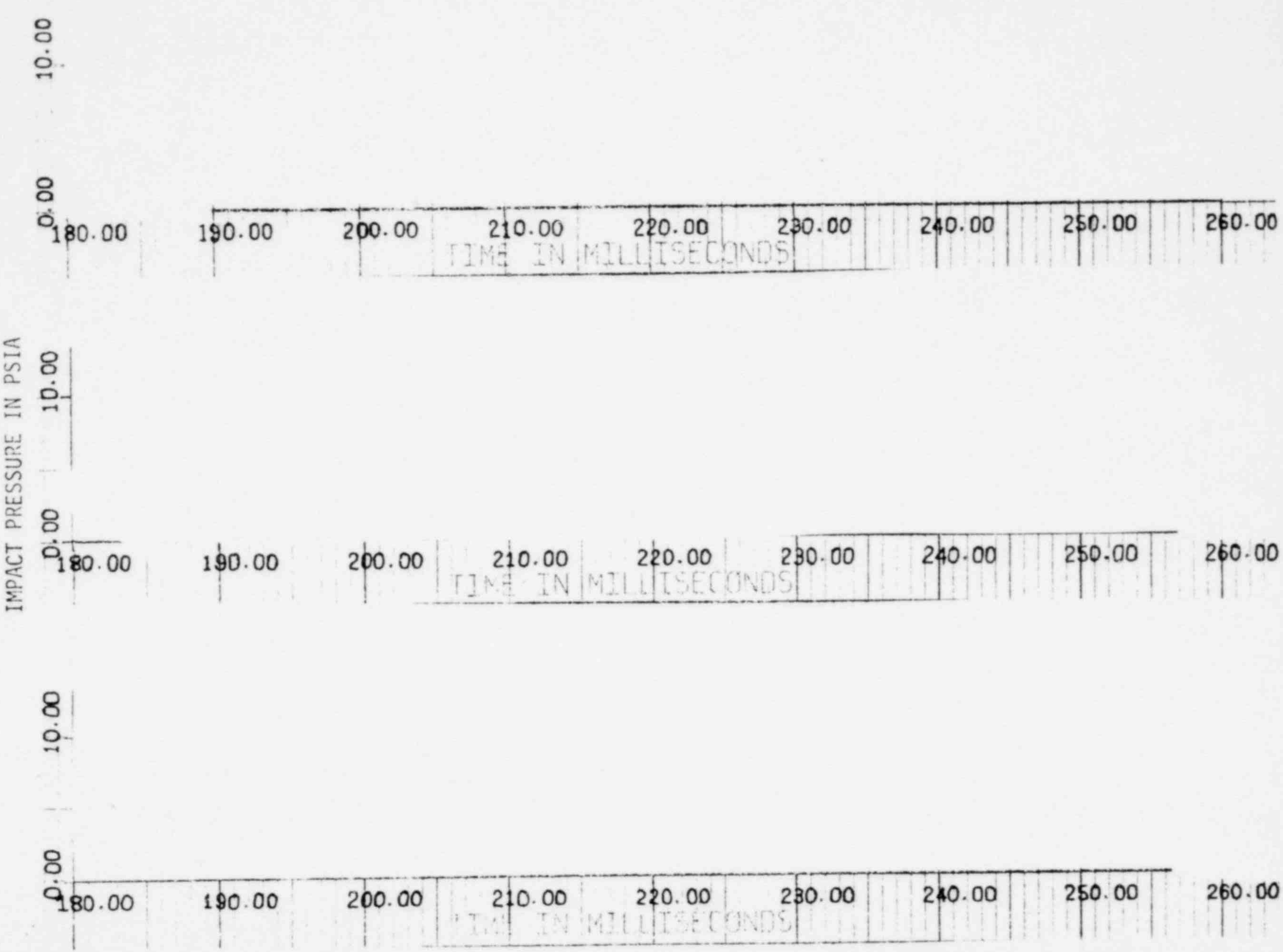


1349 318

FIGURE A-470

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Peach Bottom Test 5

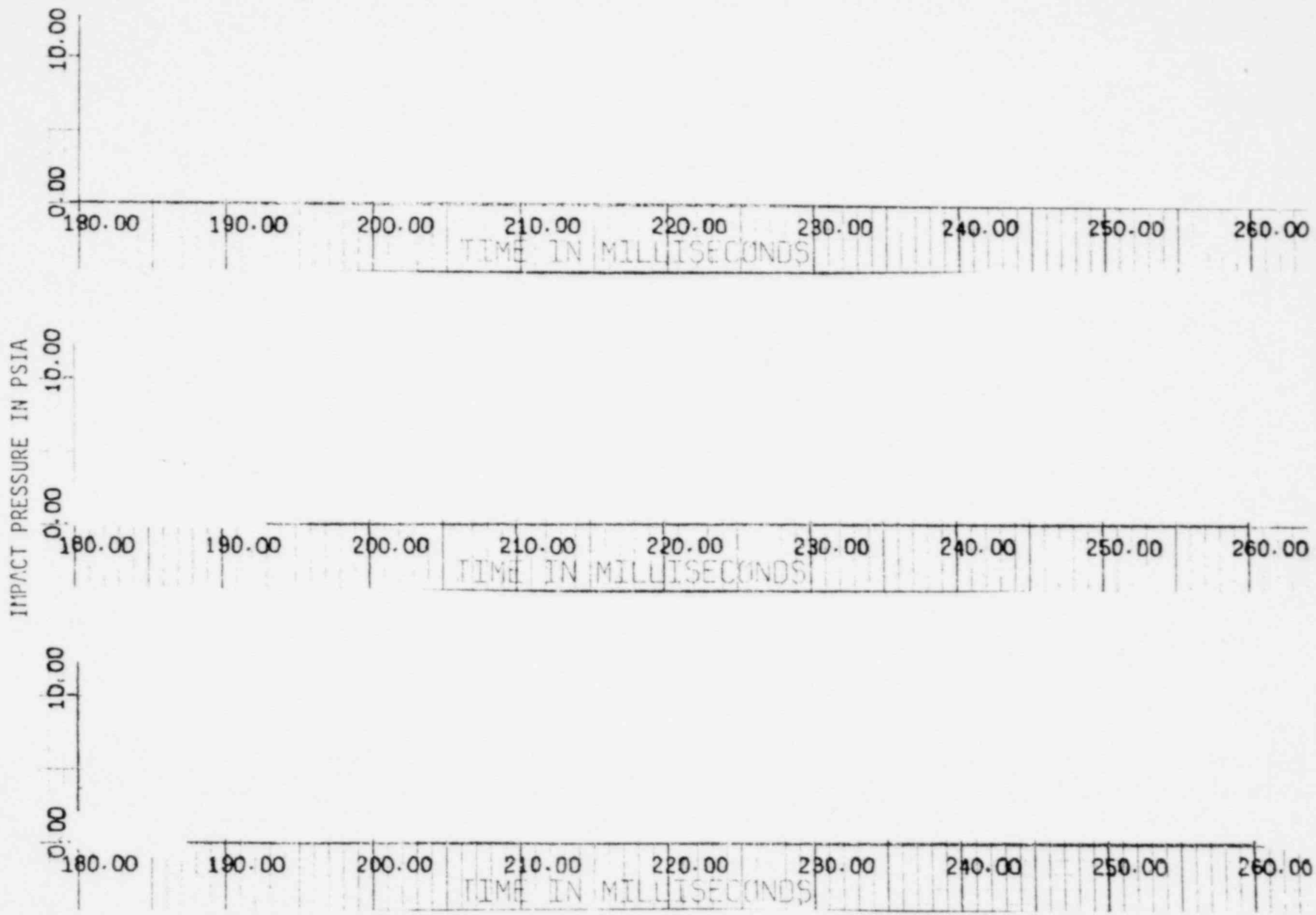


1349 319

FIGURE A-471

VENT HEADER IMPACT PRESSURES

Task 5.5.3-2 Peach Bottom Test 5

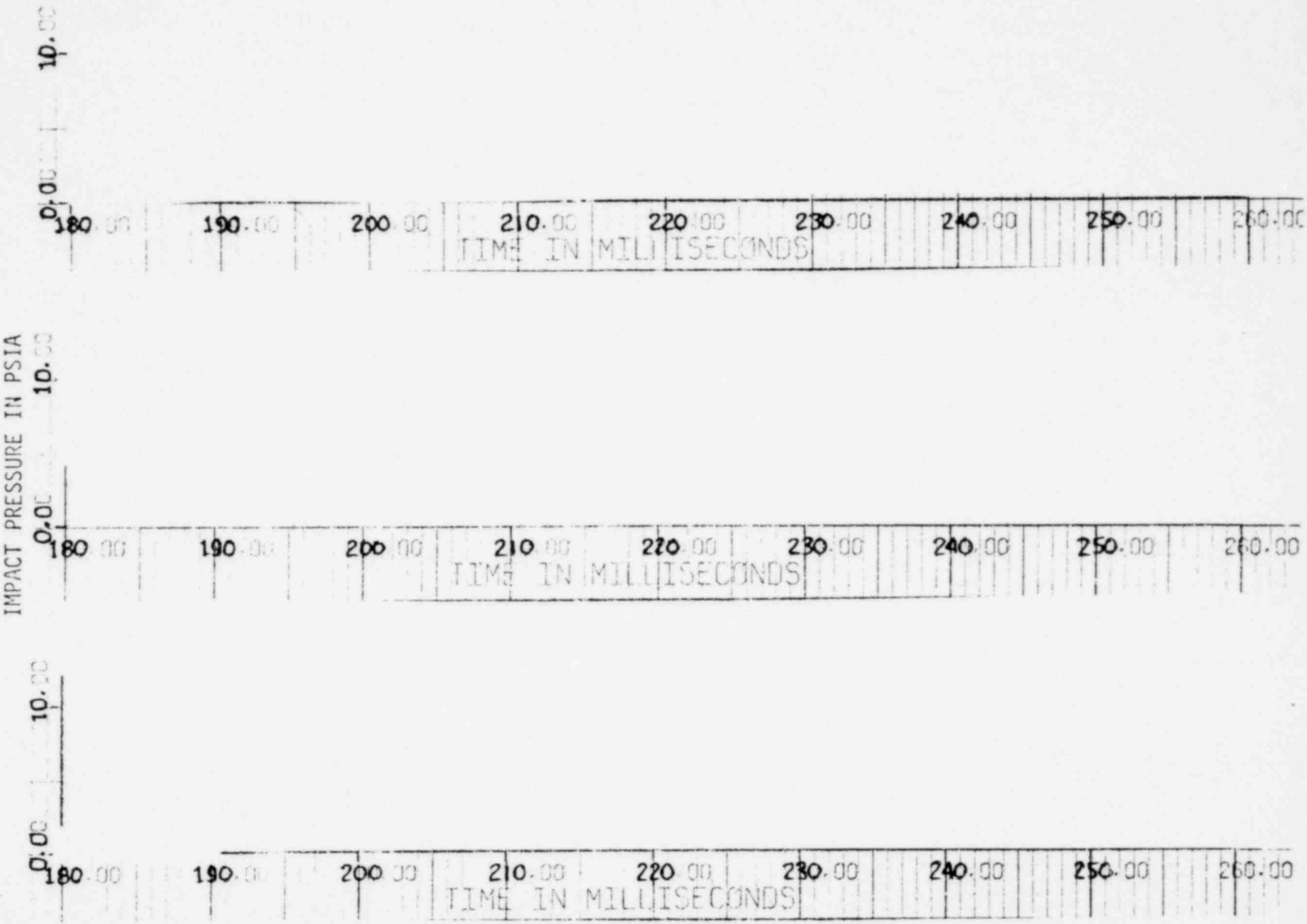


1349 320

FIGURE A-472

VENT HEADER IMPACT PRESSURES

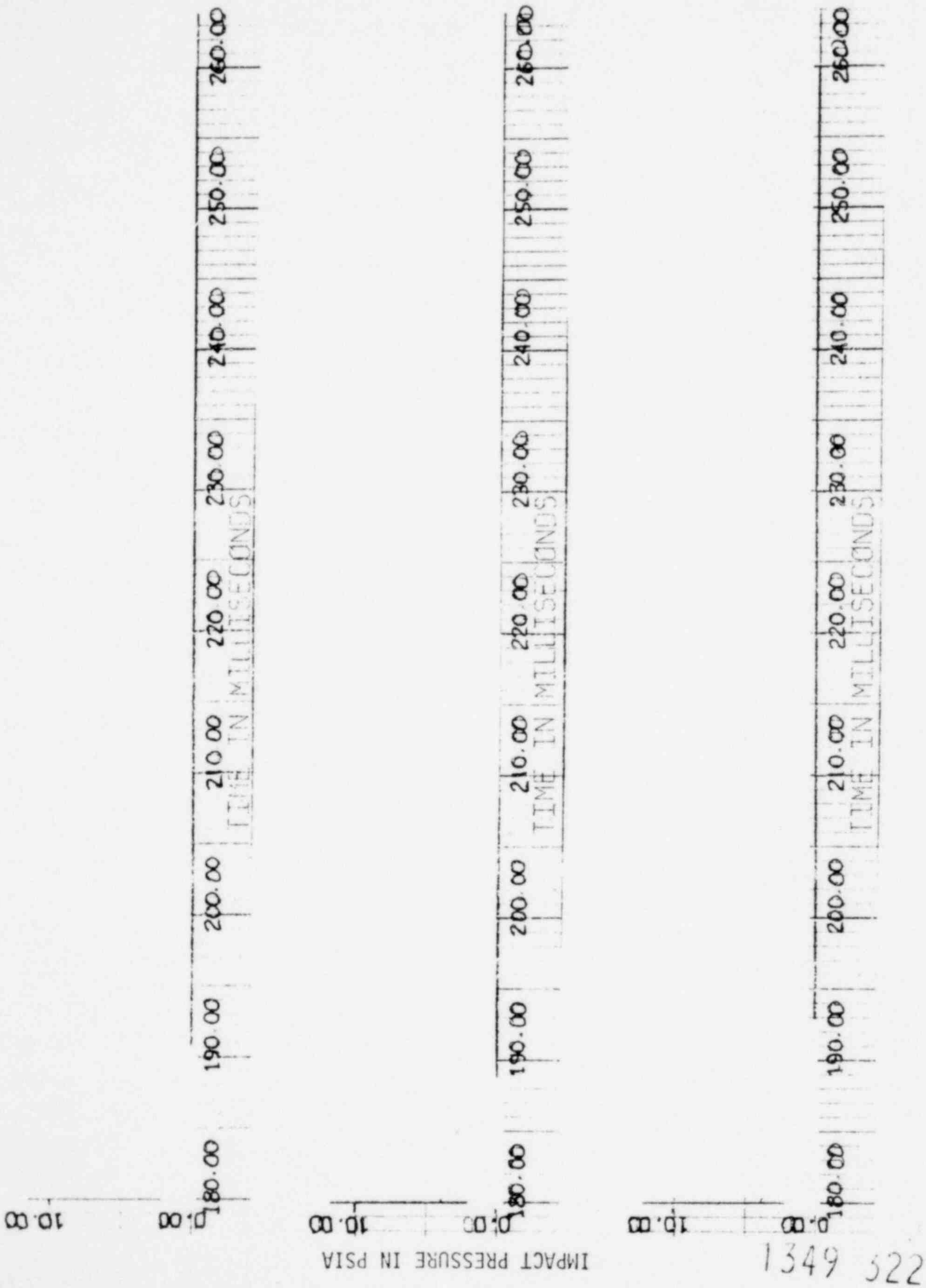
Task 5.5.3-2 Peach Bottom Test 5



1349 321

VENT HEADER IMPACT PRESSURES

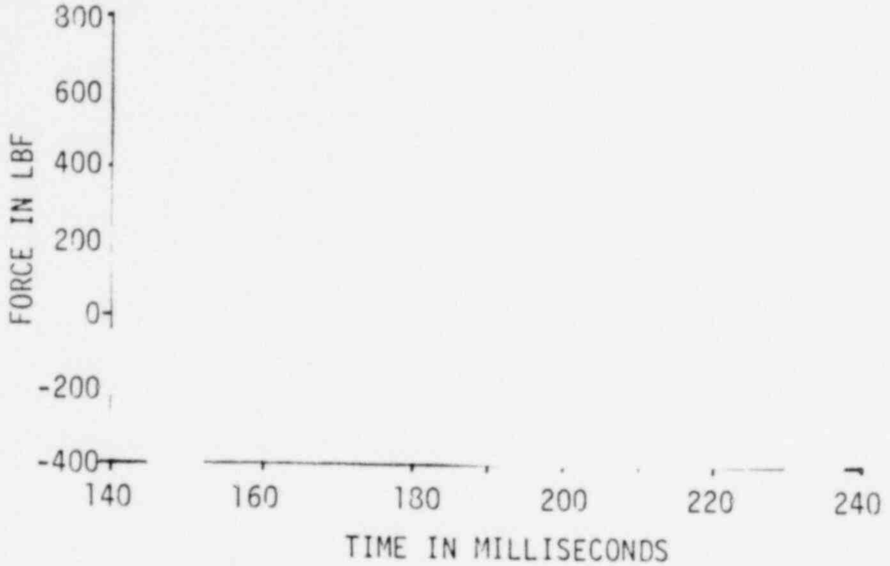
Task 5.5.3-2 Peach Bottom Test 5

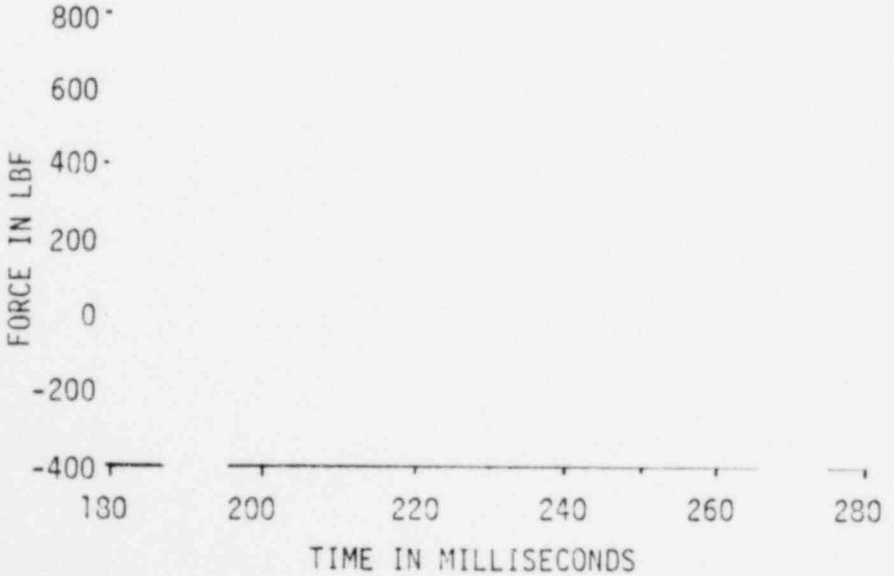


1349 322

FIGURE A-474

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



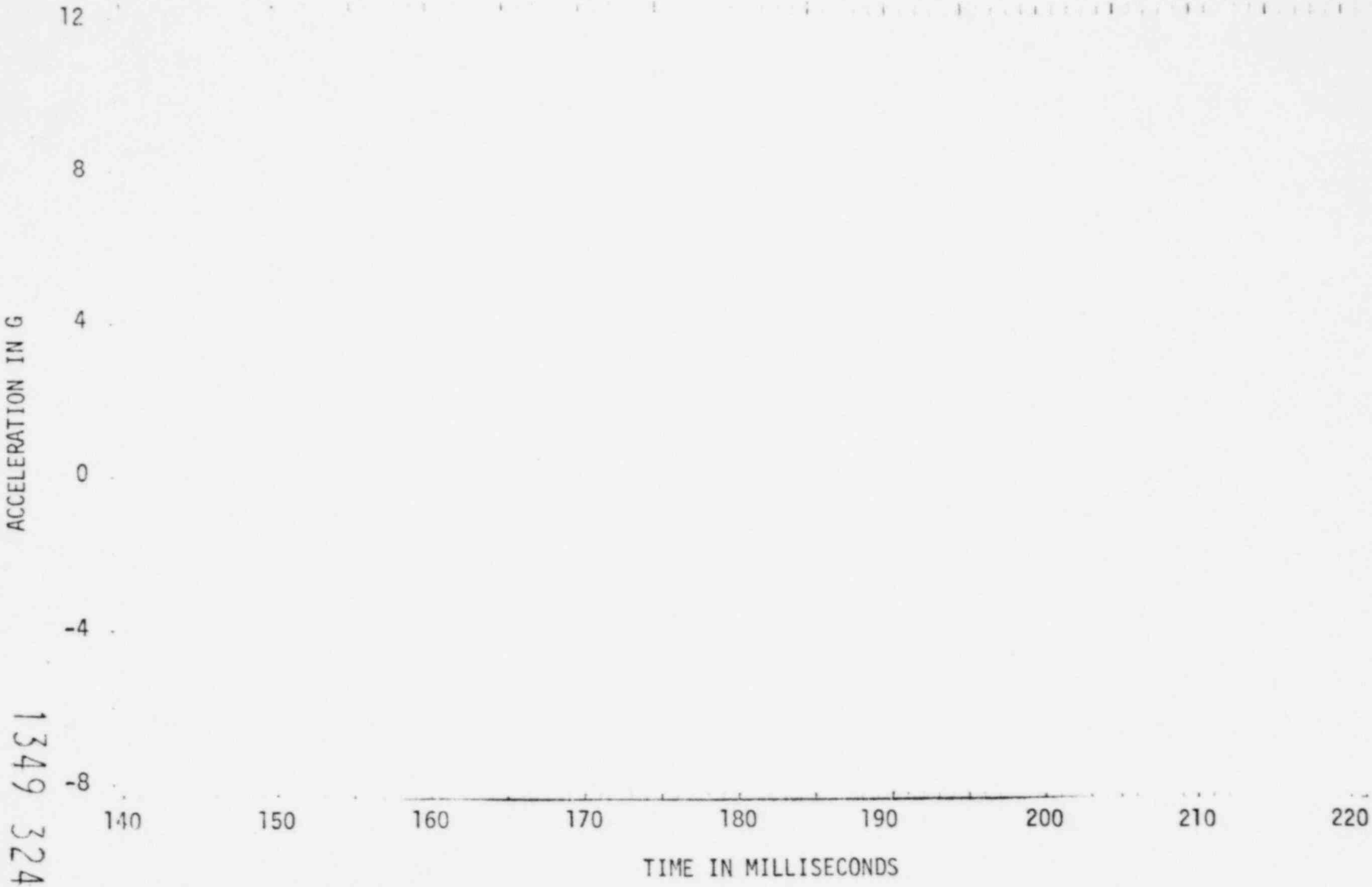


1349 323

FIGURE A-475

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3-2 Peach Bottom Test 3



1349 324

FIGURE A-476

VENT HEADER VERTICAL ACCELERATION

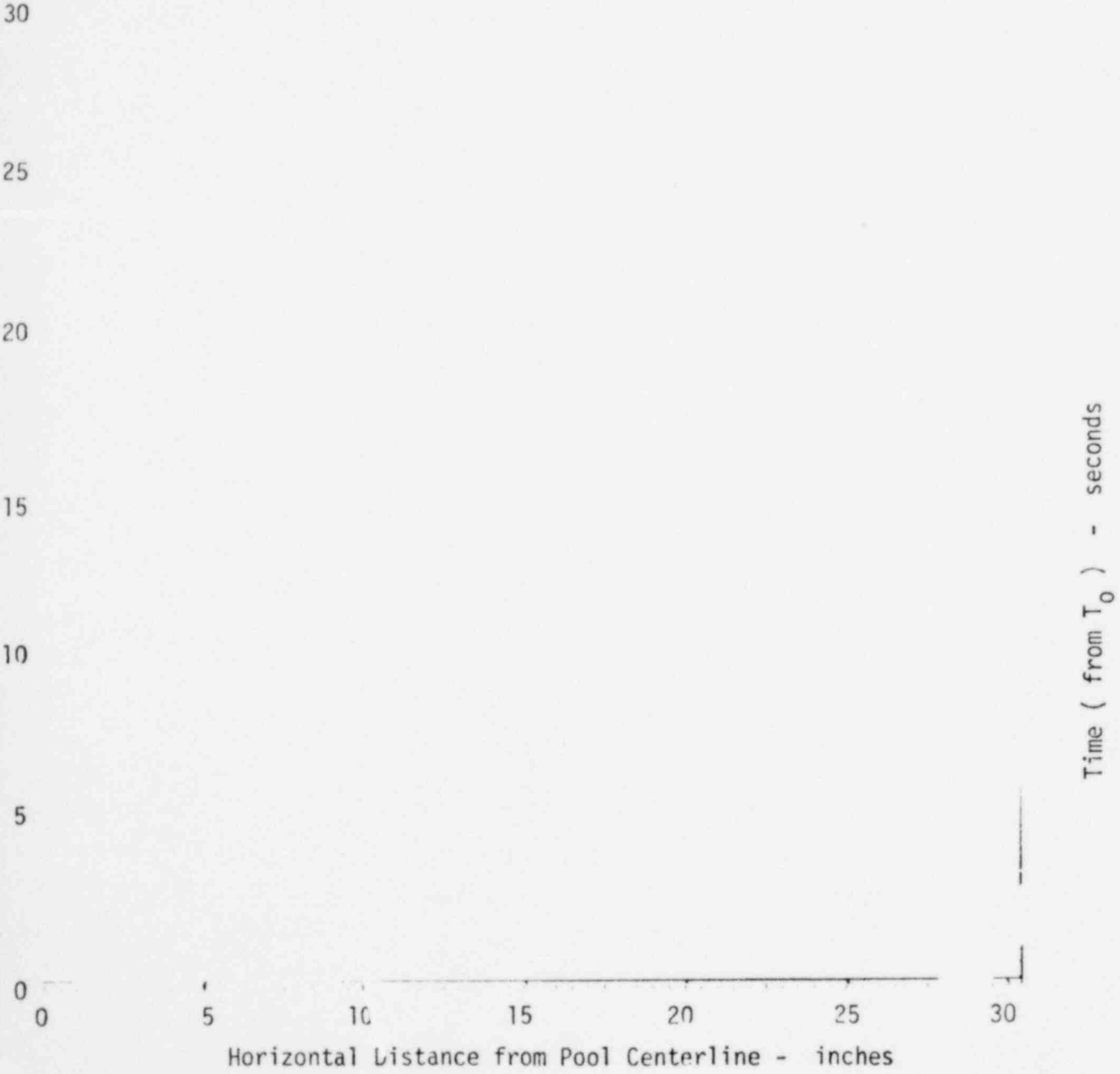
Task 5.5.3-2 Peach Bottom Test 5

1349 325

FIGURE A-477

TIME HISTORY OF
POOL DISPLACEMENT

PEACH BOTTOM, TEST 1



1349 326

FIGURE A-478

TIME HISTORY OF
POOL DISPLACEMENT

PEACH BOTTOM, 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 327

FIGURE A-479

TIME HISTORY OF
POOL DISPLACEMENT

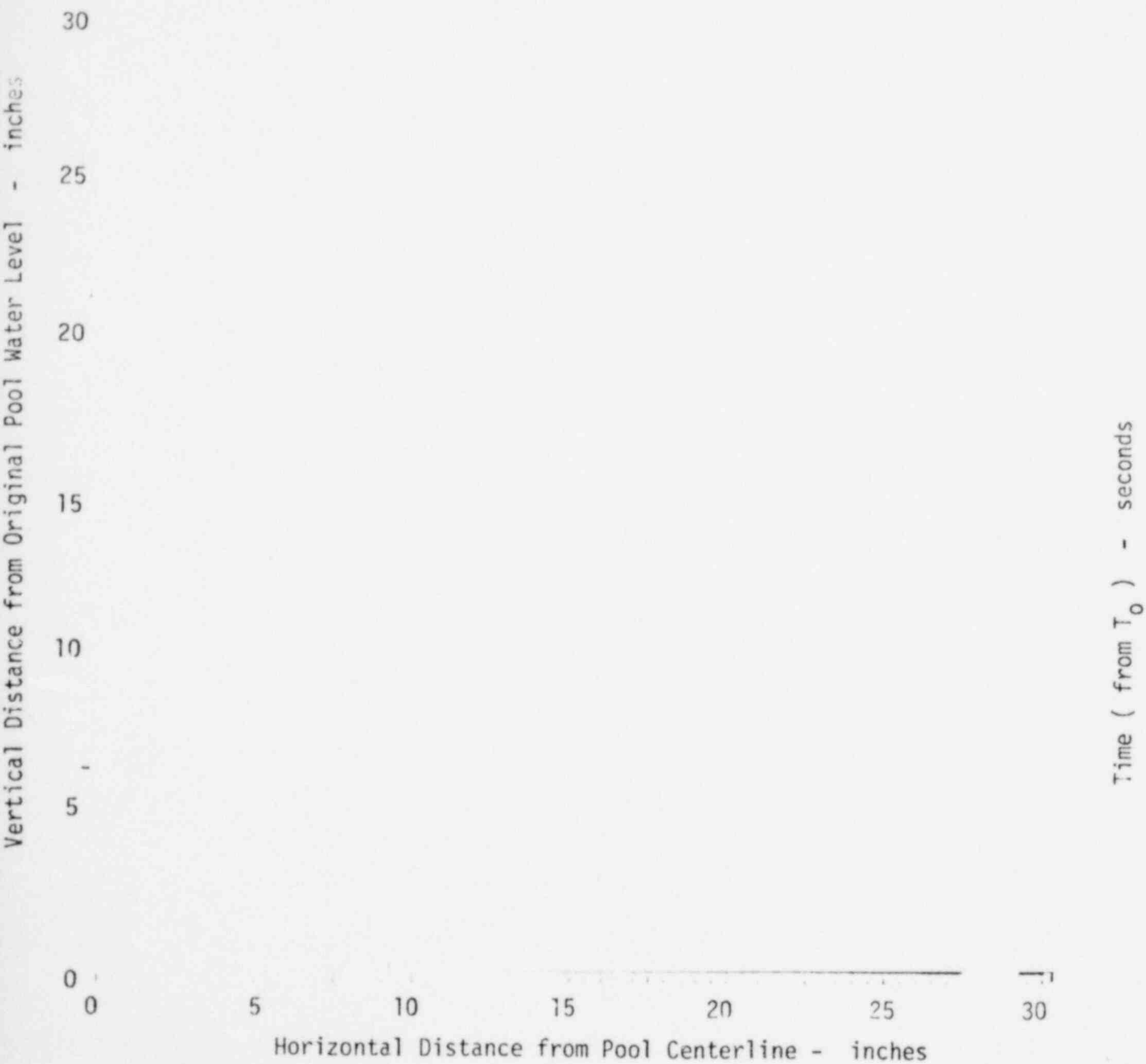
PEACH BOTTOM, TEST 3

1349 328

FIGURE A-480

TIME HISTORY OF
POOL DISPLACEMENT

PEACH BOTTOM, TEST 5



1349 329

POOL SURFACE DISPLACEMENT

FIGURE A-481

PEACH BOTTOM, TESTS 1, 2, 3

1349 330

POOL SURFACE VELOCITY PROFILES

FIGURE A-482

PEACH BOTTOM, TESTS 1, 2, 3

1349 331

POOL SURFACE DISPLACEMENT

FIGURE A-483

PEACH BOTTOM, TEST 5

Height above original pool surface - inches

25

20

15

10

5

0

0 100 200 300 400

Time- milliseconds

1349 332

POOL SURFACE VELOCITY PROFILES

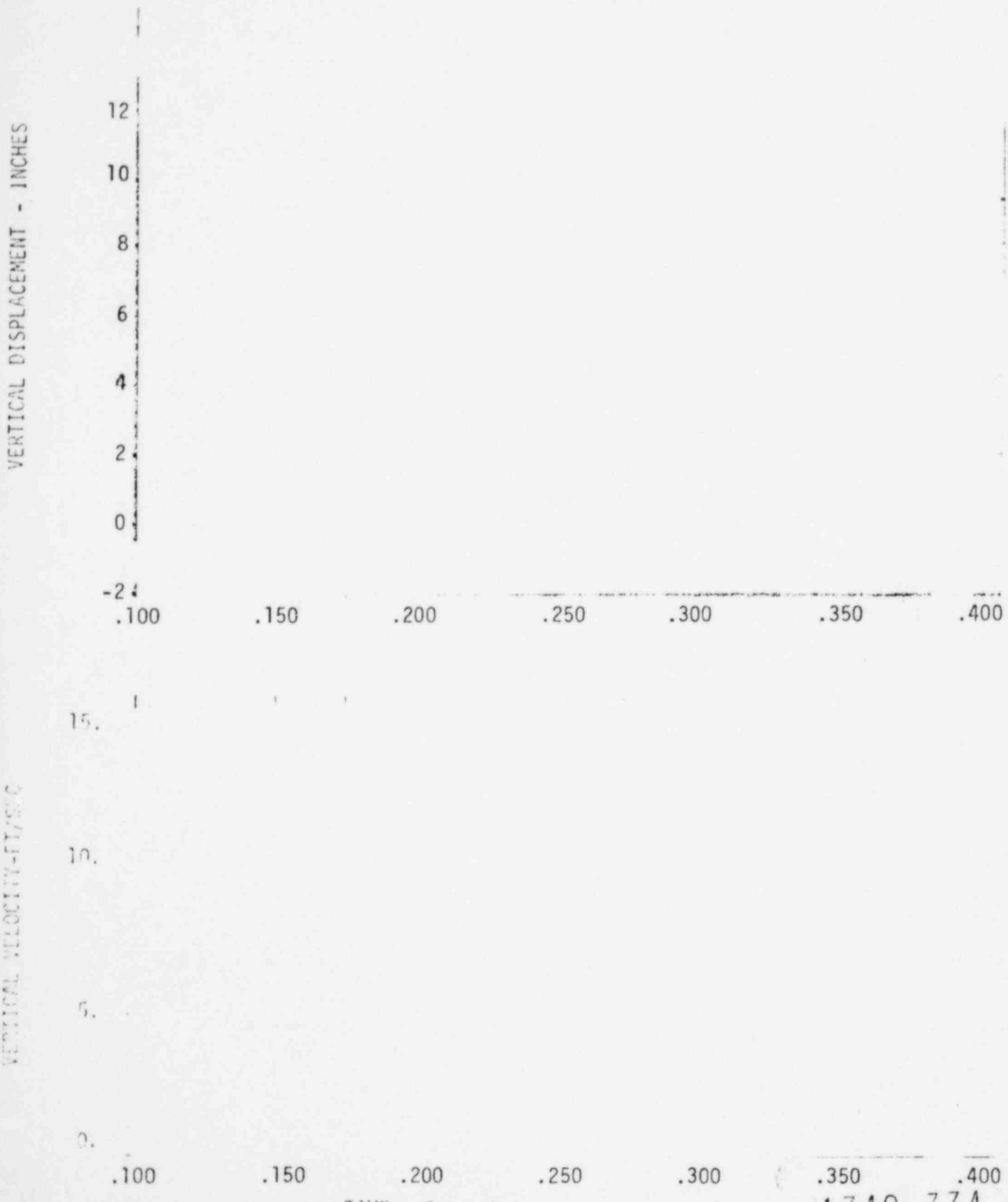
FIGURE A-484 PEACH BOTTOM, TEST 5

1349 333

FIGURE A-485

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

PEACH BOTTOM, TEST 4

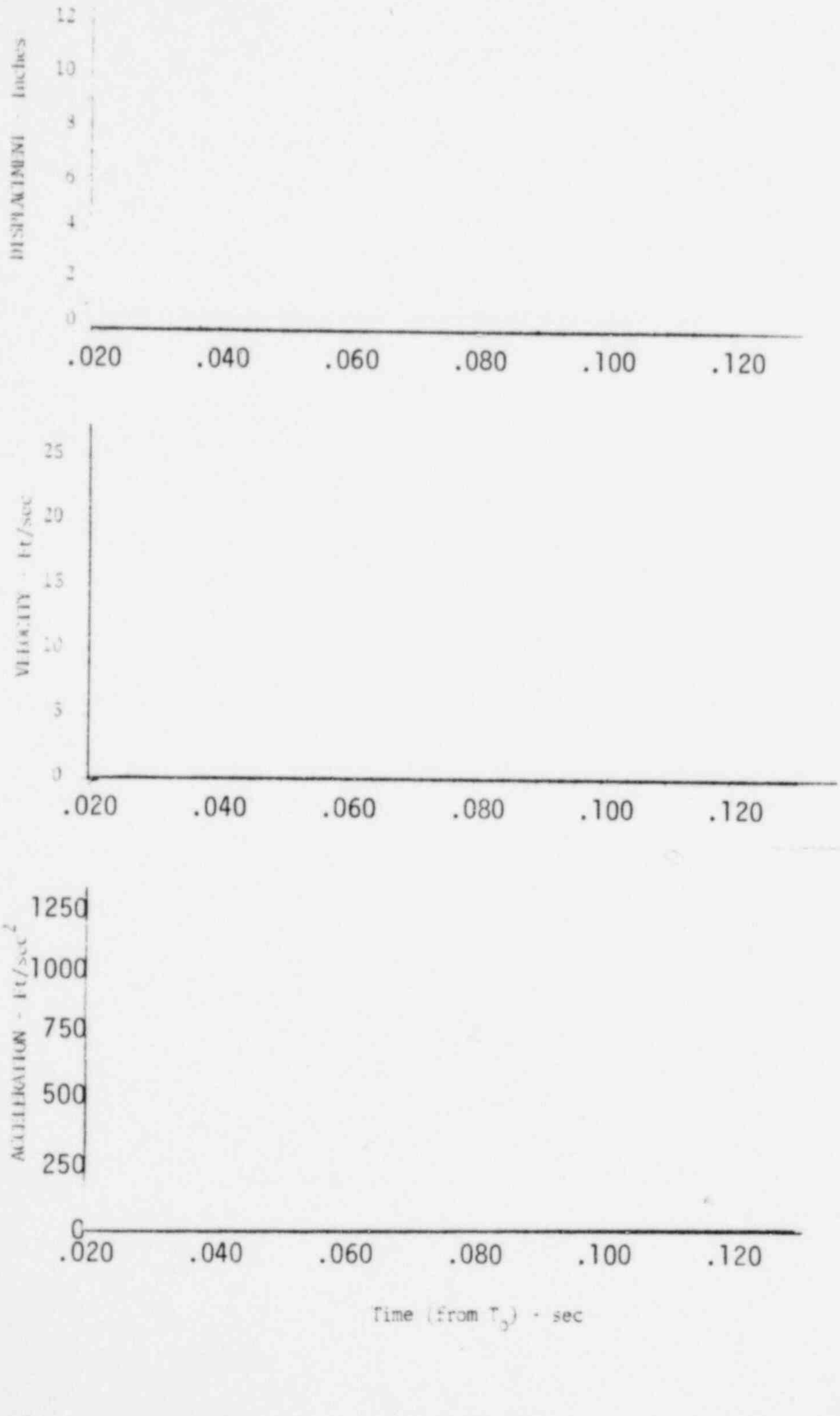


1349 334

FIGURE A-486

DOWNCOMER WATER SLUG EJECTION

PEACH BOTTOM, TEST 3

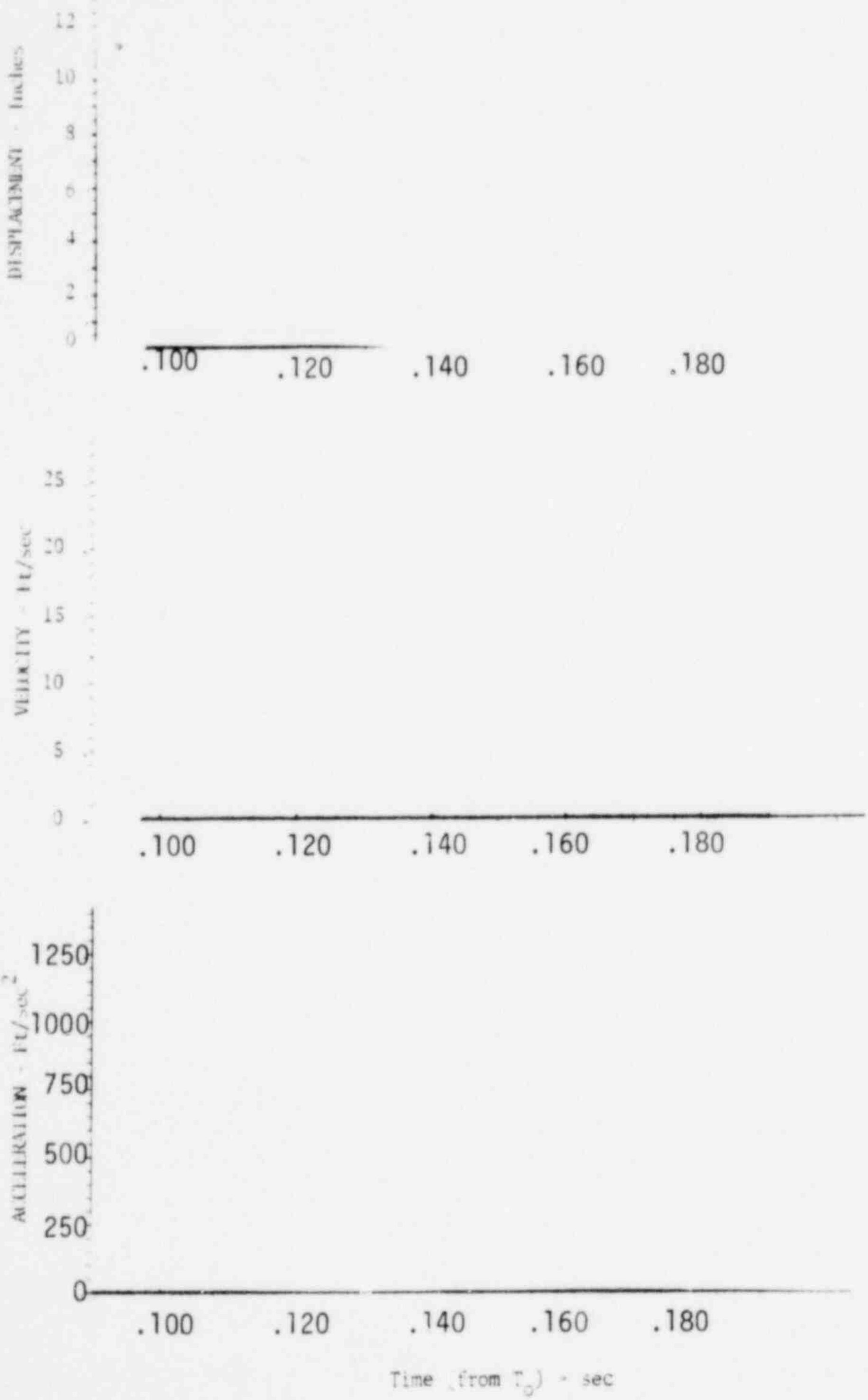


1349 335

FIGURE A-487

DOWNCOMER WATER SLUG EJECTION

PEACH BOTTOM, TEST 5



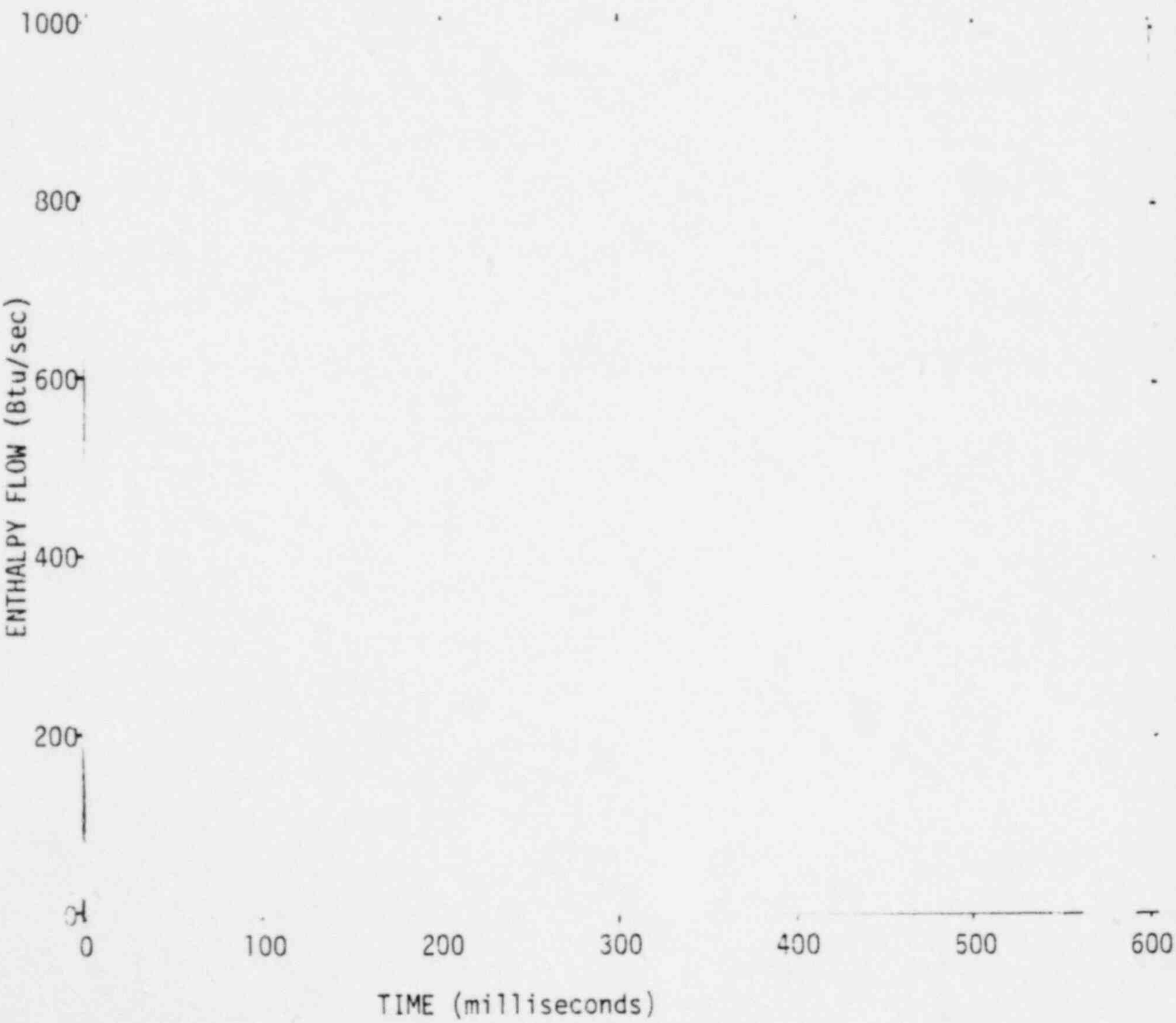
1349 336

FIGURE A-488

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Peach Bottom Tests



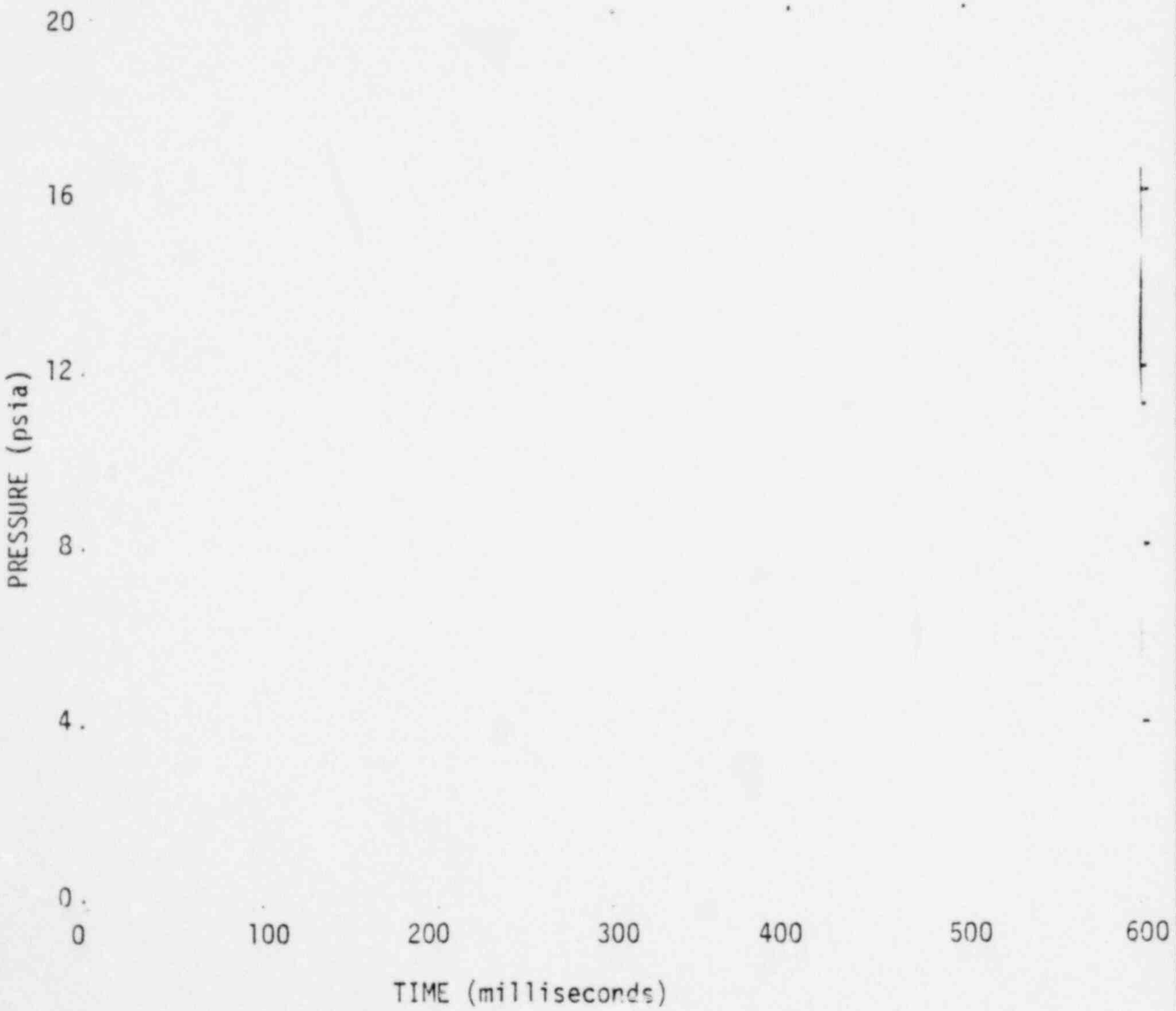
1349 337

FIGURE A-489

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Peach Bottom Tests



1349 338

FIGURE A-490

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Peach Bottom Tests

1349 339

TABLE A-21

*Time at force is zero (from T_o)

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3-2 Peach Bottom Tests

Parameter \ Test No.	7.61" ΔP, 6.5" Winged Deflector (26" 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)							

1340 740

TABLE A-21

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3-2 Peach Bottom 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.	7.61" ΔP, 6.5" Winged Deflector (26" 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 341

TABLE A-22

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2 Peach Bottom Tests

Parameter \ Test No.		7.61" ΔP, 4.50"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.

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

1349 342

A.11 Millstone Tests

A.11.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Millstone Tests 3 and 5. Tests 3 was a load definition test which was conducted at drywell/wetwell differential pressure of 8.73" H_2O. Test 5 was a ΔP sensitivity test which was conducted without an initial drywell/wetwell differential pressure (0" H_2O ΔP). The Millstone tests were conducted with a pipe vent header deflector having side angle extensions (winged deflector).

A.11.1.1 Driving Conditions

Driving conditions for Millstone Test 3 are presented in Figures A-491 through A-495. Similar plots for Millstone Test 5 are shown in Figures A-496 through A-500. Millstone driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.11.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Millstone Tests 3 and 5 are presented in Figures A-501 through A-502 and A-503 through A-504, respectively. For the load definition tests, net torus force from spatial integration of the measured wetwell pressure (Figure A-505) indicates some downforce oscillations which dampen out rapidly after the peak downforce. For the zero ΔP test, the torus pressure integral shows a pronounced downforce oscillation which is thought to be caused by bubble pressure variations during vent clearing (Figure A-506). Net torus force is also determined from the torus load cell (Figures A-507 and A-509) by applying inertial correction with the torus accelerometer (Figures A-508 and A-510) and subtracting the initial weight of the torus. Figures A-511 and A-512 show reasonably good agreement between the

net torus force based on the torus pressure integral and the corrected load cell during Millstone Tests 3 and 5. Figures A-513 and A-514 present the net torus force based on the torus pressure integral, corrected for inertia.

The "average" pool pressures for Millstone Tests 3 and 5 are shown in Figures A-515 and A-517. Figures A-516 and A-518 are the same as Figures A-513 and A-514 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Millstone Test 3 are presented in Figures A-519 through A-523. Vent header impact pressures for Millstone Test 5 are presented in Figures A-524 through A-528. These figures indicate that the deflector was effective in reducing vent header impact pressures. A comparison of the vent header force from the corrected load cell with the pressure integral (Figure A-529) shows reasonably good agreement. Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-530 and A-531, respectively.

A.11.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-532 through A-535 for Millstone Tests 1, 2, 3, and 5. Tests 1, 2, and 3 were performed at a drywell/wetwell differential pressure of 8.73" H_2O, while Test 5 was performed at 0" ΔP.

Pool surface displacement curves for Tests 1, 2, and 3 are shown in Figure A-536. The pool velocity profiles are shown in Figure A-537. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-538 and A-539, respectively. The Test 4 pool surface displacement graph and velocity profile (as viewed from the side window) is shown in Figure A-540.

1349 344

The downcomer water slug displacement, velocity, and acceleration plots for Tests 3 and 5 are presented in Figures A-541 and A-542, respectively.

A.11.3 Data Summaries

Table A-23 presents the Millstone test data for wetwell vertical forces.

Table A-24 presents the Millstone test data for vent header impact forces.

A.11.4 Discussion and Analysis

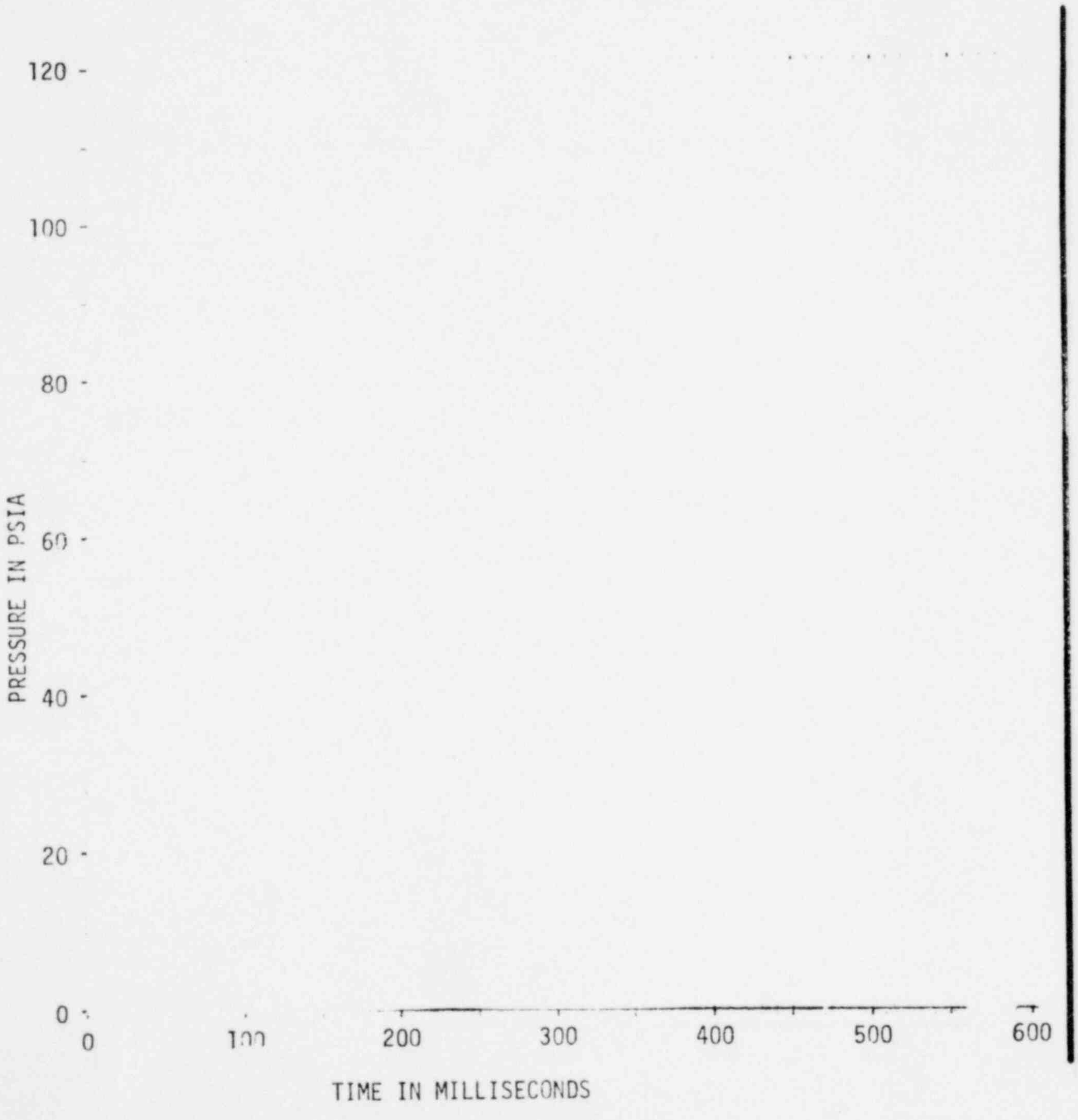
Figure A-543 presents the effect of drywell/wetwell ΔP on enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-544. Figure A-545 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. This data for Millstone parallels that for the "typical" plant in Section 3.0.

The Millstone load definition tests were conducted at 8.73" H_2O ΔP and with a winged pipe deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. Both the downforce and upforce showed some oscillations. The winged pipe deflector (19.5" full scale) effectively reduced vent header impact force.

FIGURE A-491

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Millstone Test 3

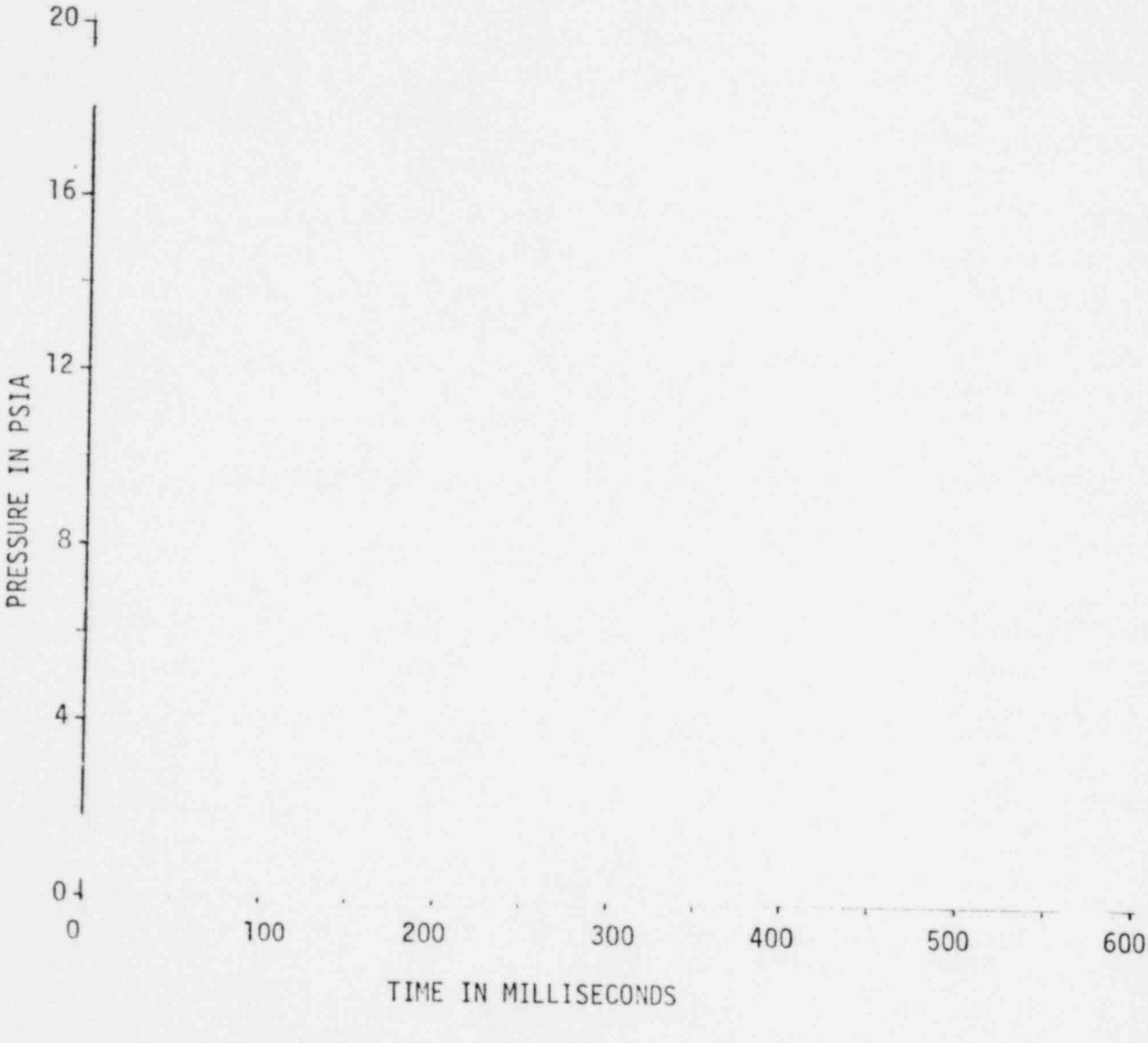


1349 346

FIGURE A-492

DRYWELL PRESSURE

Task 5.5.3 Millstone Test 3

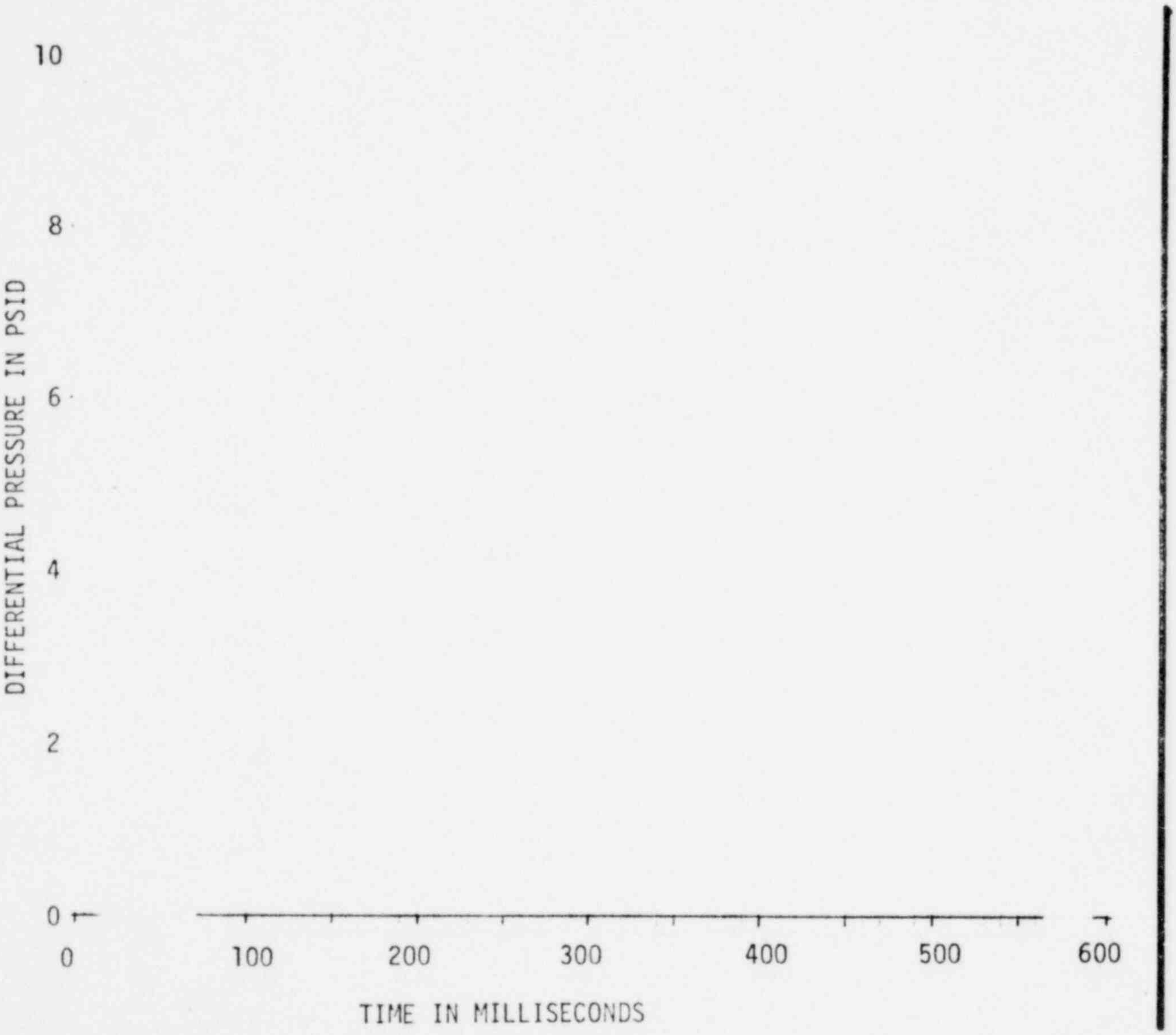


1349 347

FIGURE A-493

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Millstone Test 3

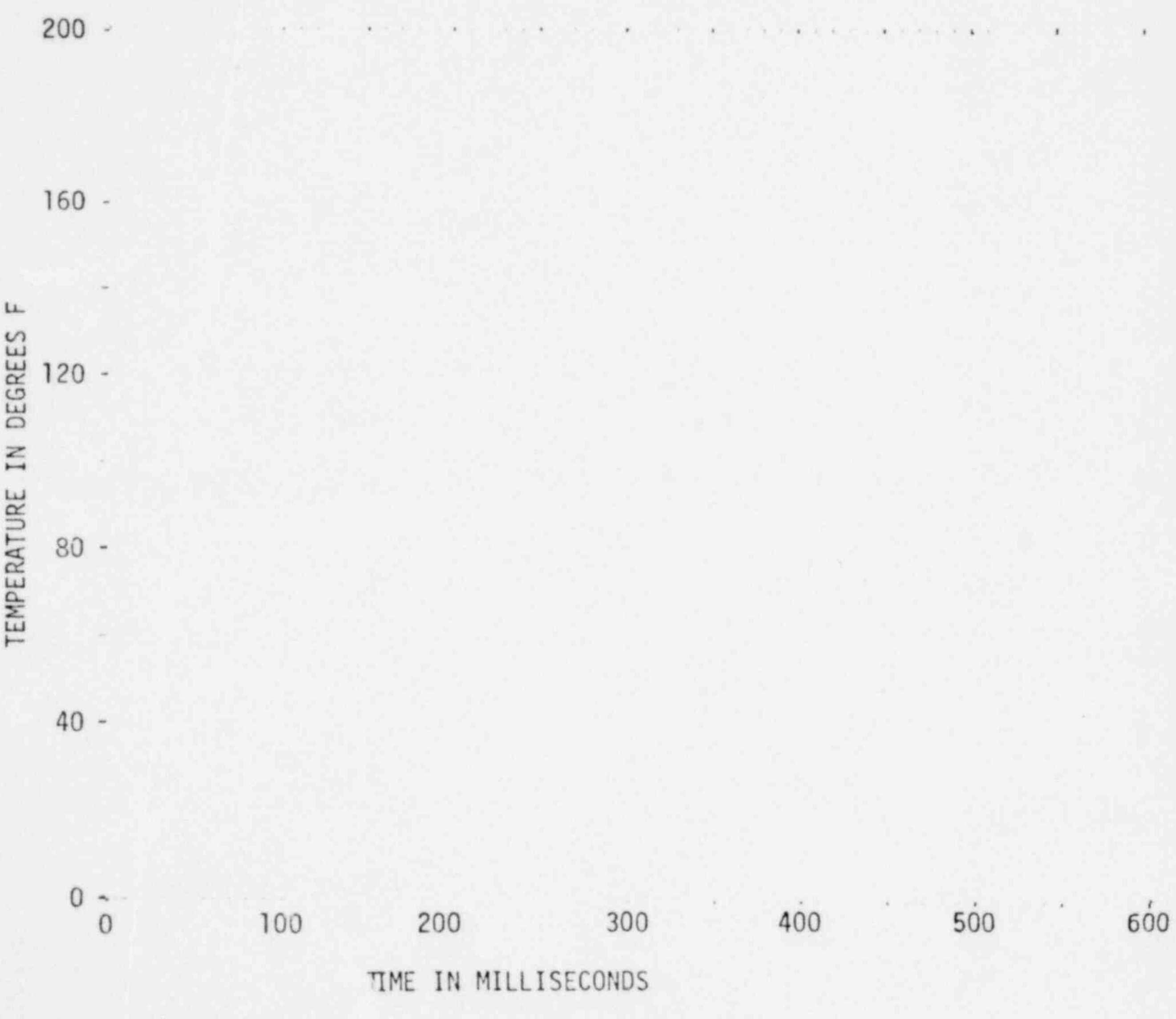


1349 348

FIGURE A-494

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Millstone Test 3

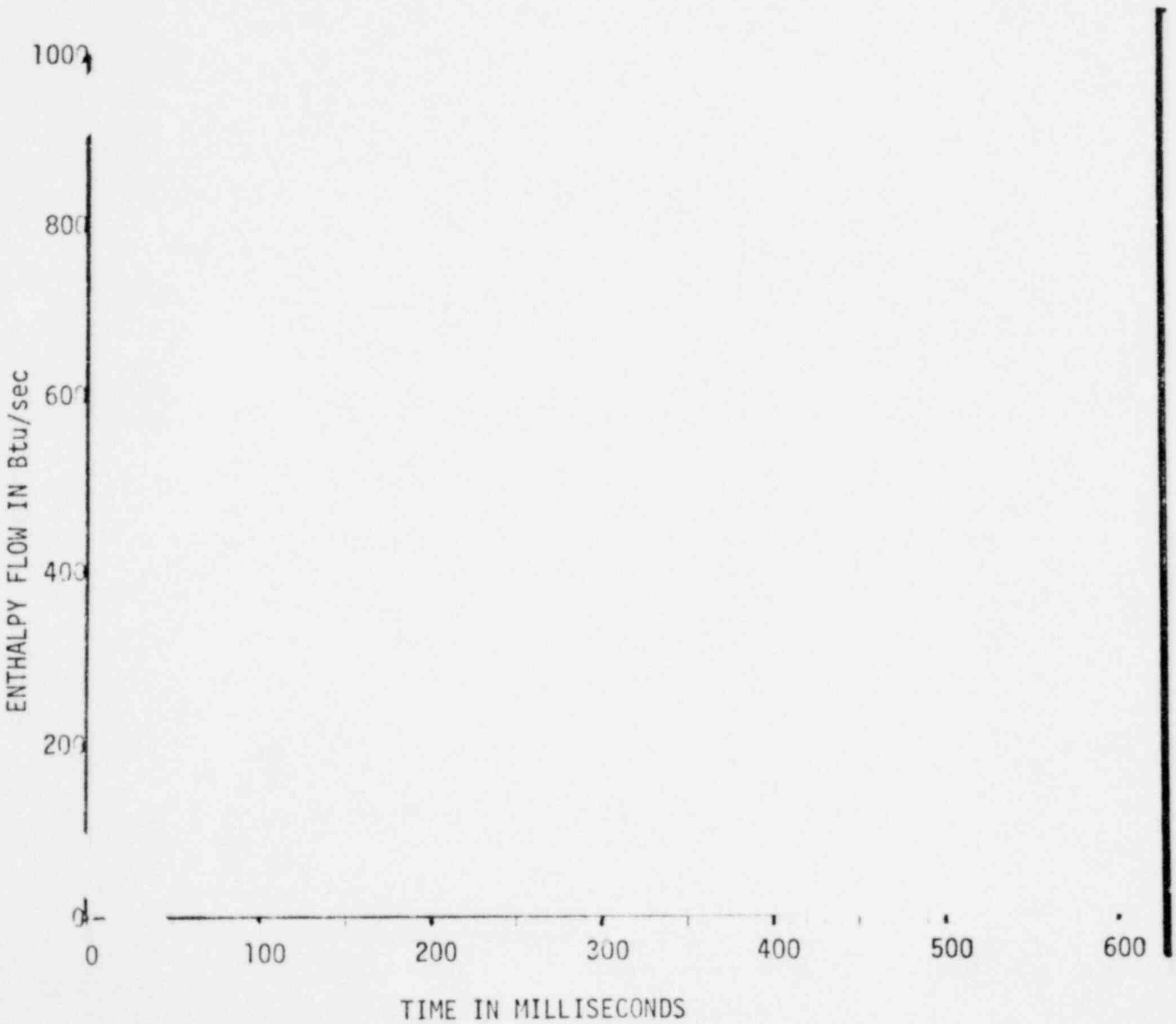


1349 349

FIGURE A-495

ENTHALPY FLOW INTO POOL

Task 5.5.3 Millstone Test 3

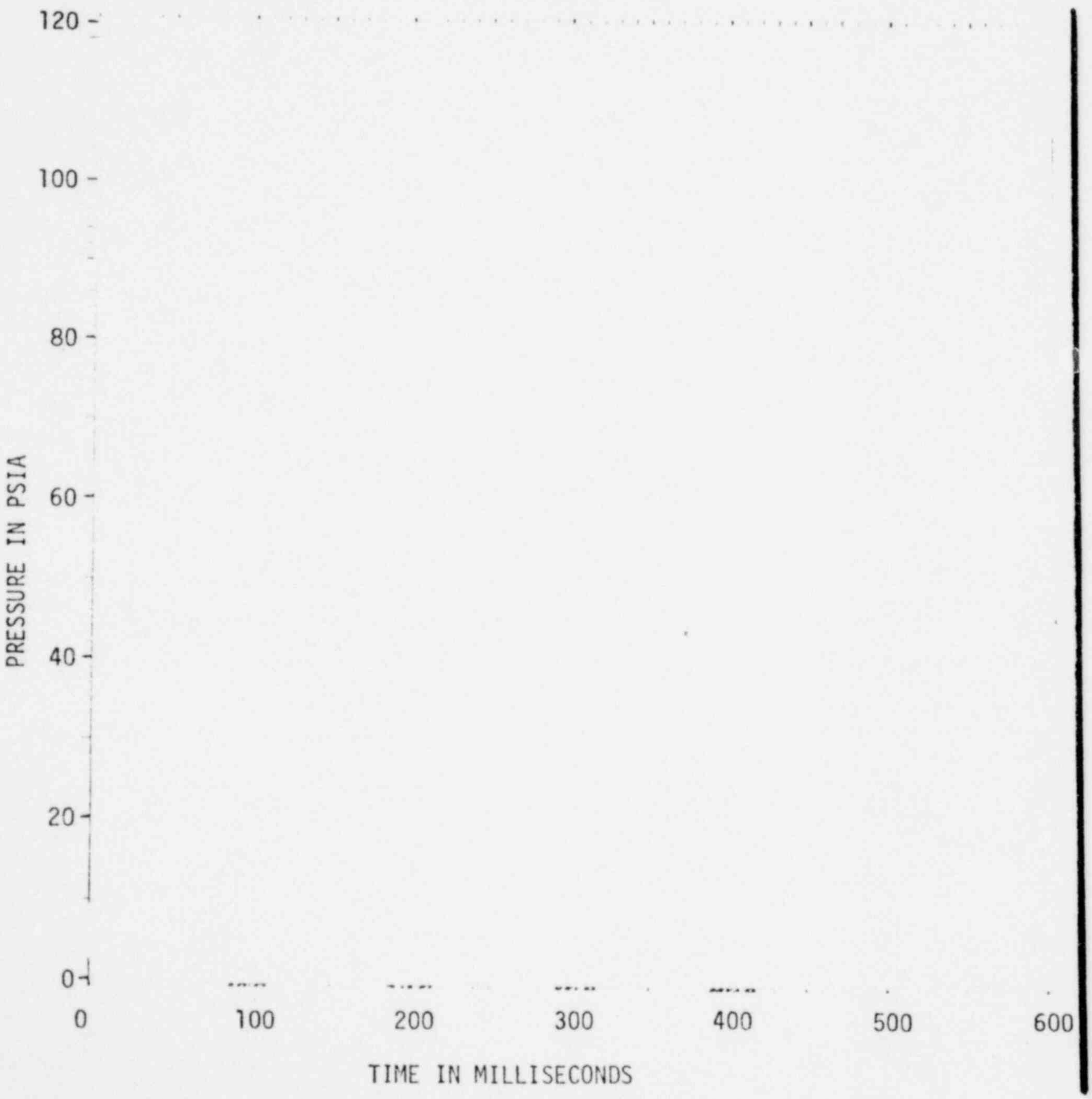


1349 350

FIGURE A-496

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Millstone Test 5

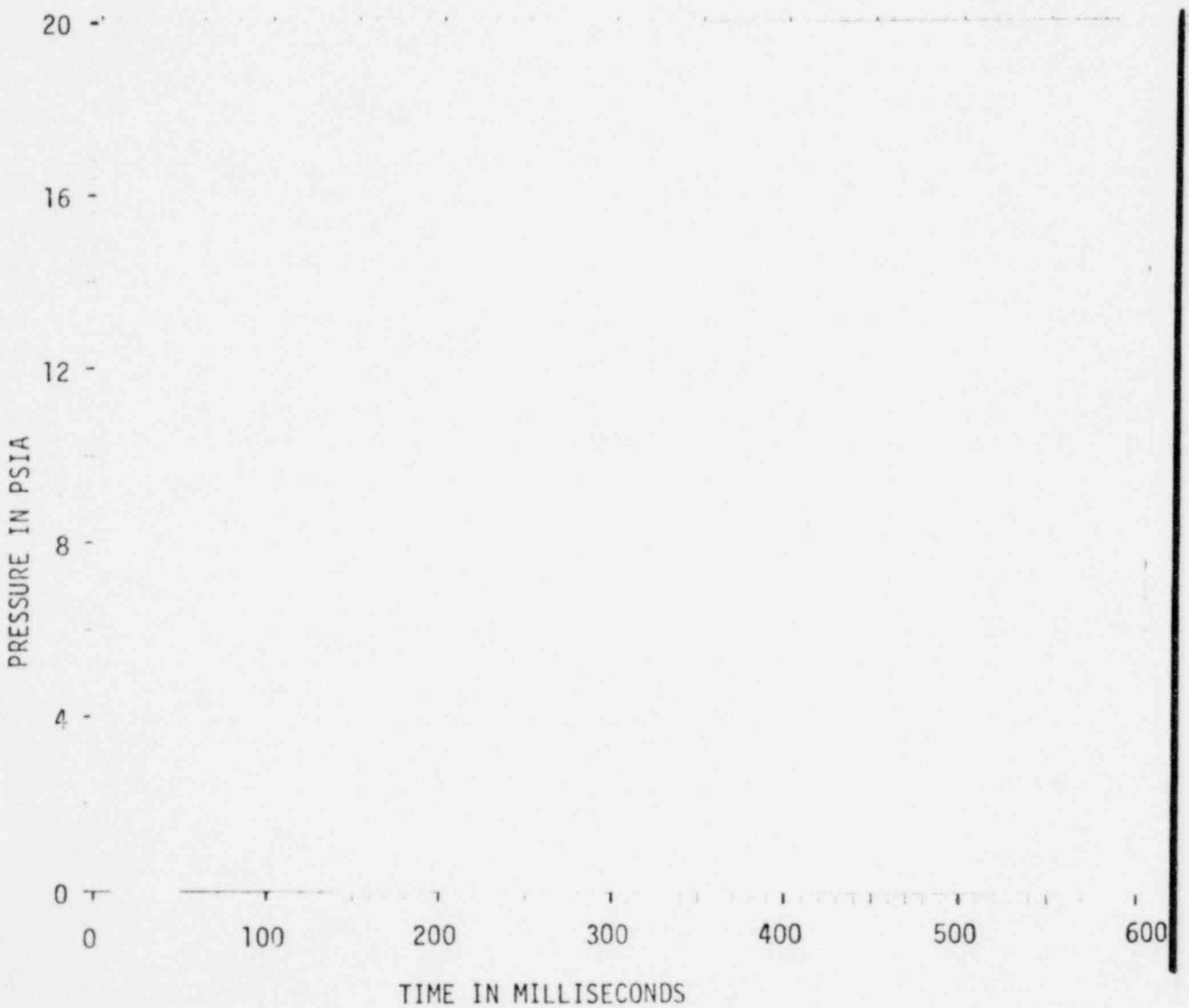


1349 351

FIGURE A-497

DRYWELL PRESSURE

Task 5.5.3 Millstone Test 5

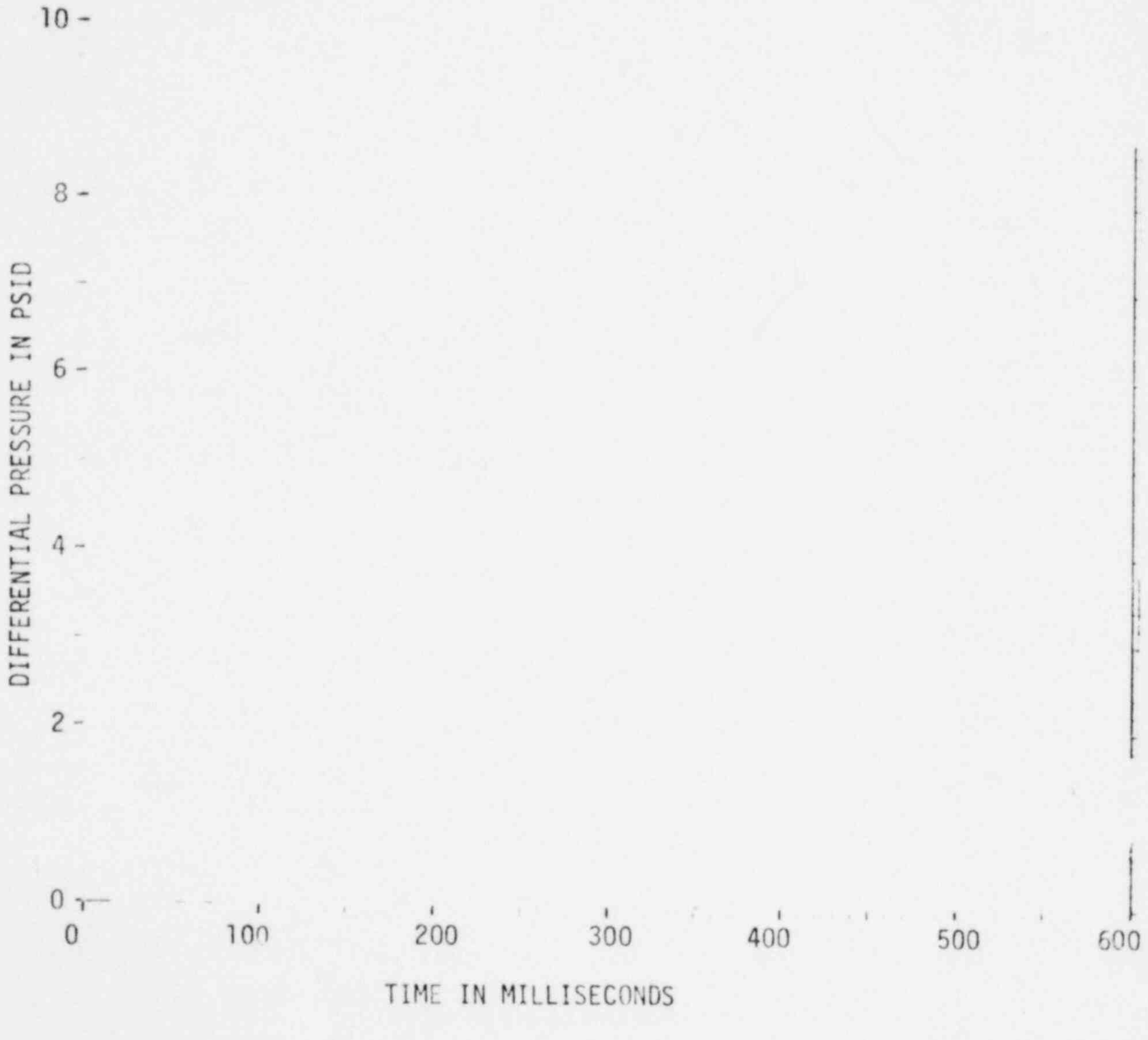


1349 352

FIGURE A-498

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Millstone Test 5

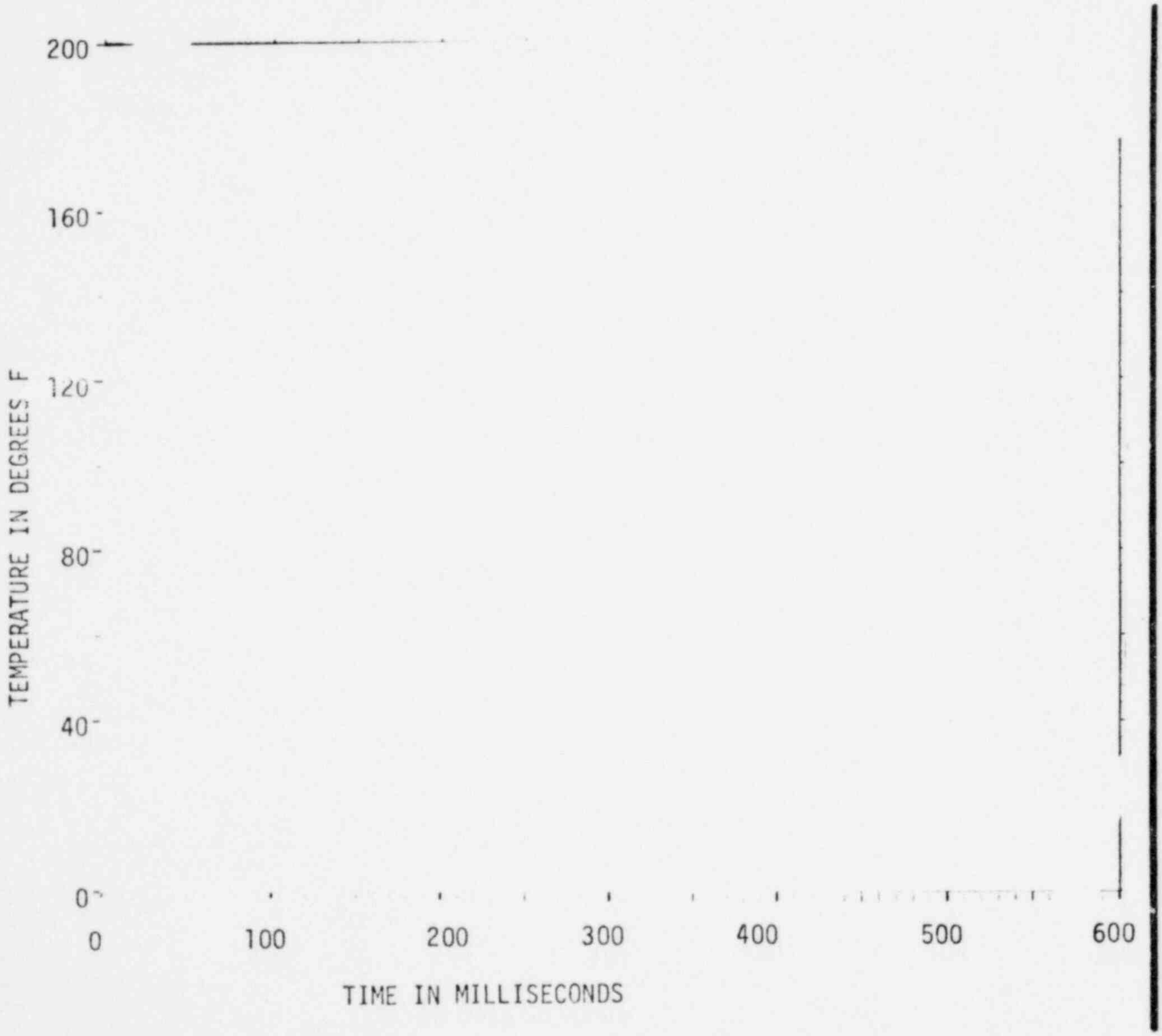


1349 353

FIGURE A-499

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Millstone Test 5

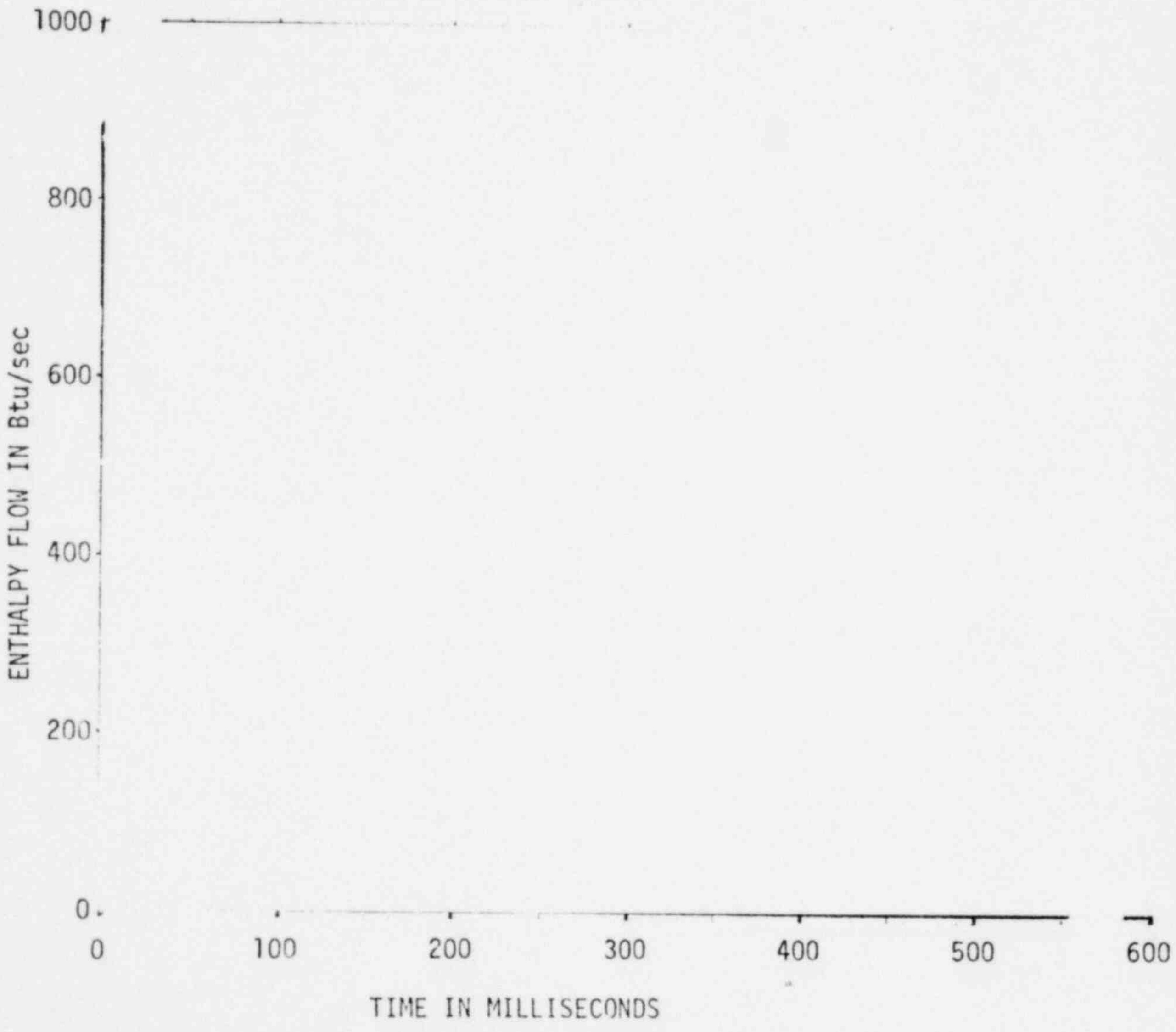


1349 354

FIGURE A-500

ENTHALPY FLOW INTO POOL

Task 5.5.3 Millstone Test 5



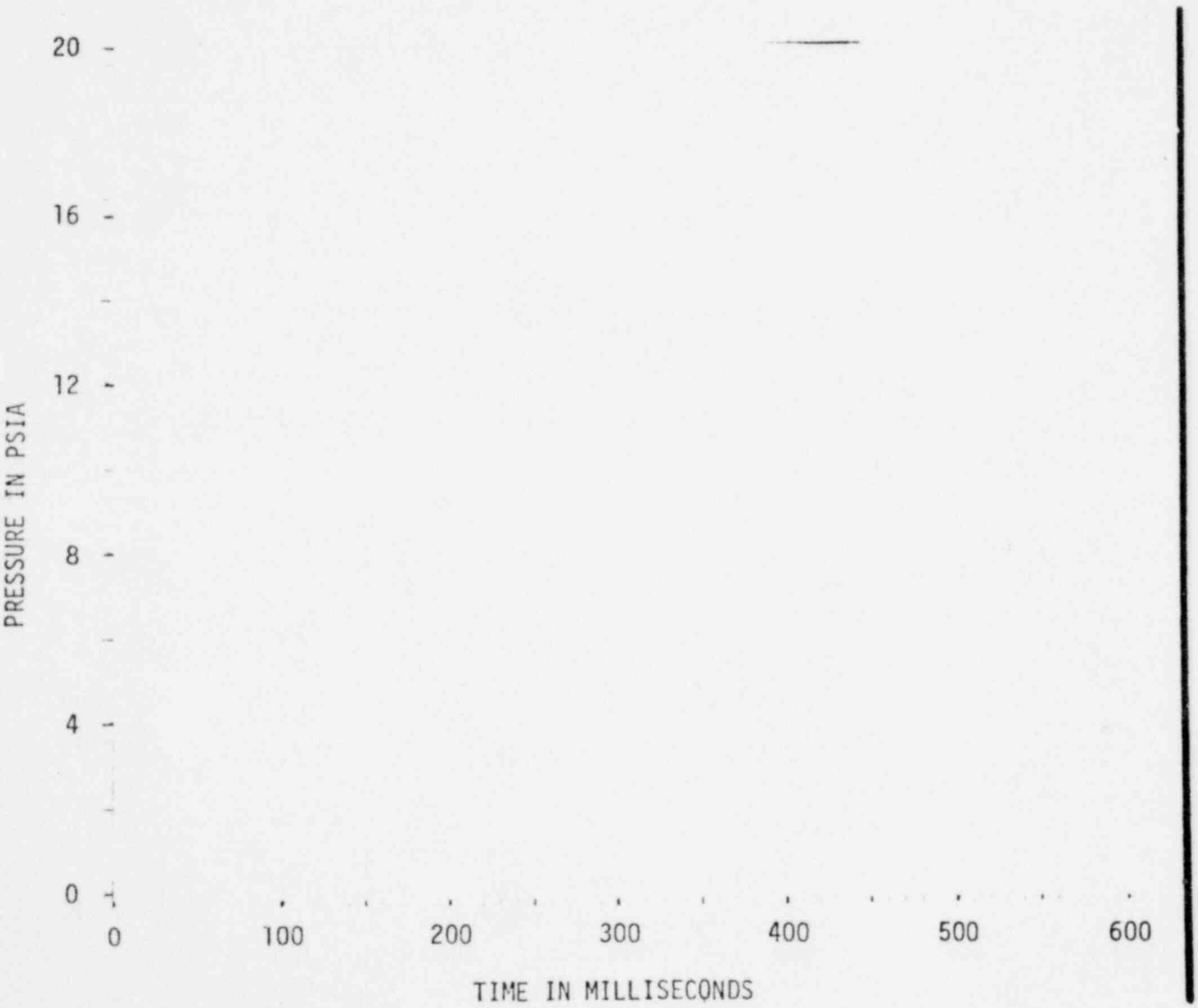
1349 355

FIGURE A-501

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Millstone Test 3

(measured one inch above downcomer exit)

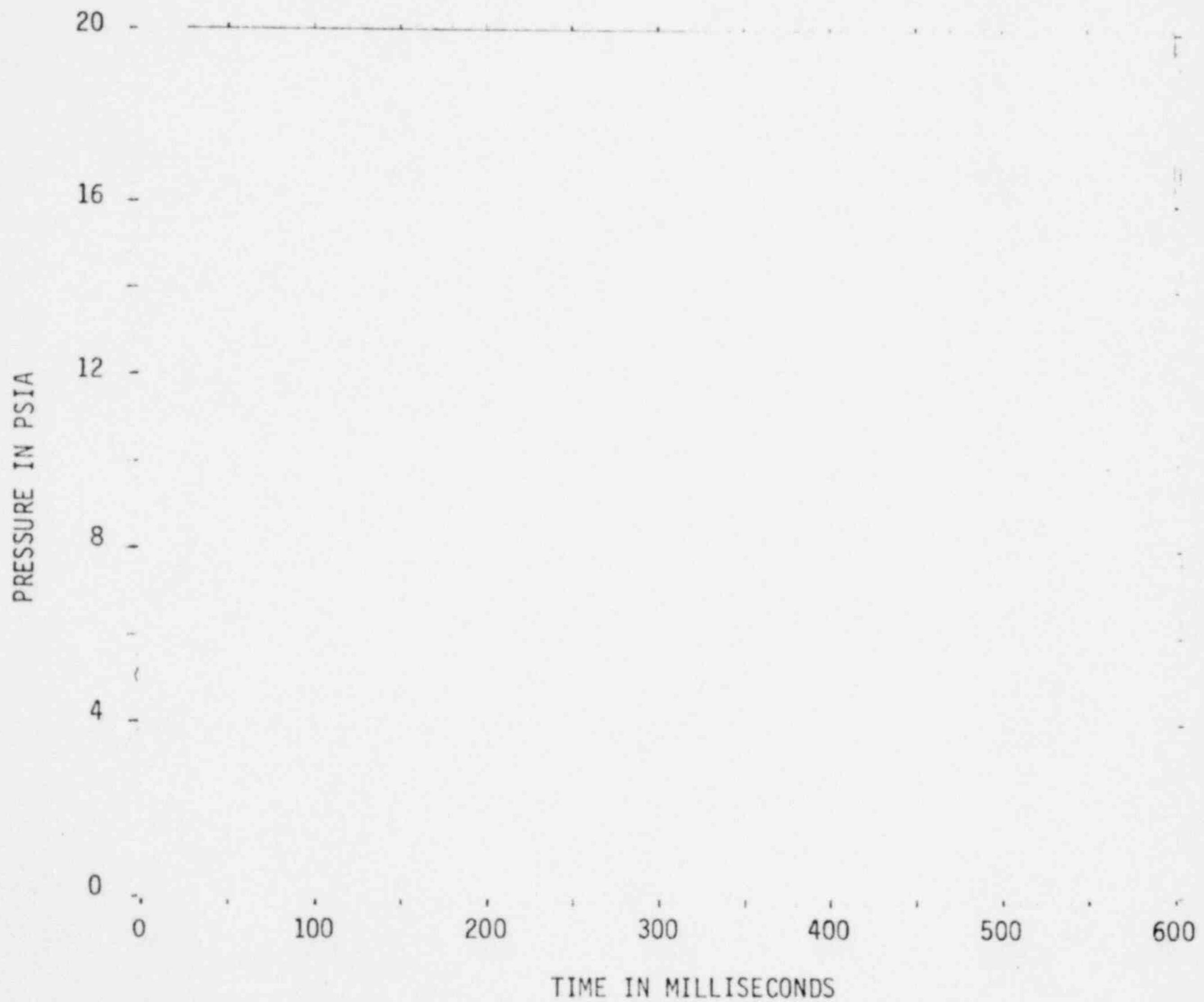


1349 356

FIGURE A-502

WETWELL PRESSURES

Task 5.5.3 Millstone Test 3

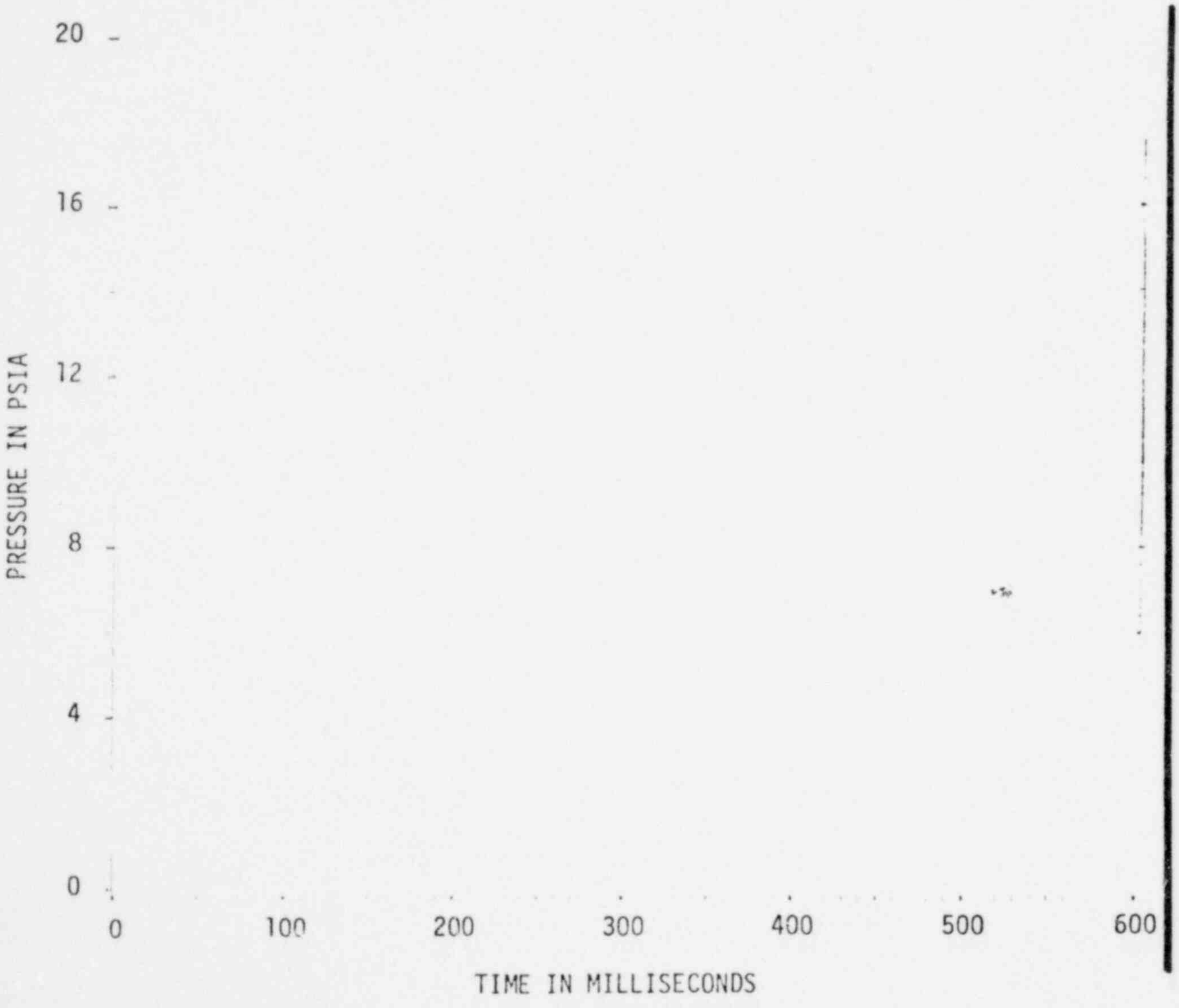


1349 357

FIGURE A-503

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Millstone Test 5

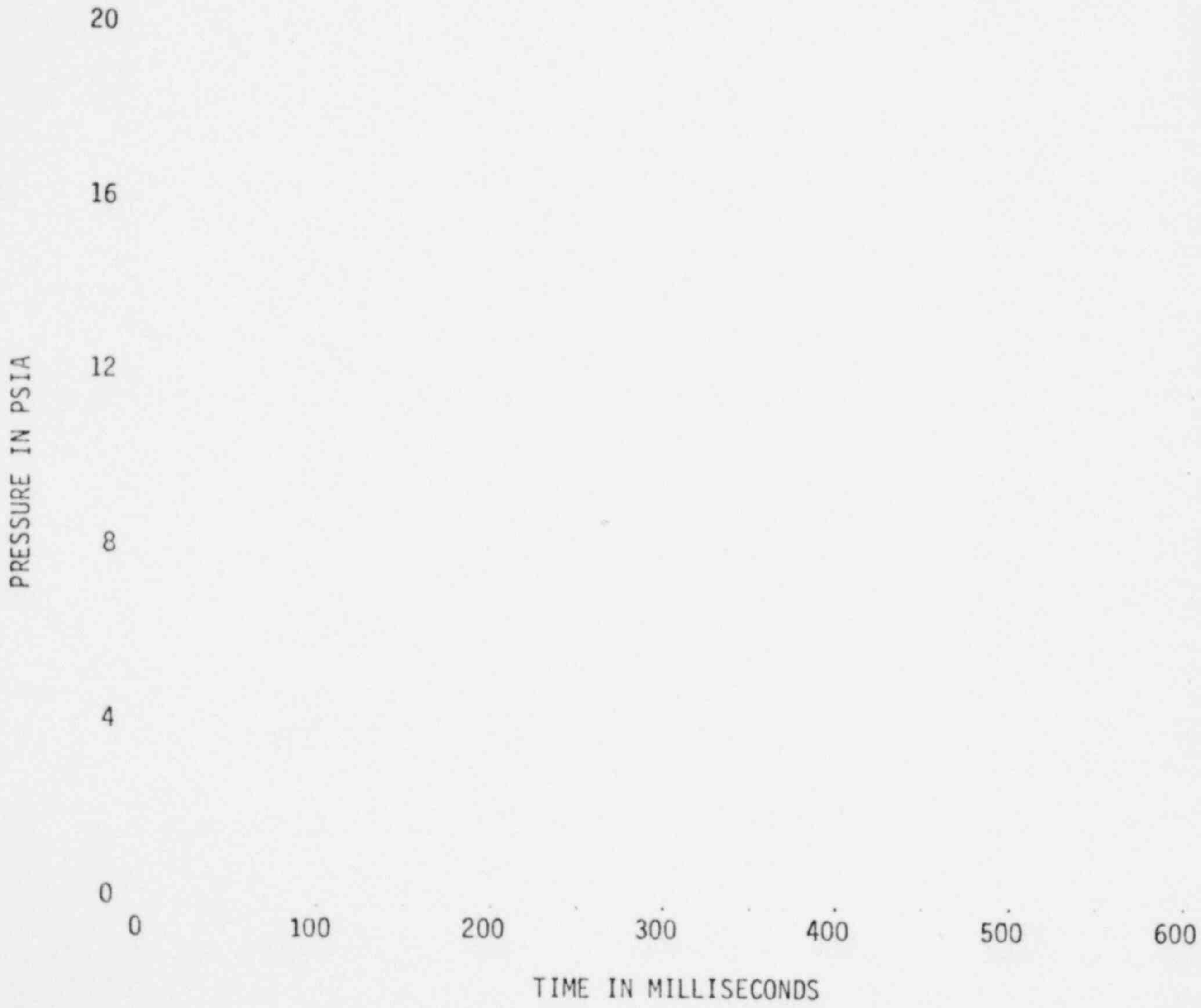


1349 358

FIGURE A-504

WETWELL PRESSURES

Task 5.5.3 Mill tone Test 5

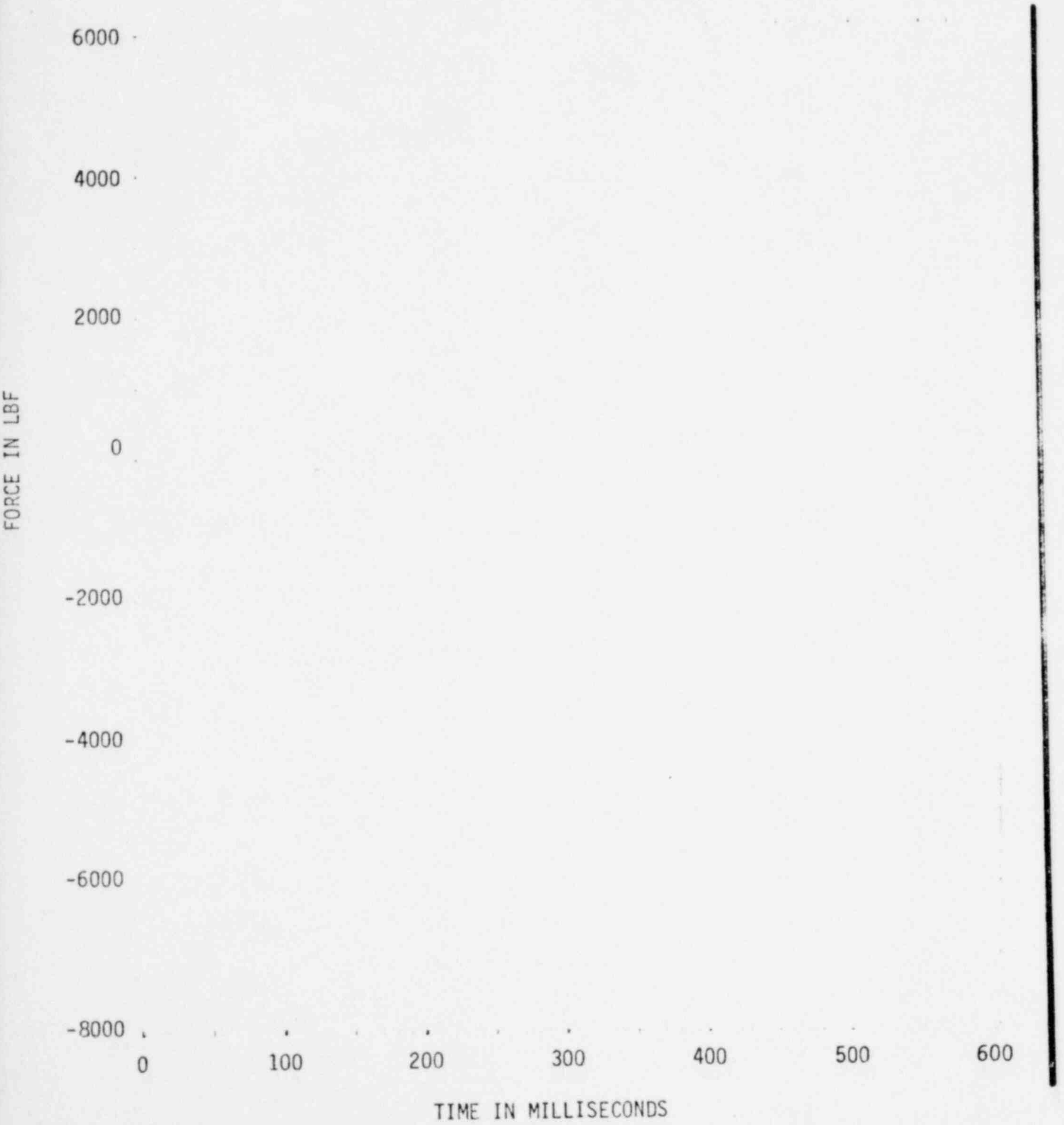


1349 359

FIGURE A-505

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Millstone Test 3

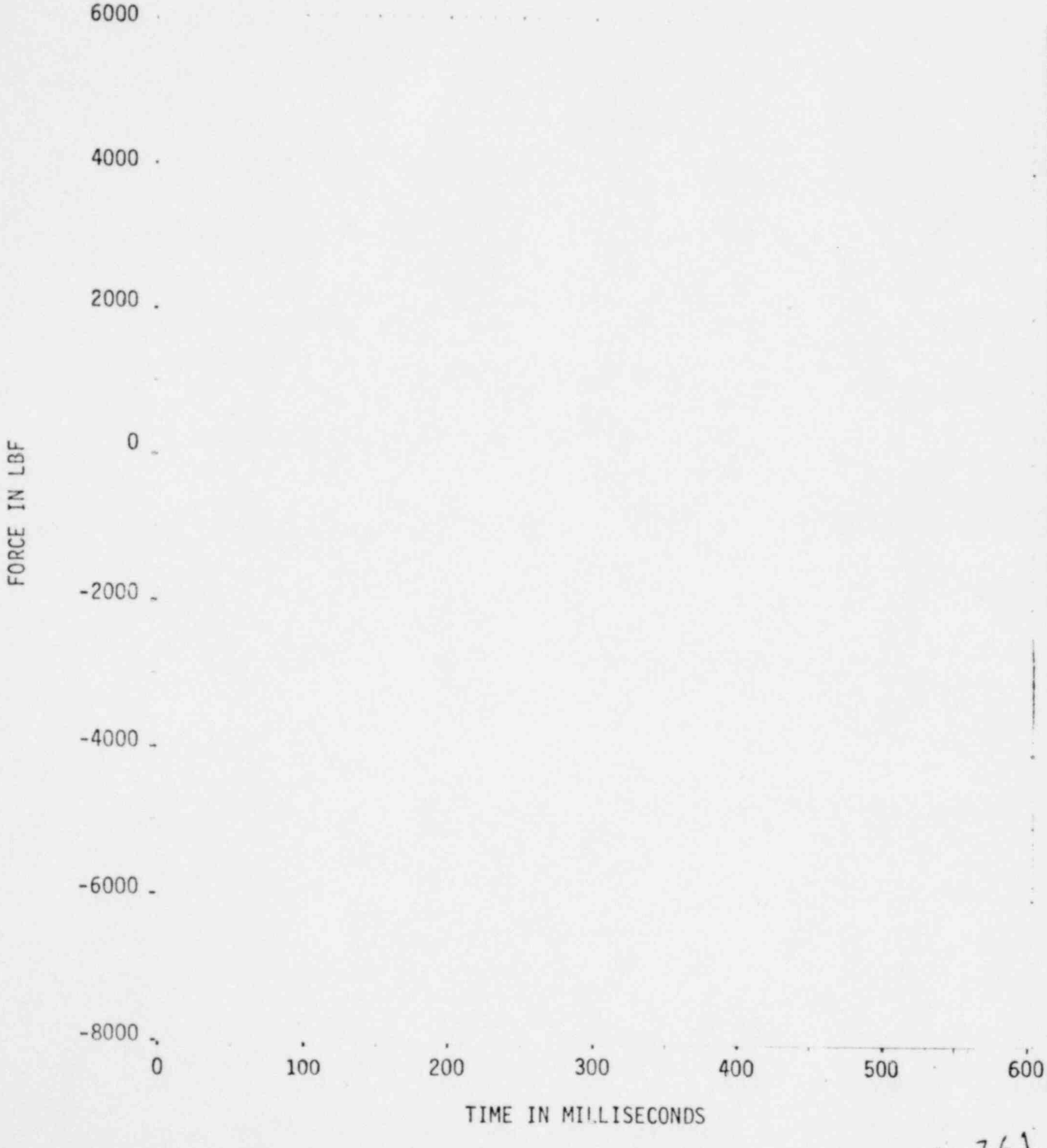


1349 360

FIGURE A-506

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Millstone Test 5



1349 361

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

IMAGE EVALUATION
TEST TARGET (MT-3)

6″

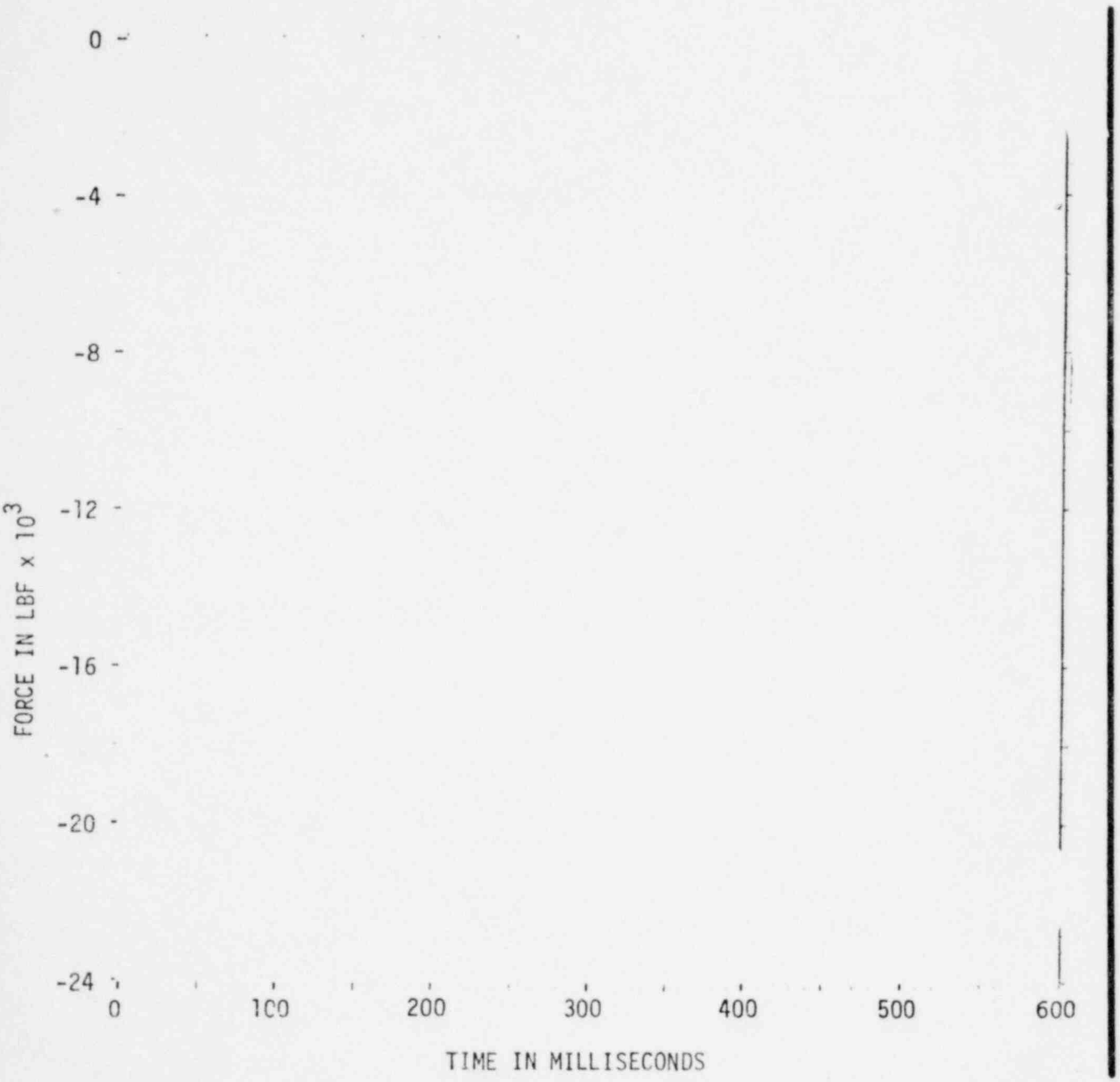
IMAGE EVALUATION
TEST TARGET (MT-3)

6″

FIGURE A-507

TORUS LOAD CELL

Task 5.5.3 Millstone Test 3

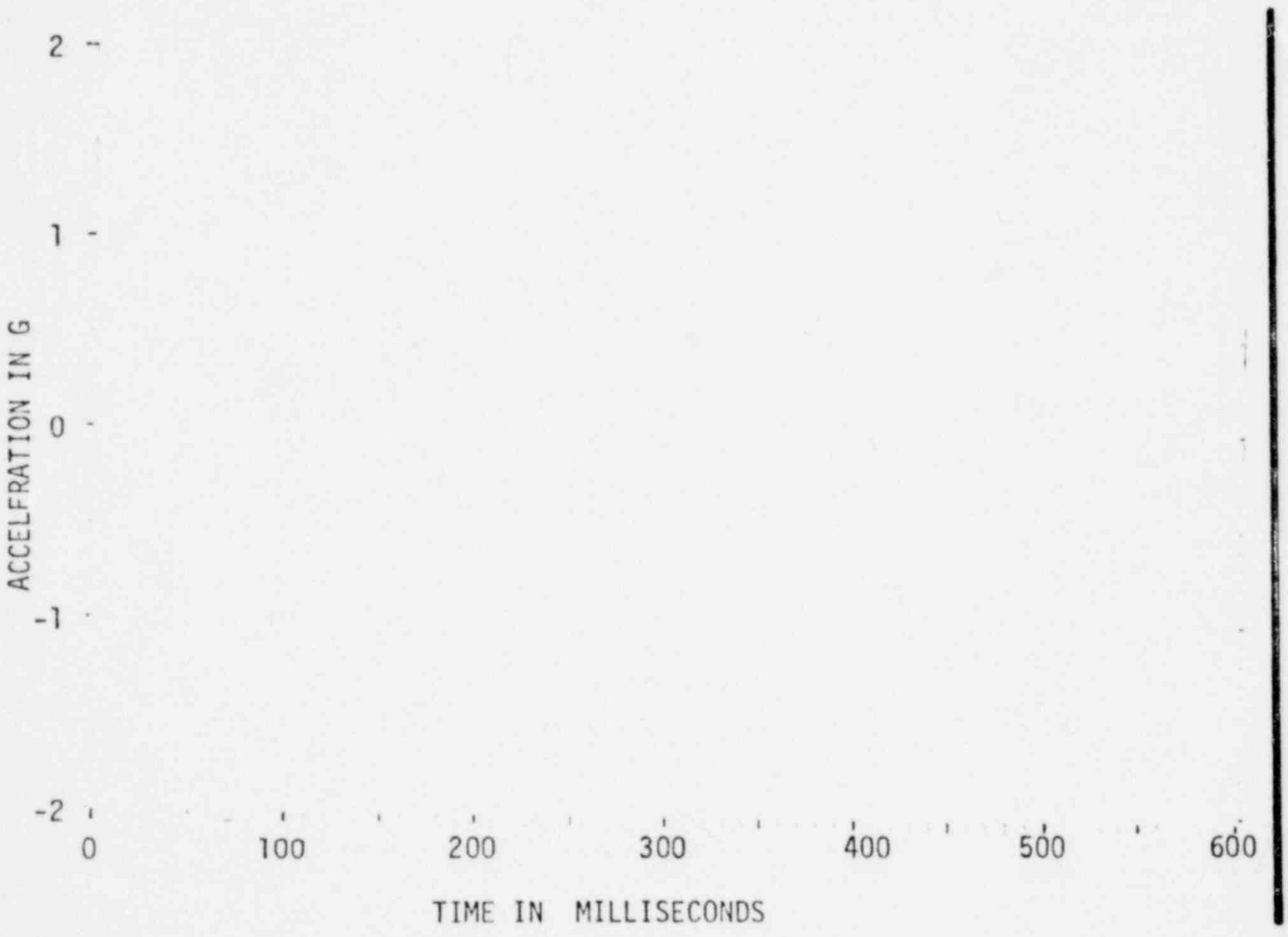


1350 001

FIGURE A-508

TORUS VERTICAL ACCELERATION

Task 5.5.3   Millstone Test 3

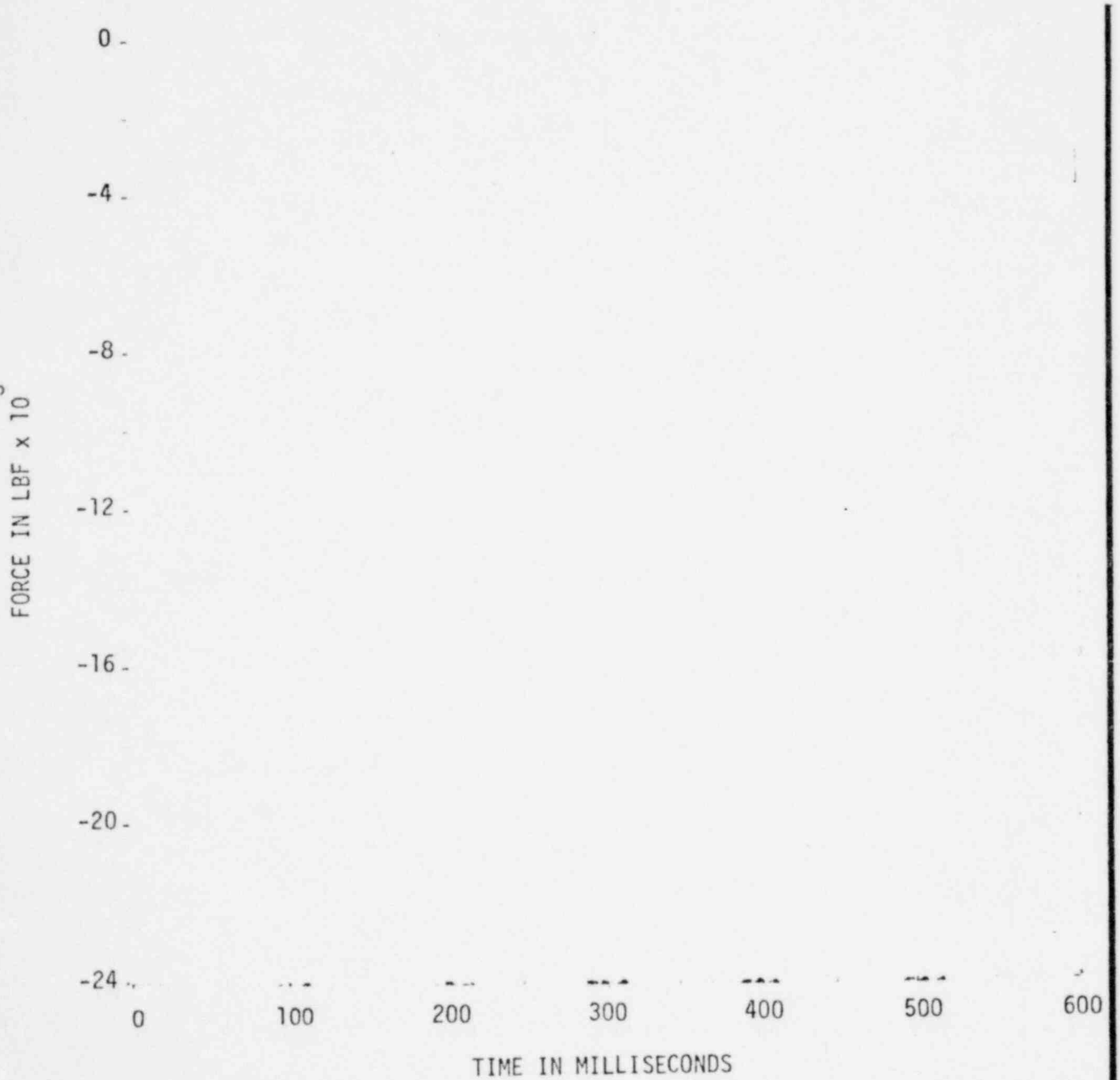


1350 002

FIGURE A-509

TORUS LOAD CELL

Task 5.5.3 Millstone Test 5

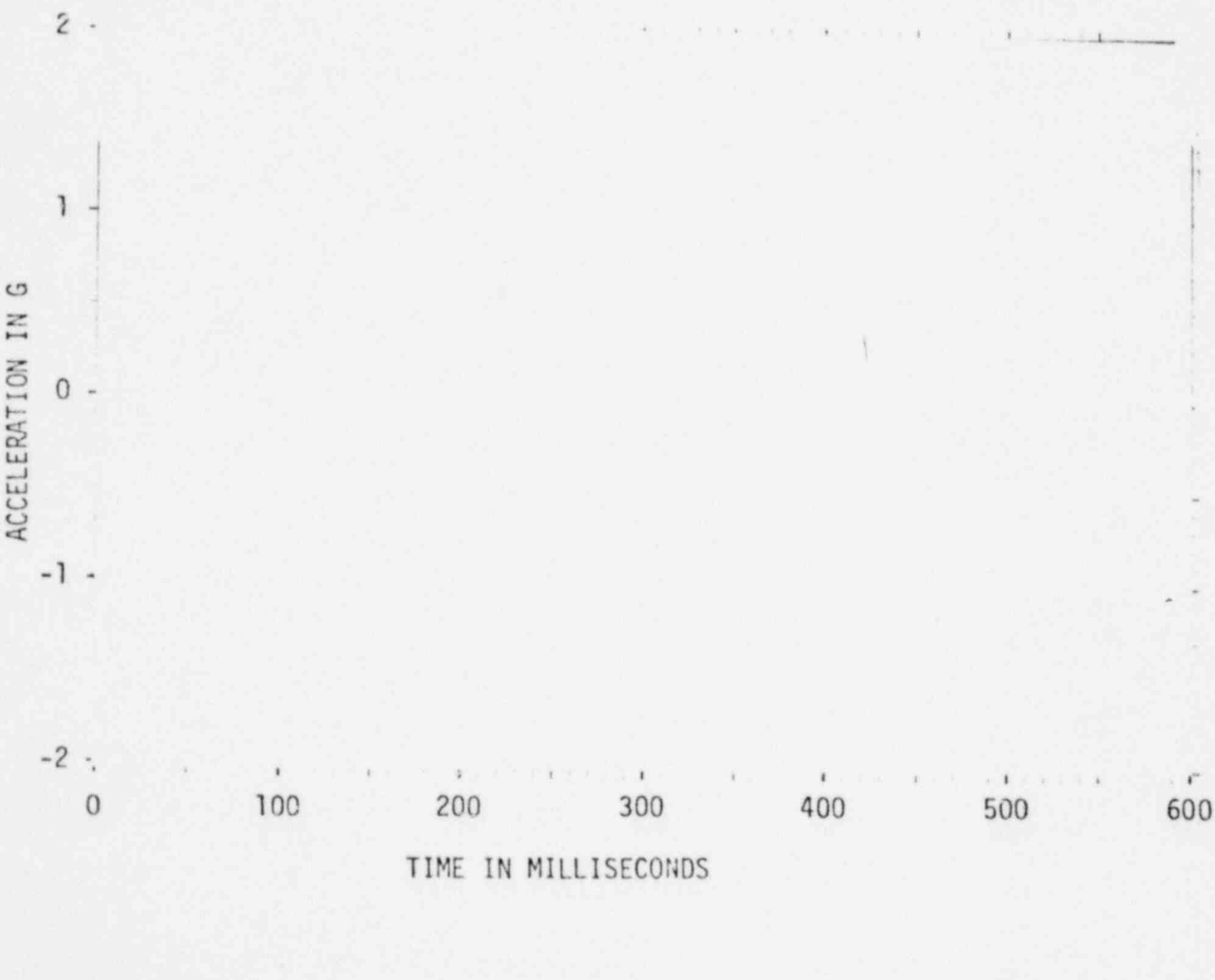


1350 003

FIGURE A-510

TORUS VERTICAL ACCELERATION

Task 5.5.3 Millstone Test 5

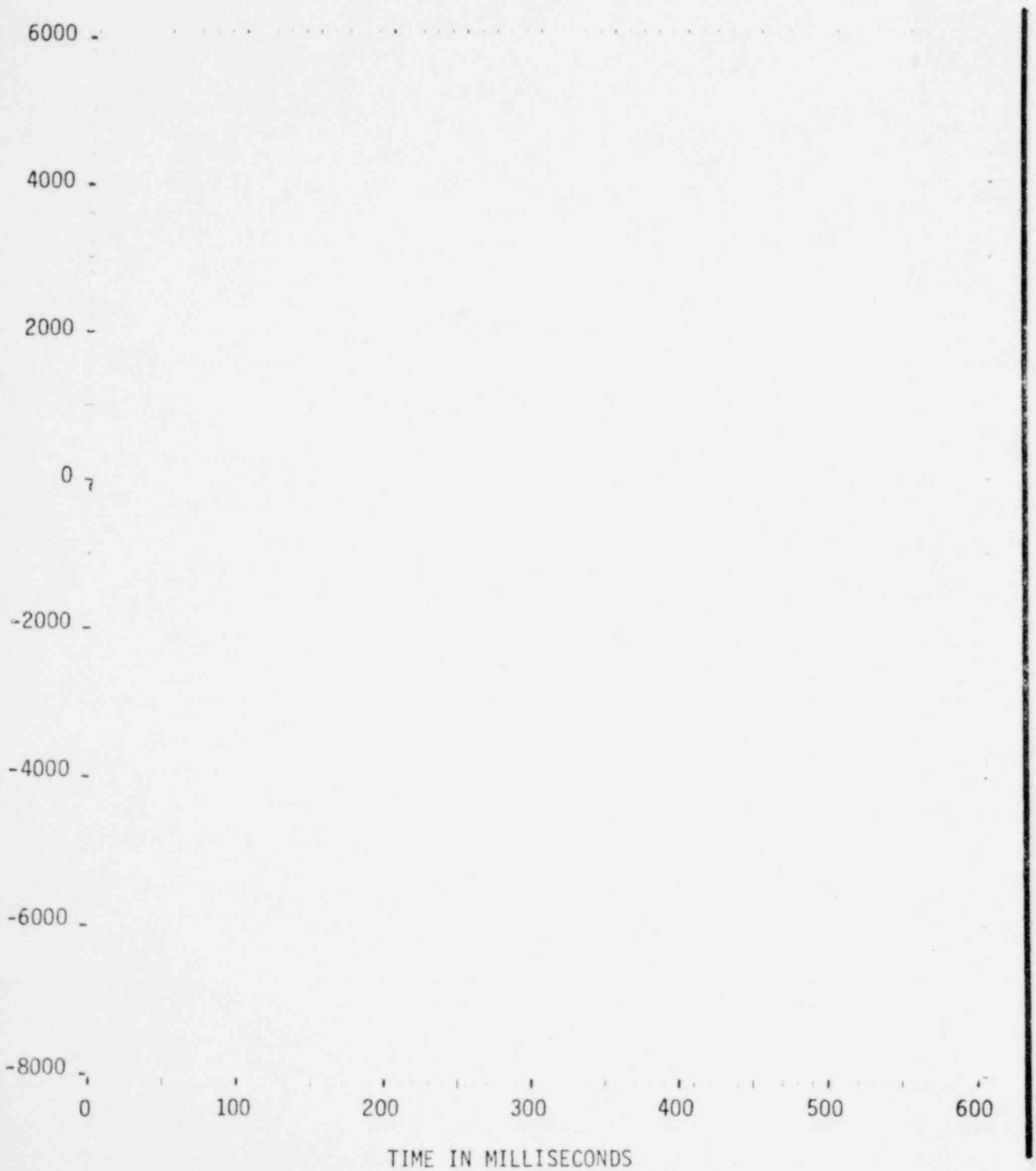


1350 004

FIGURE A-511

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

Task 5.5.3 Millstone Test 3



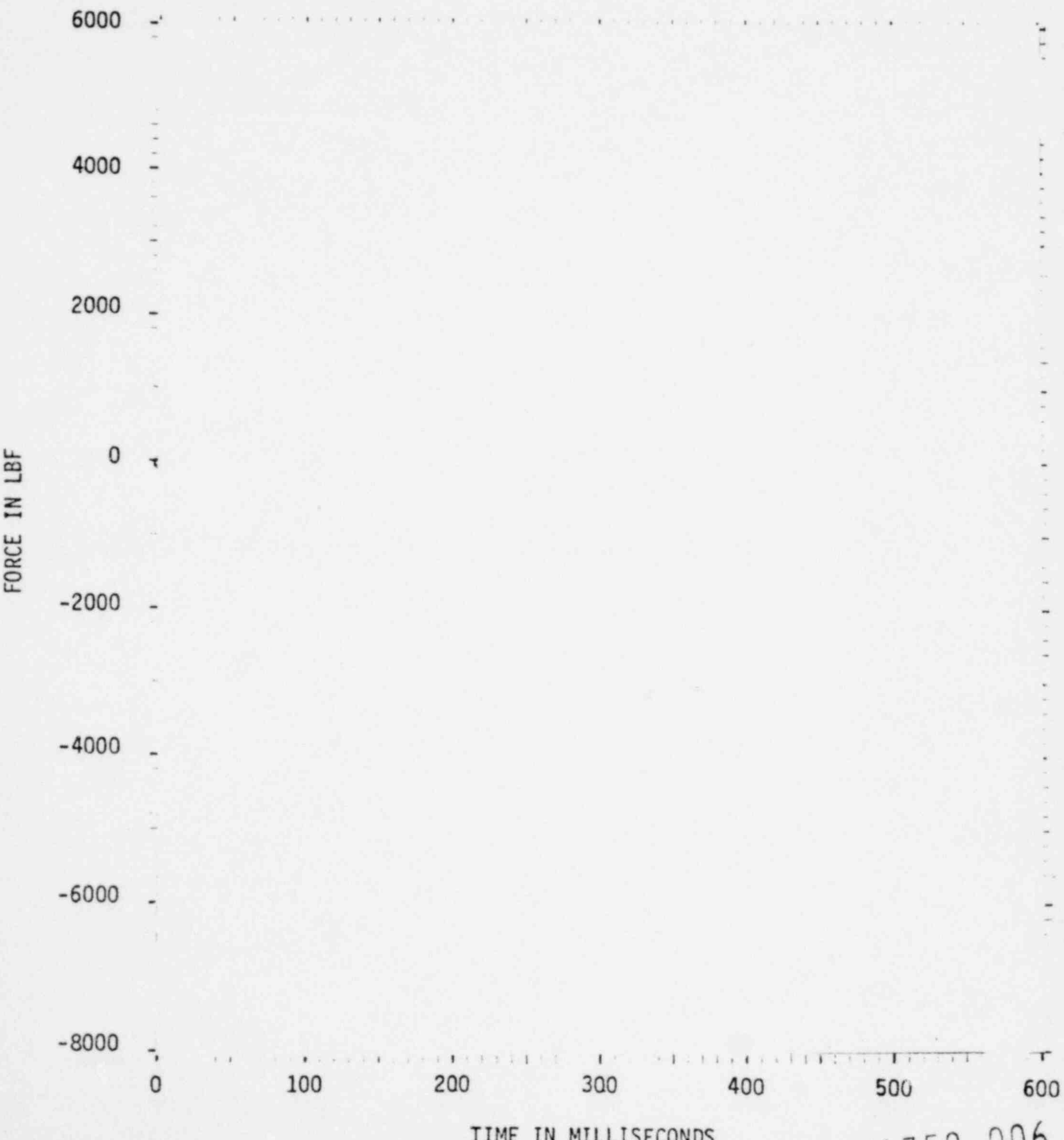
1350 005

FIGURE A-512

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Millstone Test 5

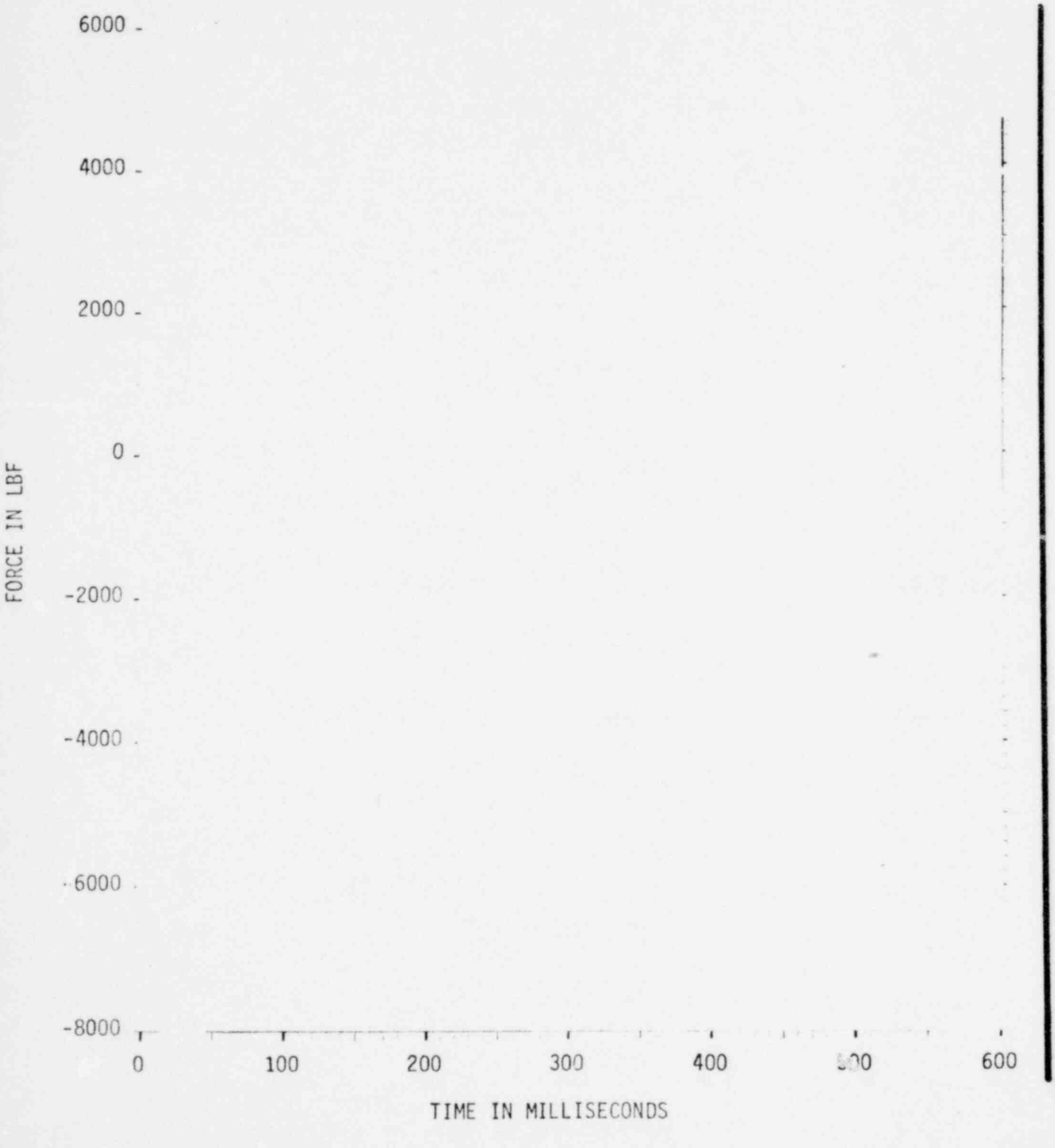


1350 006

FIGURE A-513

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Millstone Test 3



1350 007

FIGURE A-514

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Millstone Test 5

1350 008

FIGURE A-515

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

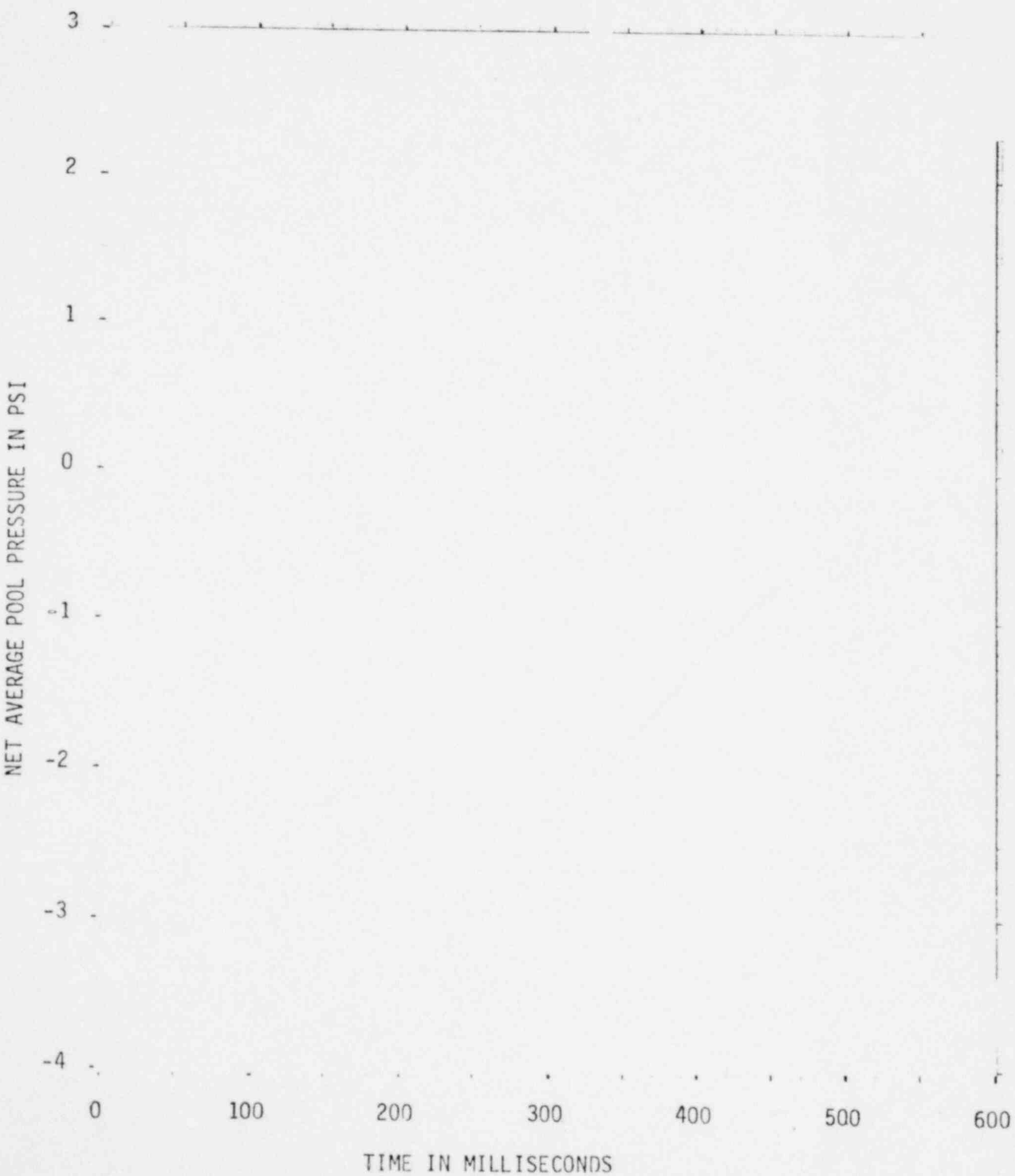
Task 5.5.3 Millstone Test 3

1350 009

FIGURE A-516

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Millstone Test 3

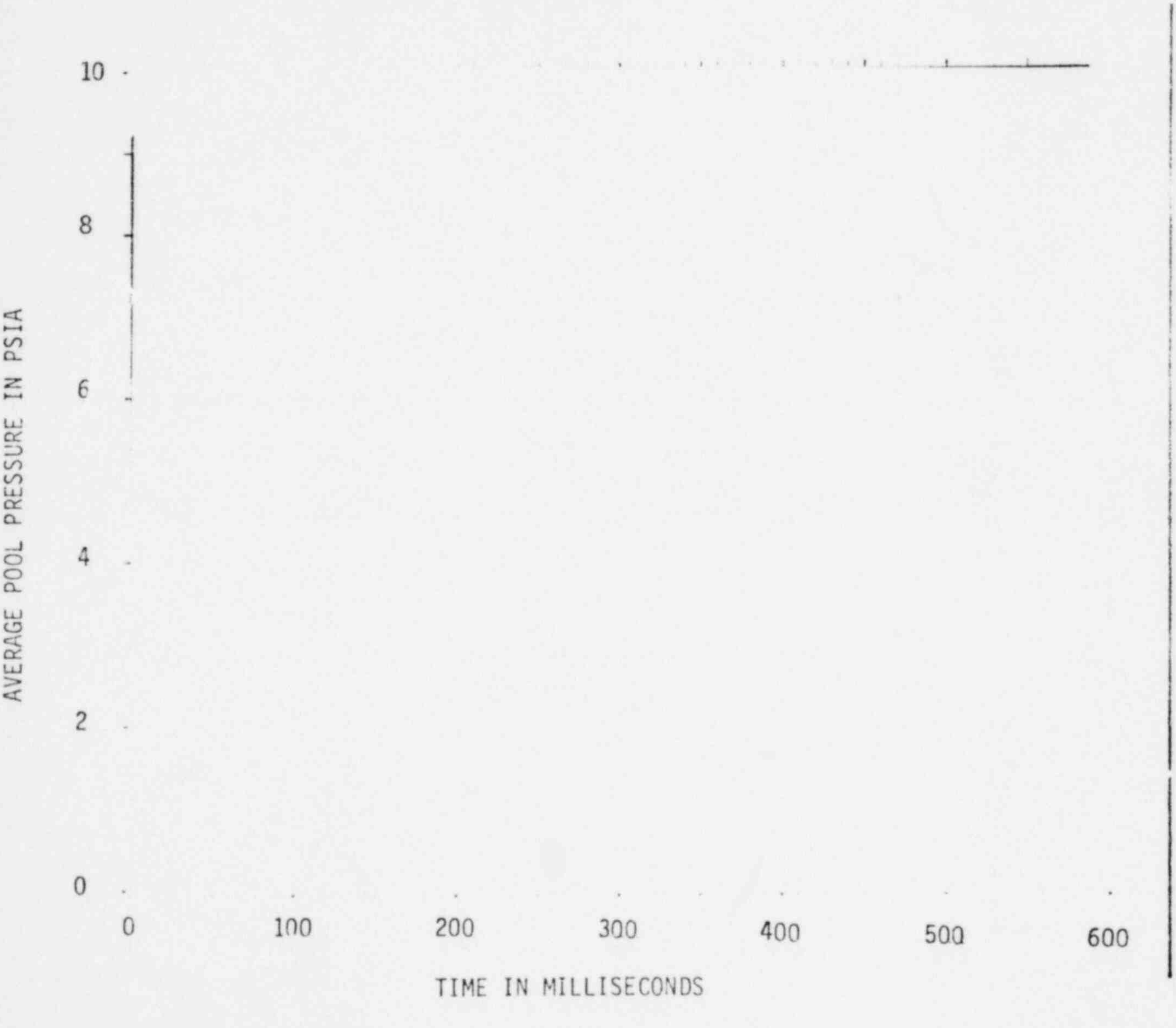


1350 010

FIGURE A-517

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Millstone Test 5



1350 011

FIGURE A-518

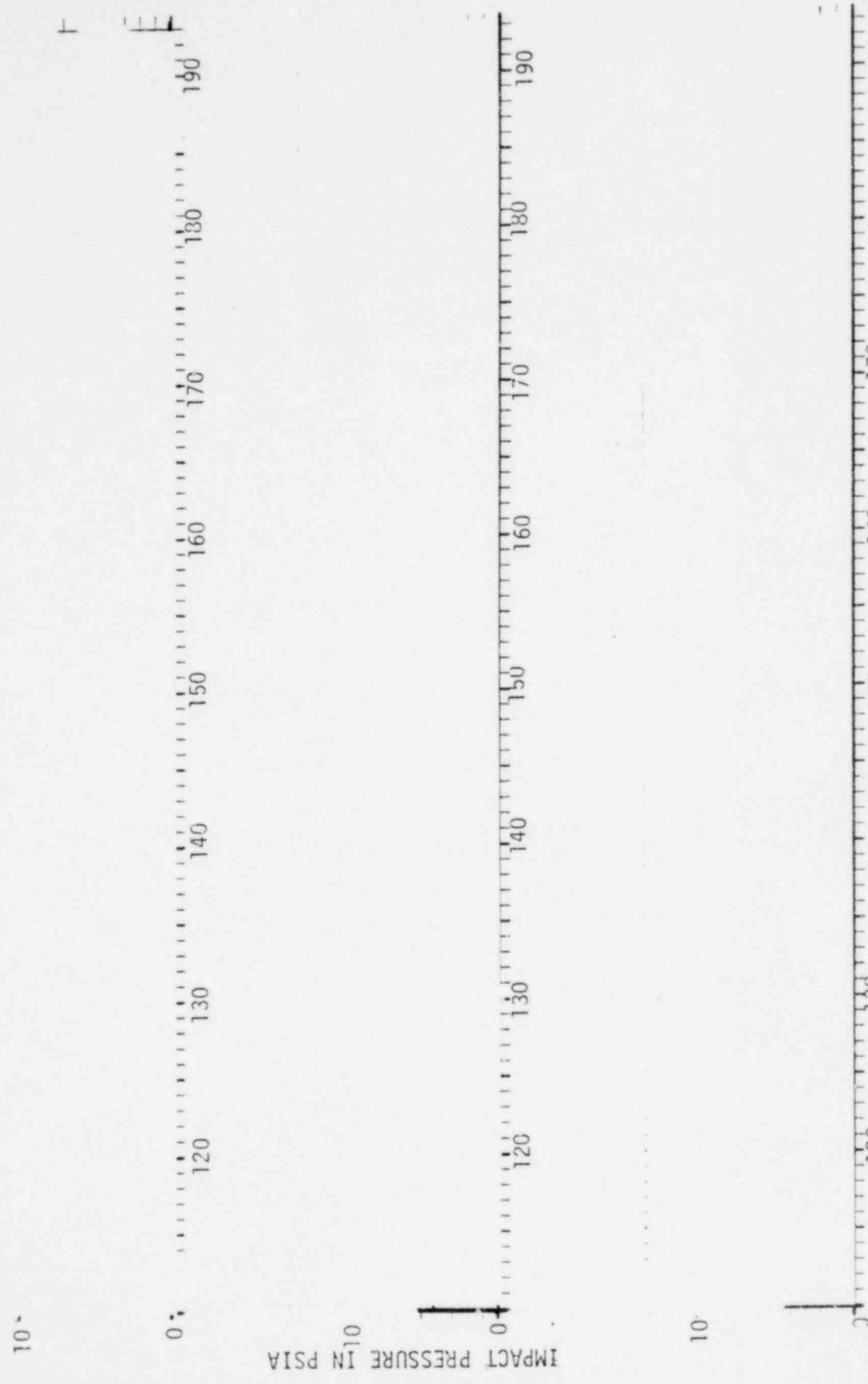
NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Millstone Test 5

1350 012

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 3

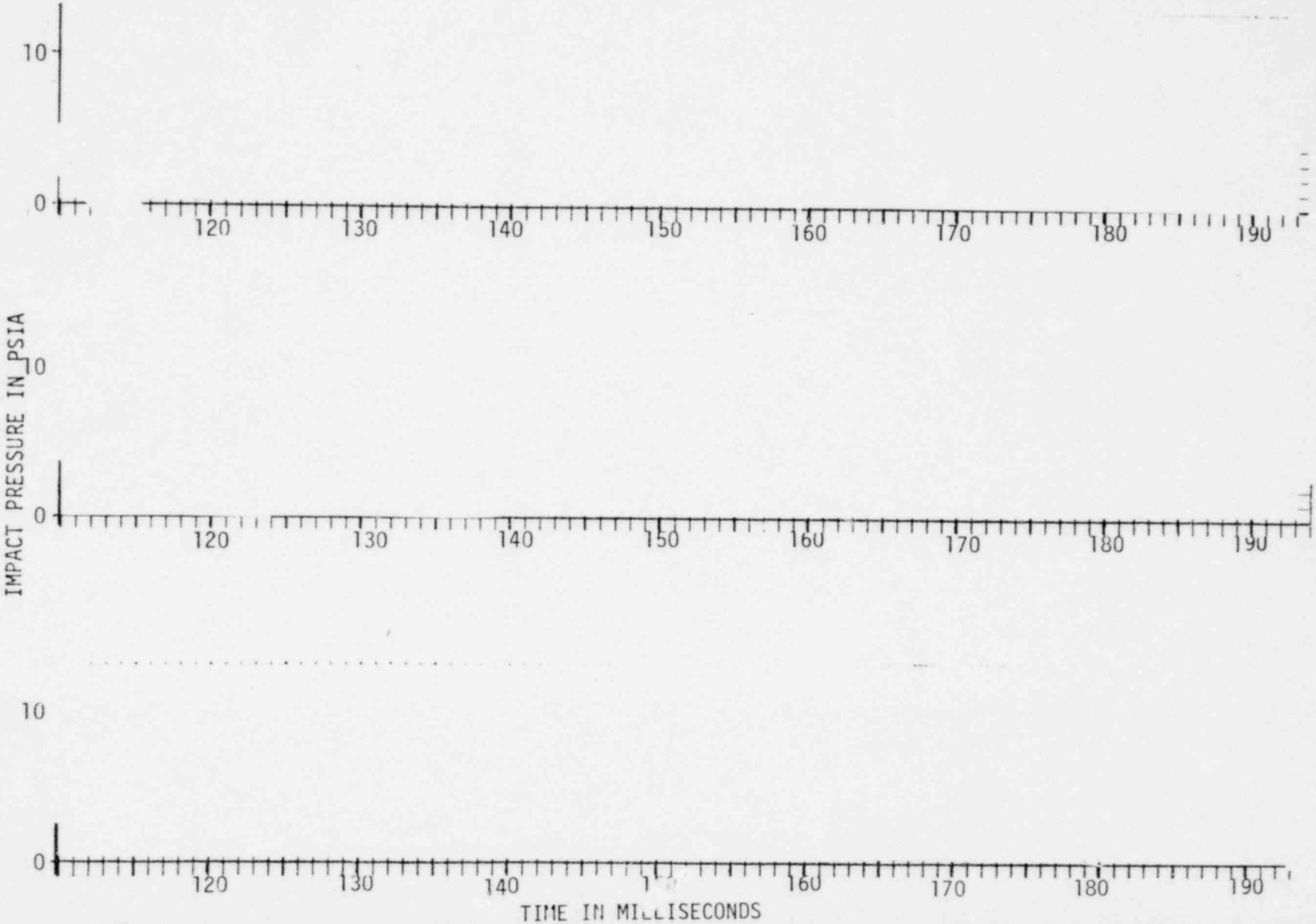


1350 013

FIGURE A-520

VENT HEADER IMPACT PRESSURES

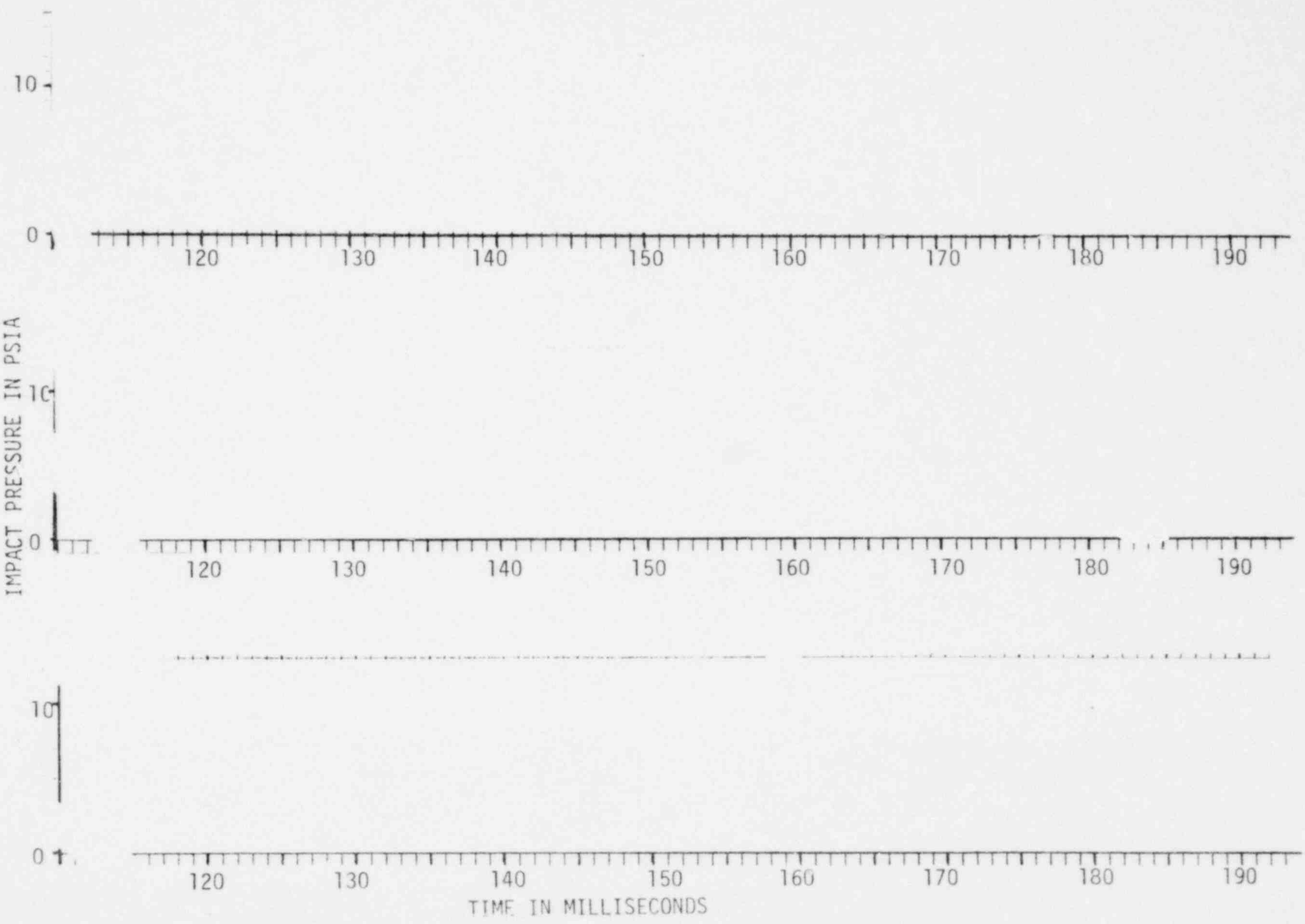
Task 5.5.3   Millstone Test 3



1350 014

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 3

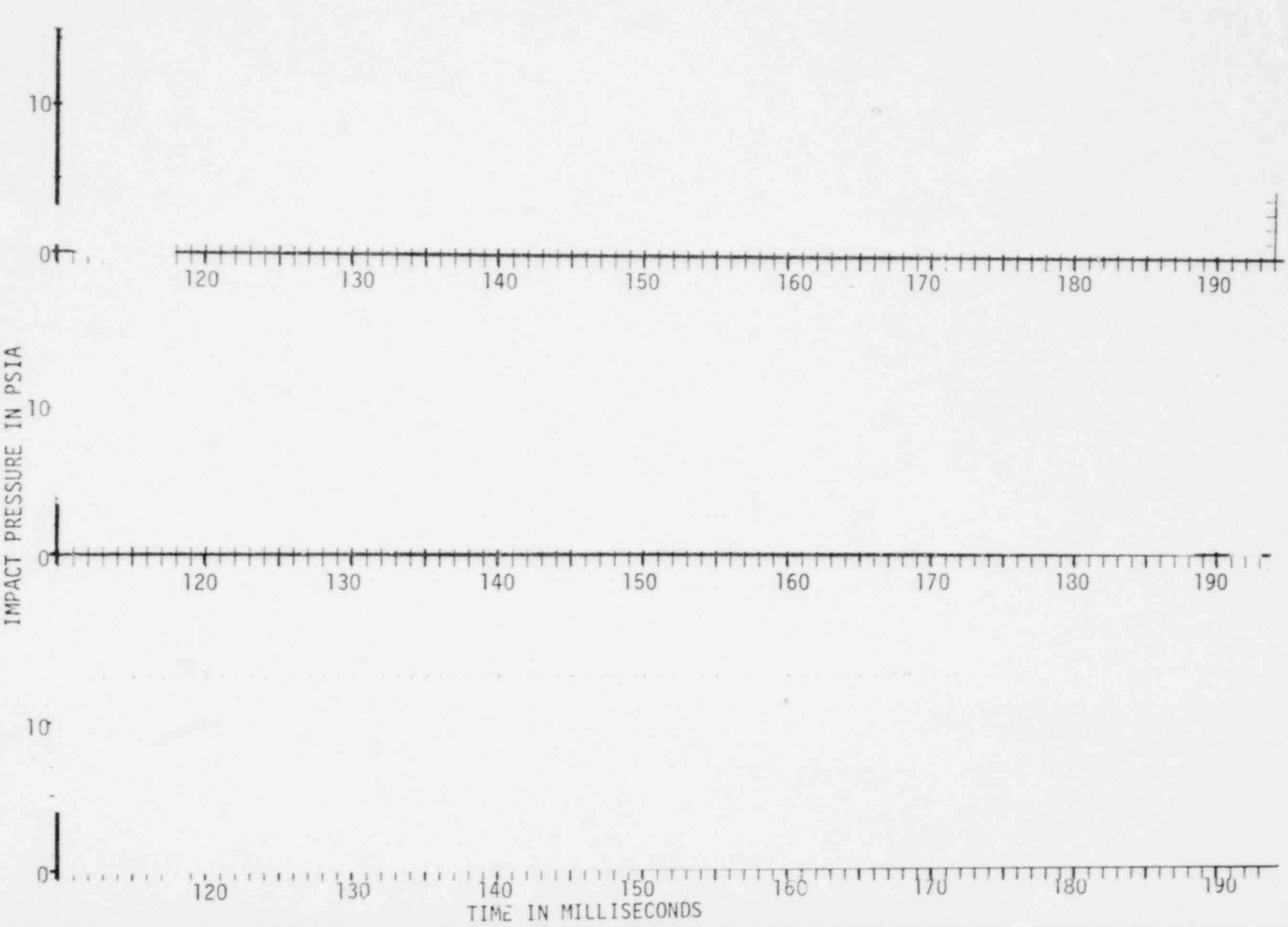


1350 015

FIGURE A-522

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 3



1350 016

FIGURE A-523

VENT HEADER IMPACT PRESSURES

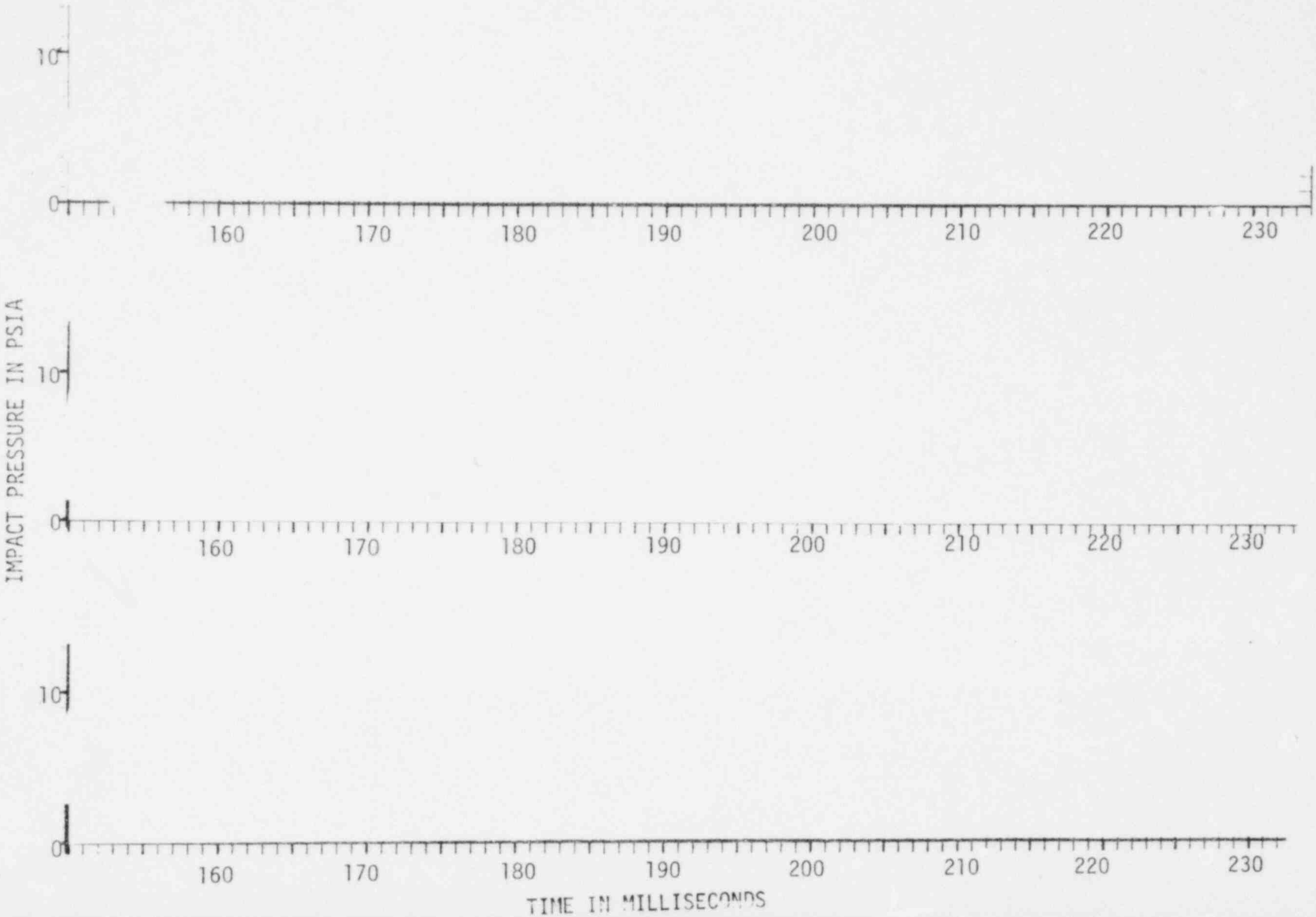
Task 5.5.3 Millstone Test 3

1350 017

FIGURE A-524

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 5

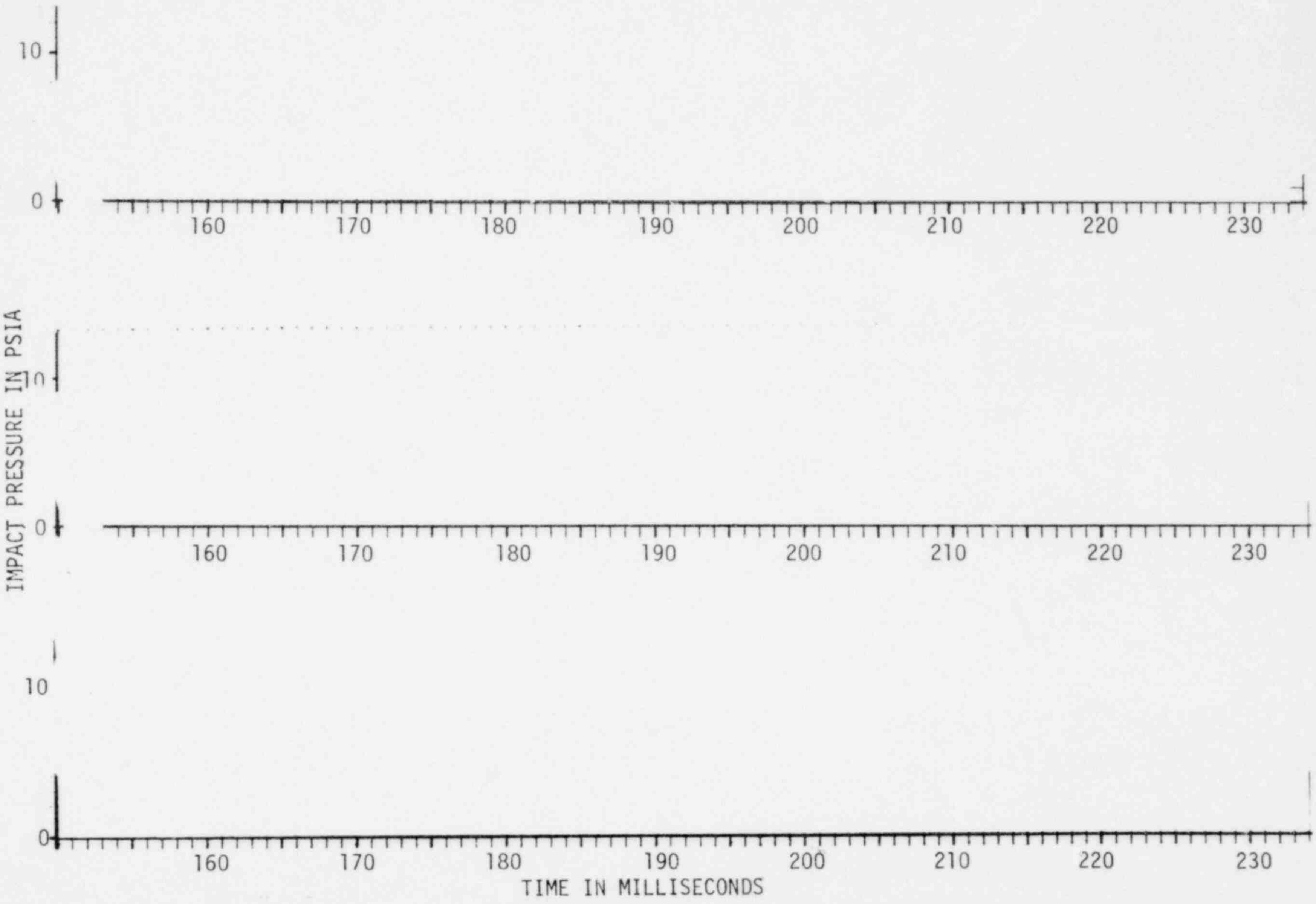


1350 018

FIGURE A-525

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 5

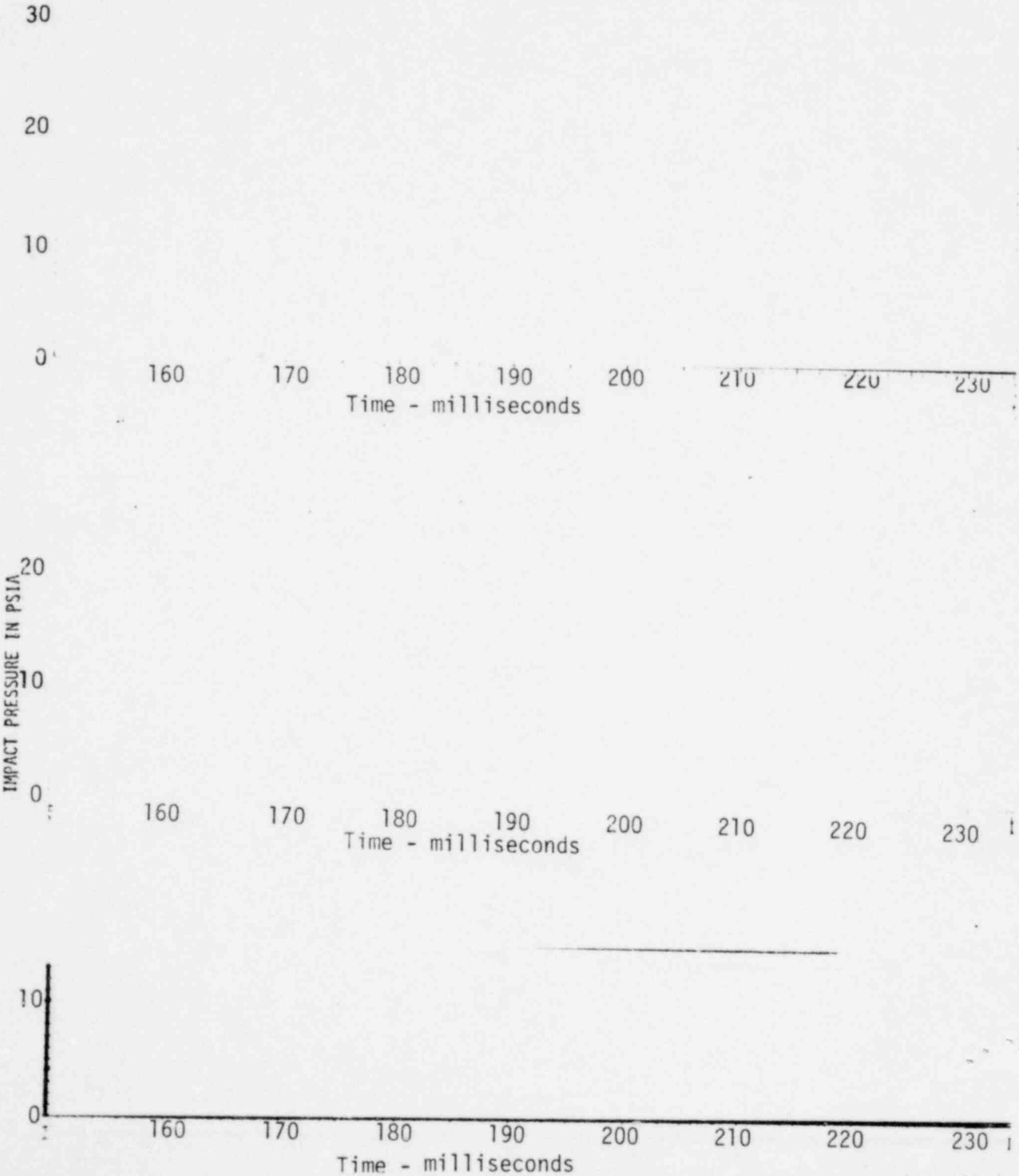


1350 019

FIGURE A-526

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 5



1350 020

FIGURE A-527

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Millstone Test 5

1350 021

FIGURE A-528

VENT HEADER IMPACT PRESSURES

Task 5.5.3   Millstone Test 5

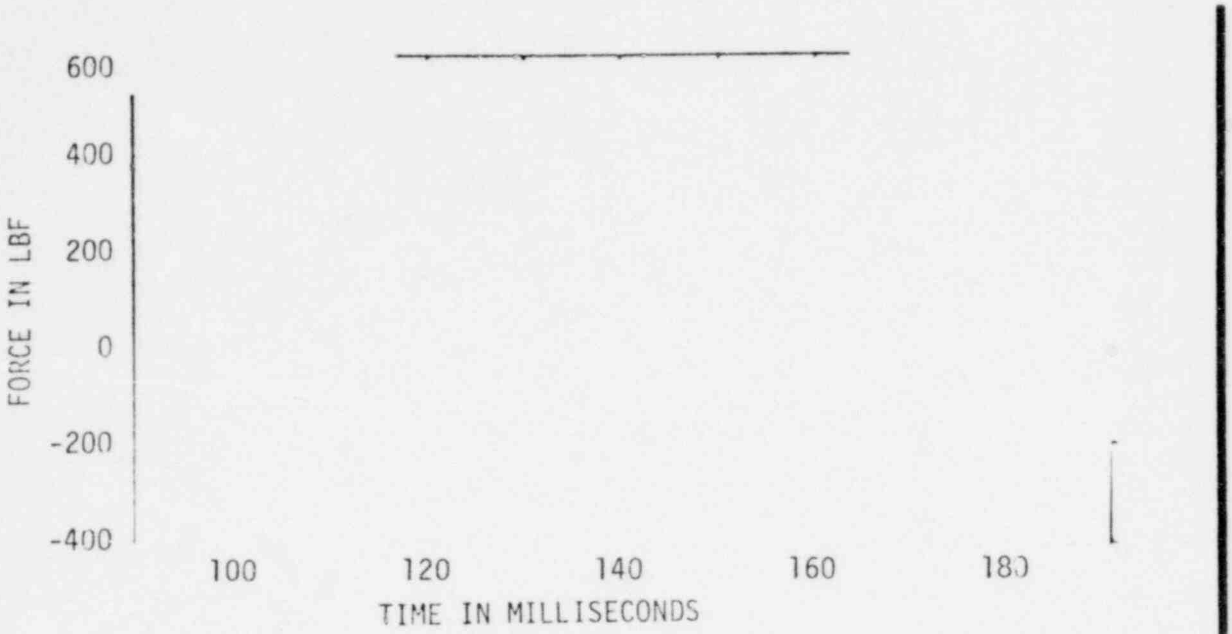
1350 022

FIGURE A-529

COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)

Task 5.5.3

Millstone Tests 3,5



1350 023

FIGURE A-530

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3   Millstone Test 3

1350 024

FIGURE A-531

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Millstone Test 5

1350 025

FIGURE A-532

TIME HISTORY OF

POOL DISPLACEMENT

Millstone Test 1

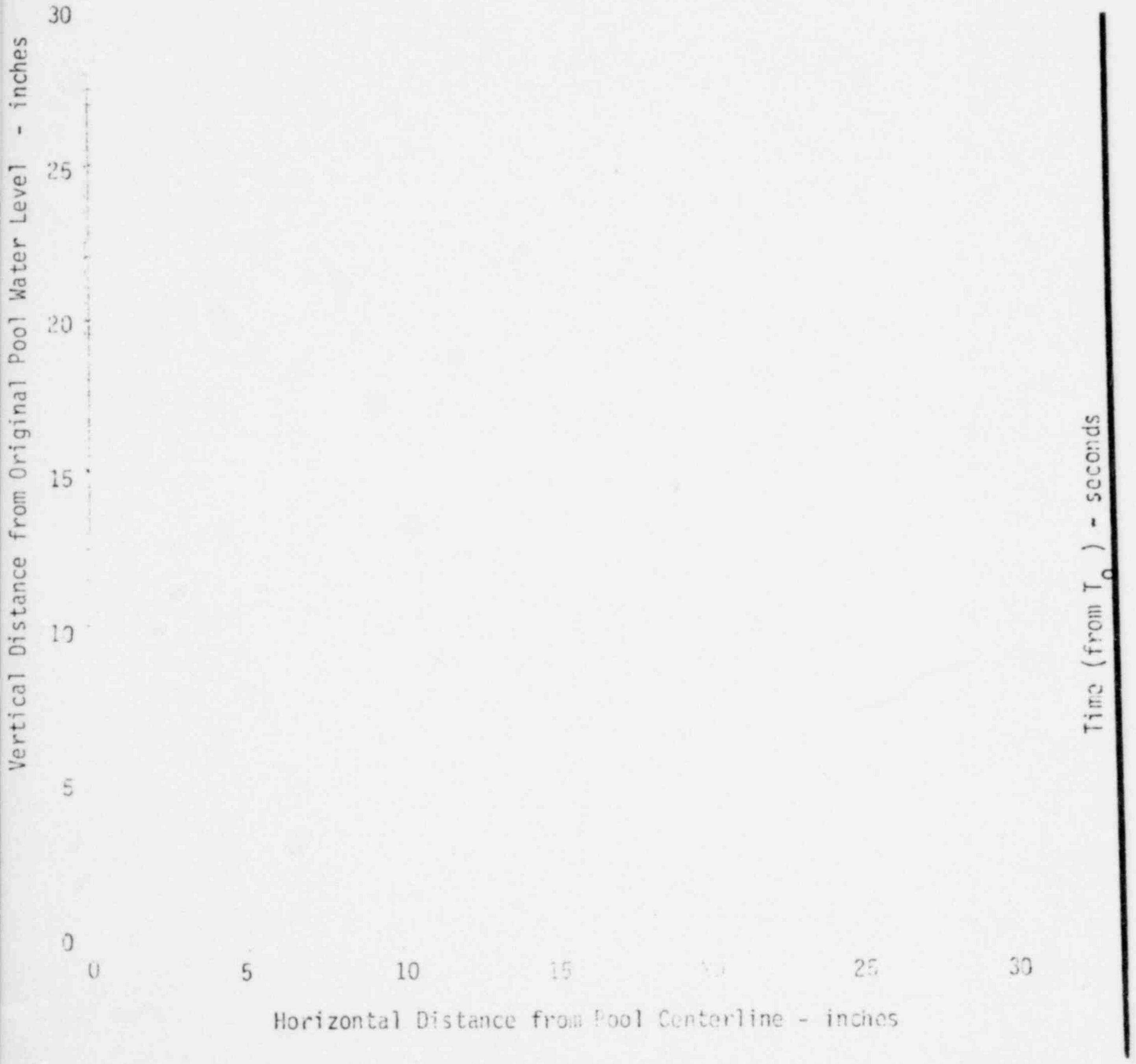
1350 026

FIGURE A-533

TIME HISTORY OF

POOL DISPLACEMENT

Millstone Test 2

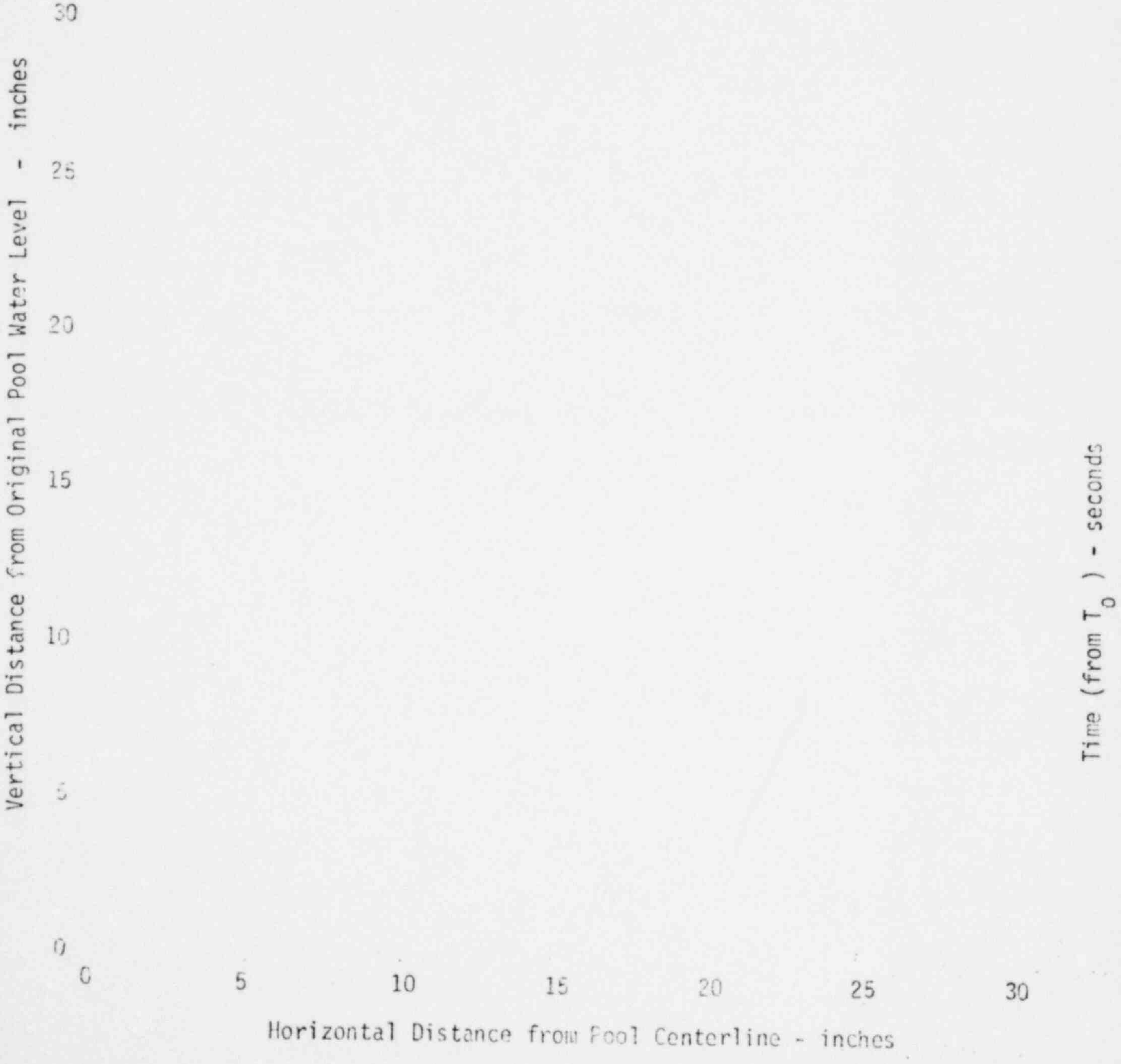


1350 027

FIGURE A-534

TIME HISTORY OF
POOL DISPLACEMENT

Millstone Test 3



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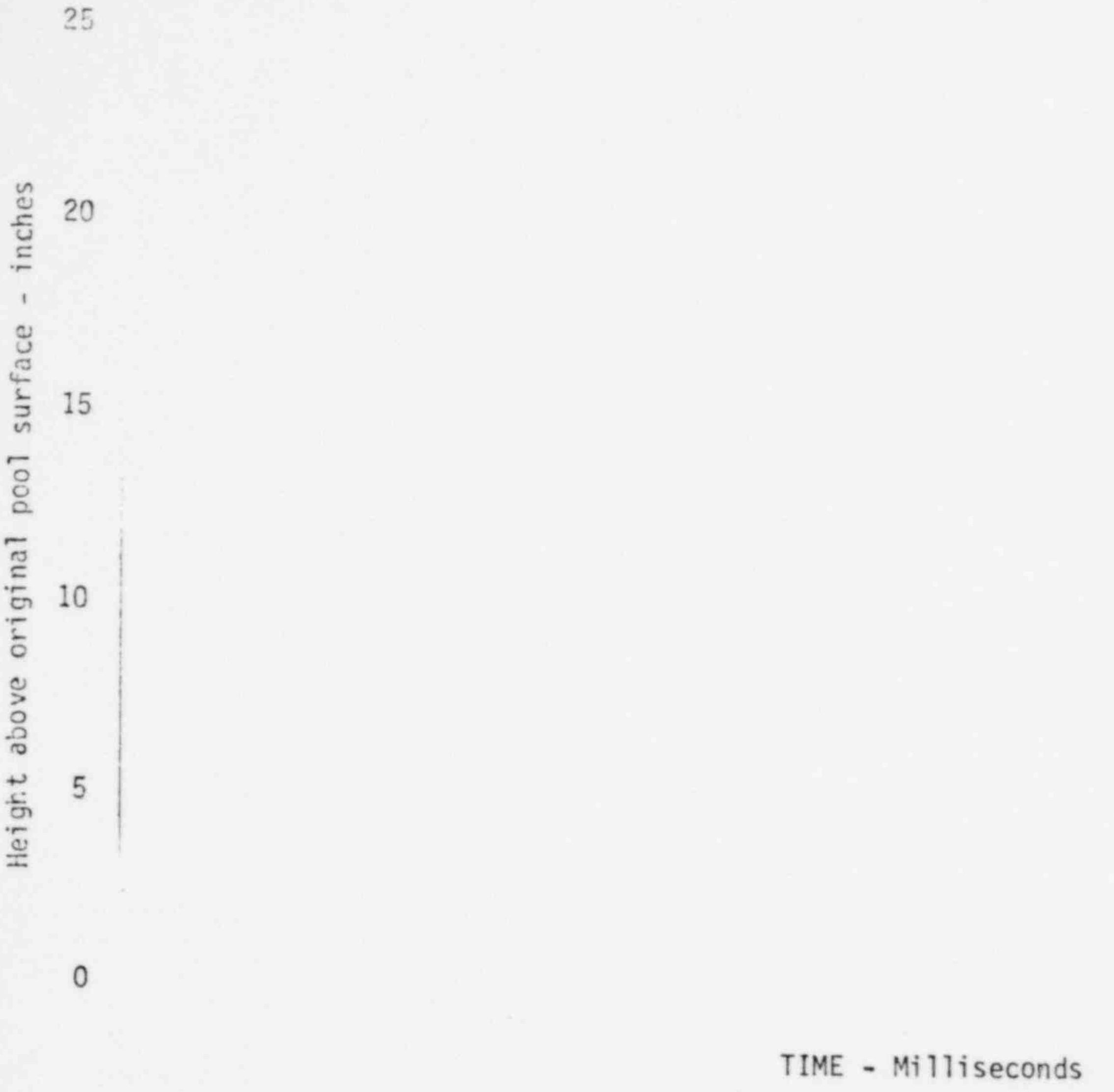
POOL SURFACE DISPLACEMENT

Millstone Tests 1, 2, 3



A-599-a

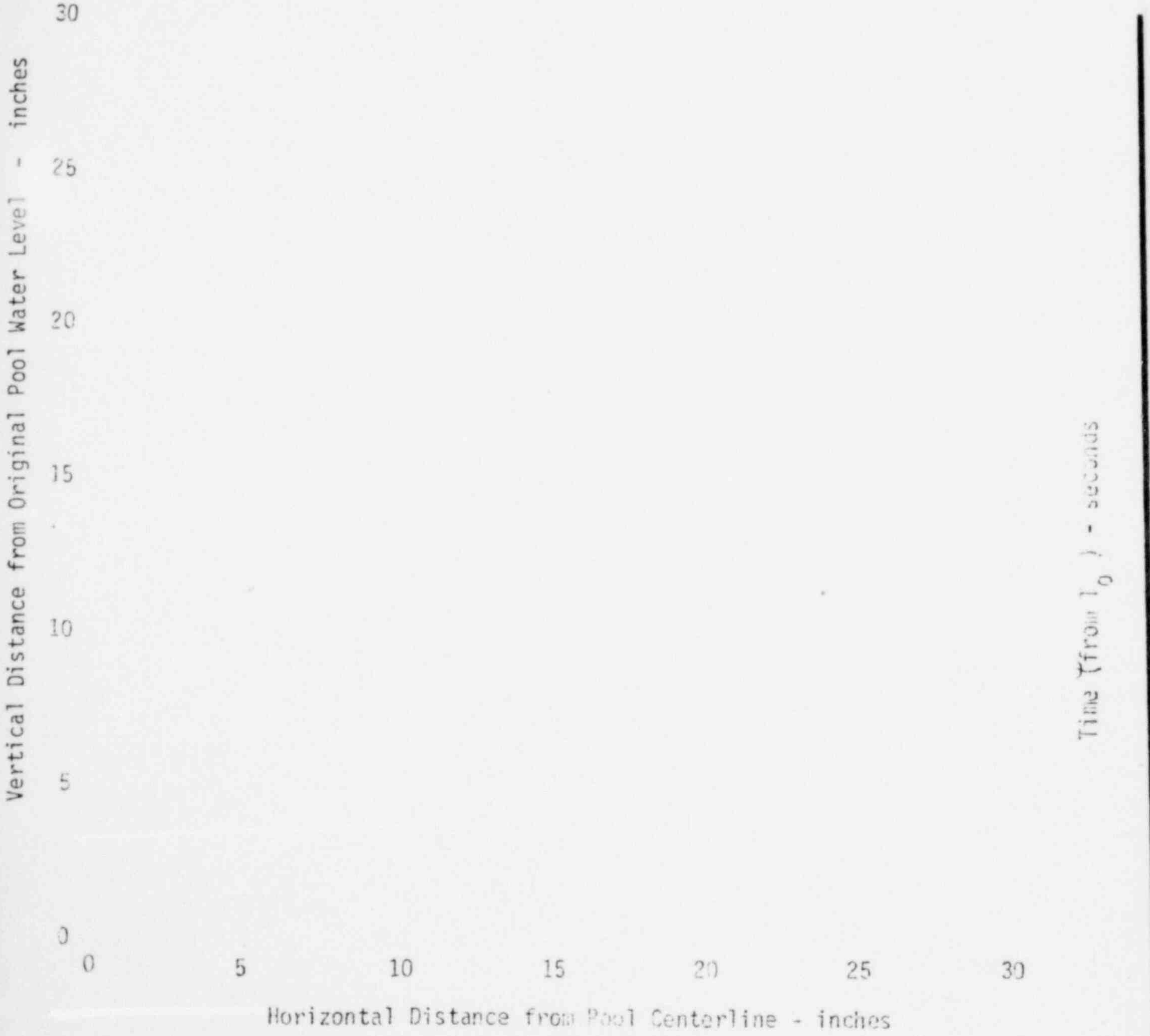
1350 029

FIGURE A-535

TIME HISTORY OF

POOL DISPLACEMENT

Millstone Test 5



1350 030

FIGURE A-537

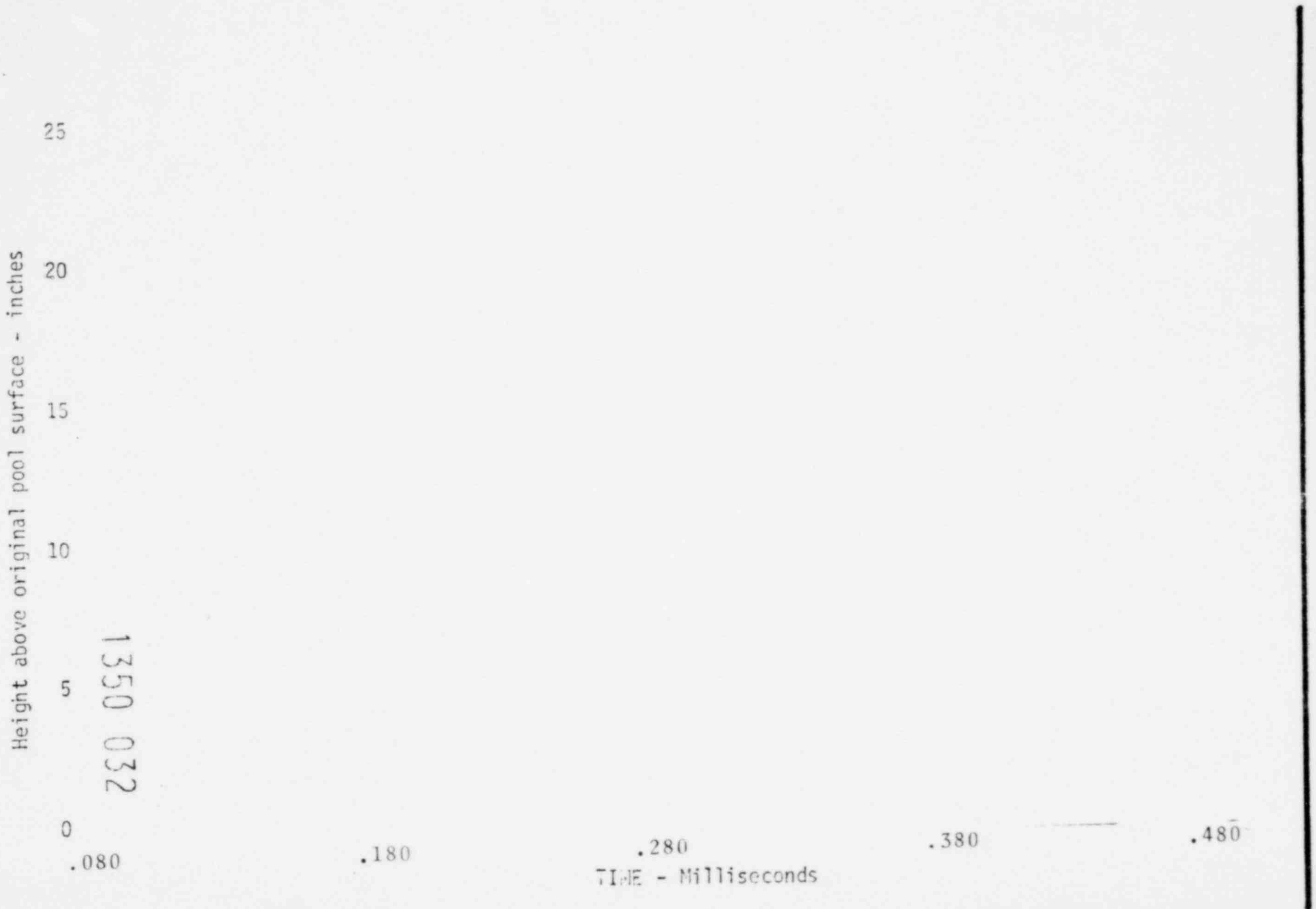
POOL SURFACE VELOCITY PROFILES

Millstone Tests 1, 2 , 3

FIGURE A-538

POOL SURFACE DISPLACEMENT

Millstone Test 5



1350 032

FIGURE A-539

POOL SURFACE VELOCITY PROFILES

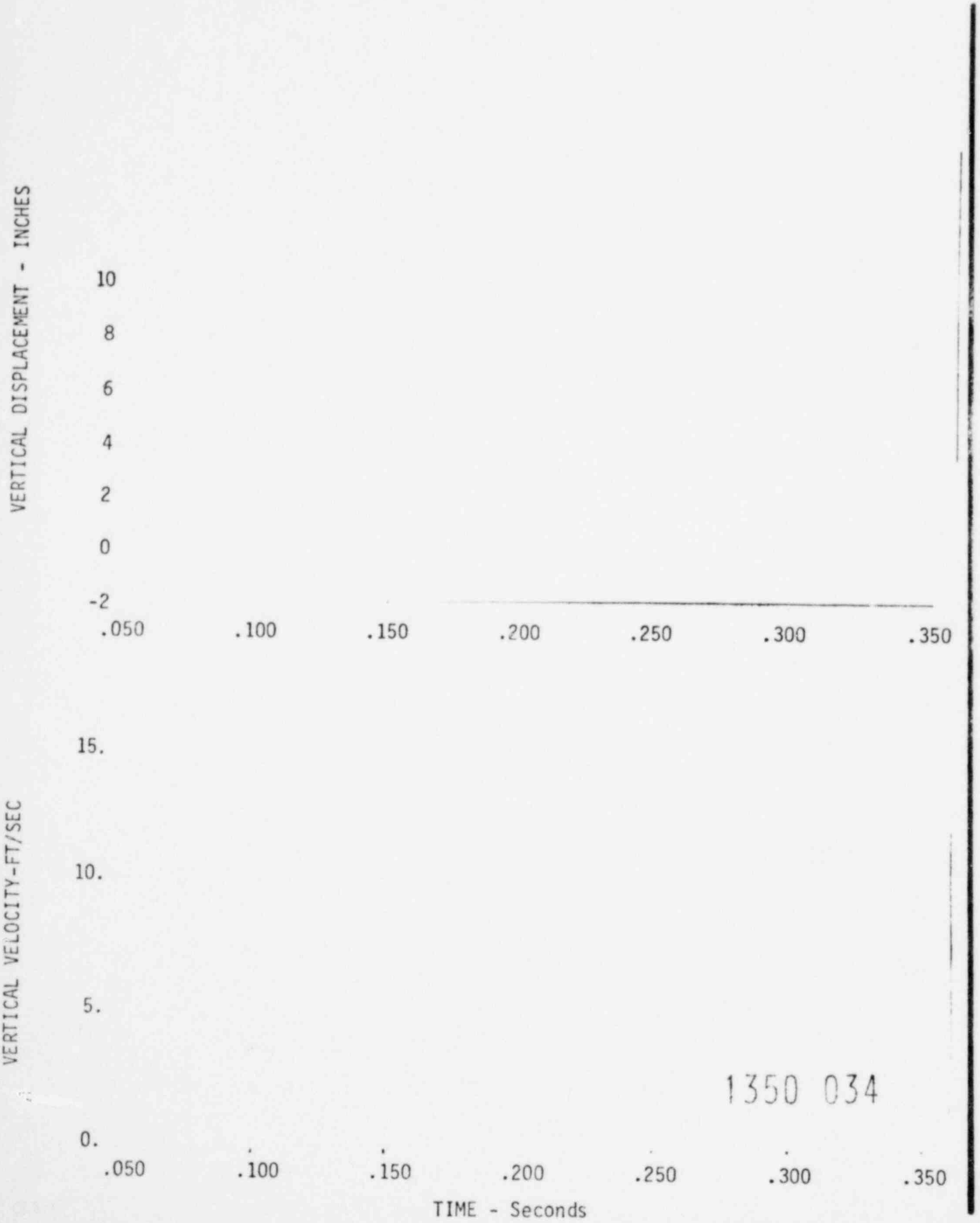
Millstone Test 5

1350 033

FIGURE A-540

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

Millstone Test 4

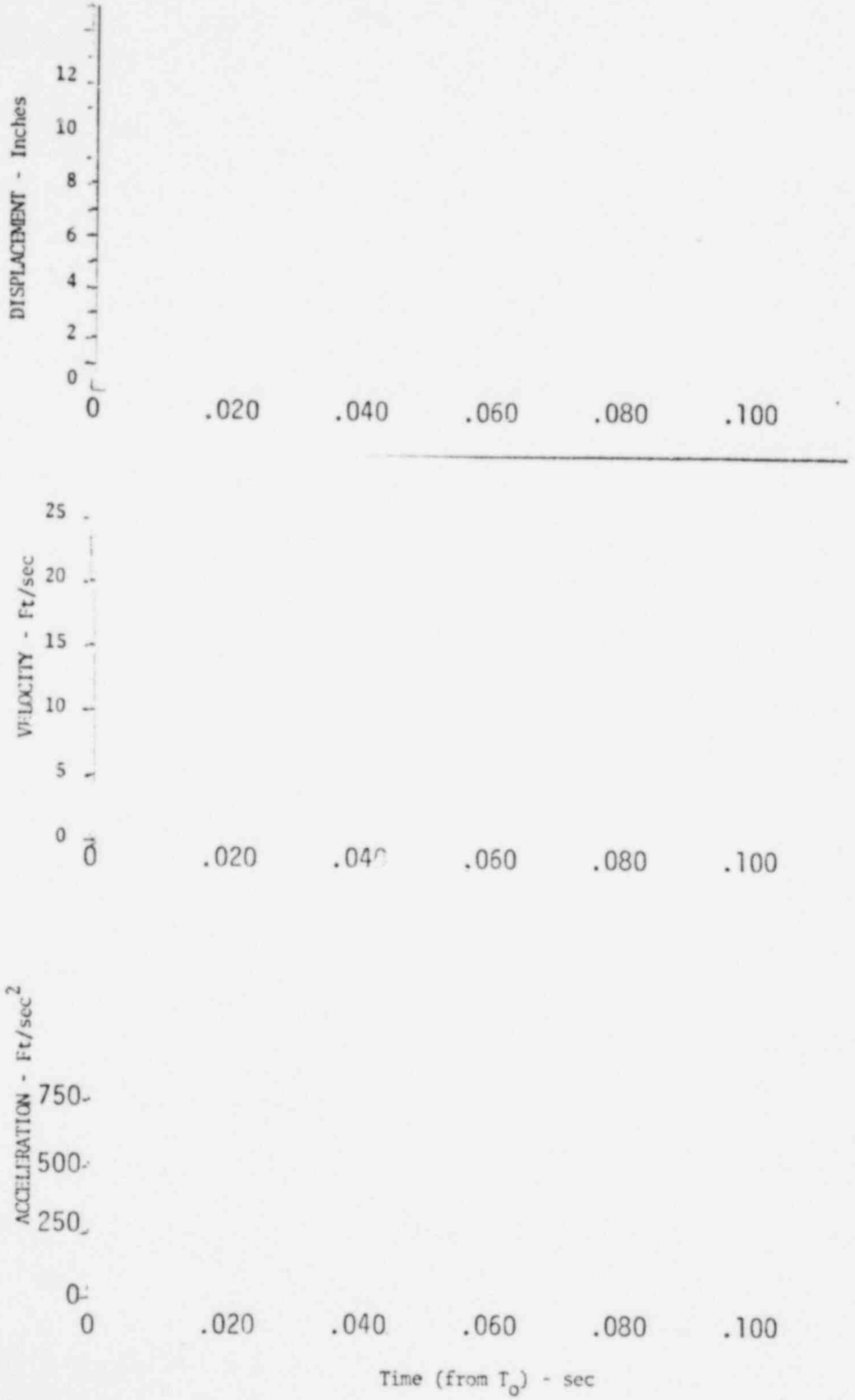


1350 034

FIGURE A-541

DOWNCOMER WATER SLUG EJECTION

MILLSTONE, TEST 3

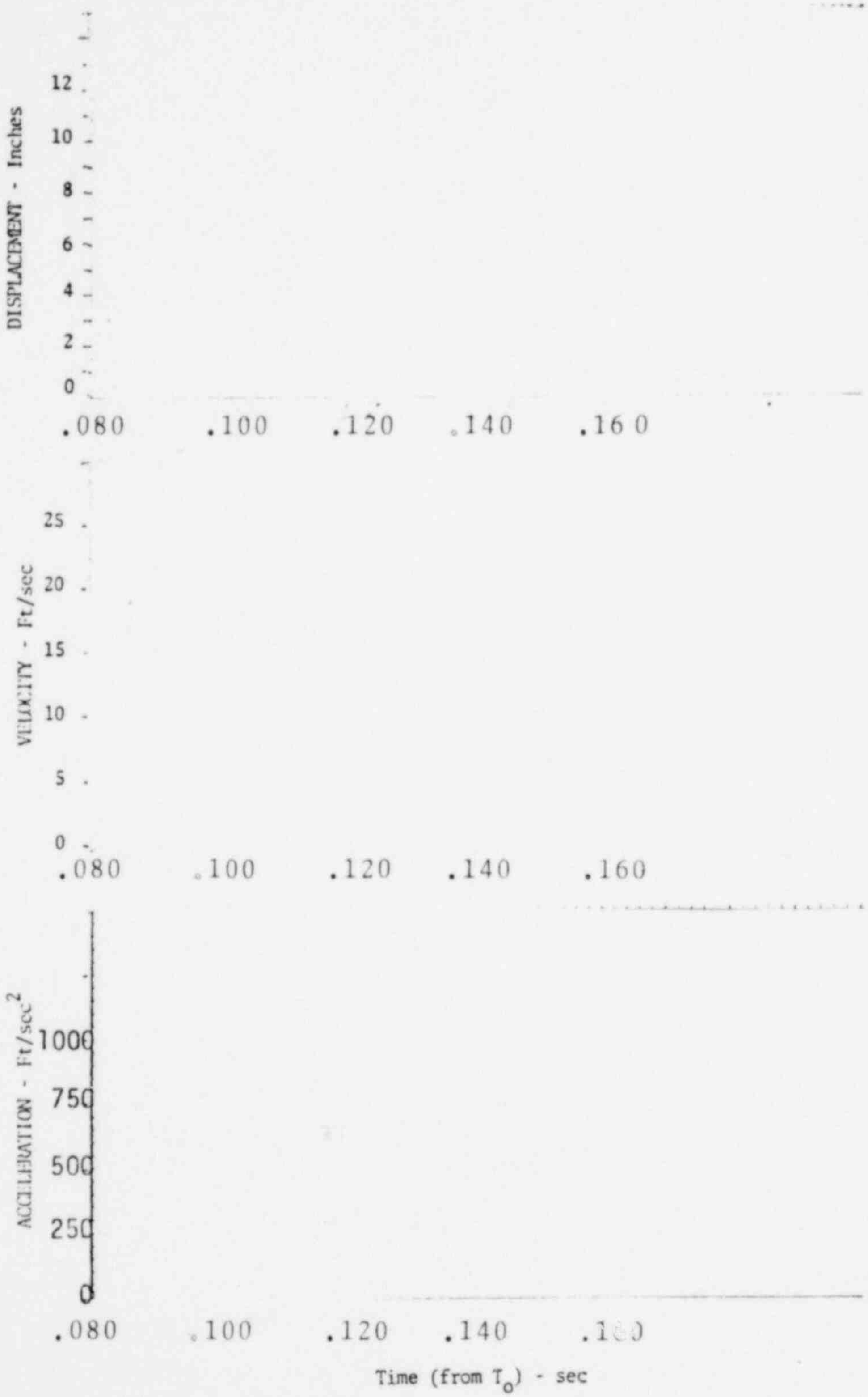


1350 035

FIGURE A-542

DOWNCOMER WATER SLUG EJECTION

MILLSTONE, TEST 5



NOTE: The air/water interface was not visible above 3-1/2 inches because the test downcomer is not constructed of plexiglass above that point.

1350 036

FIGURE A-543

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Millstone Tests

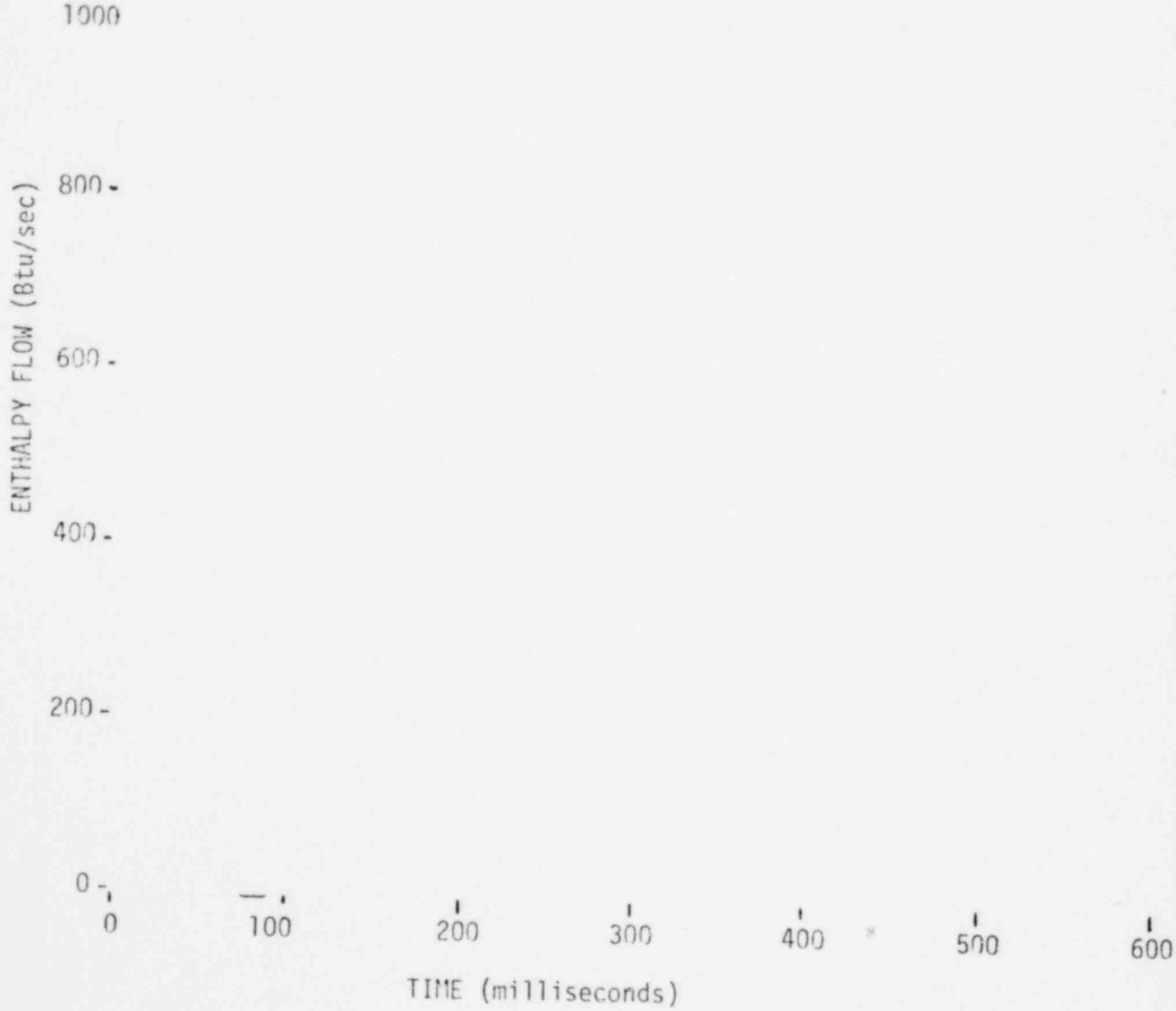
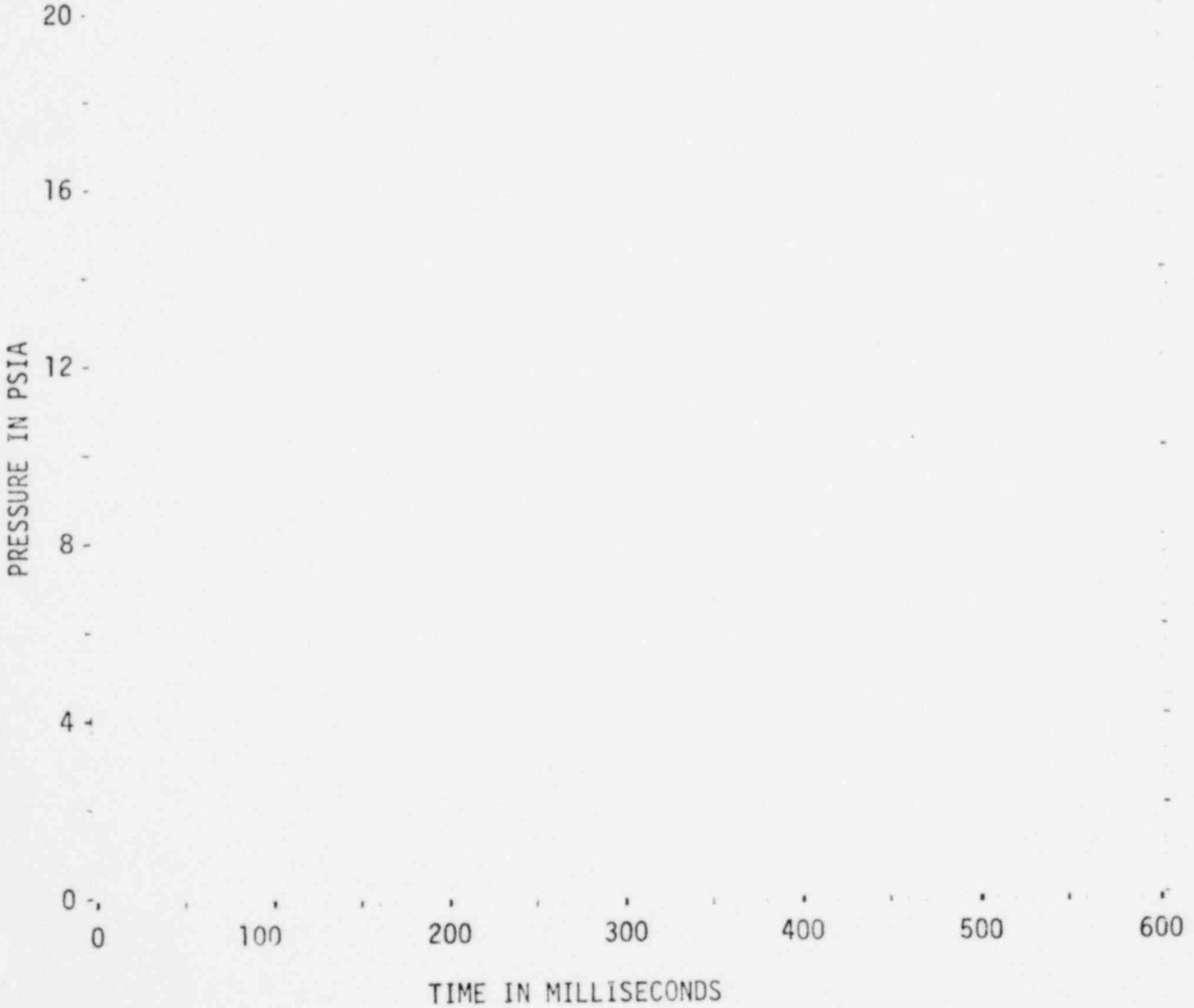


FIGURE A-544

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTE..'AL PRESSURE

Millstone Tests



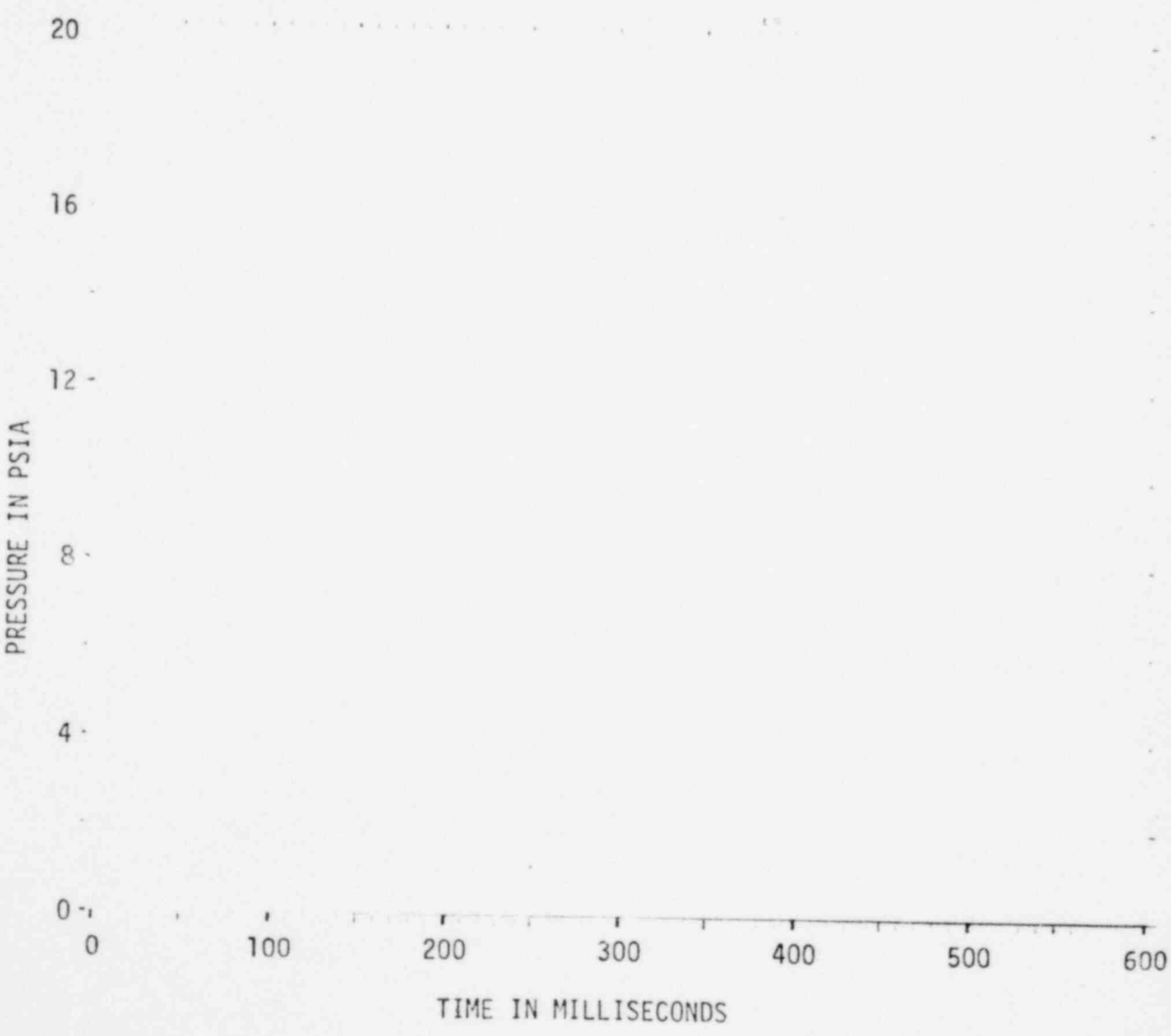
1350 038

FIGURE A-545

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Millstone Tests



1350 039

TABLE A-23

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Millstone Tests

Parameter \ Test No.	8.7 ΔP, 4.20" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0 ΔP (5)
T_o † (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)							

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

† = Start of test reference time

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TABLE A-23

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Millstone Tests

Parameter \ Test No.	8.73" 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)							

***= Time at force is zero (from t_o)

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TABLE A-24

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3-2, Millstone

Parameter	Test No.	8.73" ΔP, 4.20" 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

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A.12 Oyster Creek Tests

A.12.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Oyster Creek, Tests 2 and 5. Test 2 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.12.1.1 Driving Conditions

Driving conditions for Oyster Creek, Test 2 are presented in Figures A-546 through A-550. Similar plots for Oyster Creek Test 5 are shown in Figures A-551 through A-555. Oyster Creek's driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.12.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Oyster Creek Tests 2 and 5 are presented in Figures A-556 through A-557 and A-558 through A-559, respectively. These pressure plots have the same characteristics as the "typical" plant in Section 3.0.

Figures A-560 and A-561 present net torus force based on the torus pressure integral for Oyster Creek Tests 2 and 5, respectively. Some downforce oscillations are present, but they dampen out rapidly after the first oscillation. During the Oyster Creek tests, 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

1350 043

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 (Figures A-560 and A-561).

The net torus force which was determined by applying the inertial correction from the torus accelerometer (Figures A-563 and A-565) to the torus load cell (Figures A-562 and A-564) is compared with the torus force obtained from the torus pressure integral in Figures A-566 and A-567. Residual oscillations are present in the corrected load cell. Figures A-568 and A-569 present the net torus force based on the torus pressure integral corrected for inertia.

The "average" pool pressures for Oyster Creek Tests 2 and 5 are shown in Figures A-570 and A-572. Figures A-571 and A-573 are the same as Figures A-568 and A-569 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Oyster Creek, Test 2 are presented in Figures A-574 through A-578. Vent header pressures for Oyster Creek Test 5 are presented in Figures A-579 through A-583. These figures indicate that the deflector was effective in reducing the peak local vent header impact pressure.

Figure A-584 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 for Tests 2 and 5 are shown in Figures A-585 and A-586, respectively.

A.12.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-587 through A-590 for Oyster Creek, Tests 1, 2, 3, and 5.

1350 044

The pool surface displacement curves for Tests 1, 2, and 3 are shown on Figure A-591. The pool surface velocities for Tests 1, 2, and 3 are shown on Figure A-592. The pool surface displacement graph and pool surface velocity profiles for Test 5 are shown in Figures A-593 and A-594, respectively.

The pool surface displacements and velocity profile viewed from the side window during Test 4 are shown in Figure A-595. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-596 and A-597.

A.12.3 Data Summaries

Table A-25 presents the Oyster Creek test data for wetwell vertical forces.

Table A-26 presents the Oyster Creek test data for vent header impact forces.

A.12.4 Discussion and Analysis

Figure A-598 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-599. Figure A-600 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The data for Oyster Creek parallels that for the "typical" plant in Section 3.0.

The Oyster Creek 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 oscilations were evident. The upforce was relatively smooth. The pipe deflector (20" full-scale) effectively reduced vent header impact force.

1350 045

FIGURE A-546

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Oyster Creek Test 2

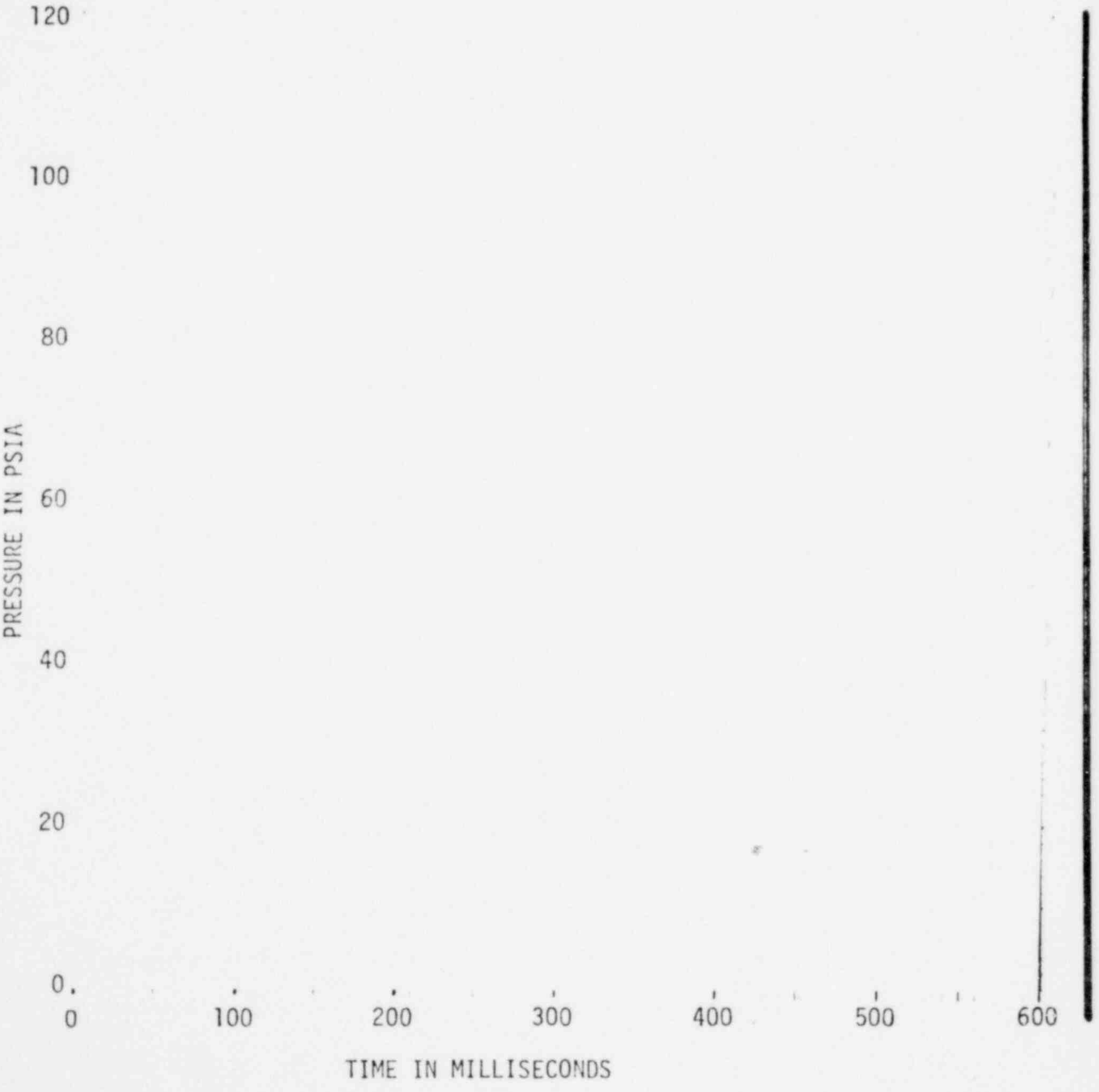

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FIGURE A-547

DRYWELL PRESSURE

Task 5.5.3 Oyster Creek Test 2

1350 047

FIGURE A-548

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Oyster Creek Test 2

1350 048

FIGURE A-549

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Oyster Creek Test 2

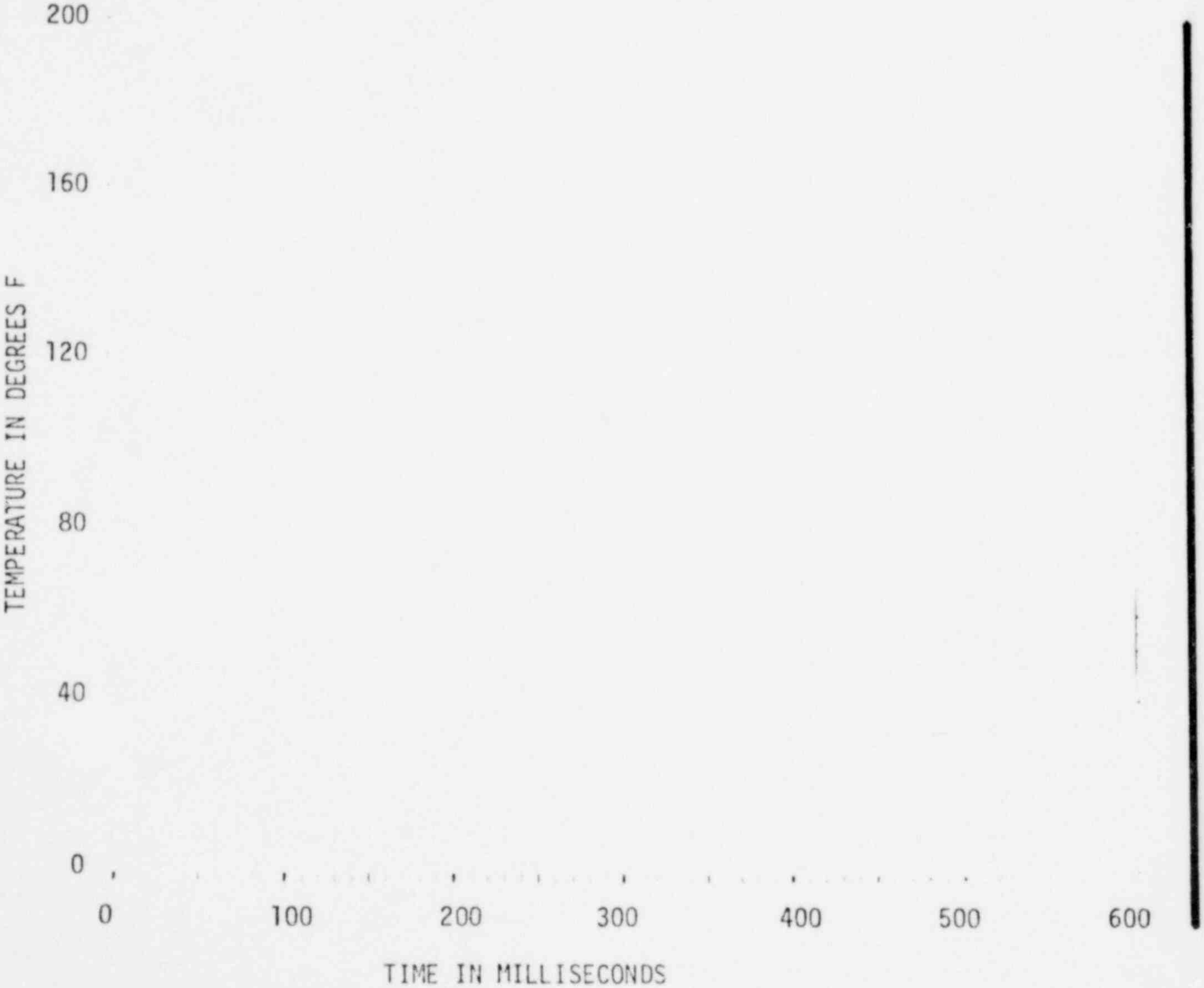

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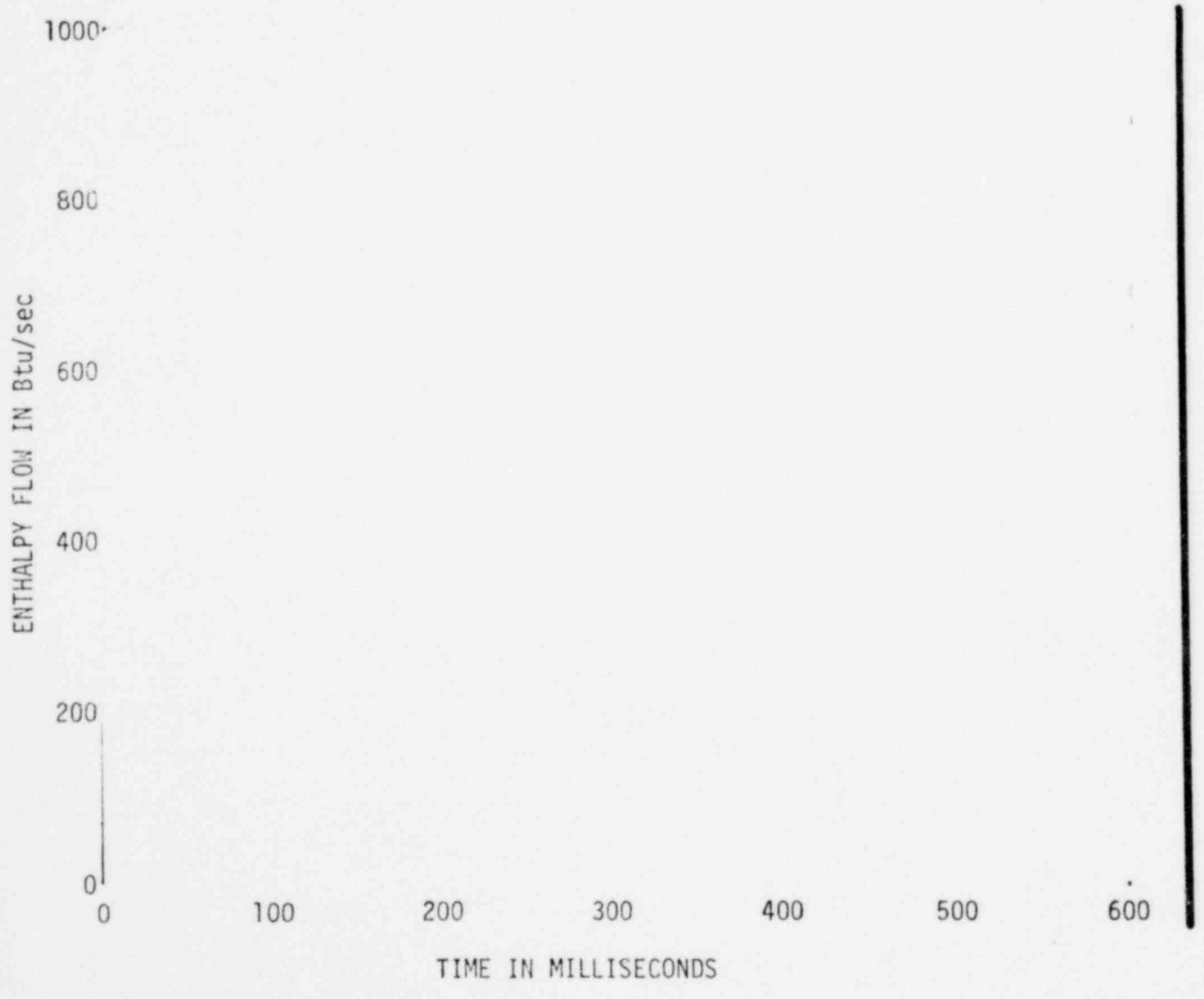
FIGURE A-550

ENTHALPY FLOW INTO POOL

Task 5.5.3 Oyster Creek Test 2

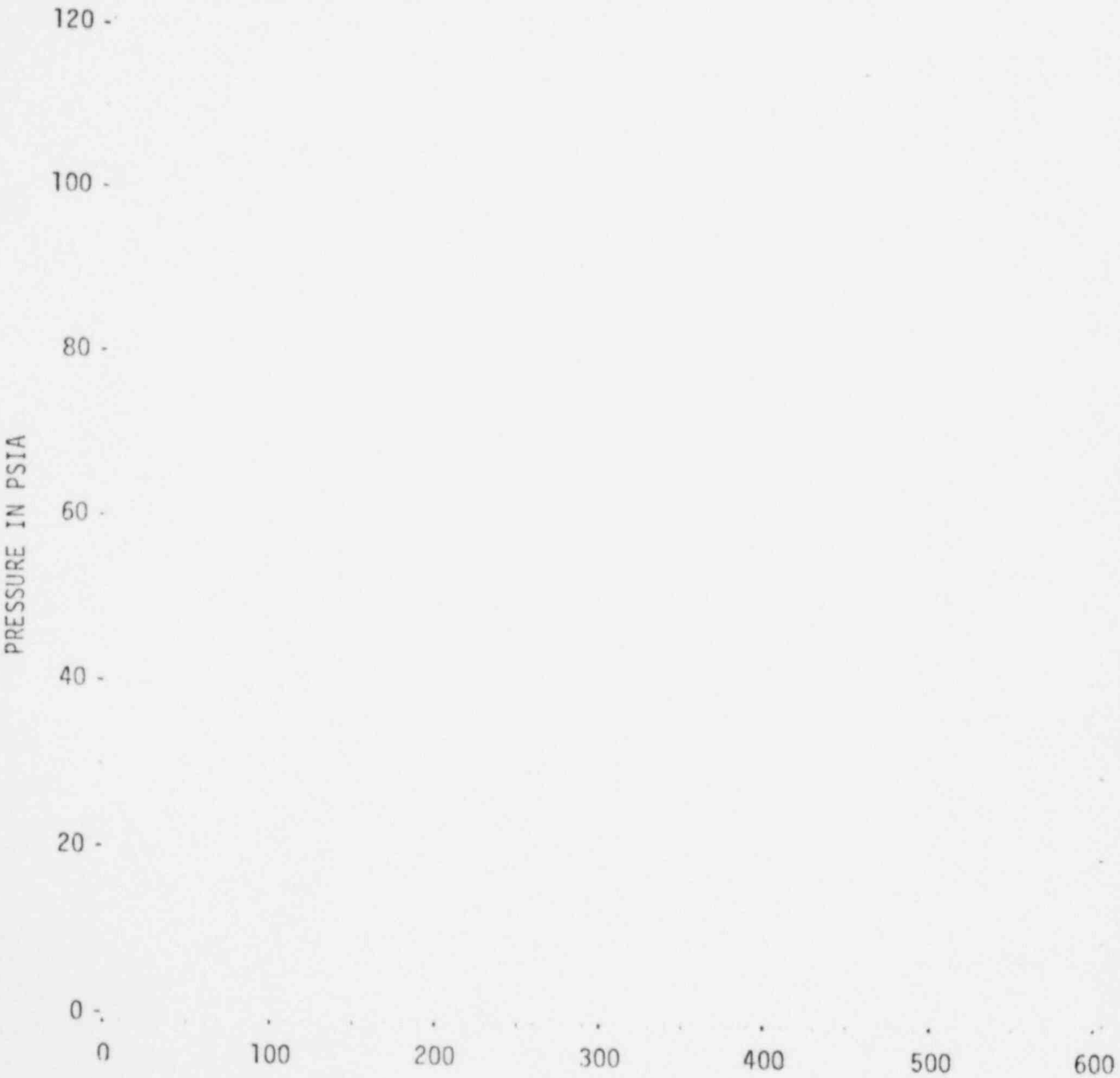


1350 050

FIGURE A-551

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Oyster Creek Test 5

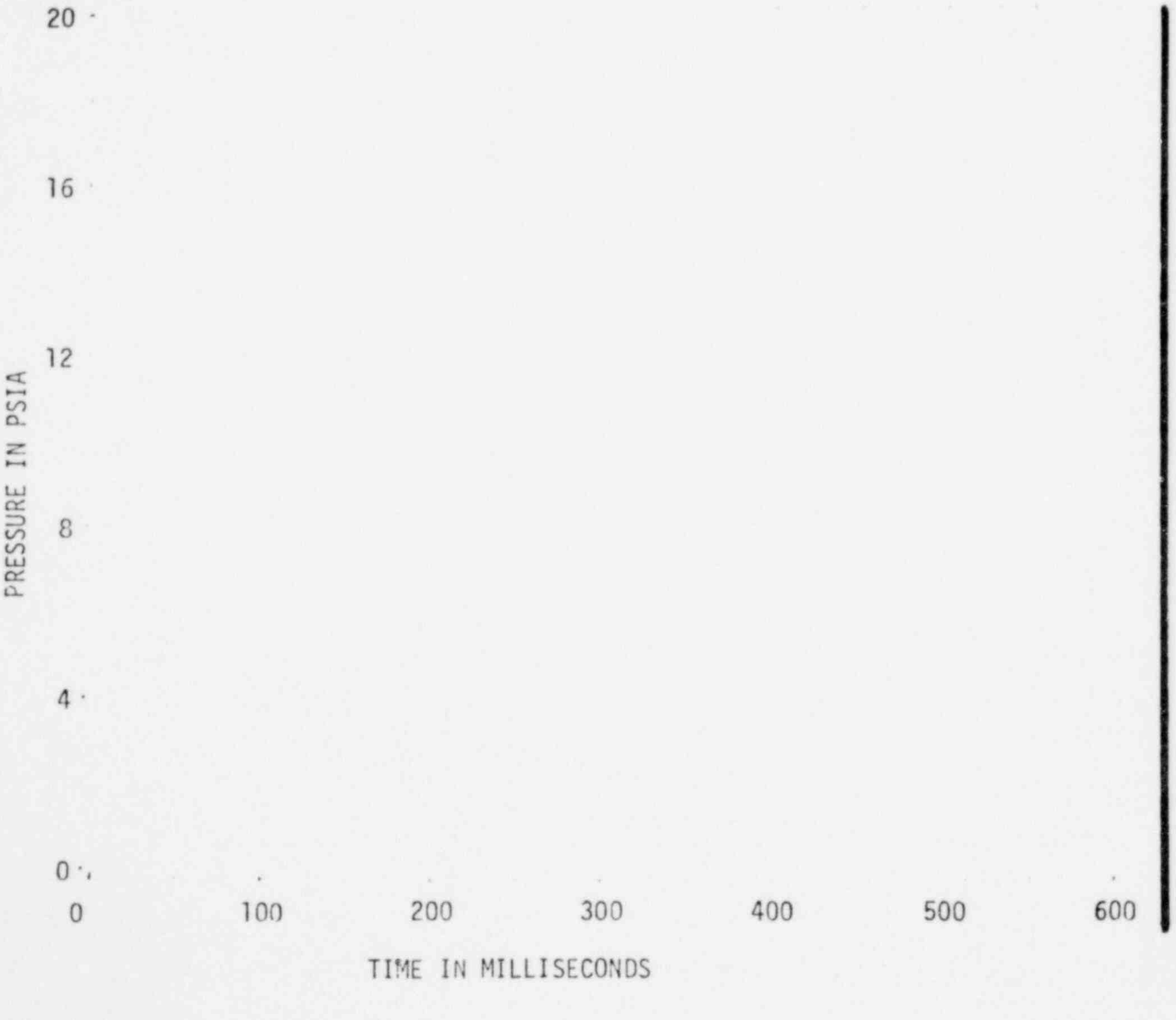


1350 051

FIGURE A-552

DRYWELL PRESSURE

Task 5.5.3 Oyster Creek Test 5

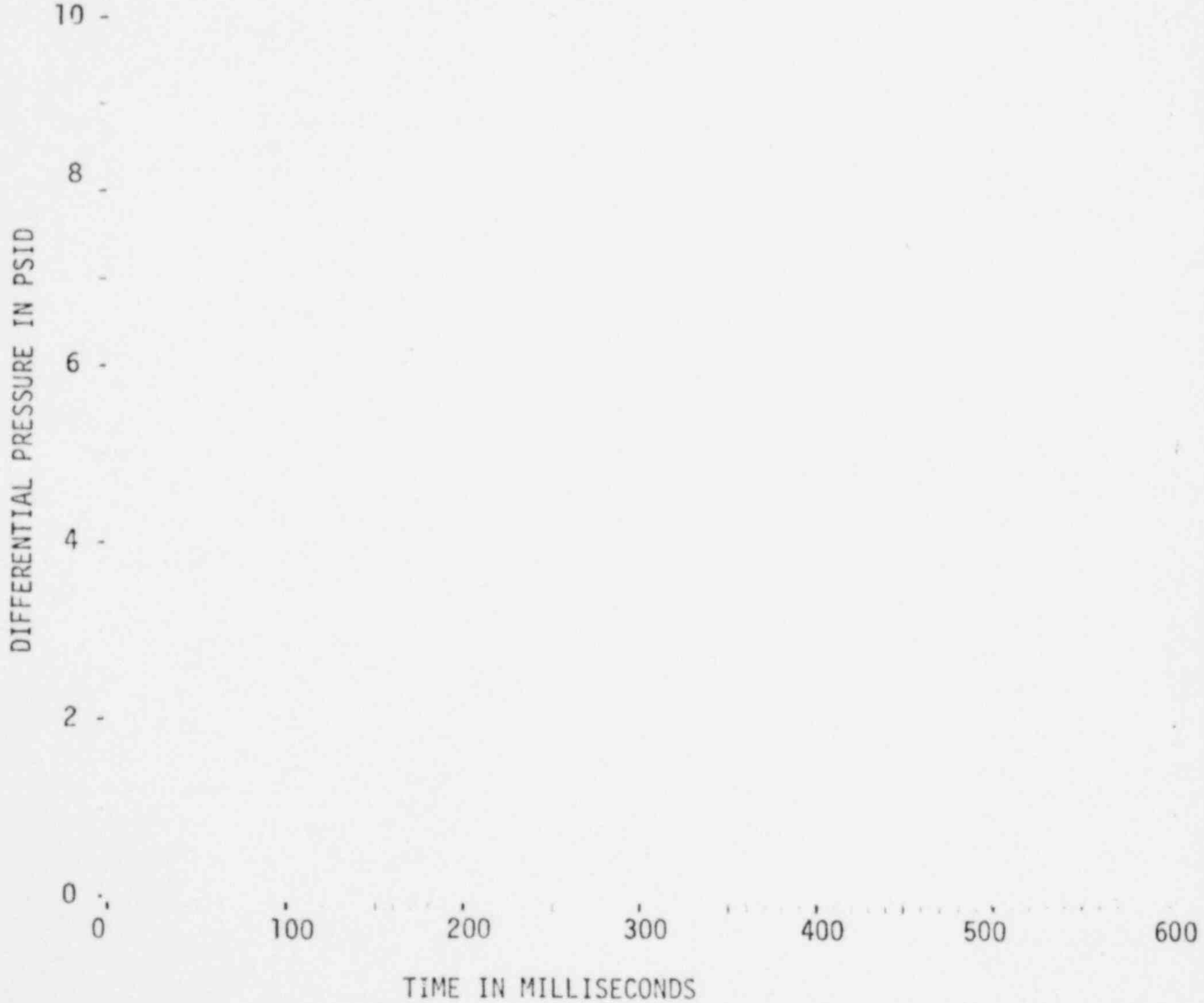


1350 052

FIGURE A-553

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Oyster Creek Test 5

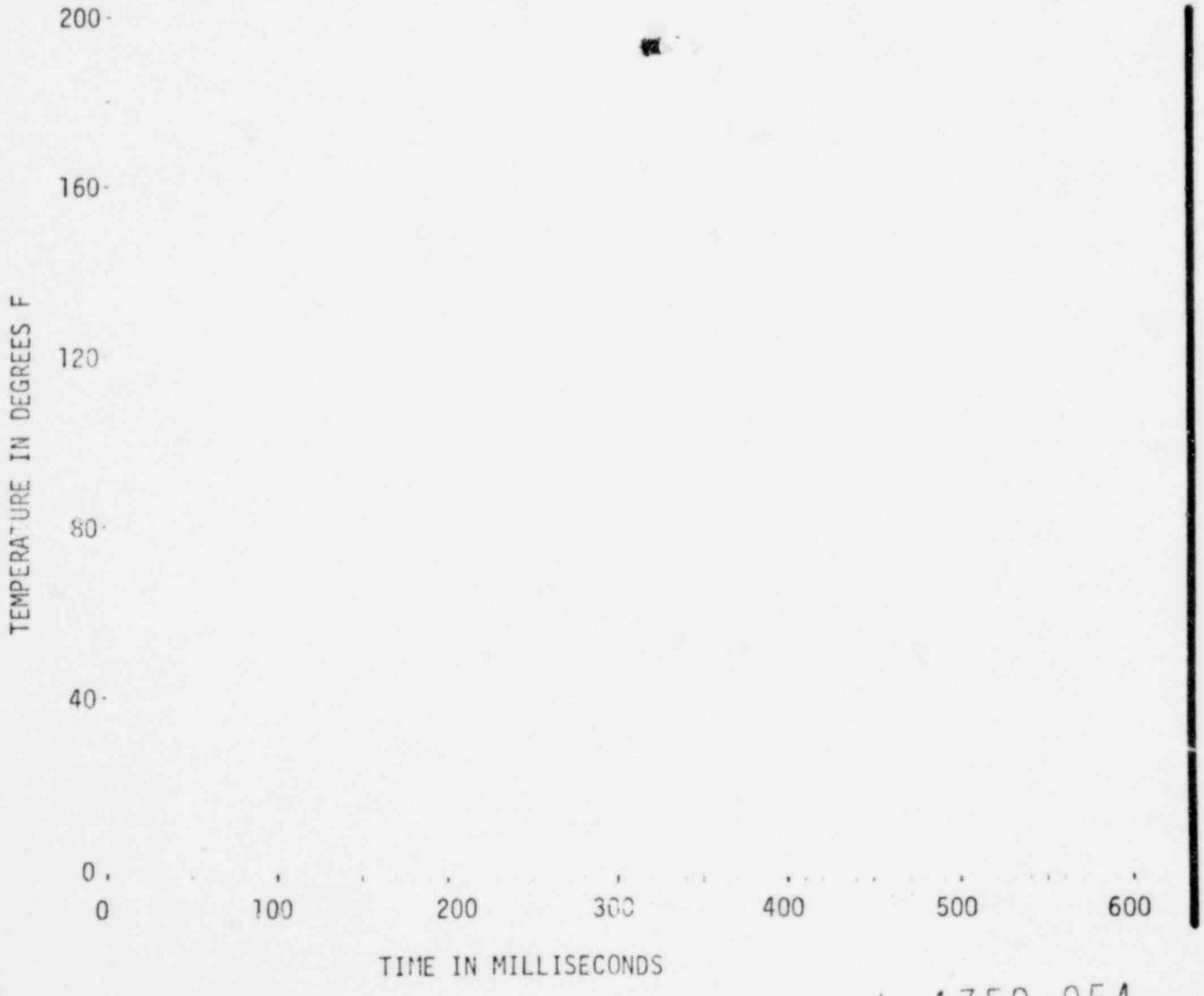


1350 053

FIGURE A-554

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Oyster Creek Test 5

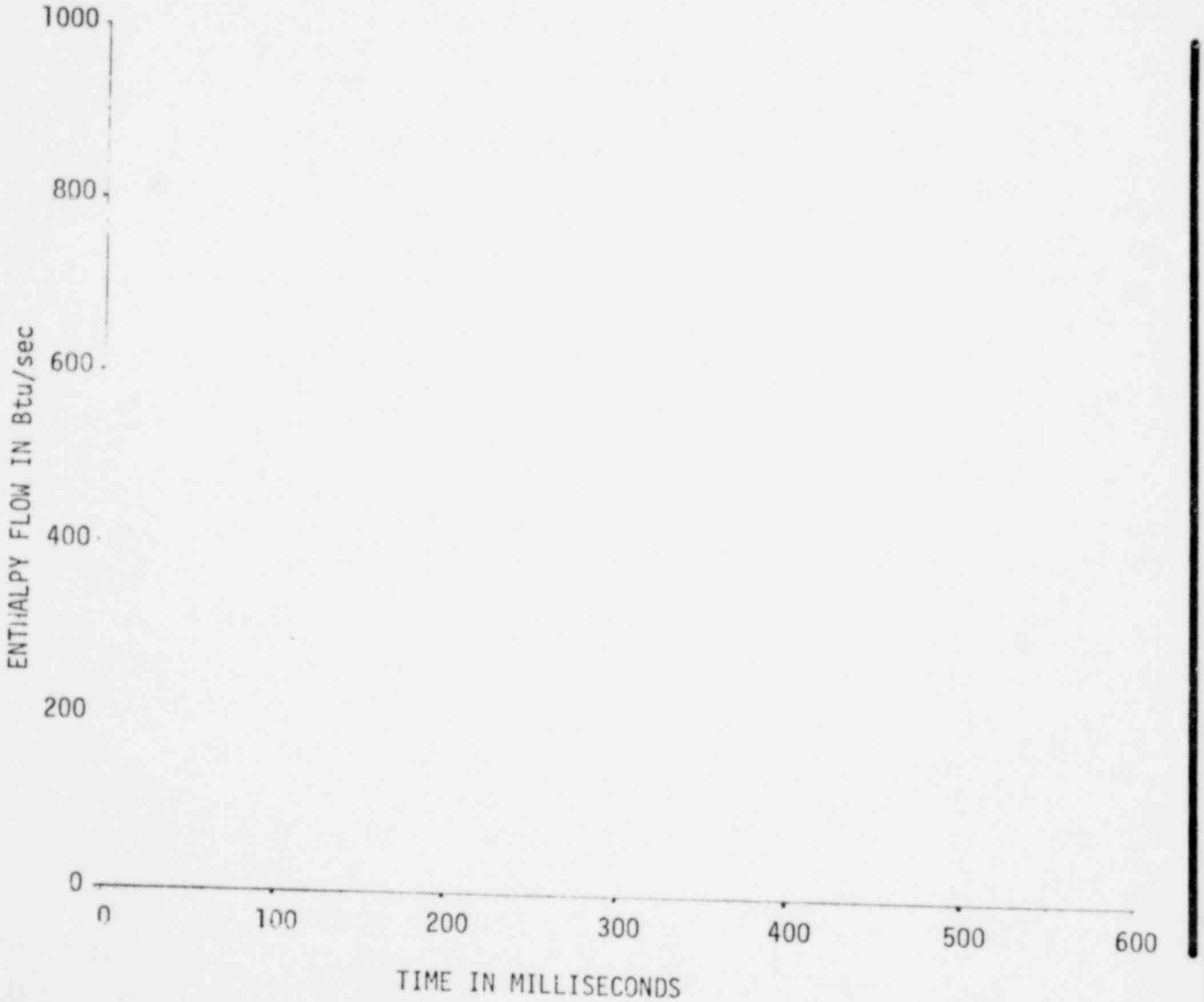


1350 054

FIGURE A-555

ENTHALPY FLOW INTO POOL

Task 5.5.3 Oyster Creek Test 5

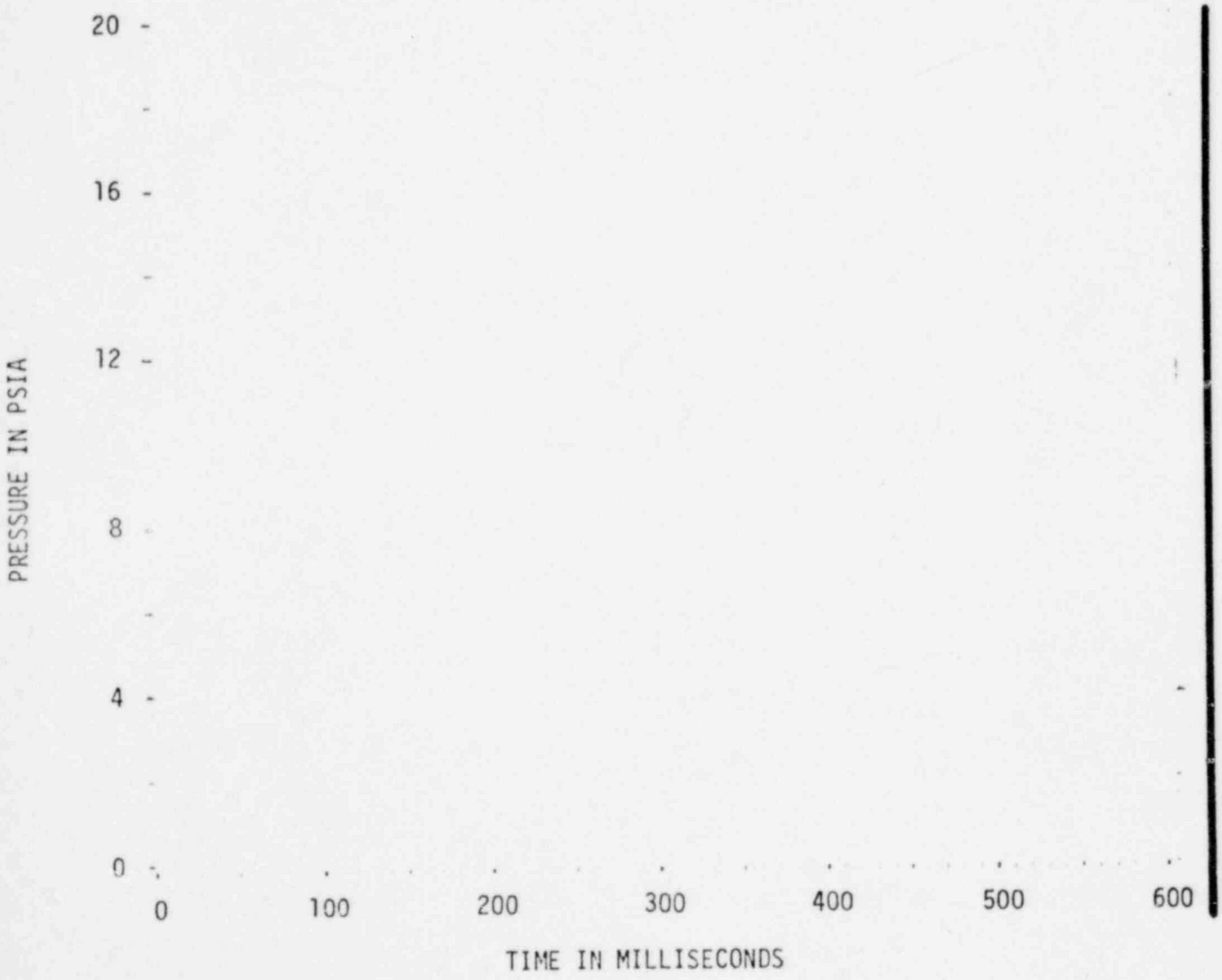


1350 055

FIGURE A-556

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Oyster Creek Test 2

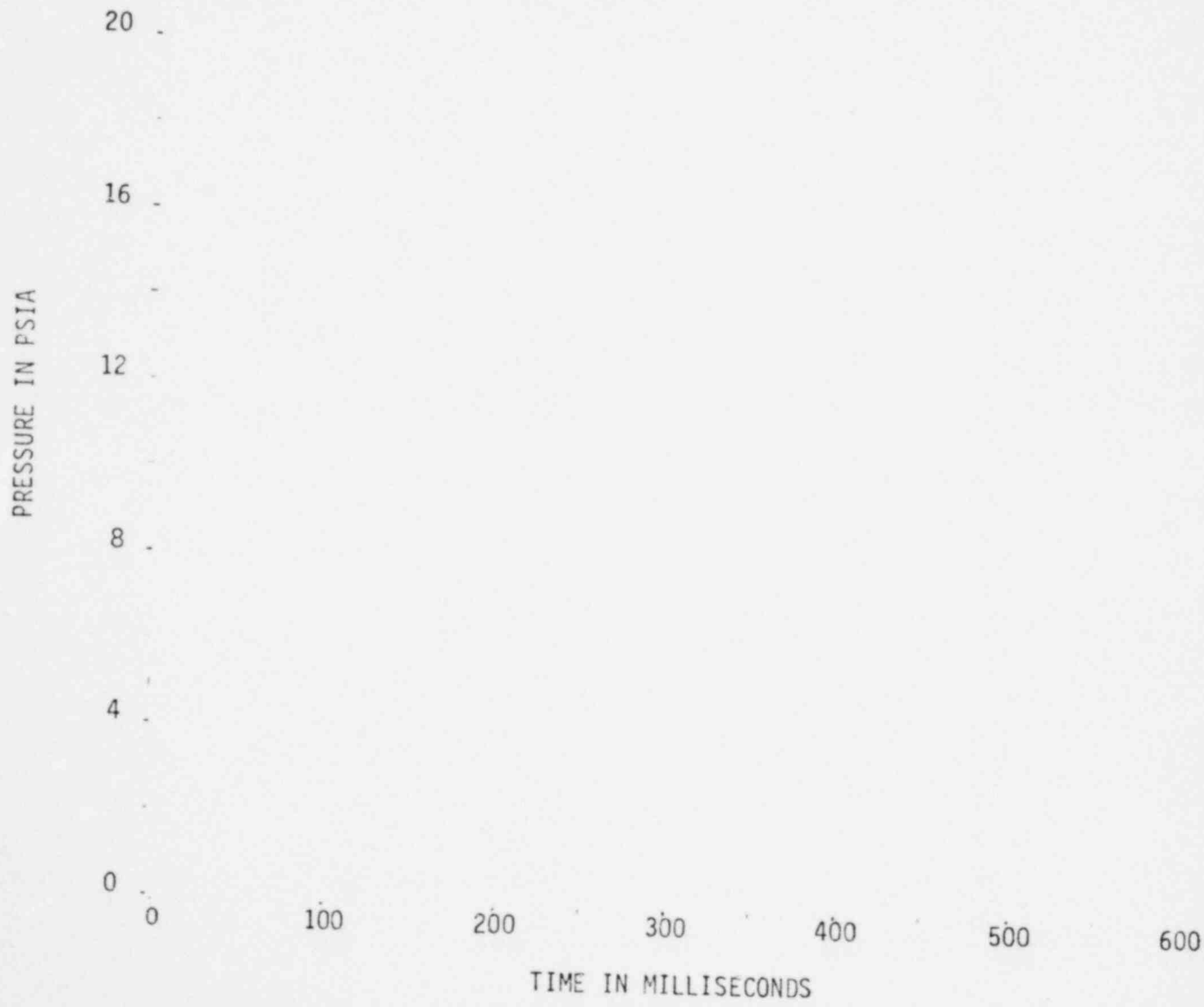


1350 056

FIGURE A-557

WETWELL PRESSURES

Task 5.5.3 Oyster Creek Test 2

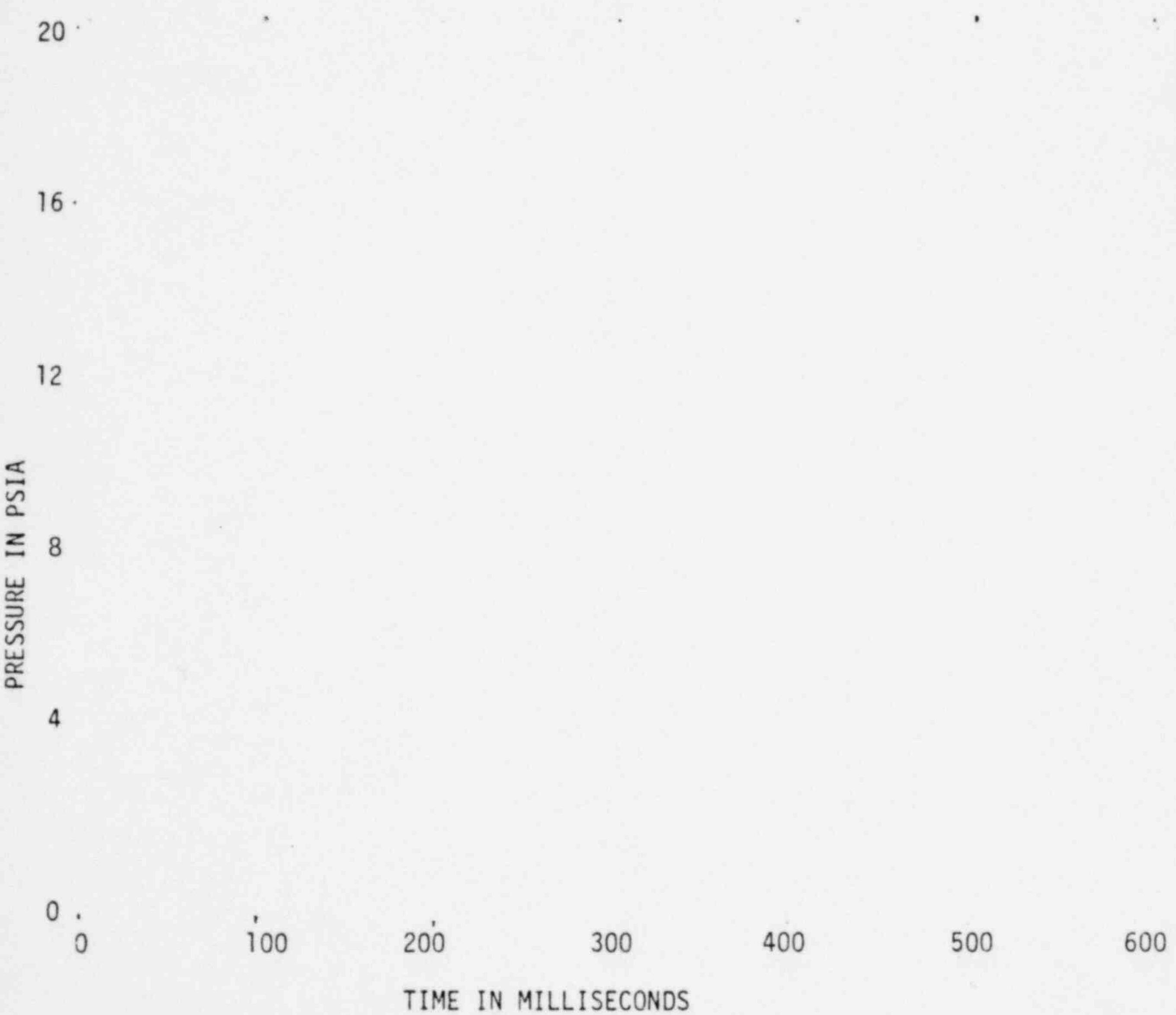


1350 057

FIGURE A-558

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Oyster Creek Test 5

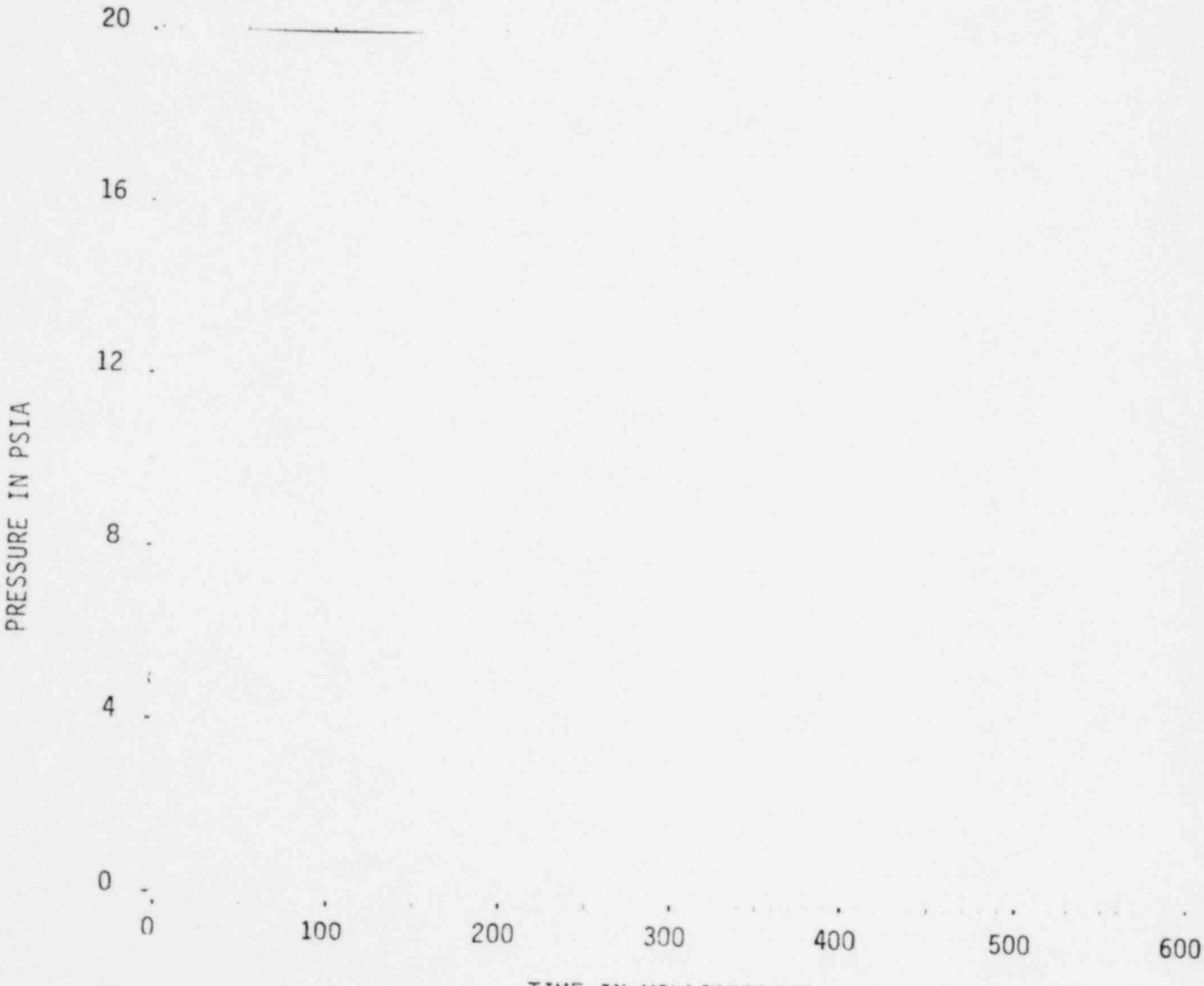


1350 058

FIGURE A-559

WETWELL PRESSURES

Task 5.5.3 Oyster Creek Test 5

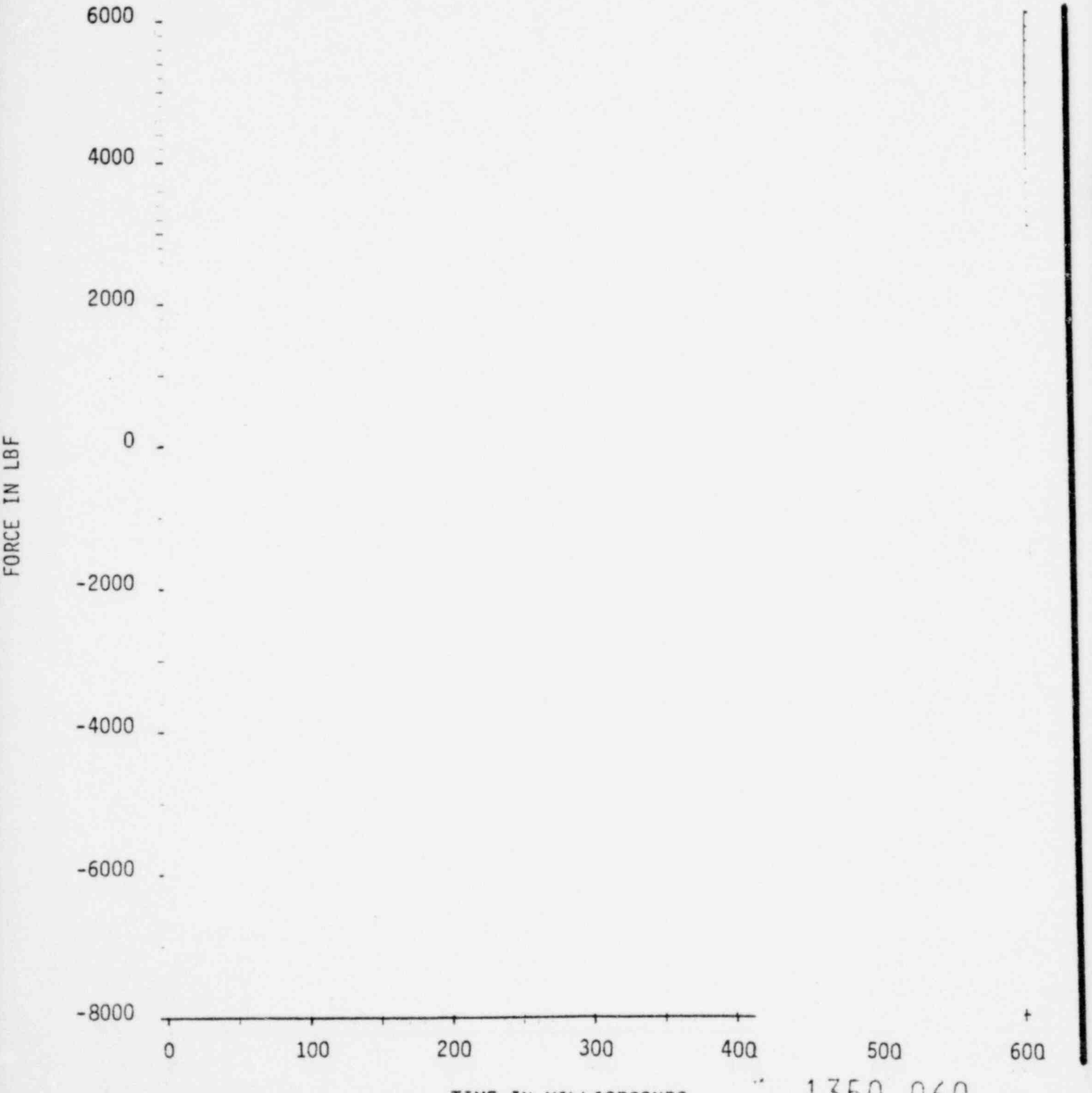


1350 059

FIGURE A-560

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Oyster Creek Test 2



1350 060

FIGURE A-561

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Oyster Creek Test 5

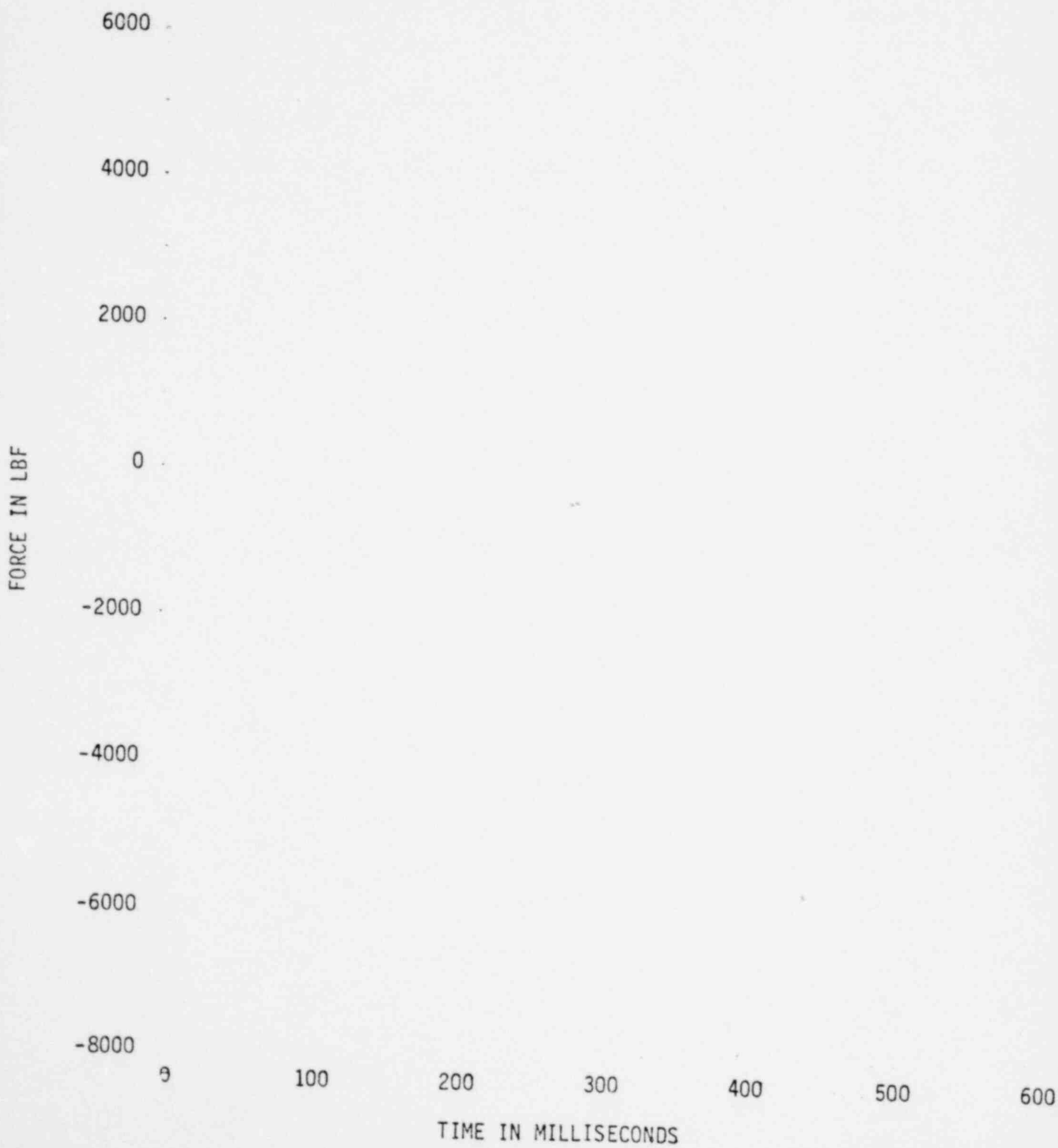
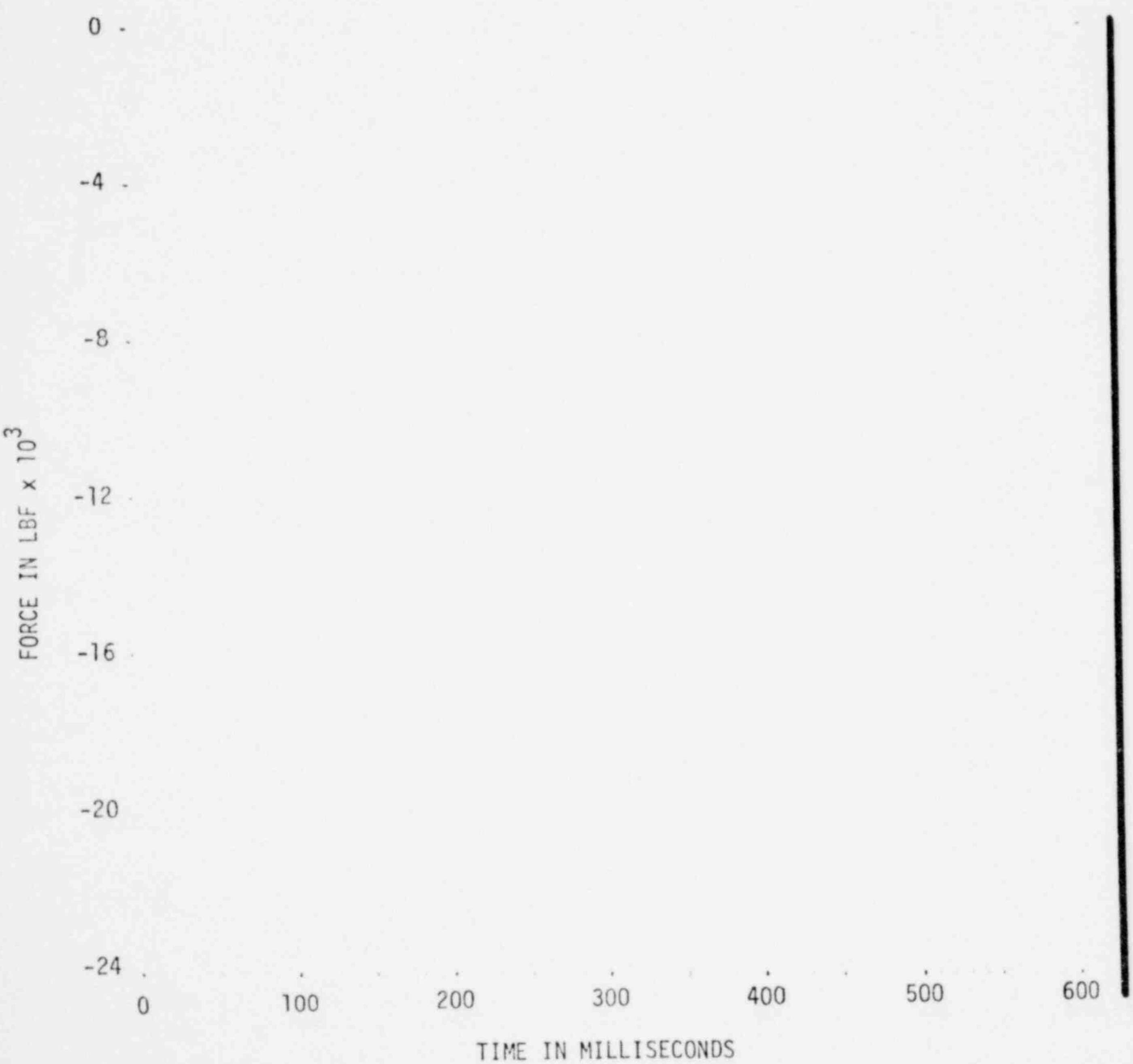


FIGURE A-562

TORUS LOAD CELL

Task 5.5.3 Oyster Creek Test 2



1350 062

FIGURE A-563

TORUS VERTICAL ACCELERATION

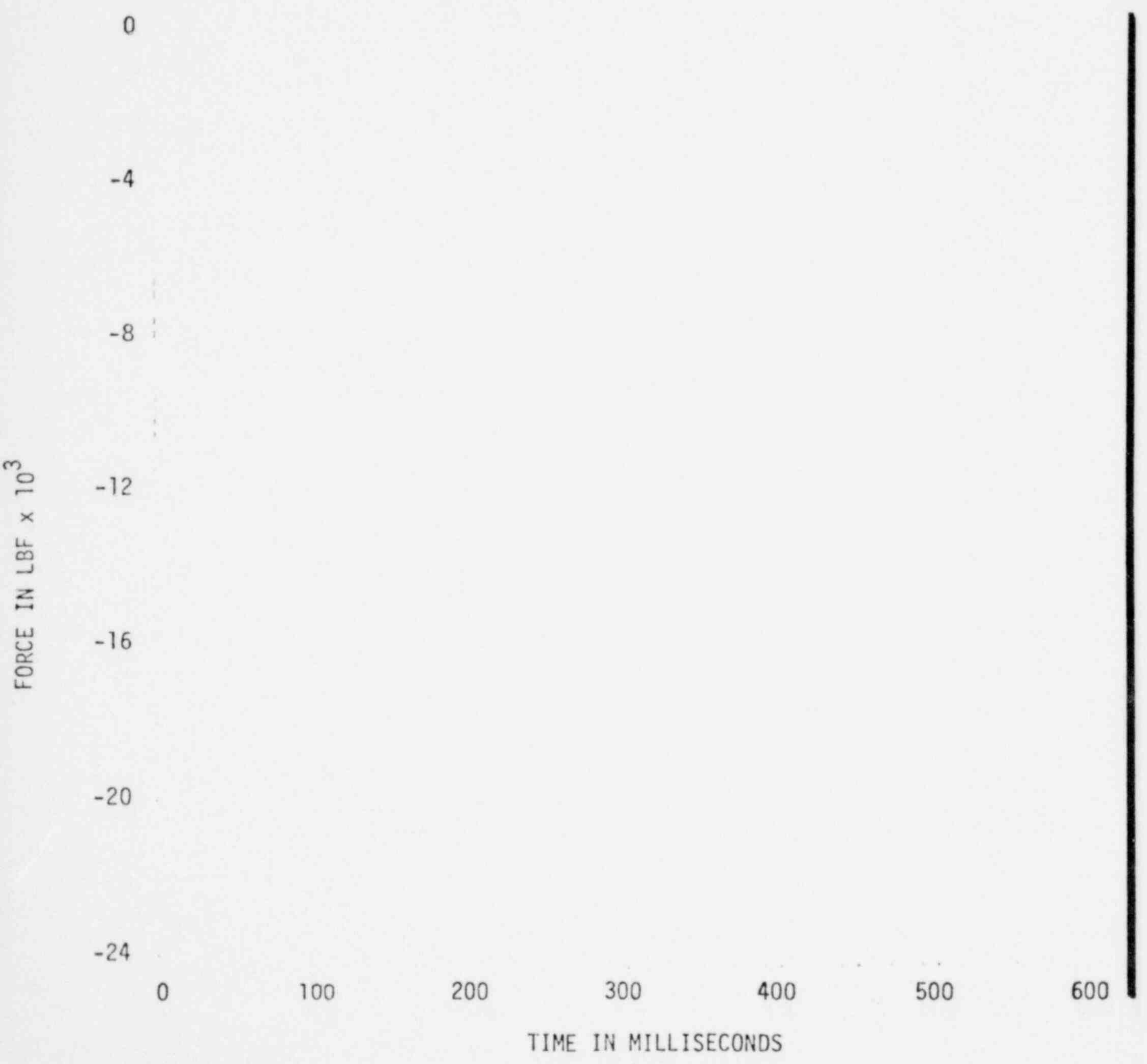
Task 5.5.3 Oyster Creek Test 2

1350 063

FIGURE A-564

TORUS LOAD CELL

Task 5.5.3 Oyster Creek Test 5

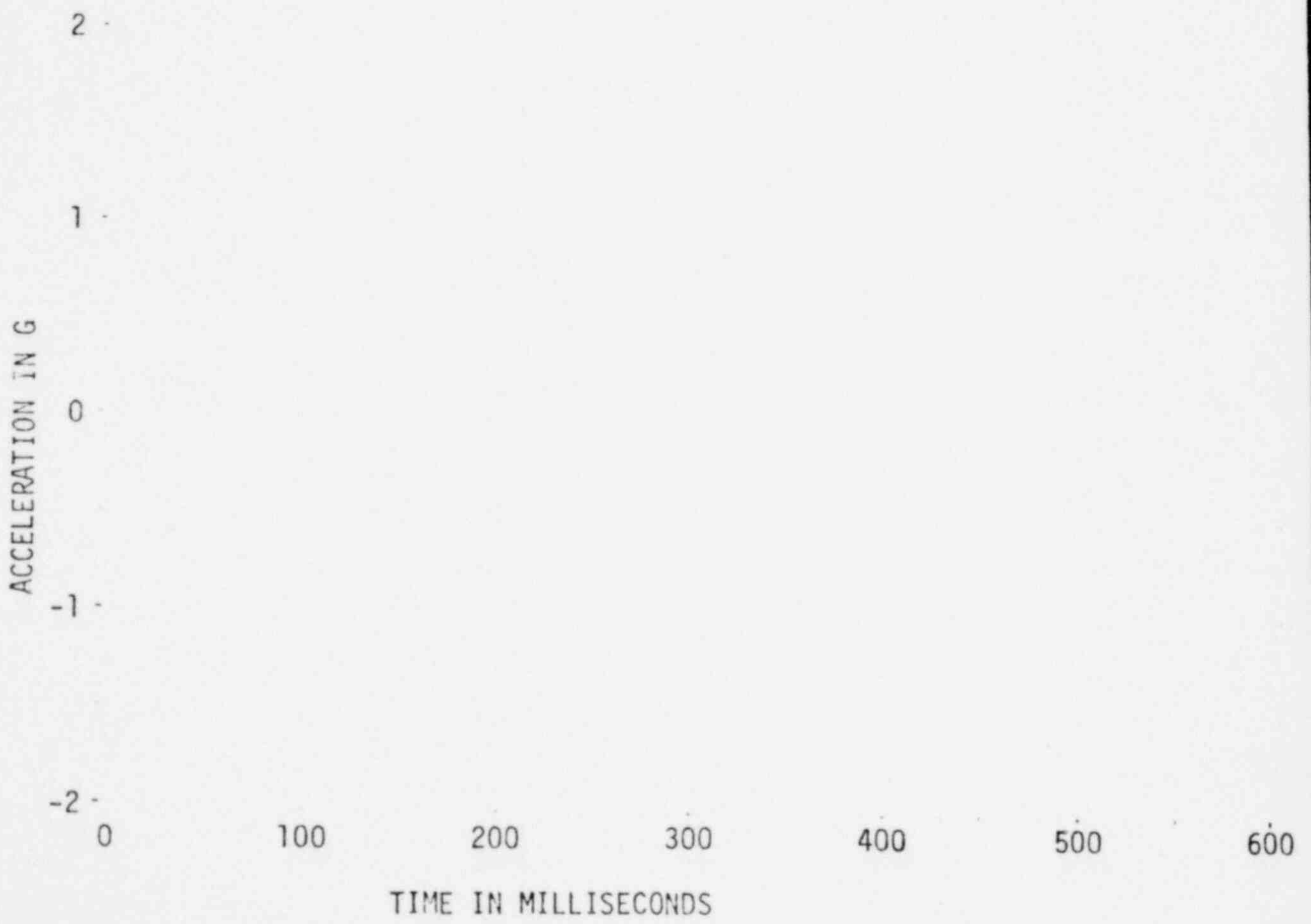


1350 064

FIGURE A-565

TORUS VERTICAL ACCELERATION

Task 5.5.3 Oyster Creek Test 5



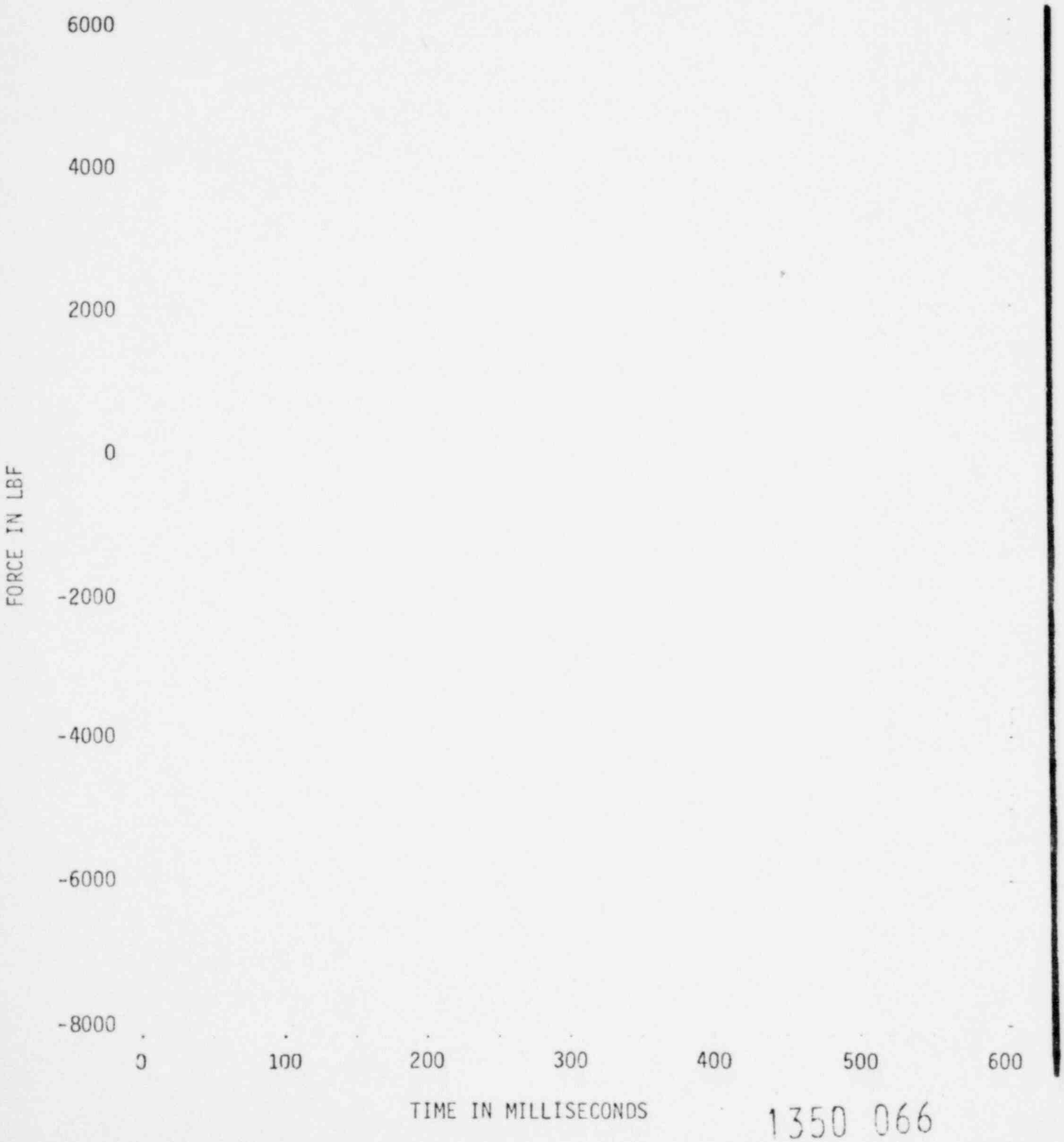
1350 065

FIGURE A-566

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Oyster Creek Test 2



1350 066

FIGURE A-567

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3   Oyster Creek Test 5

FORCE IN LBF

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

0 100 200 300 400 500 600

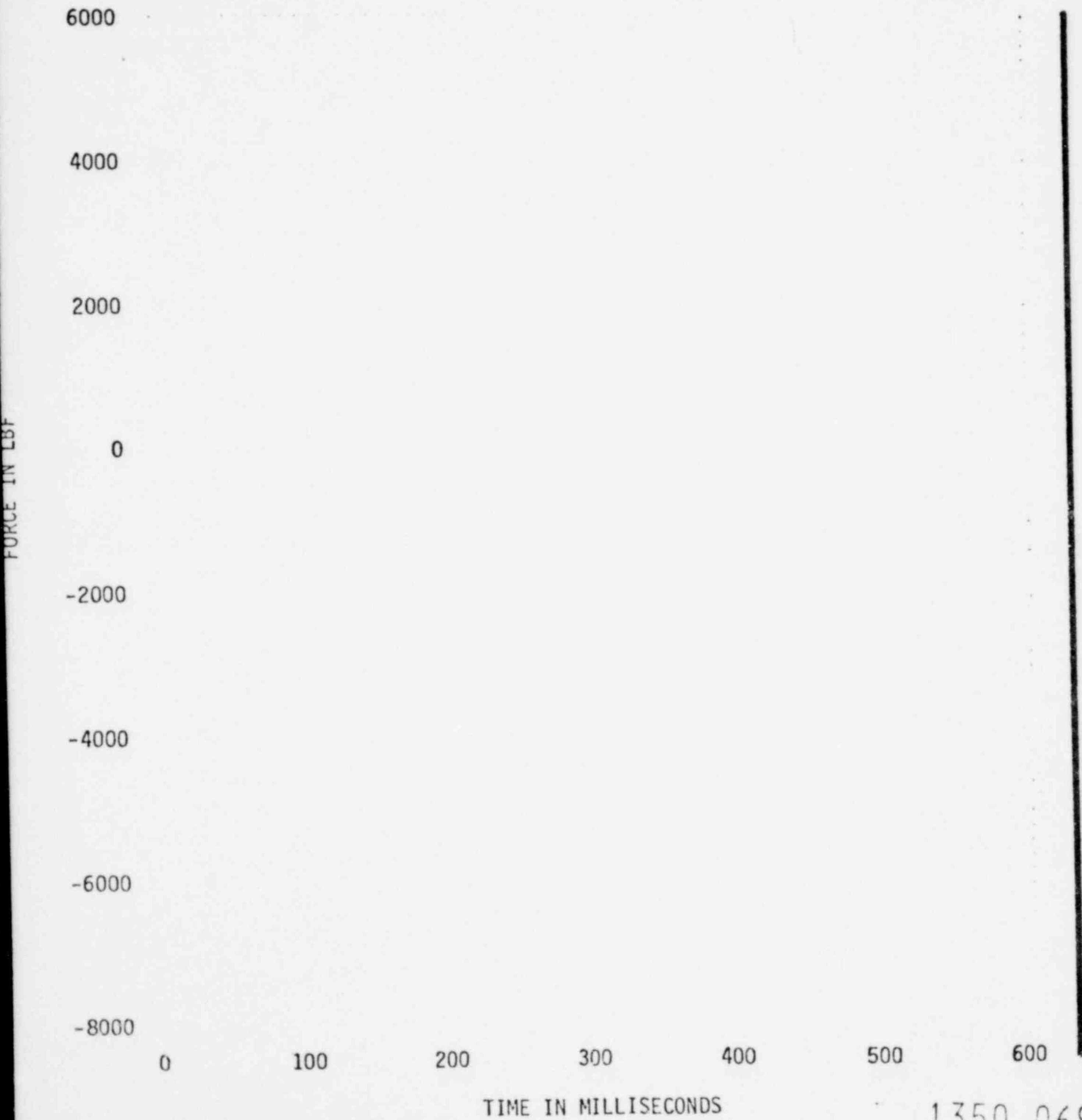
TIME IN MILLISECONDS

1350 067

FIGURE A-568

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Oyster Creek Test 2

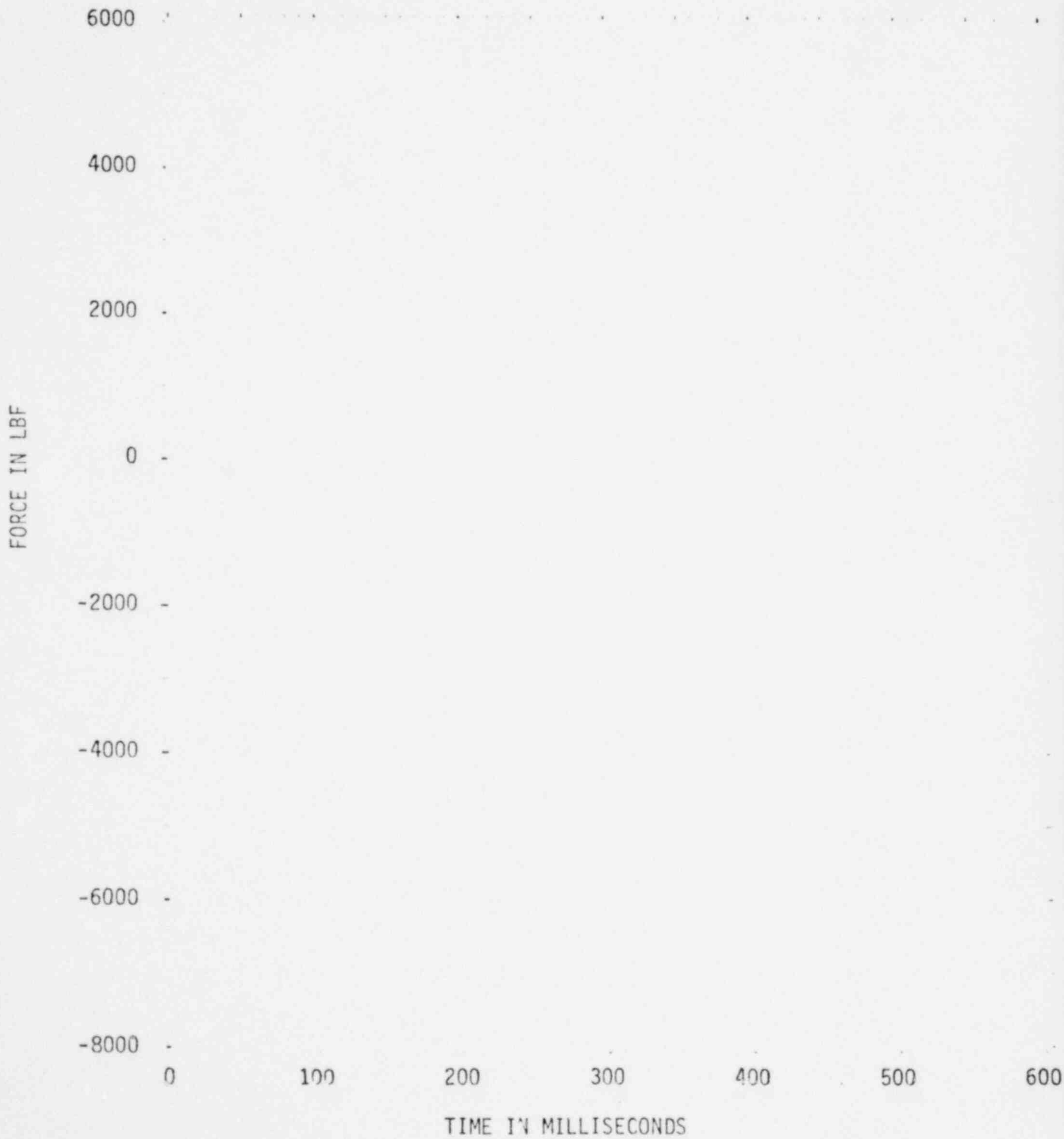


1350 068

FIGURE A-569

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER IN. TIA

Task 5.5.3 Oyster Creek Test 5

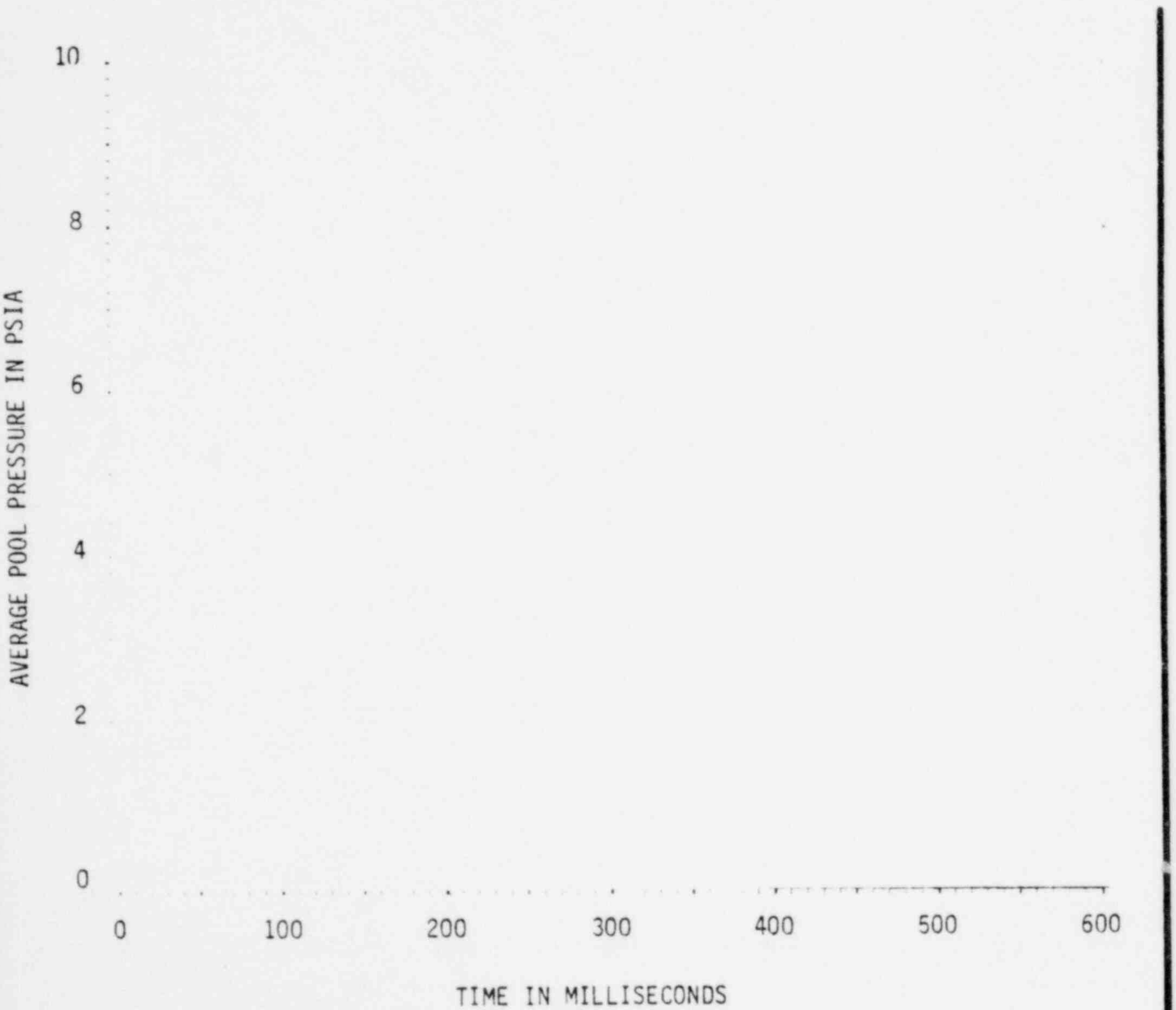


1350 069

FIGURE A-570

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Oyster Creek Test 2

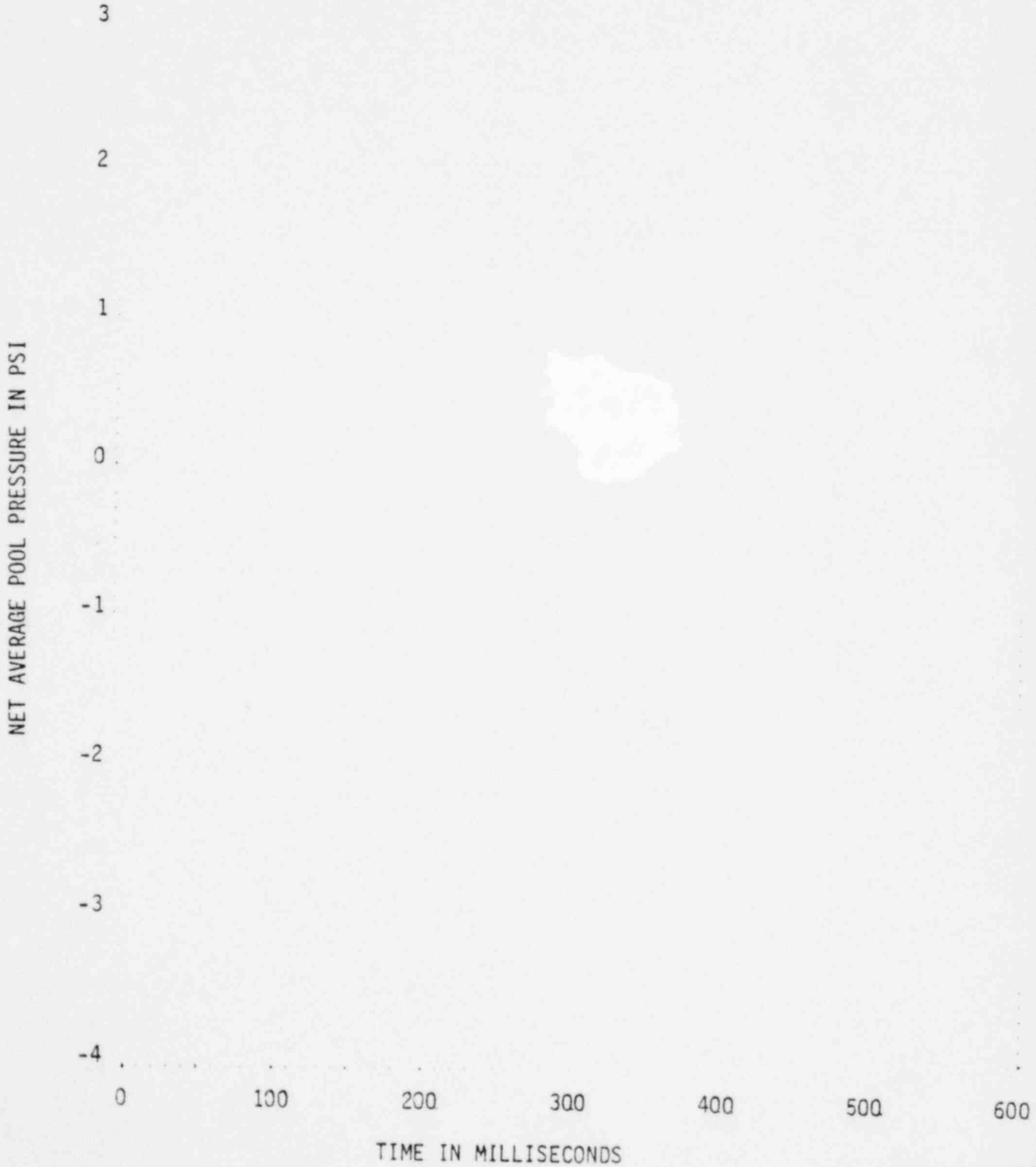


1350 070

FIGURE A-571

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Oyster Creek Test 2

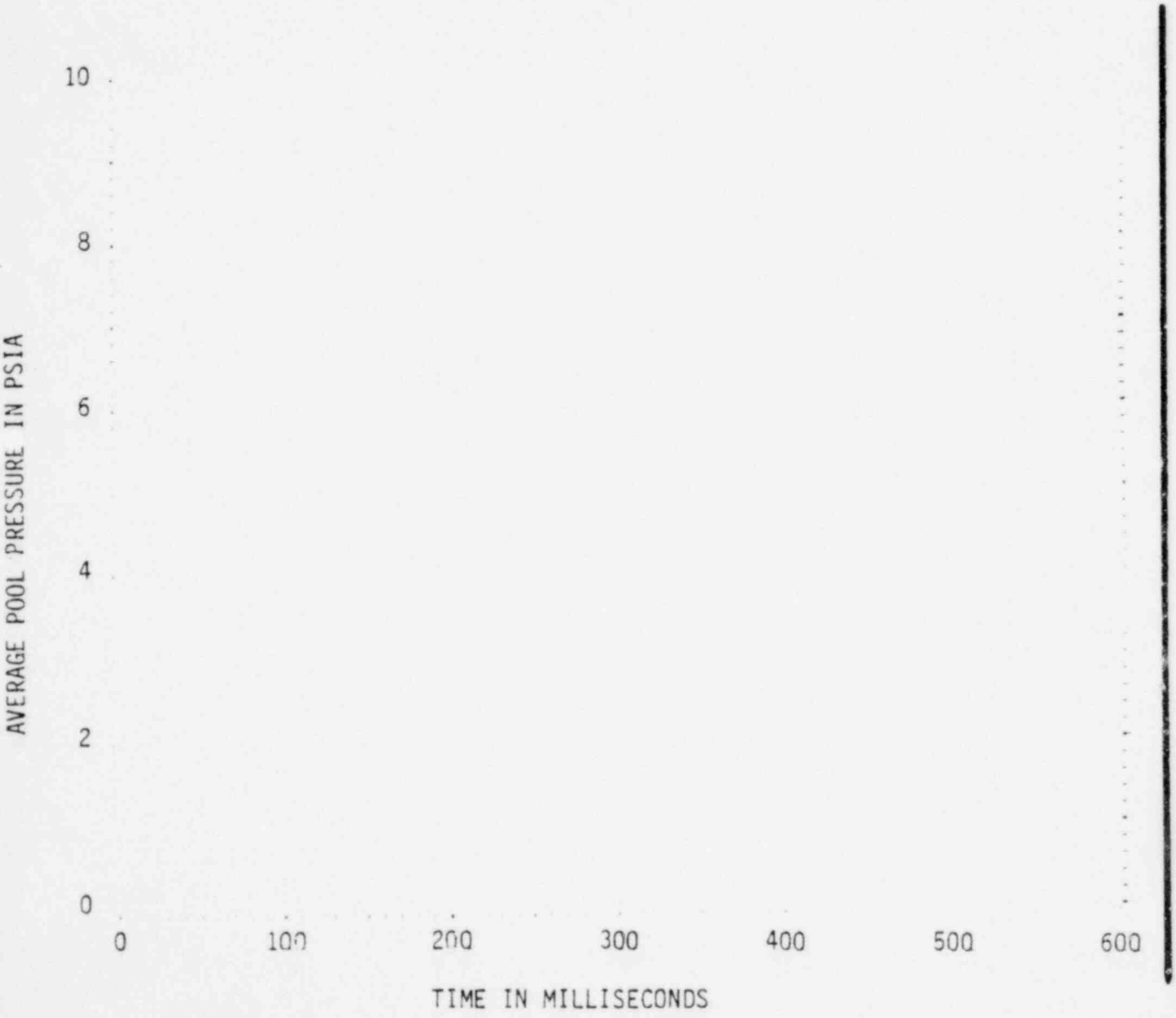


1350 071

FIGURE A-572

AVERAGE POOL PRESSURE* CORRECTED FOR WATER INERTIA

Task 5.5.3 Oyster Creek Test 5



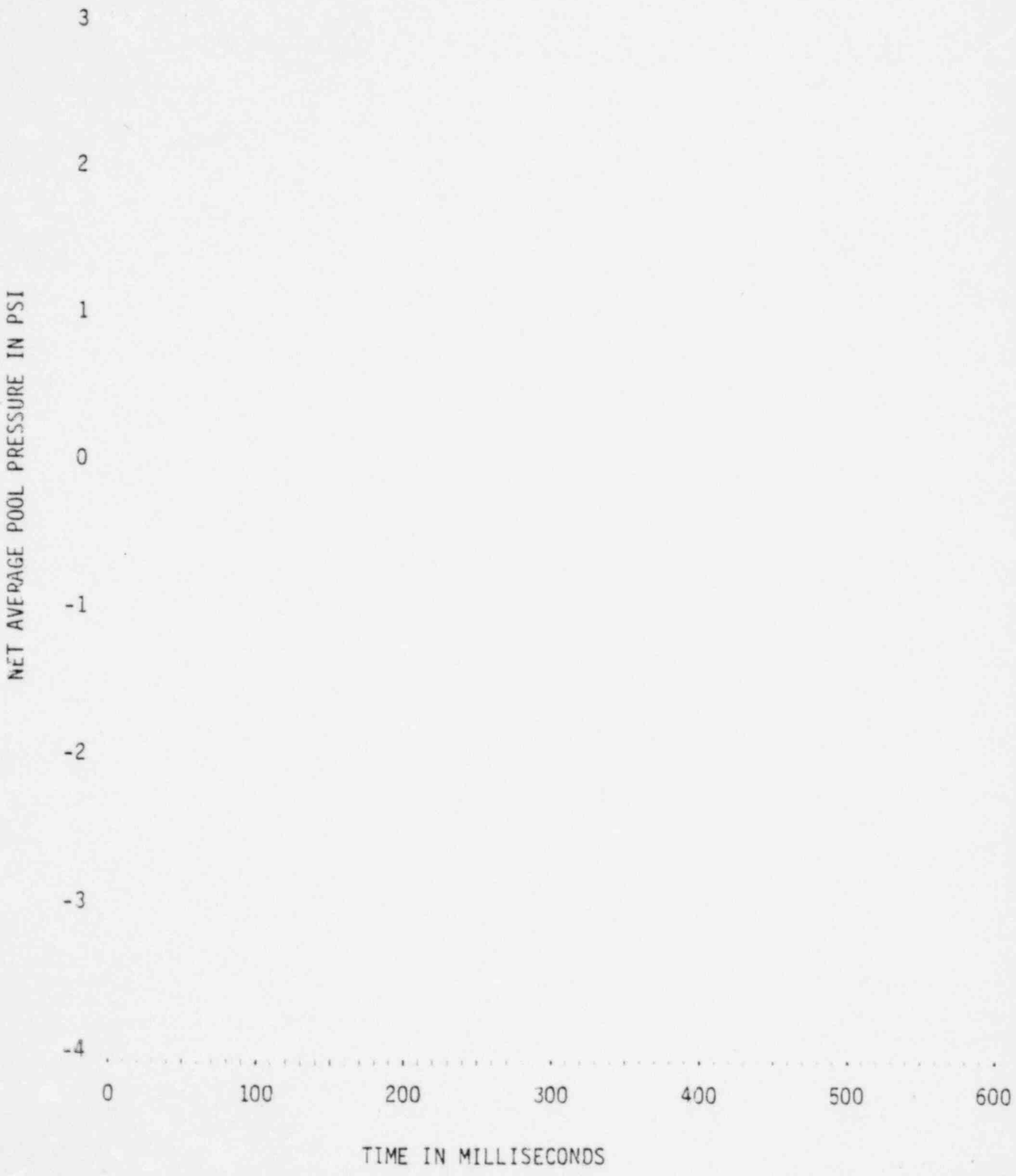
* Using 300° Freespace Transducer

1350 072

FIGURE A-573

NET AVERAGE POOL PRESSURE* CORRECTED FOR WATER INERTIA

Task 5.5.3   Oyster Creek Test 5

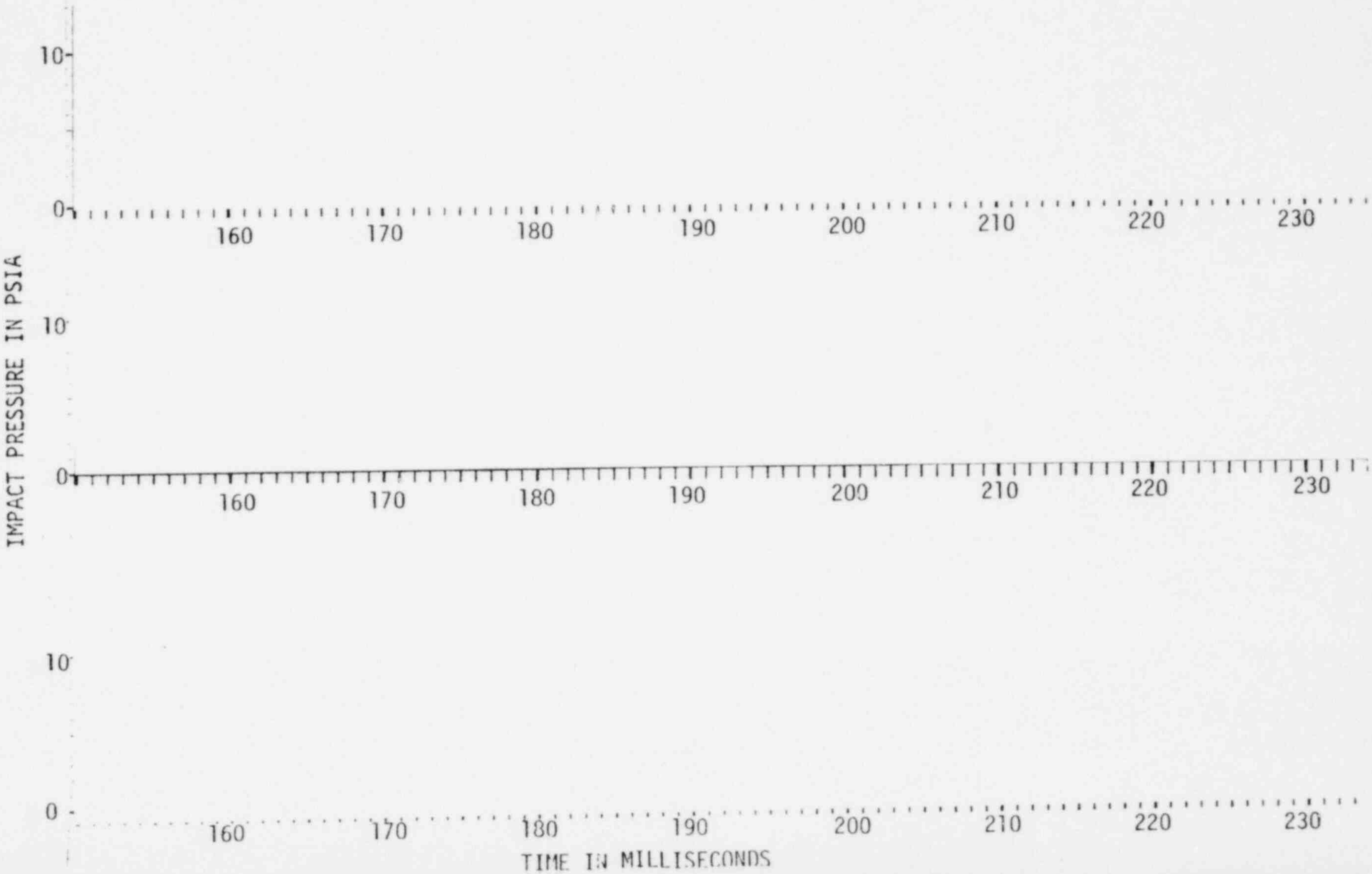


* Using 300° Freespace Transducer

1350 073

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 2



1350 074

FIGURE A-575

VENT HEADER IMPACT PRESSURES

Task 5.5.3   Oyster Creek Test 2

1350 075

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 2

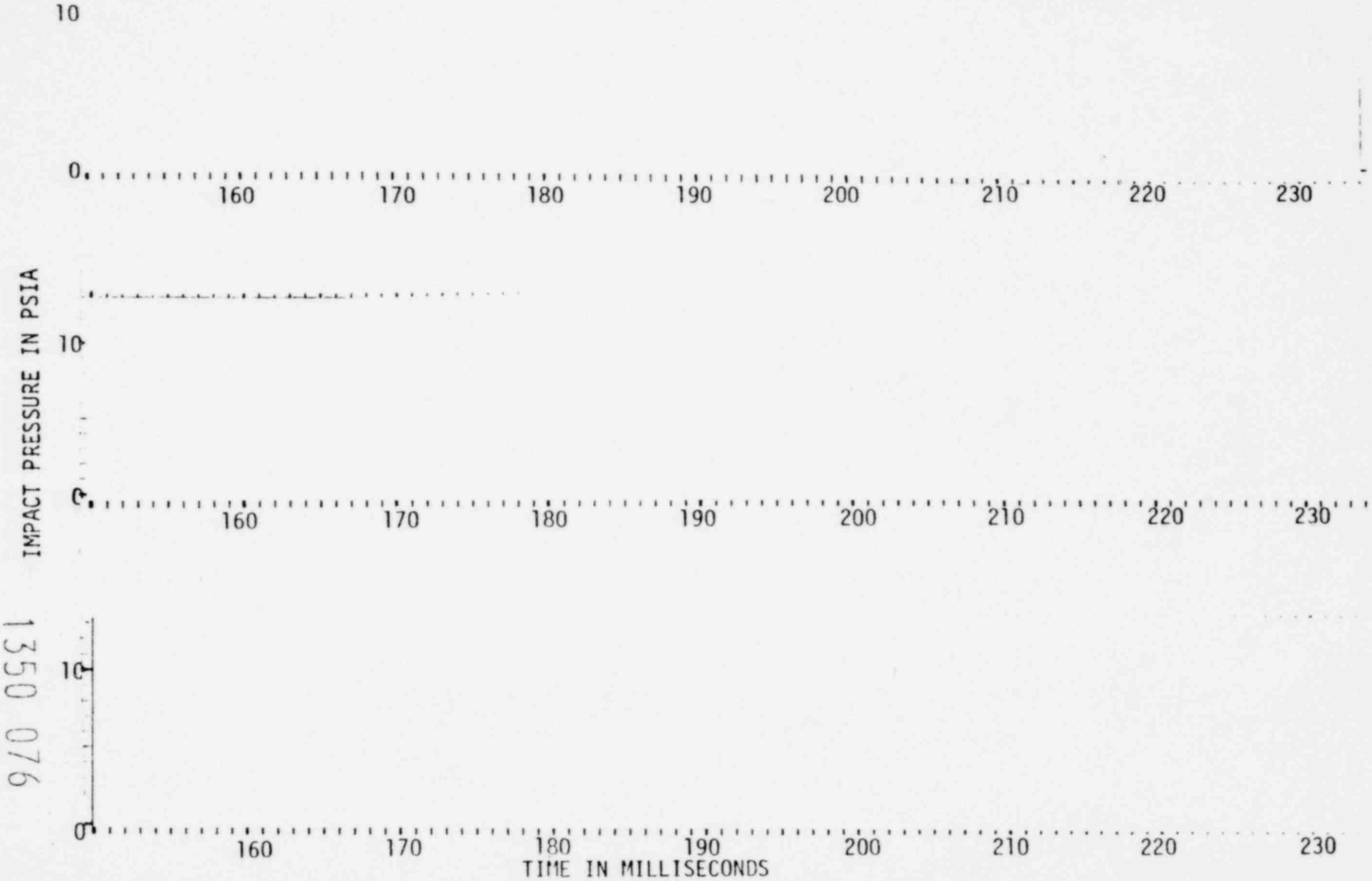


FIGURE A-577

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 2

1350 077

FIGURE A-578

VENT HEADER IMPACT PRESSURES

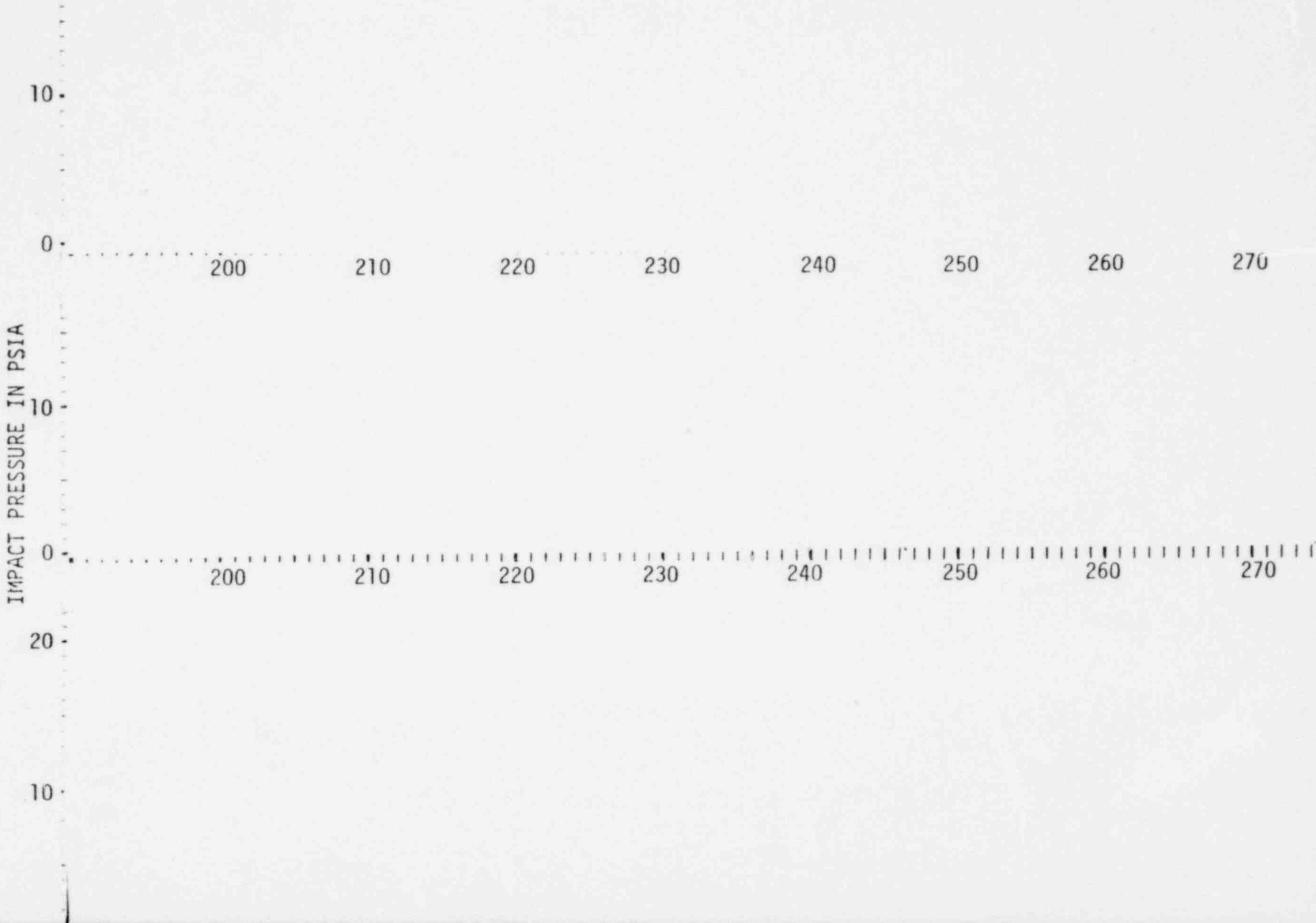
Task 5.5.3 Oyster Creek Test 2

1350 078

FIGURE A-579

VENT HEADER IMPACT PRESSURES

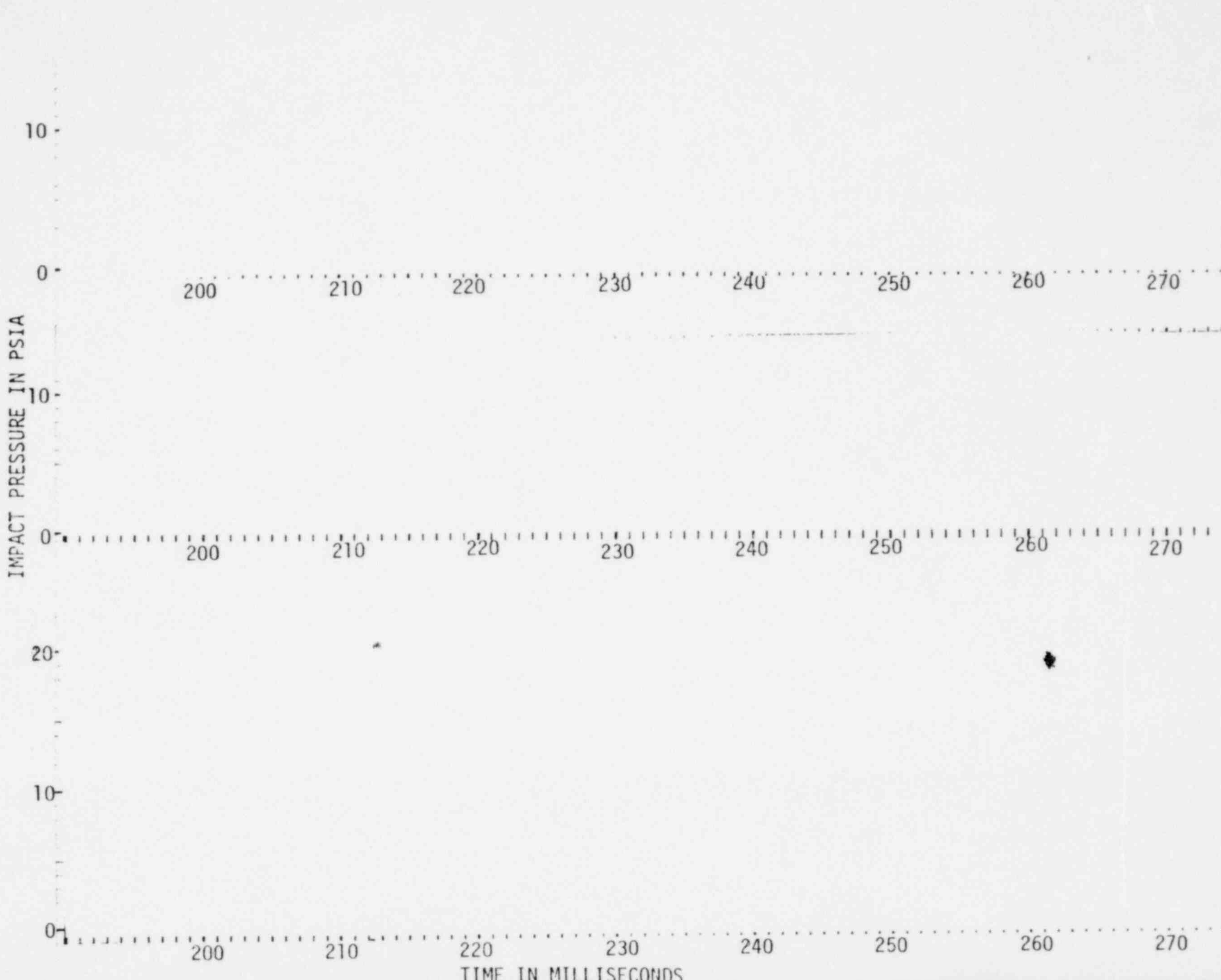
Task 5.5.3   Oyster Creek Test 5



1350 079

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 5

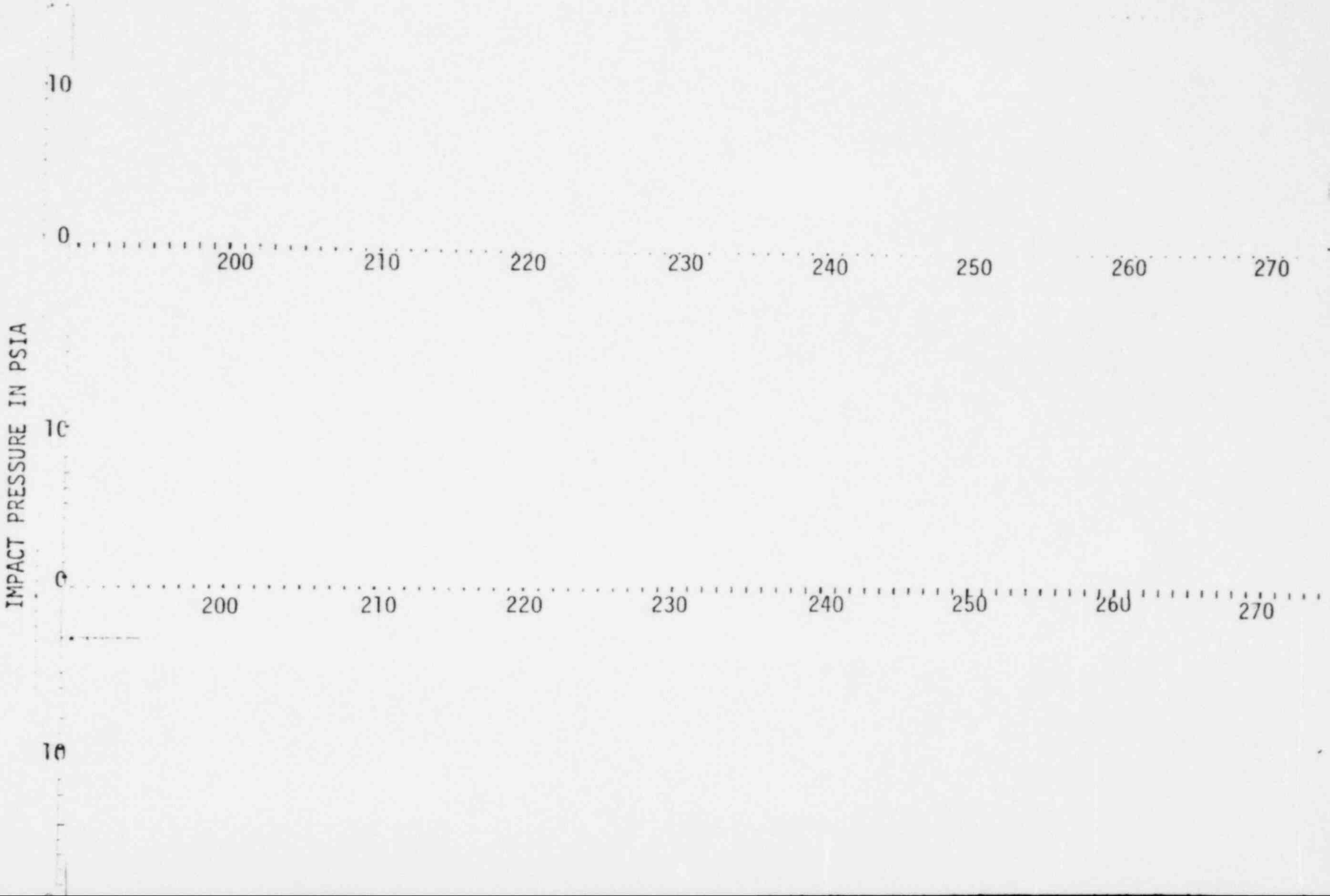


1350 080

FIGURE A-581

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 5



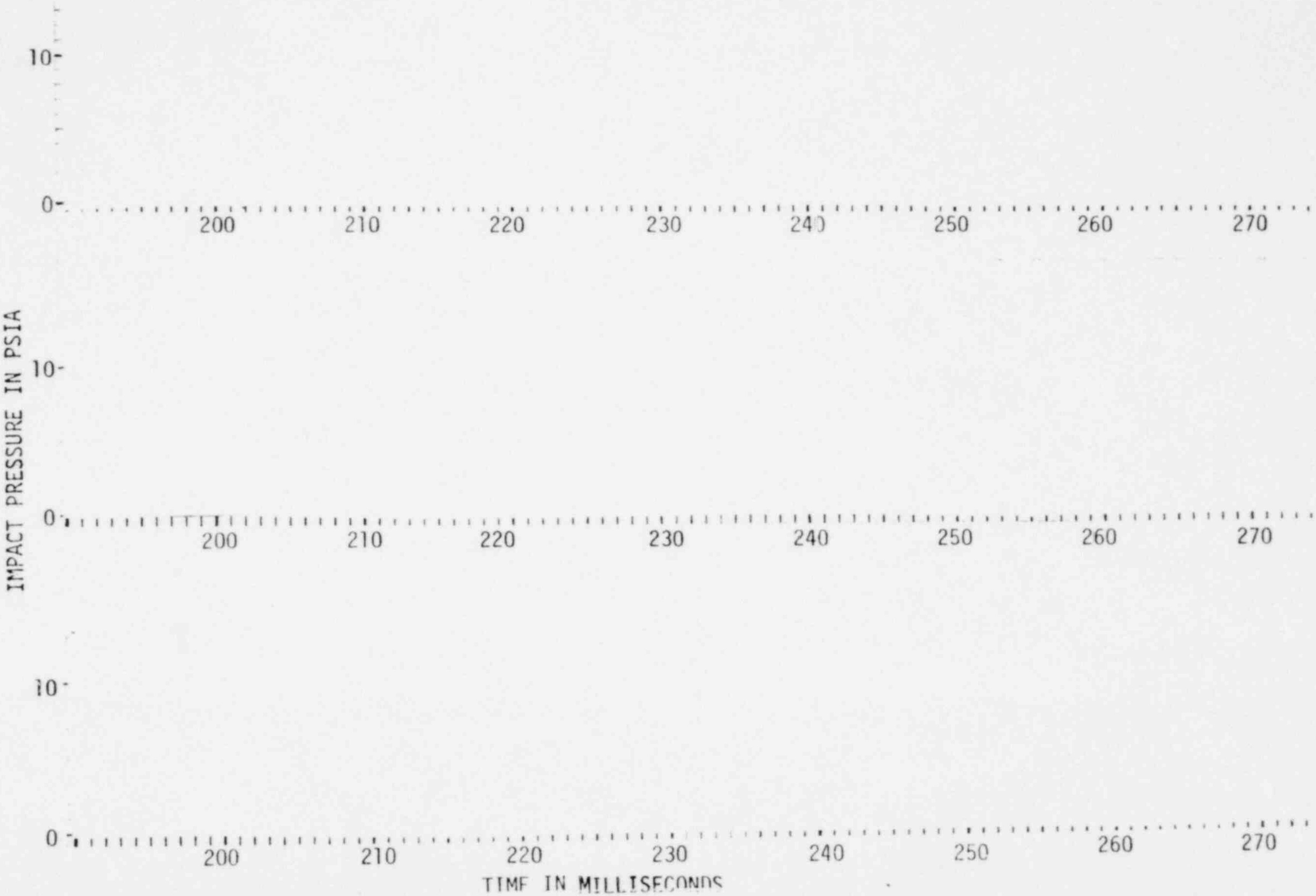
NEDO-21944

A-650

1350 081

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 5



1350 082

FIGURE A-583

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Oyster Creek Test 5

IMPACT PRESSURE IN PSIA

10

0

200 210 220 230 240 250 260 270

TIME IN MILLISECONDS

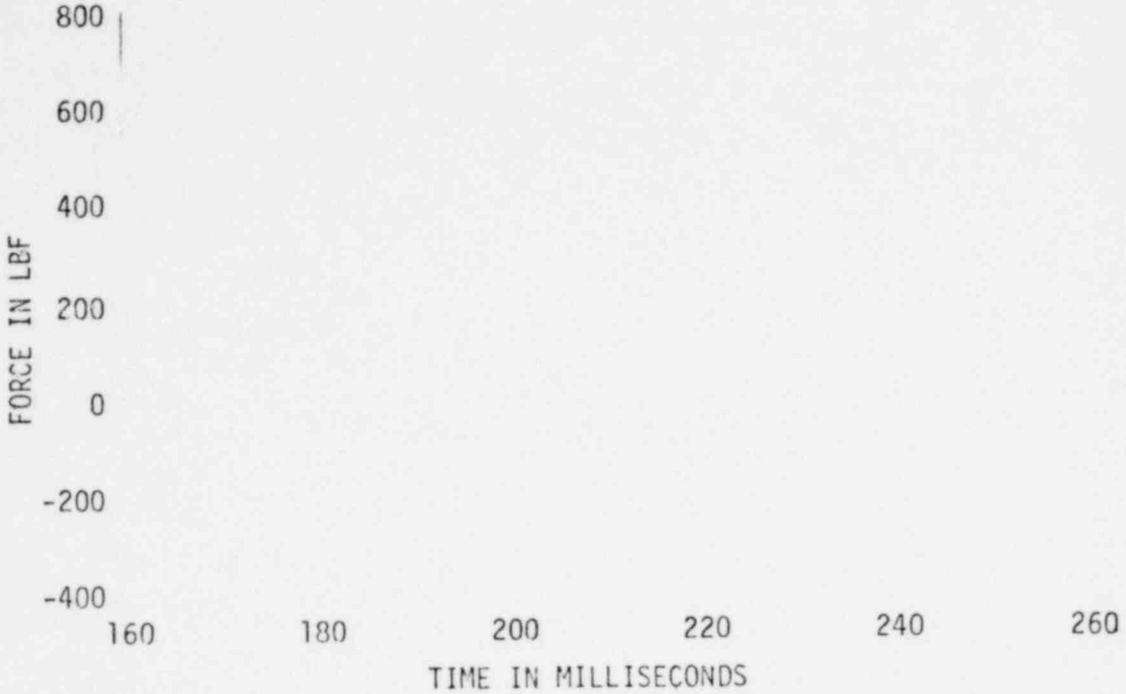
1350 083

FIGURE A-584

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Oyster Creek Tests 2,5

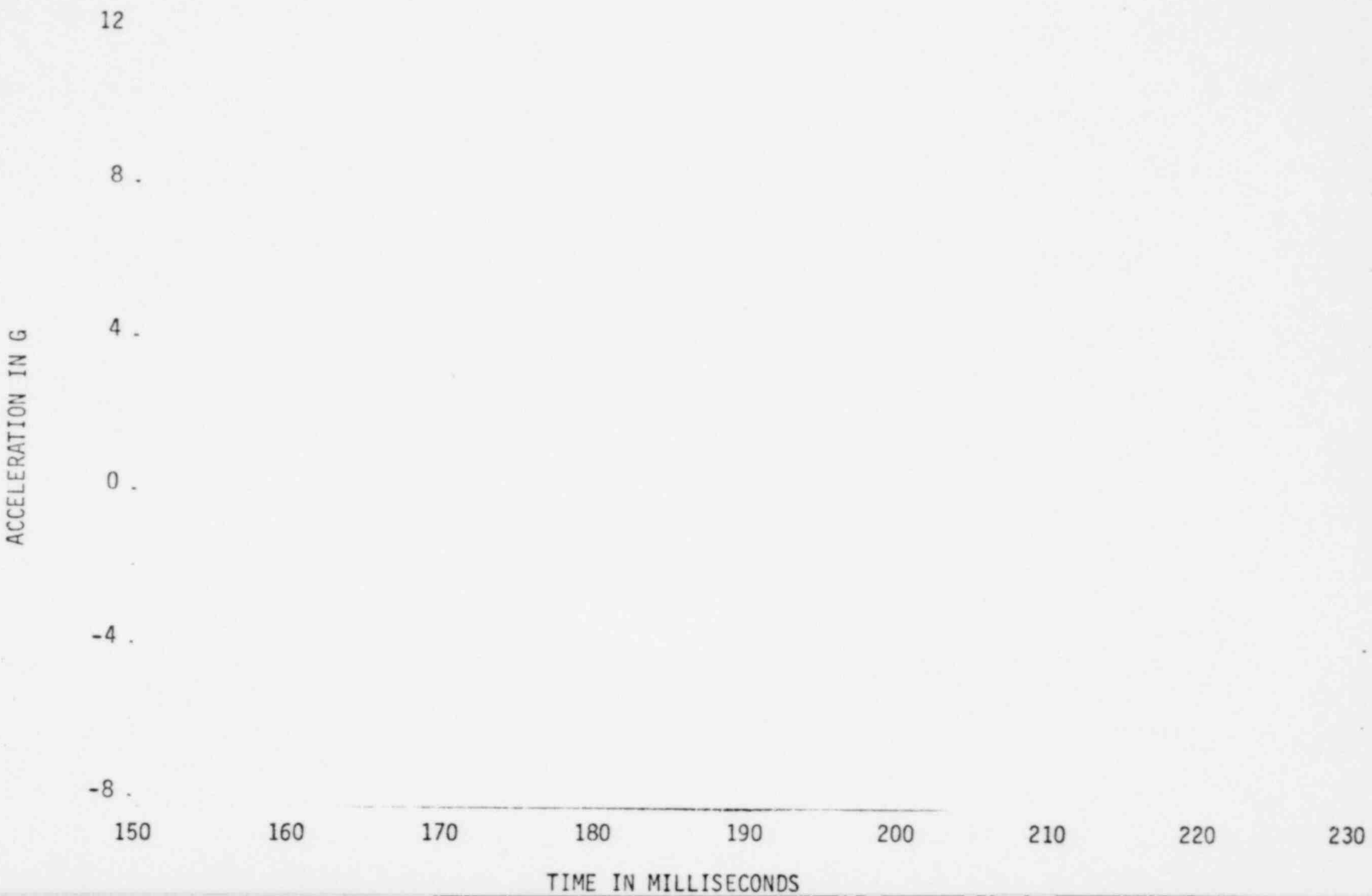


1350 084

FIGURE A-585

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Oyster Creek Test 2

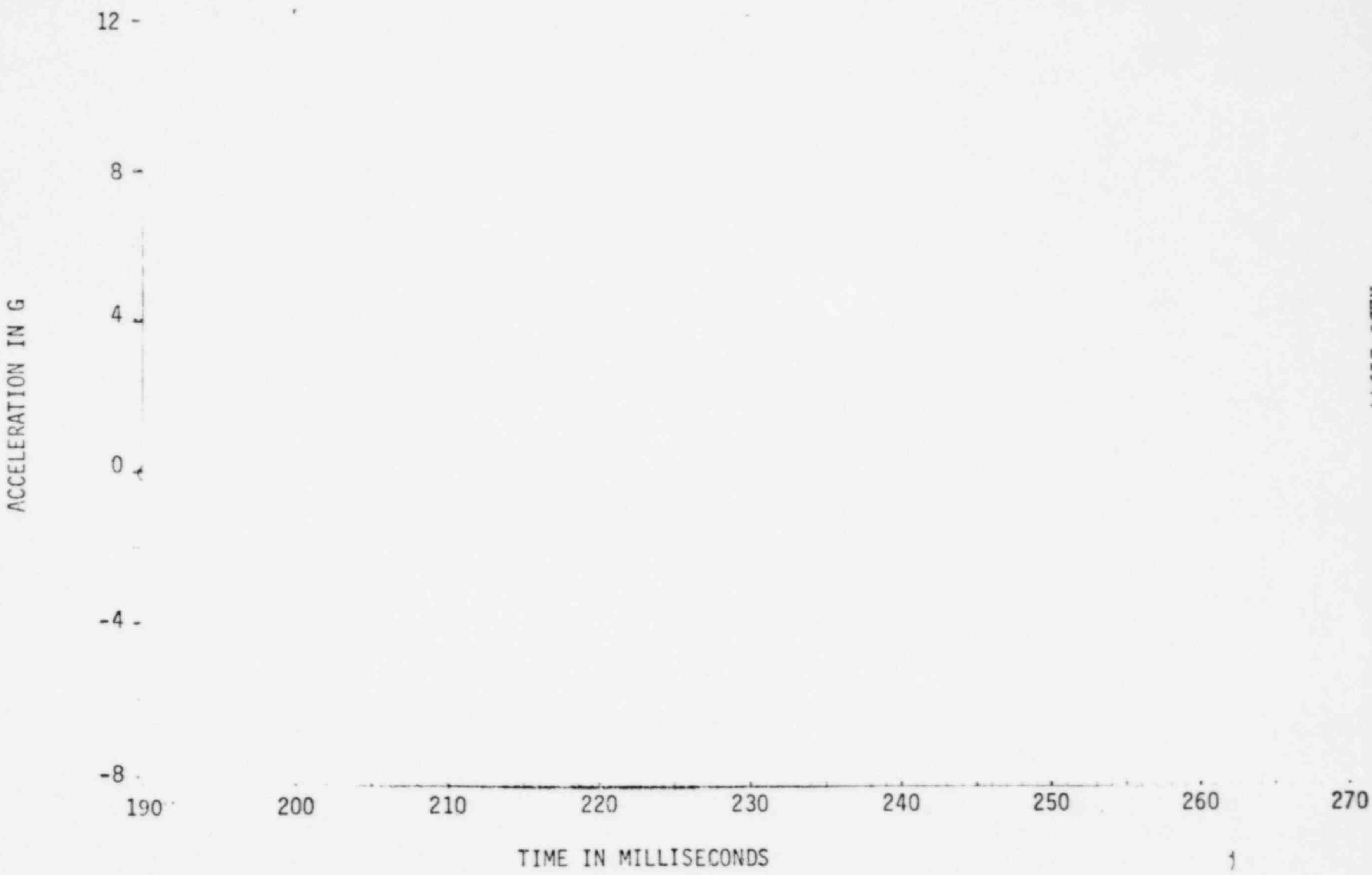


1350 085

FIGURE A-586

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Oyster Creek Test 5



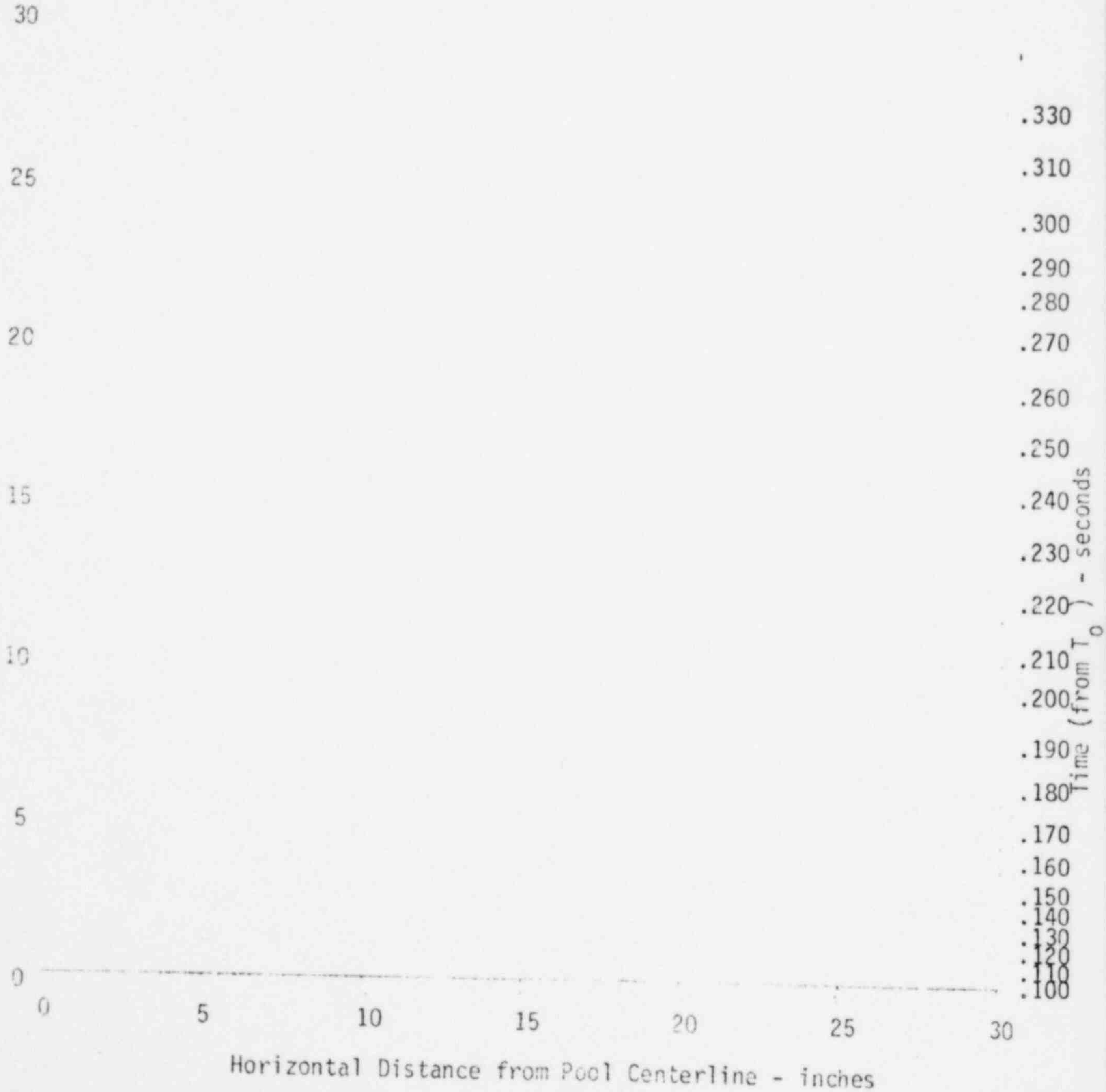
1350 086

FIGURE A-587

TIME HISTORY OF

POOL DISPLACEMENT

OYSTER CREEK, TEST 1

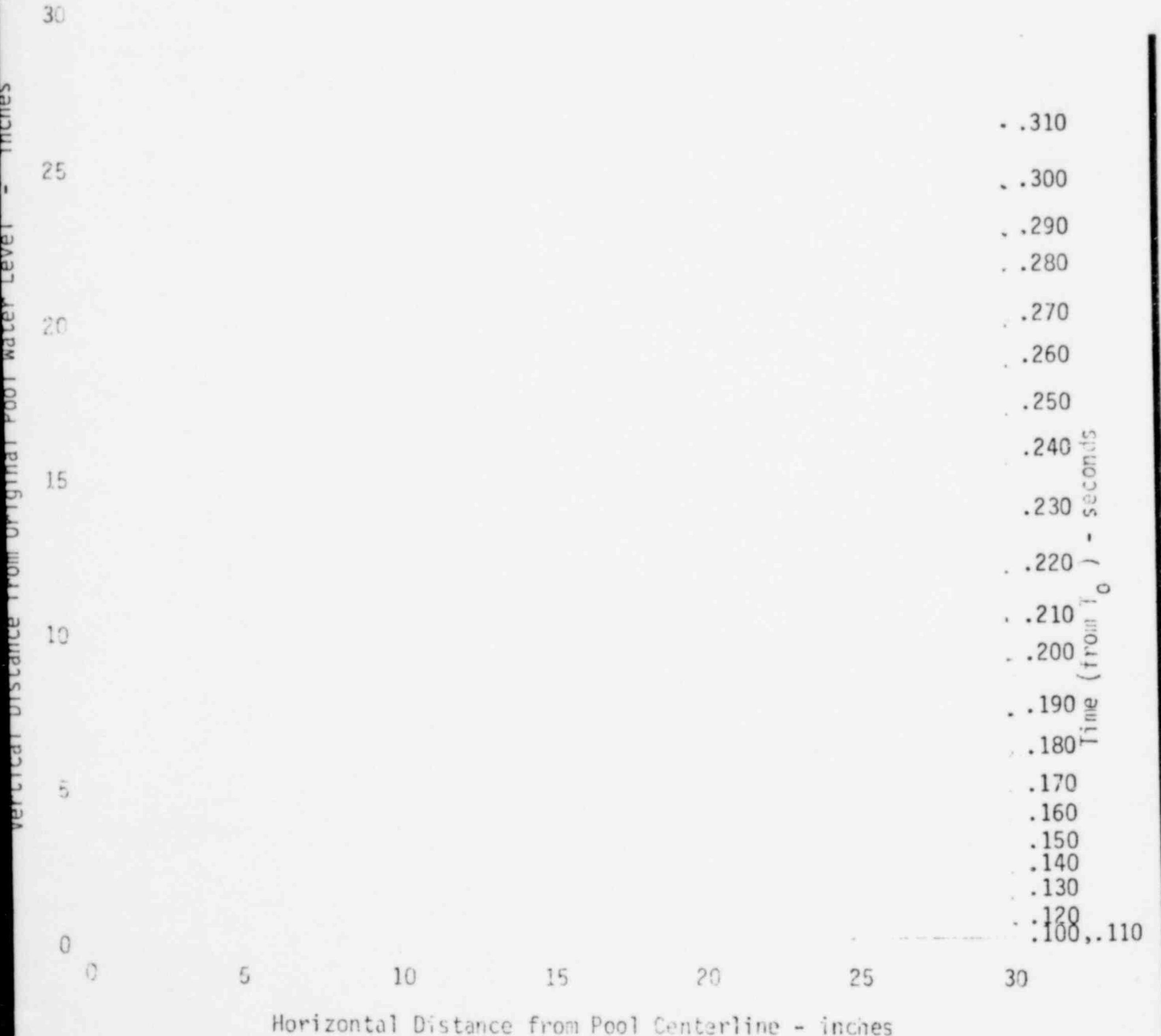


1350 087

FIGURE A-588

TIME HISTORY OF
POOL DISPLACEMENT

OYSTER CREEK, TEST 2



1350 088

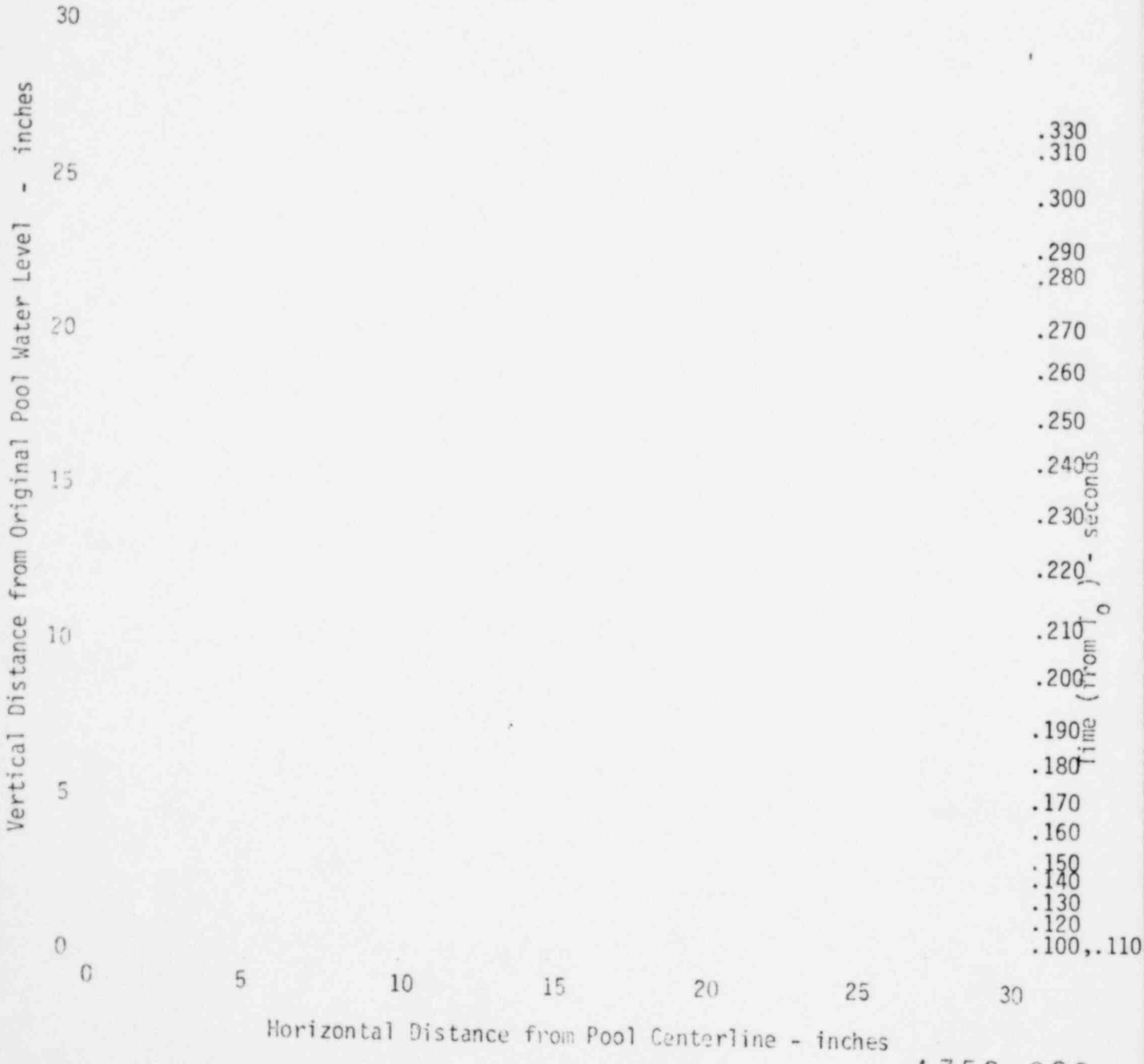
NEDO-21944

FIGURE A-589

TIME HISTORY OF

POOL DISPLACEMENT

OYSTER CREEK, TEST 3

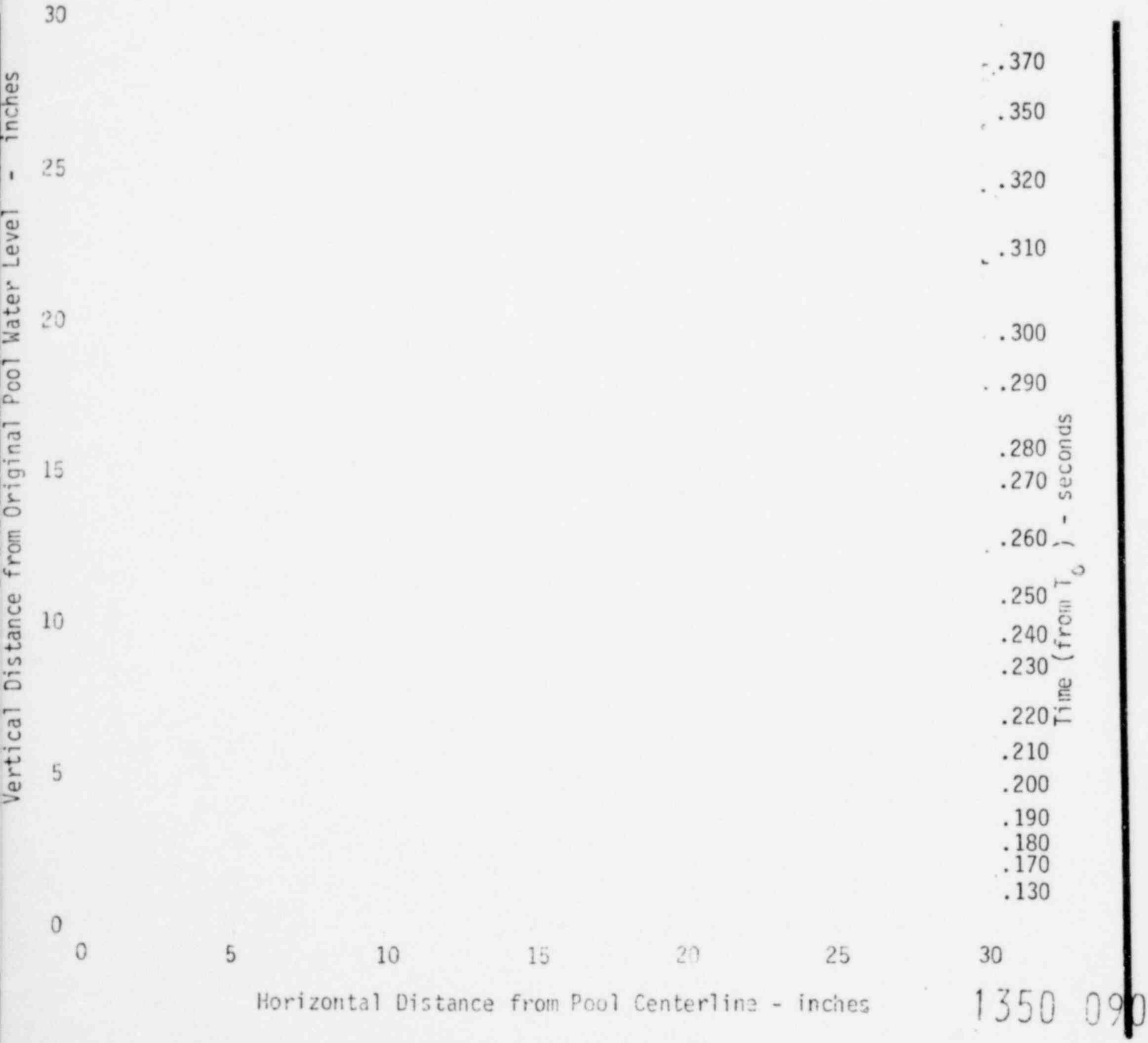


1350 089

FIGURE A-590

TIME HISTORY OF
POOL DISPLACEMENT

OYSTER CREEK, TEST 5



1350 090

FIGURE A-591

POOL SURFACE DISPLACEMENT

Oyster Creek Tests 1, 2, 3

FIGURE A-592

POOL SURFACE VELOCITY PROFILES

Oyster Creek Tests 1,2,3

25

20

15

10

5

0

0 5 10 15 20 25 30 35 40

VELOCITY - FT/SEC

DISTANCE FROM POOL CENTERLINE - INCHES

1350 092

FIGURE A-593

POOL SURFACE DISPLACEMENT

Oyster Creek Test 5

Height above original pool surface - inches

25

20

15

10

5

0

0 100 200 300 400

1350 093

FIGURE A-594

POOL SURFACE VELOCITY PROFILES

Oyster Creek Test 5

1350 094

FIGURE A-595

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

Oyster Test 4

VERTICAL DISPLACEMENT - INCHES

10
8
6
4
2
0
-2
-4
-6
-8
-10

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

VERTICAL VELOCITY-FT/SEC

15.
10.
5.
0.

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

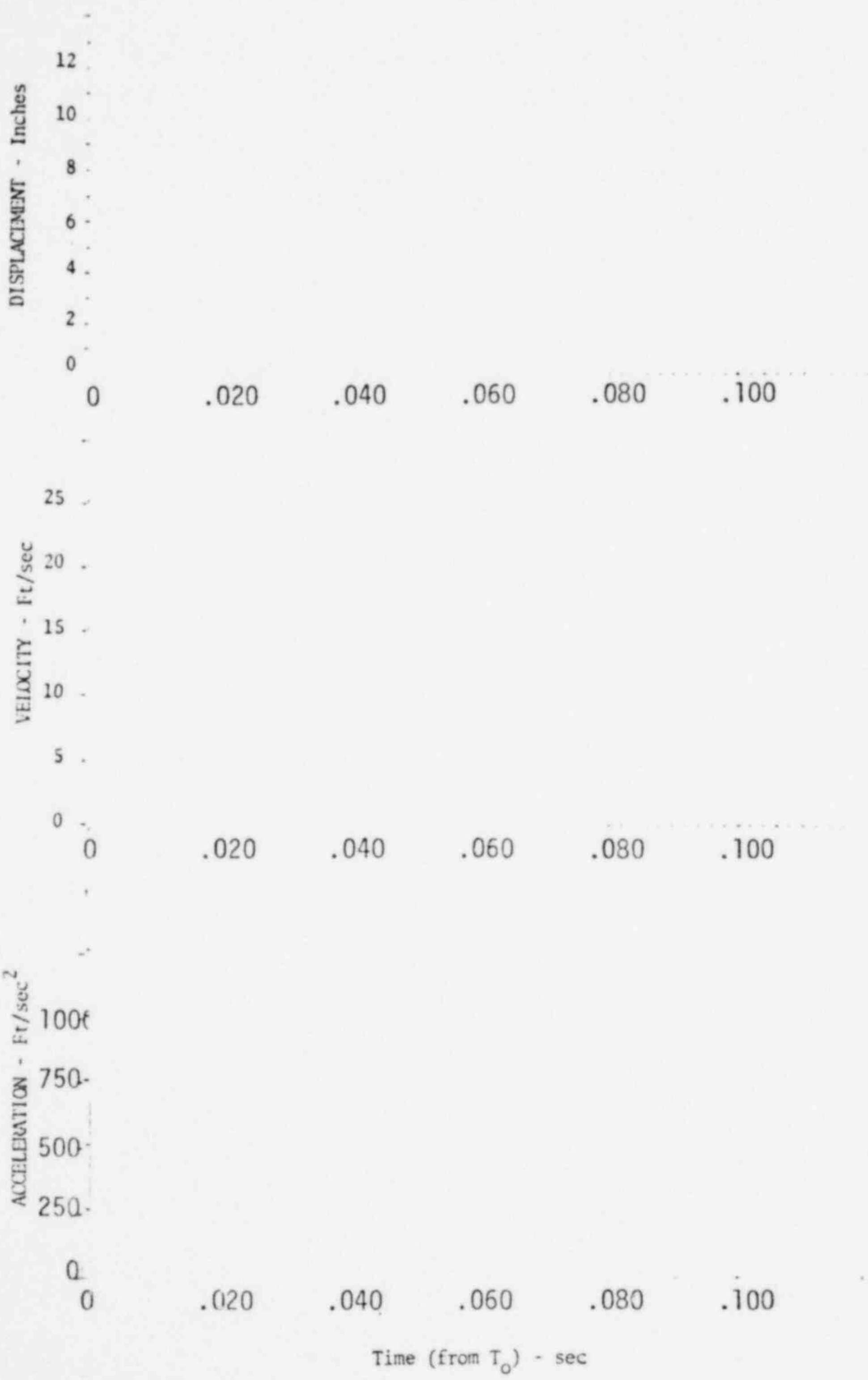
TIME - Seconds

1350 095

FIGURE A-596

DOWNCOMER WATER SLUG EJECTION

OYSTER CREEK, TEST 2



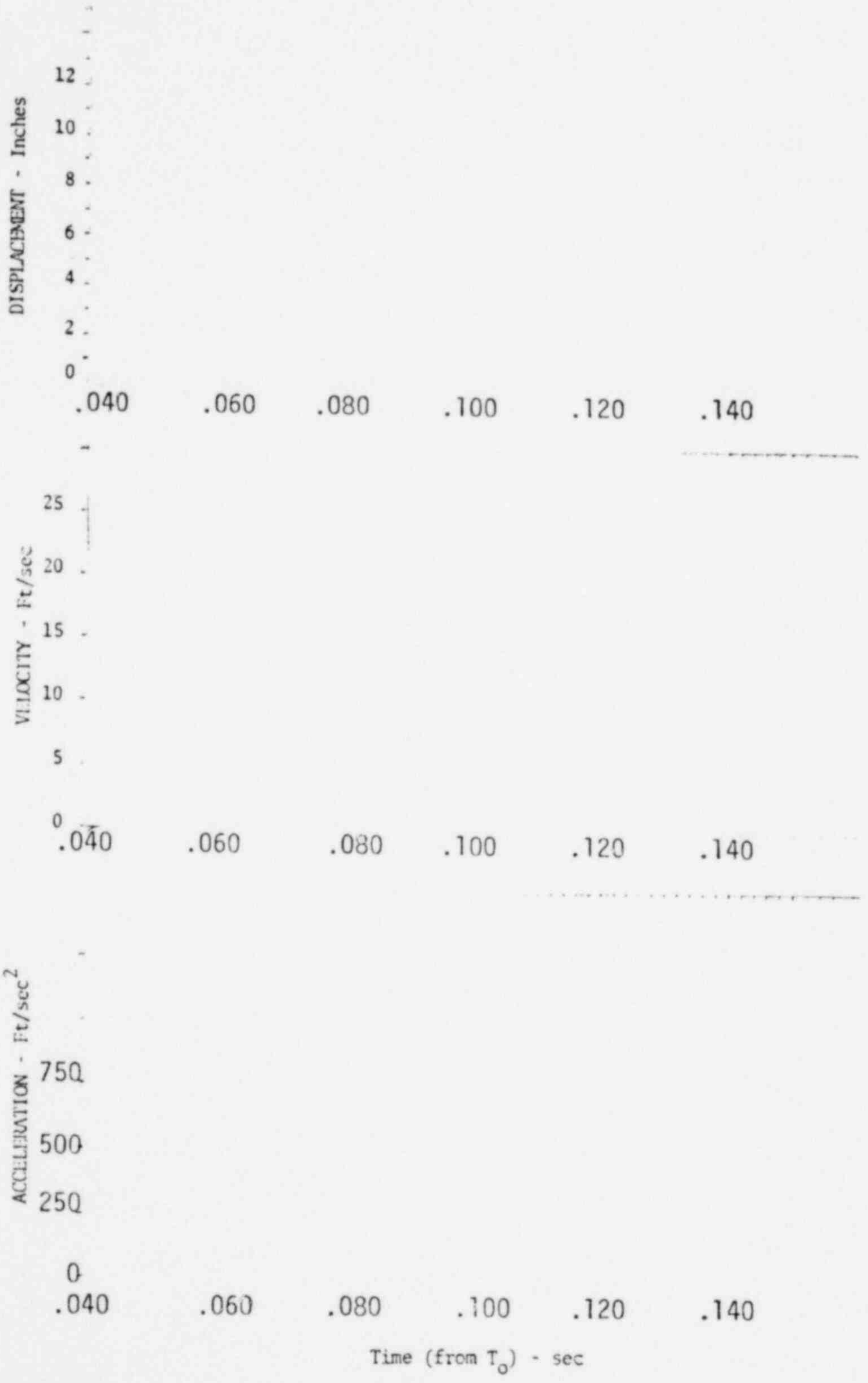
1350 096

NEDO-21944

FIGURE A-597

DOWNCOMER WATER SLUG EJECTION

OYSTER CREEK, TEST 5



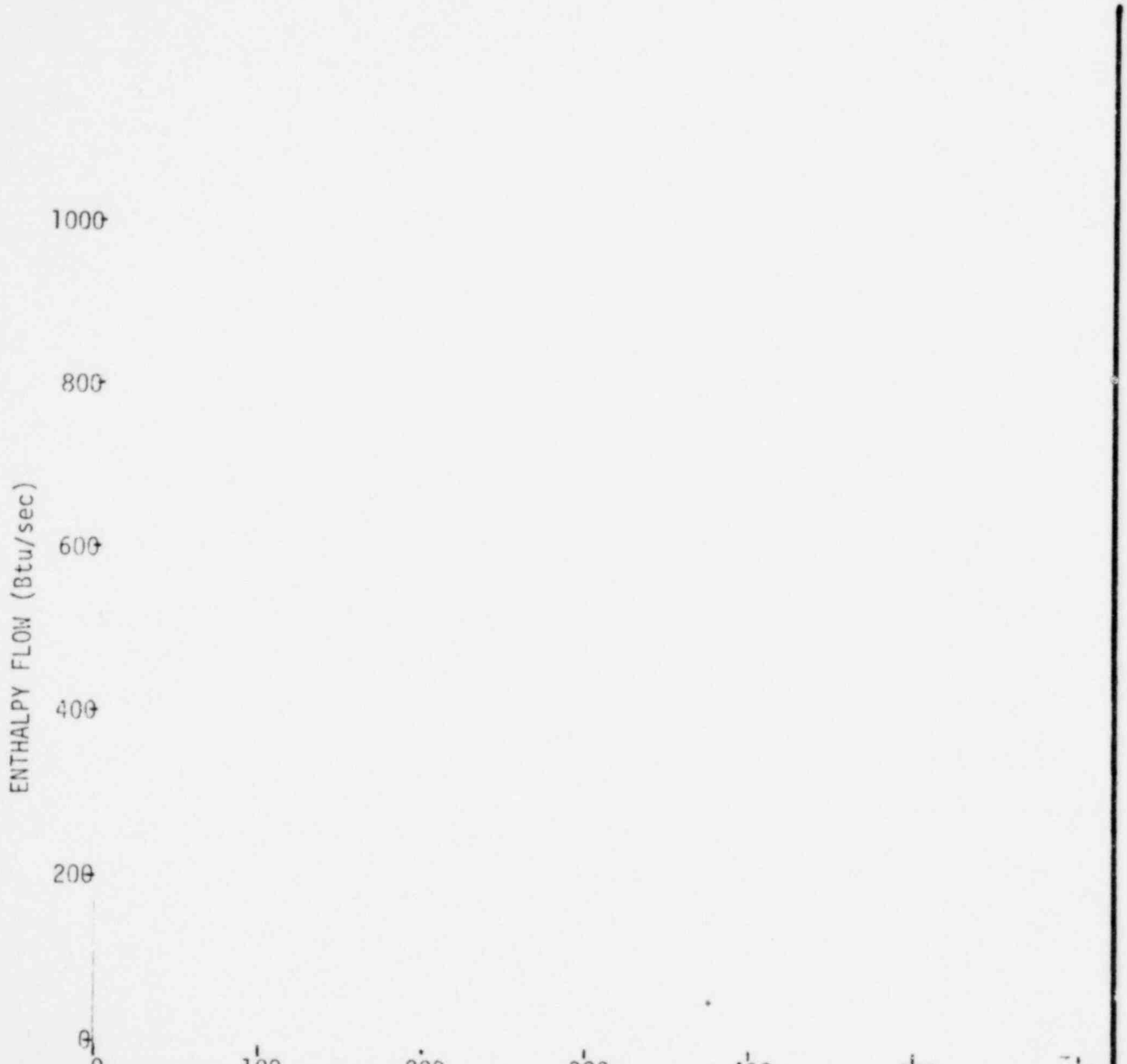
1350 097

FIGURE A-598

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Oyster Creek Tests



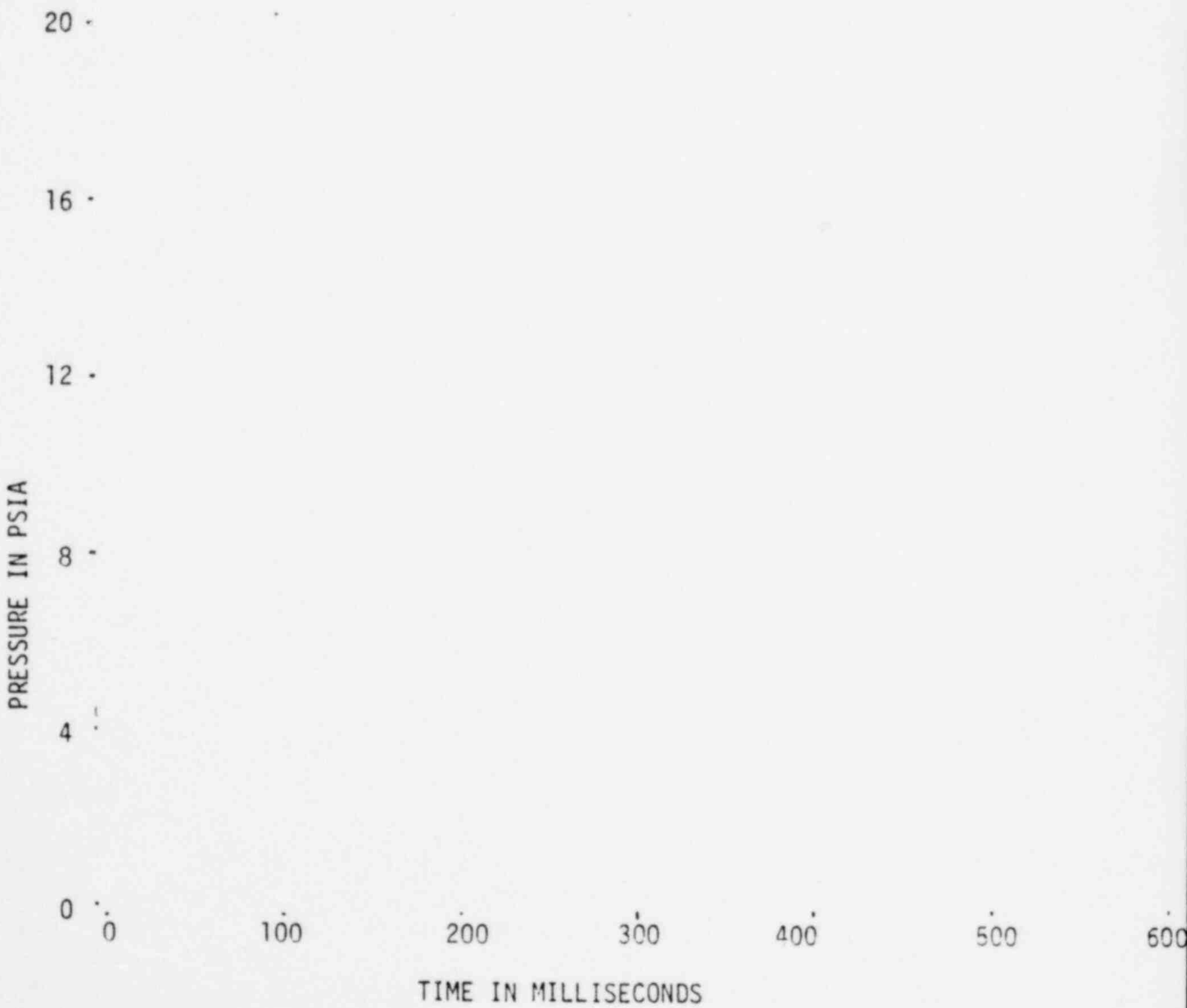
1350 098

FIGURE A-599

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Oyster Creek Tests



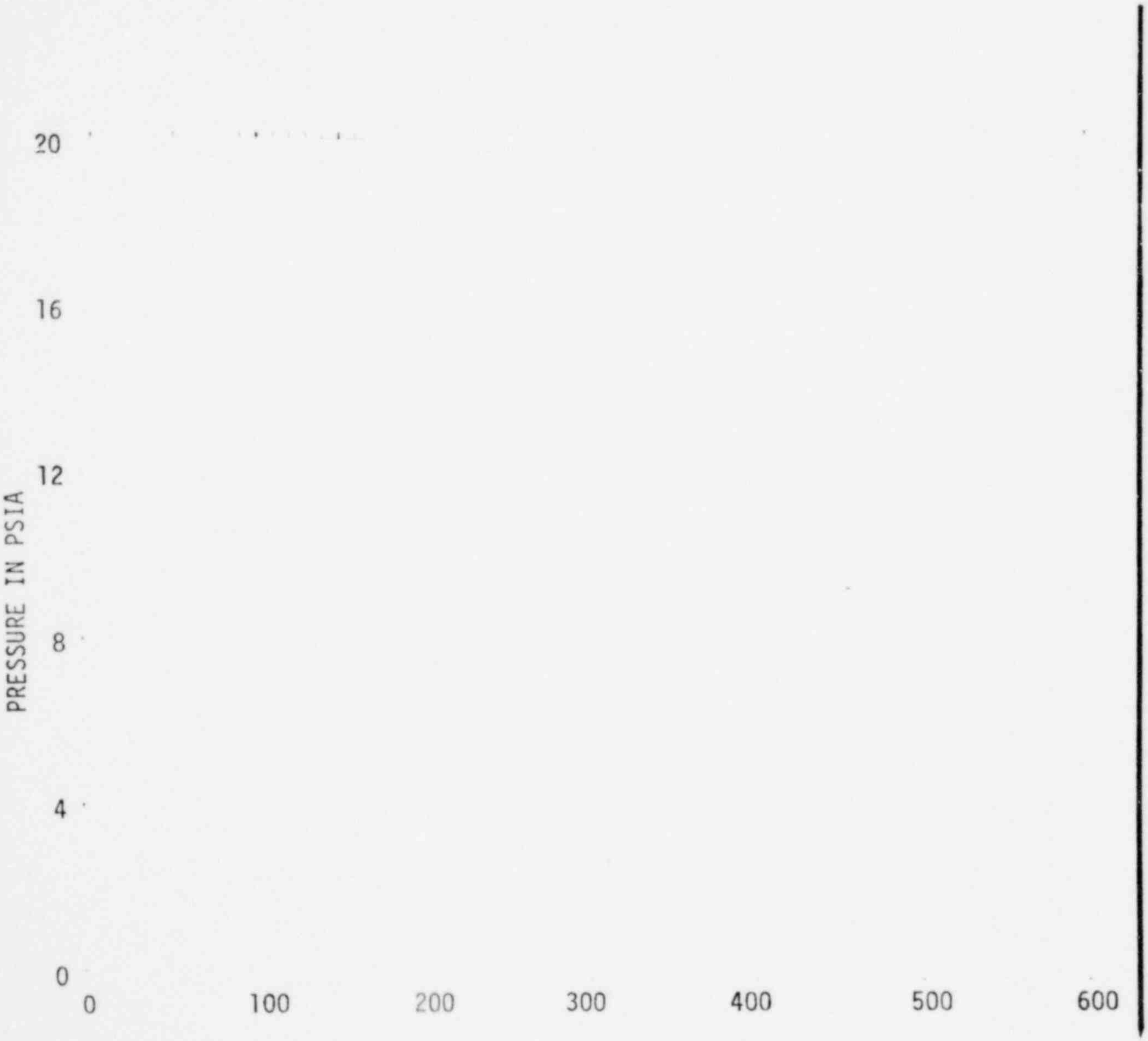
1350 099

FIGURE A-600

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Oyster Creek Tests



1350 100

TABLE A-25

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Oyster Creek Tests

Parameter / Test No.		7.15" ΔP, 5.17" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o +	(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)							

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

+ = Start of test reference time

1350 101

TABLE A-25

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Oyster Creek Tests

Parameter \ Test No.		7.15"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)							

*** =Time at force is zero (from T_o)

1350 102

TABLE A-26

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3 Oyster Creek Tests

Parameter / Test No.		7.15" ΔP, 5.17" 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

1350 103

A.13 Hatch 1 Tests

A.13.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Hatch 1 Tests 3 and 5. Test 3 was a load definition test conducted with an initial drywell/wetwell differential pressure of 11.46" H_2O and with a 7.17 inch winged pipe deflector (26" full-scale)*. Test 5 was conducted with 0" H_2O ΔP and with the same 7.17 inch winged deflector.

A.13.1.1 Driving Conditions

Driving conditions for Hatch 1 Test 3 are presented in Figures A-601 through A-605. Similar plots for Test 5 are shown in Figures A-606 through A-610. Hatch 1 driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.13.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Hatch 1 Tests 3 and 5 are presented in Figures A-611 through A-612 and A-613 through A-614, respectively. Net torus force from the pressure integral (Figures A-615 and A-616) shows relatively smooth upforce but some minor downforce oscillation. Net torus force that is determined from the torus load cell (Figures A-617 and A-619) by applying inertial correction with the torus accelerometer (Figures A-618 and A-620) is shown in Figures A-621 and A-622 and compared to net torus force determined from the pressure integral. Figures A-623 and A-624 present the net torus force based on the torus pressure integral, corrected for inertia.

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*Winged deflector is a pipe with structural angles

1350 104

The "average" pool pressures for Hatch 1 Tests 2 and 5 are shown in Figures A-625 and A-627. Figures A-626 and A-628 are the same as Figures A-623 and A-624 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Hatch 1 Test 3 are presented in Figures A-629 through A-633. Vent header pressures for Test 5 are presented in Figures A-634 through A-638. These figures indicate that the deflector was effective in reducing vent header impact pressures. The vent header impact forces from the pressure integral and the corrected load cell agree reasonably well (Figure A-639). Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-640 and A-641, respectively.

A.13.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-642 through A-645 for Hatch 1 Tests 1, 2, 3, and 5.

Pool surface displacement curves, are shown in Figures A-646 and A-648. The pool surface velocity profiles are shown in Figures A-647 and A-649.

The pool surface displacement and velocity profile viewed from the side window during Test 4 are shown in Figure A-650. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are presented in Figures A-651 and A-652.

A.13.3 Data Summaries

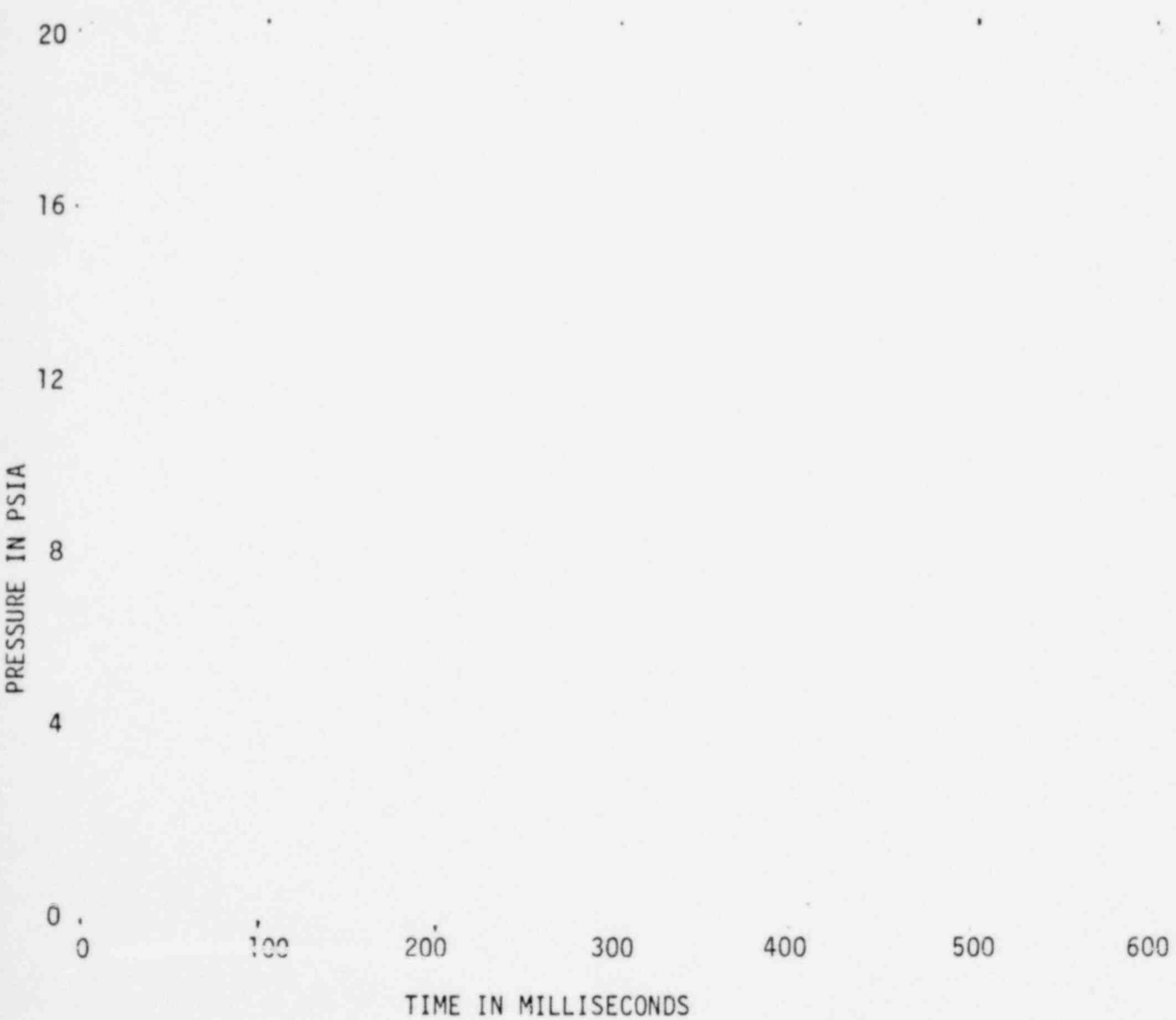
Table A-27 presents the Hatch 1 test data for wetwell vertical forces.

Table A-28 presents the Hatch 1 test data for vent header impact forces.

FIGURE A-558

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Oyster Creek Test 5

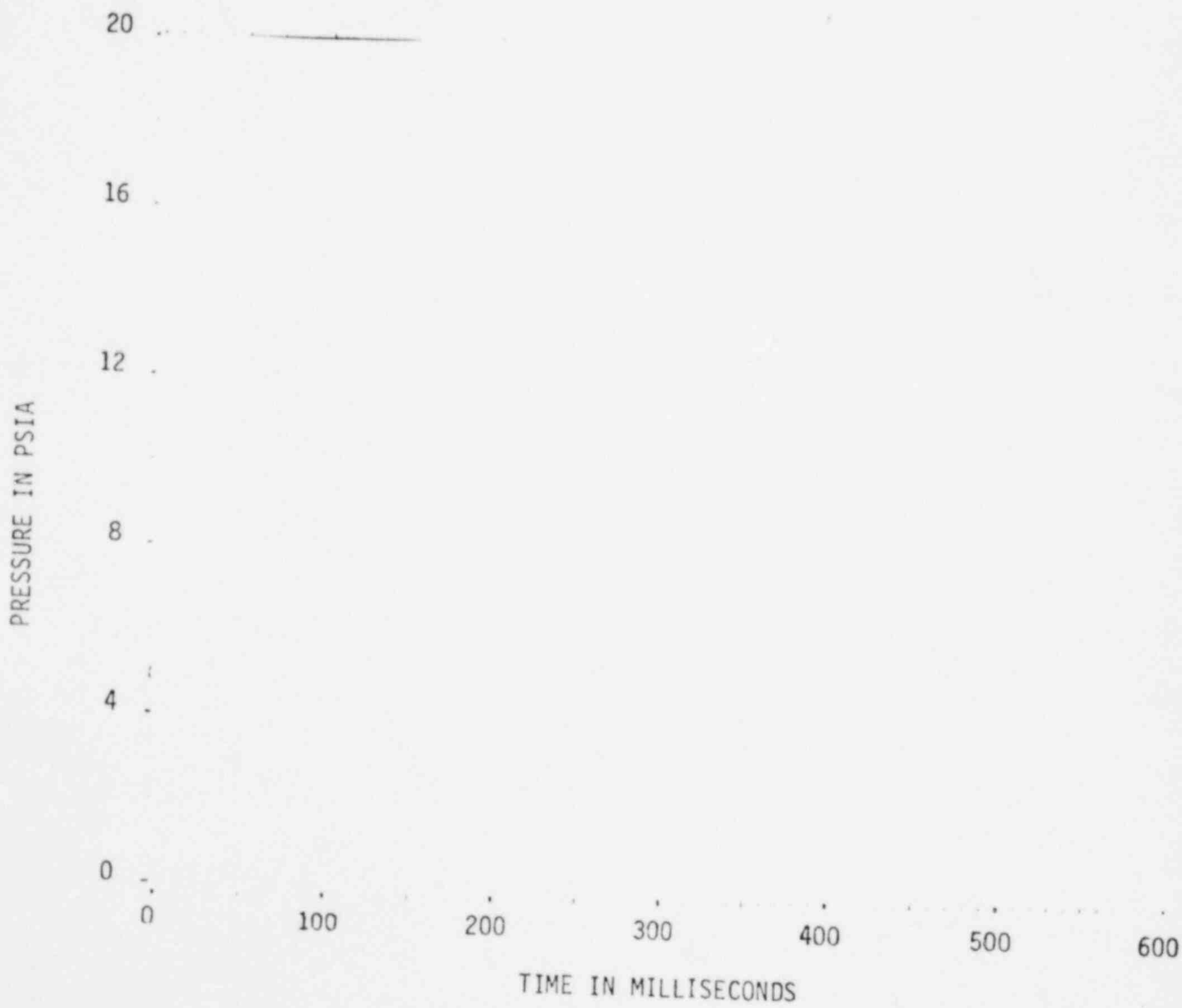


1350 106

FIGURE A-559

WETWELL PRESSURES

Task 5.5.3 Oyster Creek Test 5



1350 107

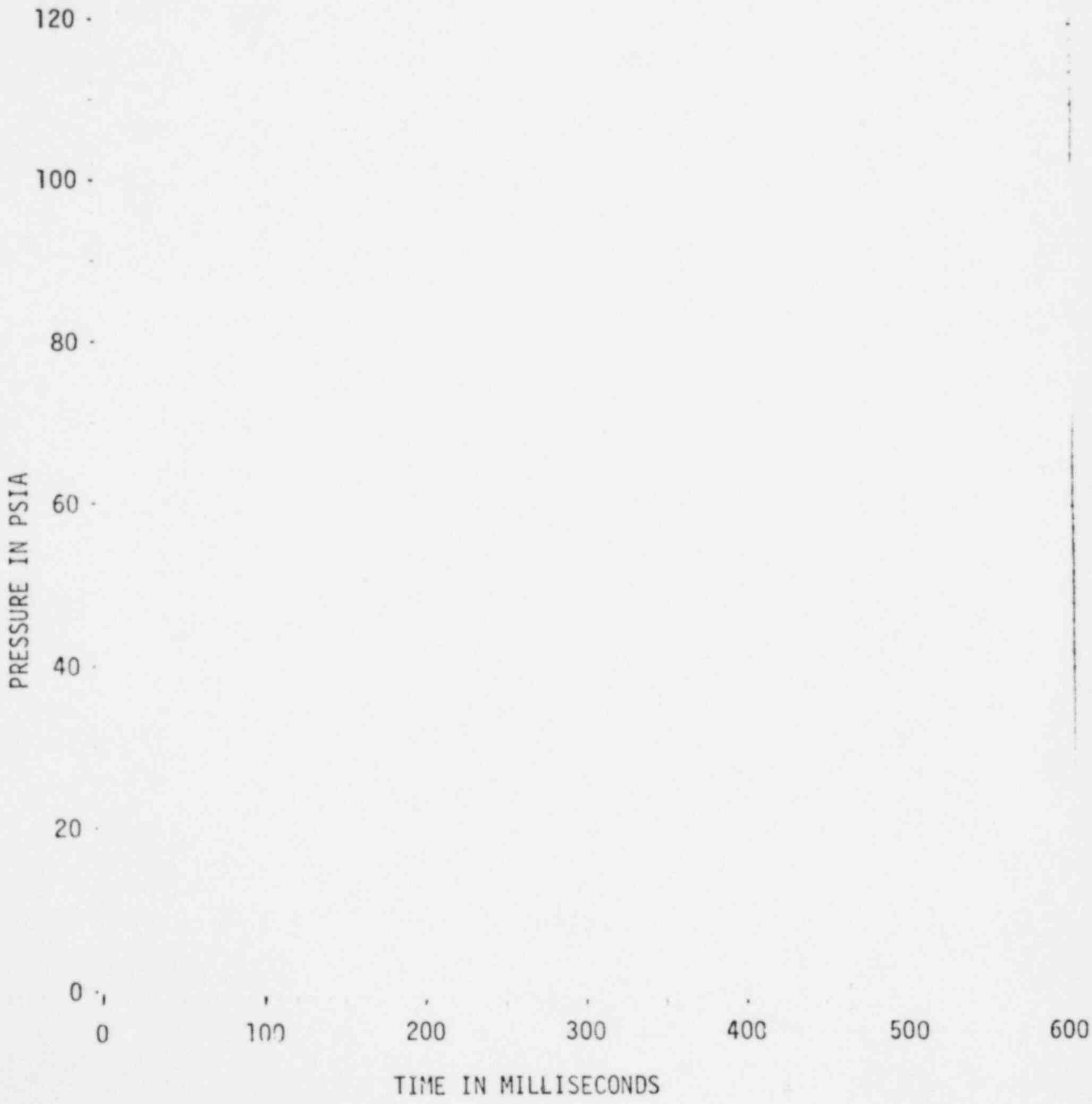
A.13.4 Discussion and Analysis

Figure A-653 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-654. Figure A-655 presents the effect of ΔP on pool and freespace pressures. This data for Hatch 1 parallels that for the "typical" plant in Section 3.0. The Hatch 1 load definition tests were conducted at 11.46" H_2O ΔP and with a winged pipe deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. Both the downforce and upforce were relatively smooth. The pipe deflector (26" full-scale) effectively reduced vent header impact force.

FIGURE A-601

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Hatch 1 Test 3

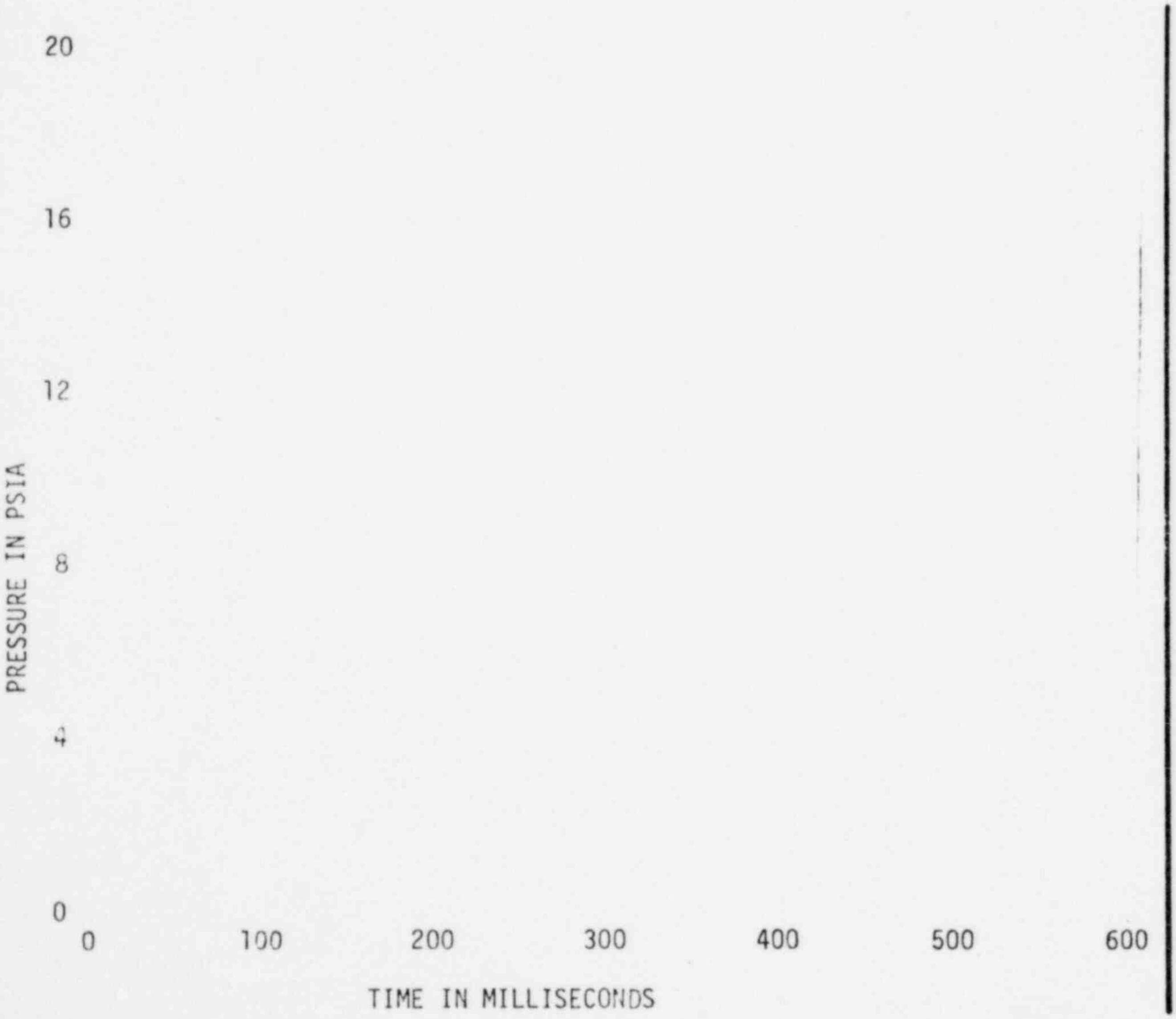


1350 109

FIGURE A-602

DRYWELL PRESSURE

Task 5.5.3 Hatch 1 Test 3



1350 110

FIGURE A-603

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

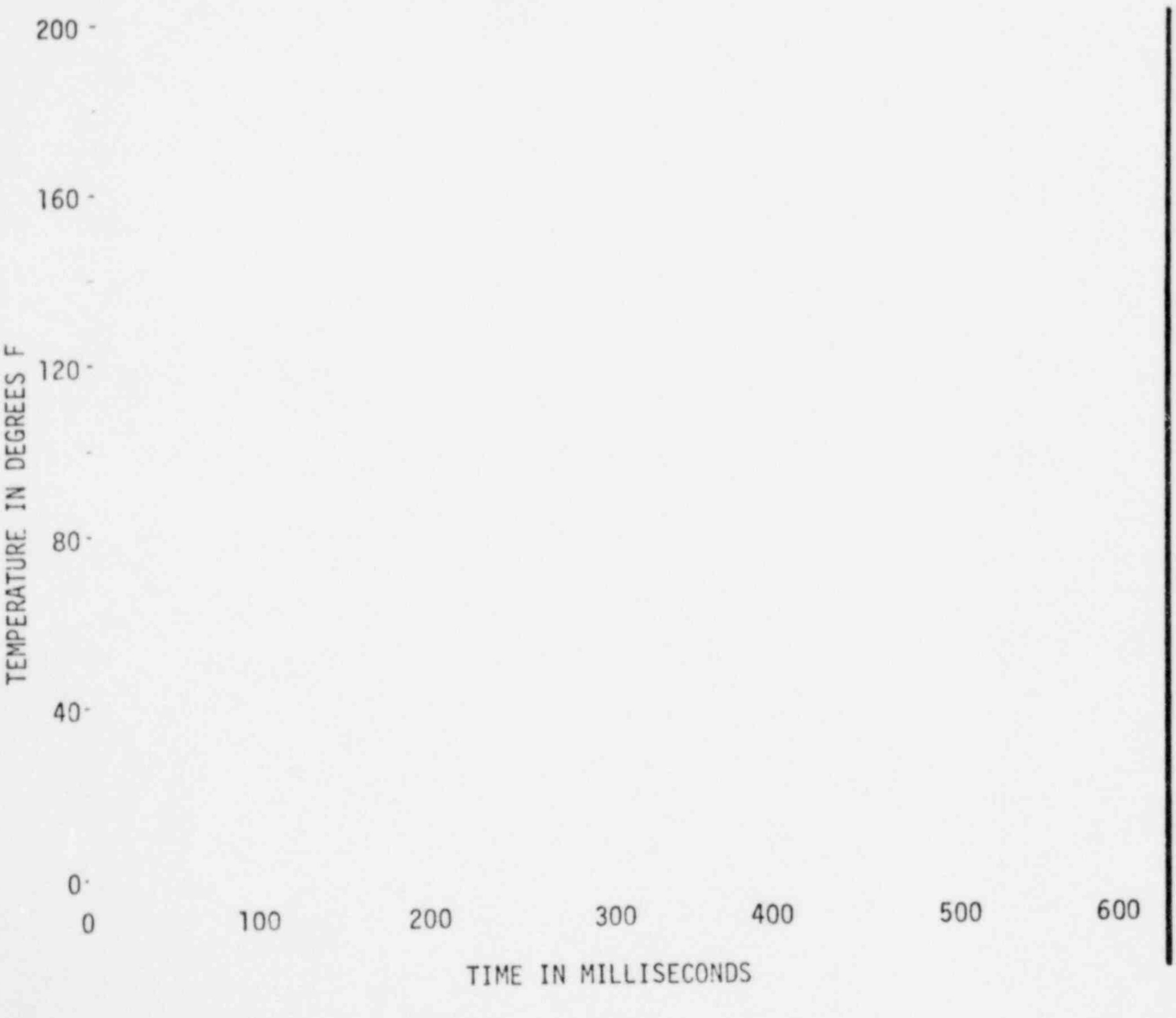
Task 5.5.3 Hatch 1 Test 3

1350 111

FIGURE A-604

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Hatch : Test 3



1350 112

FIGURE A-605

ENTHALPY FLOW INTO POOL

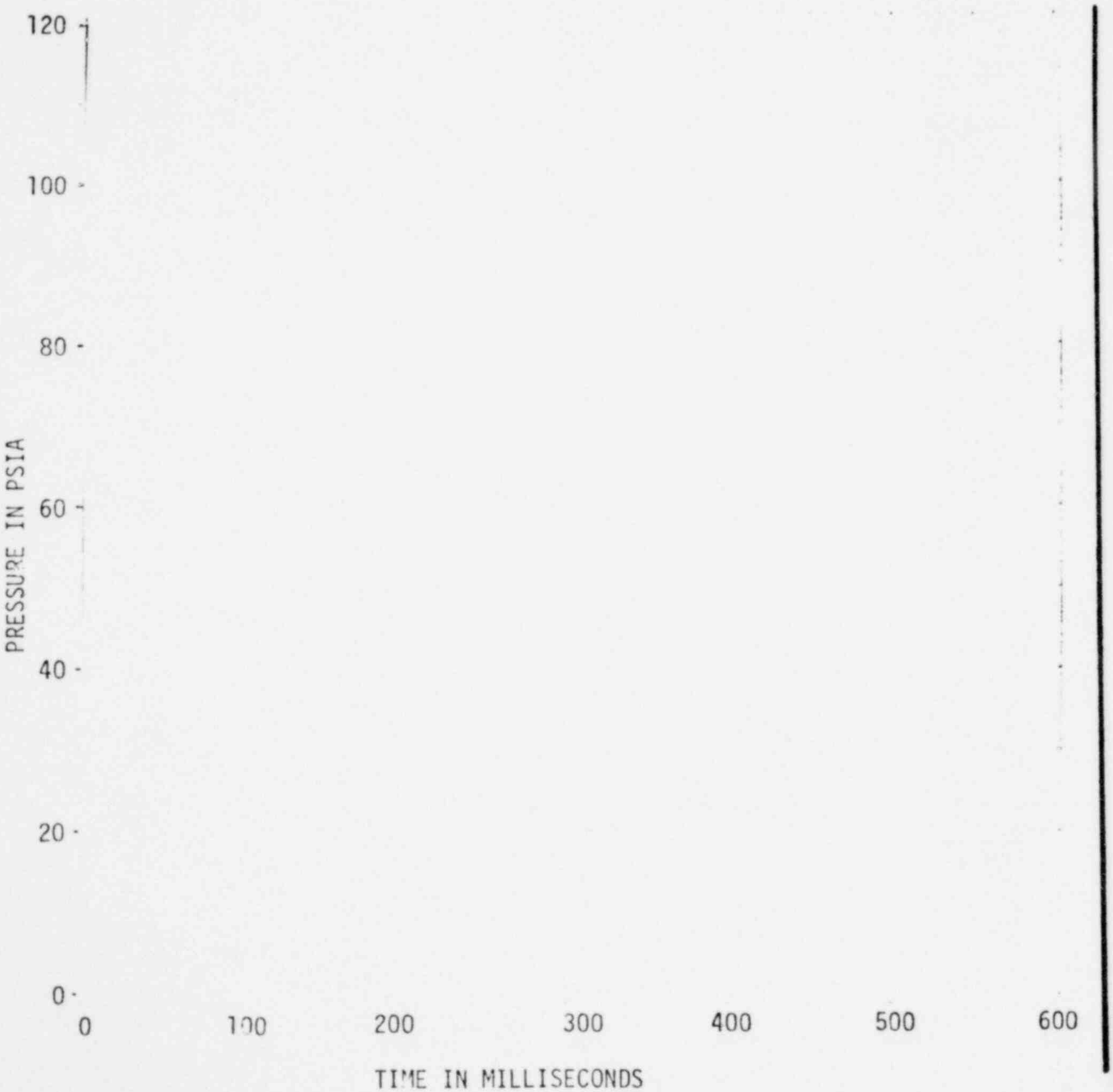
Task 5.5.3 Hatch 1 Test 3

1350 113

FIGURE A-606

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Hatch 1 Test 5

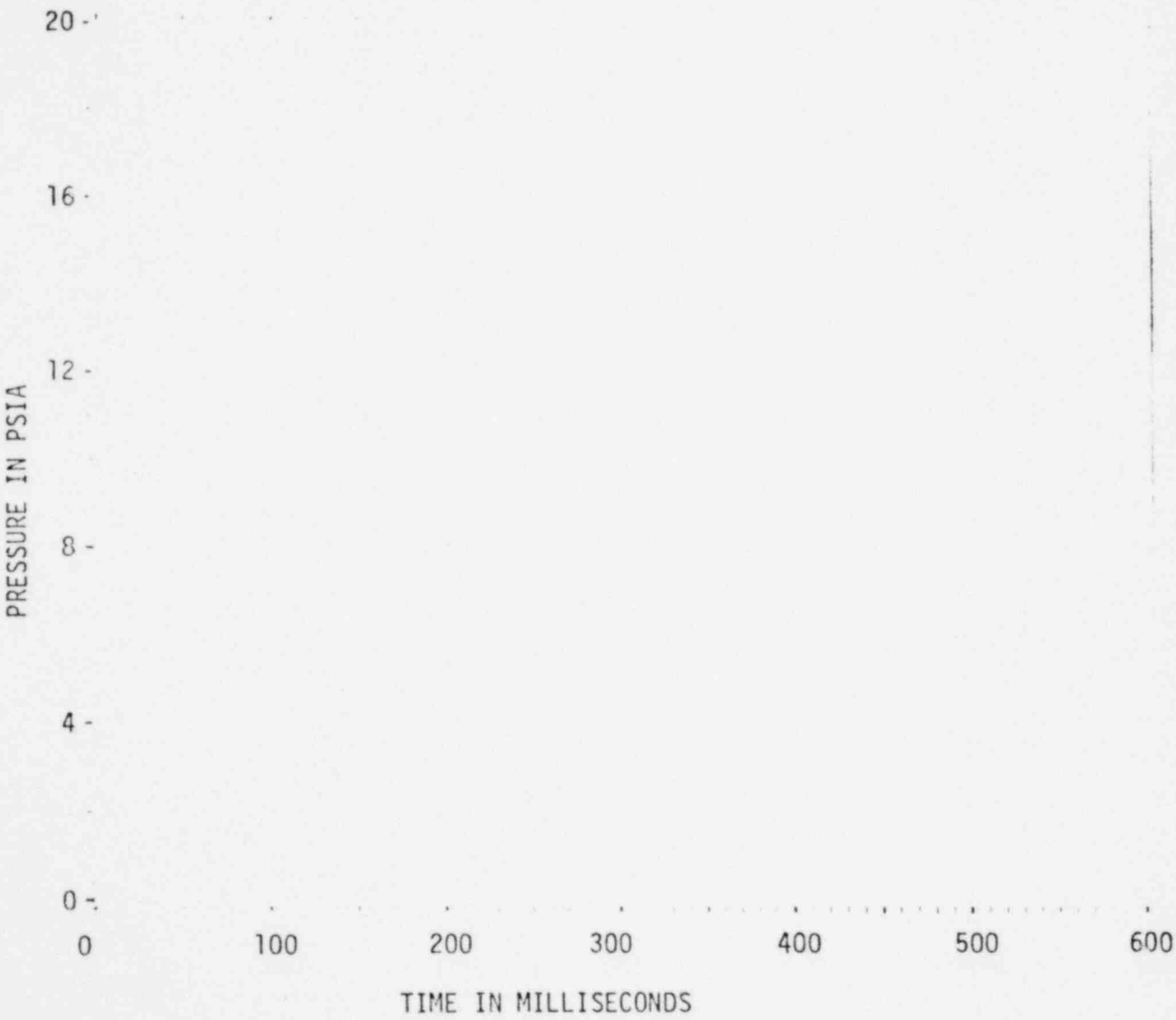


1350 114

FIGURE A-607

DRYWELL PRESSURE

Task 5.5.3 Hatch 1 Test 5

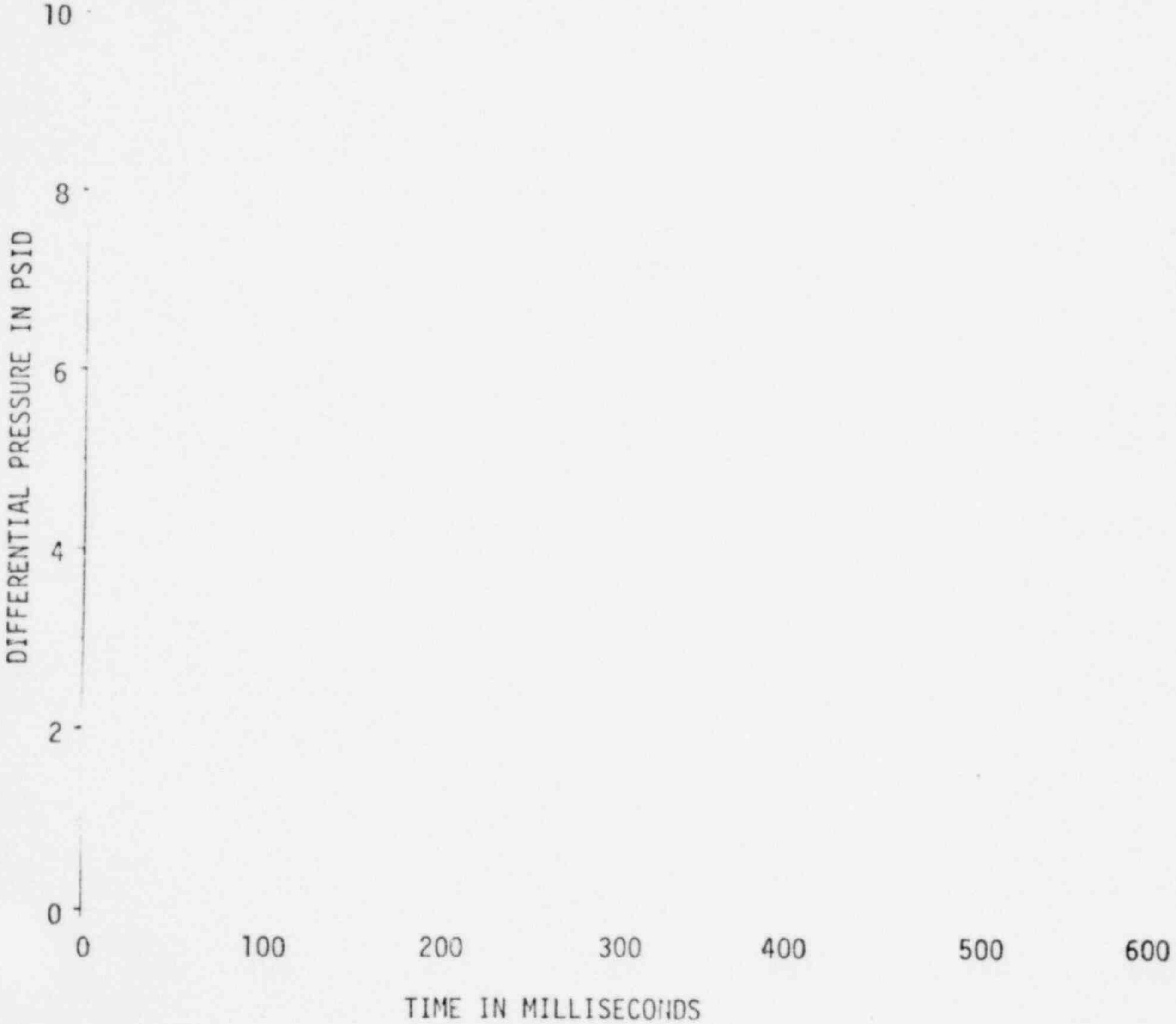


1350 115

FIGURE A-608

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Hatch 1 Test 5

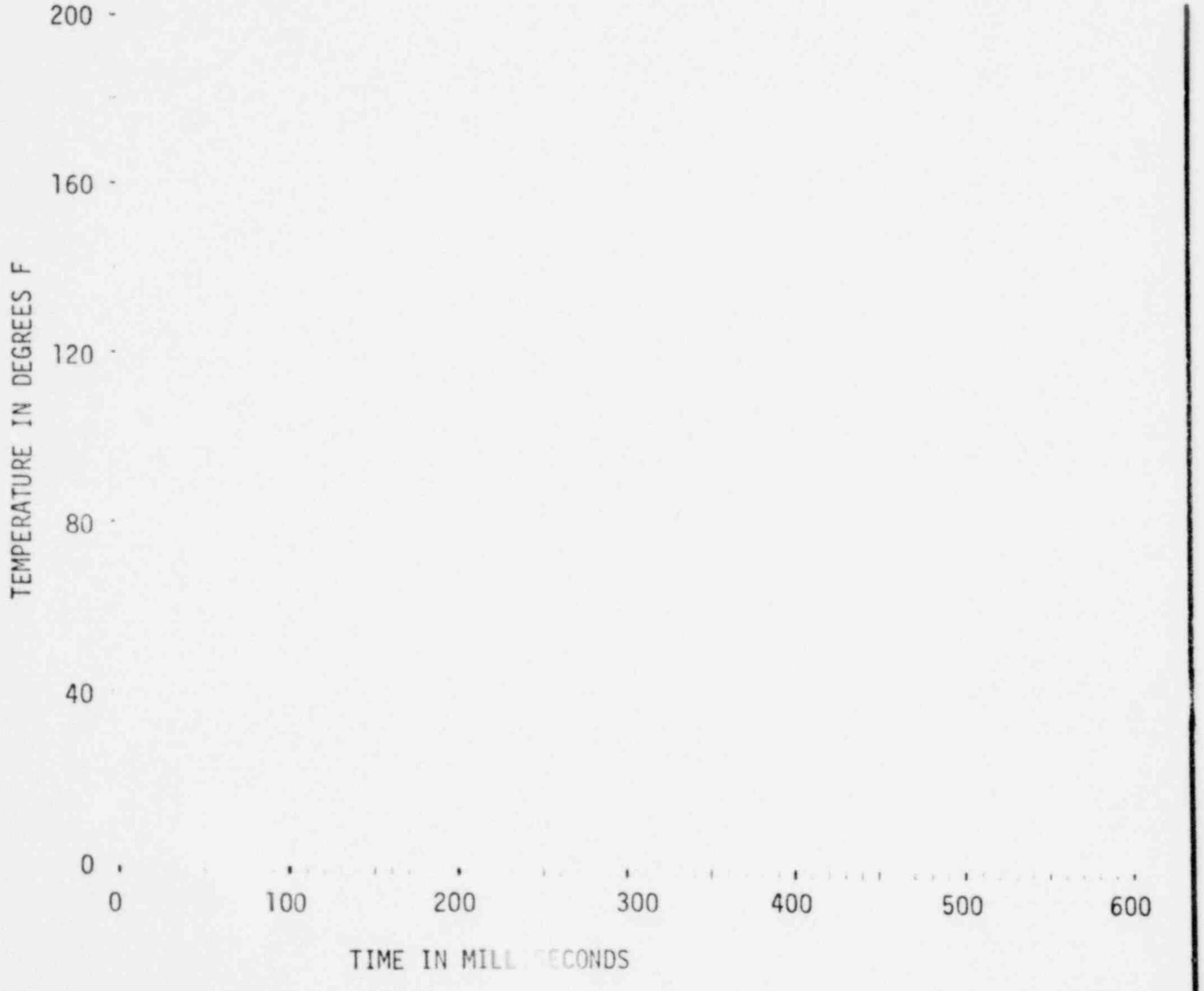


1350 116

FIGURE A-609

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Hatch 1 Test 5

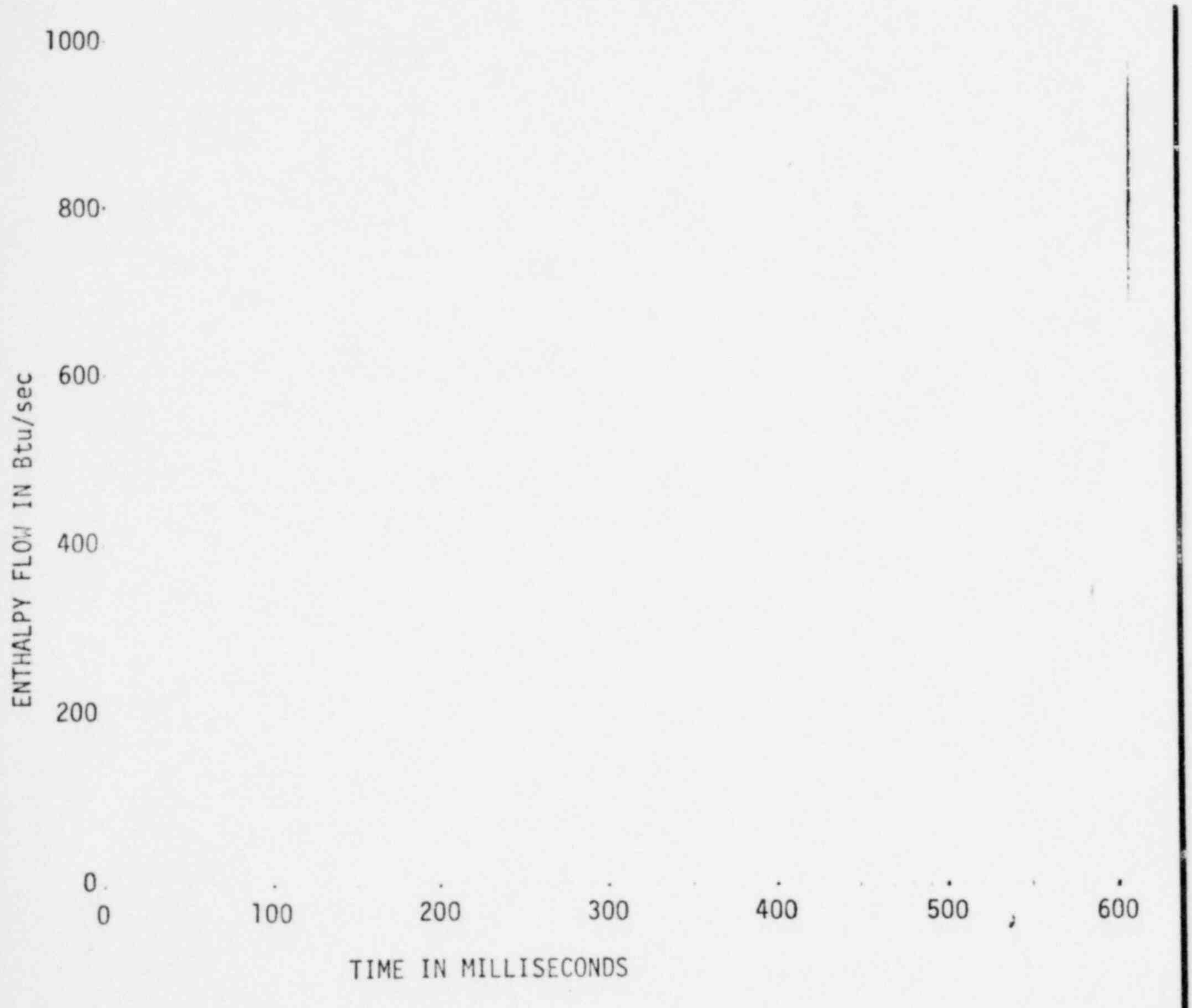


1350 117

FIGURE A-610

ENTHALPY FLOW INTO POOL

Task 5.5.3 Hatch 1 Test 5

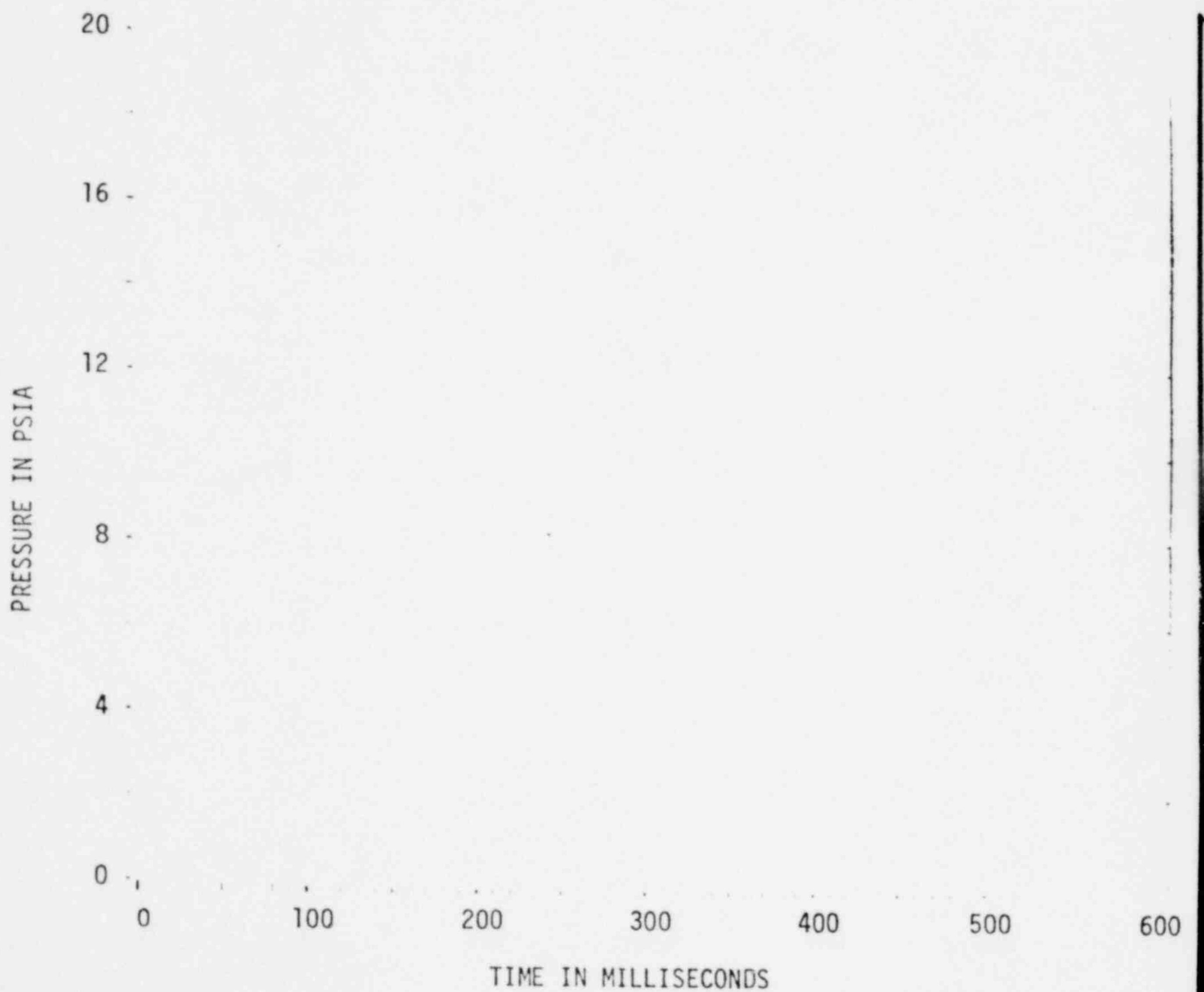


1350 118

FIGURE A-611

DOWNCOMER INTERNAL PRESSURE

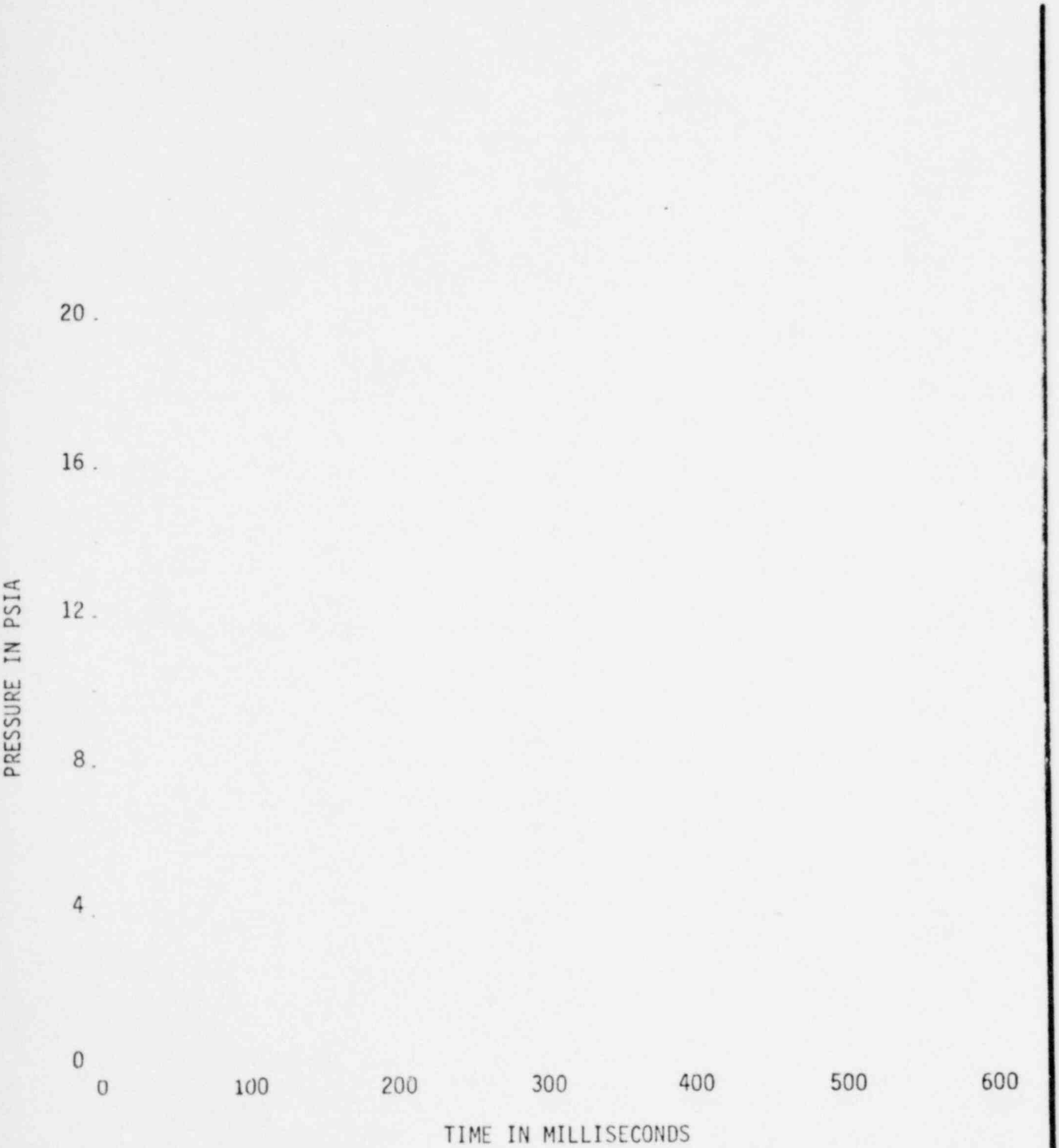
Task 5.5.3   Hatch 1 Test 3



1350 119

FIGURE A-612
NEDO-21944
WETWELL PRESSURES

Task 5.5.3 Hatch 1 Test 3

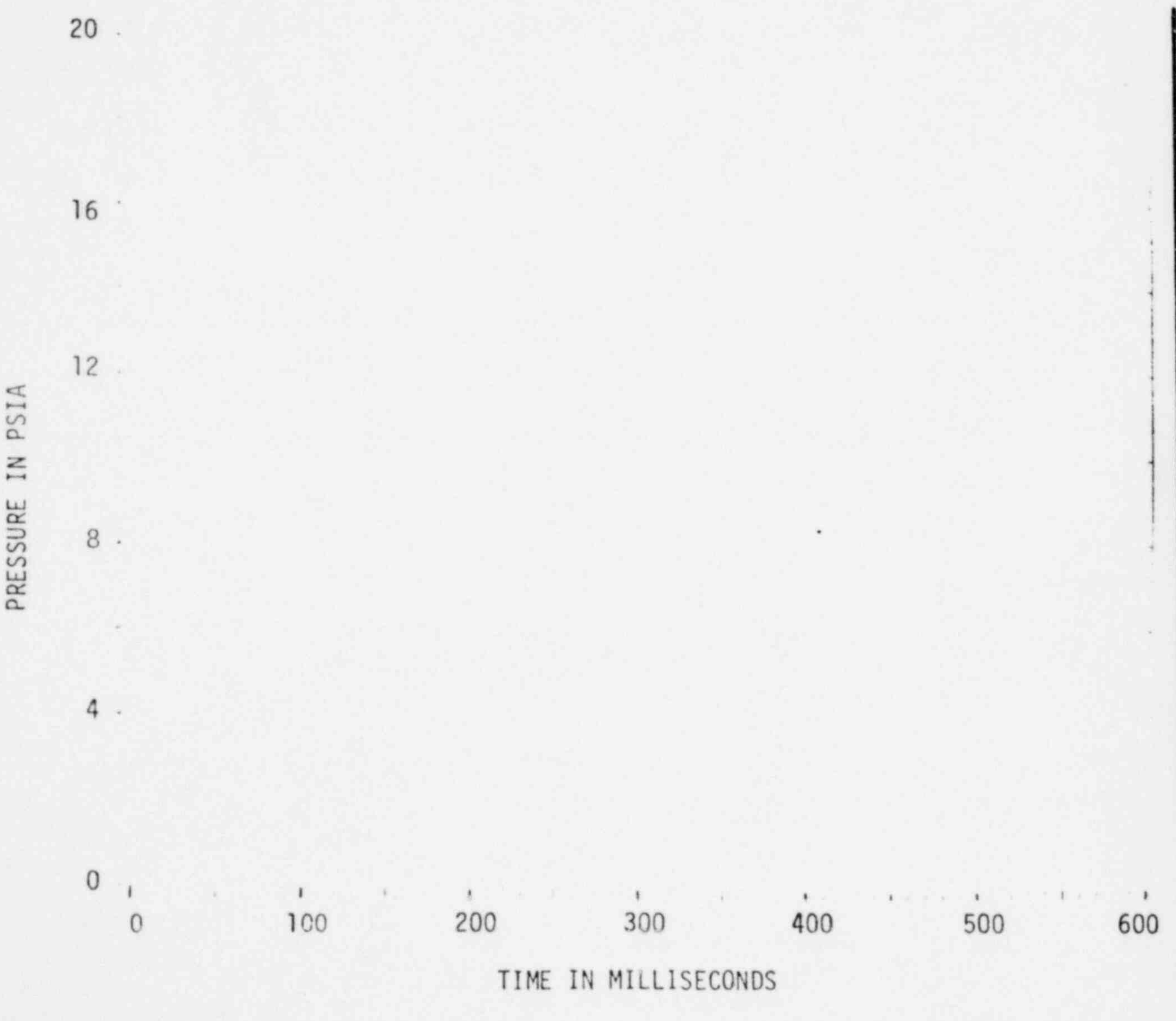


1350 120

FIGURE A-613

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Hatch 1 Test 5



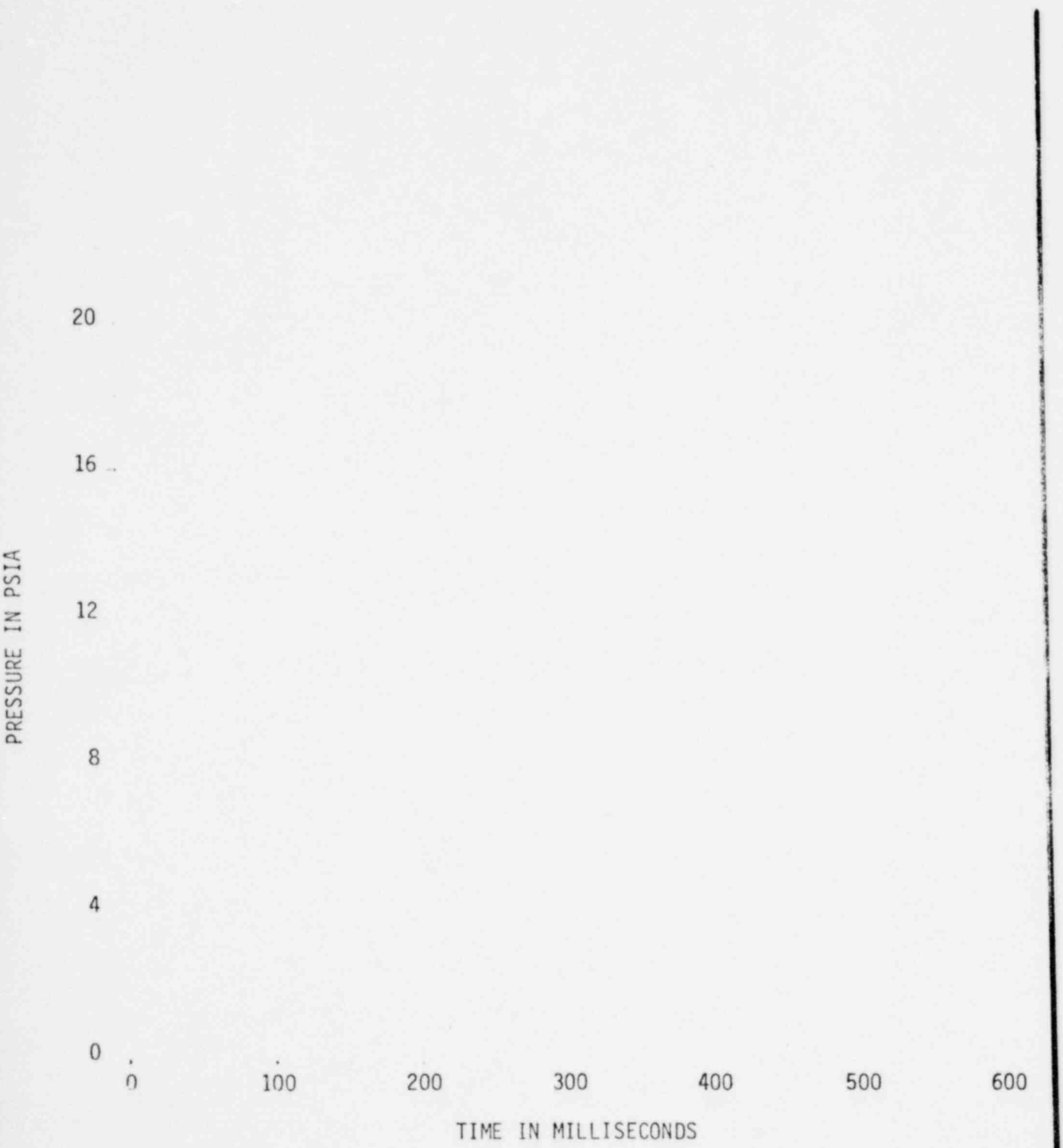
1350 121

FIGURE A-614

NEDO-21944

WETWELL PRESSURES

Task 5.5.3 Hatch 1 Test 5

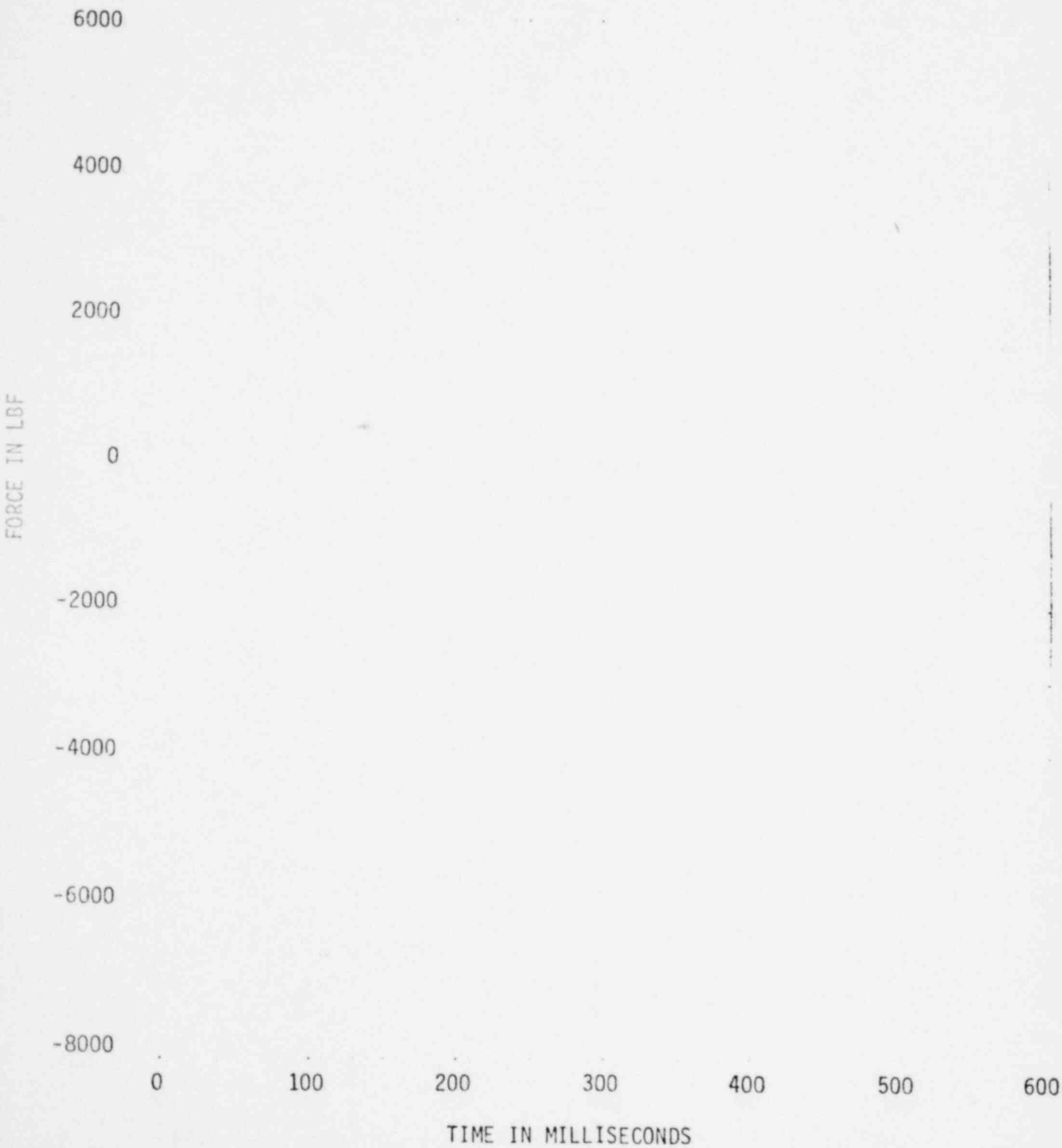


1350 122

FIGURE A-615

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Hatch 1 Test 3



1350 123

FIGURE A-616

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Hatch 1 Test 5

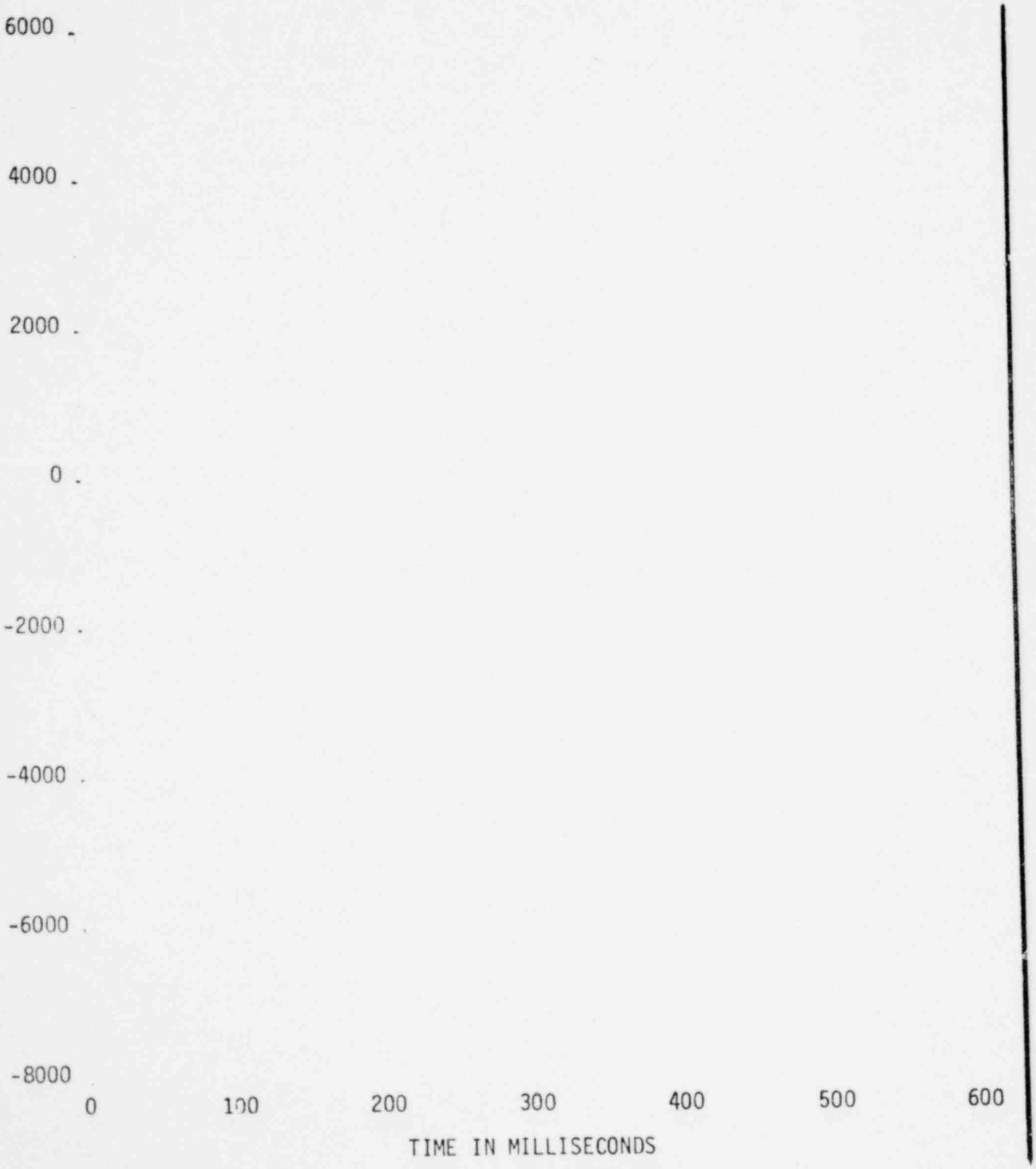
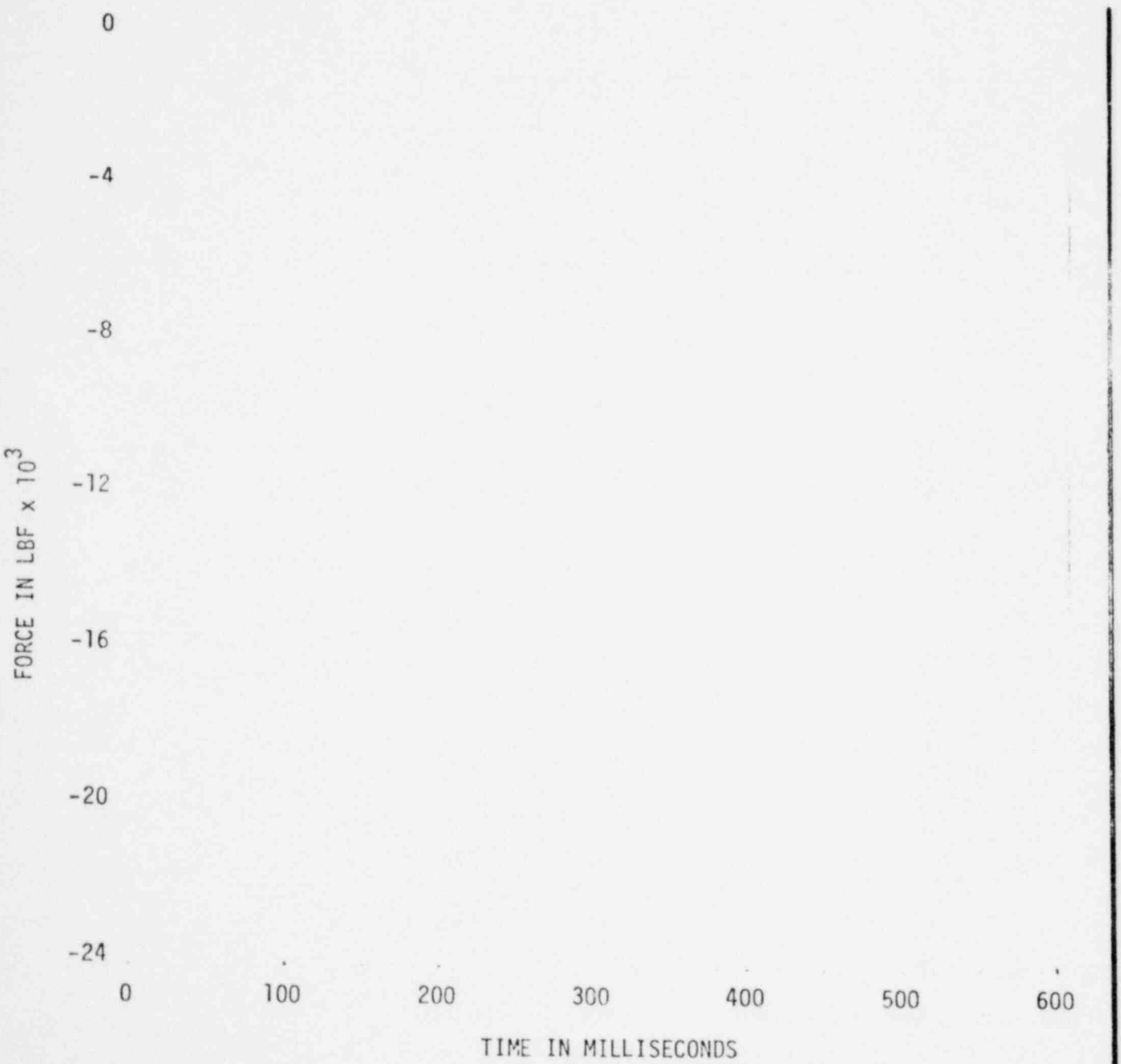


FIGURE A-617

TORUS LOAD CELL

Task 5.5.3 Hatch 1 Test 3



1350 125

FIGURE A-618

TORUS VERTICAL ACCELERATION

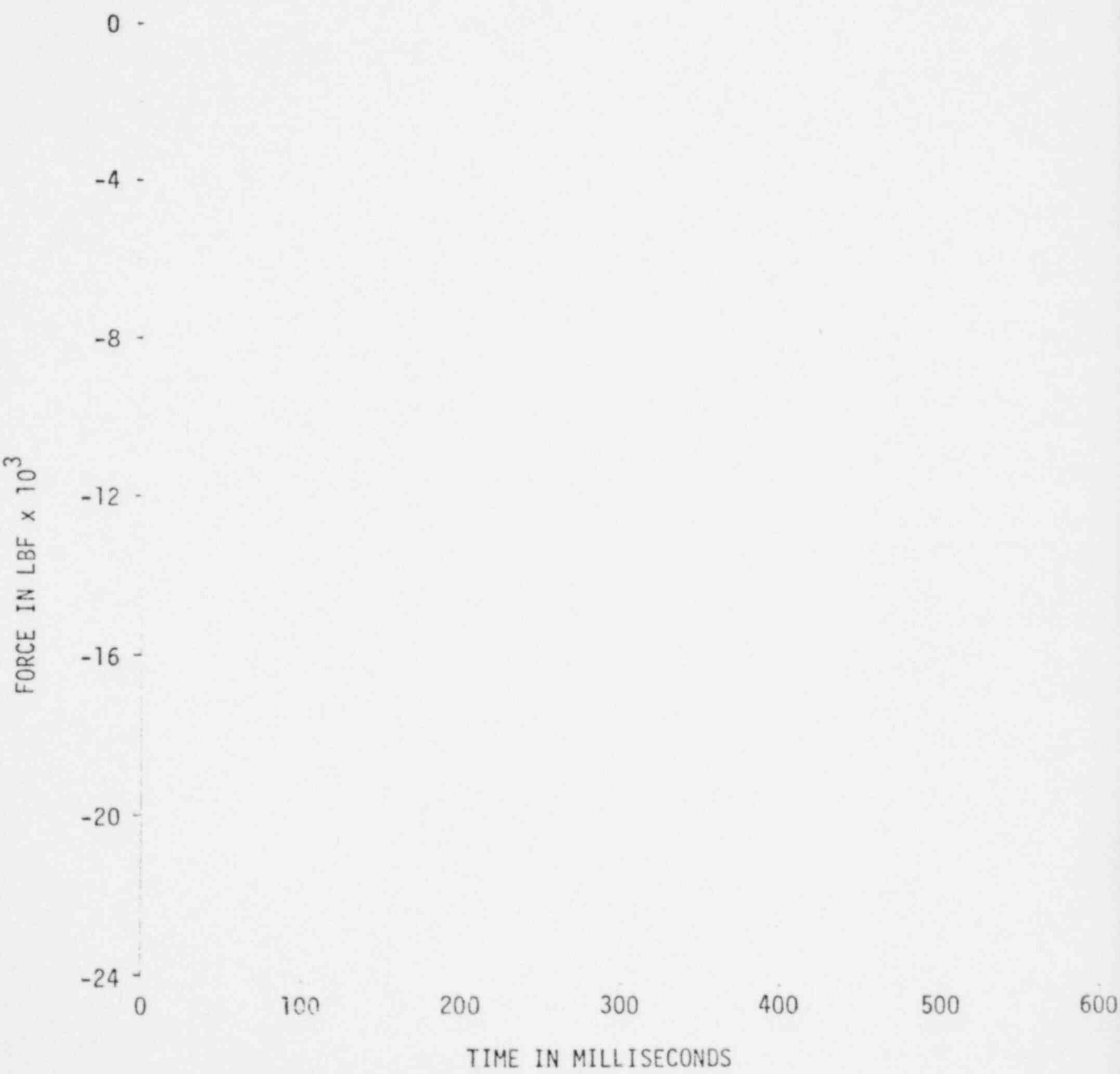
Task 5.5.3 Hatch 1 Test 3

1350 126

FIGURE A-619

TORUS LOAD CELL

Task 5.5.3 Hatch 1 Test 5



1350 127

FIGURE A-620

TORUS VERTICAL ACCELERATION

Task 5.5.3 Hatch 1 Test 5

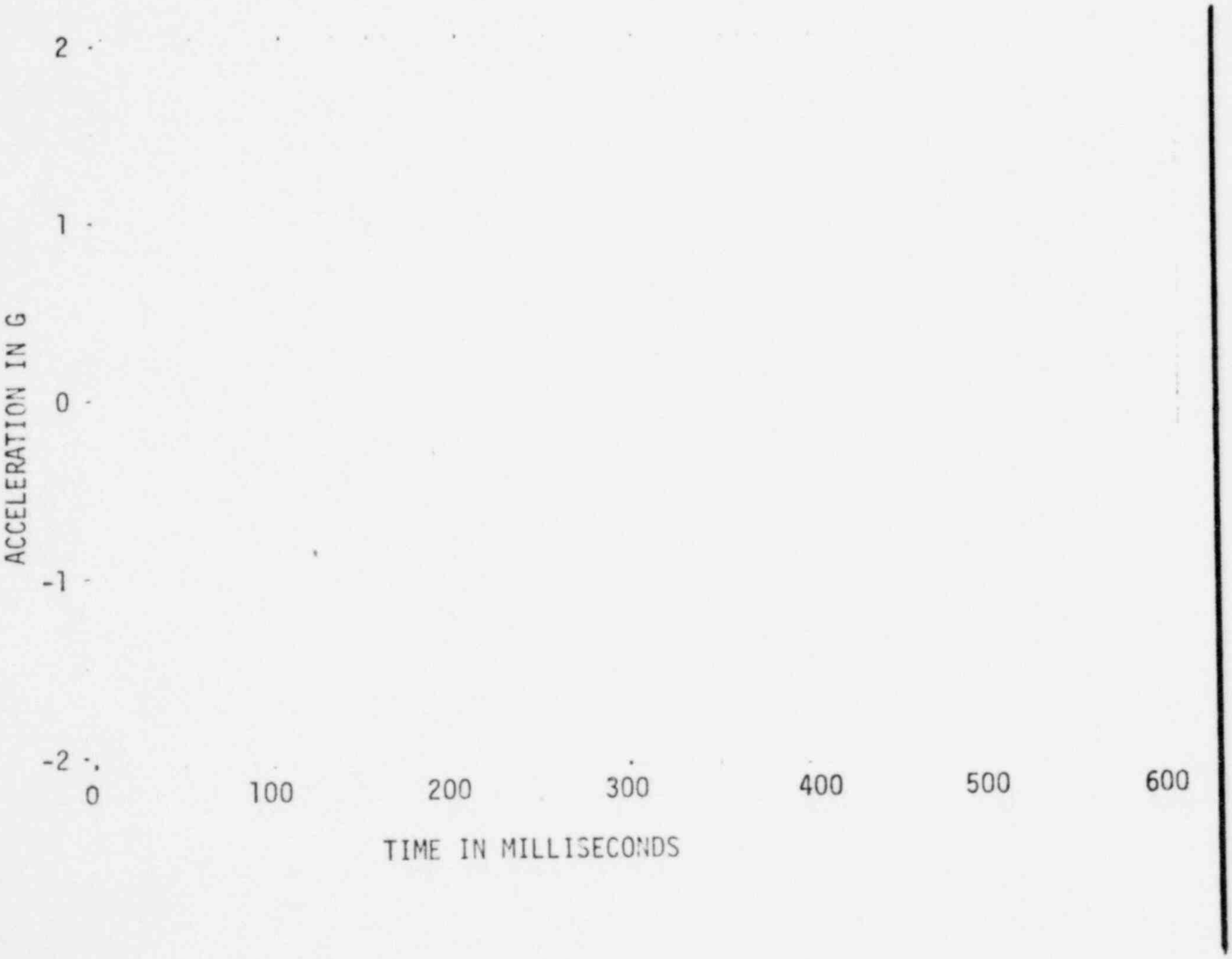
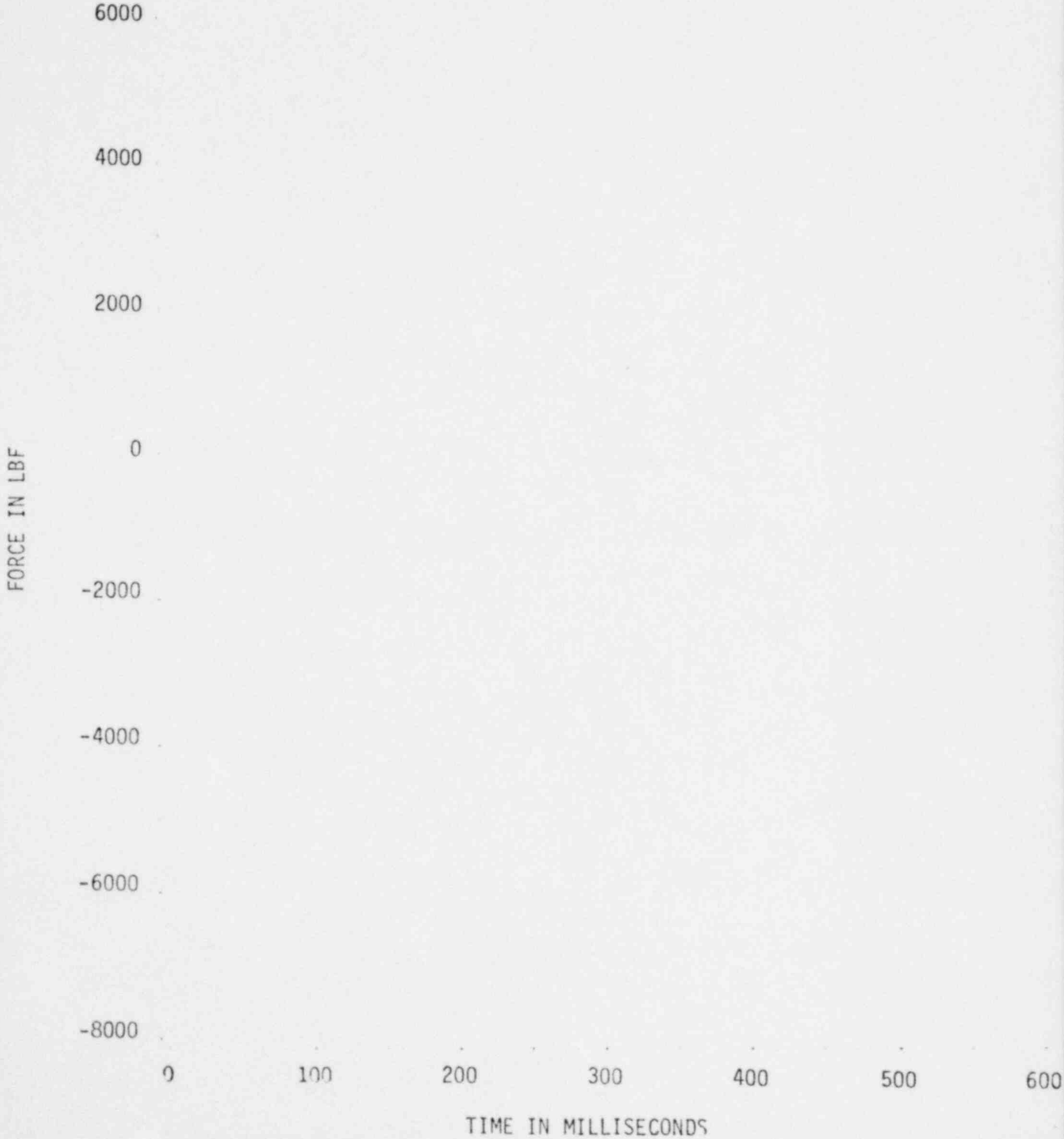


FIGURE A-621

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

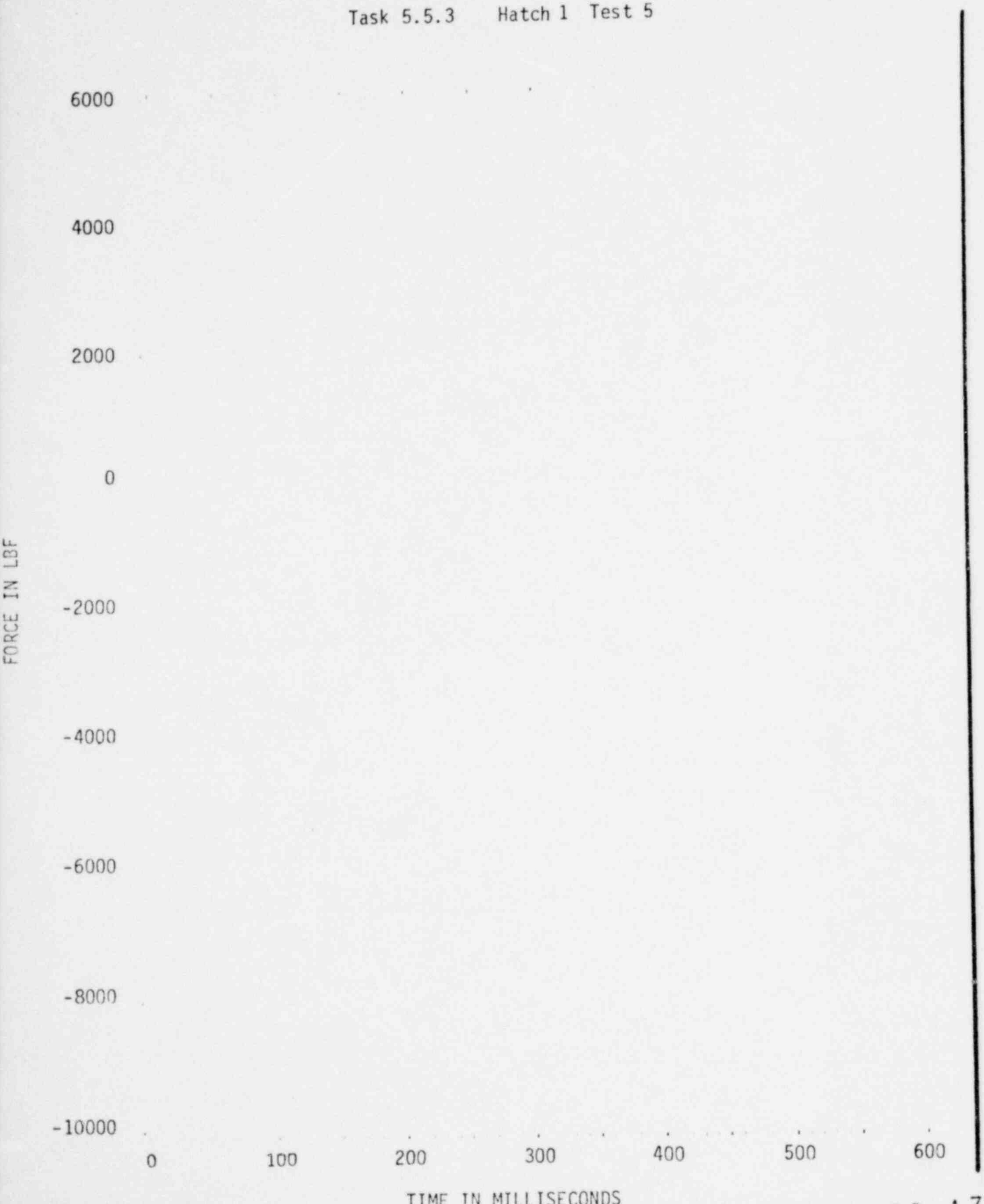
Task 5.5.3 Hatch 1 Test 3



1350 129

FIGURE A-622
COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL
WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Hatch 1 Test 5



1350 130

FIGURE A-623

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

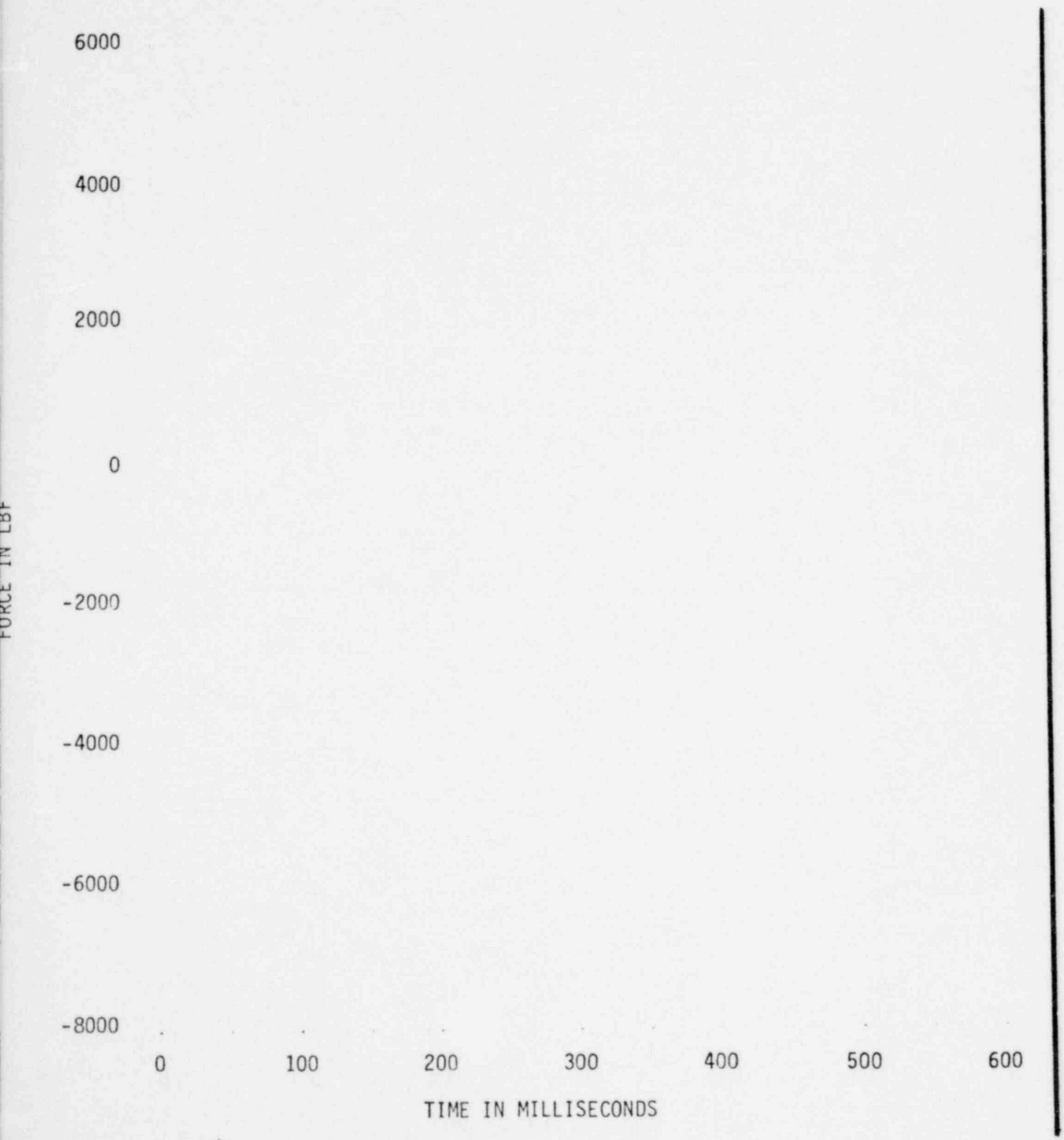
Task 5.5.3 Hatch 1 Test 3

1350 131

FIGURE A-624

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hatch 1 Test 5



1350 132

FIGURE A-625

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

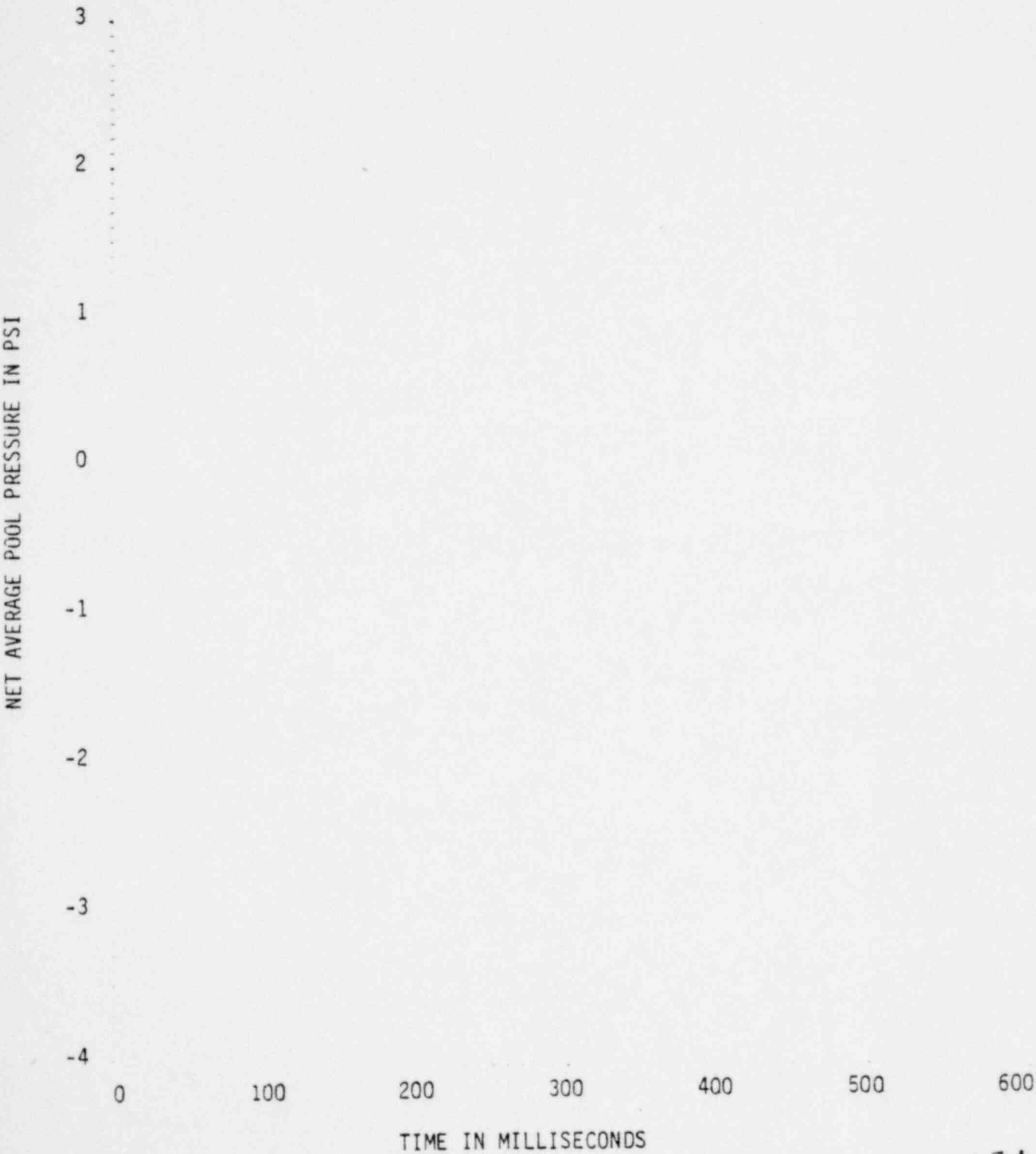
Task 5.5.3 Hatch 1 Test 3

1350 133

FIGURE A-626

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hatch 1 Test 3

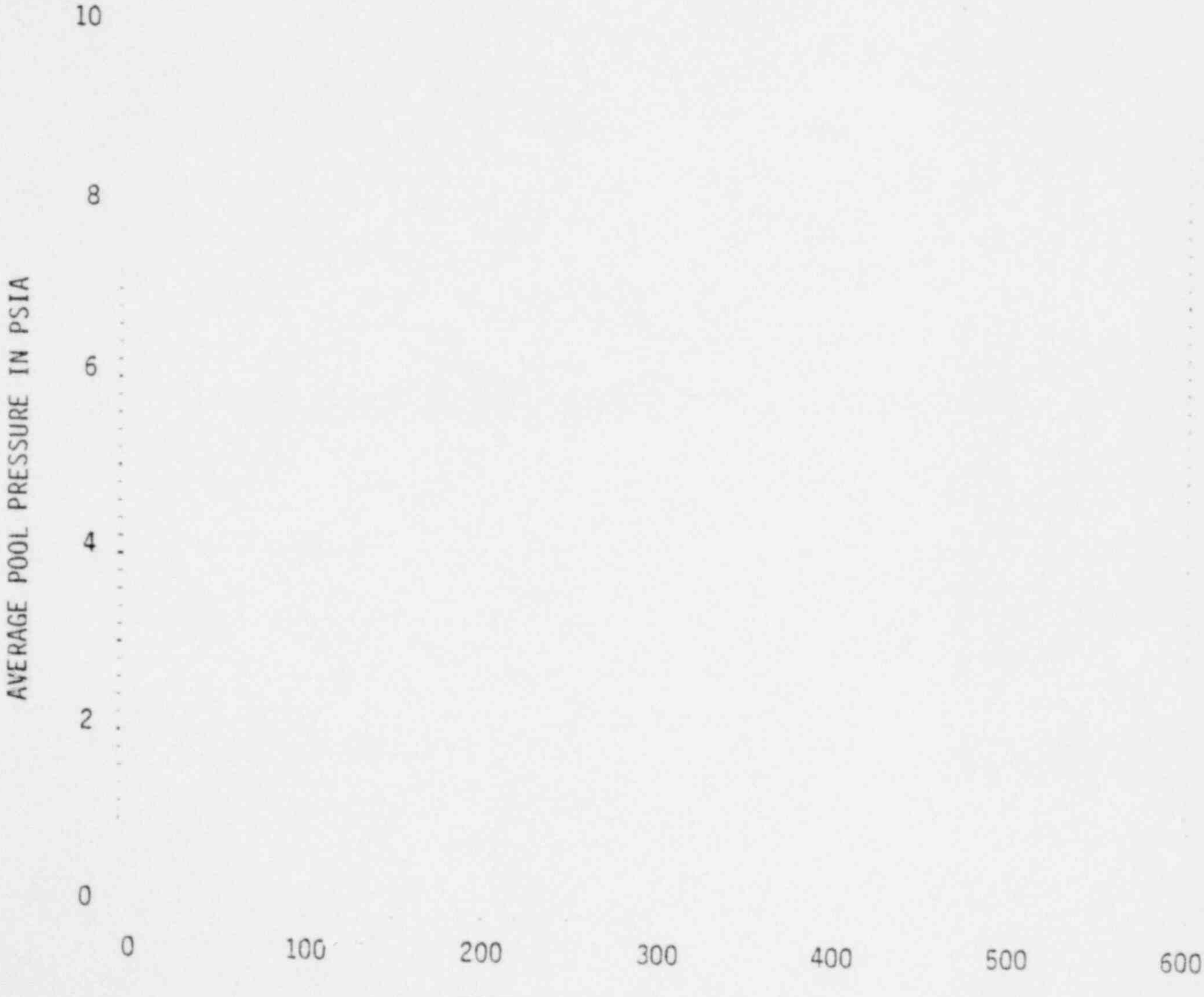


1350 134

FIGURE A-627

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hatch 1 Test 5

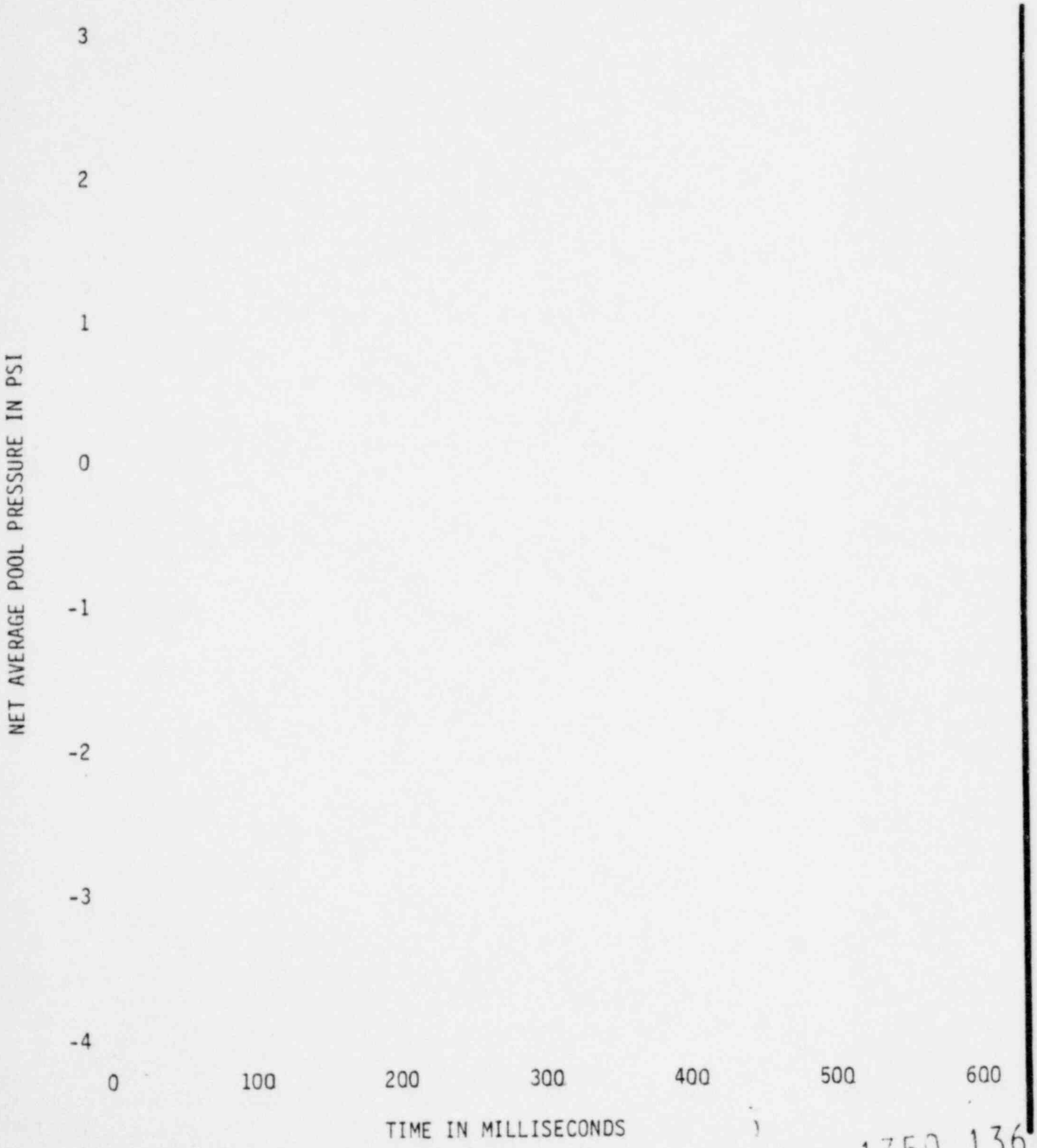


1350 135

FIGURE A-628

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hatch 1 Test 5



1350 136

FIGURE A-629

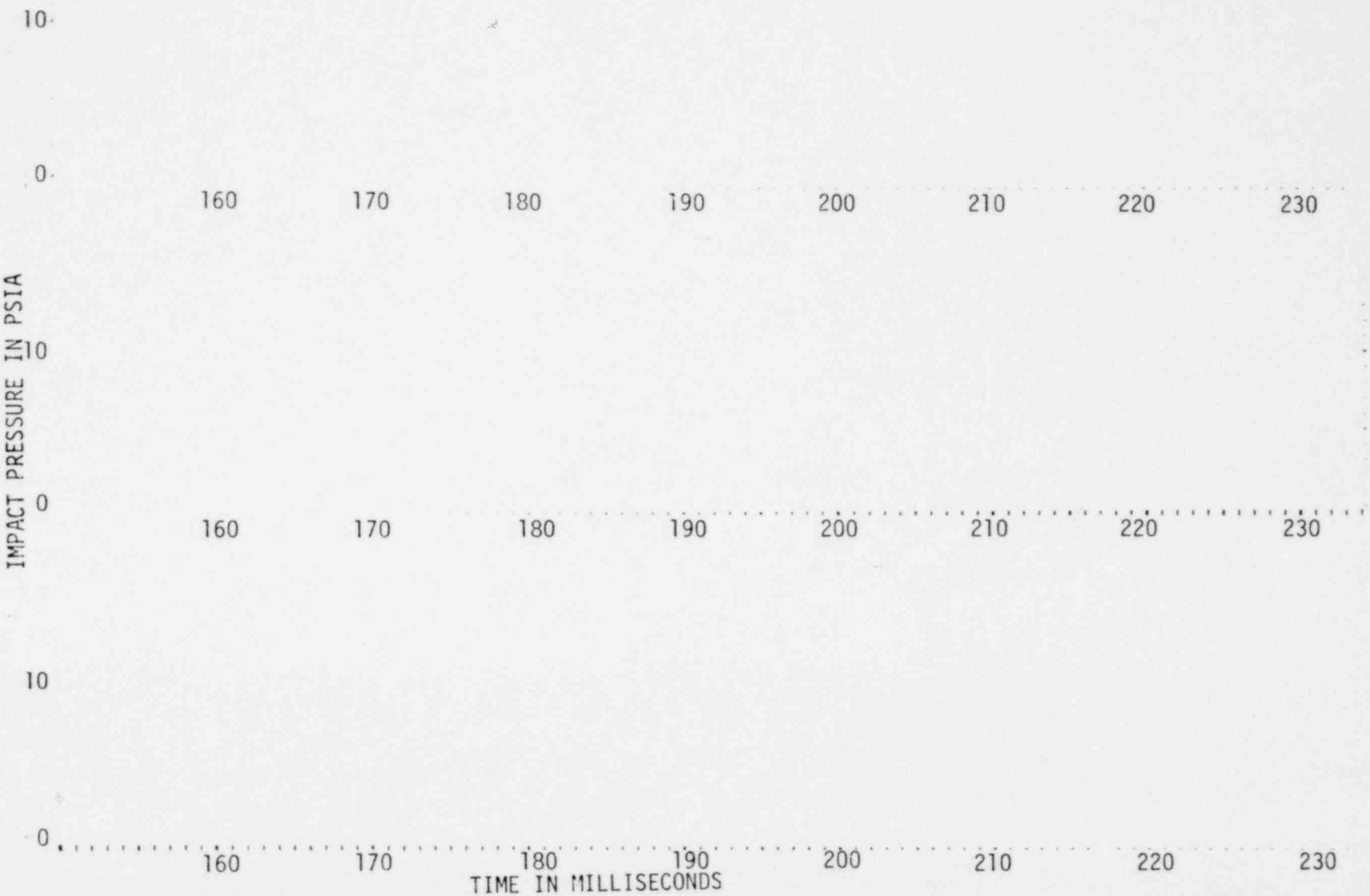
VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 3

1350 137

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 3

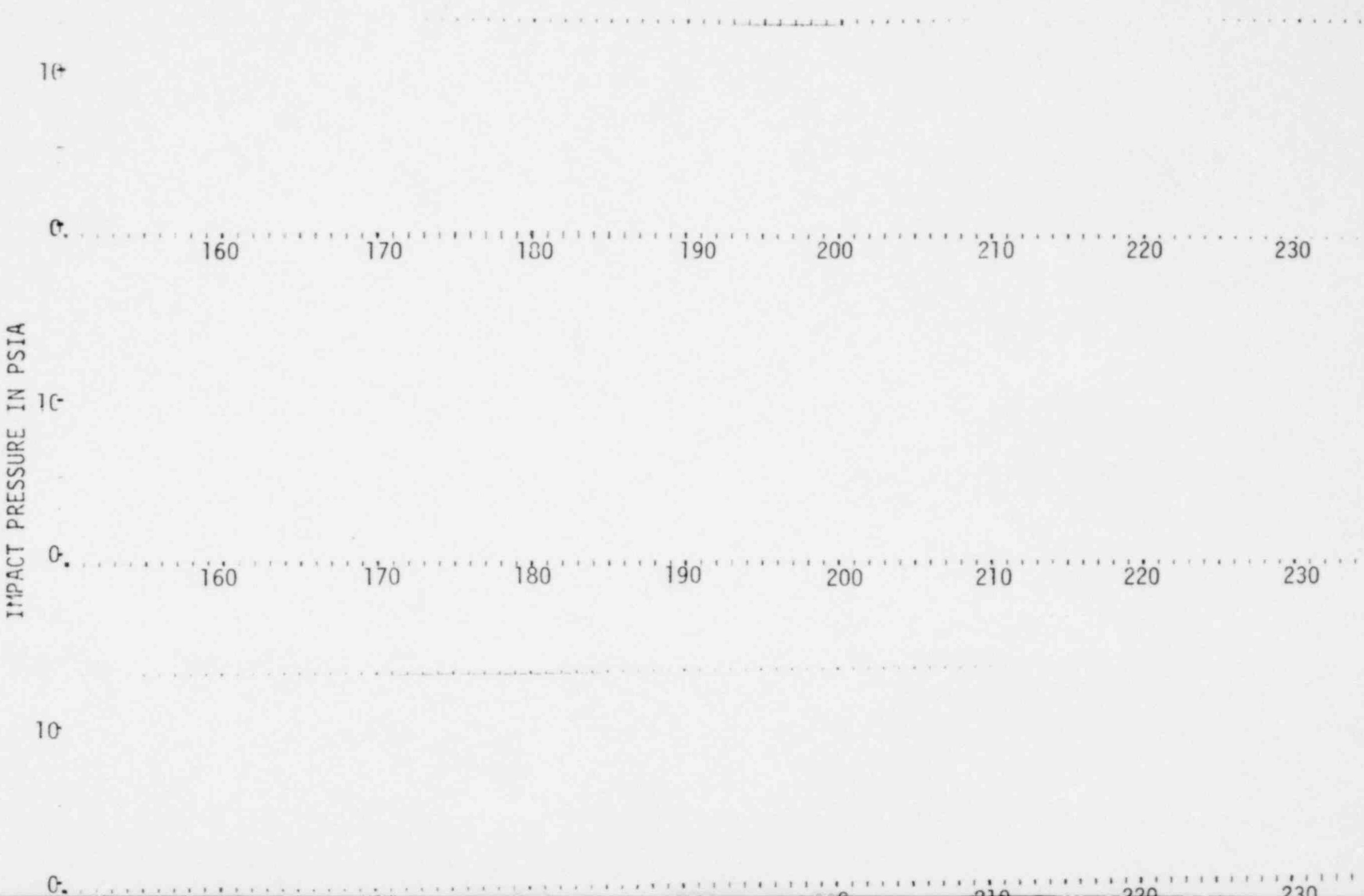


1350 138

FIGURE A-631

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 3



1350 139

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 3

NEDO-21944

1350 140

FIGURE A-633

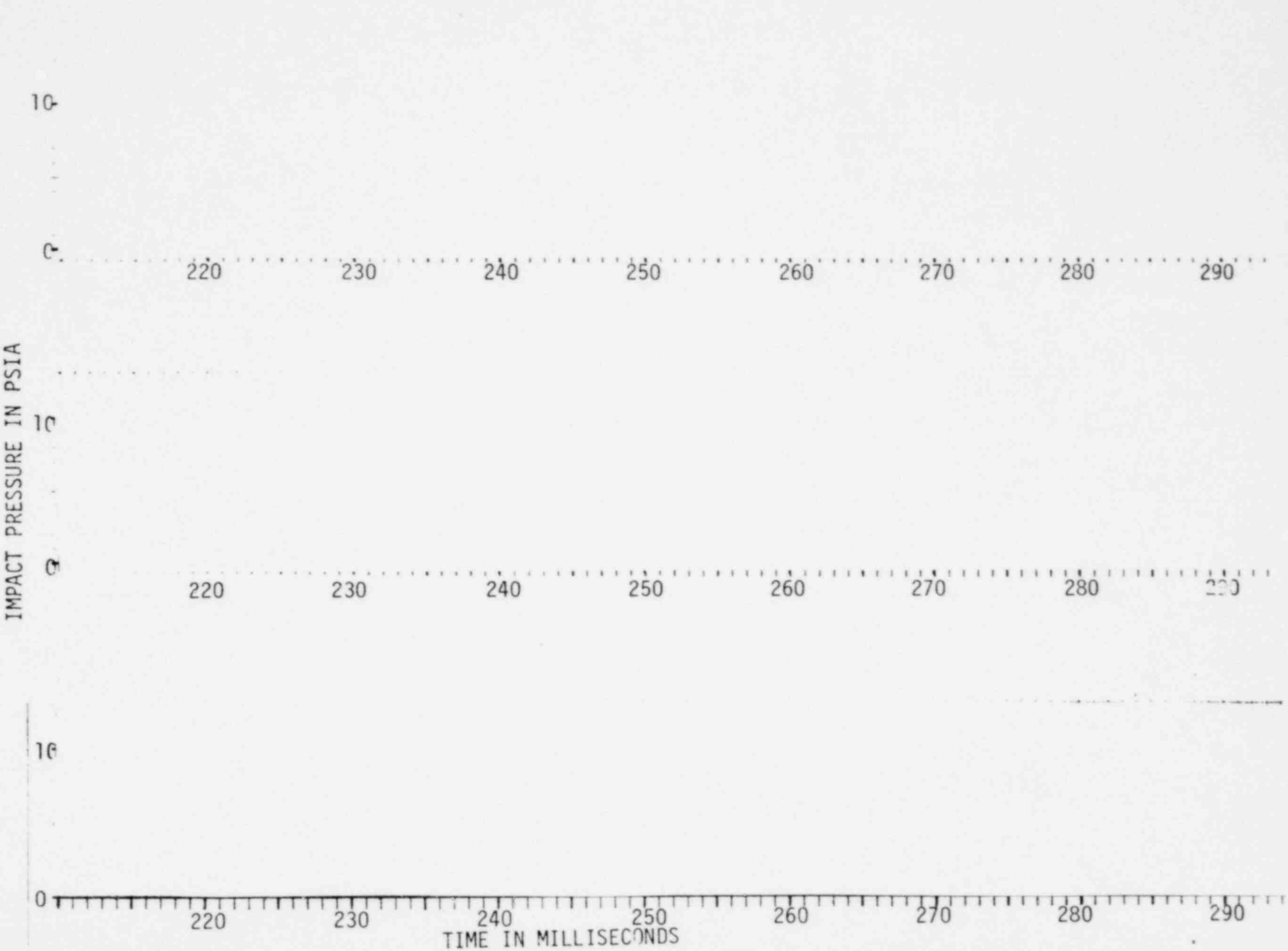
VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 3

1350 141

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 5



1350 142

FIGURE A-635

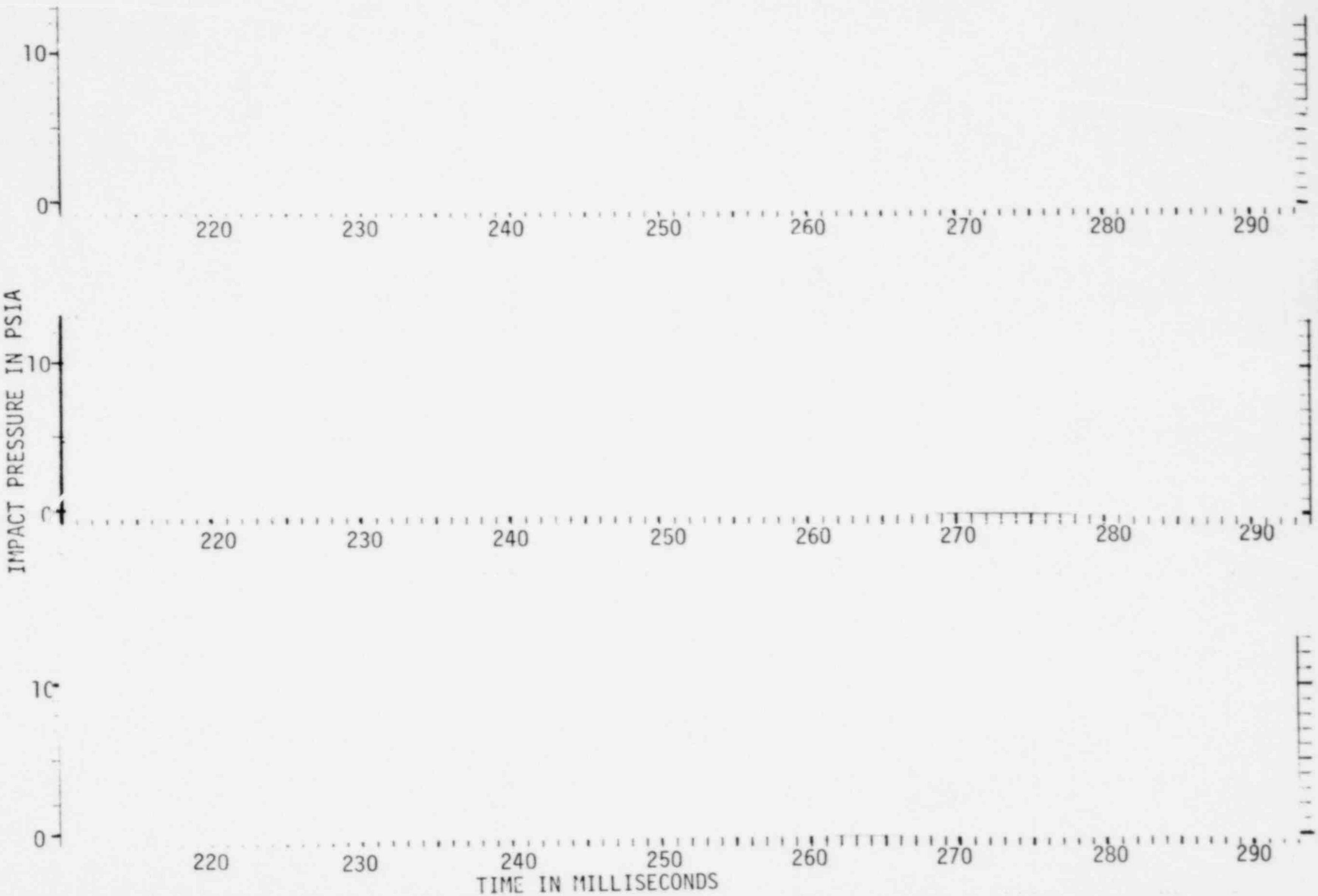
VENT HEADER IMPACT PRESSURES

Task 5.5.3   Hatch 1 Test 5

1350 143

VENT HEADER IMPACT PRESSURES

Task 5.5.3   Hatch 1 Test 5



1350 144

FIGURE A-637

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 5

FIGURE A-638

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hatch 1 Test 5

1350 146

FIGURE A-639

COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3
Hatch 1 Tests 3,5

FORCE IN LBF

400
200
0
-200
-400

140 160 180 200 220

TIME IN MILLISECONDS

FORCE IN LBF

400
200
0
-200
-400

210 230 250 270 290

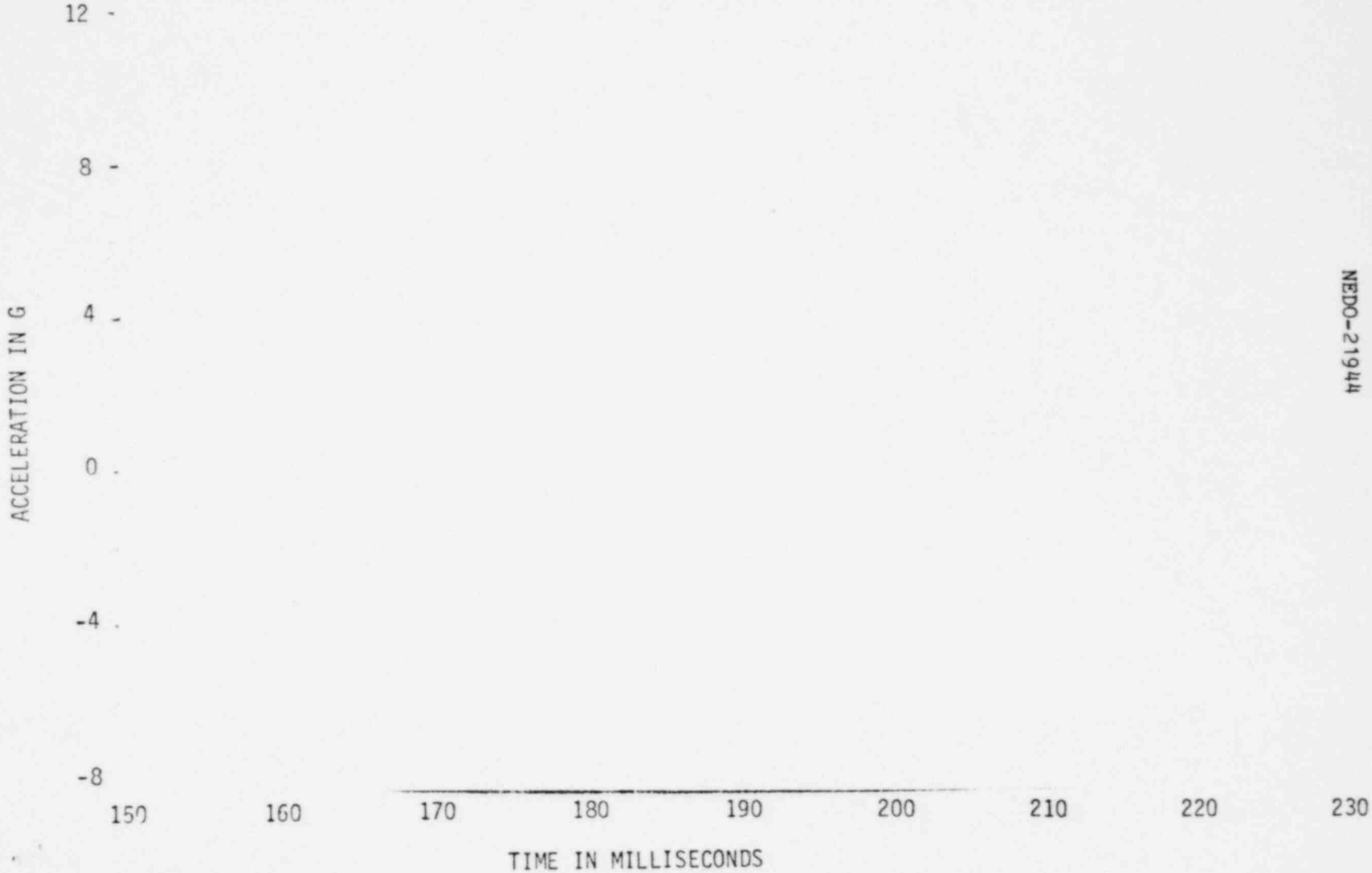
TIME IN MILLISECONDS

1350 147

FIGURE A-640

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Hatch 1 Test 3

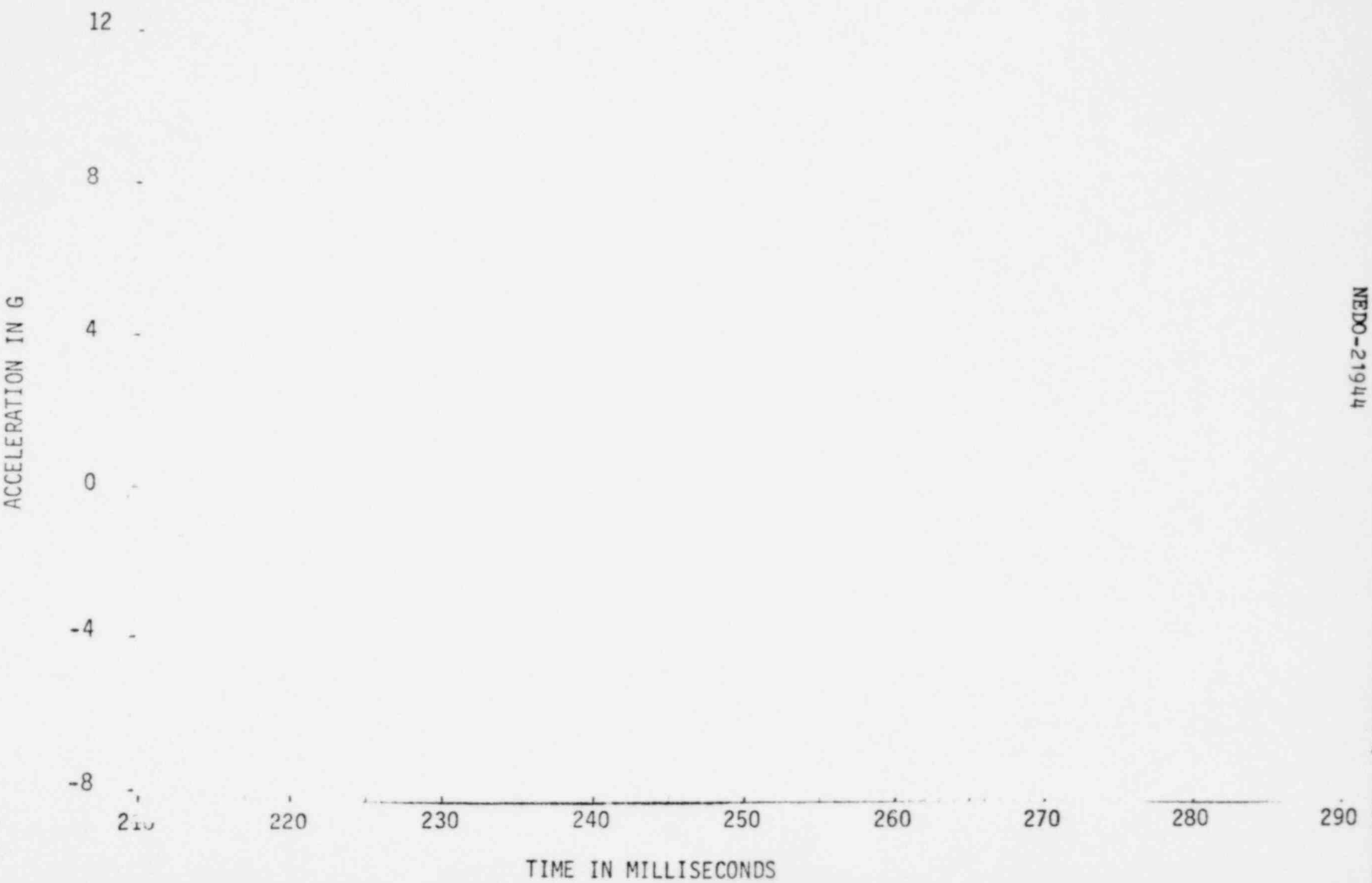


1350 148

FIGURE A-641

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Hatch 1 Test 5

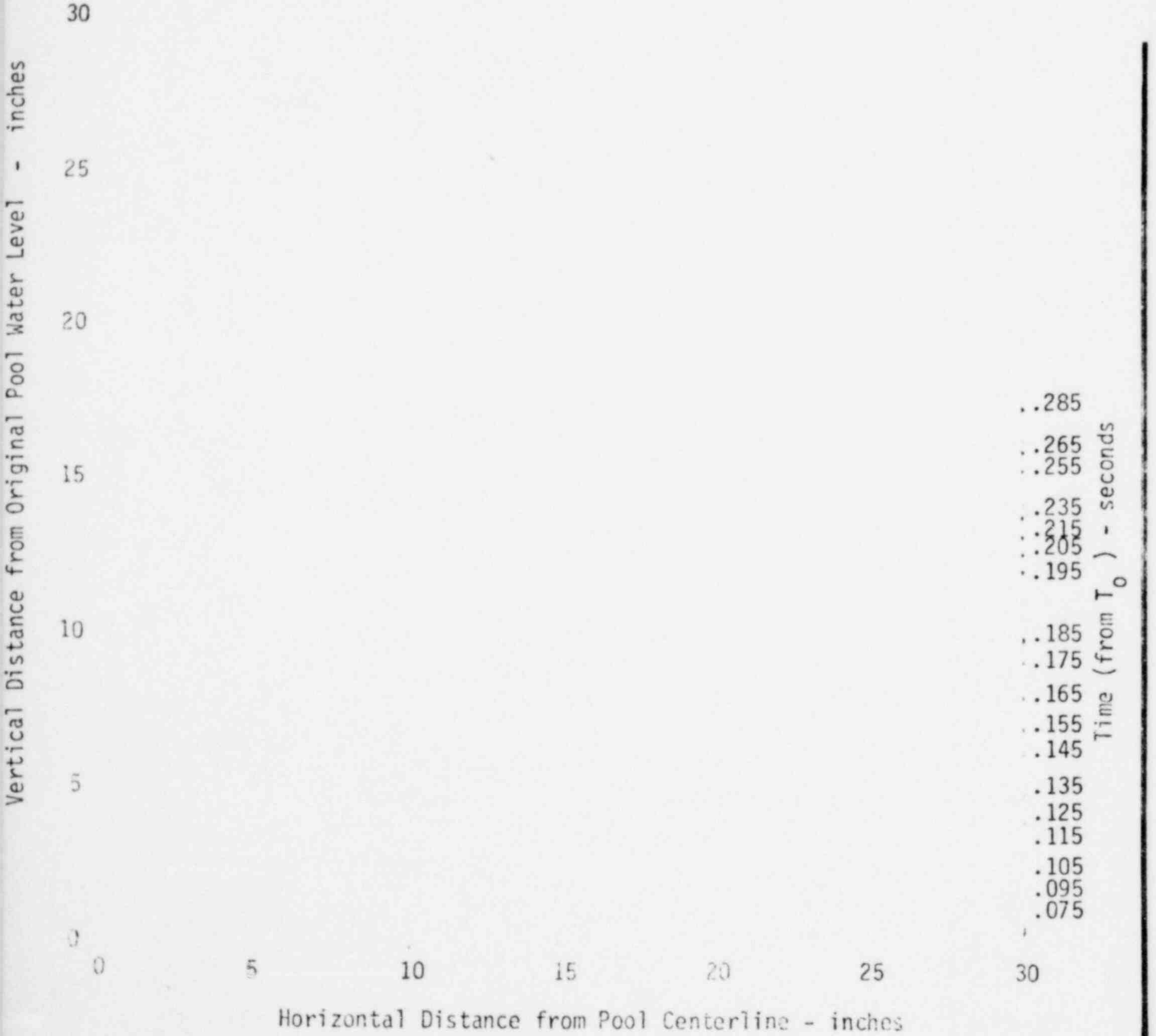


1350 149

FIGURE A-642
NEDO-21944

TIME HISTORY OF
POOL DISPLACEMENT

HATCH 1, TEST 1



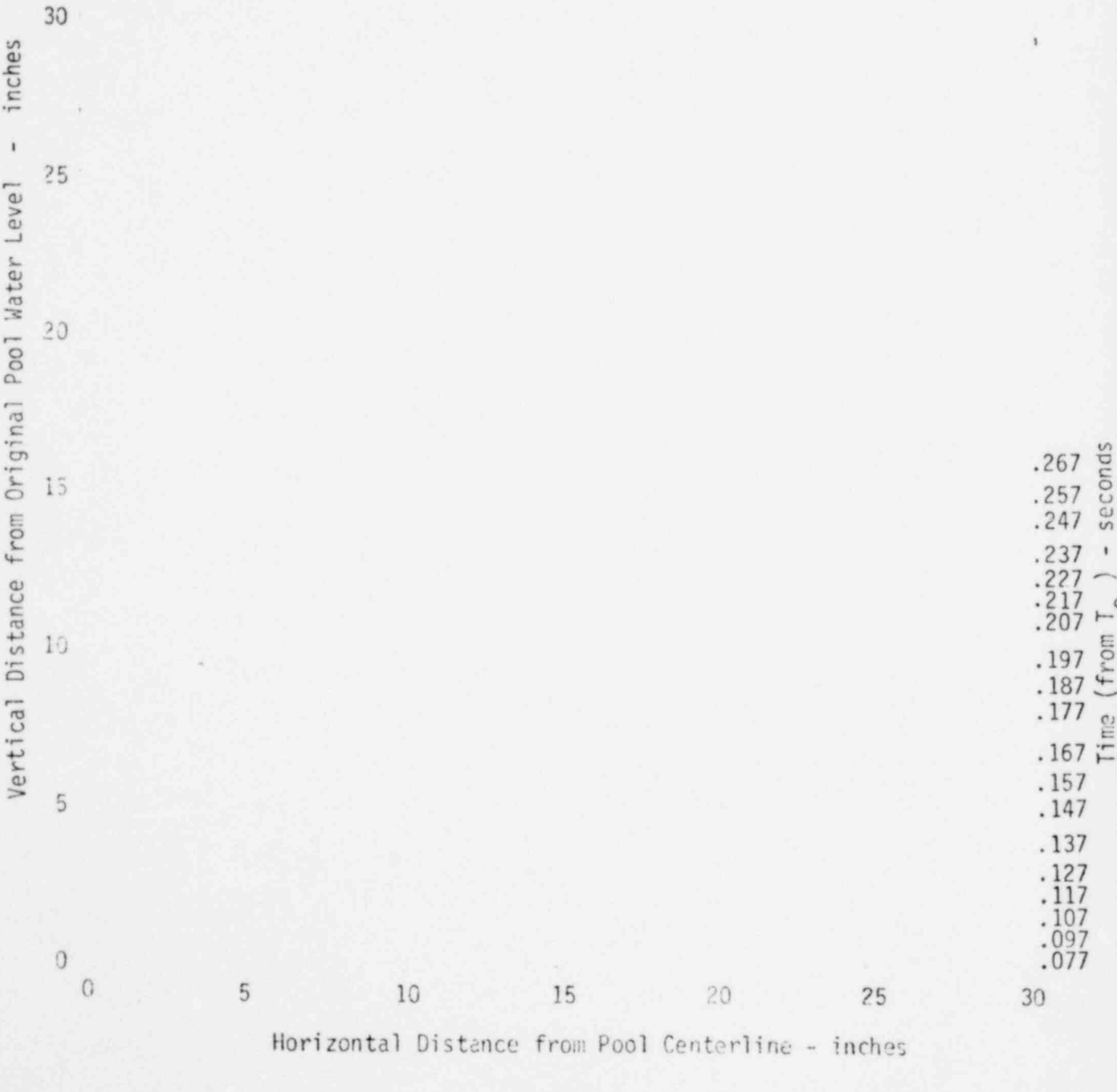
1350 150

FIGURE A-643

TIME HISTORY OF

POOL DISPLACEMENT

HATCH 1, TEST 2



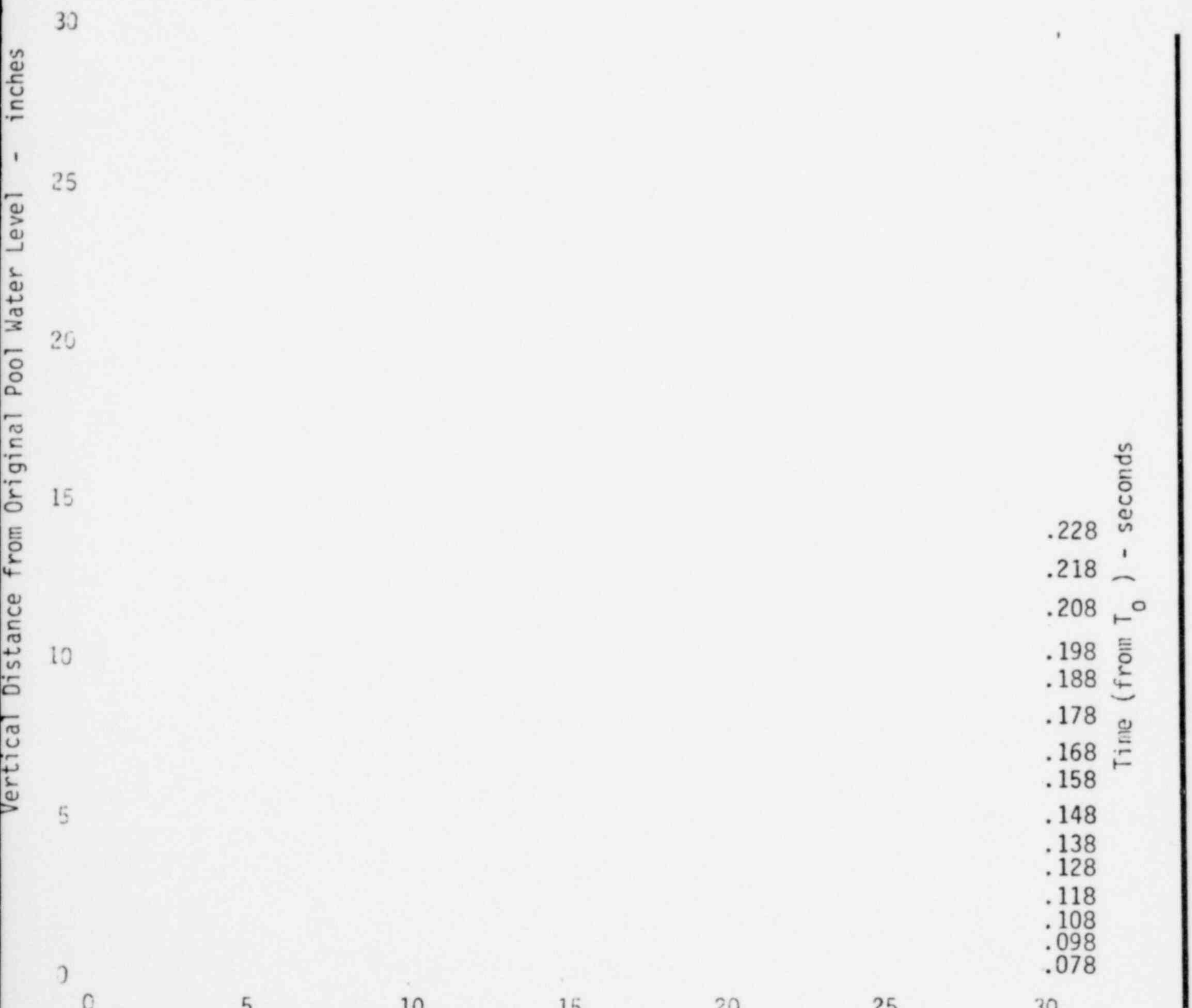
1350 151

FIGURE A-644

TIME HISTORY OF

POOL DISPLACEMENT

HATCH 1, TEST 3



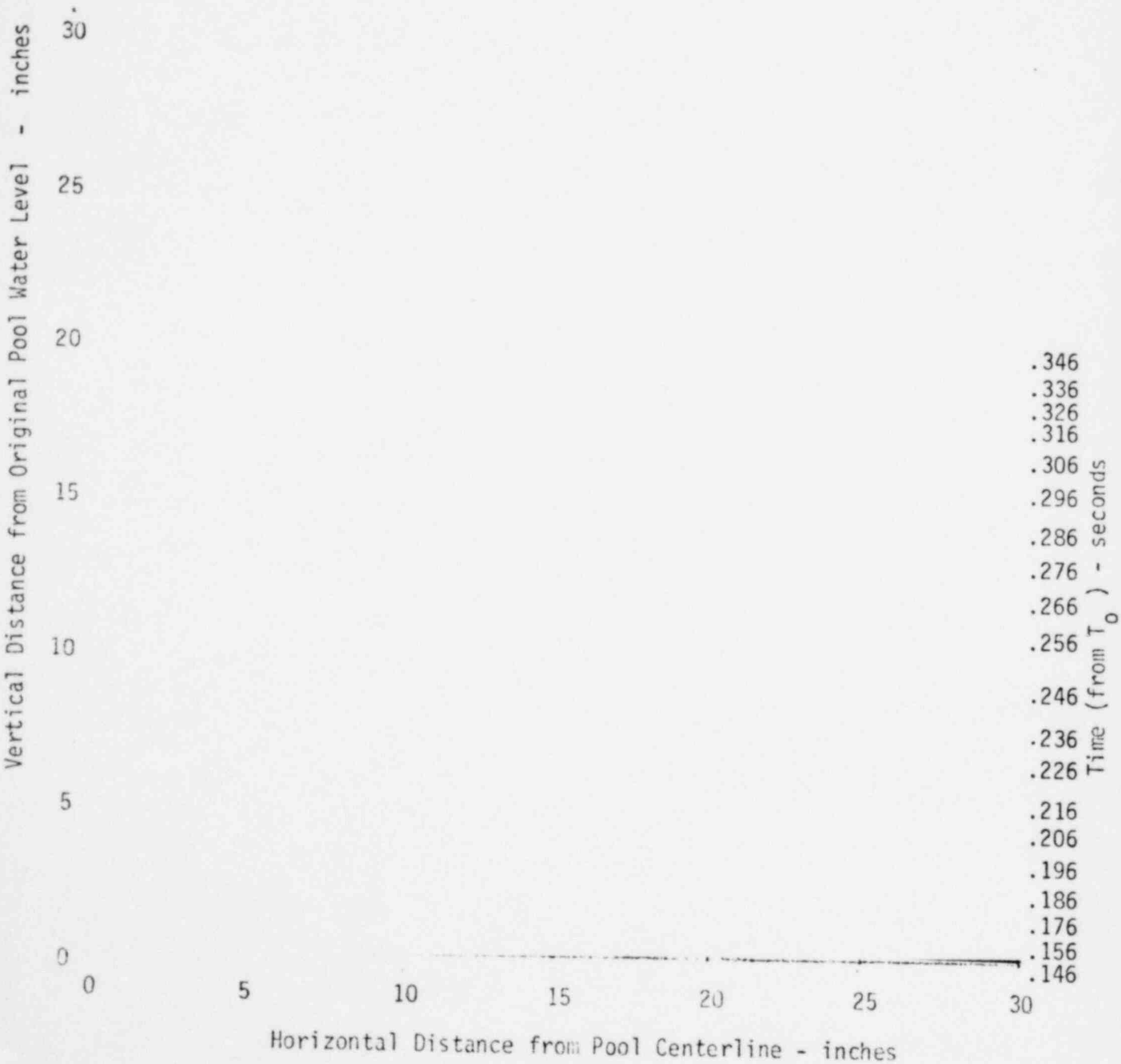
1350 152

FIGURE A-645

NEDO-21944

TIME HISTORY OF POOL DISPLACEMENT

HATCH 1, TEST 5



1350 153

POOL SURFACE DISPLACEMENT

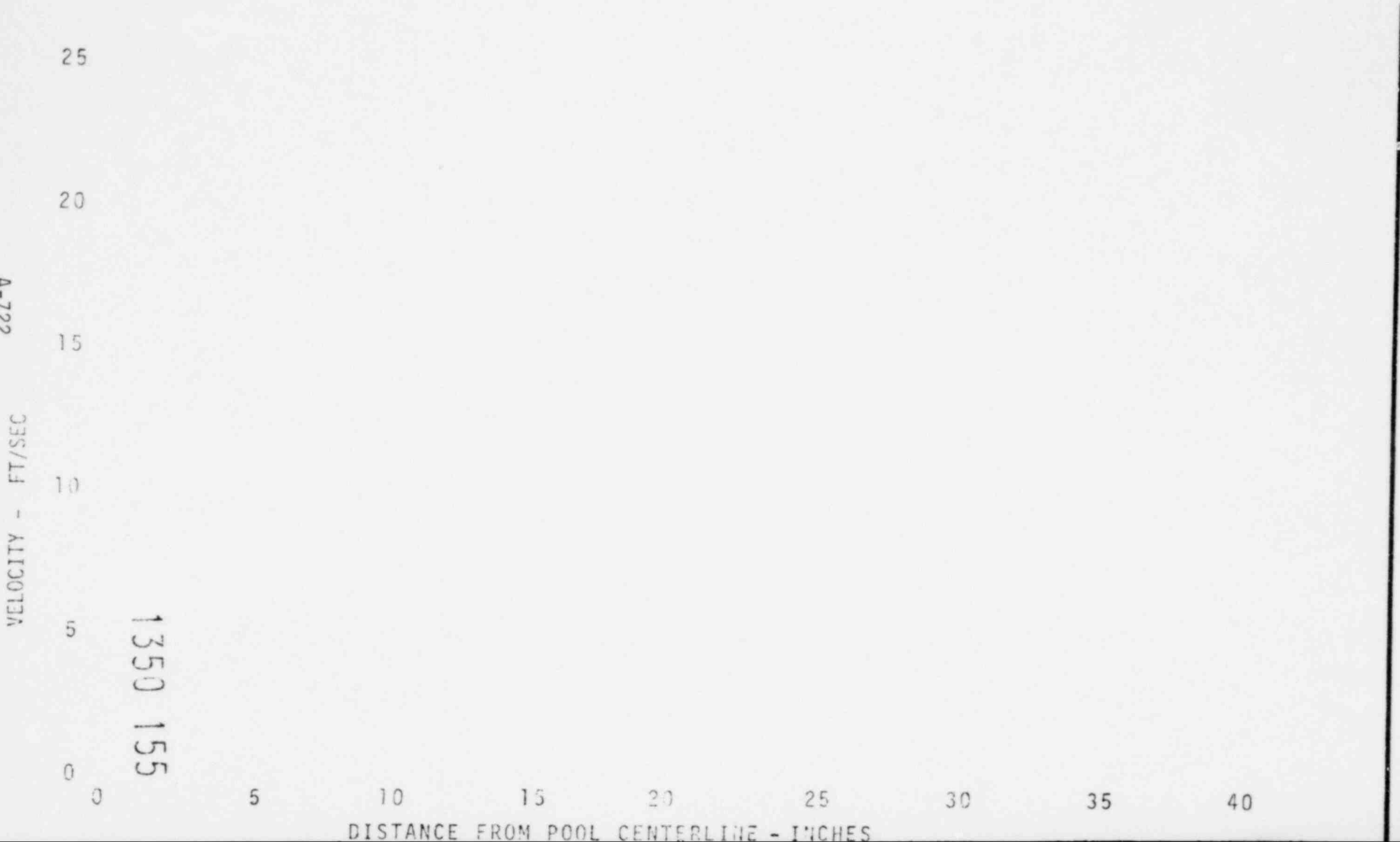
Hatch 1 Test 1, 2, 3

1350 154

FIGURE A-647

POOL SURFACE VELOCITY PROFILES

Hatch 1 Tests 1, 2, 3



1350 155

POOL SURFACE DISPLACEMENT

Hatch 1 Test 5

1350 156

FIGURE A-649

POOL SURFACE VELOCITY PROFILES

Hatch 1 Test 5

1350 157

FIGURE A-650
NEDO-21944

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

Hatch 1 Test 4

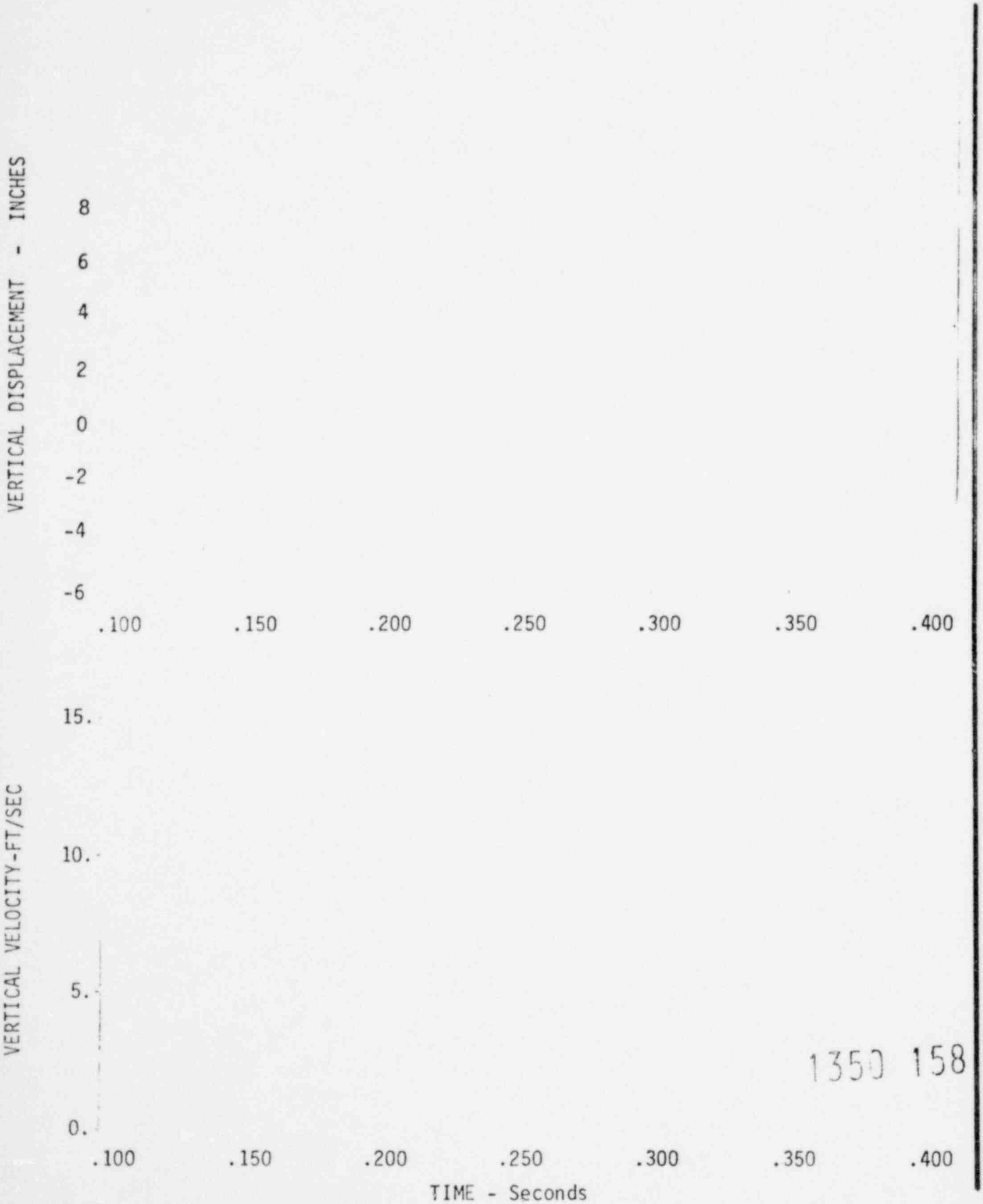
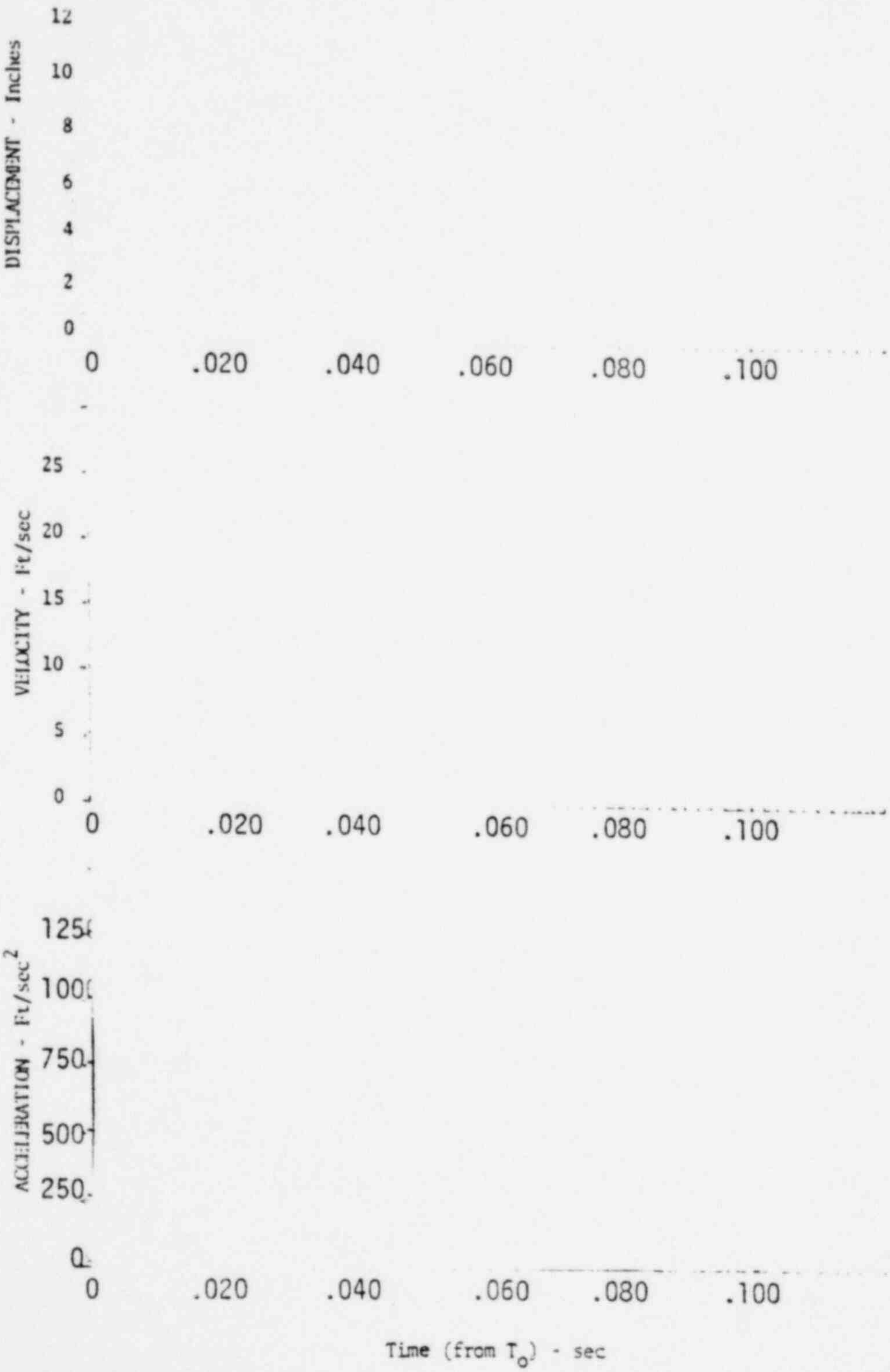


FIGURE A-651

NEDO-21944

DOWNCOMER WATER SLUG EJECTION

HATCH 1, TEST 3

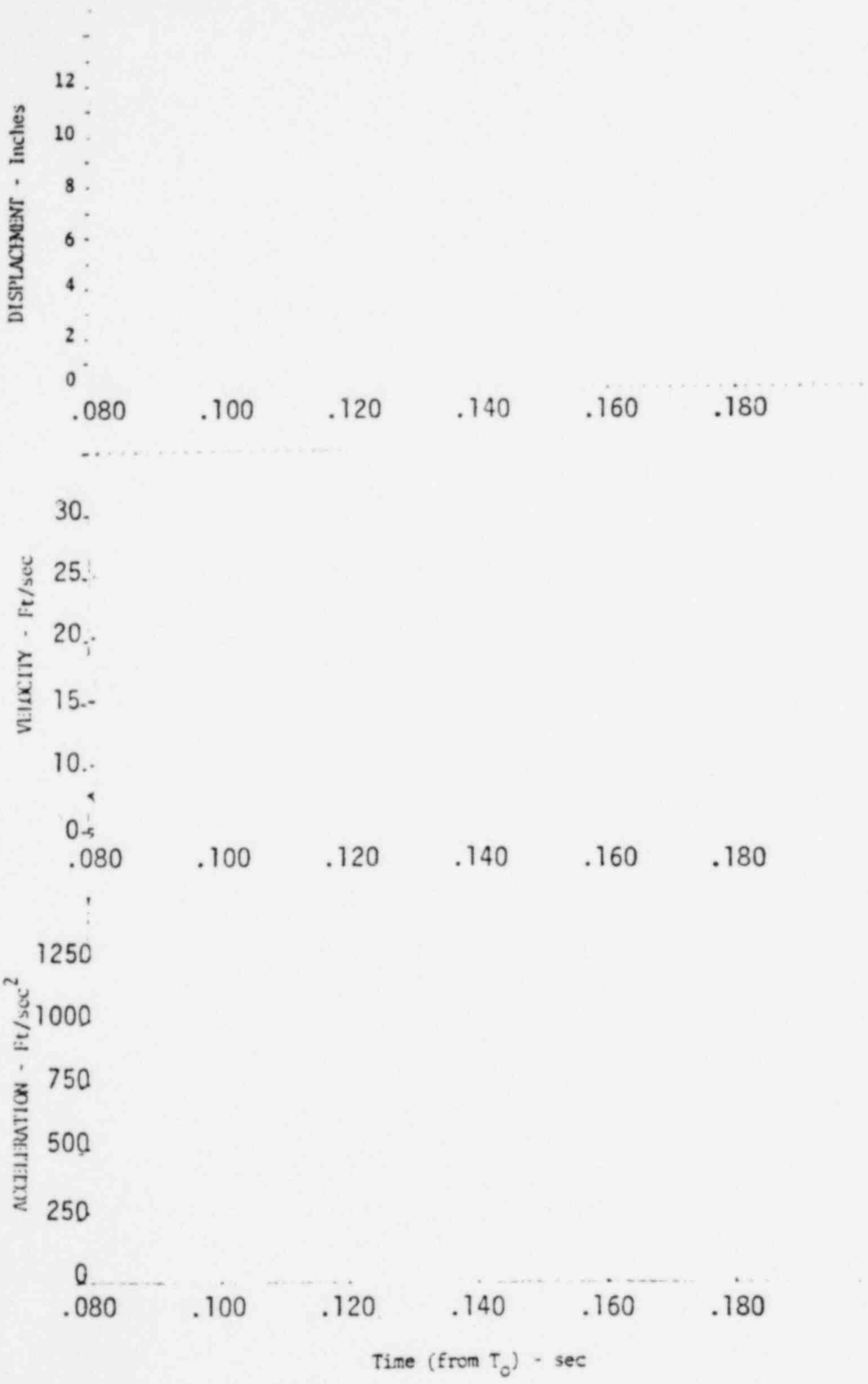


Note: Nearly Full ΔP makes measurement of the water slug ejection parameters difficult

1350 159

DOWNCOMER WATER SLUG EJECTION

HATCH 1, TEST 5



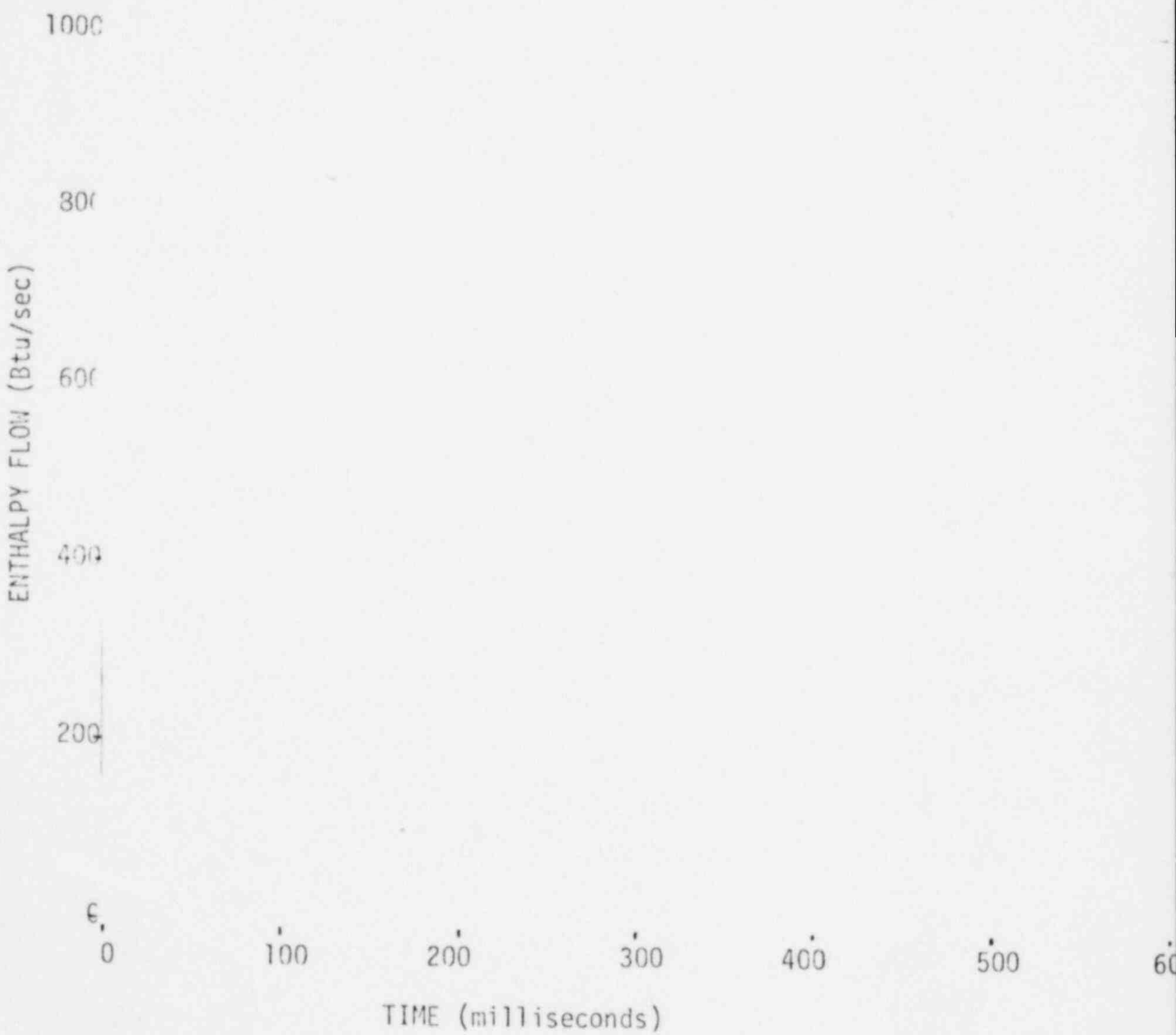
1350 160

FIGURE A-653

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Hatch 1 Tests



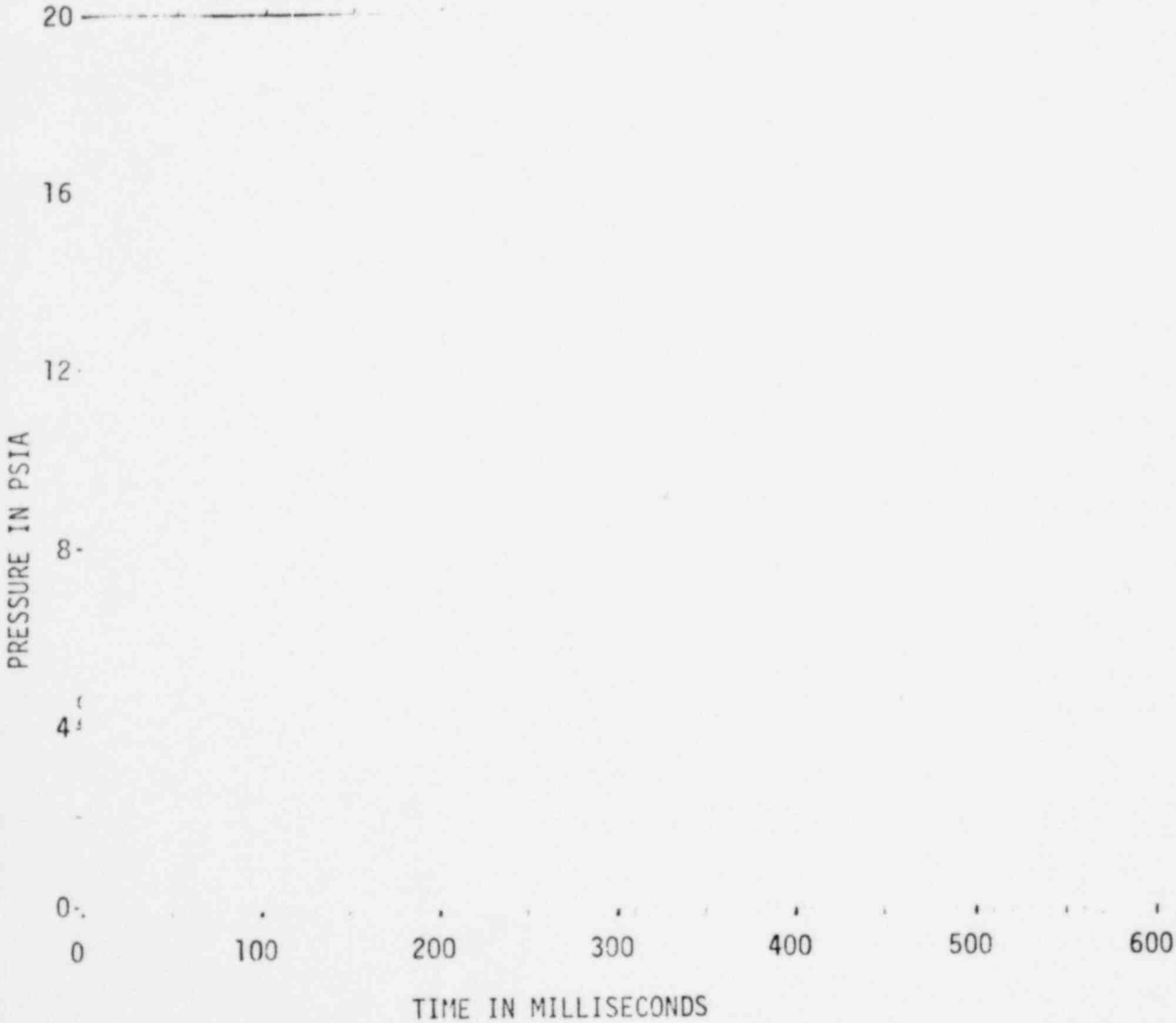
1350 161

FIGURE A-654

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Hatch 1 Tests



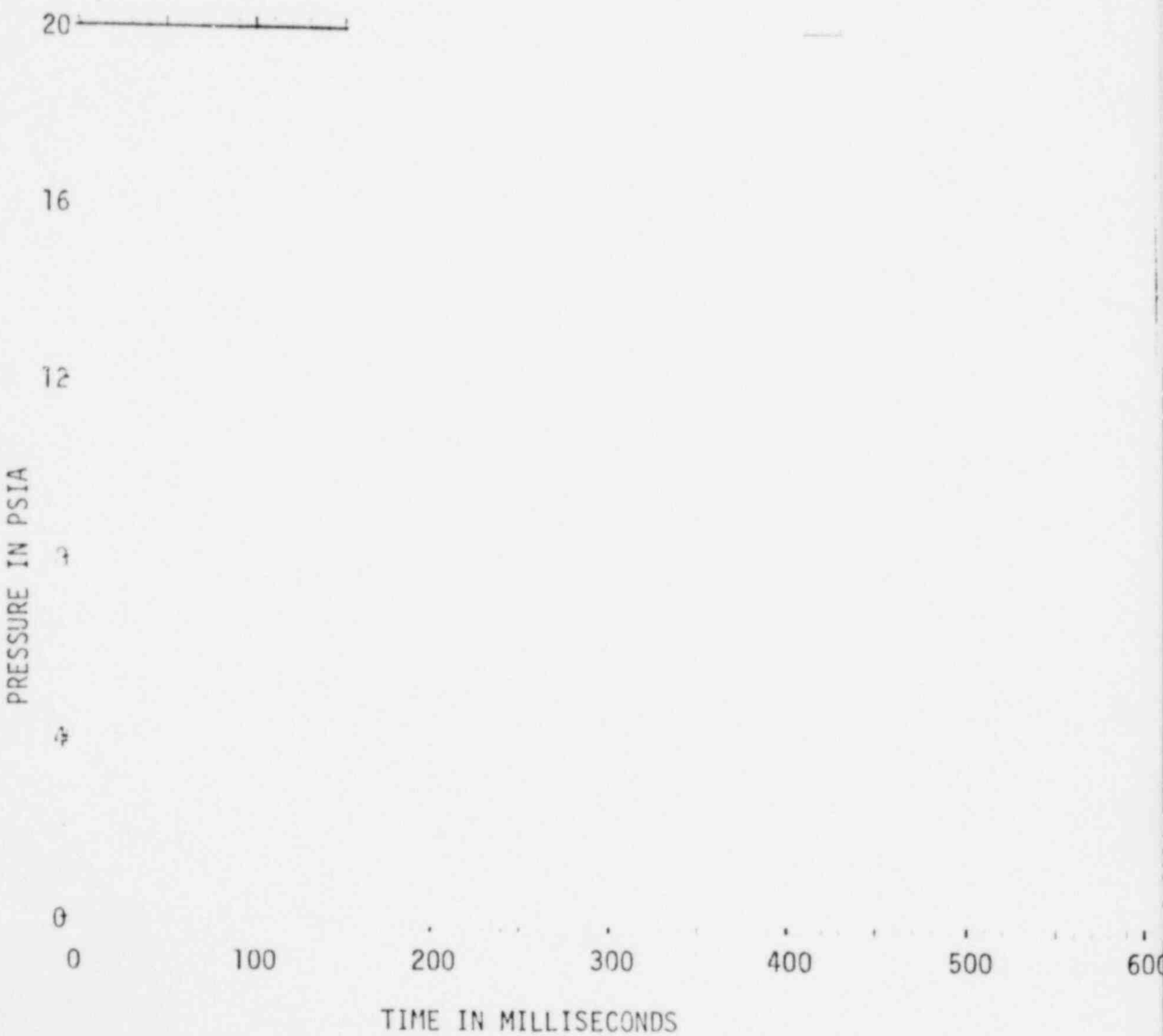
1350 162

FIGURE A-655

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Hatch 1 Tests



1350 163

TABLE A-27

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Hatch 1 Tests

Parameter \ Test No.	11.46"ΔP, 4.97" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0"ΔP (5)
T_o † (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)							

+ = Load cell failed Hatch 1, Test 4

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

† = Start of test reference time

1350 164

TABLE A-27

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Hatch 1 Tests

Parameter \ Test No.	11.46" ΔP, 4.97" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_0) (sec)							
Upforce Valley							
Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_0) (sec)							
2nd Peak Upforce							
Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Pressure Integral:							
Force (lb)							
Time (from T_0) (sec)							
Corrected Load Cell:							
Force (lb)							
Time (from T_0) (sec)							
Zero Force Time* **							
Pressure Integral (sec)							
Corrected Pressure Integral (sec)							
Corrected Load Cell (sec)							

*** = Time at force is zero (from T_0)

1350 165

TABLE A-28

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3 Hatch 1 Tests

Parameter / Test No.		11.46" ΔP, 4.97" 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.

1350 166

A.14 Vermont Yankee Tests

A.14.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Vermont Yankee Tests 3 and 5. Test 3 was a load definition test, which was conducted at a partial drywell/wetwell differential pressure of 13.2" H_2O ΔP and with a 7.21 inch winged pipe deflector (25.75 inches full-scale)*. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 7.21 inch winged pipe deflector.

A.14.1.1 Driving Conditions

Driving conditions for Vermont Yankee Test 3 are presented in Figures A-656 through A-660. Similar plots for Test 5 are shown in Figures A-661 through A-665. Vermont Yankee driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.14.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Vermont Yankee, Tests 3 and 5 are presented in Figures A-666 through A-667 and A-668 through A-669, respectively. Net torus force from the pressure integral (Figures A-670 and A-671) shows relatively smooth upforce. Some downforce oscillatons are present in Test 3, but they dampen out rapidly before peak downforce. Test 5 experienced the one-cycle downforce oscillation which is attributable to vent clearing. (Refer to Section 4.4.2 of this report for a detailed discussion of this phenomenon.) Net torus force that is determined from the load cell (Figures A-672 and A-674) by applying inertial correction with the torus accelerometer (Figures A-673 and A-675) is shown in Figures A-676 and A-677 and compared to net torus force

*Winged pipe deflector is a pipe with structural angles.

1350 167

determined from the pressure integral. Figures A-678 and A-679 present the net torus force based on the torus pressure integral, corrected for inertia.

The "average" pool pressures for Vermont Yankee Tests 3 and 5 are shown in Figures A-680 and A-682. Figures A-681 and A-683 are the same as Figures A-678 and A-679 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Vermont Yankee Test 3 are presented in Figures A-684 through A-688. Vent header pressures for Test 5 are presented in Figures A-689 through A-693. These figures indicate that the deflector was very effective in mitigating the vent header impact. The vent header impact forces from the pressure integral and the corrected load cell are both small and agree reasonably well (Figure A-694). Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-695 and A-696, respectively.

A.14.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-697 through A-700 for Vermont Yankee, Tests 1, 2, 3, and 5. Pool surface displacement curves are shown in Figures A-701 and A-703. The pool surface velocity profiles are shown in Figures A-702 and A-704.

The pool surface displacement and velocity profile viewed from the side window during Test 4 are shown in Figure A-705. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are shown in Figures A-706 and A-707, respectively.

A.14.3 Data Summaries

Table A-29 presents the Vermont Yankee test data for wetwell vertical forces.

Table A-30 presents the Vermont Yankee test data for vent header impact forces.

A.14.4 Discussion and Analysis

Figure A-708 presents the effect of drywell/wetwell ΔP on the enthalpy flow into the bubbles. The effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-709. Figure A-710 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. This data for Vermont Yankee parallels that for the "typical" plant in Section 3.0.

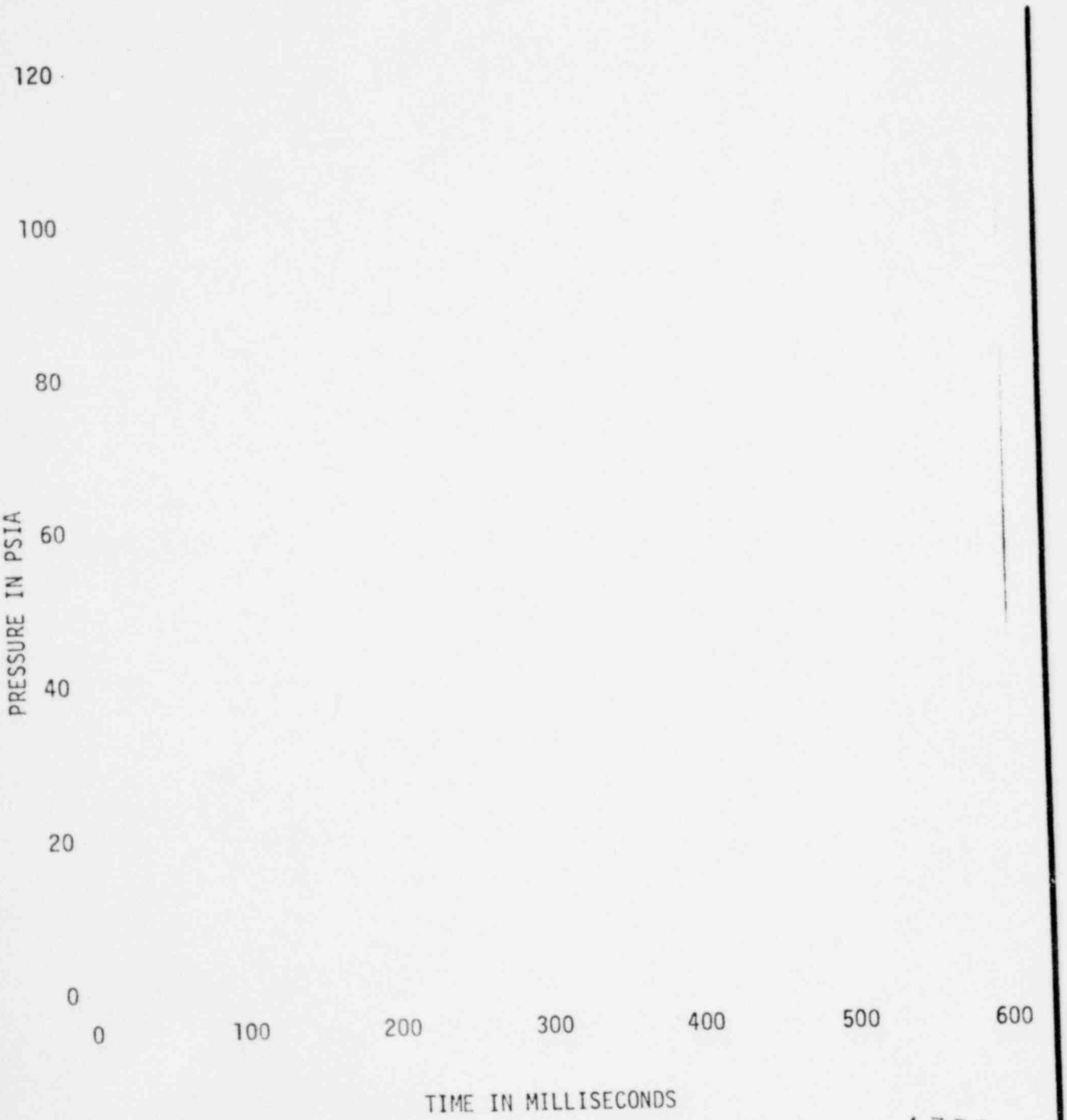
The Vermont Yankee load definition tests were conducted at 13.2" H_2O ΔP with a 7.21 inch winged pipe deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. Both the downforce and upforce were relatively smooth. The deflector (25.75" full-scale) effectively reduced vent header impact force.

1350 169

FIGURE A-656

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Vermont Yankee Test 3

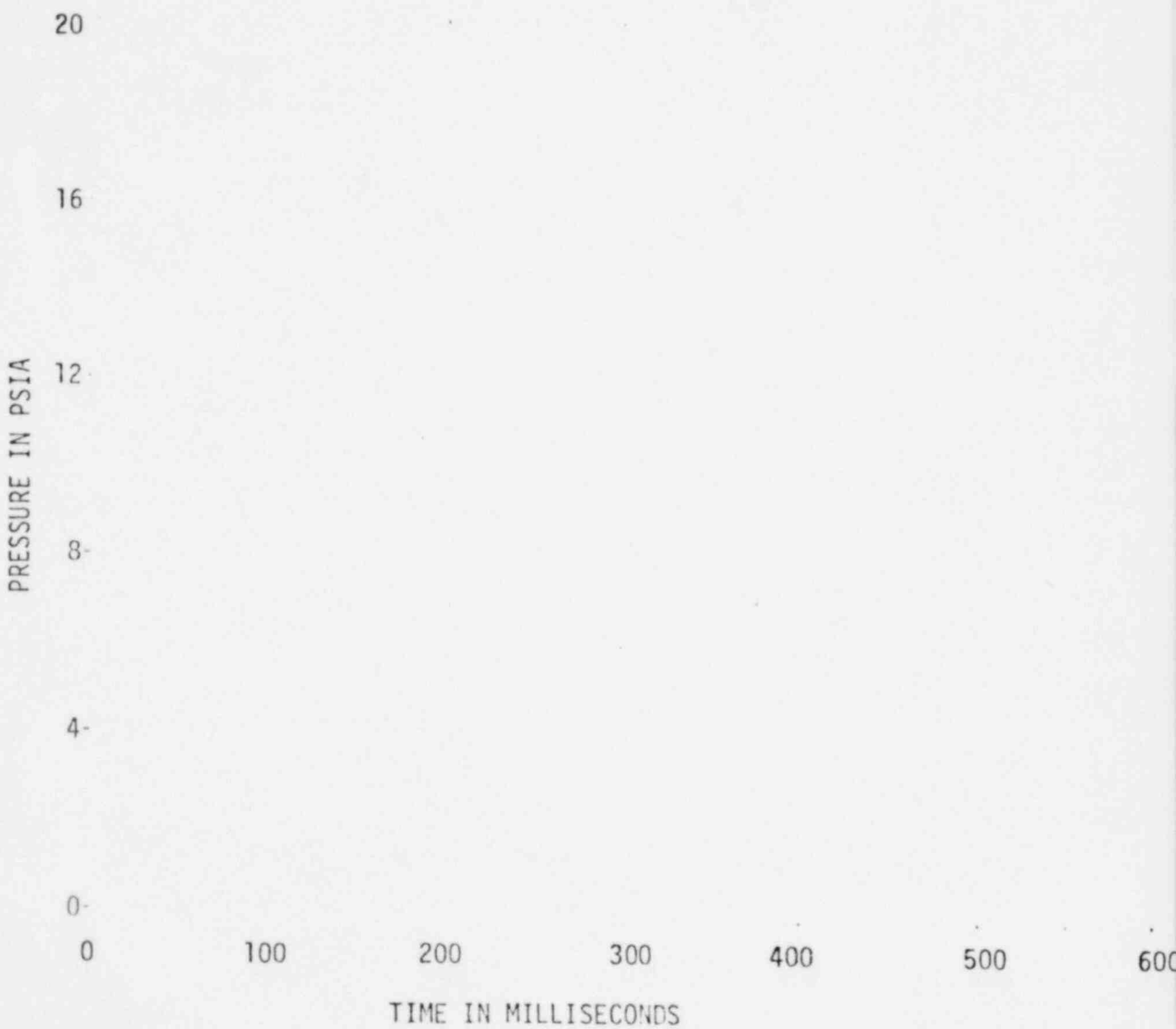


1350 170

FIGURE A-657

DRYWELL PRESSURE

Task 5.5.3 Vermont .ankee Test 3

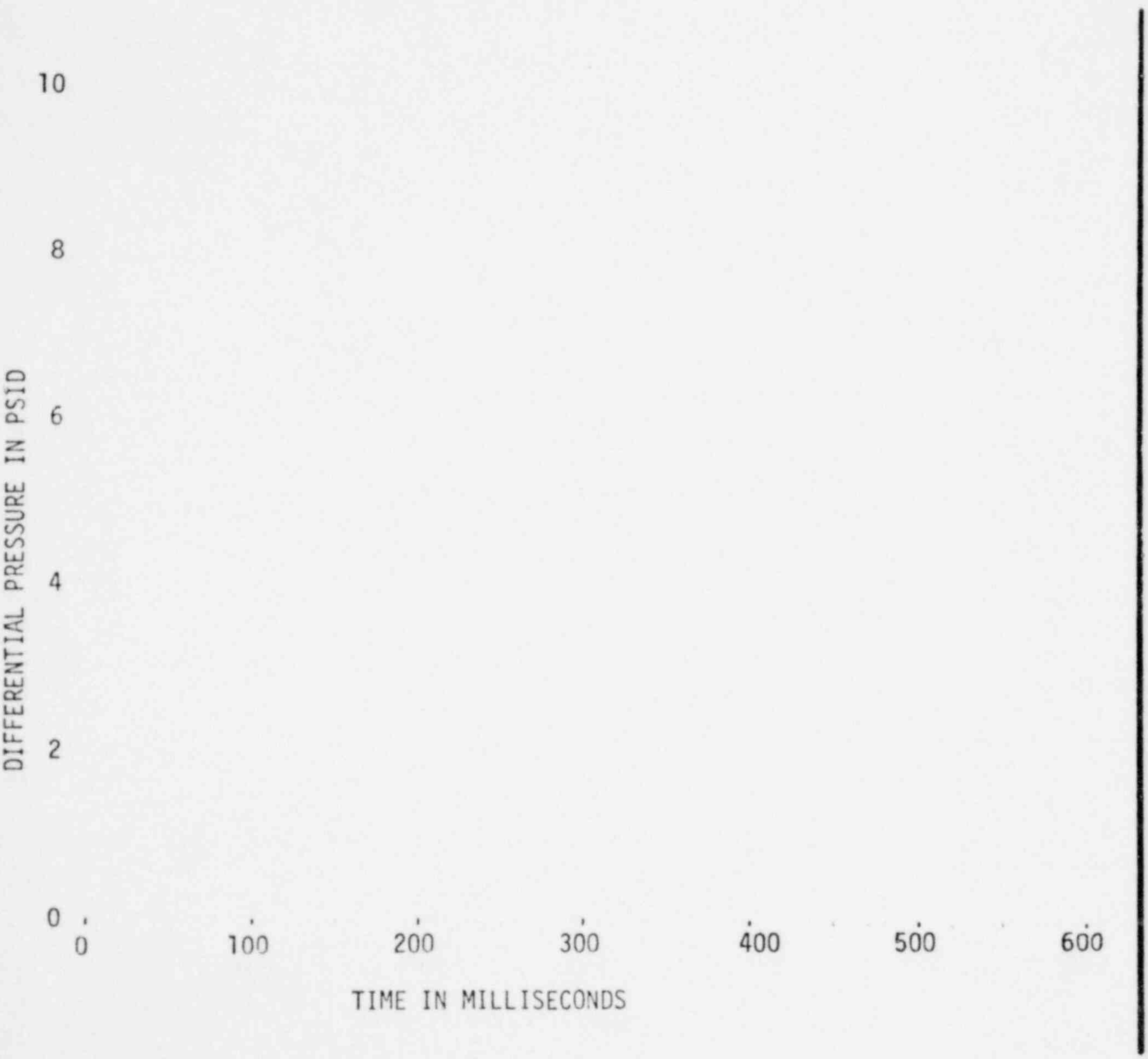


1350 171

FIGURE A-658

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 · Vermont Yankee Test 3

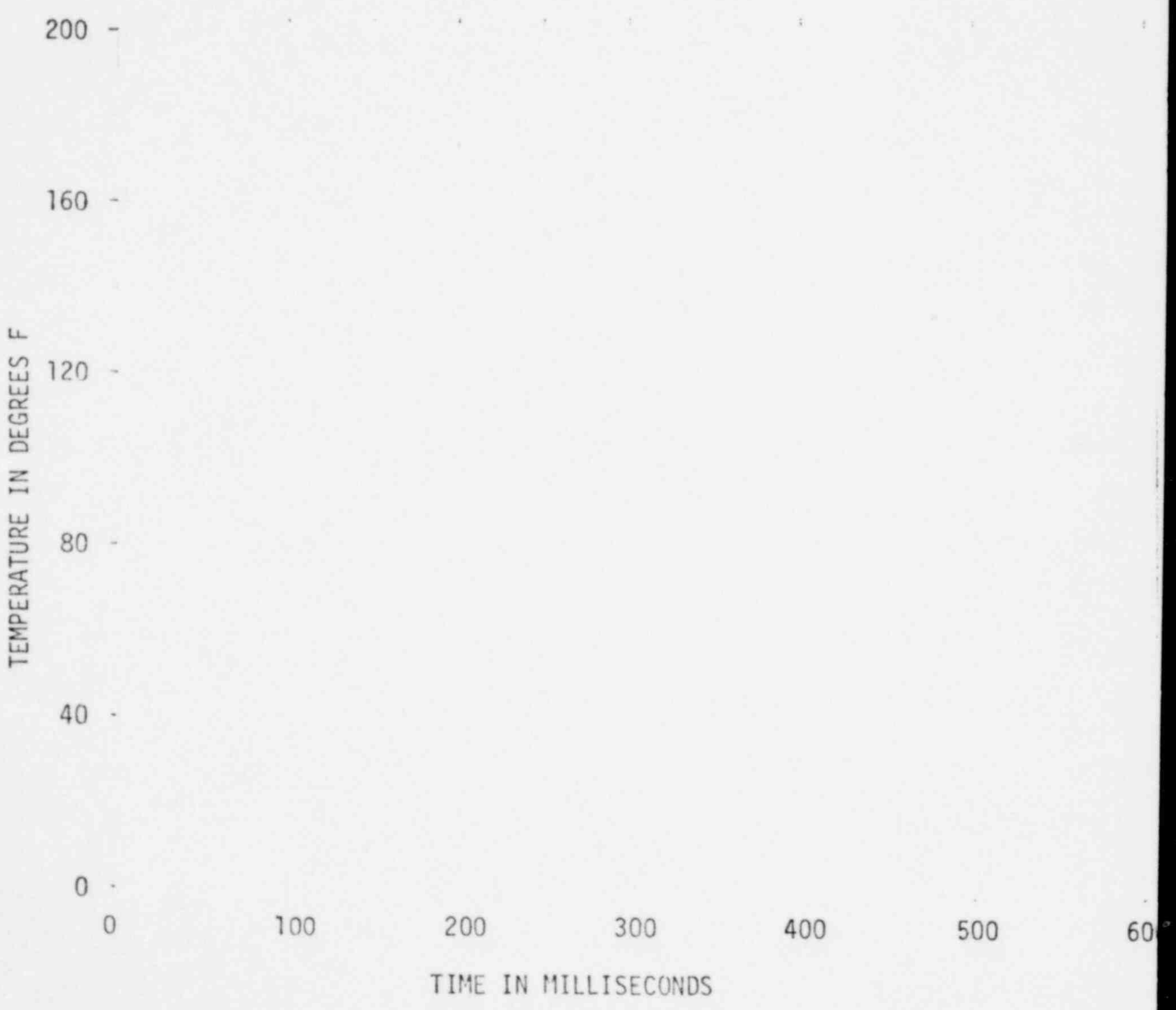


1350 172

FIGURE A-659

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Vermont Yankee Test 3

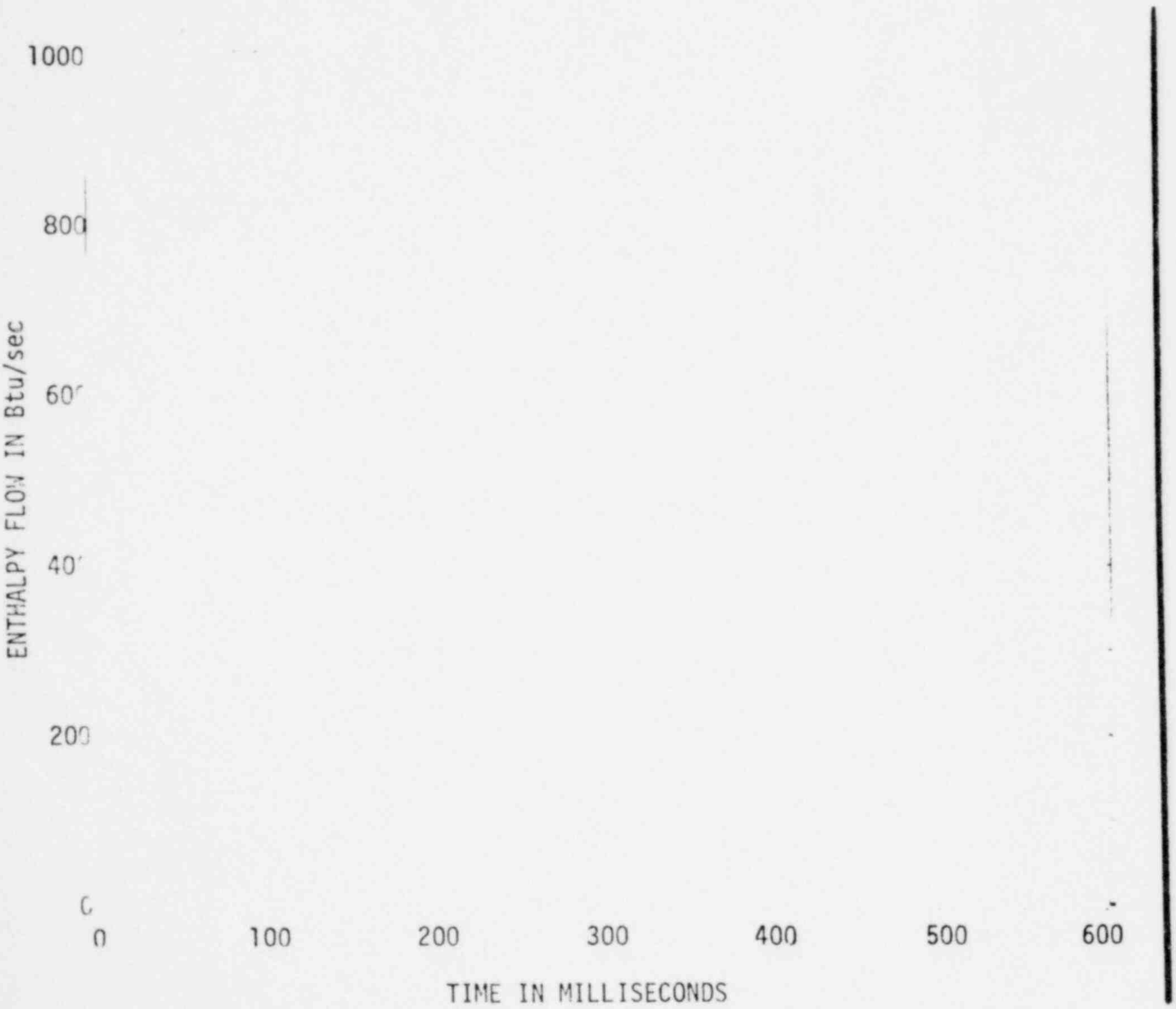


1350 173

FIGURE A-660

ENTHALPY FLOW INTO POOL

Task 5.5.3 Vermont Yankee Test 3

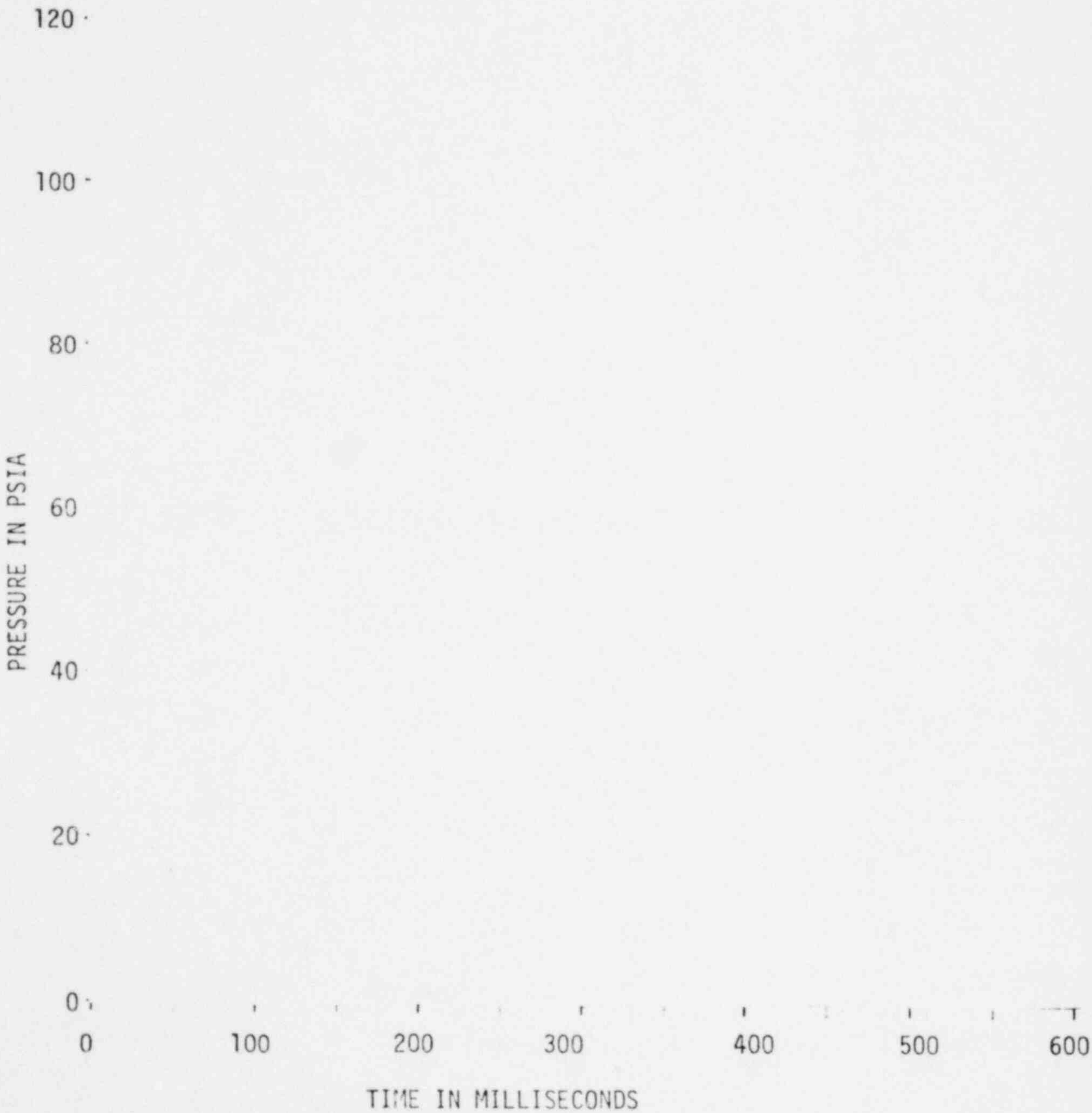


1350 174

FIGURE A-661

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Vermont Yankee Test 5

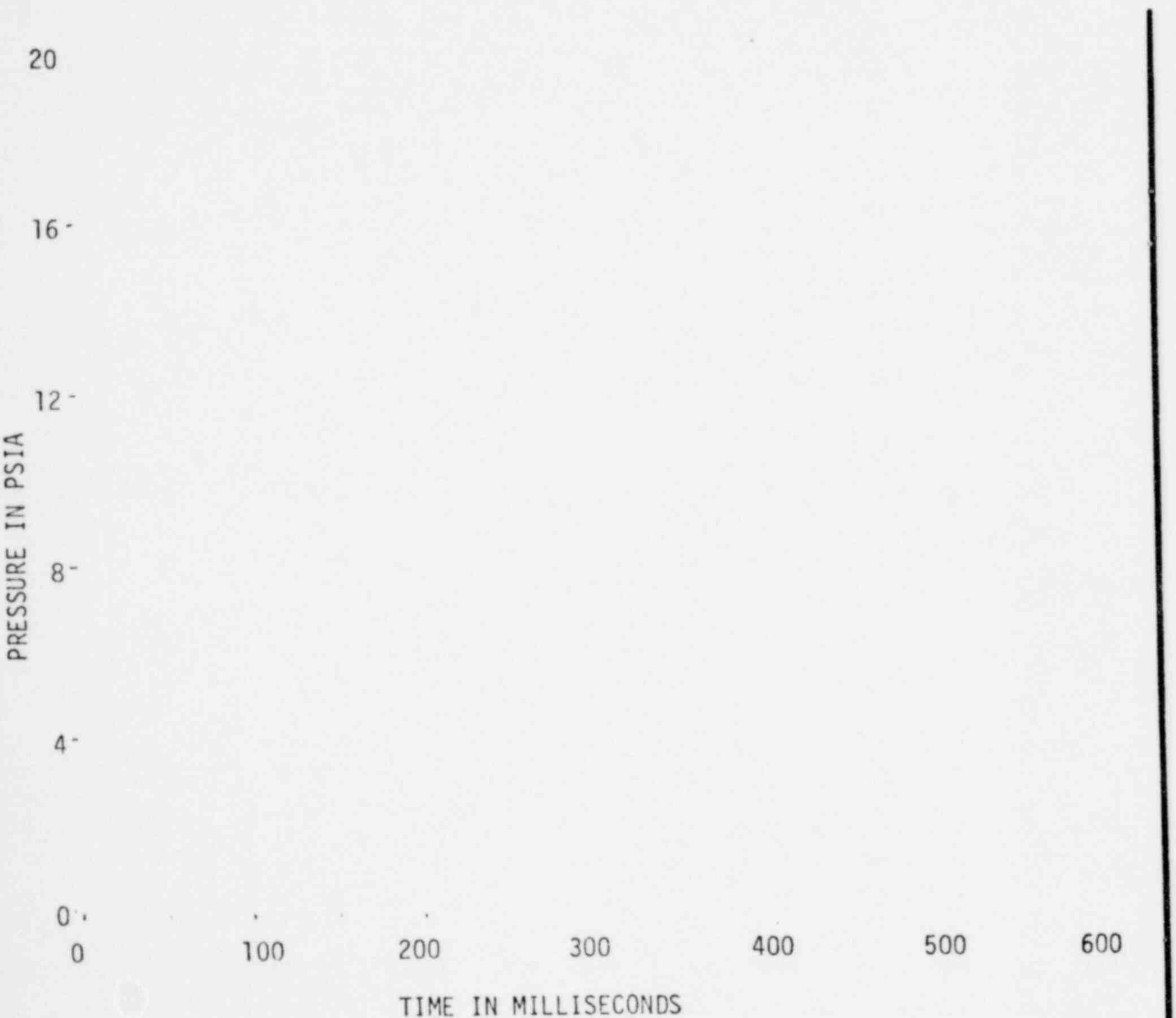


1350 175

FIGURE A-662

DRYWELL PRESSURE

Task 5.5.3 Vermont Yankee Test 5

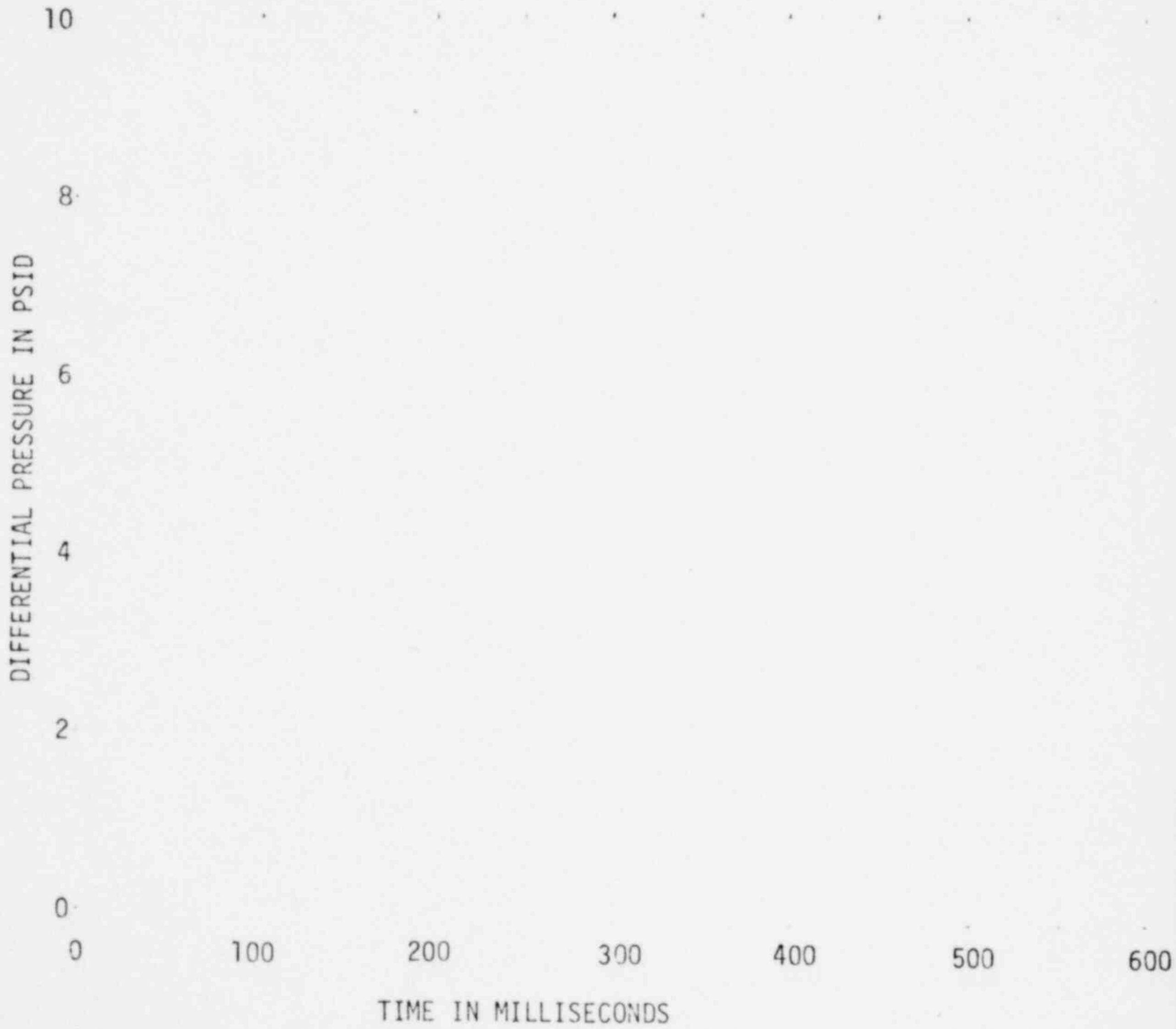


1350 176

FIGURE A-663

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Vermont Yankee Test 5

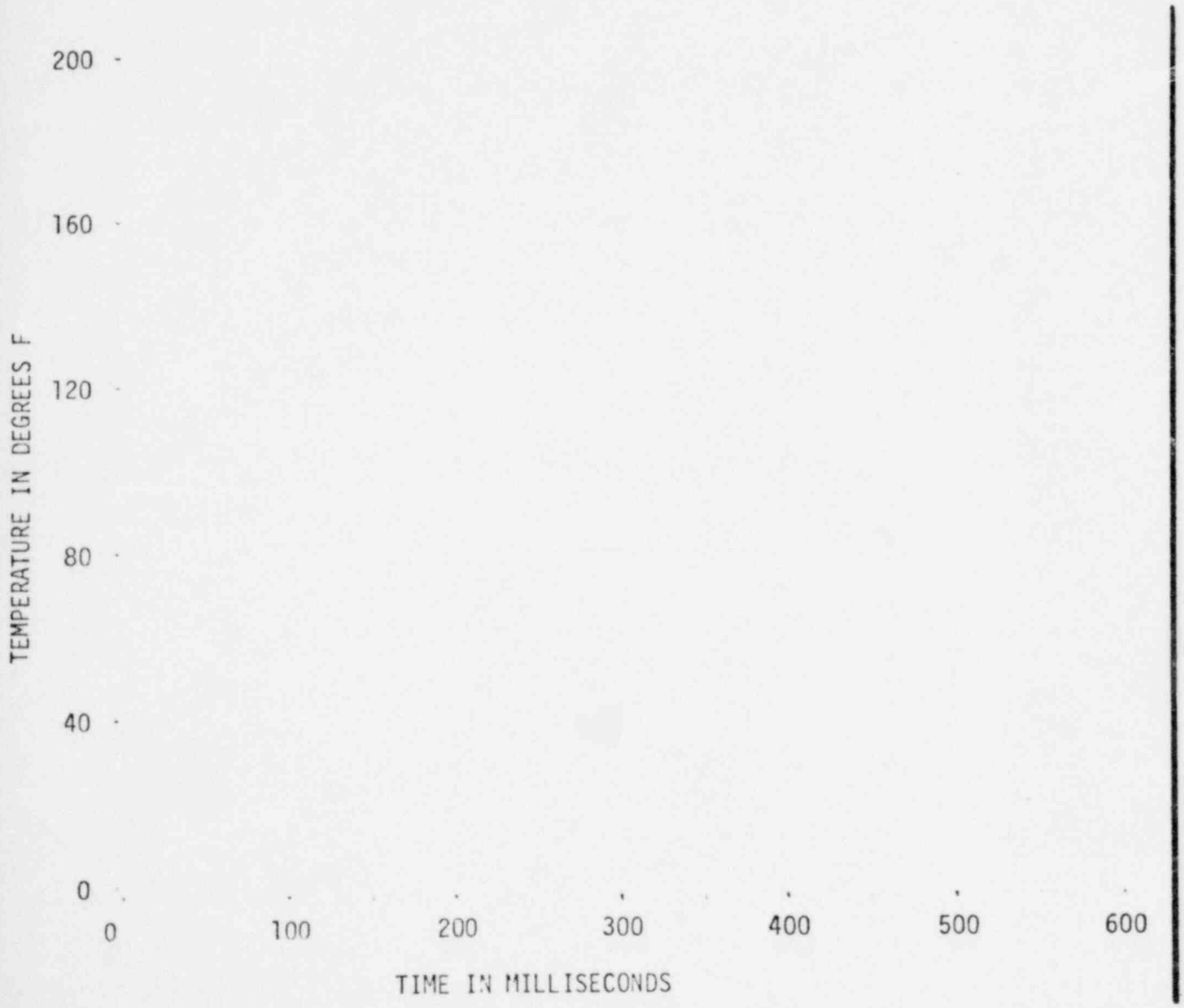


1350 177

FIGURE A-664

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Vermont Yankee Test 5



1350 178

FIGURE A-665

ENTHALPY FLOW INTO POOL

Task 5.5.3 Vermont Yankee Test 5

ENTHALPY FLOW IN Btu/sec

1000

800

600

400

200

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1350 17

FIGURE A-666

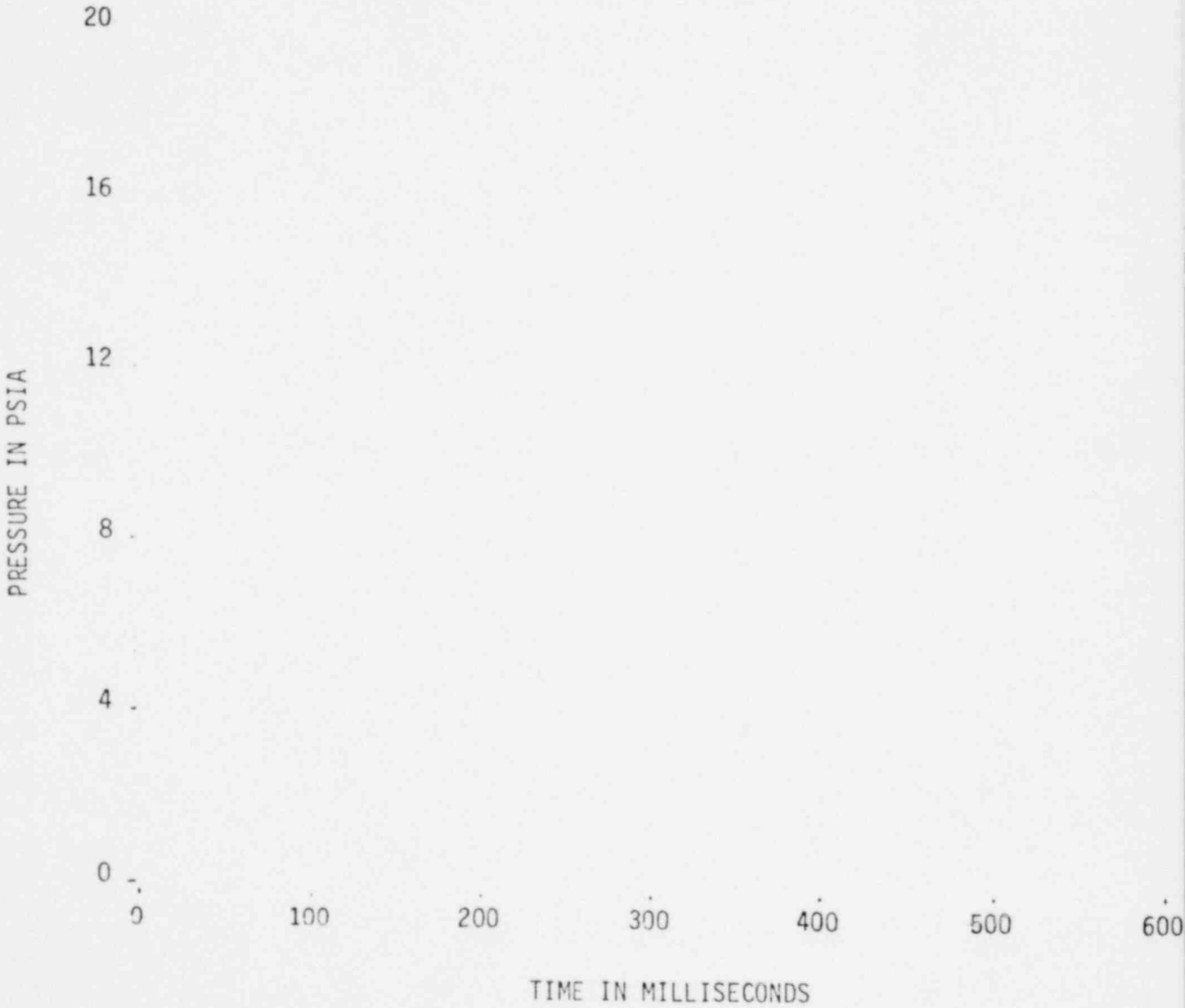
DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Vermont Yankee Test 3

1350 180

FIGURE A-667
NEDO-21944
WETWELL PRESSURES

Task 5.5.3 Vermont Yankee Test 3

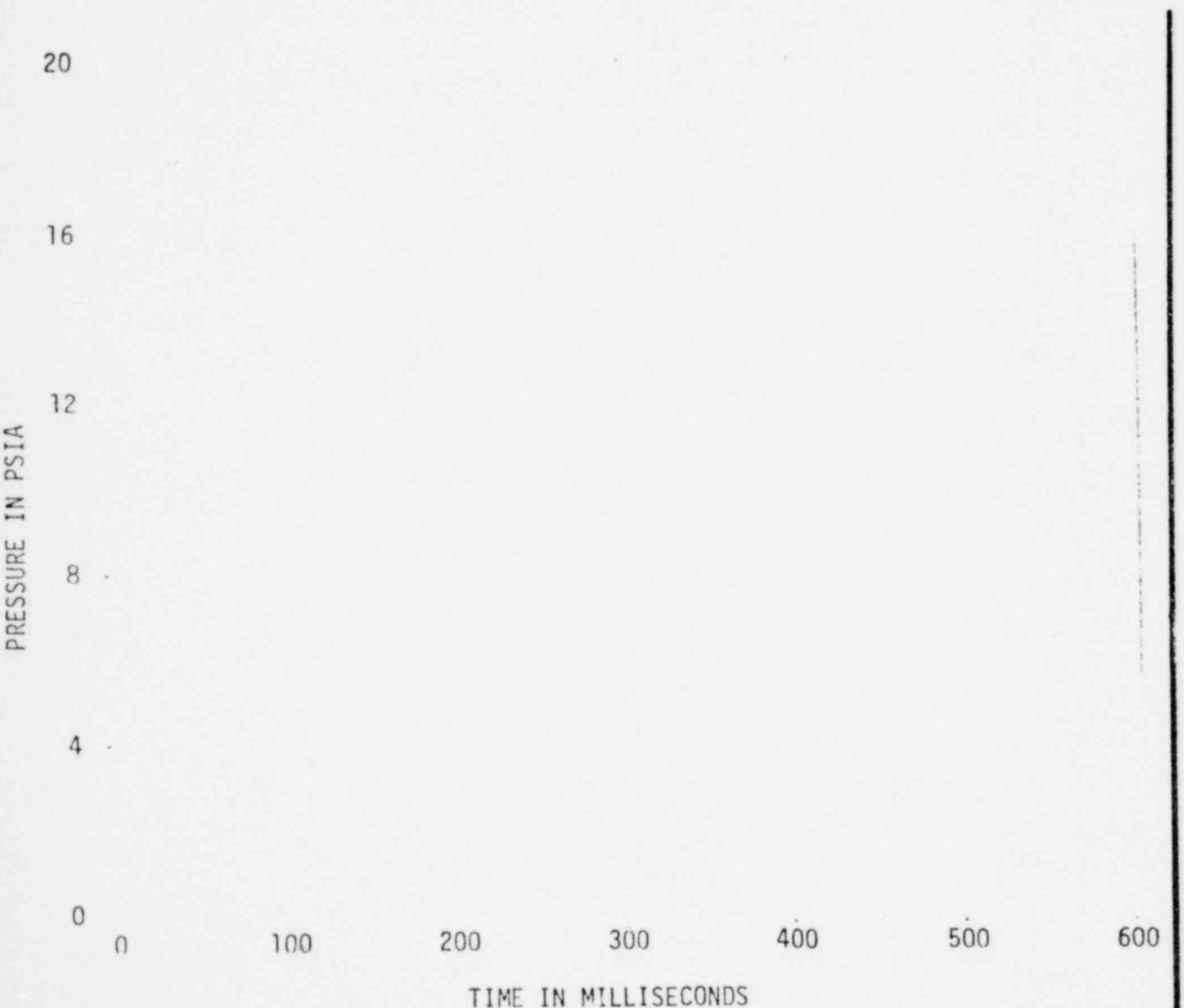


1350 18

FIGURE A-668

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Vermont Yankee Test 5



1350 182

FIGURE A-669
NEDO-21944
WETWELL PRESSURES

Task 5.5.3 Vermont Yankee Test 5

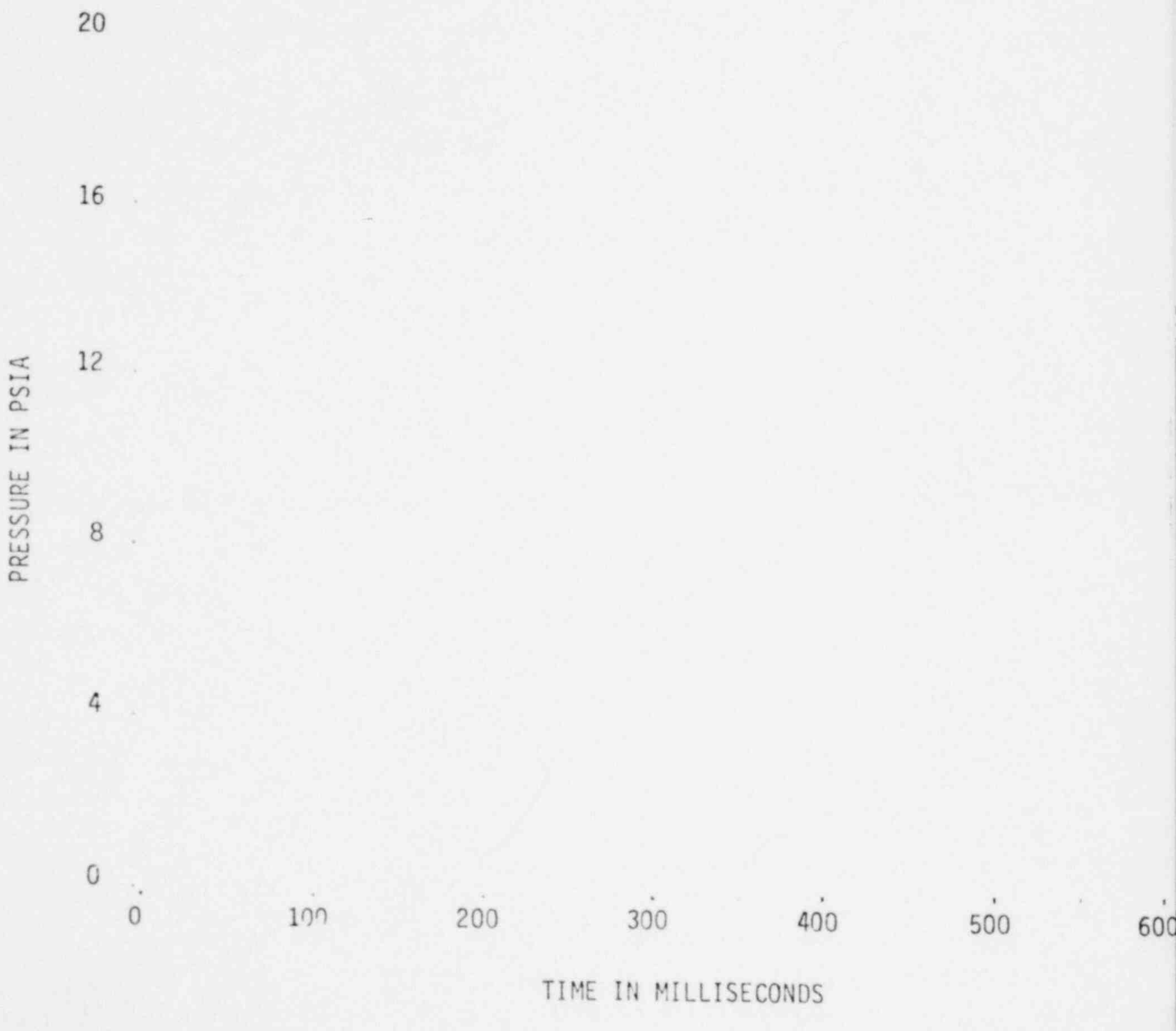
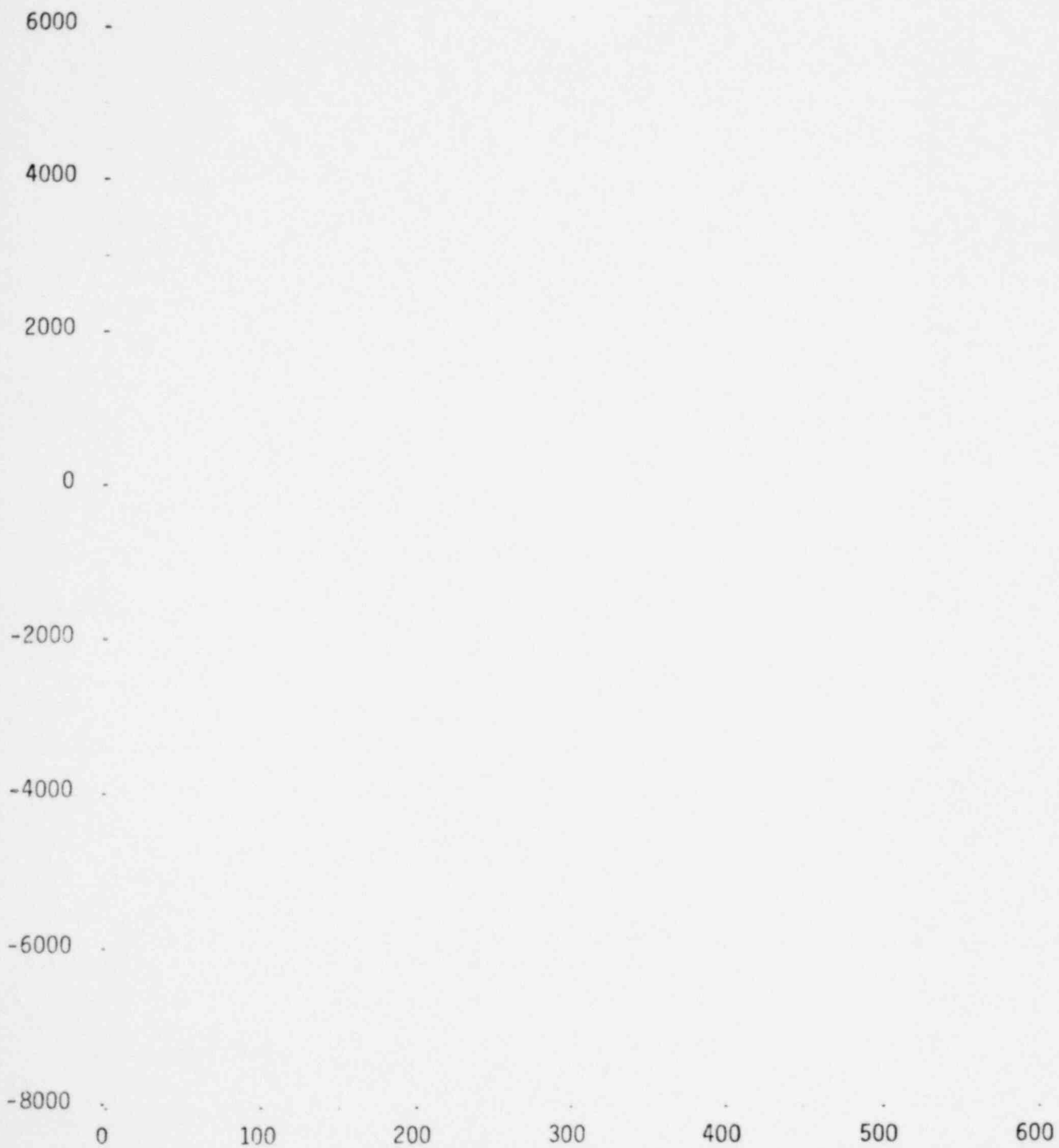


FIGURE A-670

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Vermont Yankee Test 3



1350 184

FIGURE A-671

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Vermont Yankee Test 5

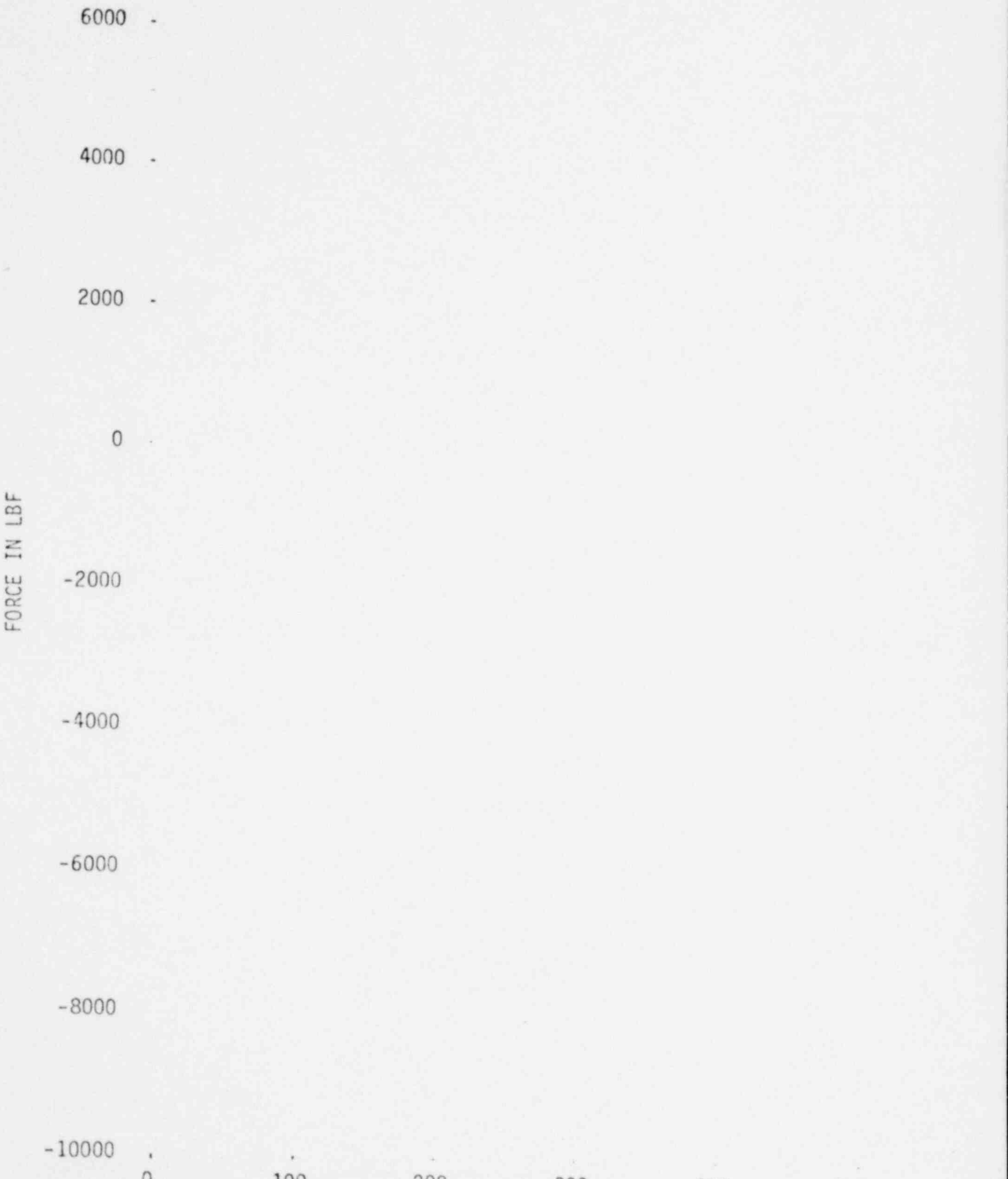
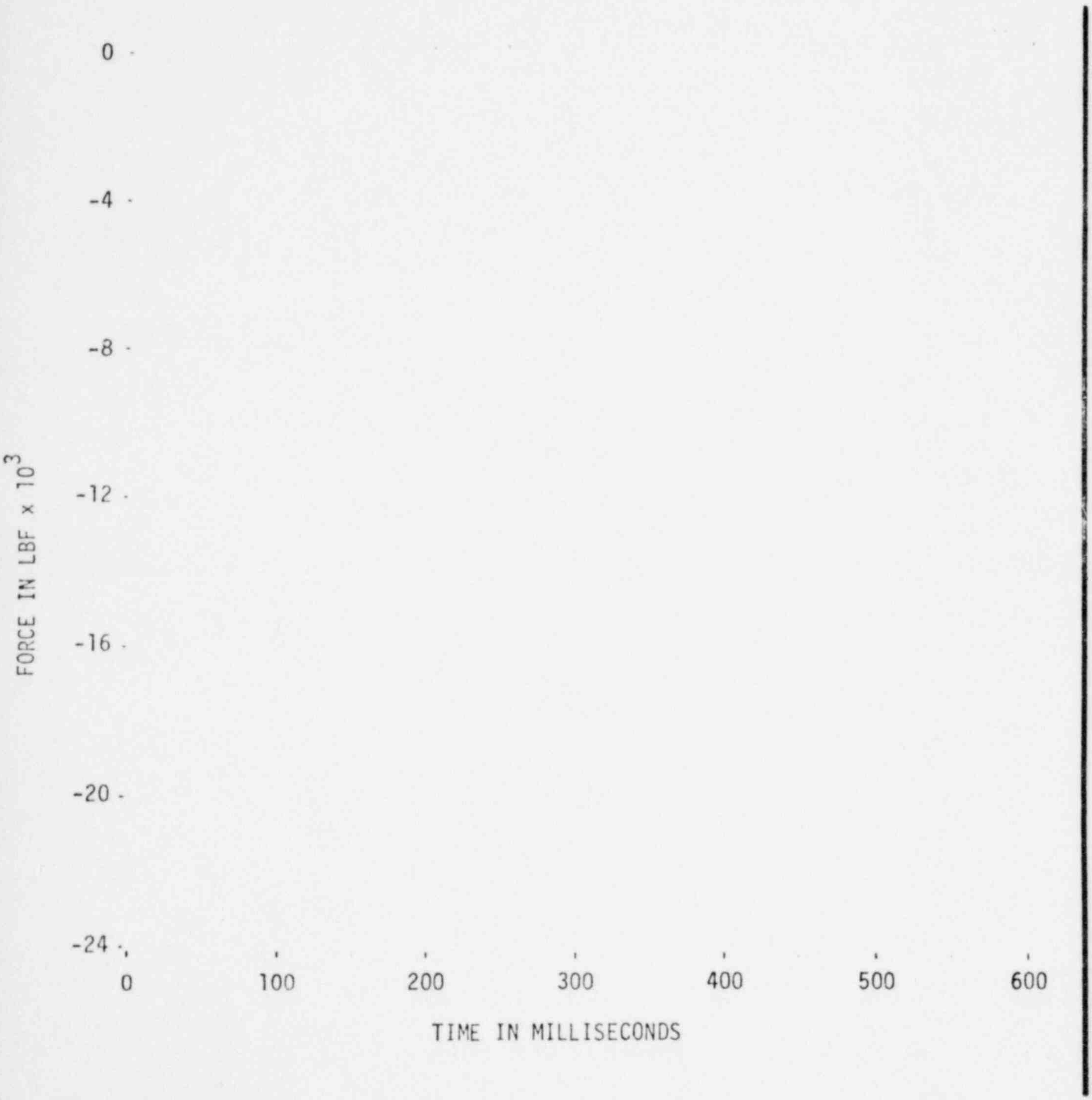


FIGURE A-672

TORUS LOAD CELL

Task 5.5.3 Vermont Yankee Test 3

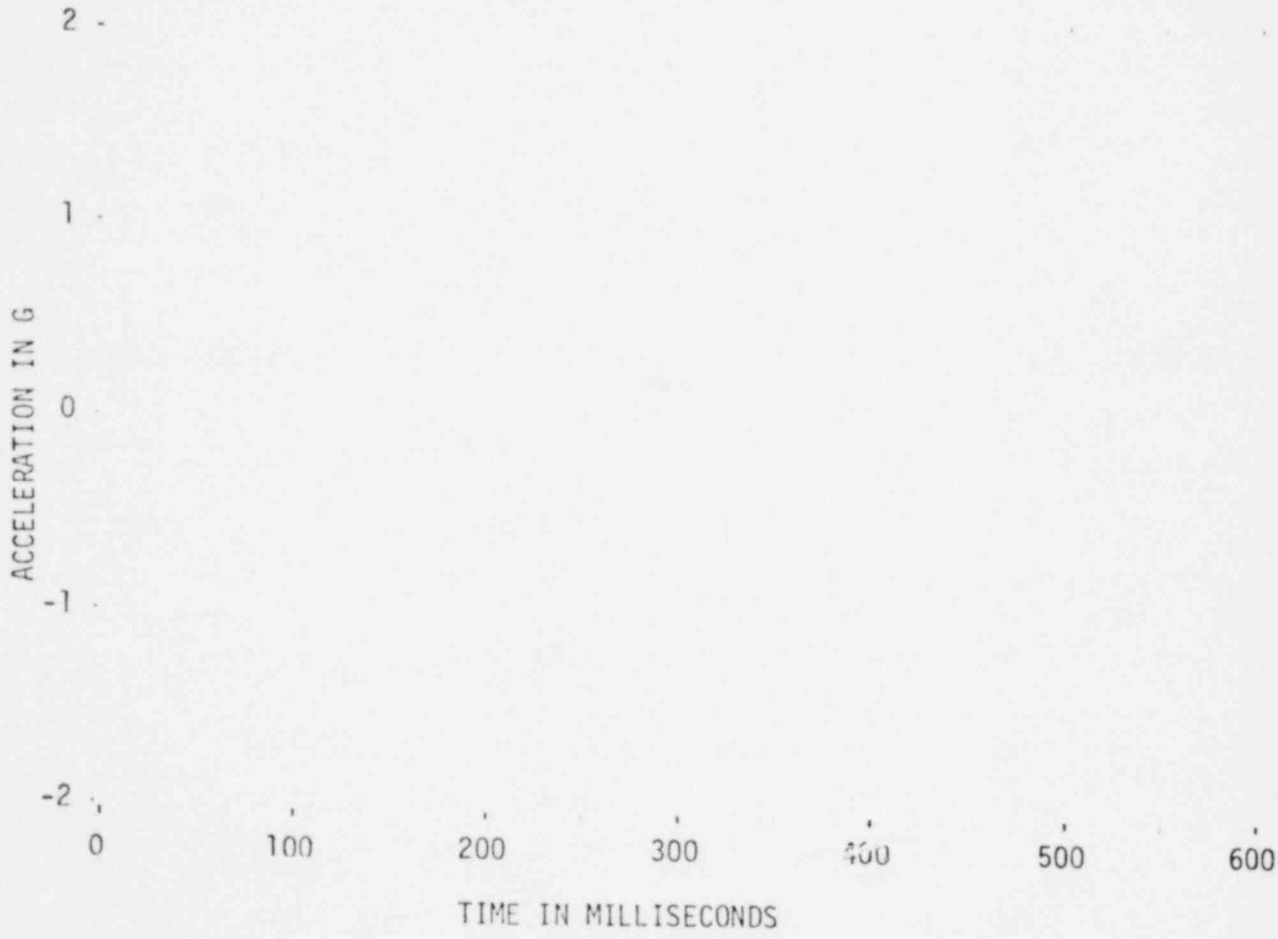


1350 186

FIGURE A-673

TORUS VERTICAL ACCELERATION

Task 5.5.3 Vermont Yankee Test 3

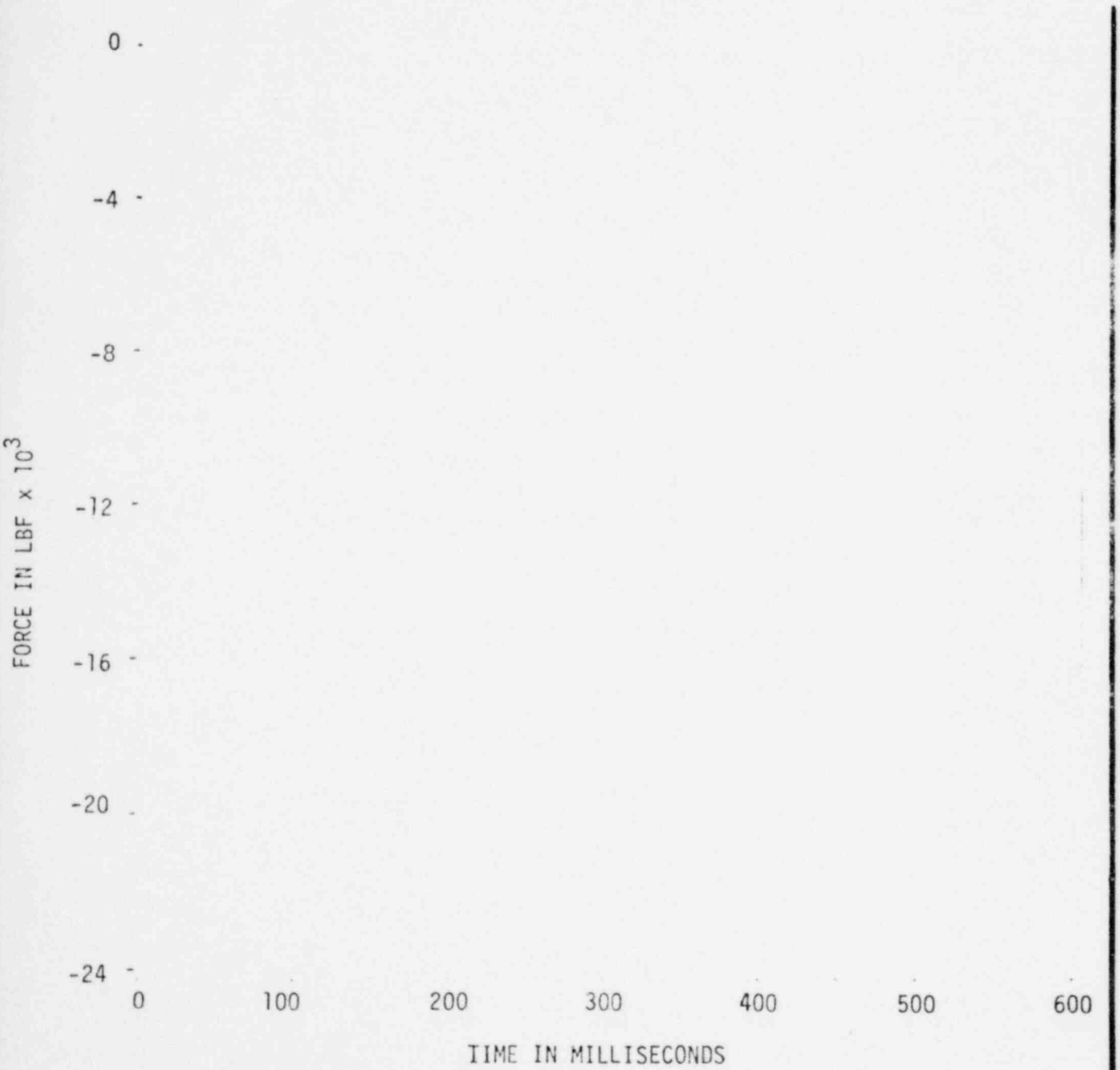


1350 187

FIGURE A-674

TORUS LOAD CELL

Task 5.5.3 Vermont Yankee Test 5

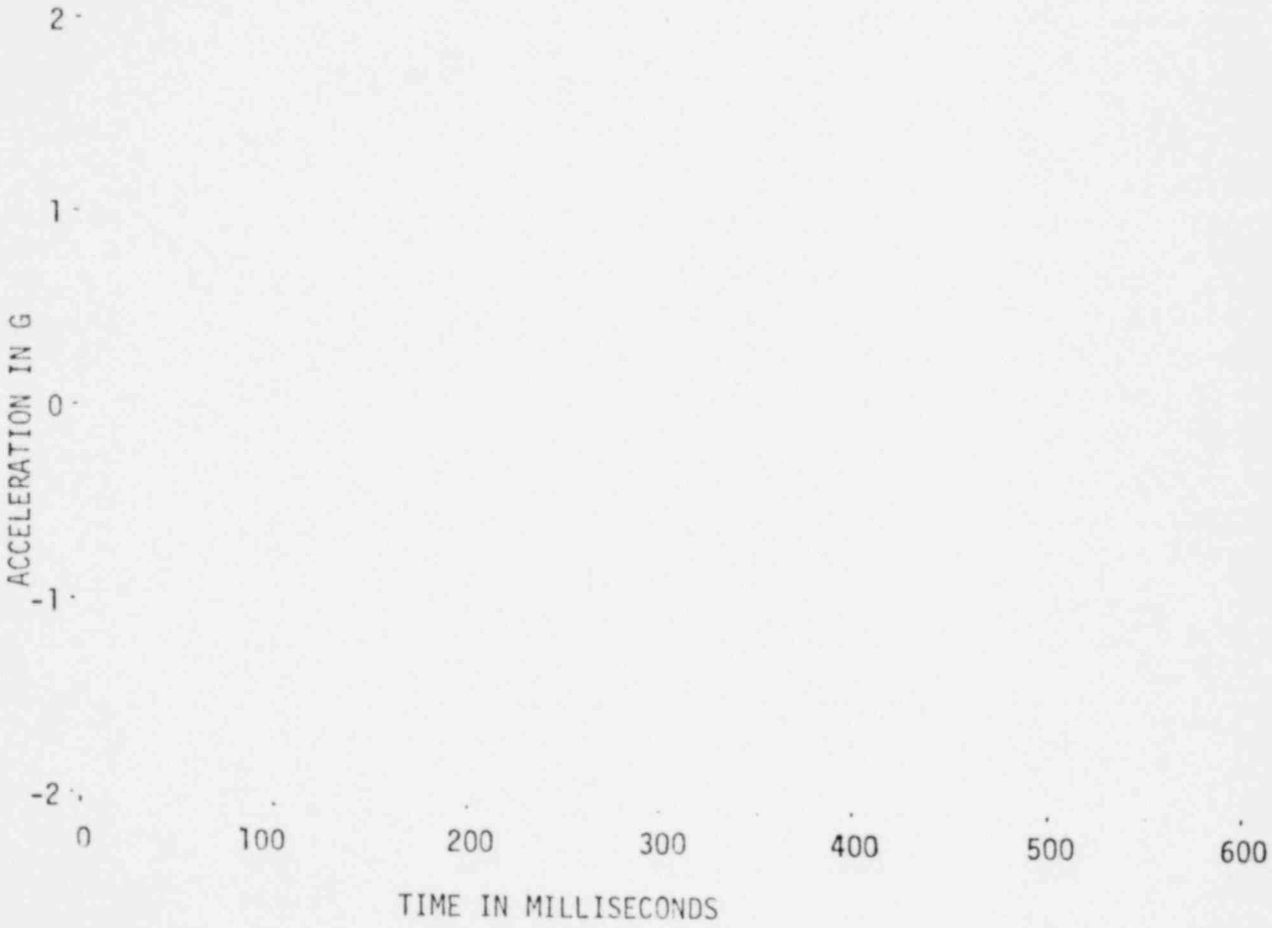


1350 188

FIGURE A-675

TORUS VERTICAL ACCELERATION

Task 5.5.3 Vermont Yankee Test 5



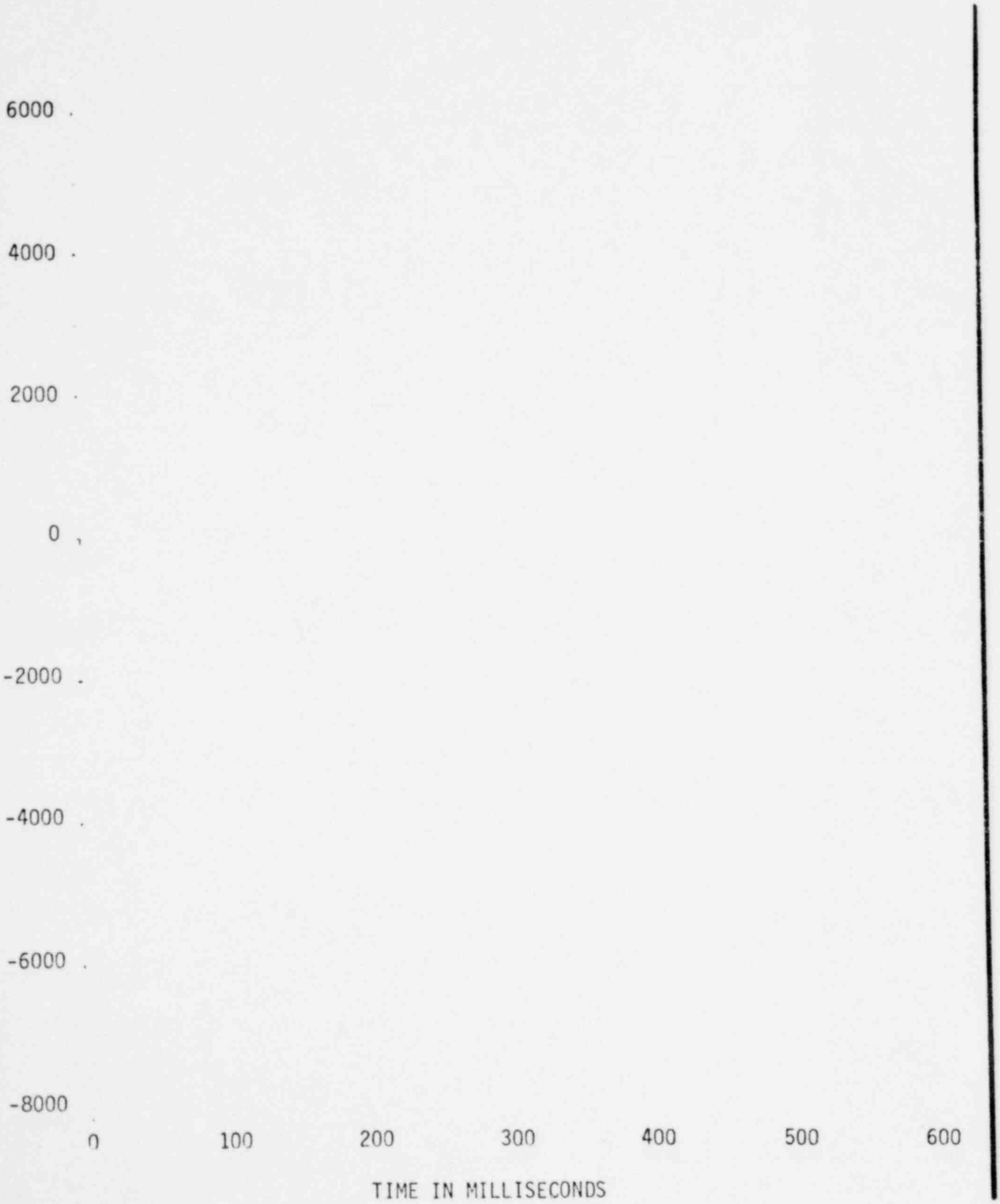
1350 189

FIGURE A-676

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Vermont Yankee Test 3

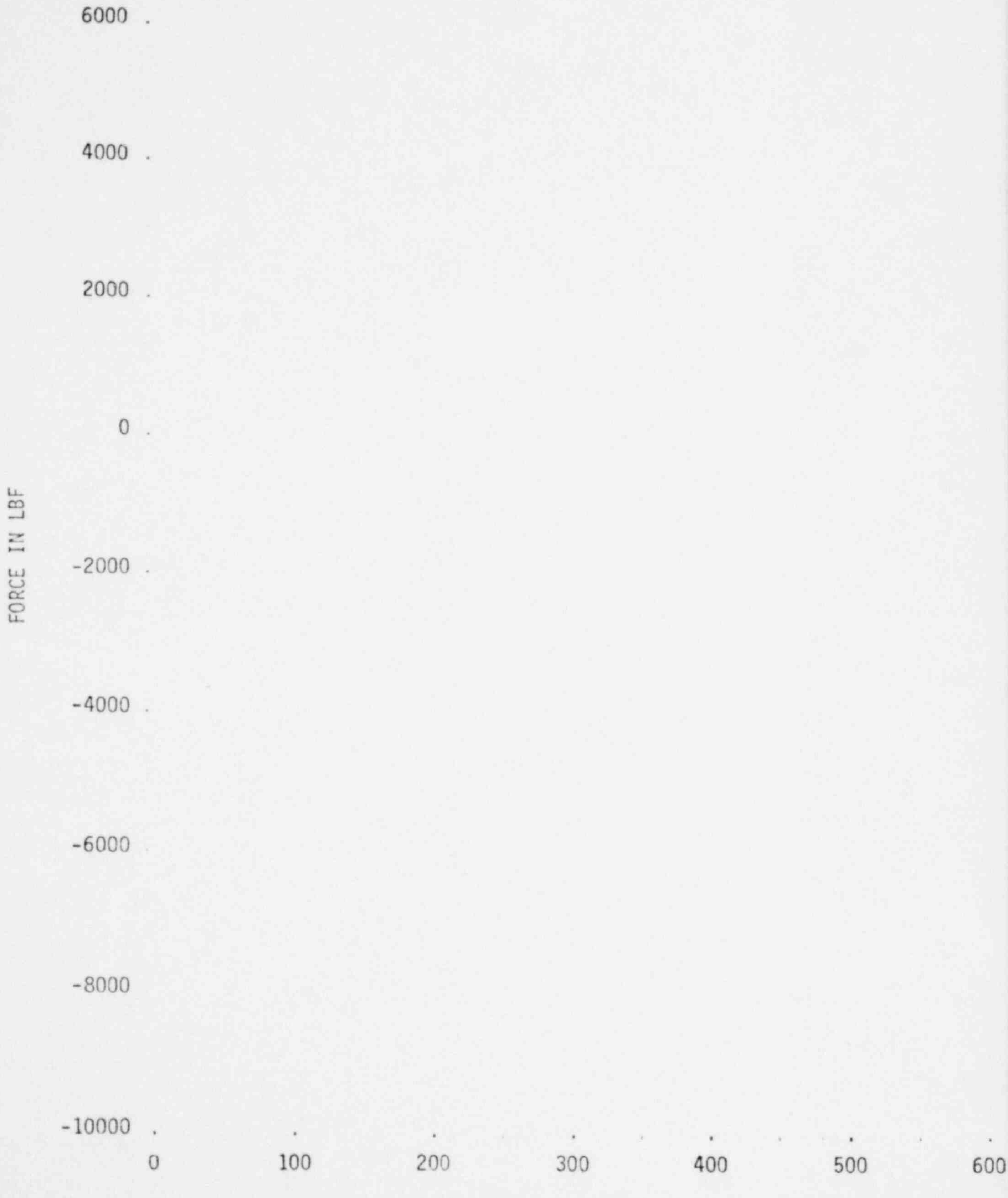


1350 190

FIGURE A-677 COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Vermont Yankee Test 5

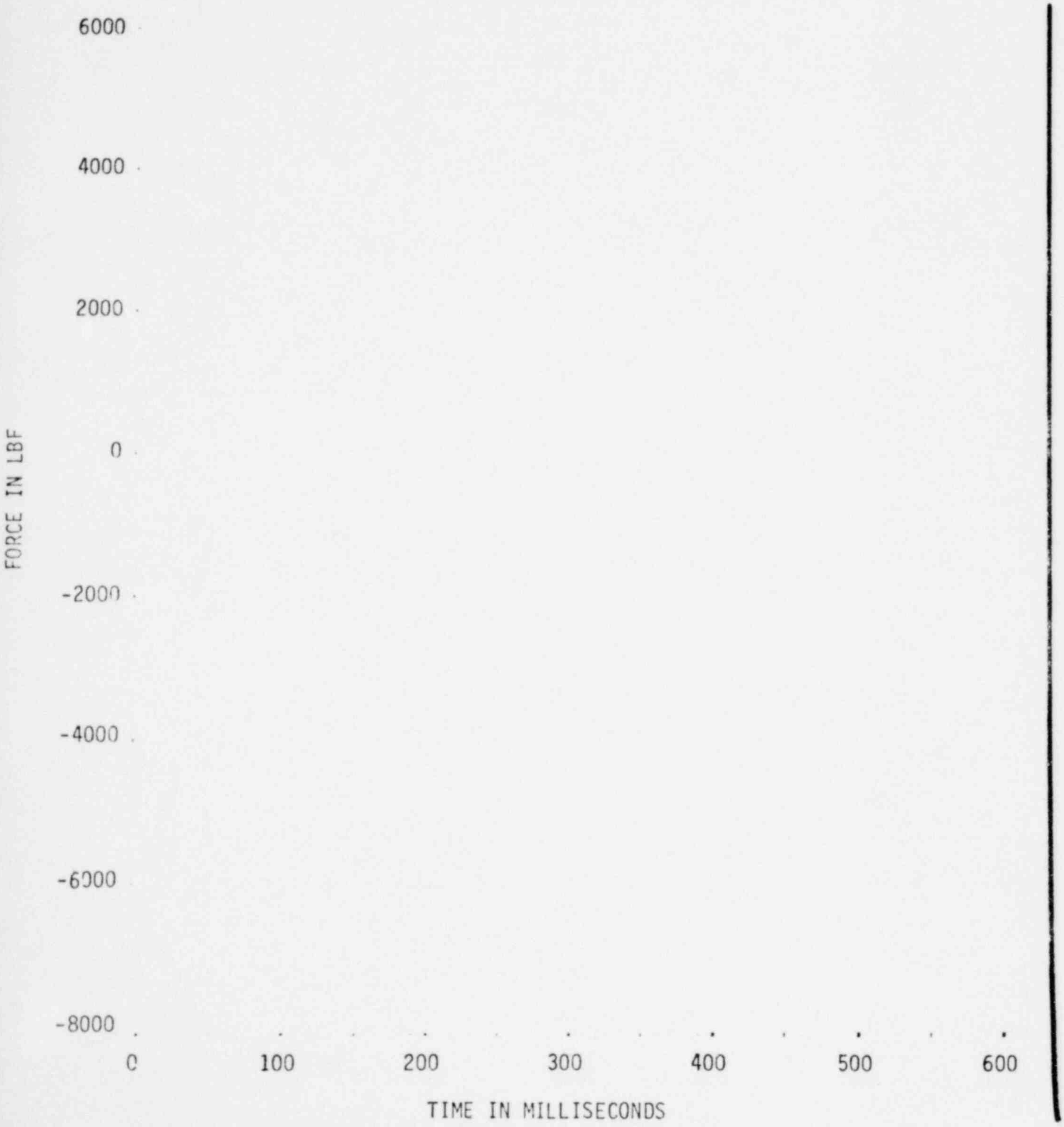


1350 191

FIGURE A-678

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 3

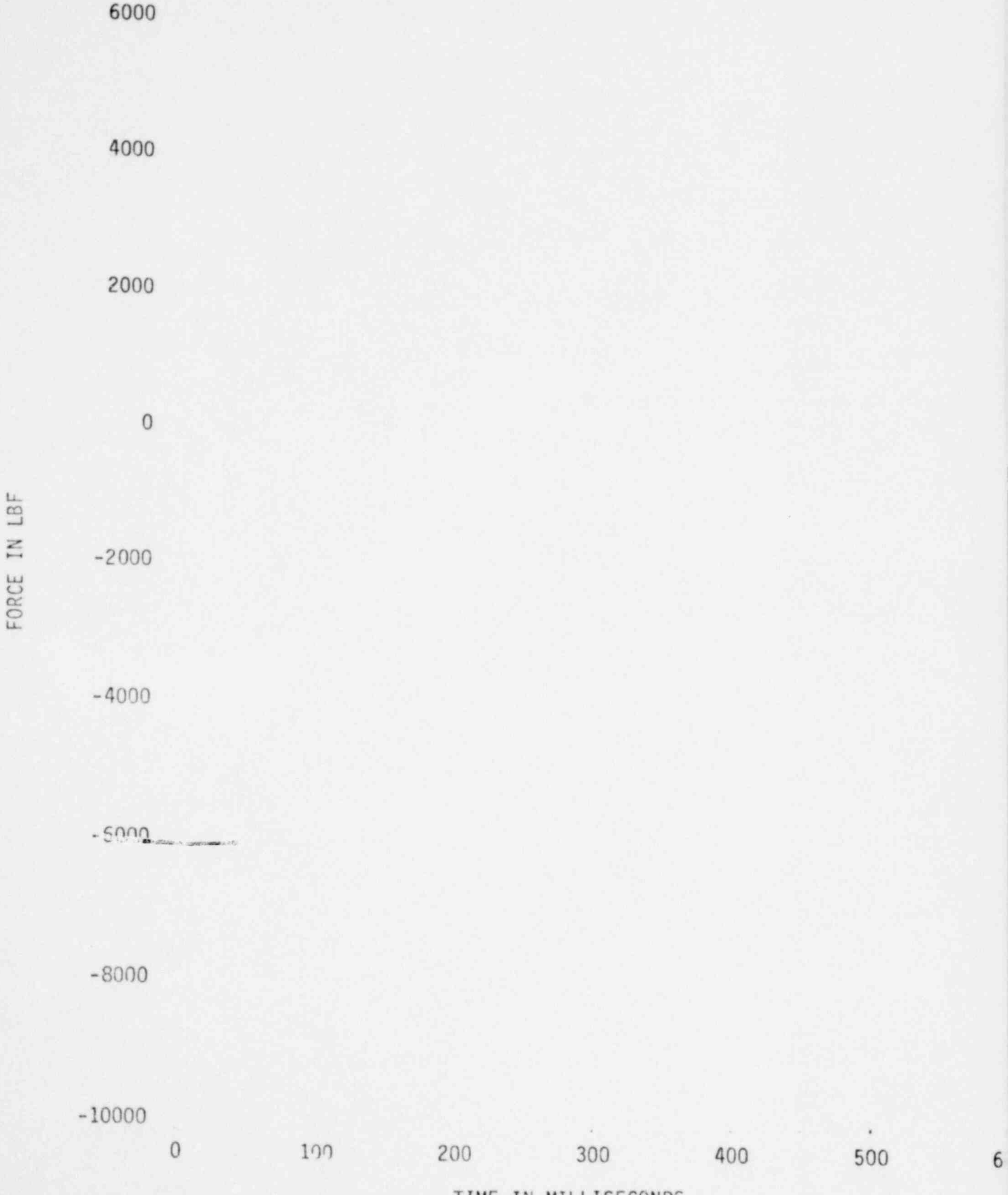


1350 192

FIGURE A-679

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 5



1350 19

FIGURE A-680

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 3

5

1350 194

FIGURE A-681

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 3

NET AVERAGE POOL PRESSURE IN PSIA

3

2

1

0

-1

-2

-3

-4

0 100 200 300 400 500 600

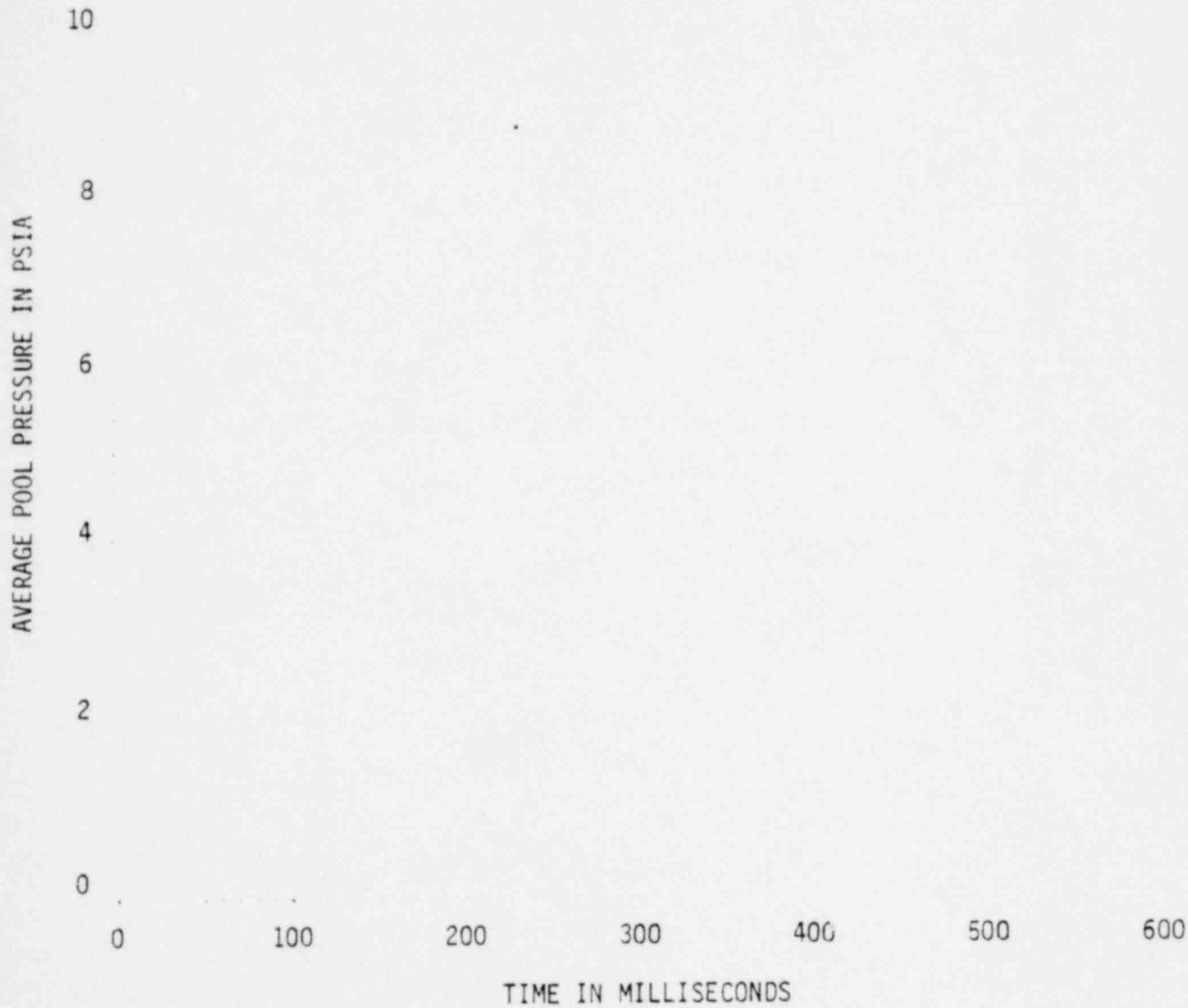
TIME IN MILLISECONDS

1350 195

FIGURE A-682

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 5



1350 196

NEDO-21944

FIGURE A-683

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Vermont Yankee Test 5

NET AVERAGE POOL PRESSURE IN PSIA

3

2

1

0

-1

-2

-3

-4

-5

0 100 200 300 400 500 600

TIME IN MILLISECONDS

1350 197

VENT HEADER IMPACT PRESSURES

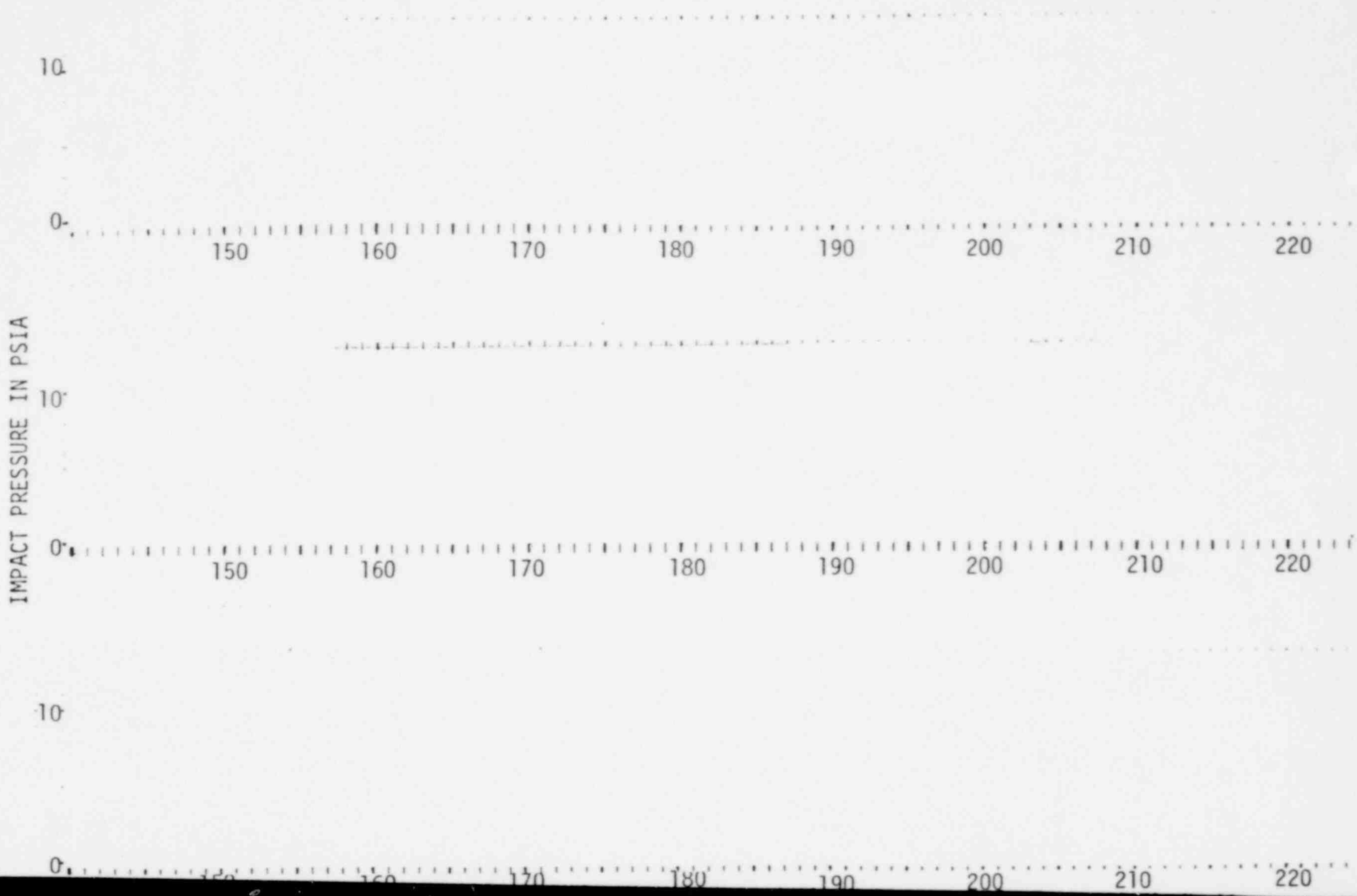
Task 5.5.3 Vermont Yankee Test 3

1350 198

FIGURE A-685

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Vermont Yankee Test 3



1350 199

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Vermont Yankee Test 3

1350 200

FIGURE A-687

VENT HEADER IMPACT PRESSURES

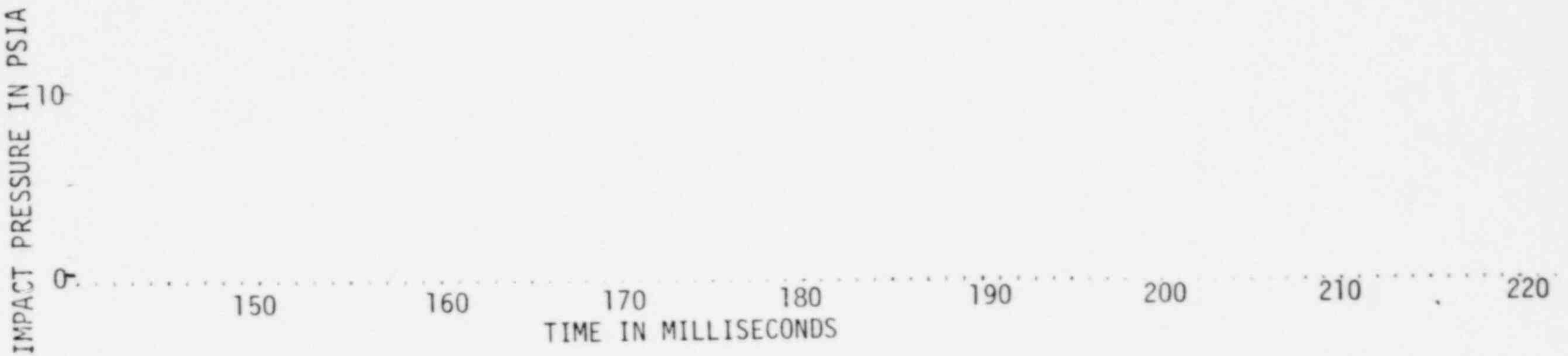
Task 5.5.3 Vermont Yankee Test 3

1350 201

FIGURE A-688

VENT HEADER IMPACT PRESSURES

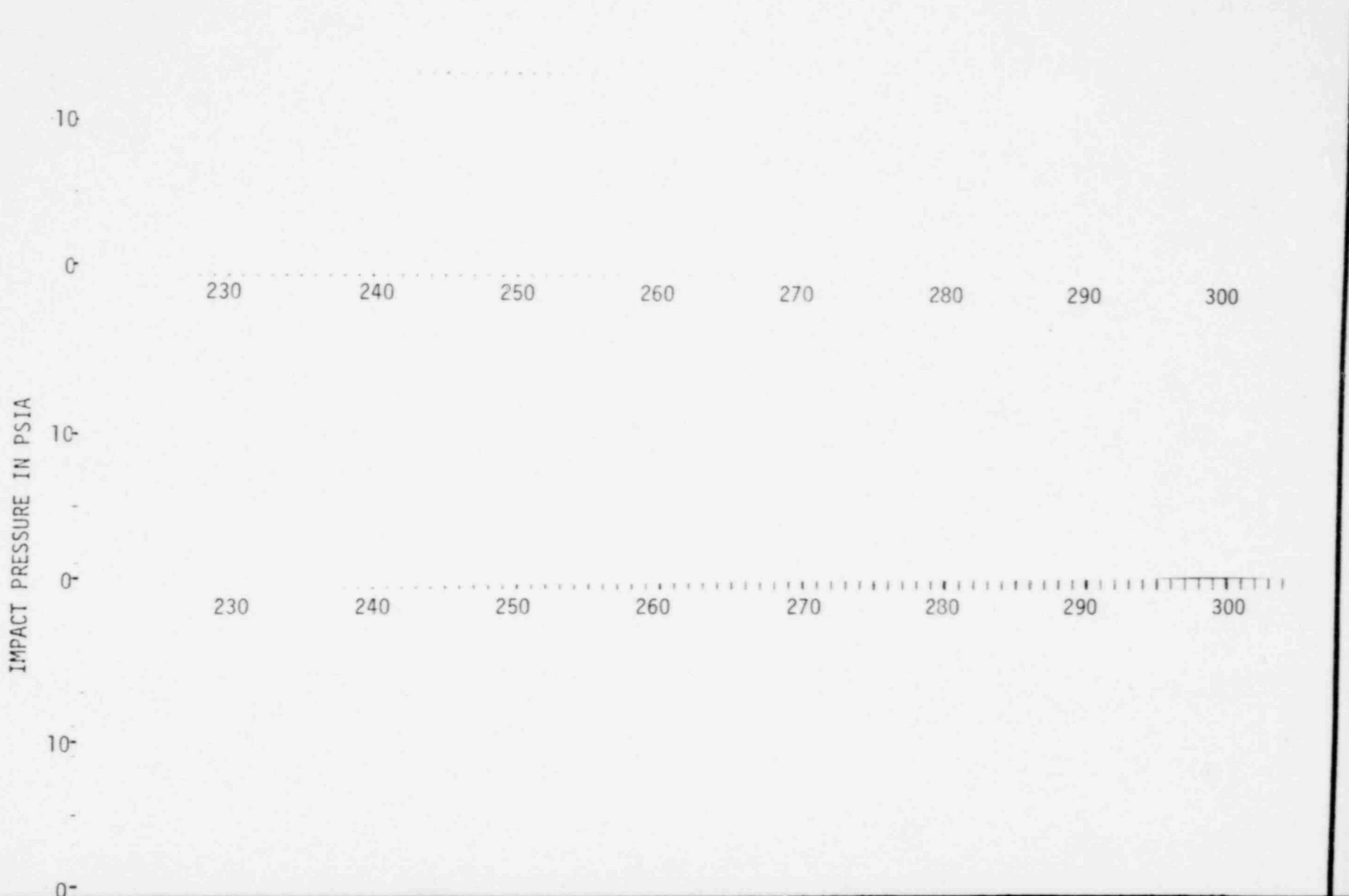
Task 5.5.3 Vermont Yankee Test 3



1350 202

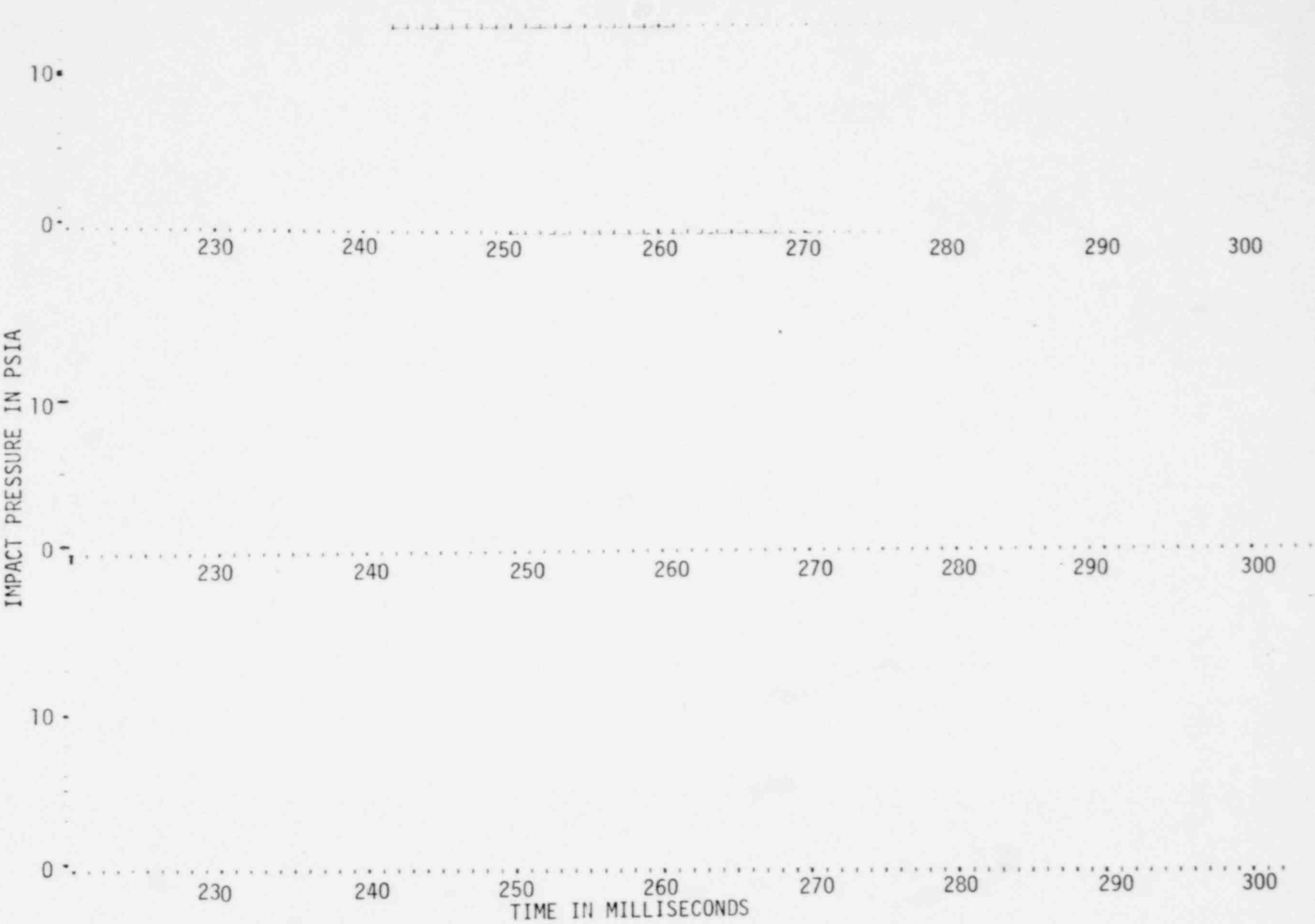
FIGURE A-689 VENT HEADER IMPACT PRESSURES

Task 5.5.3 Vermont Yankee Test 5



1350 203

FIGURE A-690



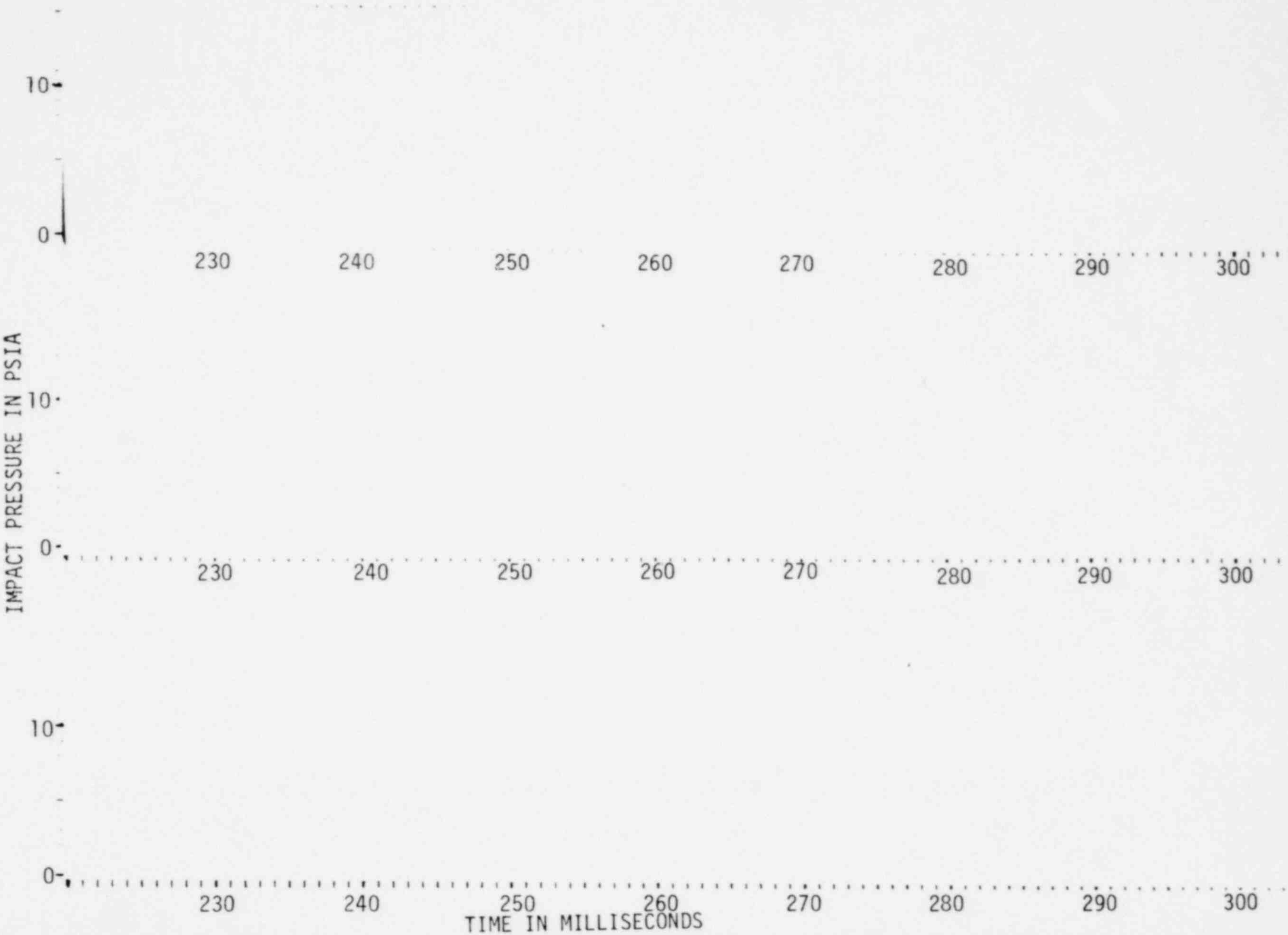
1350 204

FIGURE A-691 VENT HEADER IMPACT PRESSURES

Task 5.5.3 Vermont Yankee Test 5

1350 205

Task 5.5.3 Vermont Yankee Test 5



1350 206

FIGURE A-693

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Vermont Yankee Test 5

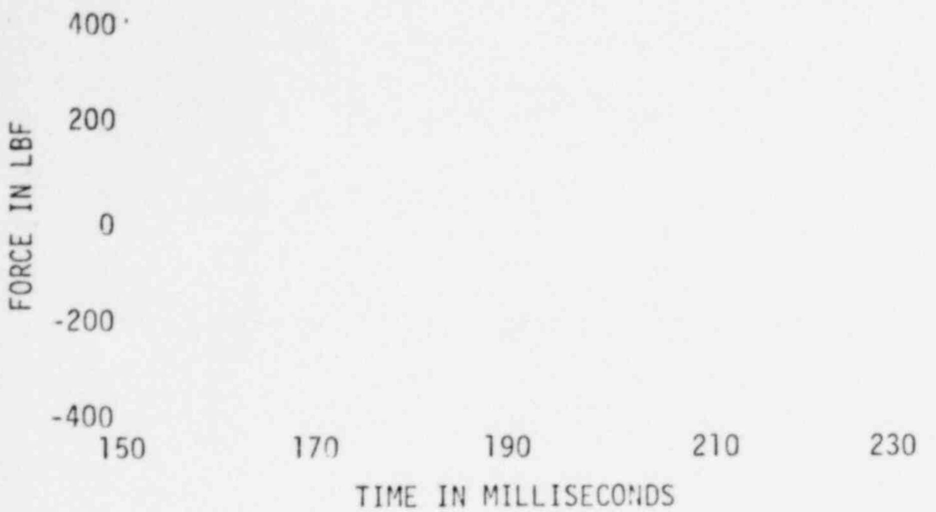
1350 207

FIGURE A-694

COMPARISON OF VENT HEADER IMPACT RESULTS

(Corrected Load Cell and Pressure Integration)

Task 5.5.3 Vermont Yankee Tests 3,5



1350 208

FIGURE A-695

VENT HEADER VERTICAL ACCELERATION

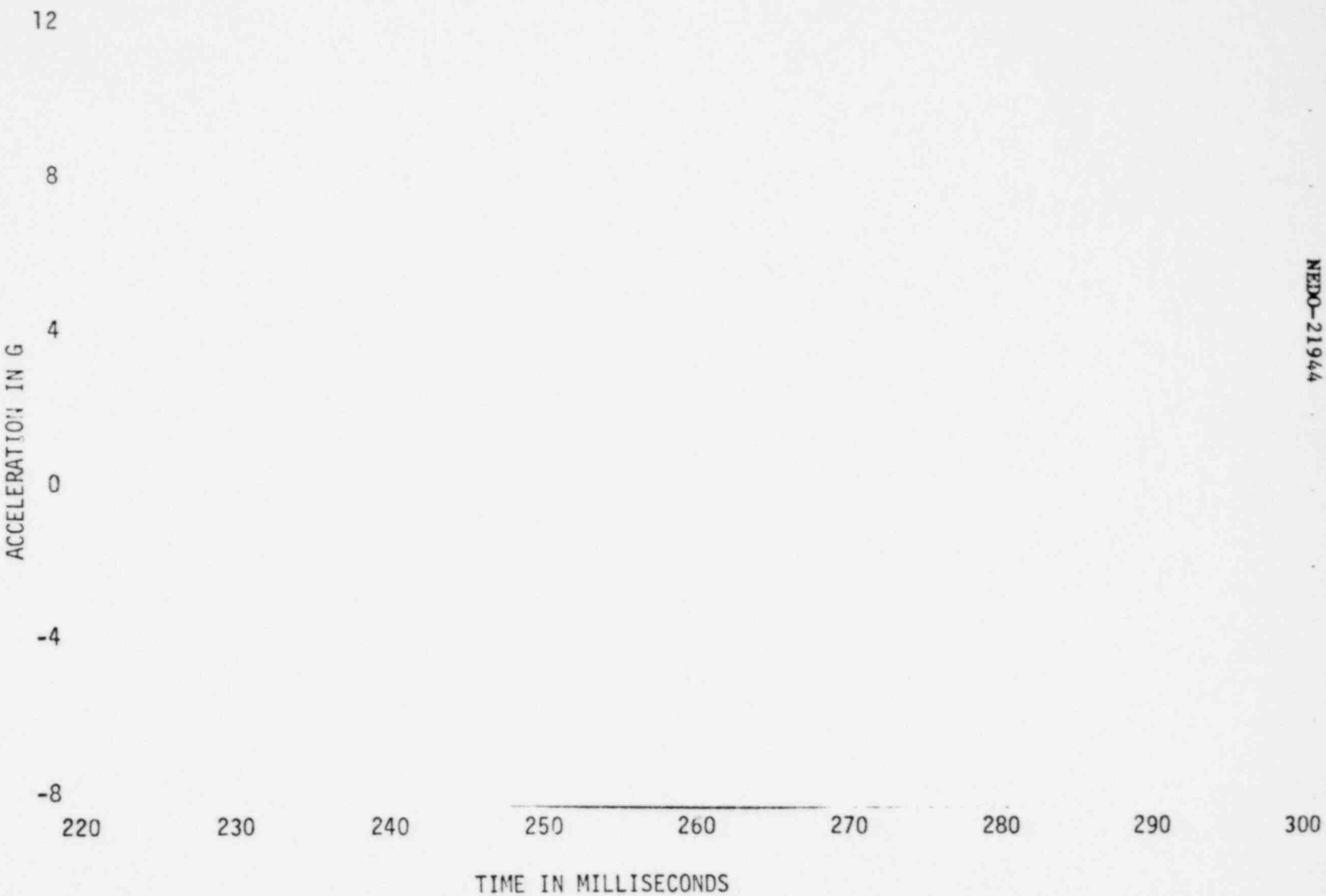
Task 5.5.3 Vermont Yankee Test 3

1350 209

FIGURE A-696

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Vermont Yankee Test 5

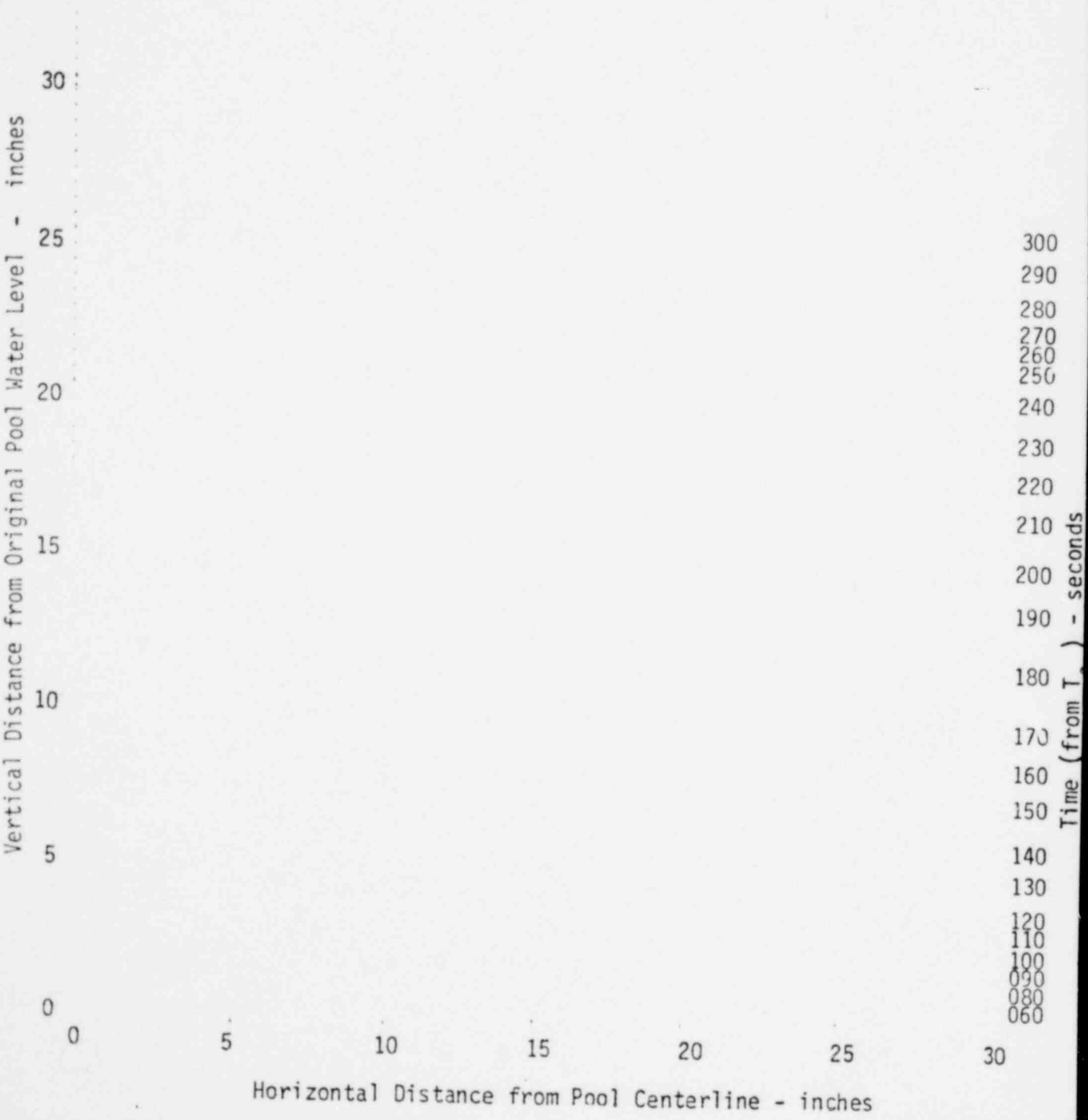


1350 210

FIGURE A-697

TIME HISTORY OF POOL DISPLACEMENT

VERMONT YANKEE, TEST 1



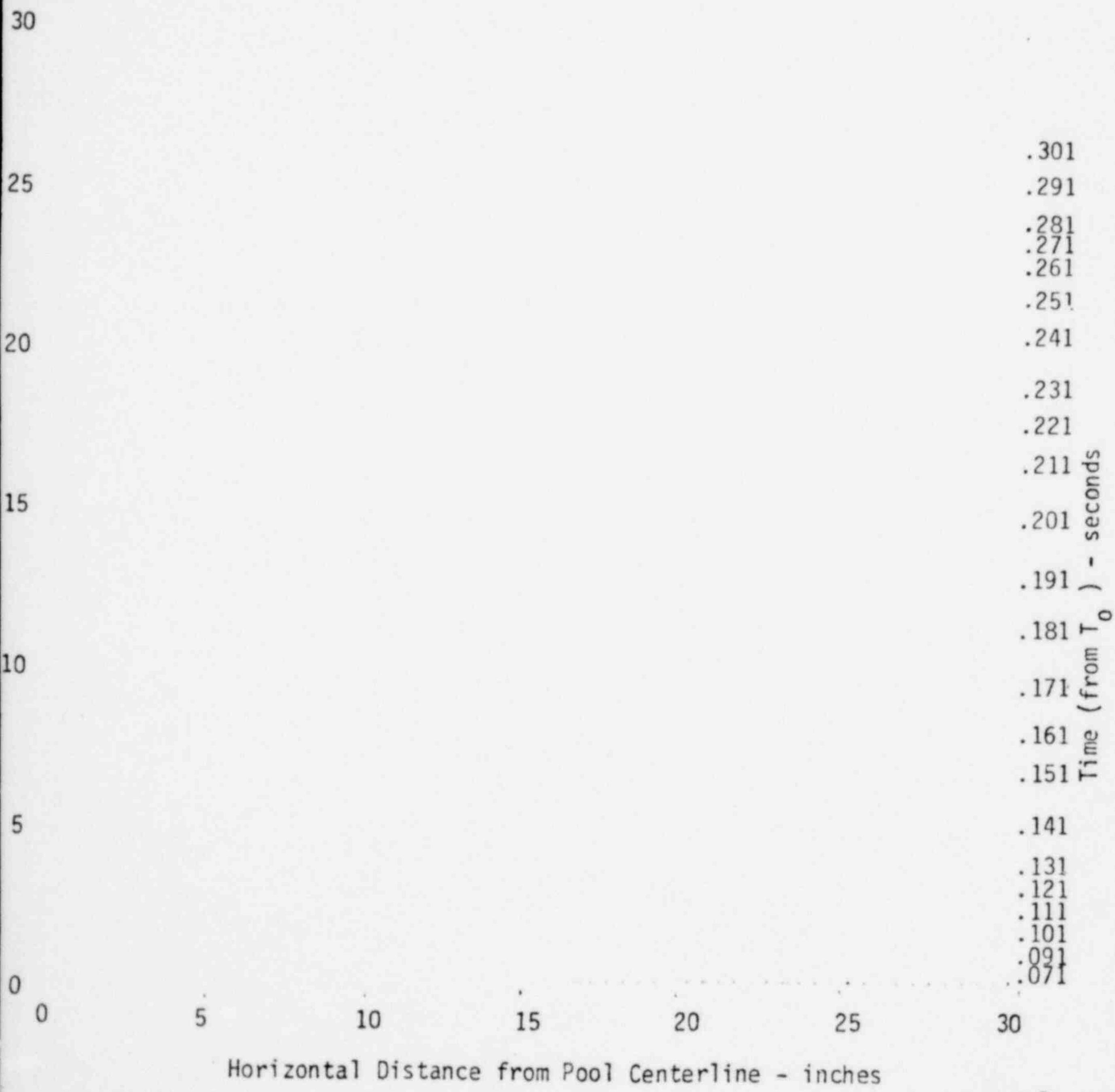
1350 211

FIGURE A-698

TIME HISTORY OF

POOL DISPLACEMENT

VERMONT YANKEE, TEST 2



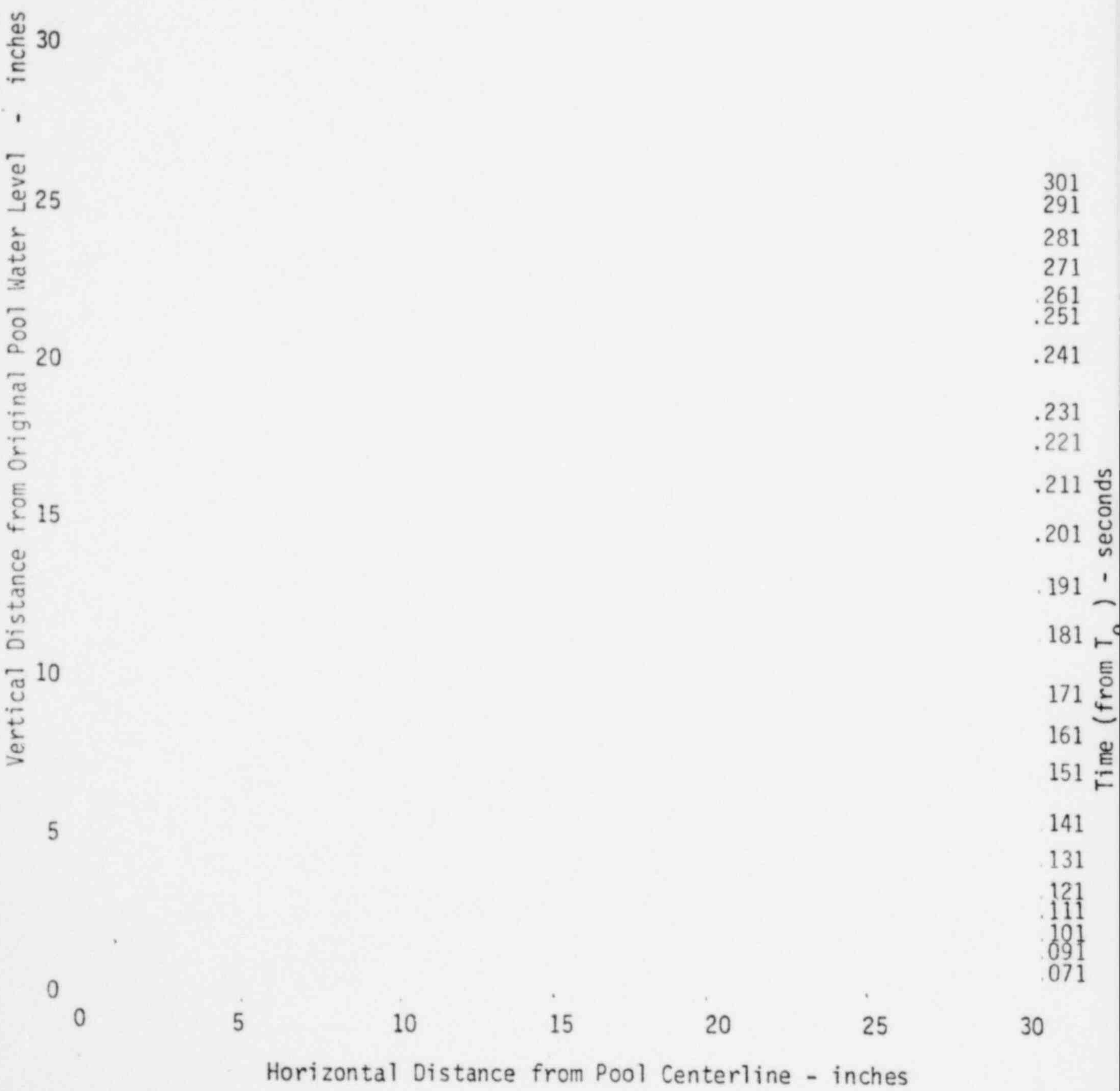
1350 212

FIGURE A-699

TIME HISTORY OF

POOL DISPLACEMENT

VERMONT YANKEE, TEST 3



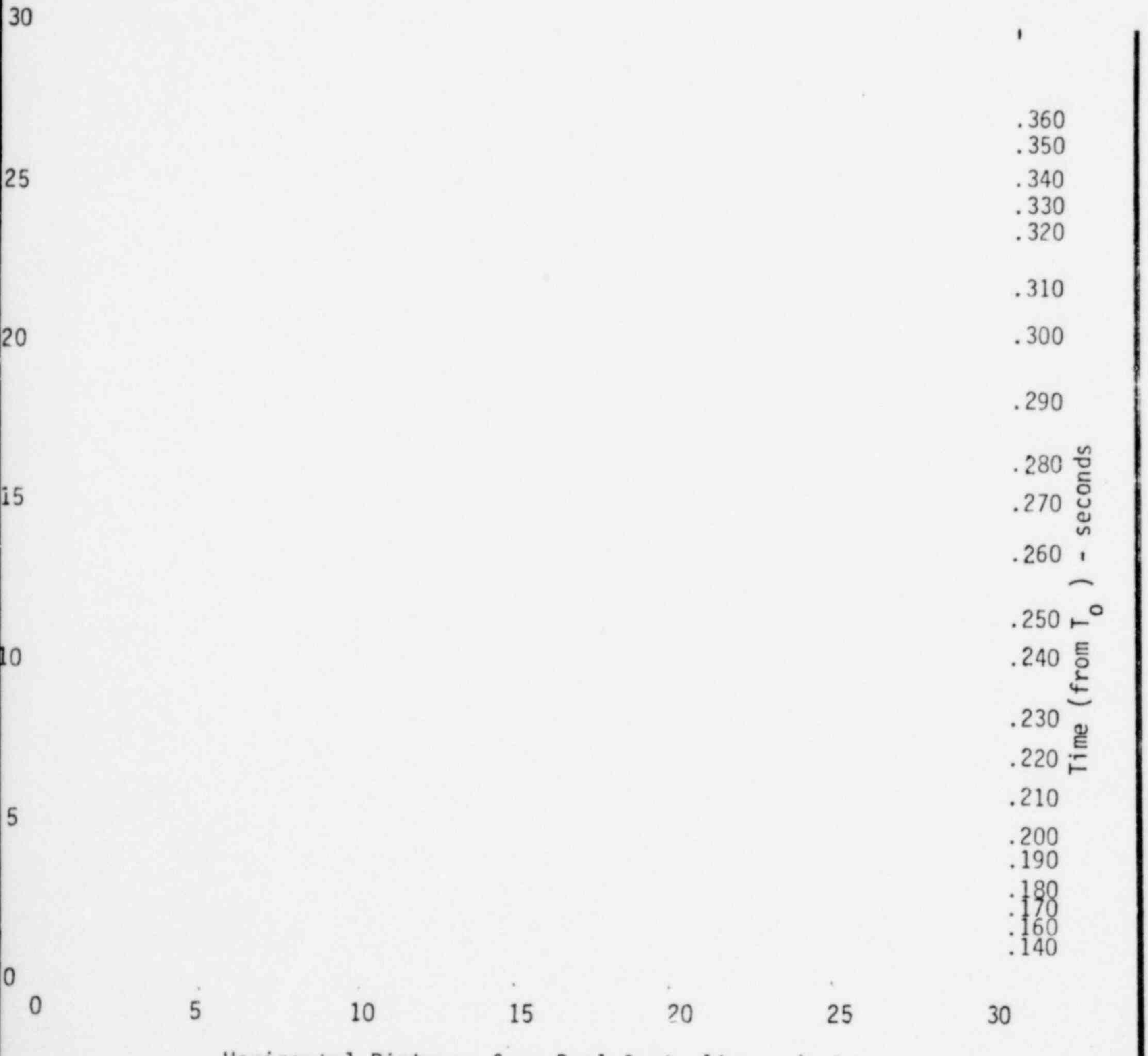
1350 213

FIGURE A-700

TIME HISTORY OF

POOL DISPLACEMENT

VERMONT YANKEE, TEST 5

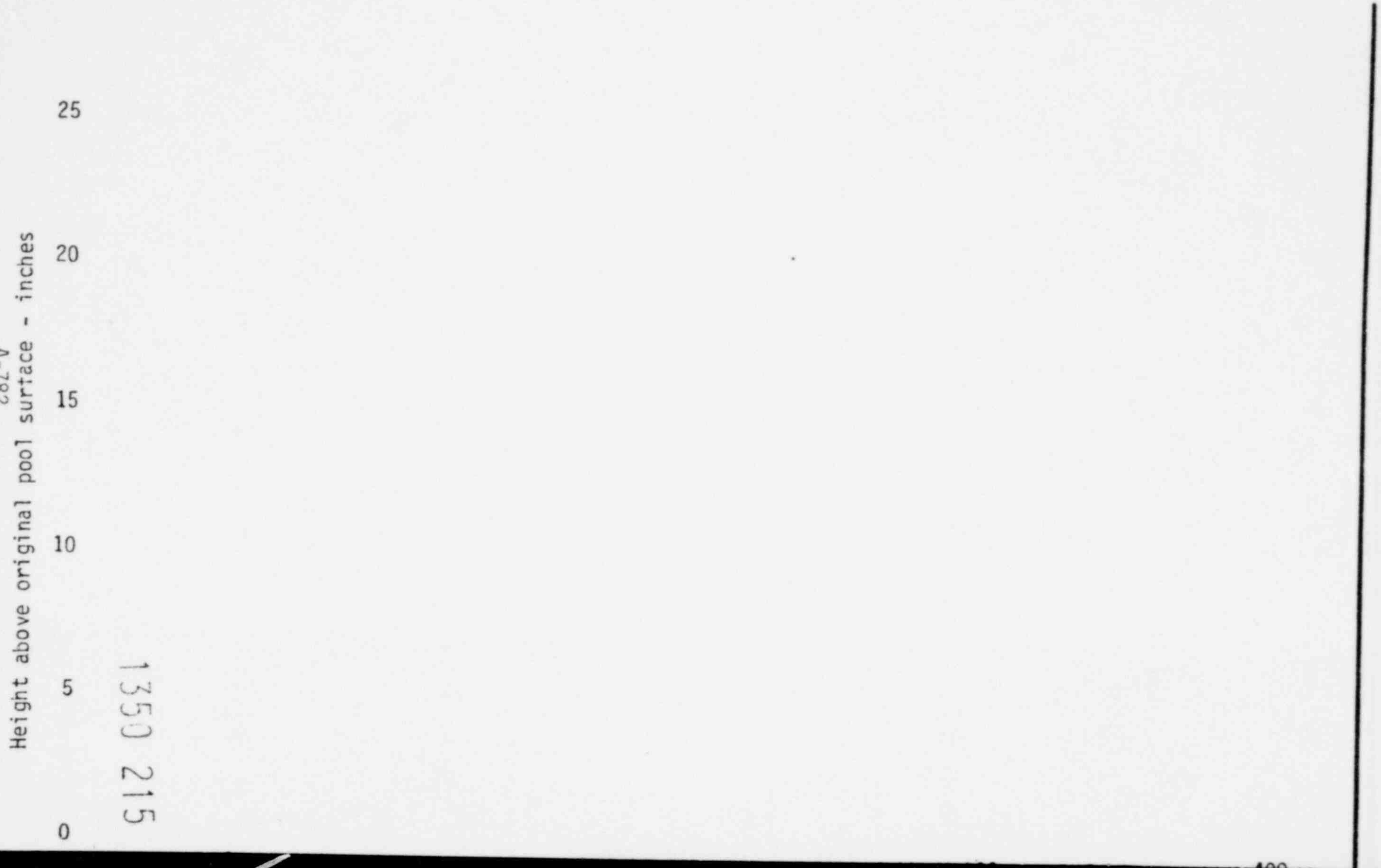


1350 214

FIGURE A-701

POOL SURFACE DISPLACEMENT

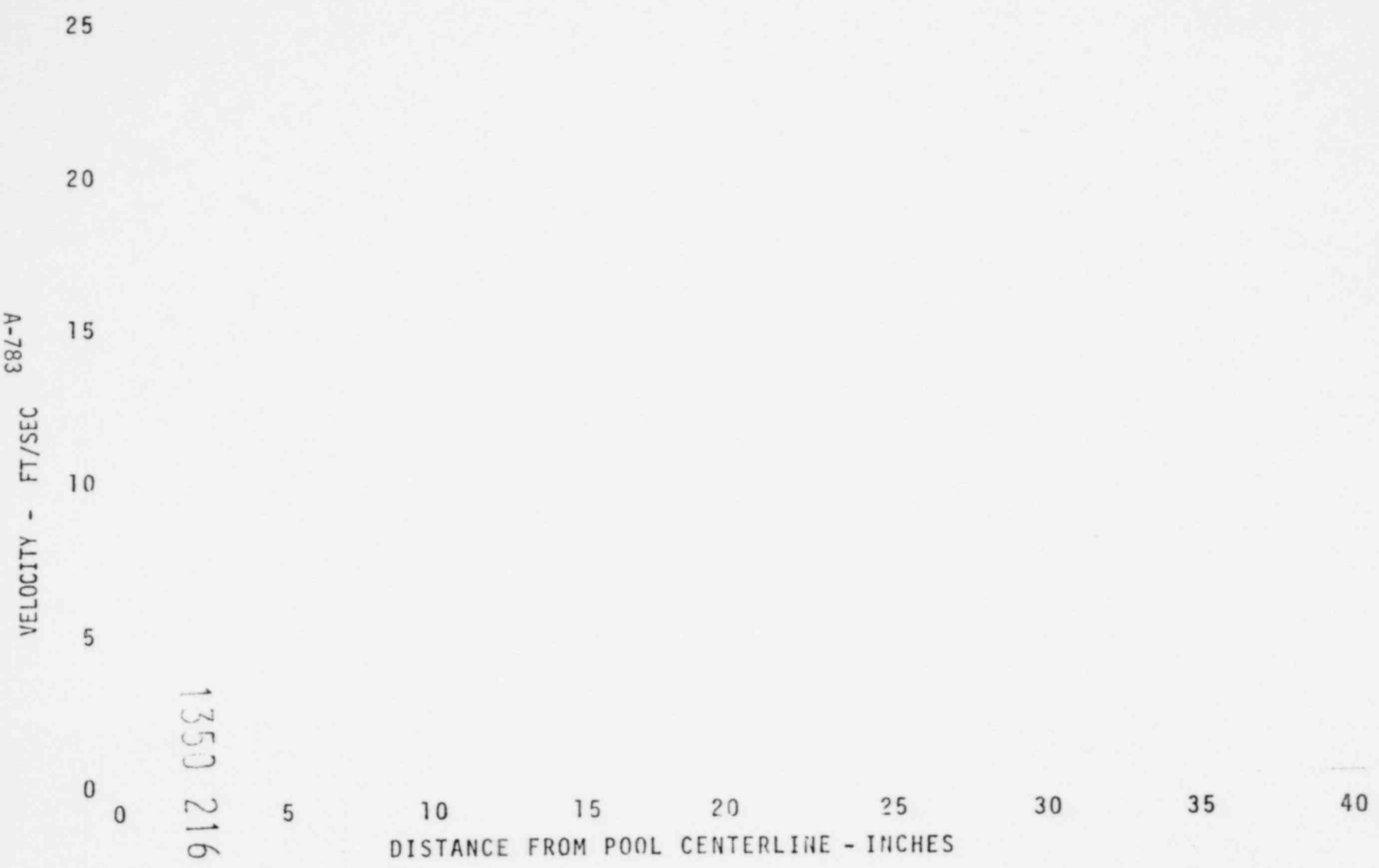
VERMONT YANKEE, TESTS 1,2,3



1350 215

FIGURE A-782 POOL SURFACE, VELOCITY PROFILES

VERMONT YANKEE, TESTS 1, 2, 3

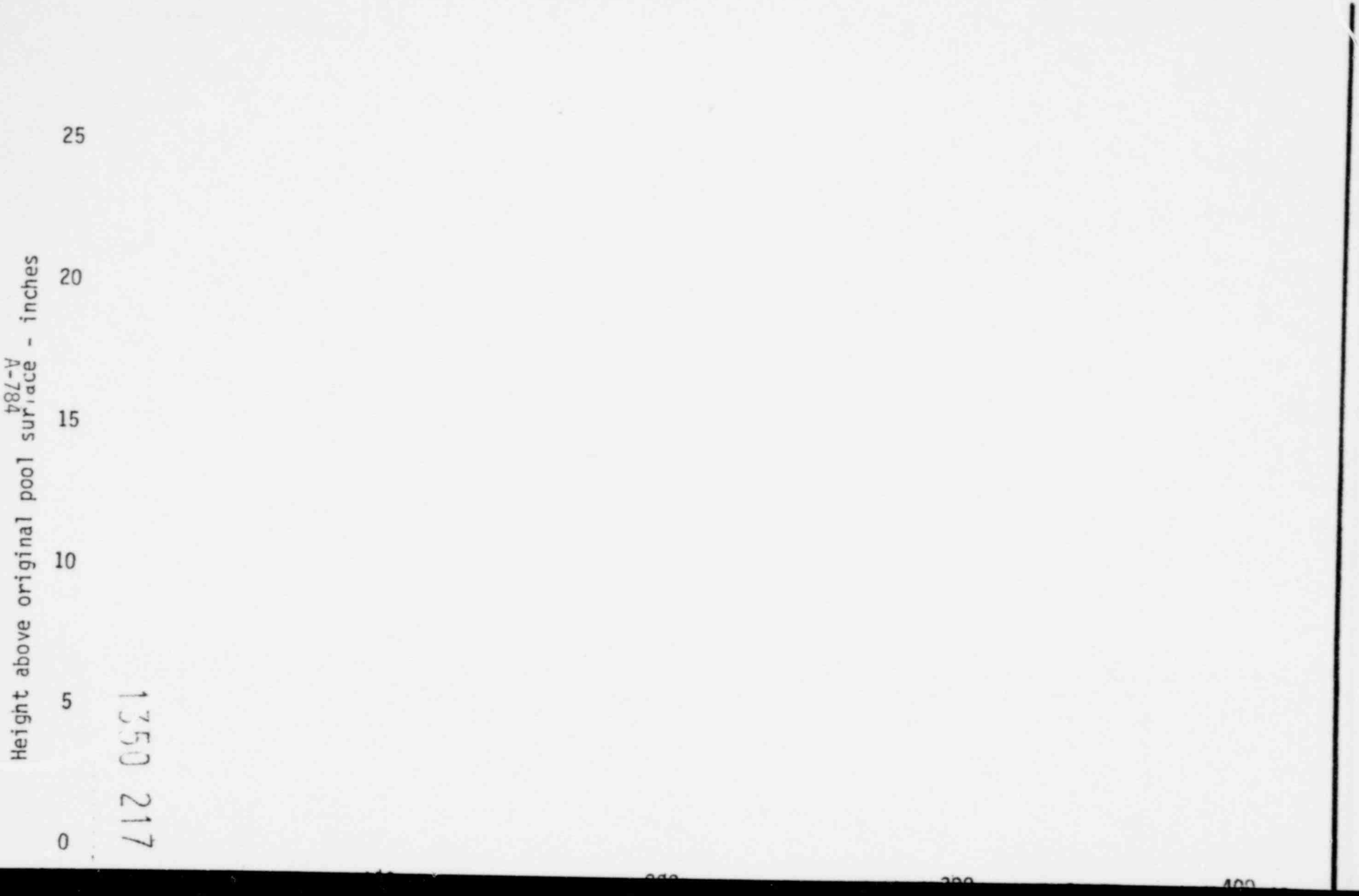


1350 216

FIGURE A-703

POOL SURFACE DISPLACEMENT

VERMONT YANKEE, TEST 5



1350 217

VERMONT YANKEE, TEST 5

0 5 10 15 20 25 30 35 40

DISTANCE FROM POOL CENTERLINE - INCHES

0 5 10 15 20 25

VELOCITY - FT/SEC

1350 218

FIGURE A-705

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

VERMONT YANKEE, TEST 4

VERTICAL DISPLACEMENT - INCHES

12
10
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

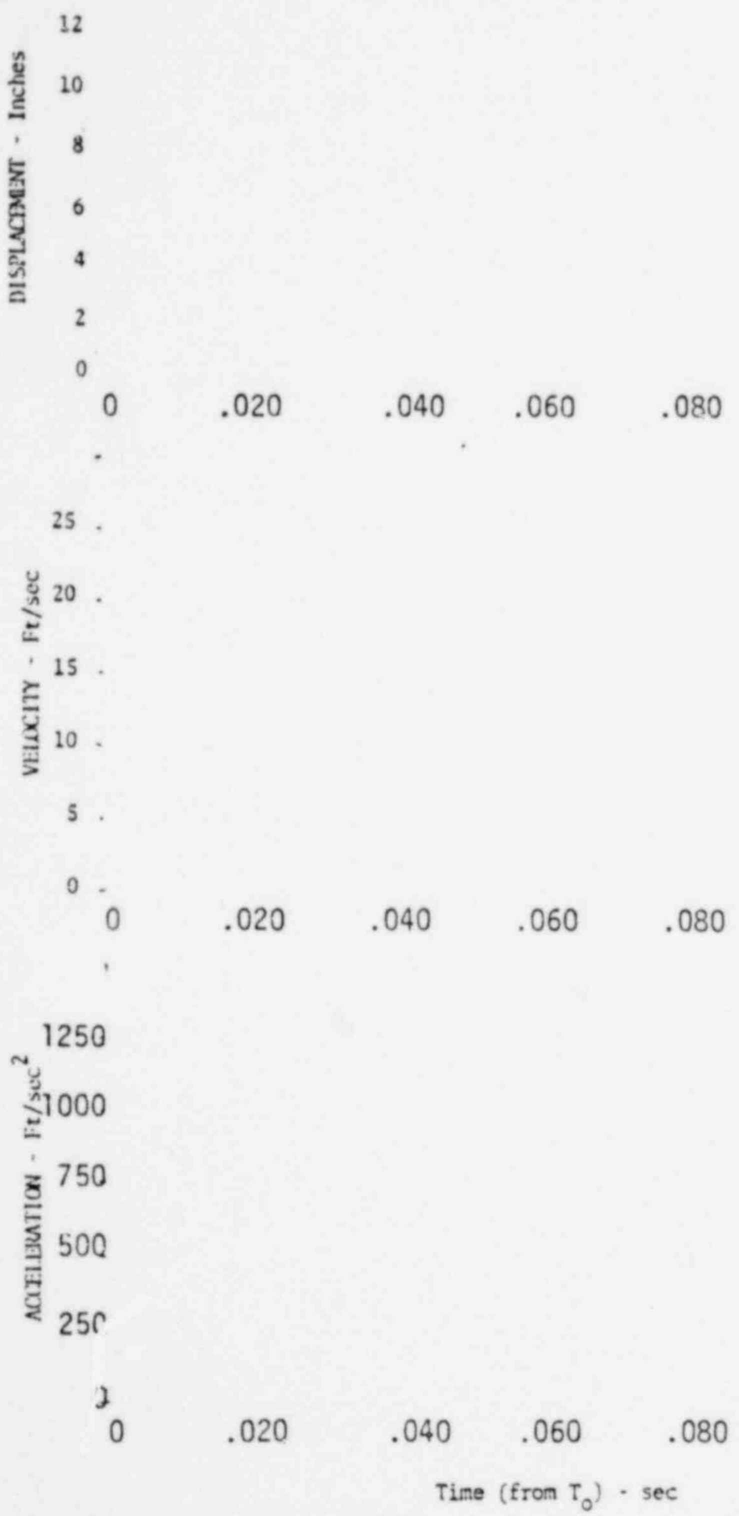
1350 219

FIGURE A-706

NEDO-21944

DOWNCOMER WATER SLUG EJECTION

VERMONT YANKEE, TEST 3



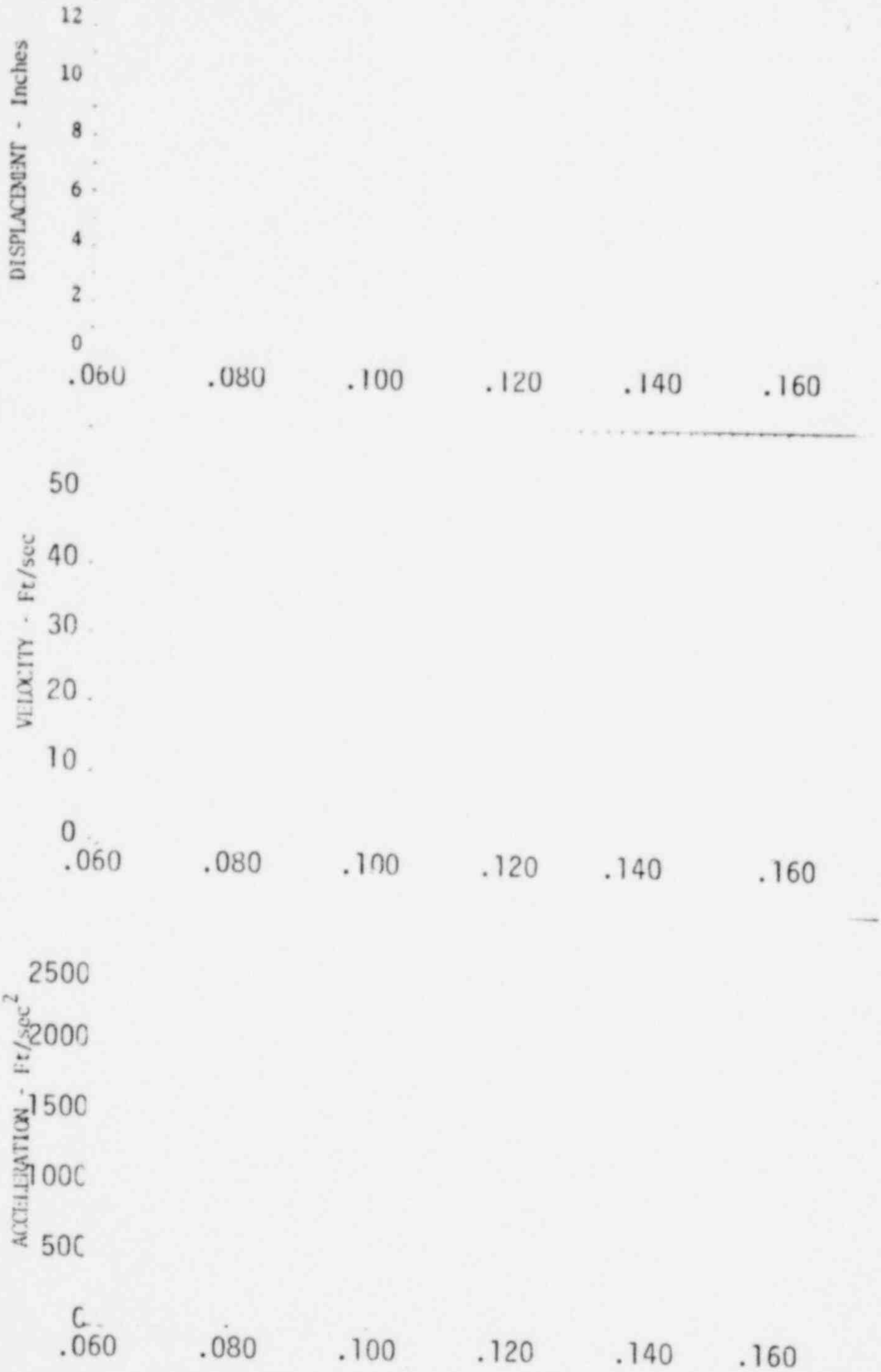
1350 220

Note: Nearly full ΔP makes measurement of the water slug ejection parameters difficult

FIGURE A-707

DOWNCOMER WATER SLUG EJECTION

VERMONT YANKEE, TEST 5



Time (from T_o) - sec

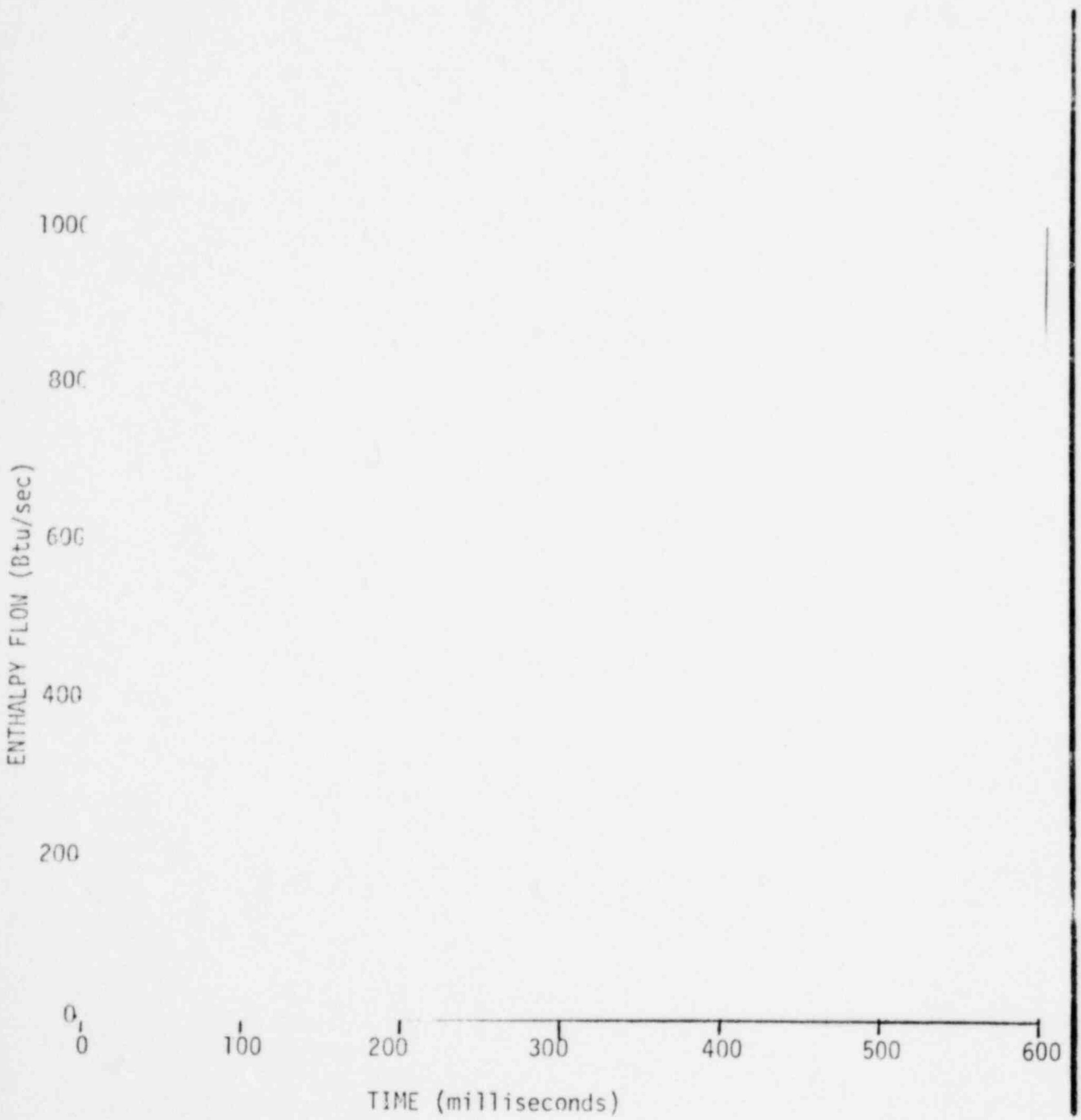
1350 221

FIGURE A-708

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Vermont Yankee Tests



1350 222

FIGURE A-709

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Vermont Yankee Tests

PRESSURE IN PSIA

20

16

12

8

4

0

0 100 200 300 400 500 600

TIME IN MILLISECONDS

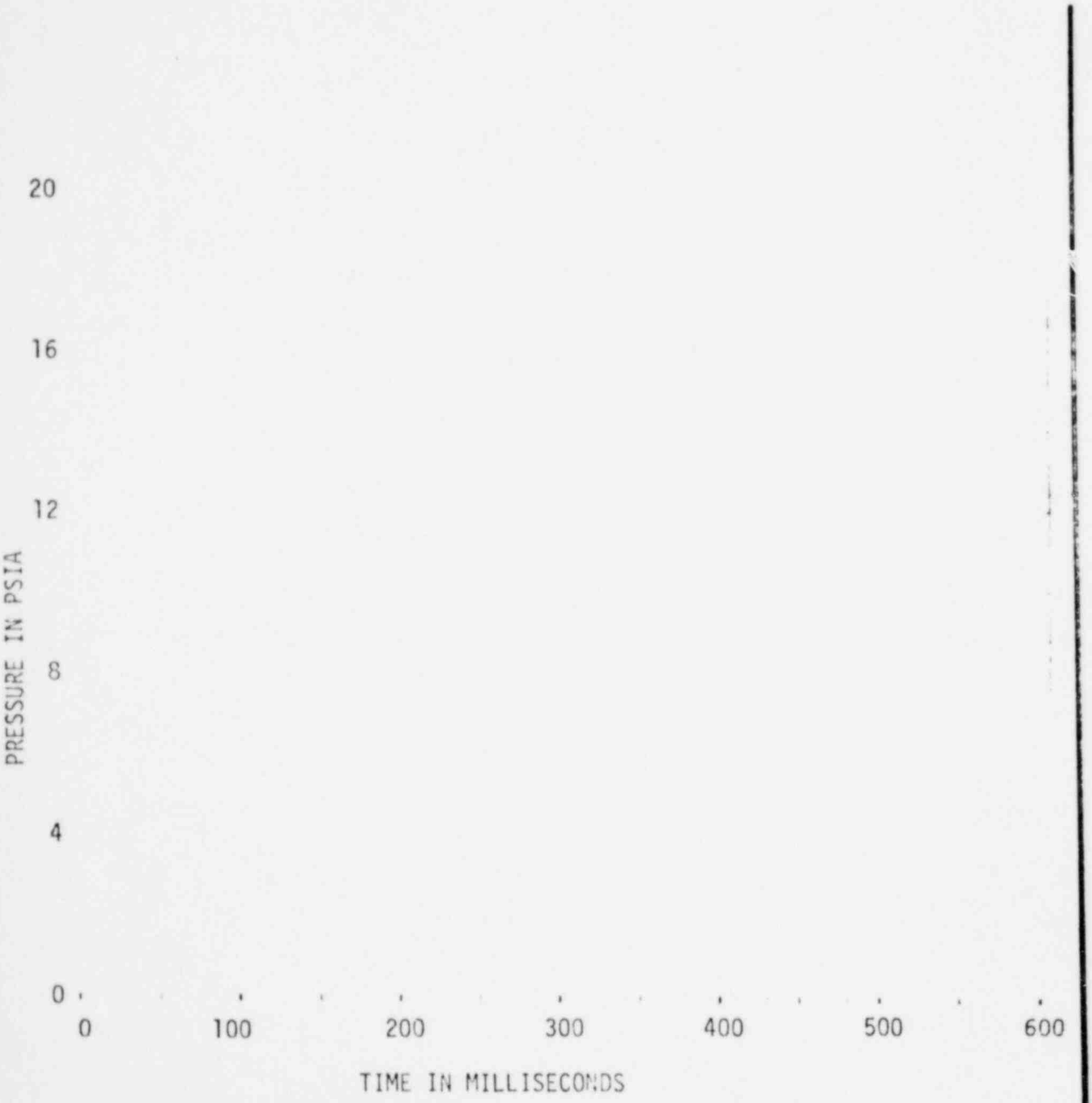
1350 223

FIGURE A-710

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Vermont Yankee Tests



1350 224

TABLE A-29

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Vermont Yankee Tests

Parameter / Test No.		13.2"ΔP, 4.48" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0"ΔP (5)
T_o †	(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)							

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

† = Start of test reference time

1350 225

TABLE A-29

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Vermont Yankee Tests

Test No. / arameter		13.2" ΔP, 4.48" Deflector						0" ΔP
		(1)	(2)	(3)	(4)	Mean	Std. Dev.	(5)
eak Upforce								
ressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
pforce Valley								
ressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
nd Peak Upforce								
ressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Pressure Integral:								
Force	(lb)							
Time (from T_o)	(sec)							
orrected Load Cell:								
Force	(lb)							
Time (from T_o)	(sec)							
ero Force Time***								
Pressure Integral	(sec)							
Corrected Pressure Integral	(sec)							
Corrected Load Cell	(sec)							

*** = Time at force is zero (from T_o)

1350 226

TABLE A-30

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3 Vermont Yankee Tests

Parameter \ Test No.		13.2" ΔP, 4.48" 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

1350 227

A.15 Fitzpatrick Tests

A.15.1 Typical Data

Time-history plots of the driving conditons and pool response are presented in this section for Fitzpatrick Tests 3 and 5. Test 3 was a load definition test which was conducted at a partial drywell/wetwell differential pressure of 12.35" H_2O ΔP and with a 7.88 inch pipe deflector. Test 5 was conducted without an initial drywell/wetwell differential pressure (0" ΔP) and with the same 7.88 inch pipe deflector.

A.15.1.1 Driving Conditions

Driving conditions for Fitzpatrick Test 3 are presented in Figures A-711 through A-715. Similar plots for Test 5 are shown in Figures A-716 through A-720. Fitzpatrick driving conditions had the same characteristics as the "typical" plant discussed in Section 3.0 of this report.

A.15.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Fitzpatrick, Tests 3 and 5 are presented in Figures A-721 through A-722 and A-723 through A-724, respectively. Net torus force from the pressure integral (Figures A-725 and A-726) shows some oscillation in downforce but practically no oscillation in upforce. Net torus force that is determined from the torus load cell (Figures A-727 and A-729) by applying inertial correction with the torus accelerometer (Figures A-728 and A-730) is shown in Figures A-731 and A-732 and compared to net torus force determined from the pressure integral. Figures A-733 and A-734 present the net torus force based on the torus pressure integral, corrected for inertia.

1350 228

The "average" pool pressures for Fitzpatrick Tests 3 and 5 are shown in Figures A-735 and A-737. Figures A-736 and A-738 are the same as Figures A-733 and A-734 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Fitzpatrick Test 3 are presented in Figures A-739 through A-743. Vent header pressures for Test 5 are presented in Figures A-744 through A-748. These figures indicate that the deflector was effective in reducing the vent header impact. The vent header impact forces from the pressure integral and the corrected load cell agree reasonably well (Figure A-749).

Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-750 and A-751, respectively.

A.15.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-752 through A-755 for Fitzpatrick Tests 1, 2, 3, and 5. Pool surface displacement curves are shown in Figures A-756 and A-758. The pool surface velocity profiles are shown in Figures A-757 and A-759.

The pool surface displacement and velocity profile veiwed from the side window during Test 4 are shown in Figure A-760. The downcomer water slug displacement, velocity, and acceleration versus time for Test 3 are presented in Figure A-761. Similar plots are shown in Figure A-762 for Test 5.

A.15.3 Data Summaries

Table A-31 presents the Fitzpatrick test data for wetwell vertical forces.

1350 229

Table A-32 presents the Fitzpatrick test data for vent header impact forces.

A.15.4 Discussion and Analysis

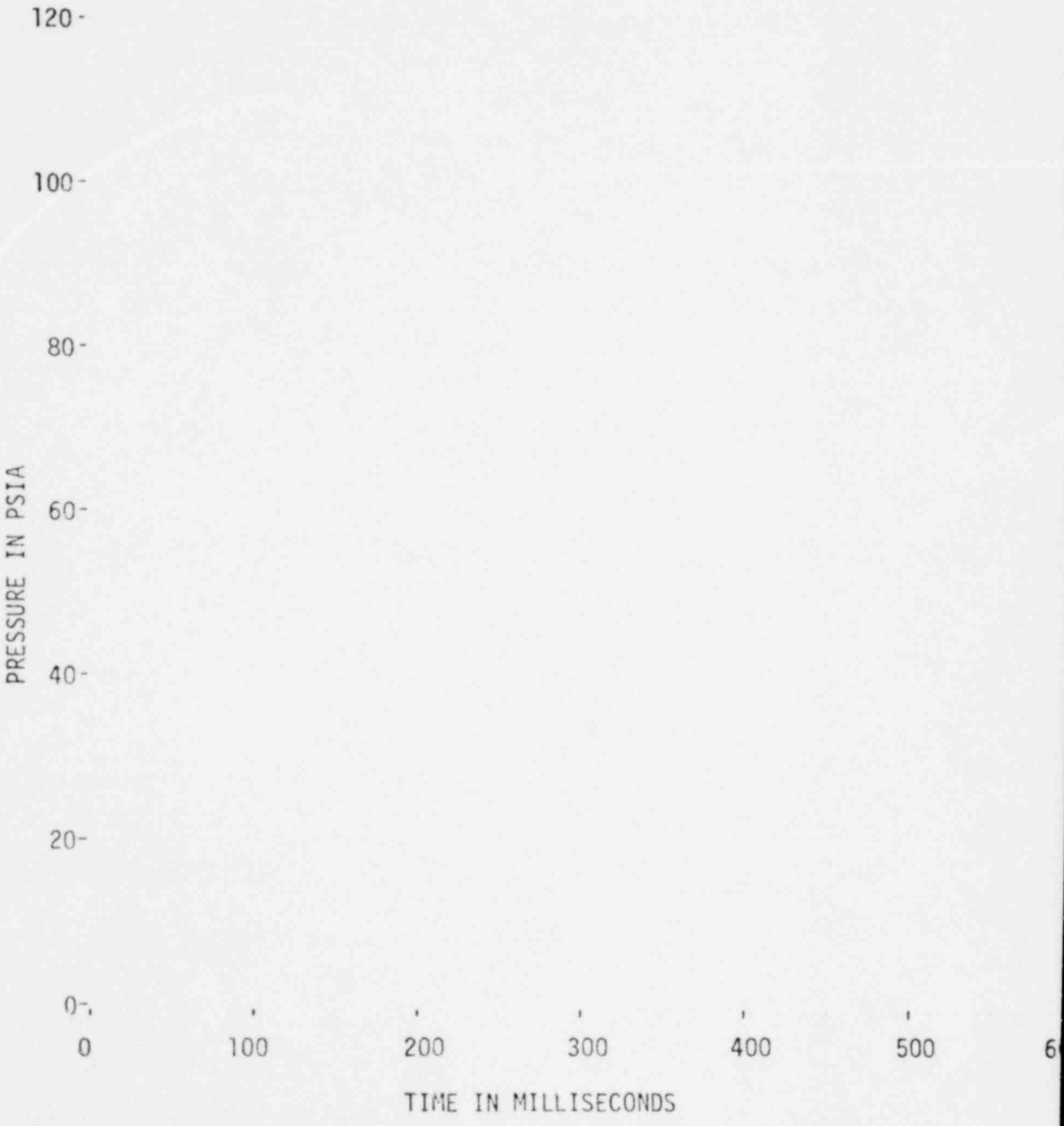
Figure A-763 presents the effect of drywell/wetwell ΔP on the enthalpy flow into the bubbles. Effect of drywell/wetwell ΔP on downcomer internal pressures is shown in Figure A-764. Figure A-765 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. This data for Fitzpatrick parallels that for the "typical" plant in Section 3.0.

The Fitzpatrick load definition tests were conducted at 12.35" H_2O ΔP with a 7.88 inch pipe deflector installed below the vent header. A ΔP sensitivity test at 0" ΔP was also conducted. The upforce was relatively smooth; the downforce had minor oscillations. The deflector (20" full-scale) effectively reduced vent header impact force.

FIGURE A-711

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 · Fitzpatrick Test 3



1350 231

FIGURE A-712

DRYWELL PRESSURE

Task 5.5.3 . Fitzpatrick Test 3

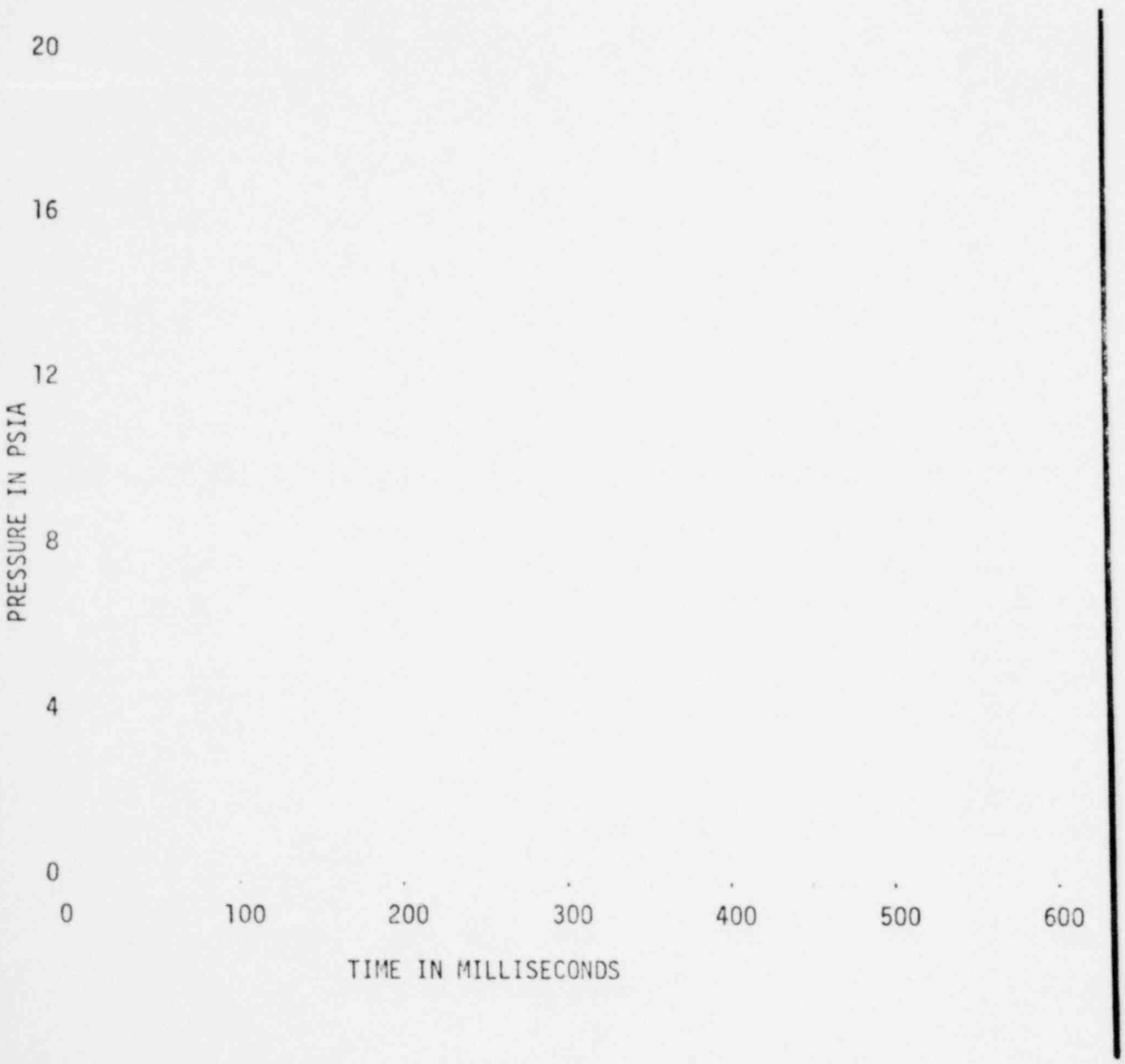
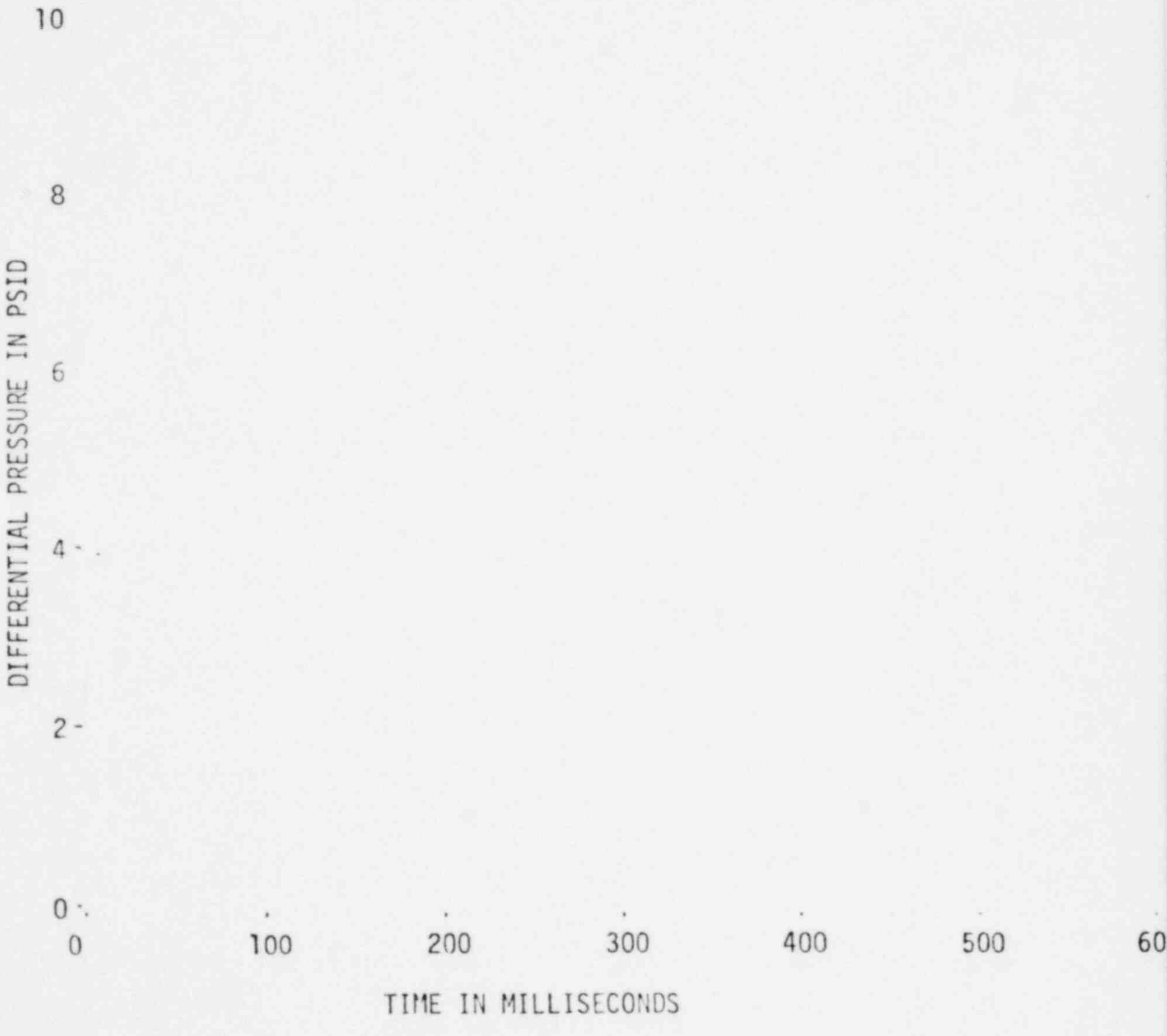


FIGURE A-713

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Fitzpatrick Test 3

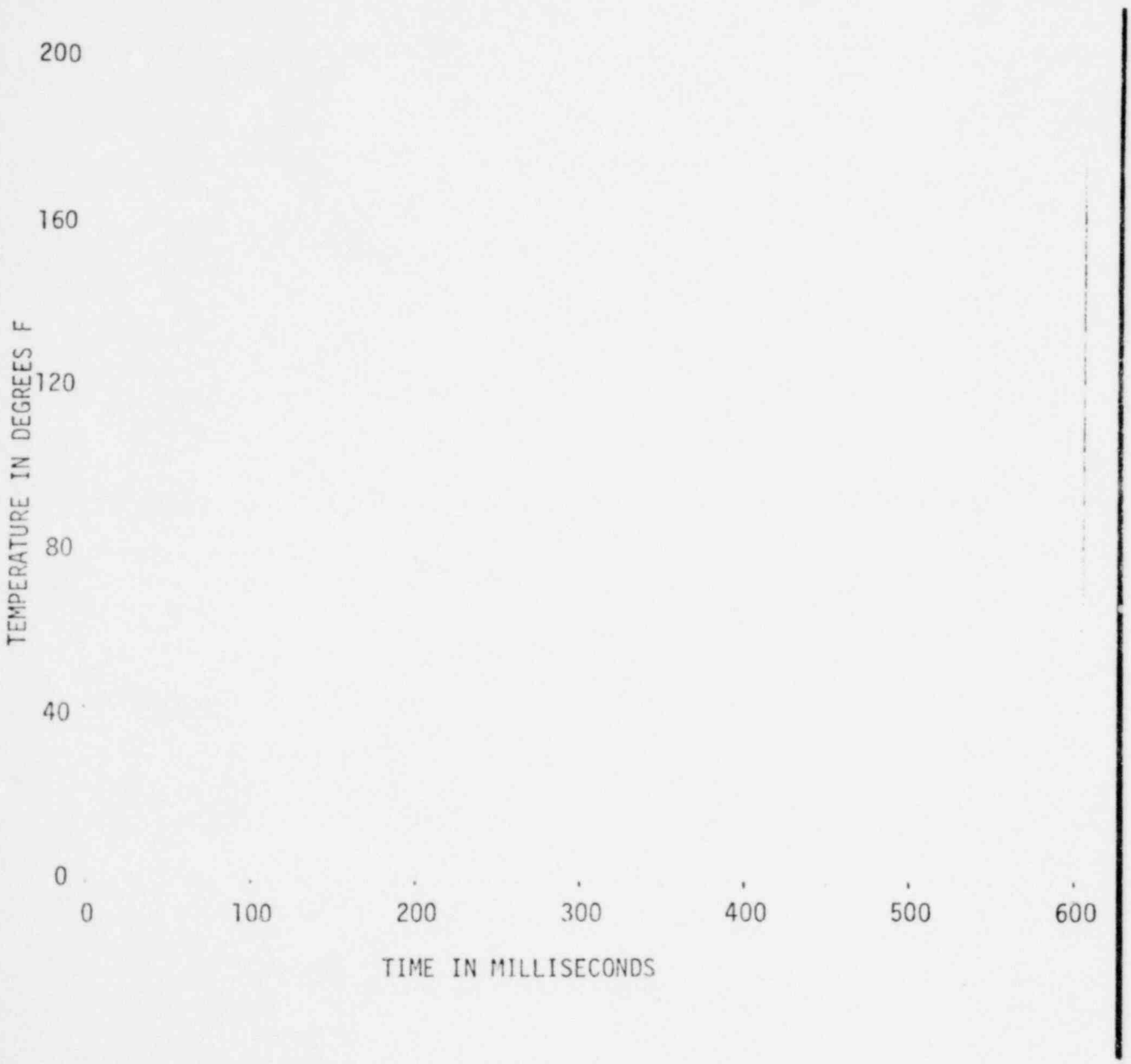


1350 233

FIGURE A-714

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Fitzpatrick Test 3

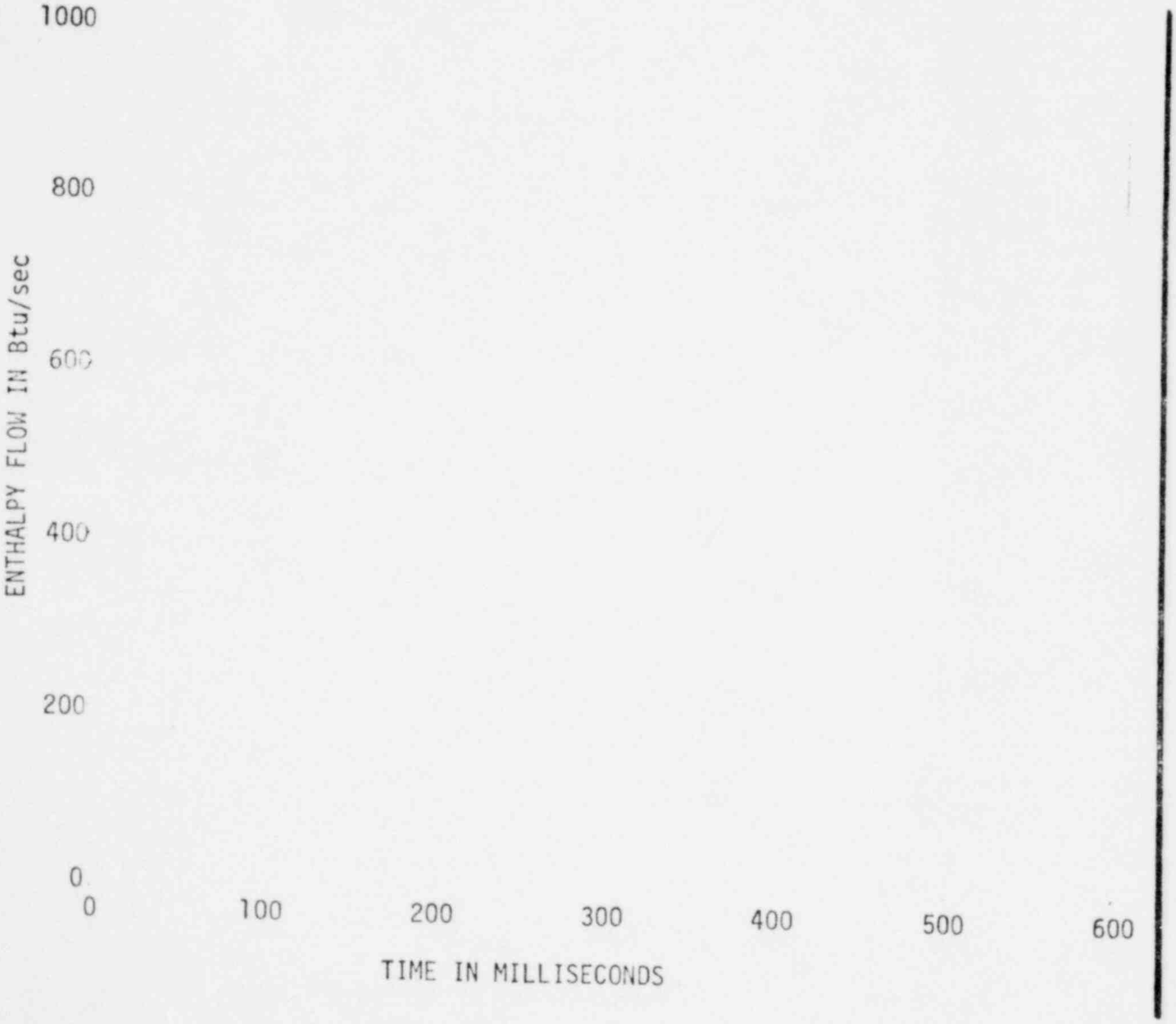


1350 234

FIGURE A-715

ENTHALPY FLOW INTO POOL

Task 5.5.3 Fitzpatrick Test 3

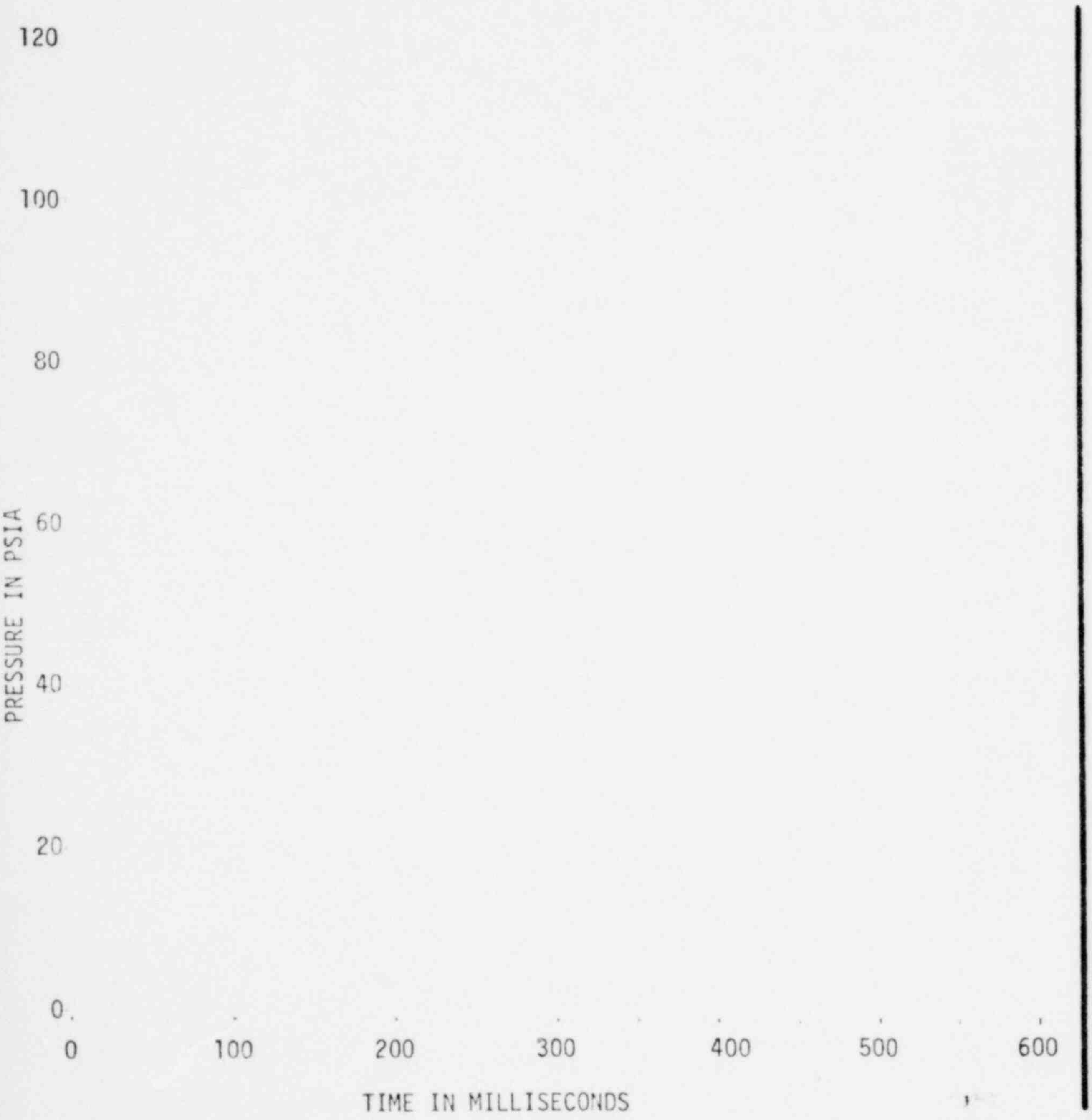


1350 235

FIGURE A-716

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Fitzpatrick Test 5

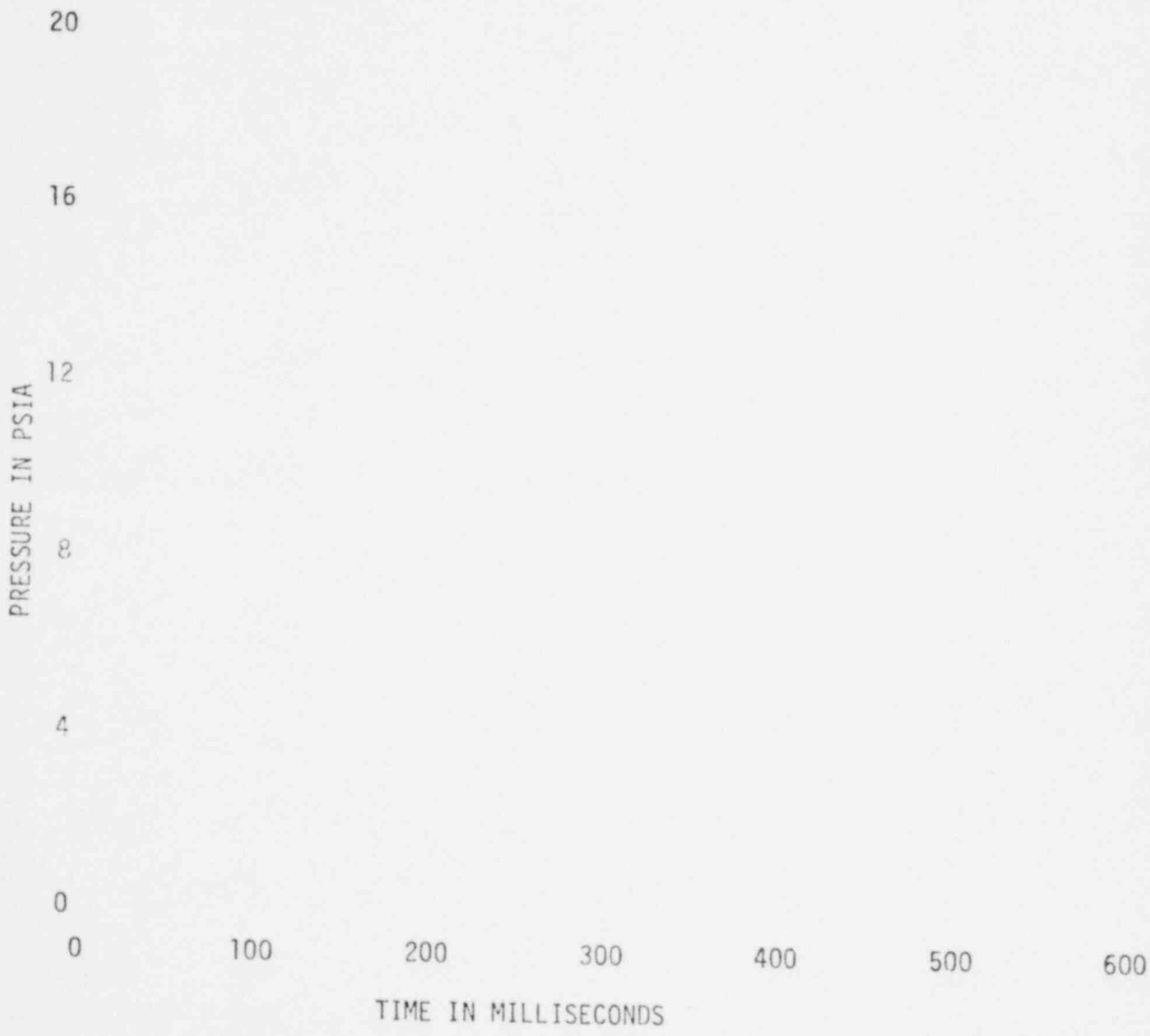


1350 236

FIGURE A-717

DRYWELL PRESSURE

Task 5.5.3 Fitzpatrick Test 5

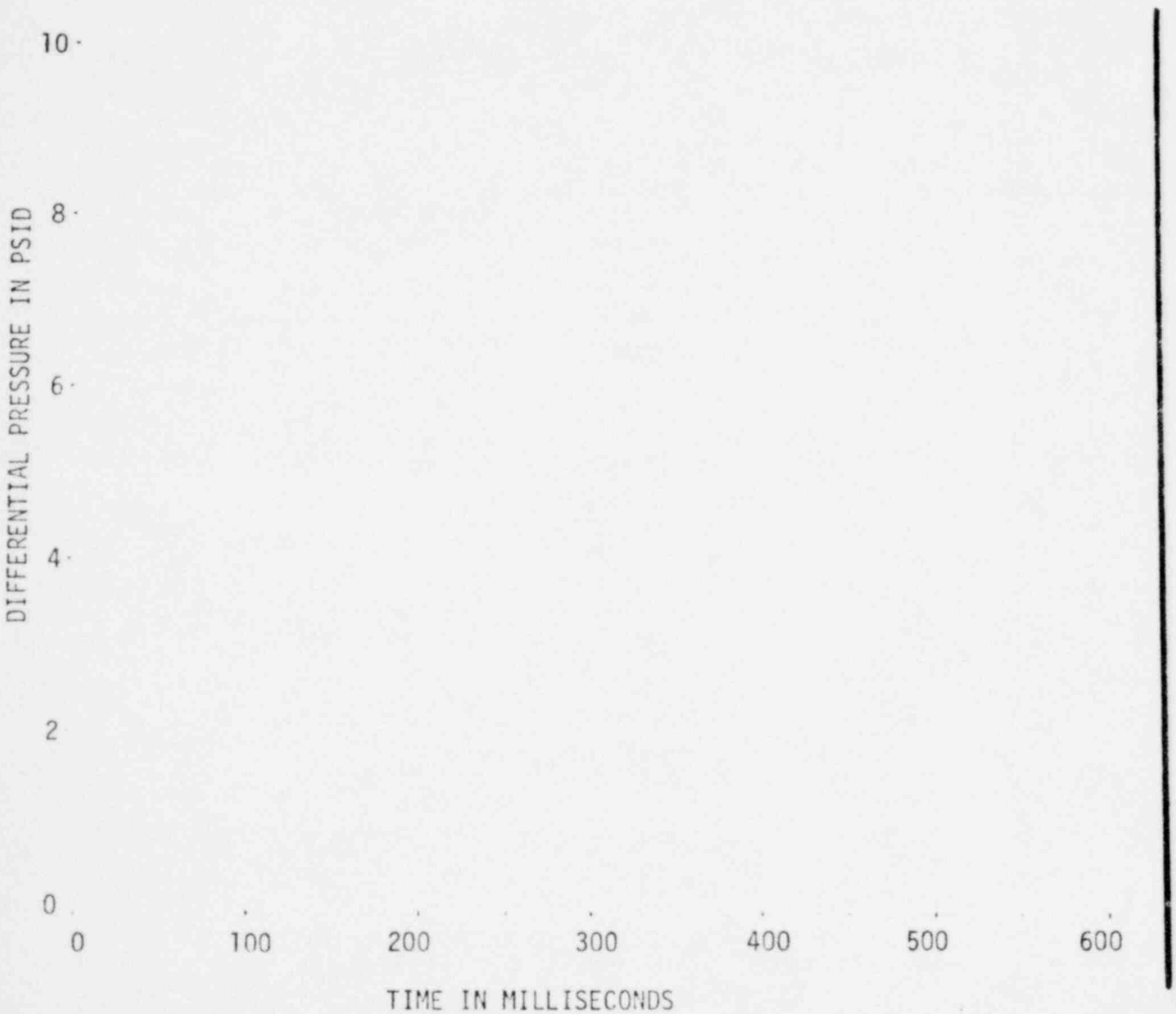


1350 237

FIGURE A-718

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Fitzpatrick Test 5

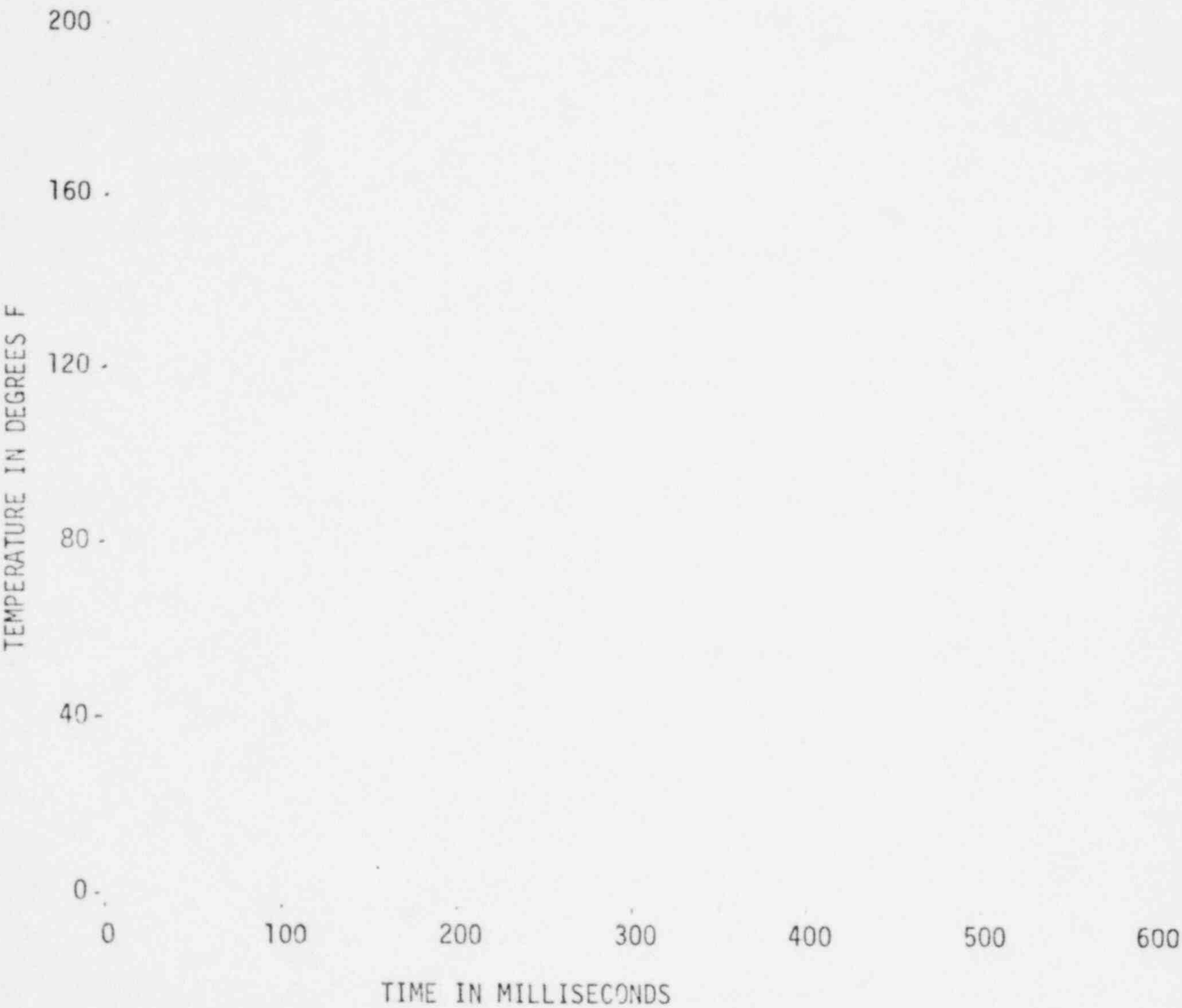


1350 238

FIGURE A-719

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Fitzpatrick Test 5

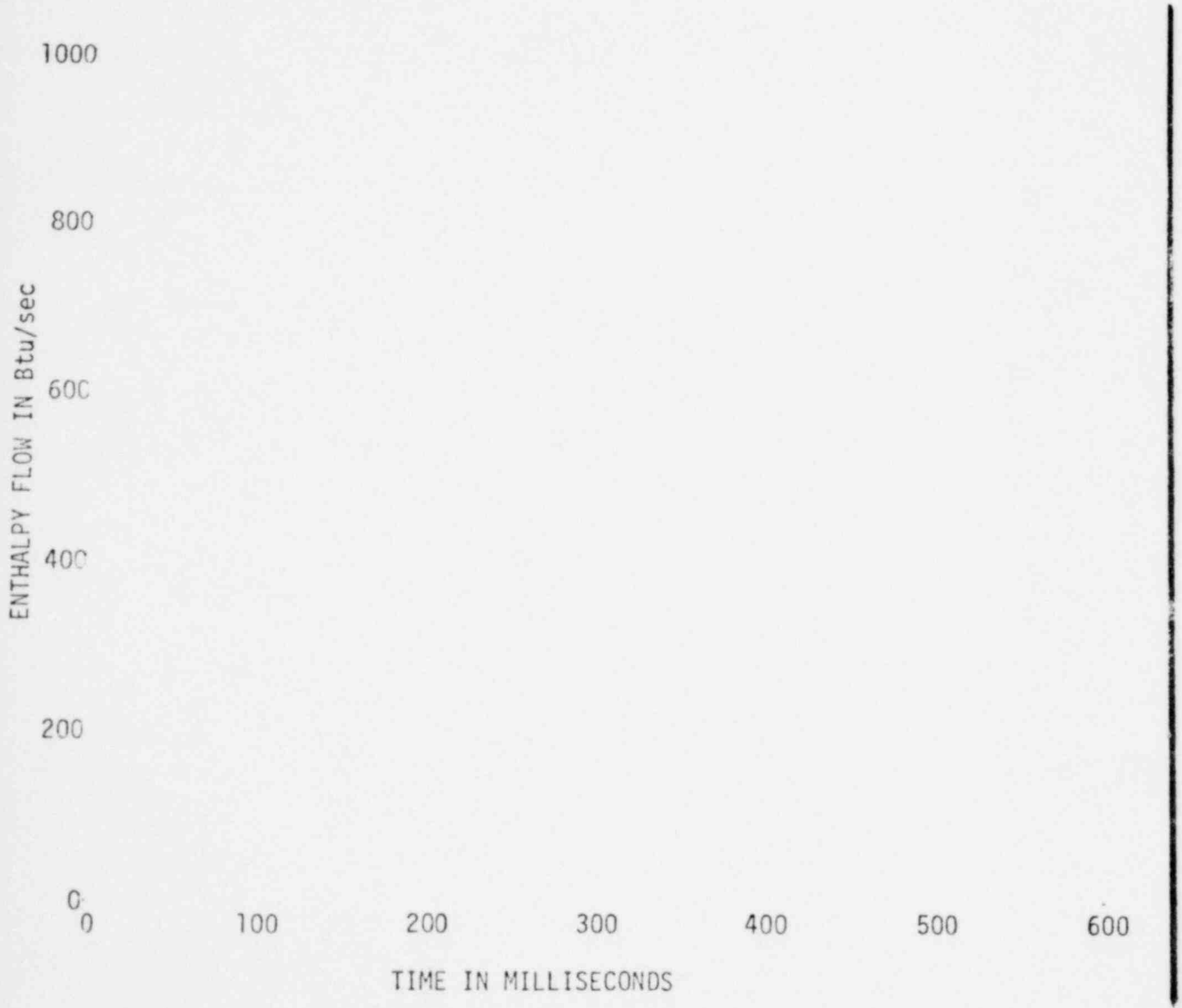


1350 239

FIGURE A-720

ENTHALPY FLOW INTO POOL

Task 5.5.3 Fitzpatrick Test 5



1350 240

FIGURE A-721

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3   Fitzpatrick Test 3

1350 241

FIGURE A-722

WETWELL PRESSURES

Task 5.5.3 Fitzpatrick Test 3

1350 242

FIGURE A-723

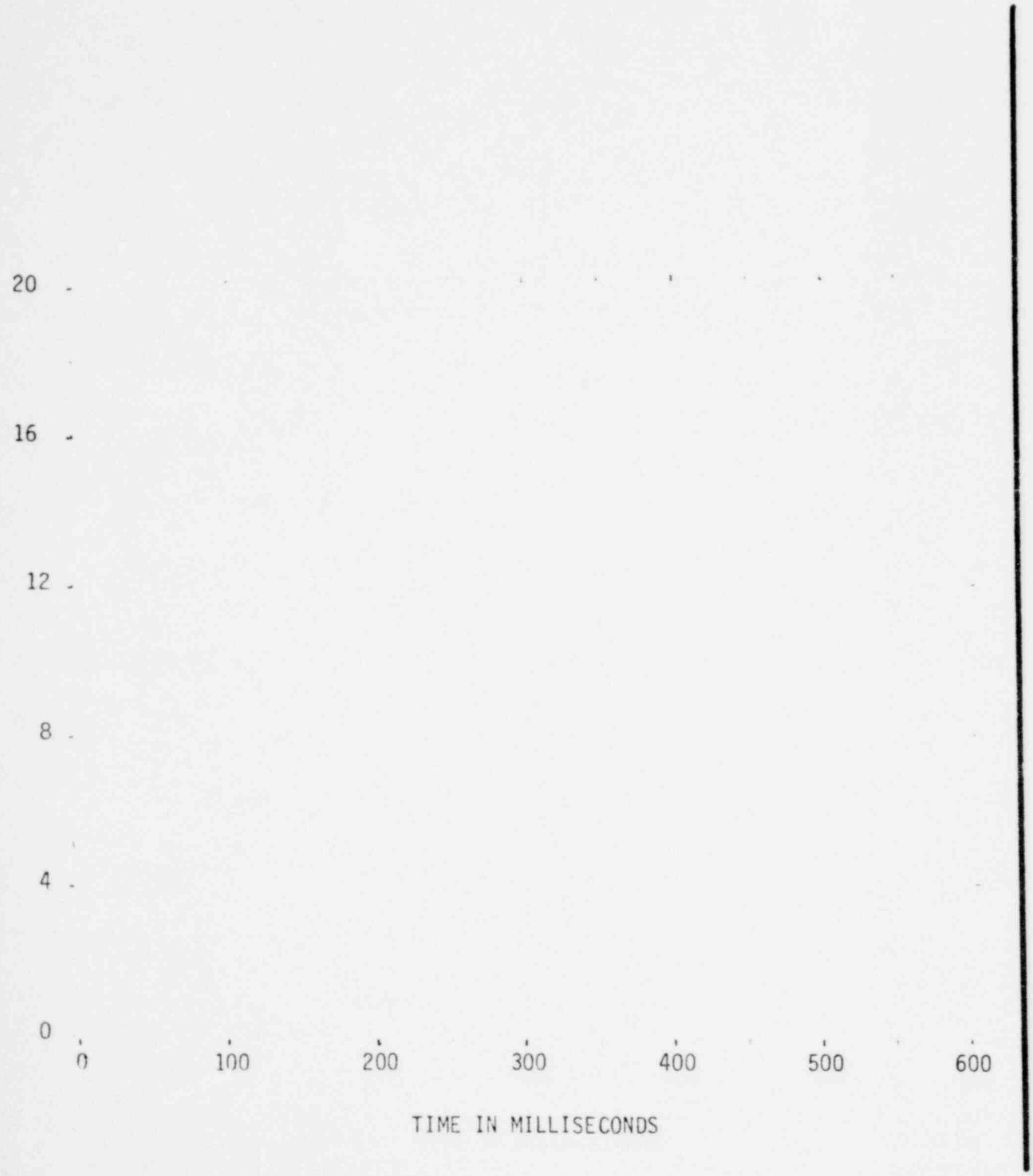
DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Fitzpatrick Test 5

1350 243

FIGURE A-724
NEDO-21944
WETWELL PRESSURES

Task 5.5.3 Fitzpatrick Test 5



1350 244

FIGURE A-725

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Fitzpatrick Test 3

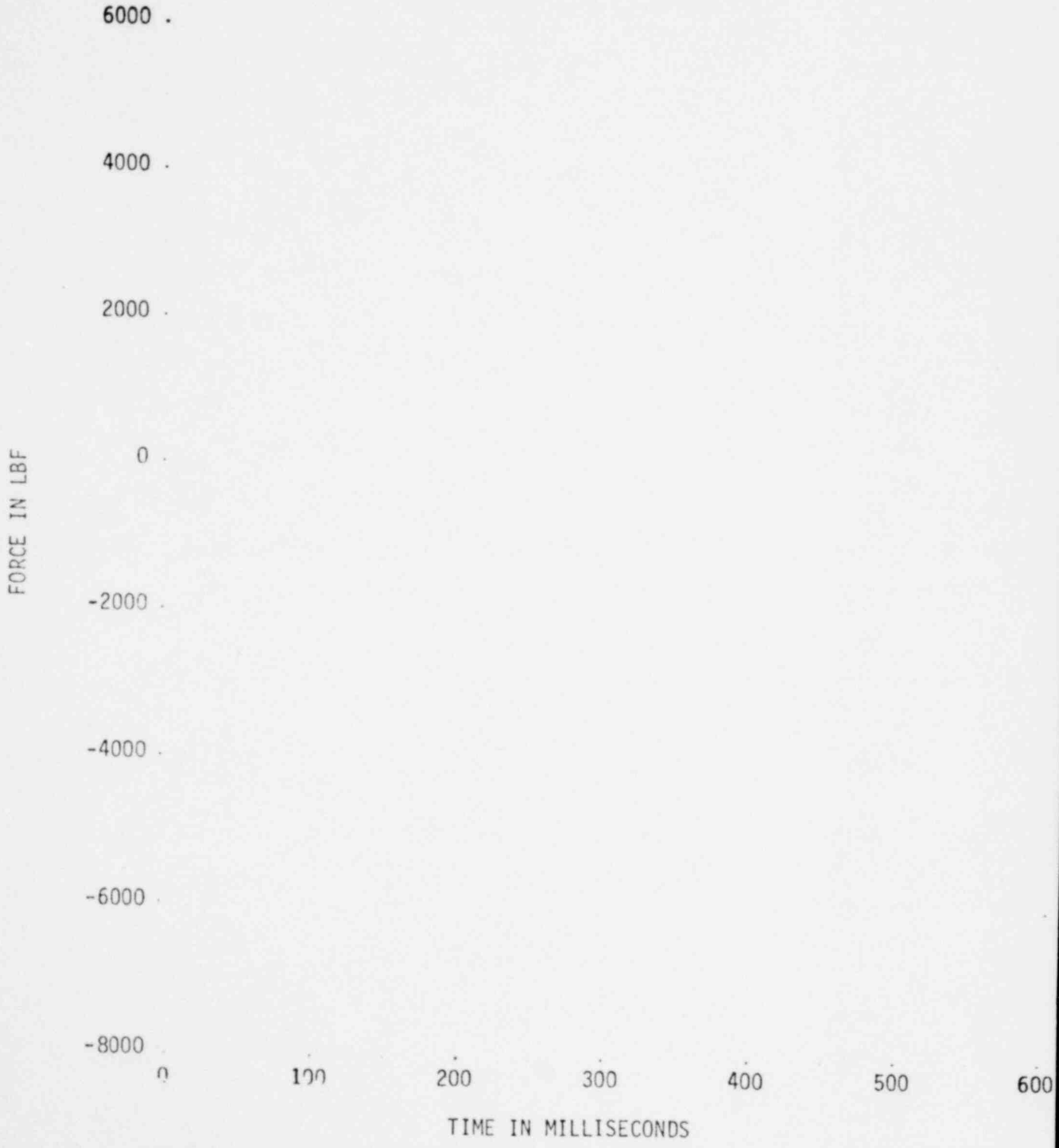
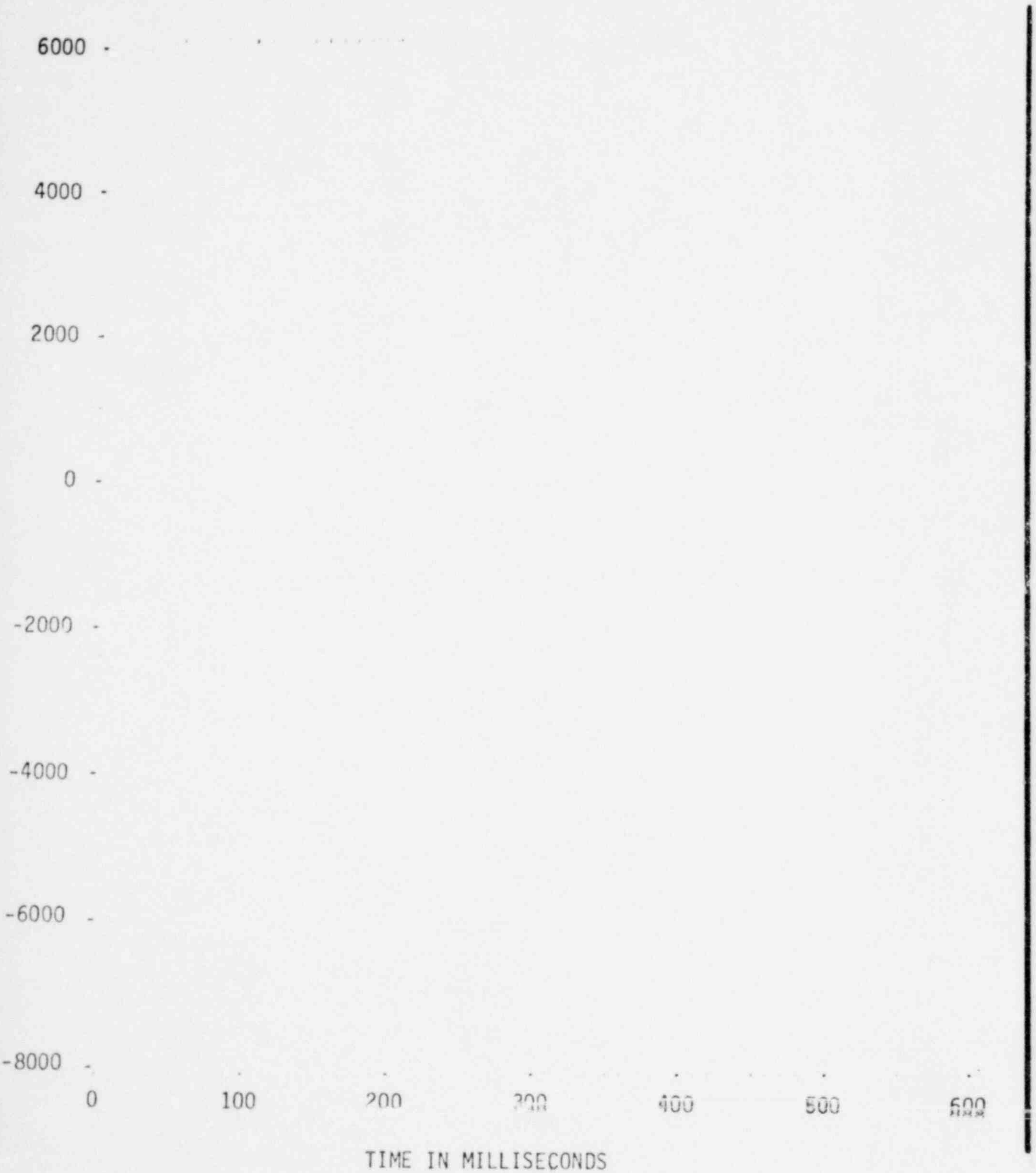


FIGURE A-726

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3   Fitzpatrick Test 5

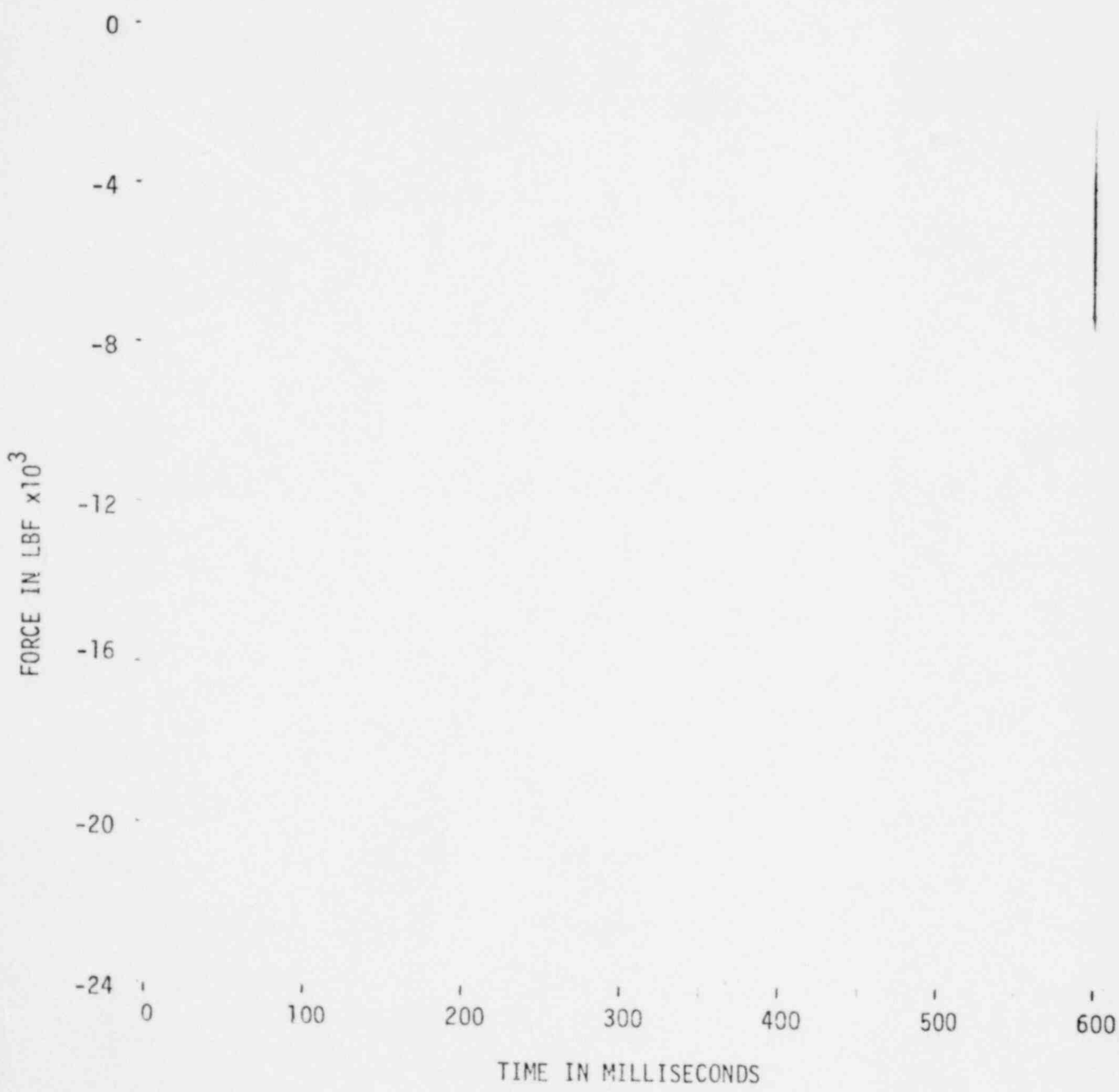


1350 246

FIGURE A-727

TORUS LOAD CELL

Task 5.5.3 Fitzpatrick Test 3

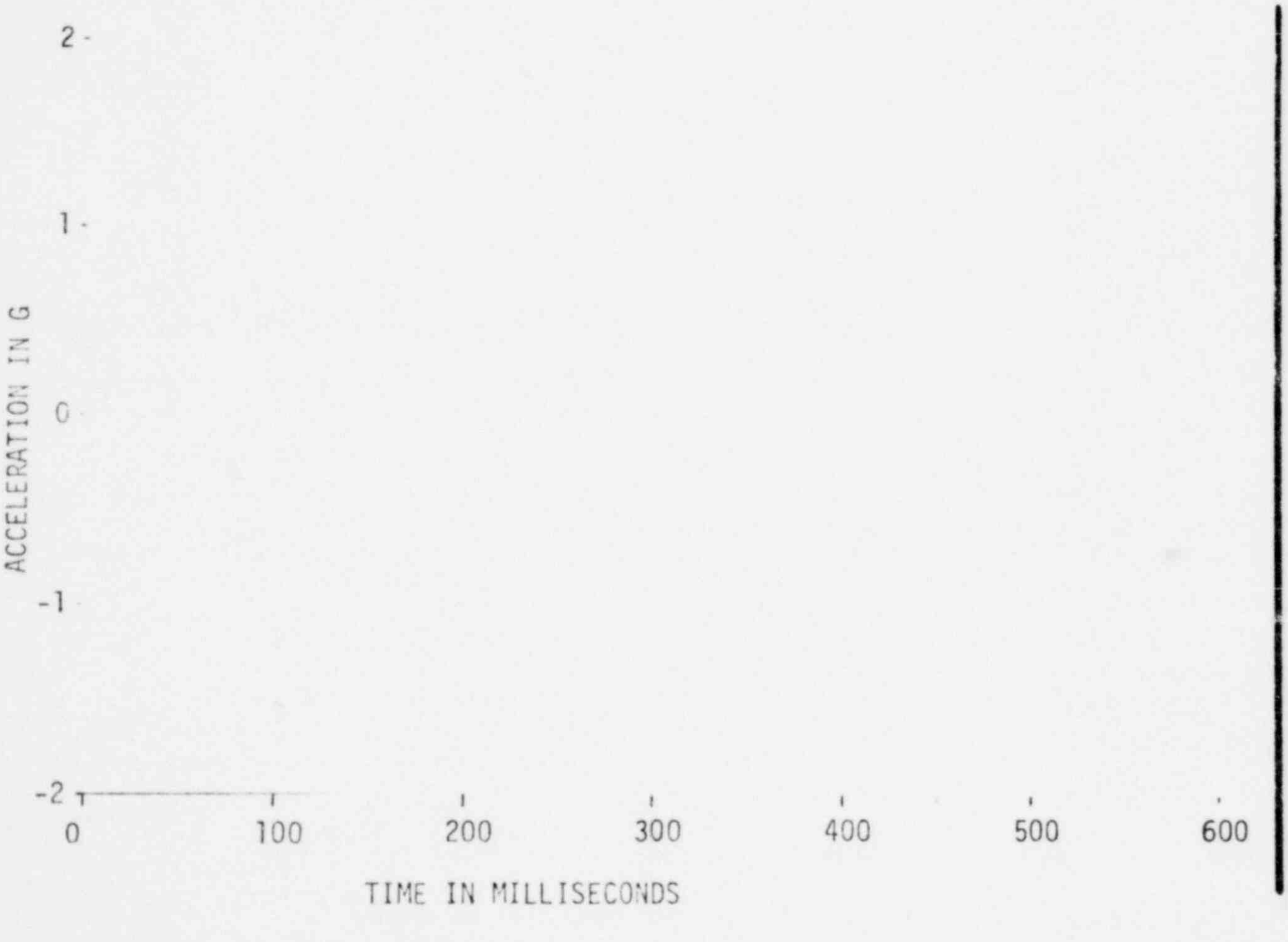


1350 247

FIGURE A-728

TORUS VERTICAL ACCELERATION

Task 5.5.3 Fitzpatrick Test 3

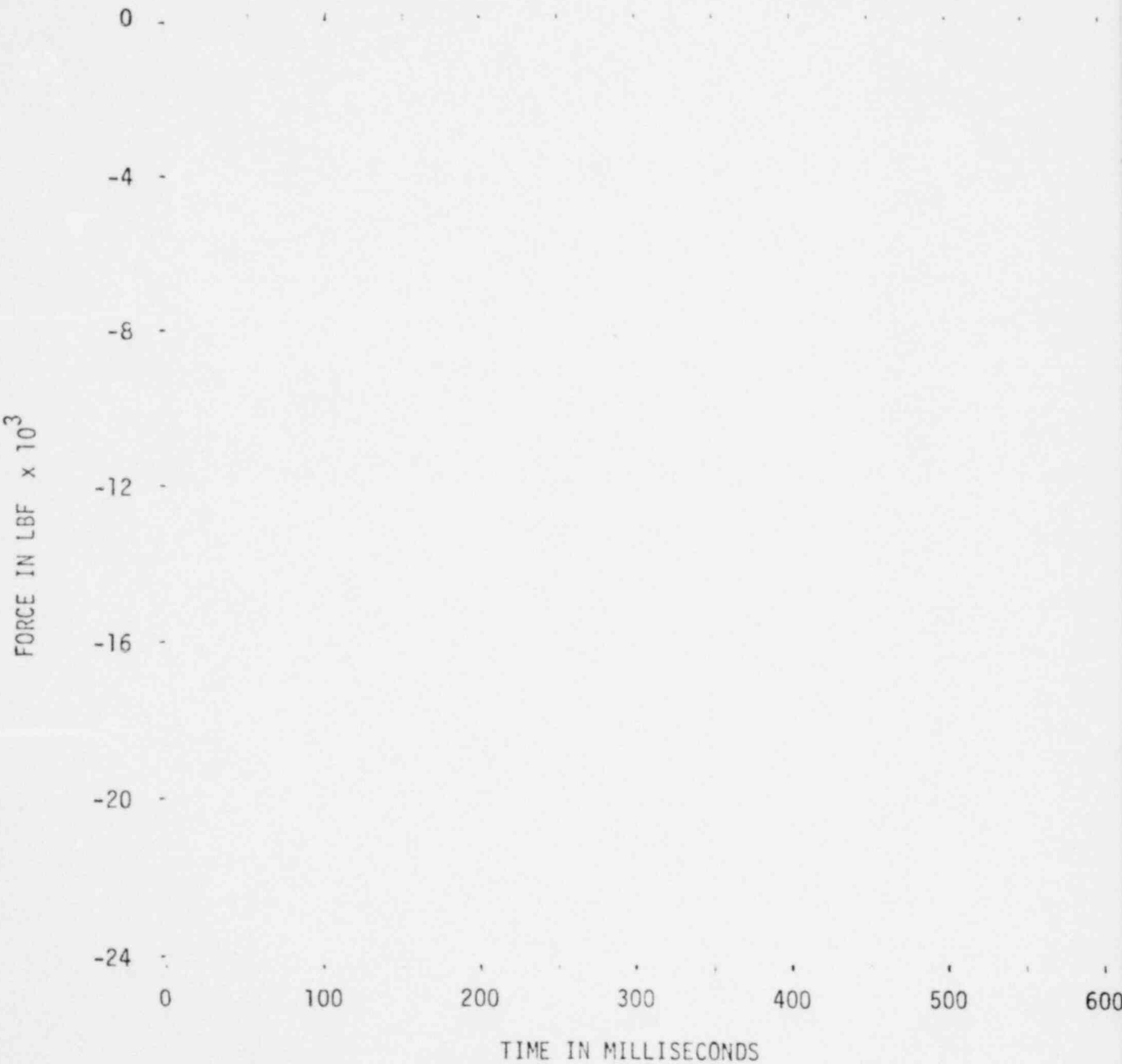


1350 248

FIGURE A-729

TORUS LOAD CELL

Task 5.5.3 Fitzpatrick Test 5



1350 249

FIGURE A-730

TORUS VERTICAL ACCELERATION

Task 5.5.3 Fitzpatrick Test 5

1350 250

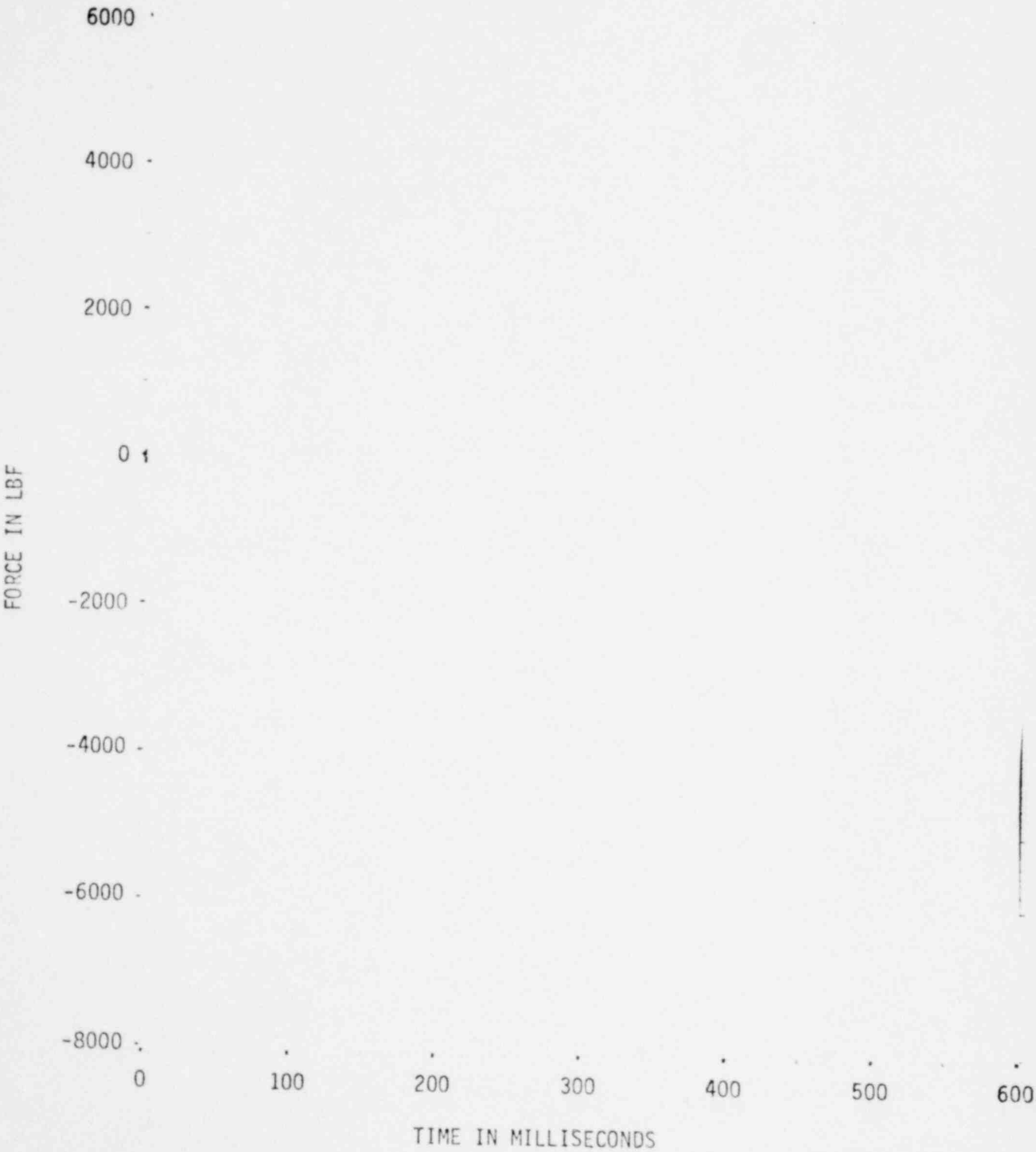
FIGURE A-731

NEDO-21944

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Fitzpatrick Test 3



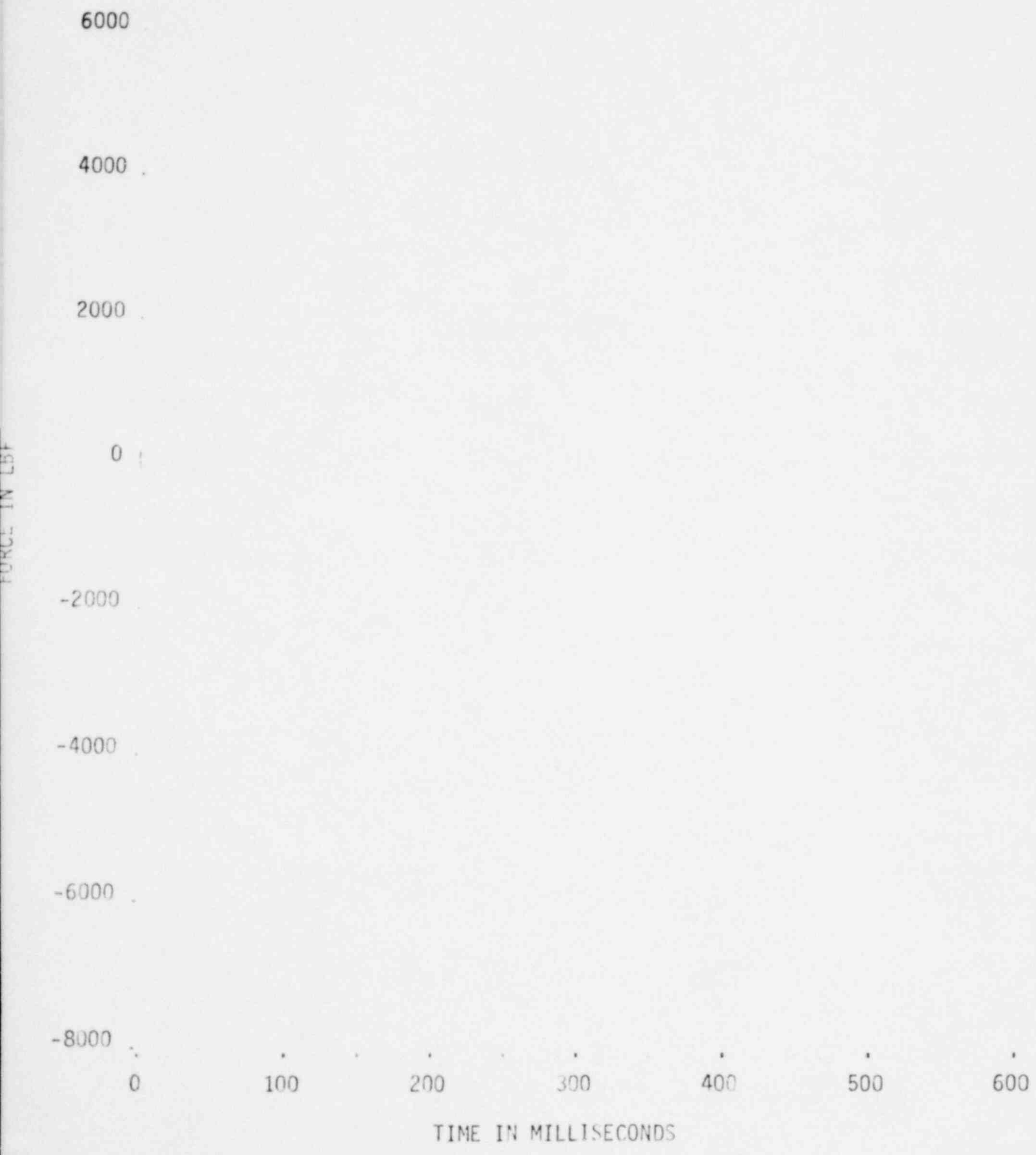
1350 251

FIGURE A-732

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3   Fitzpatrick Test 5

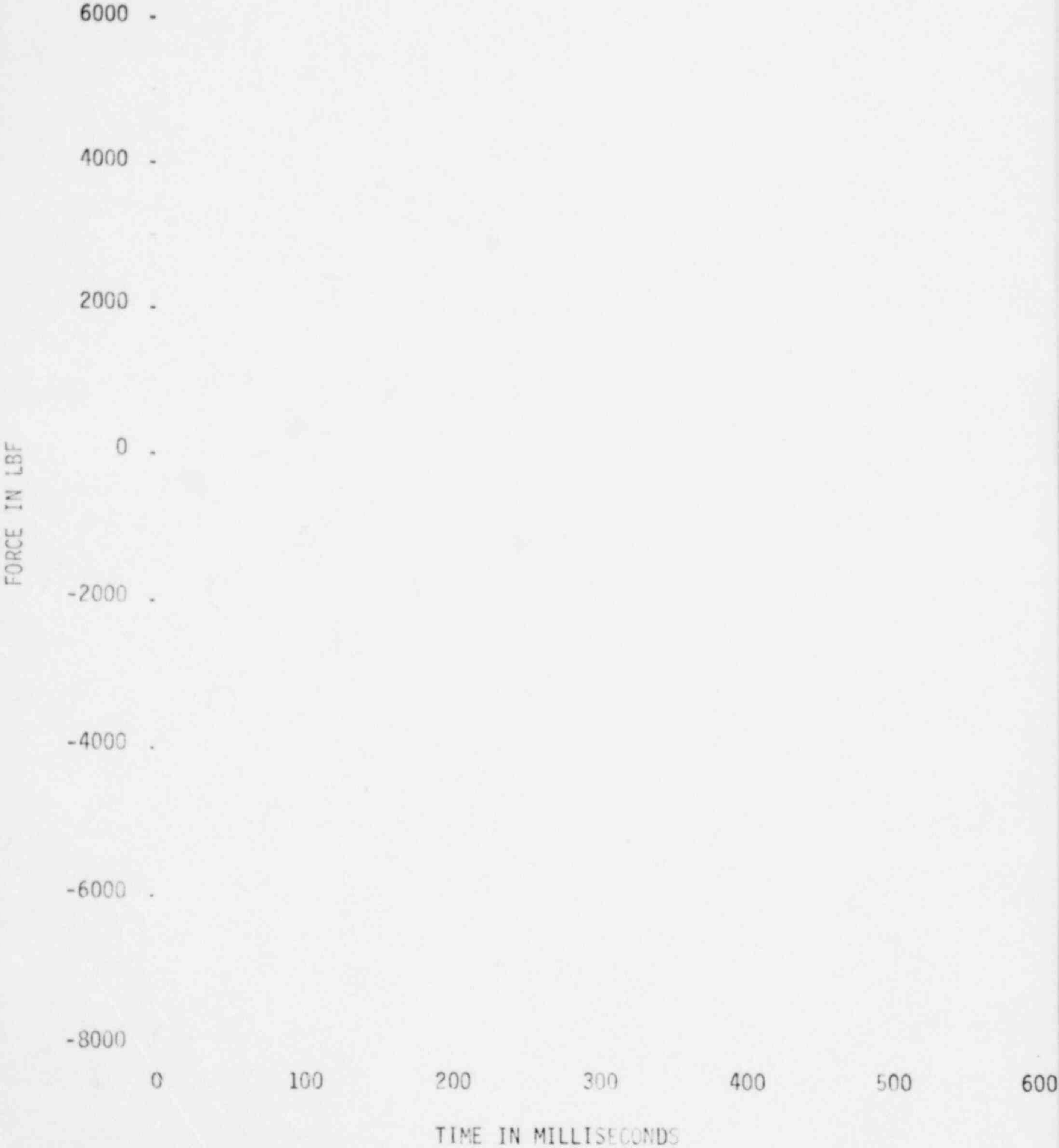


1350 252

FIGURE A-733

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Fitzpatrick Test 3

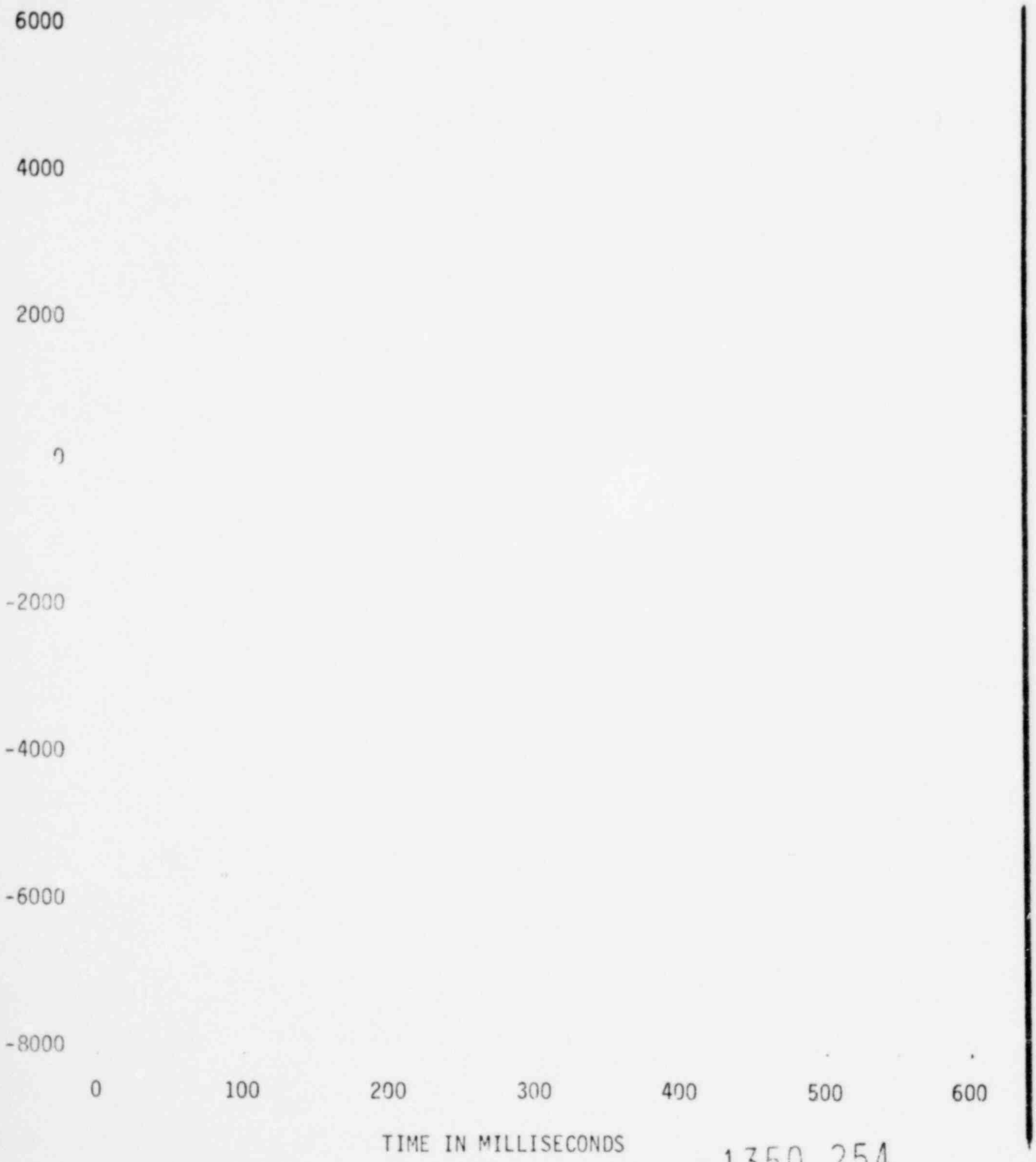


1350 253

FIGURE A-734
NEDO-21944

NET TORUS FORCE FROM PRESSURE, INTEGRAL CORRECTED FOR WATER INERTIA

Task 5.5.3   Fitzpatrick Test 5

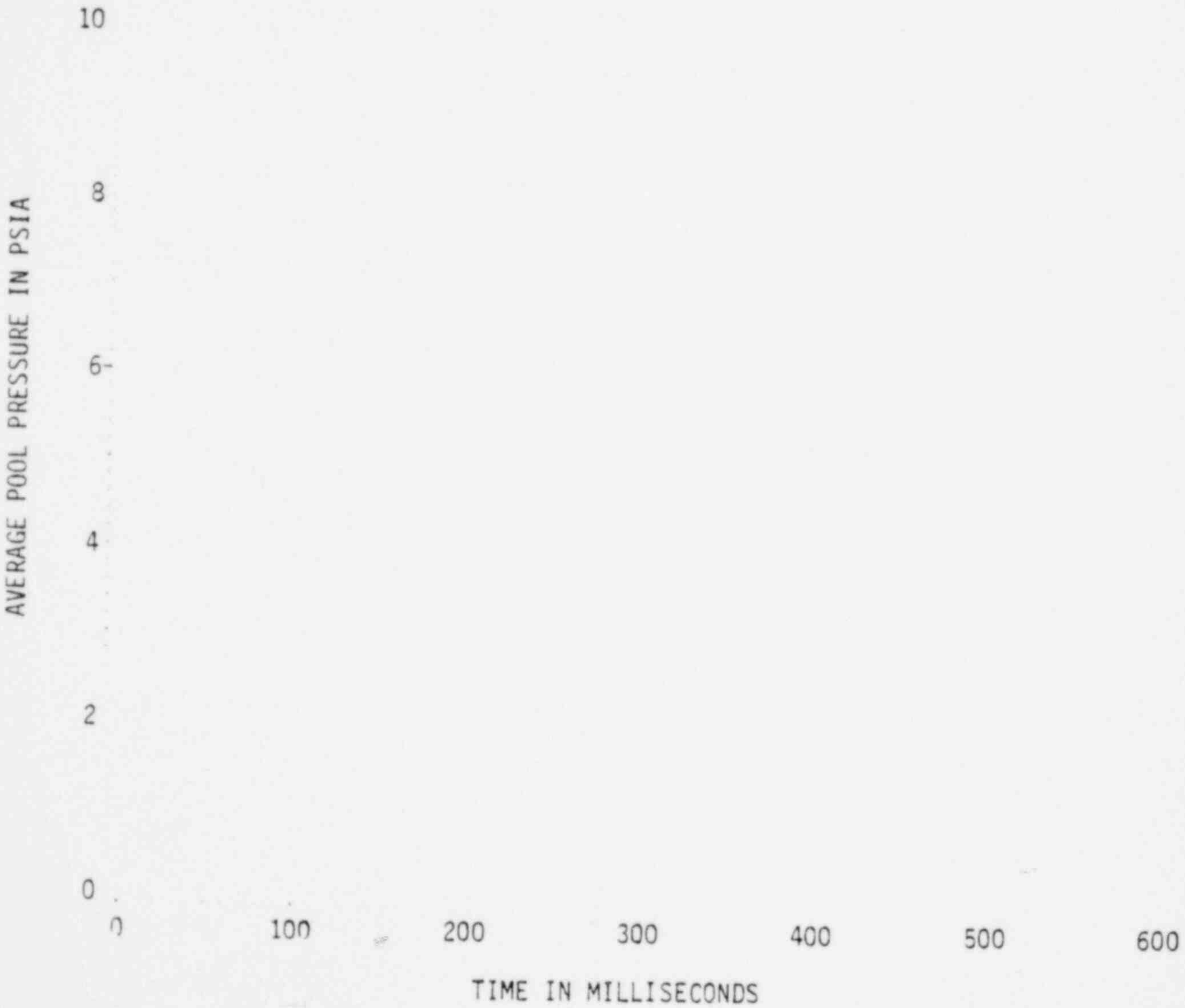


1350 254

FIGURE A-735

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Fitzpatrick Test 3

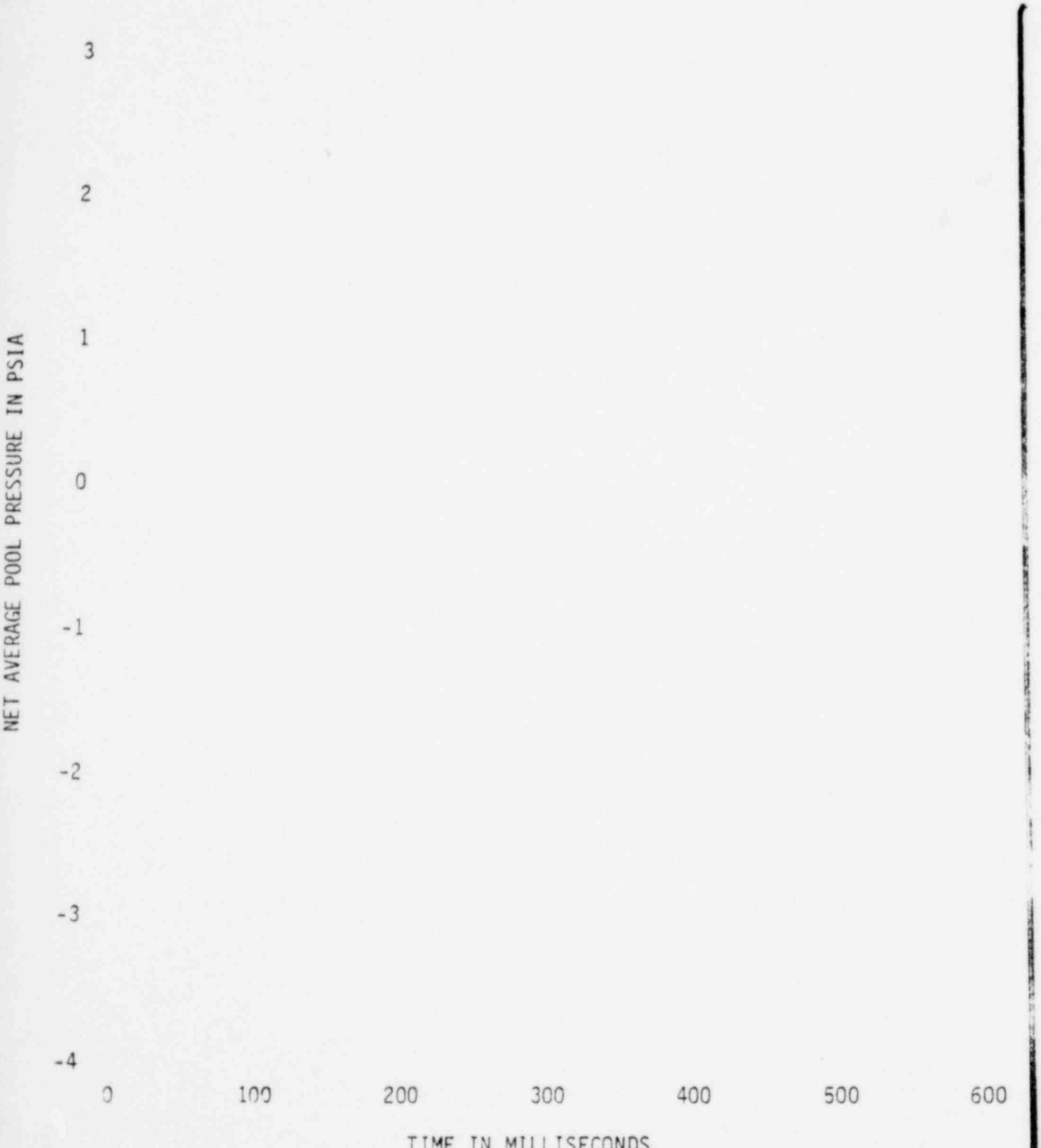


1350 255

FIGURE A-736

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Fitzpatrick Test 3

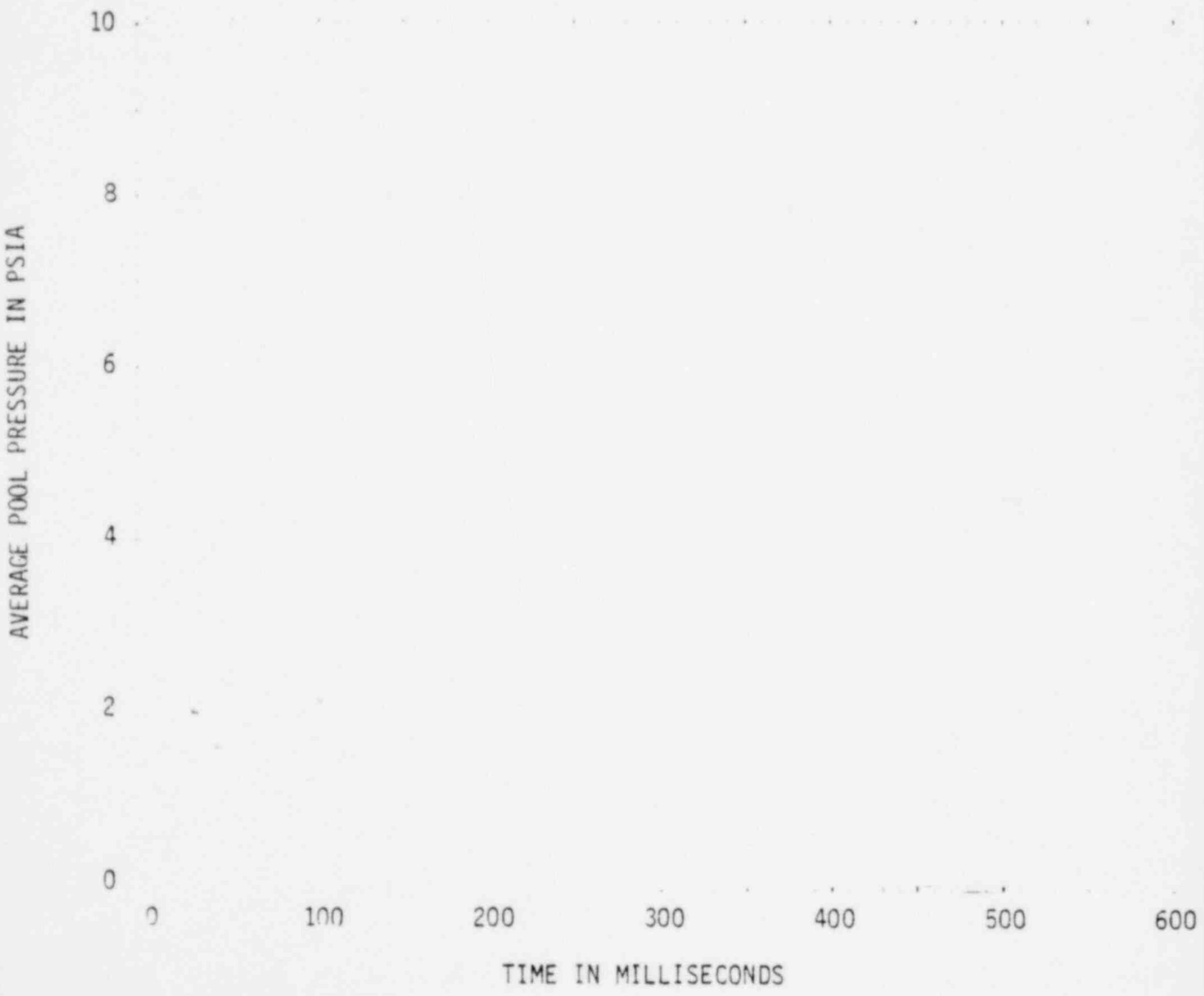


1350 256

FIGURE A-737

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Fitzpatrick Test 5



1350 257

FIGURE A-738

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

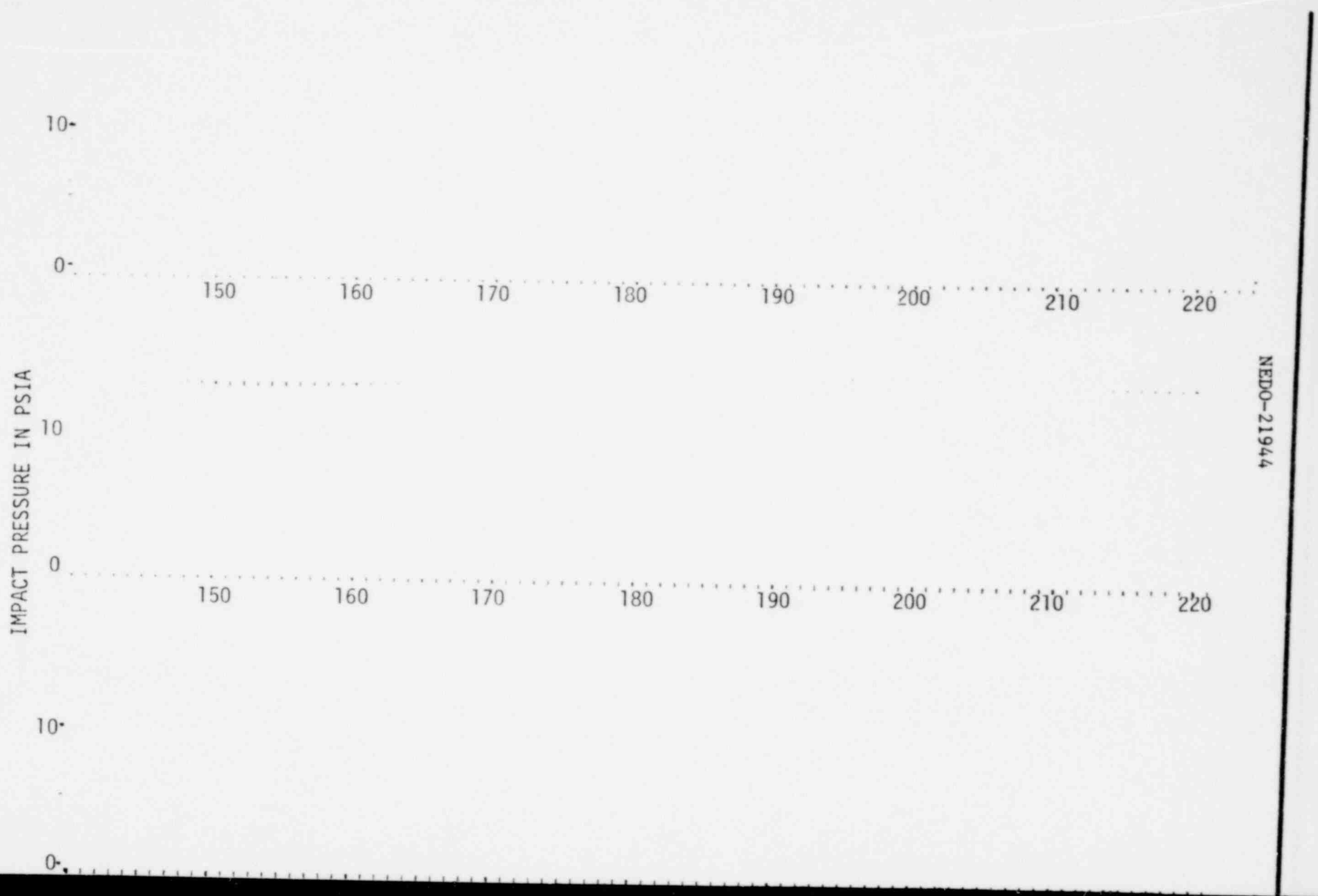
Task 5.5.3 Fitzpatrick Test 5

1350 258

FIGURE A-739

VENT HEADER IMPACT PRESSURES

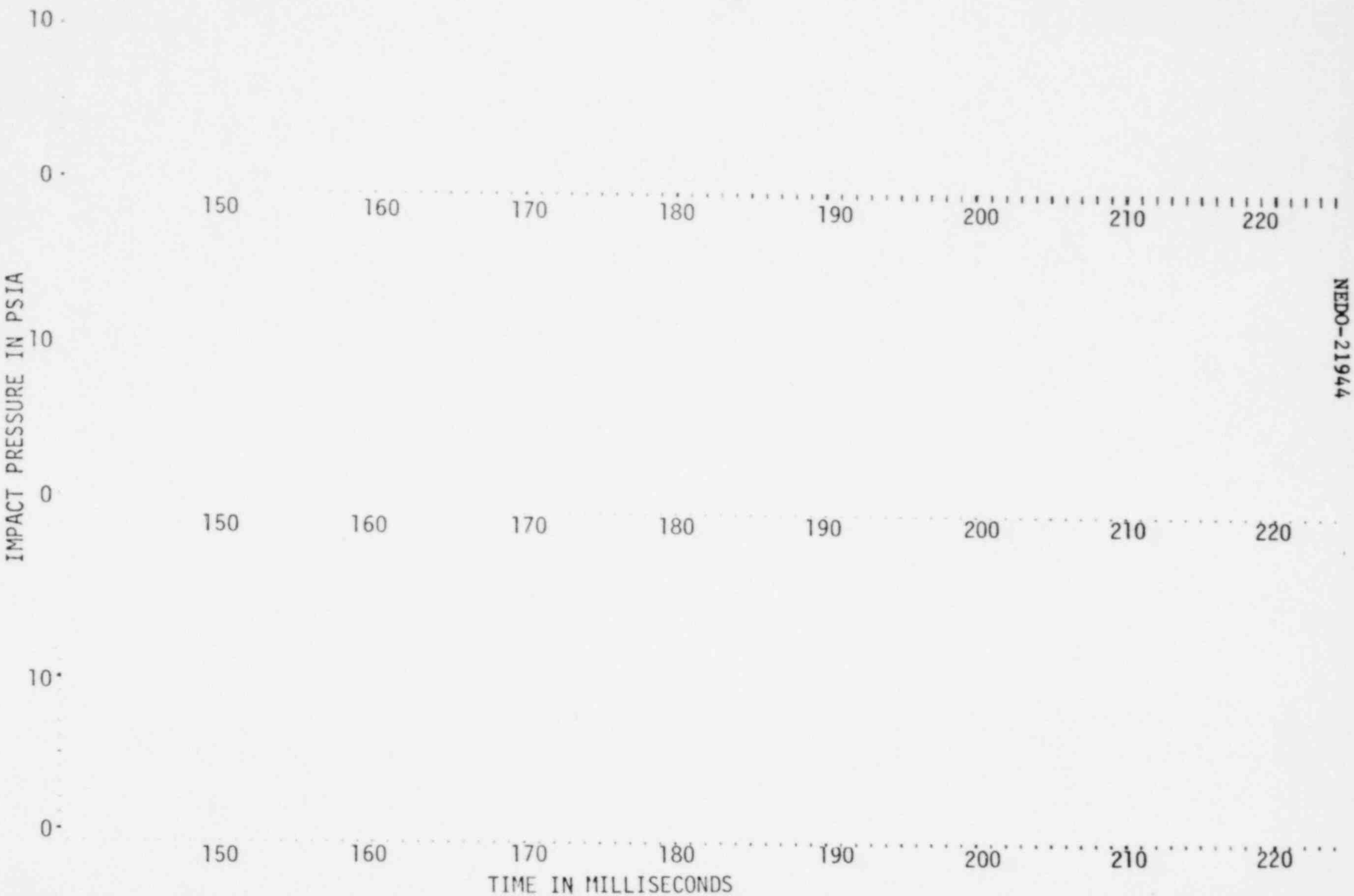
Task 5.5.3 Fitzpatrick Test 3



1350 259

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Fitzpatrick Test 3



1350 260

FIGURE A-741

VENT HEADER IMPACT PRESSURES

Task 5.5.3   Fitzpatrick Test 3

1350 261

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Fitzpatrick Test 3

1350 262

FIGURE A-743

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Fitzpatrick Test 3

1350 263

VENT HEADER IMPACT PRESSURES

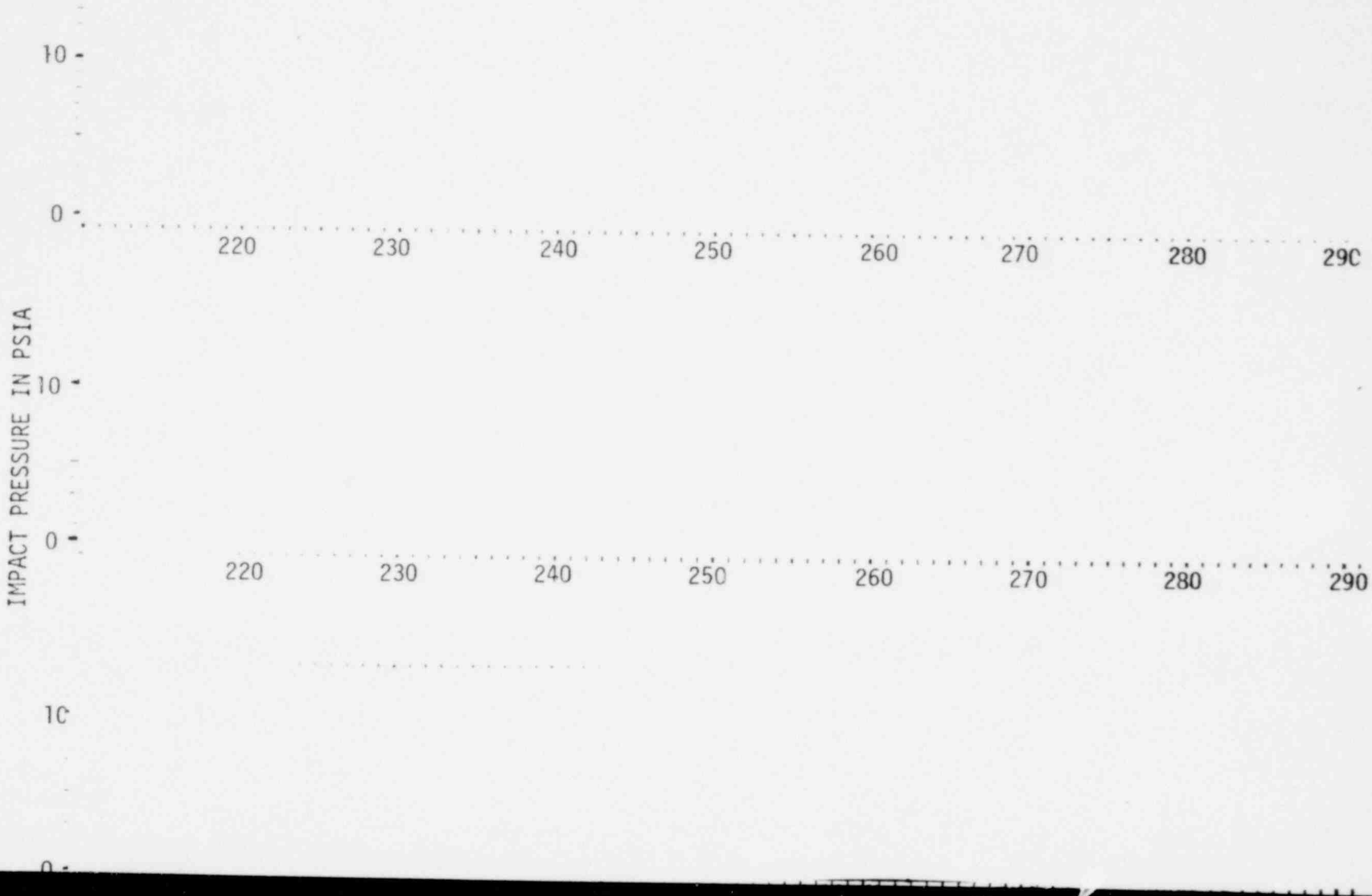
Task 5.5.3 Fitzpatrick Test 5

1350 264

FIGURE A-745

VENT HEADER IMPACT PRESSURES

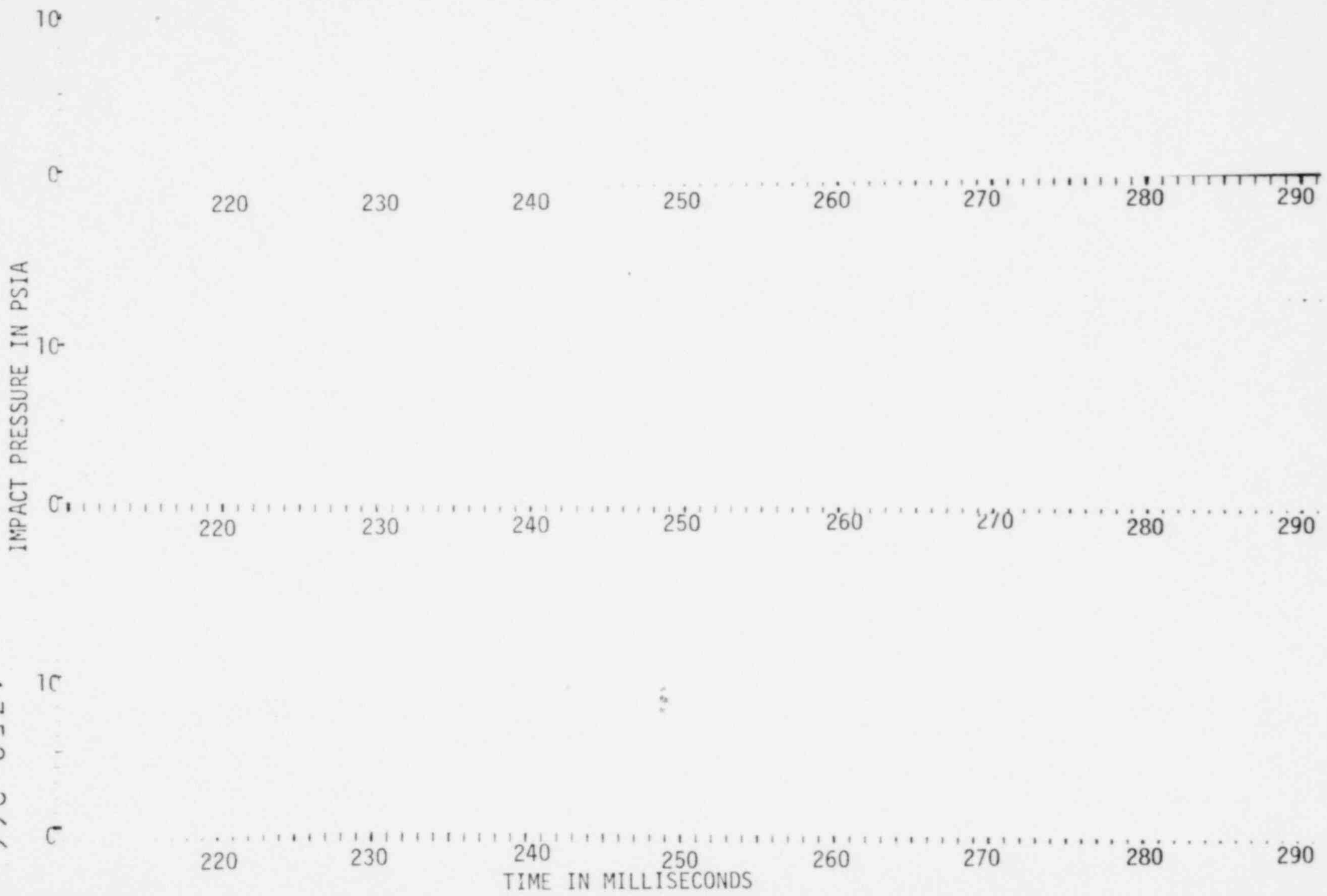
Task 5.5.3 Fitzpatrick Test 5



1350 265

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Fitzpatrick Test 5



1350 266

FIGURE A-747

VENT HEADER IMPACT PRESSURES

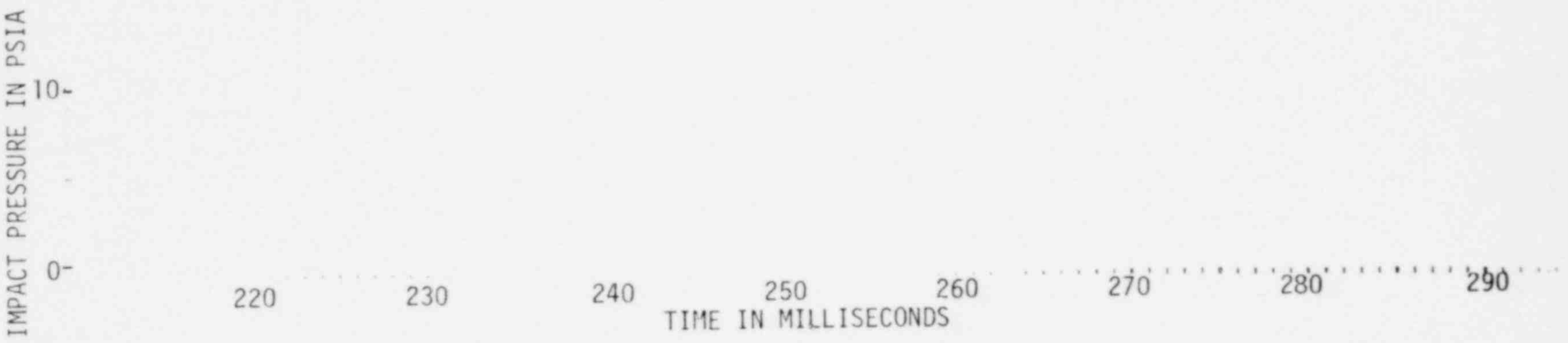
Task 5.5.3 Fitzpatrick Test 5

1350 267

FIGURE A-748

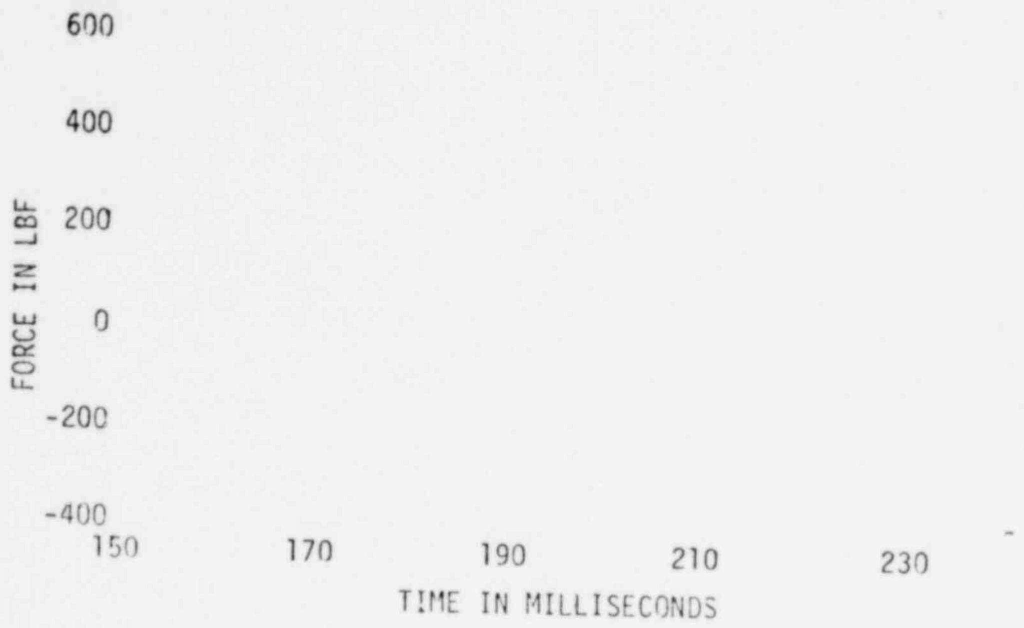
VENT HEADER IMPACT PRESSURES

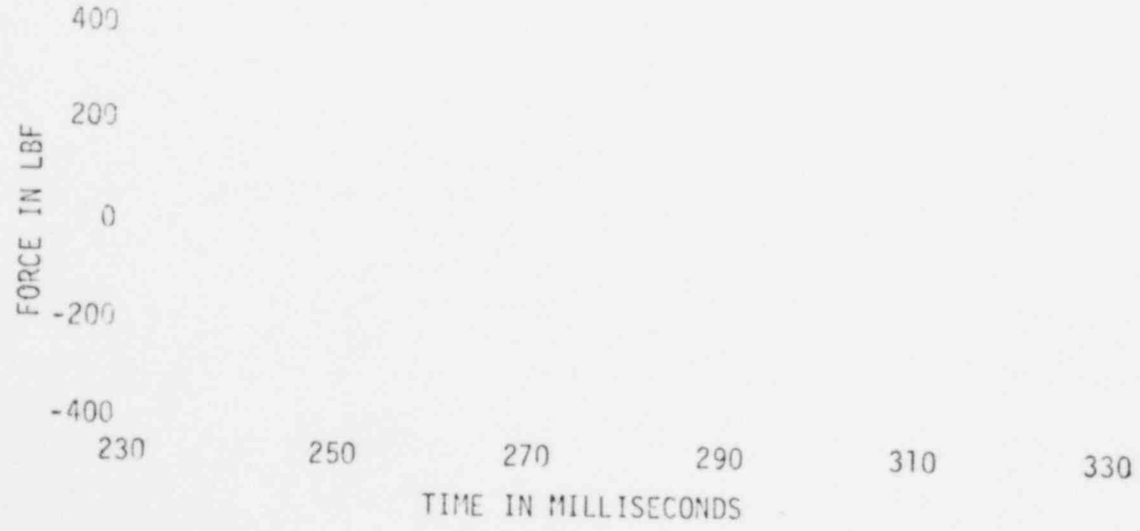
Task 5.5.3 Fitzpatrick Test 5



1350 268

FIGURE A-749 COMPARISON OF VENT HEADER IMPACT RESULTS
(Corrected Load Cell and Pressure Integration)
Task 5.5.3 Fitzpatrick Tests 3,5

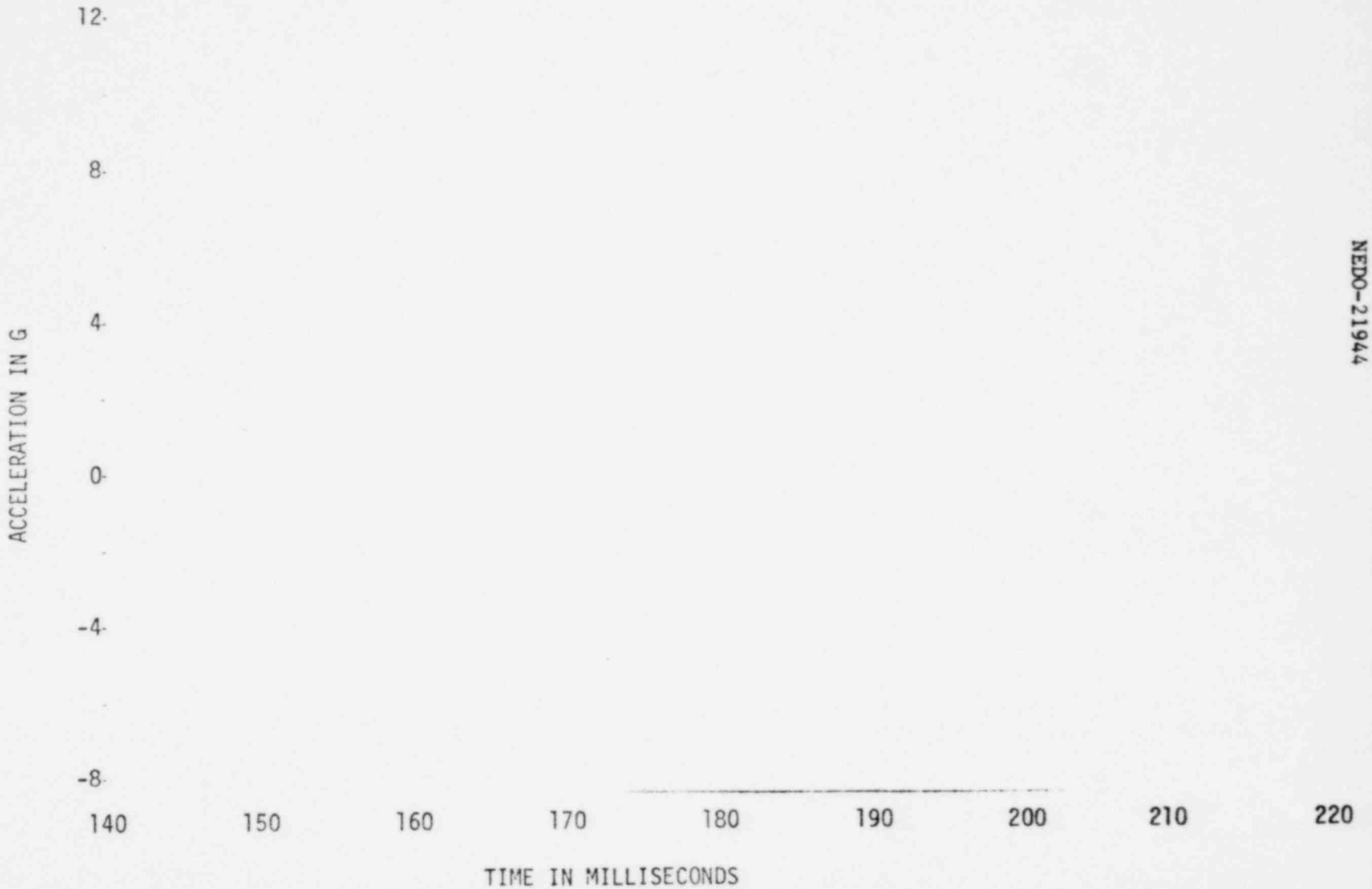




1350 269

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Fitzpatrick Test 3



1350 270

FIGURE A-751

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Fitzpatrick Test 5

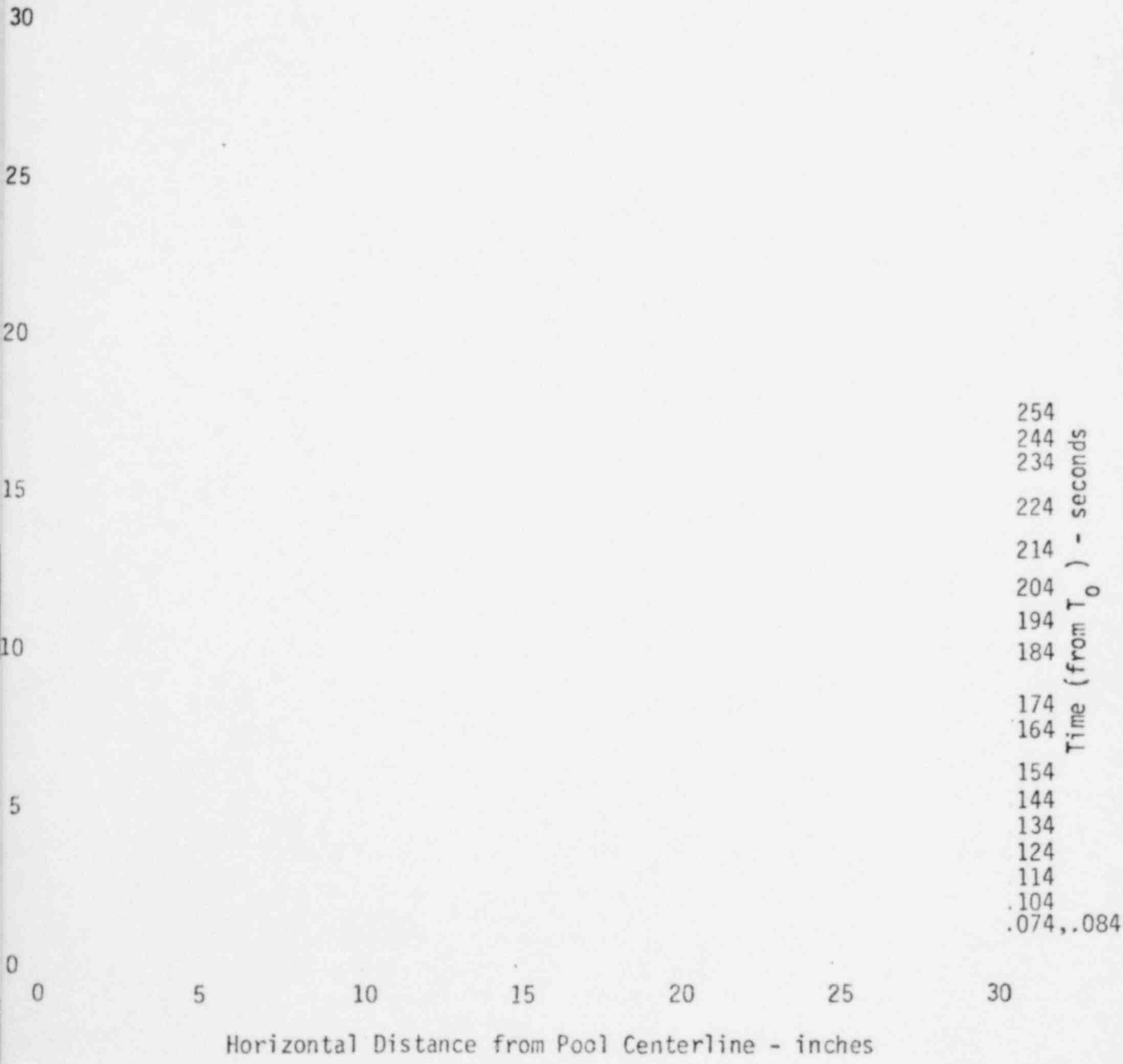
1350 271

FIGURE 4-752

TIME HISTORY OF

POOL DISPLACEMENT

FITZPATRICK, TEST 1



1350 272

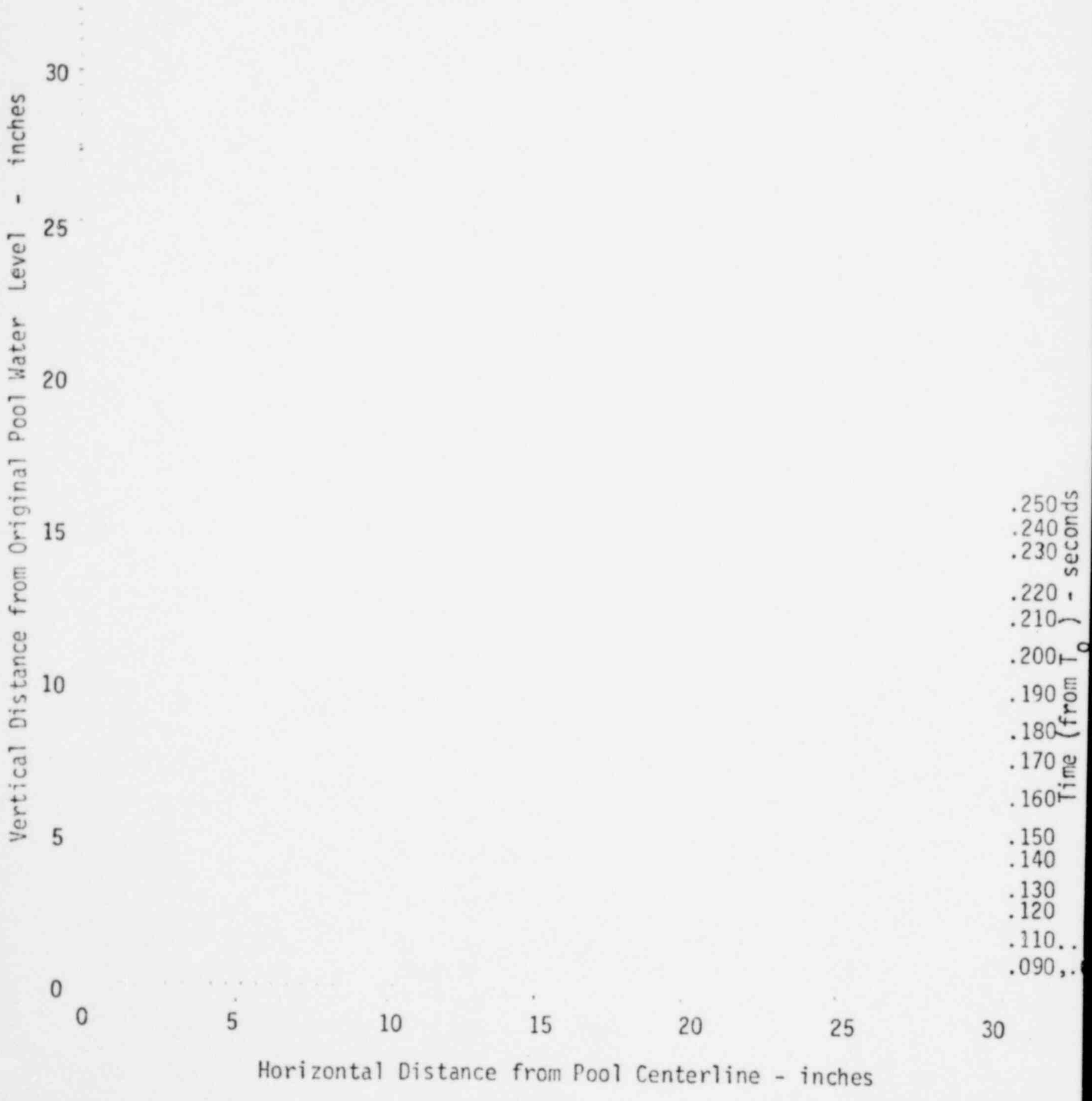
FIGURE A-753

NEDO-21944

TIME HISTORY OF

POOL DISPLACEMENT

FITZPATRICK, TEST 2



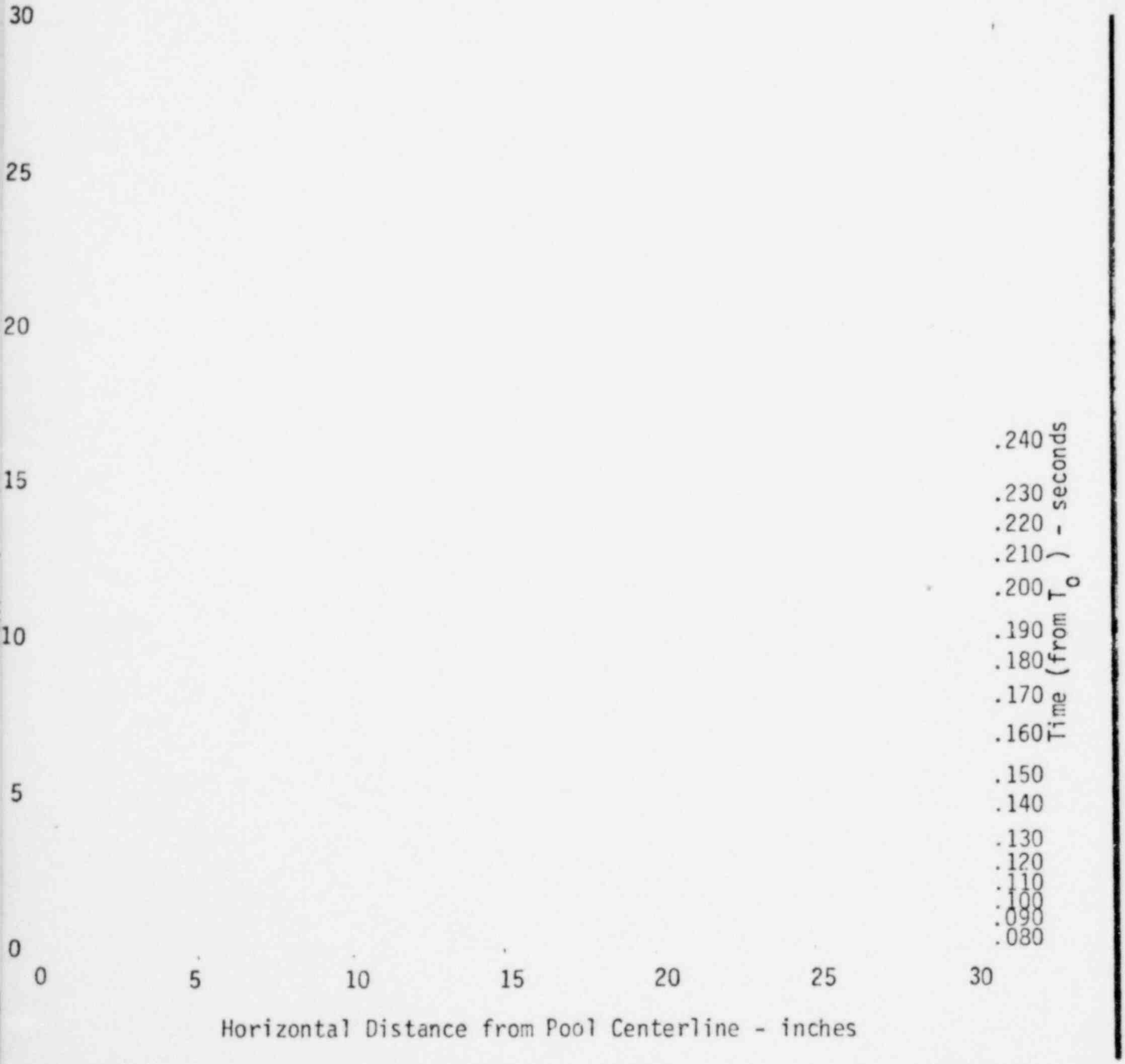
1350 273

FIGURE A-754

TIME HISTORY OF

POOL DISPLACEMENT

FITZPATRICK, TEST 3



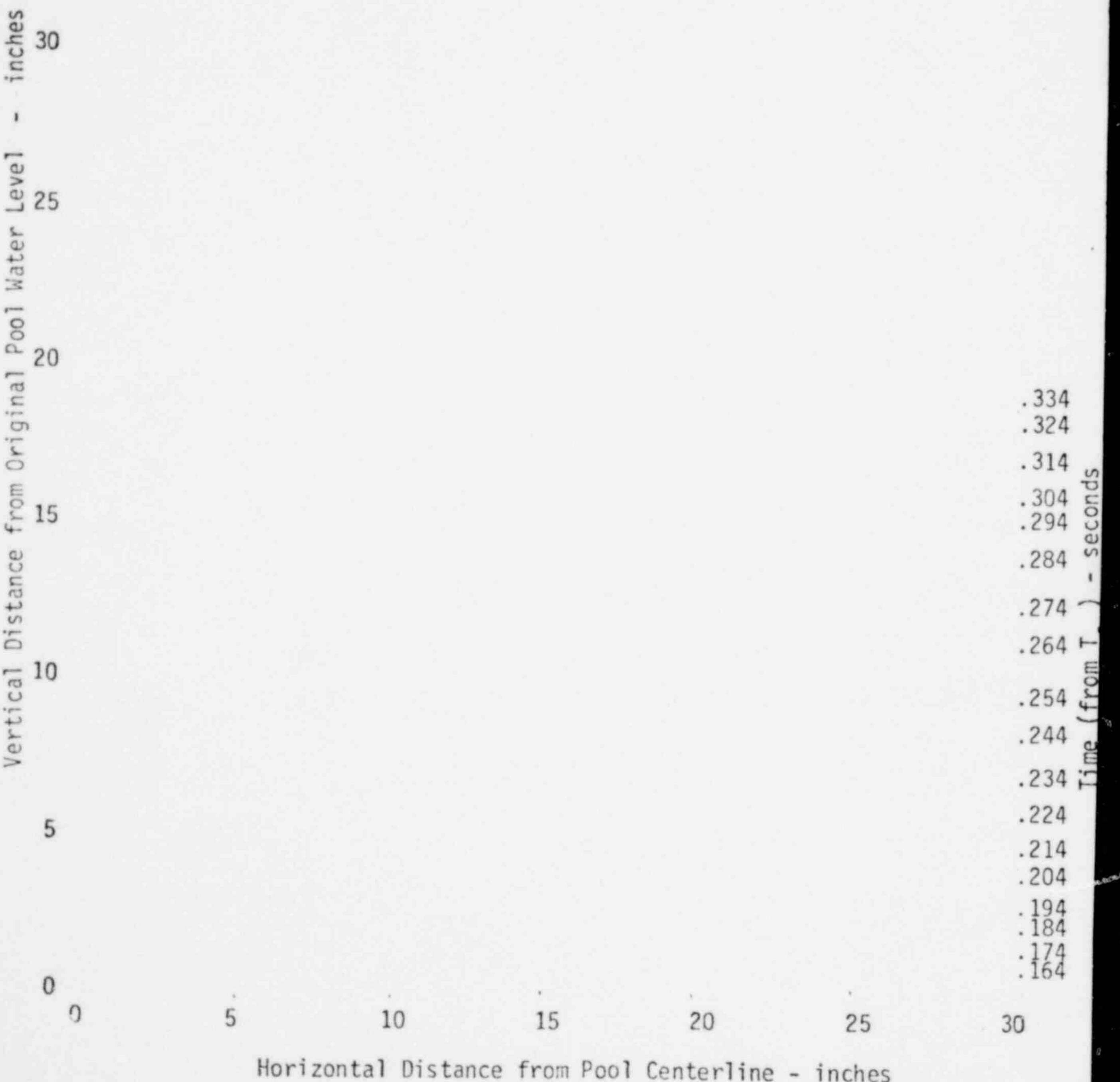
1350 274

FIGURE A-755

TIME HISTORY OF

POOL DISPLACEMENT

FITZPATRICK, TEST 5



1350 275

POOL SURFACE DISPLACEMENT

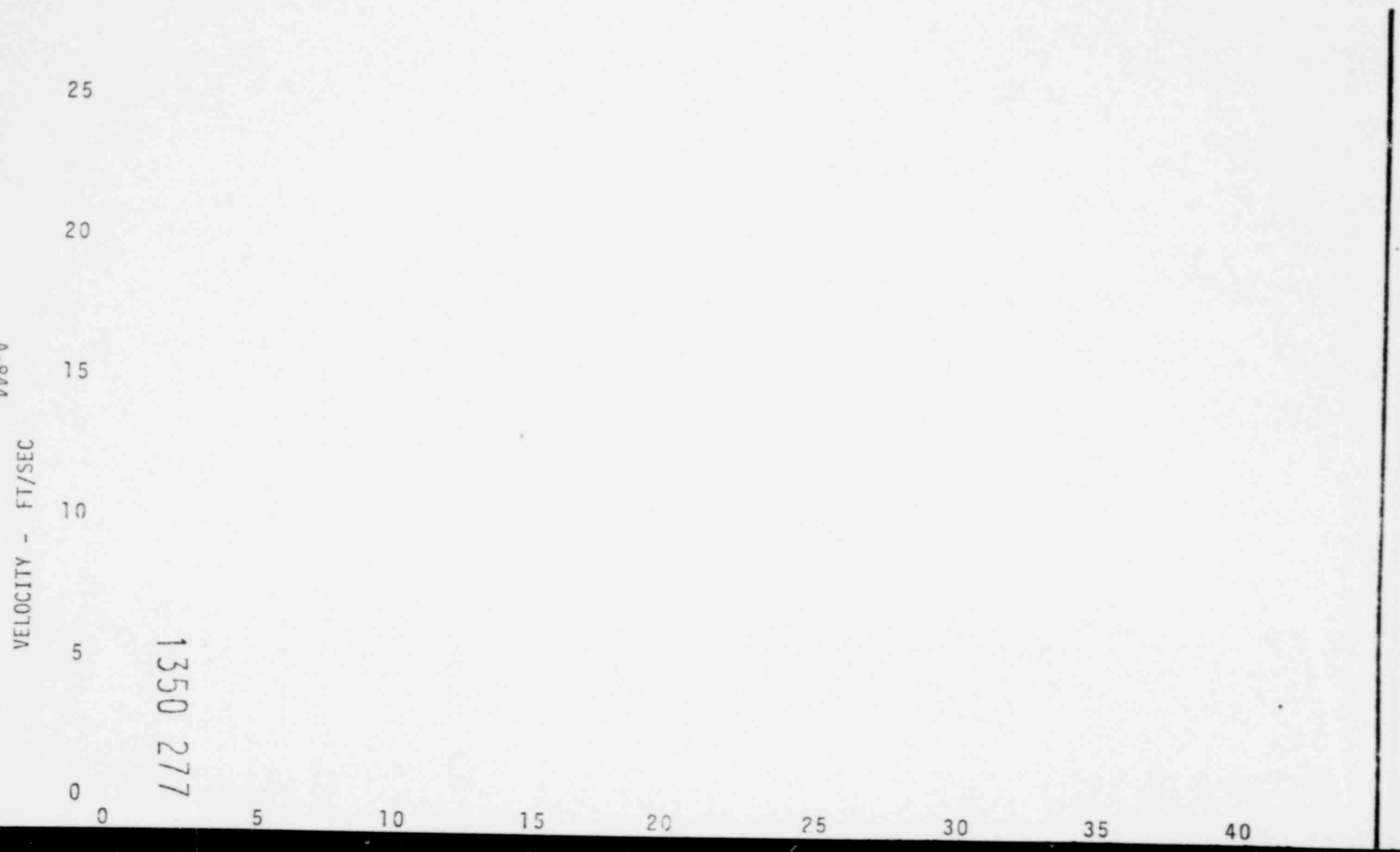
FITZPATRICK, TESTS 1, 2, 3

1350 276

FIGURE A-757

POOL SURFACE VELOCITY PROFILES

FITZPATRICK, TESTS 1, 2, 3



1350 277

POOL SURFACE DISPLACEMENT

FITZPATRICK, TEST 5

Height above original pool surface - inches

25
20
15
10
5
0

0 100 200 300 400

TIME - Milliseconds

1350 278

FIGURE A-759

POOL SURFACE VELOCITY PROFILES

FITZPATRICK, TEST 5

VELOCITY - FT/SEC

25
20
15
10
5
0

0 5 10 15 20 25 30 35 40

1350 279

FIGURE A-760

SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

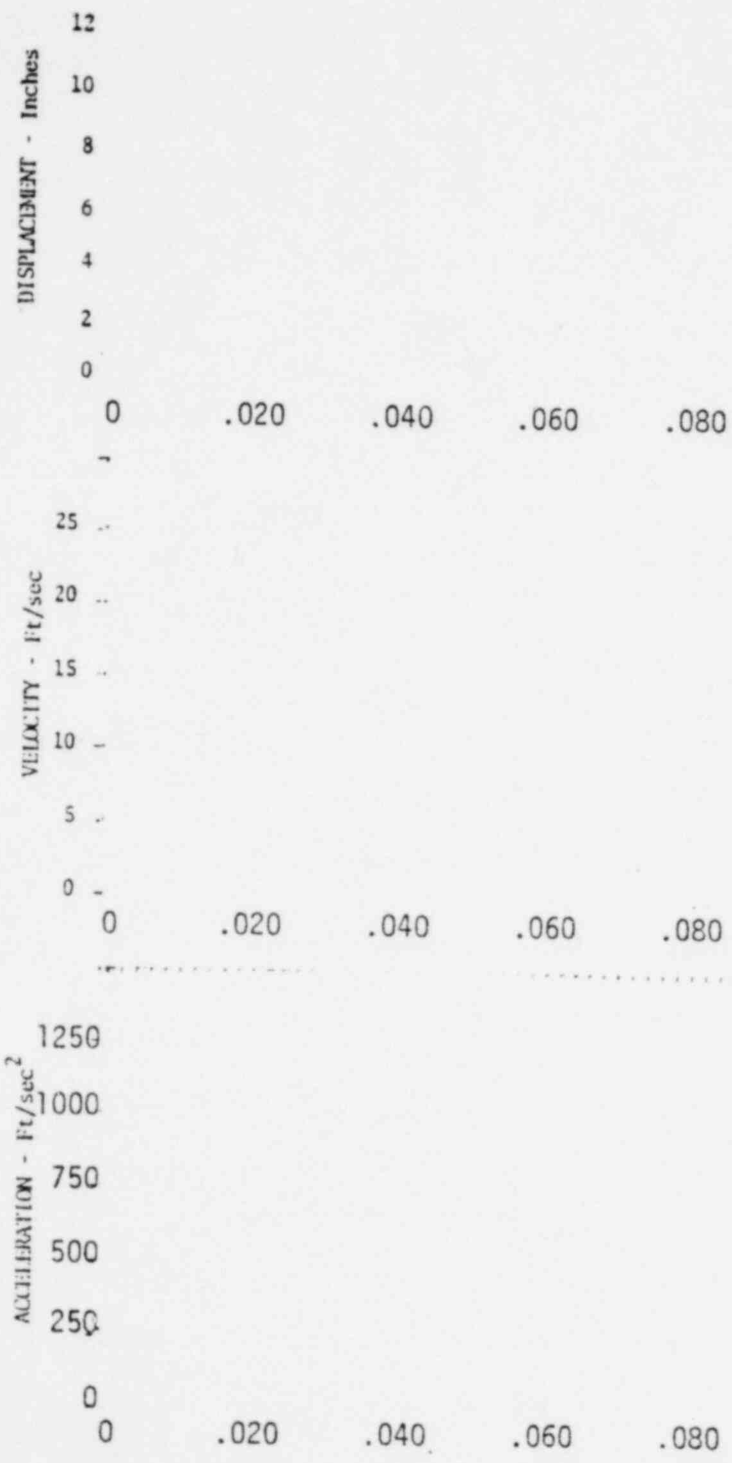
FITZPATRICK, TEST 4

1350 280

FIGURE A-761
NEDO-21944

DOWNCOMER WATER SLUG EJECTION

FITZPATRICK, TEST 3

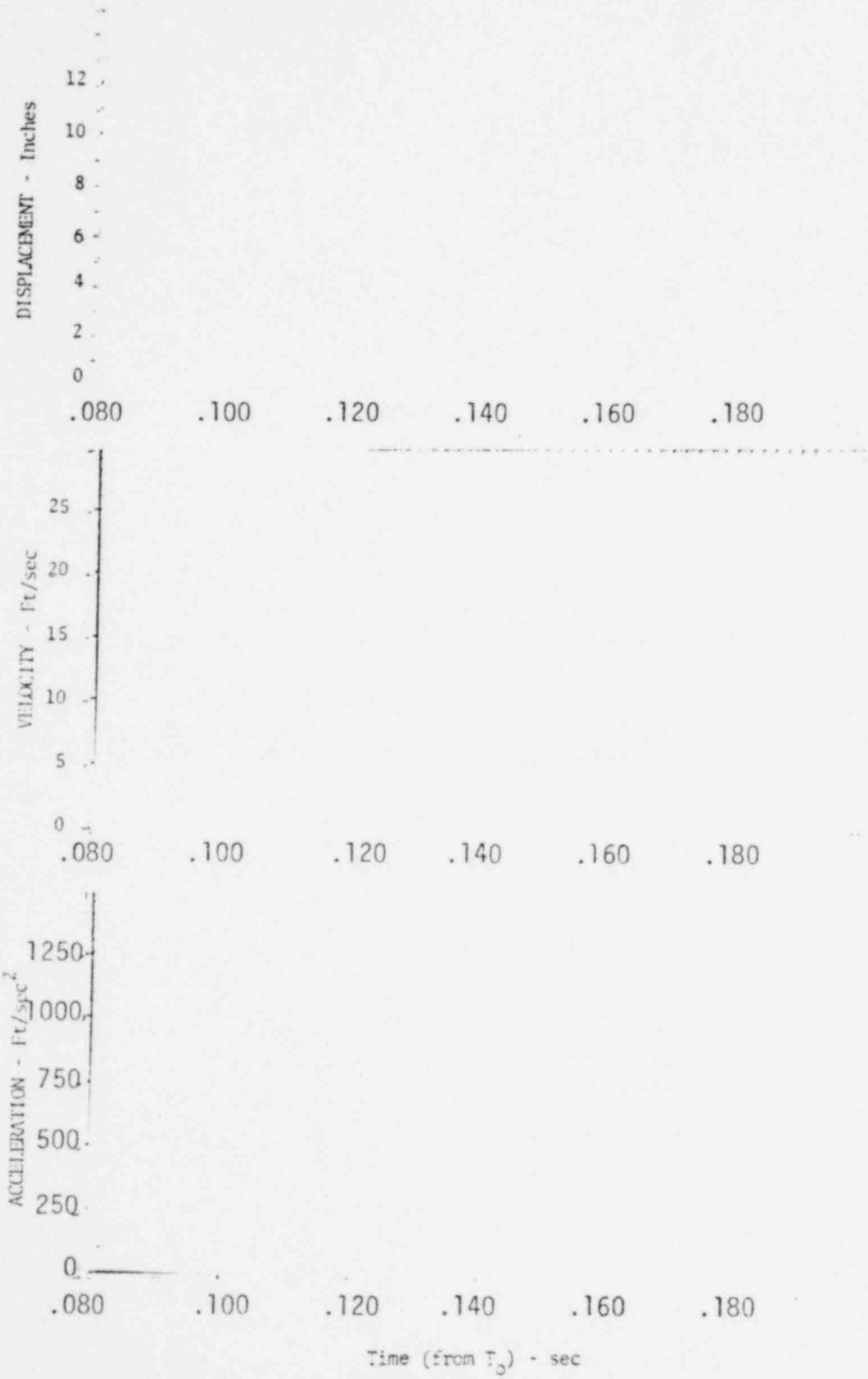


1350 281

FIGURE A-762

DOWNCOMER WATER SLUG EJECTION

FITZPATRICK, TEST 5



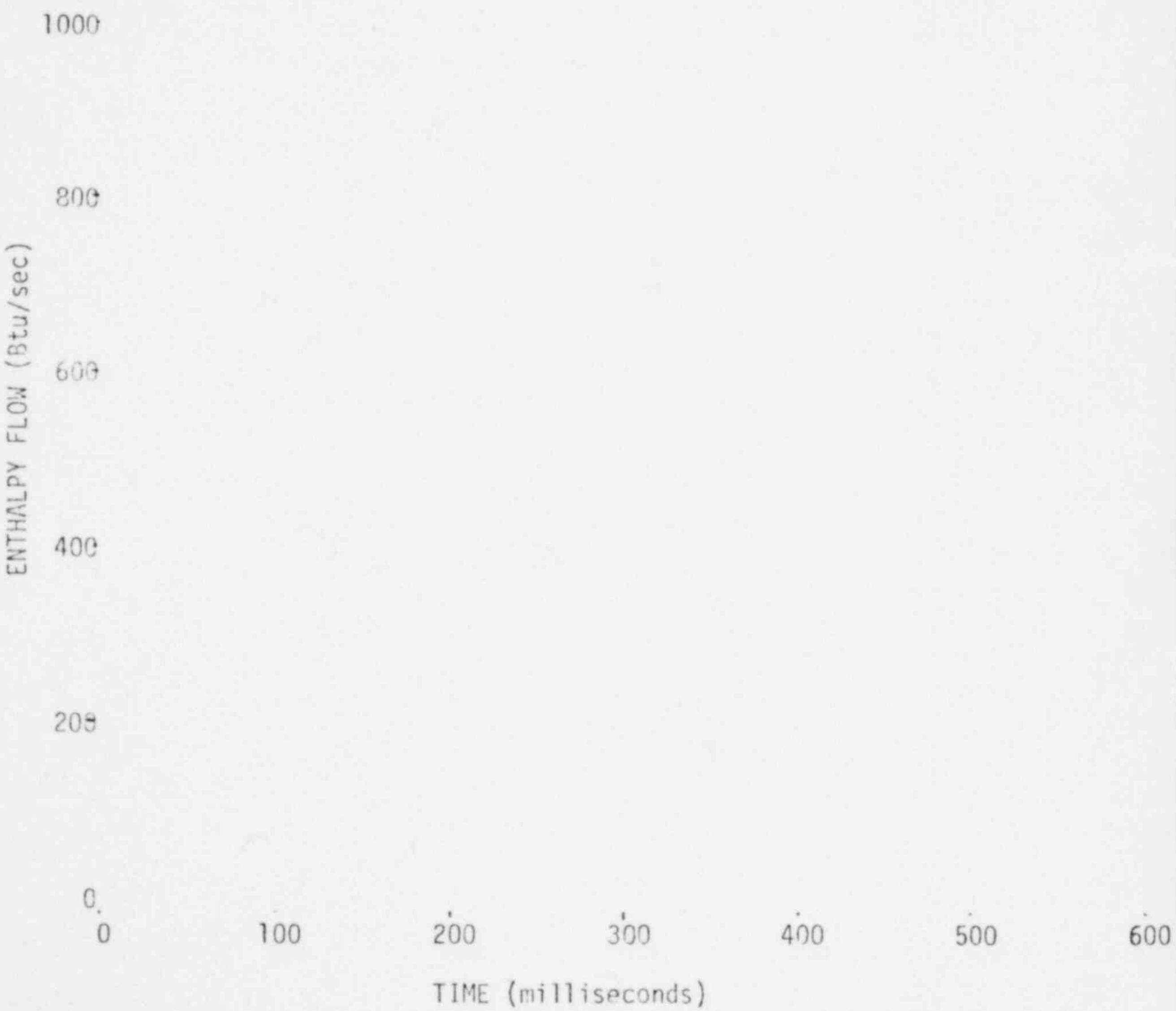
1350 282

FIGURE A-763

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Fitzpatrick Tests



1350 283

FIGURE A-764

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Fitzpatrick Tests

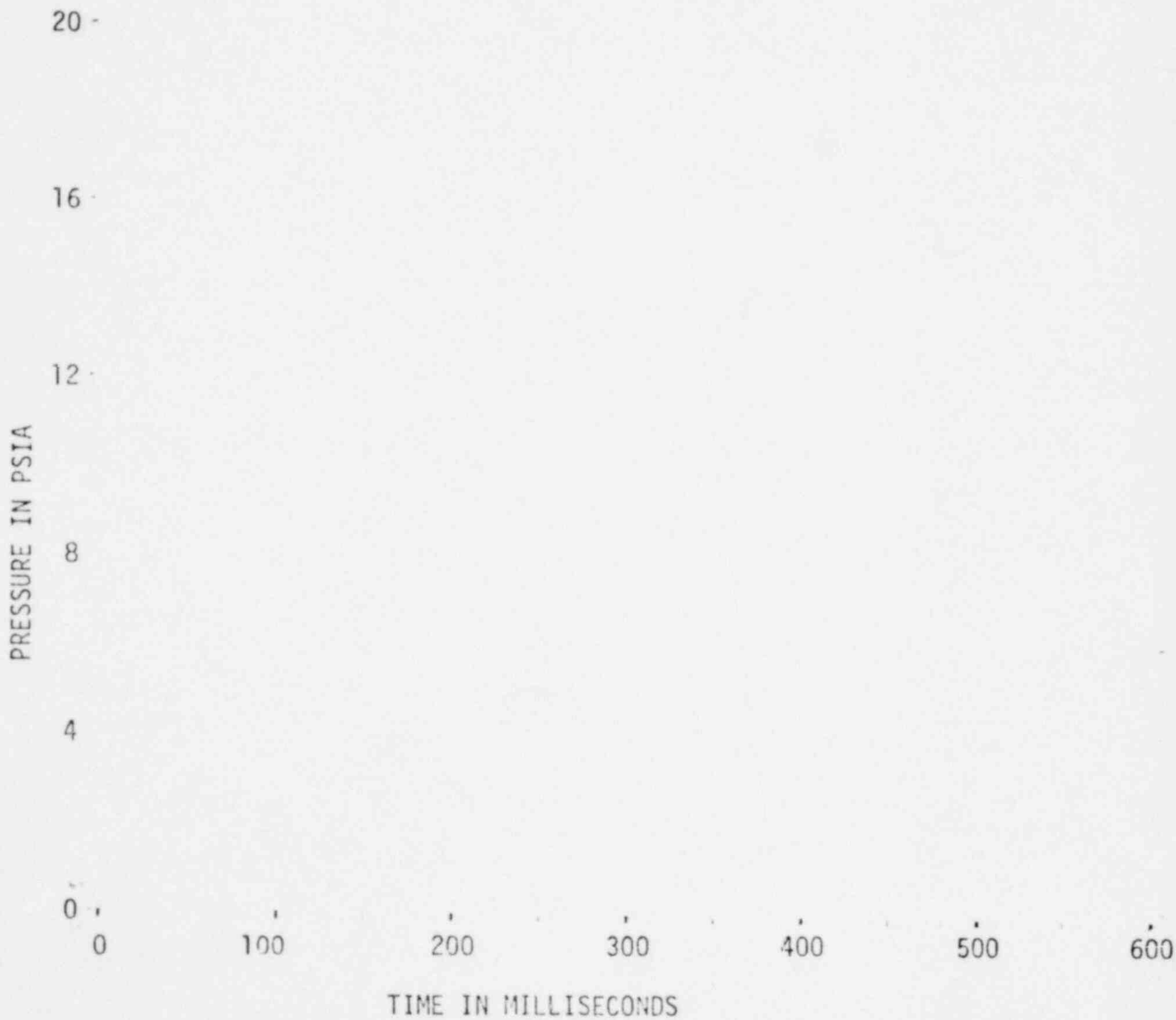
1350 284

FIGURE A-765

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Fitzpatrick Tests



1350 285

TABLE A-31

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Fitzpatrick Tests

Parameter	Test No.	12.35" ΔP, 7.88" Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	0" ΔP (5)
T_o +	(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)							

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

\+ = Start of test reference time

1350 286

TABLE A-31

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Fitzpatrick Tests

Parameter / Test No.		12.35" ΔP, 7.88" 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)							

*** = Time at force is zero (from T_o)

1350 287

TABLE A-32

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3 Fitzpatrick Tests

Parameter \ Test No.		12.36" ΔP, 7.88" 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

1350 288

A.16 Hope Creek Tests

A.16.1 Typical Data

Time-history plots of the driving conditions and pool response are presented in this section for Hope Creek Tests 3 and 5. Test 3 was a load definition test, which was conducted at zero drywell/wetwell differential pressure (0" ΔP) and with no deflector. Test 5 was conducted with an initial drywell/wetwell differential pressure of 7.0" H_2O ΔP and with no deflector.

A.16.1.1 Driving Conditions

Driving conditions for Hope Creek Test 3 are presented in Figures A-766 through A-770. Similar plots for Test 5 are shown in Figures A-771 through A-775. Comparison of the driving conditions indicates that enthalpy flow into the pool starts at an earlier time and peaks out at a slightly lower value in Test 5 with 7.0" ΔP (Figures A-770 versus A-775).

A.16.1.2 Pool Response

Downcomer internal pressure and wetwell pressures for Hope Creek Test 3 are presented in Figures A-776 and A-777, respectively. The same pressures for Test 5 are shown in Figures A-778 and A-779. Net torus force from the pressure integral (Figures A-780 and A-781) shows only minor oscillations in downforce and upforce. Net torus force that is determined from the torus load cell (Figures A-782 and A-784) by applying inertial correction with the torus accelerometer (Figures A-783 and A-785) is shown in Figures A-786 and A-787 and compared with net torus force determined from the pressure integral. Figures A-788 and A-789 present the net torus force based on the torus pressure integral, corrected for inertia.

1350 289

The "average" pool pressures for Hope Creek Tests 3 and 5 are shown in Figures A-790 and A-792. Figures A-791 and A-793 are the same as Figures A-788 and A-789 with force replaced by average pressure (force/torus projected area).

The vent header impact pressures for Hope Creek Test 3 are presented in Figures A-794 through A-797. Vent header impact pressures for Test 5 are presented in Figures A-798 through A-801.

The vent header impact forces from the pressure integral and the corrected load cell agree reasonably well (Figure A-802). Vent header vertical acceleration measurements from Tests 3 and 5 are shown in Figures A-803 and A-804, respectively.

A.16.2 Pool Dynamics

The pool contours at various times of pool swell are shown in Figures A-805 through A-808 for Hope Creek Tests 1, 2, 3, and 5.

Pool surface displacement curves are shown in (Figures A-809 and A-811). The pool surface velocity profiles are shown in Figures A-810 and A-812.

The pool surface displacement versus time and velocity profile viewed from the side window during Test 4 are shown in Figure A-813. The downcomer water slug displacement, velocity, and acceleration versus time for Tests 3 and 5 are shown in Figures A-814 and A-815, respectively.

A.16.3 Data Summaries

Table A-33 presents the Hope Creek test data for wetwell vertical forces.

1350 290

Table A-34 presents the Hope Creek test data for vent header impact forces.

A.16.4 Discussion and Analysis

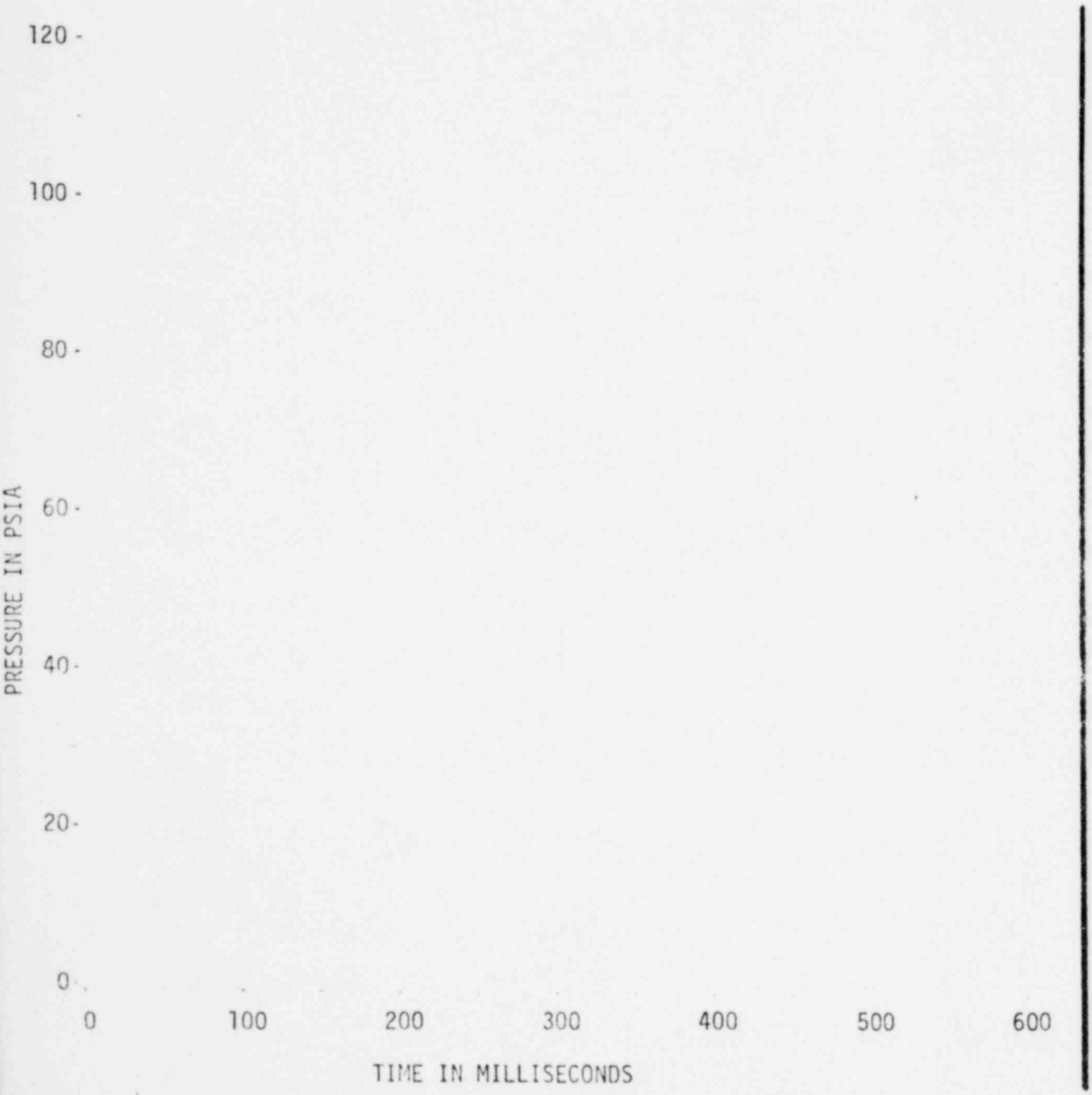
Figure A-816 presents the effect of drywell/wetwell ΔP on the enthalpy flow into the bubbles. The effect of drywell/wetwell ΔP on downcomer internal pressure is shown in Figure A-817. Figure A-818 presents the effect of drywell/wetwell ΔP on pool and freespace pressures. The Hope Creek Test 3 data parallels that for Test 8 data of the "typical" plant in Section 3.0. The Hope Creek Test 5 data parallels the "typical" Test 2 data.

The Hope Creek load definition tests were conducted at 0" H_2O ΔP with no deflector. A ΔP sensitivity test at 7" H_2O ΔP was also conducted. Upforce and downforce only showed minor oscillations. The vent header impact force was significantly higher than for plants using deflectors.

FIGURE A-766

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Hope Creek Test 3

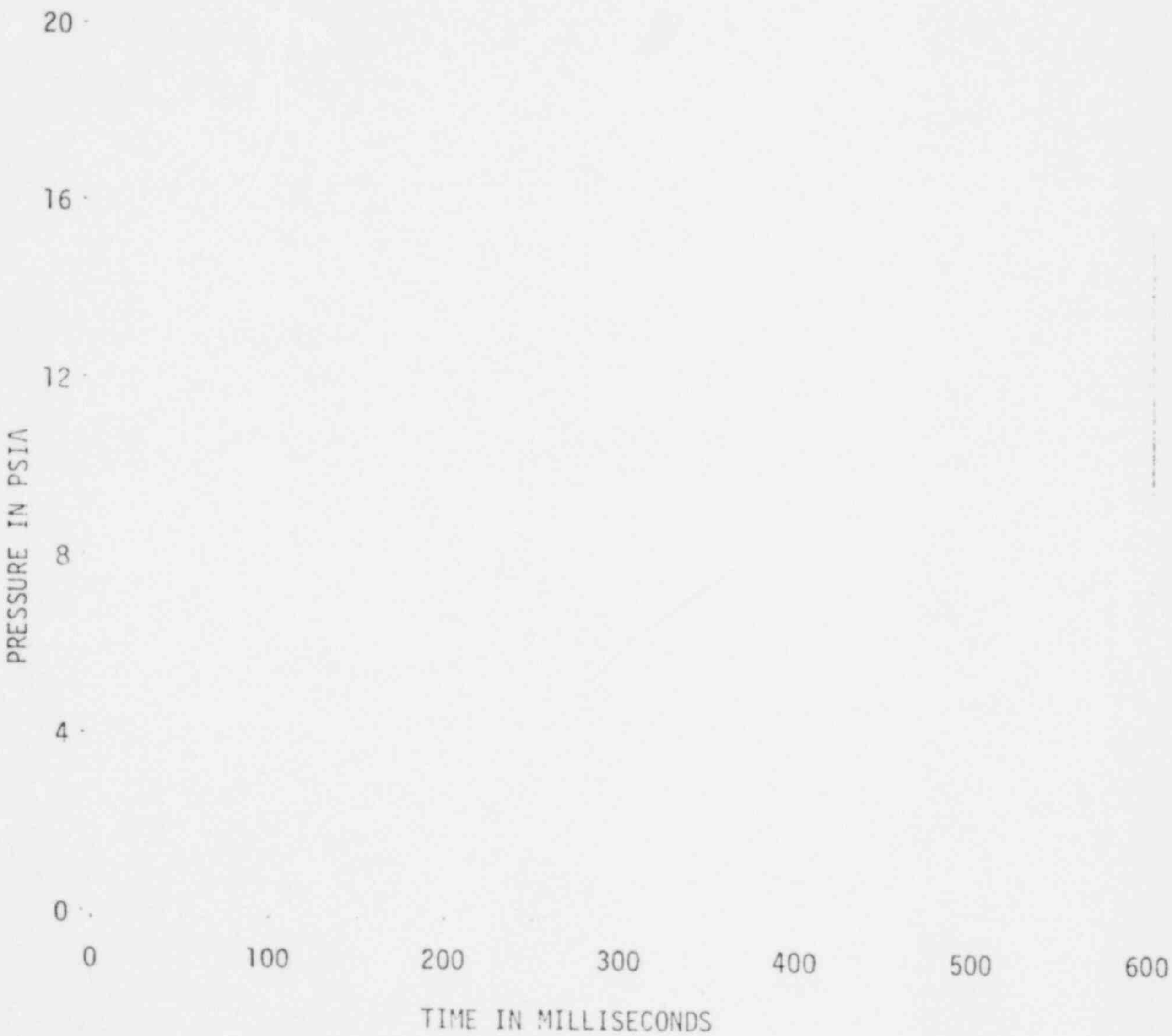


1350 292

FIGURE A-767

DRYWELL PRESSURE

Task 5.5.3   Hope Creek Test 3

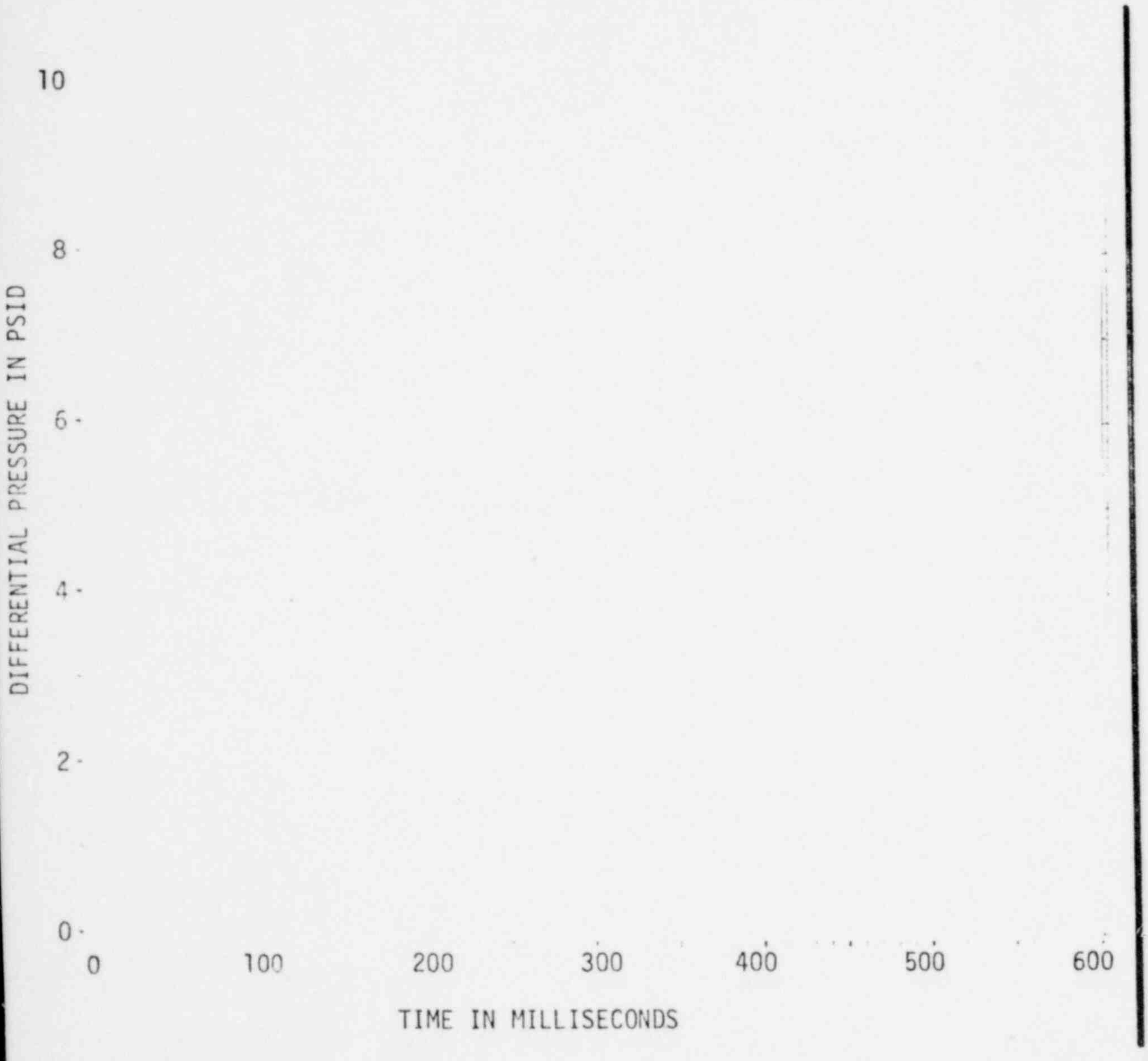


1350 293

FIGURE A-768

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Hope Creek Test 3



1350 294

FIGURE A-769

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

Task 5.5.3 Hope Creek Test 3

TEMPERATURE IN DEGREES F

200

160

120

80

40

0

0 100 200 300 400 500 600

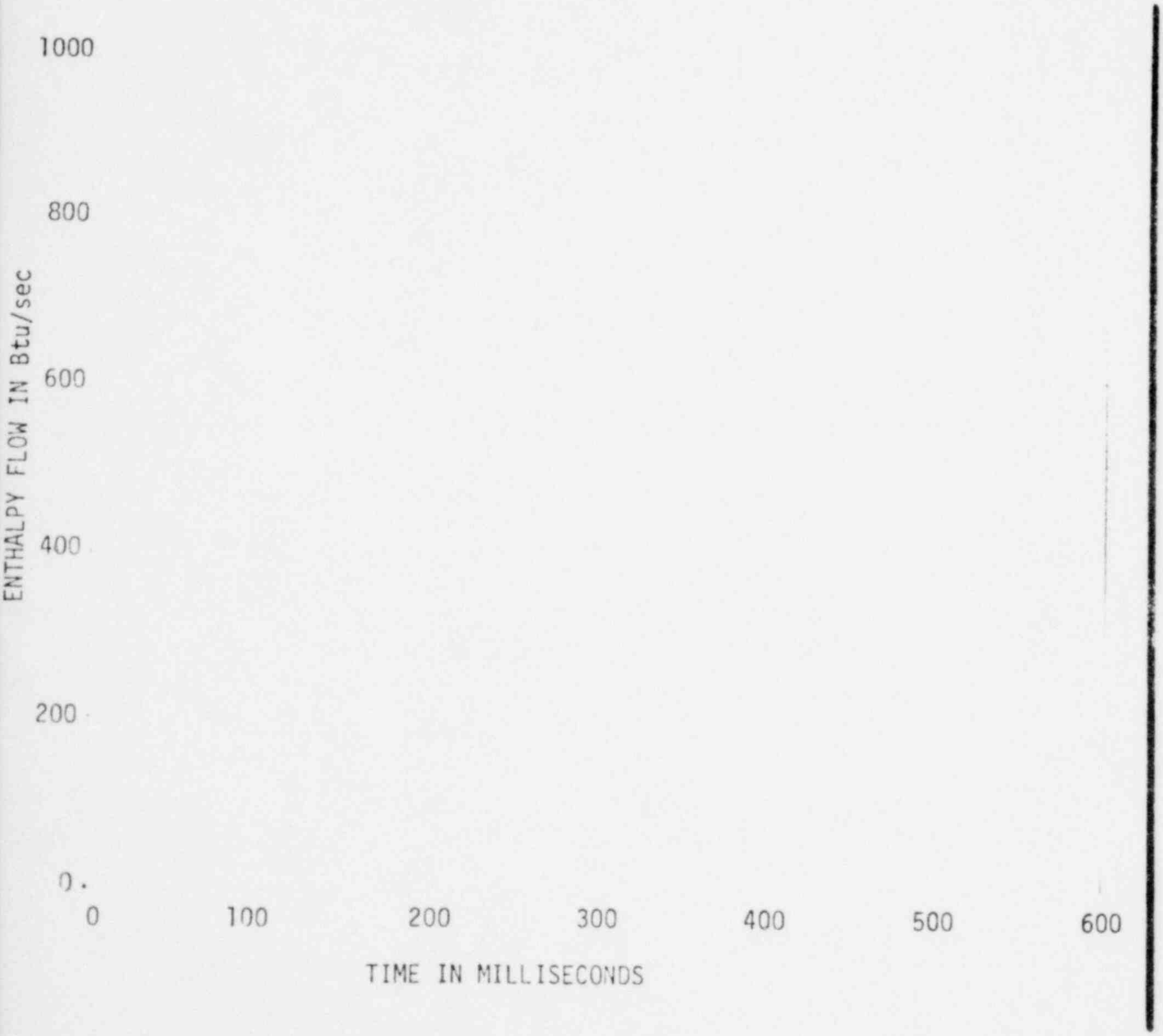
TIME IN MILLISECONDS

1350 295

FIGURE A-770

ENTHALPY FLOW INTO POOL

Task 5.5.3 Hope Creek Test 3

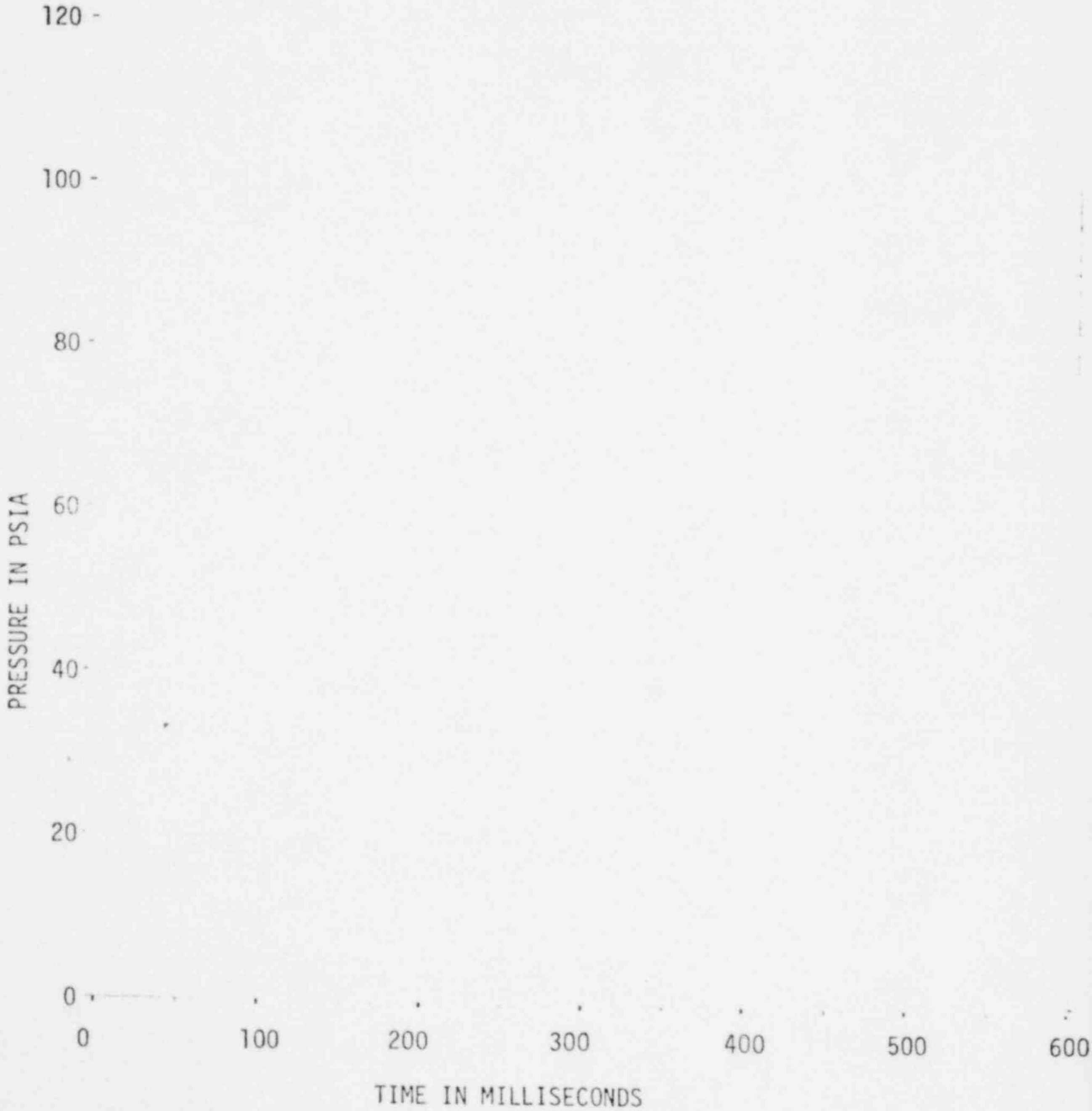


1350 296

FIGURE A-771

DRYWELL ORIFICE UPSTREAM PRESSURE

Task 5.5.3 Hope Creek Test 5

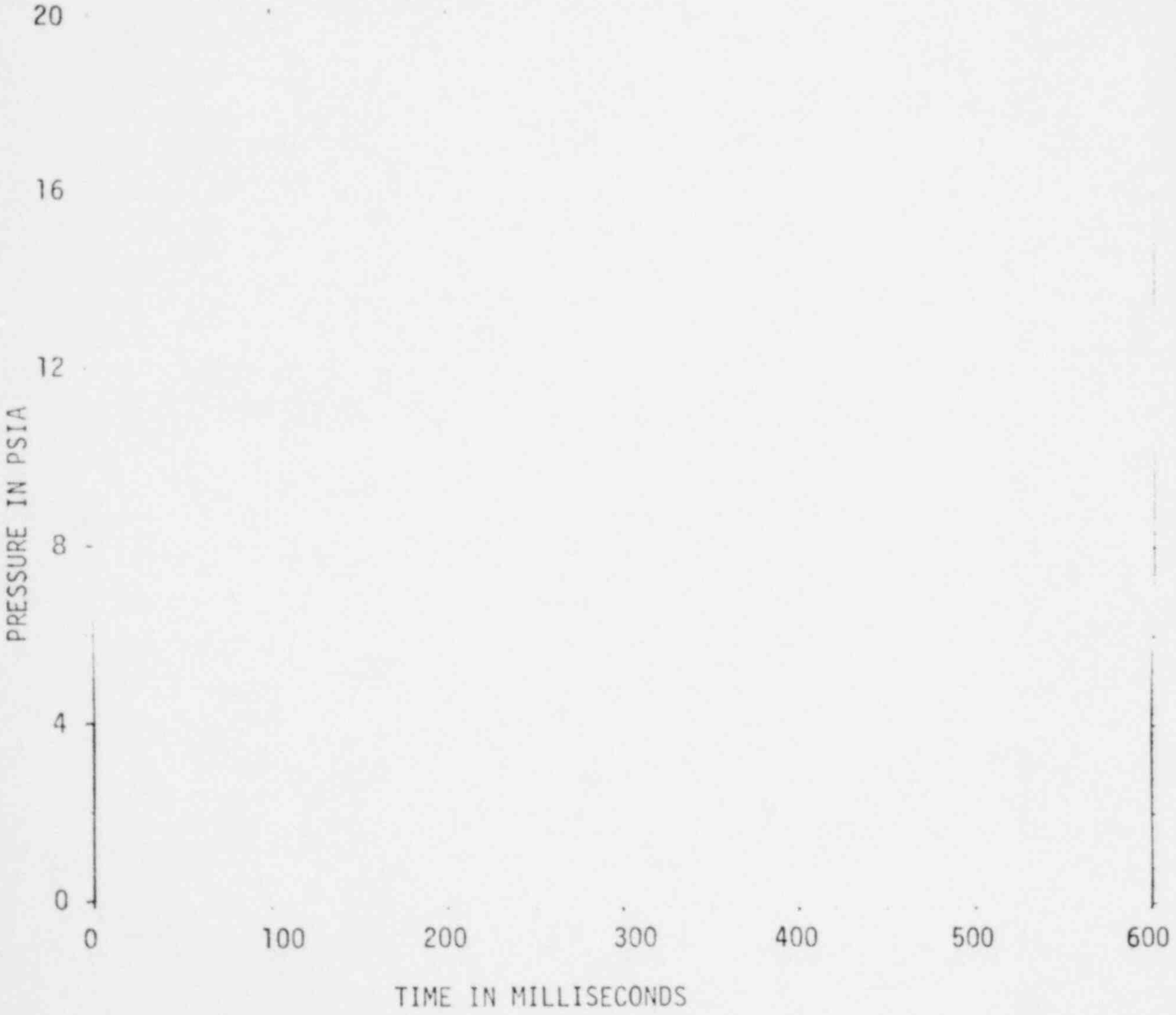


1350 297

FIGURE A-772

DRYWELL PRESSURE

Task 5.5.3 Hope Creek Test 5

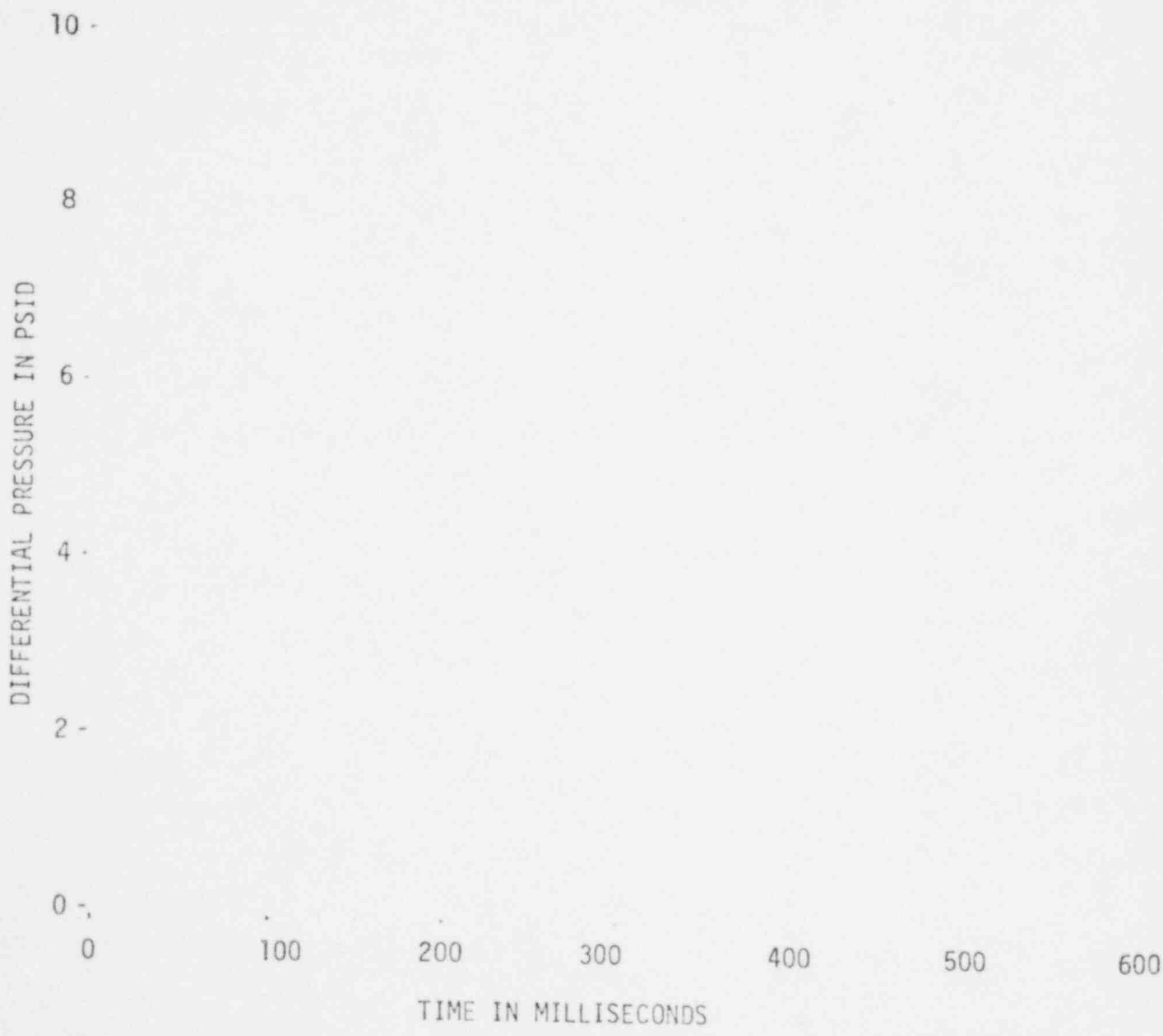


1350 298

FIGURE A-773

DOWNCOMER ORIFICE DIFFERENTIAL PRESSURE

Task 5.5.3 Hope Creek Test 5



1350 299

FIGURE A-774

DOWNCOMER ORIFICE UPSTREAM TEMPERATURE

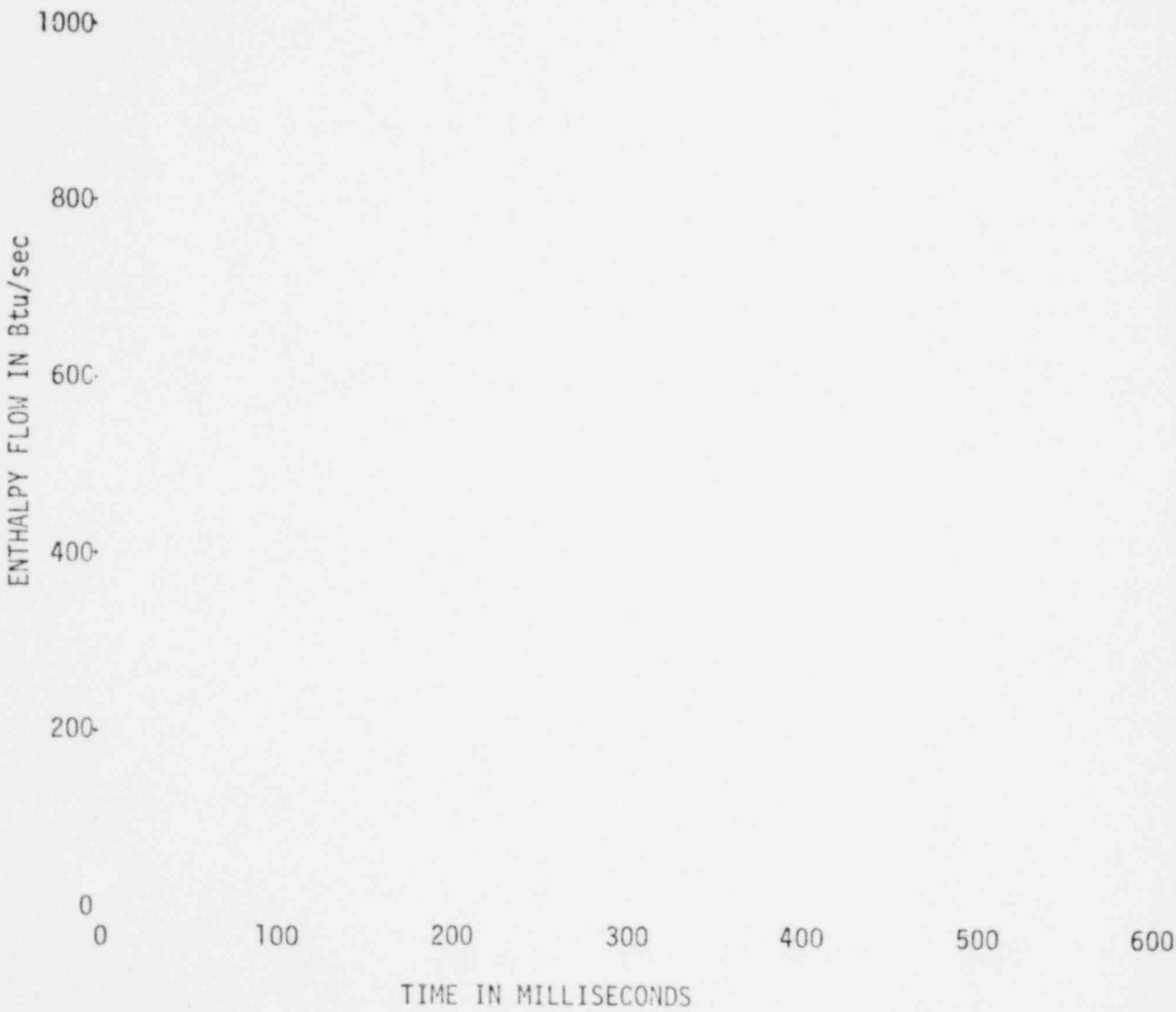
Task 5.5.3 Hope Creek Test 5

1350 300

FIGURE A-775

ENTHALPY FLOW INTO POOL

Task 5.5.3 Hope Creek Test 5

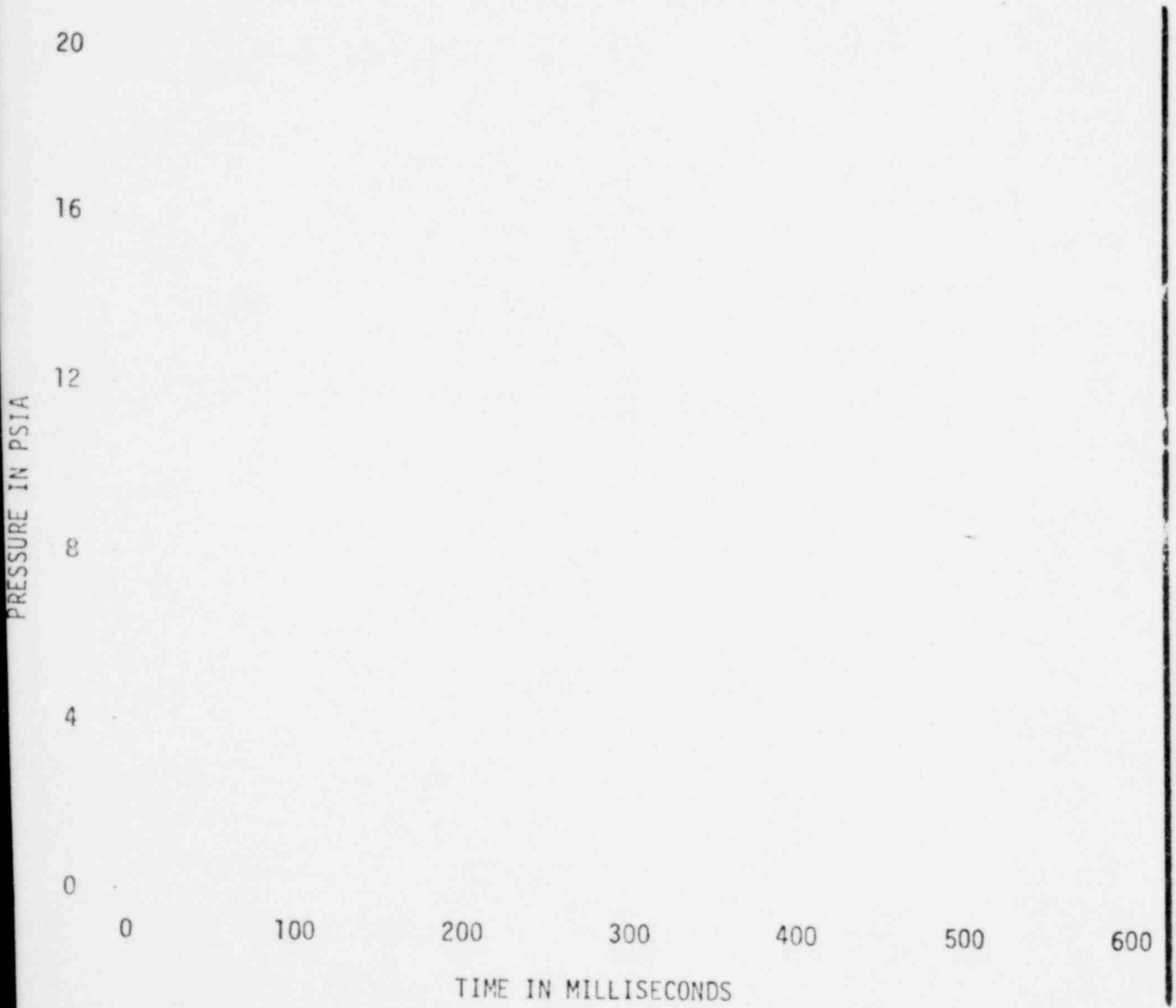


1350 301

FIGURE A-776

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 Hope Creek Test 3



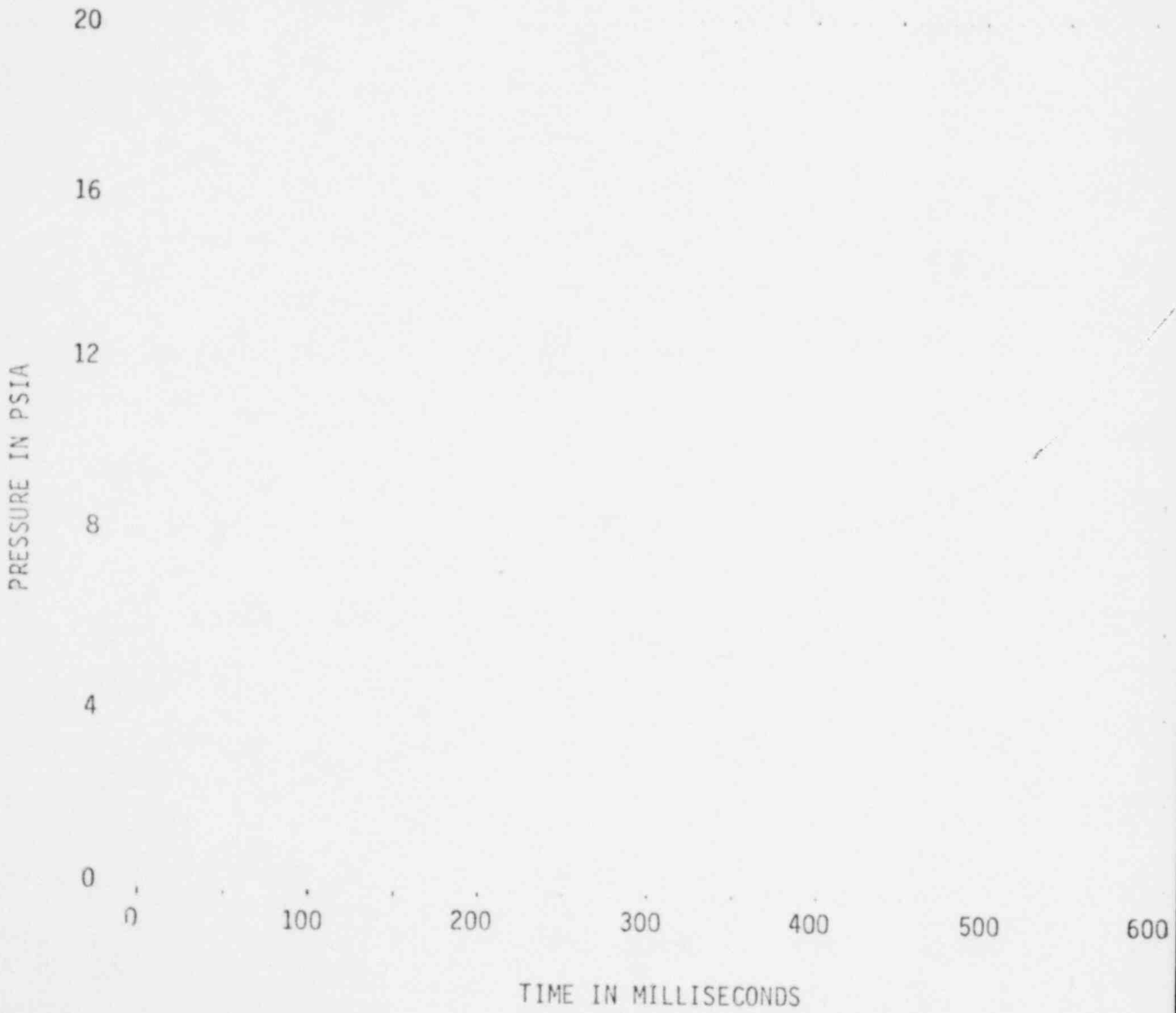
1350 302

FIGURE A-777

NEDO-21944

WETWELL PRESSURES

Task 5.5.3 Hope Creek Test 3

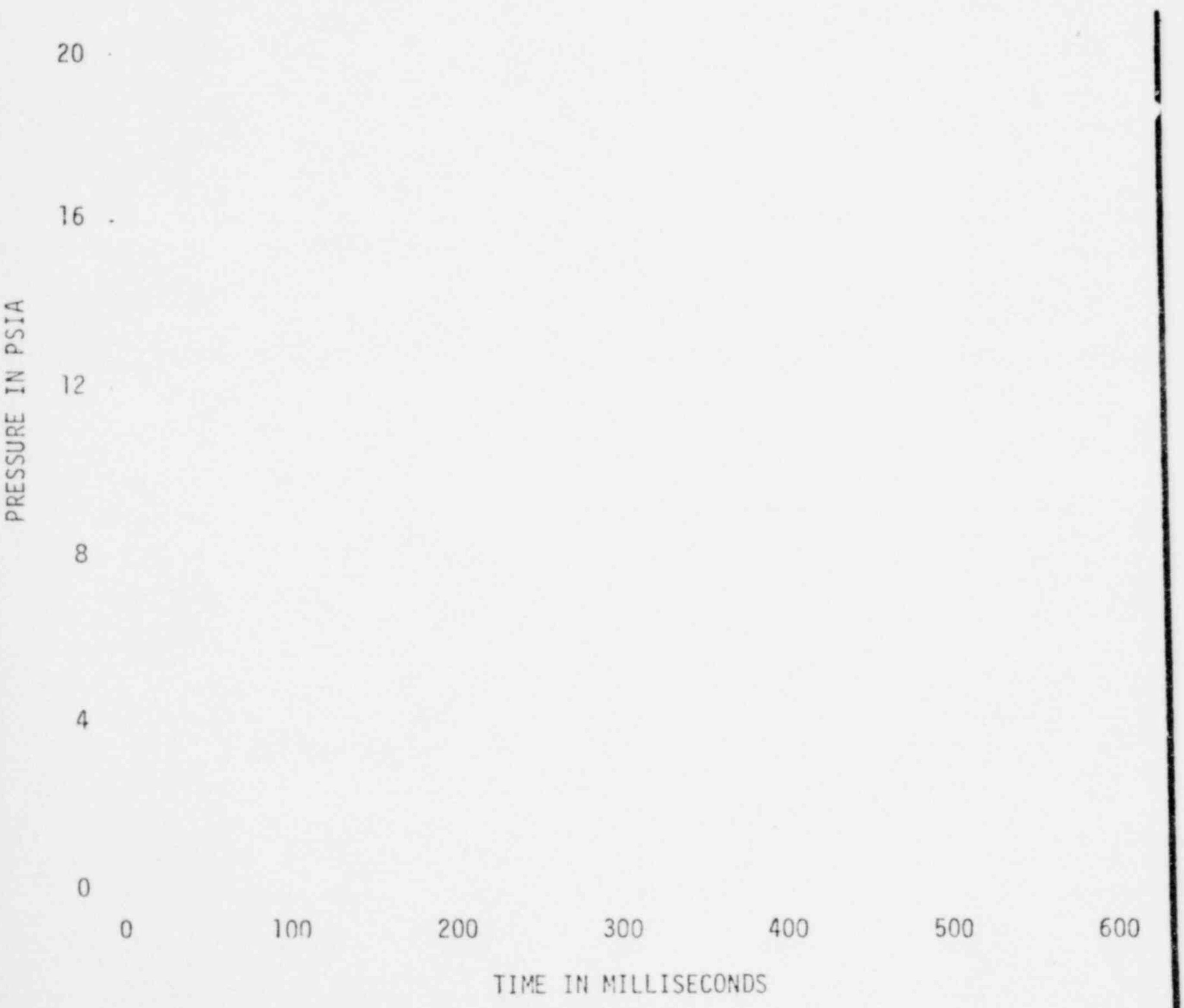


1350 303

FIGURE A-778

DOWNCOMER INTERNAL PRESSURE

Task 5.5.3 ' Hope Creek Test 5

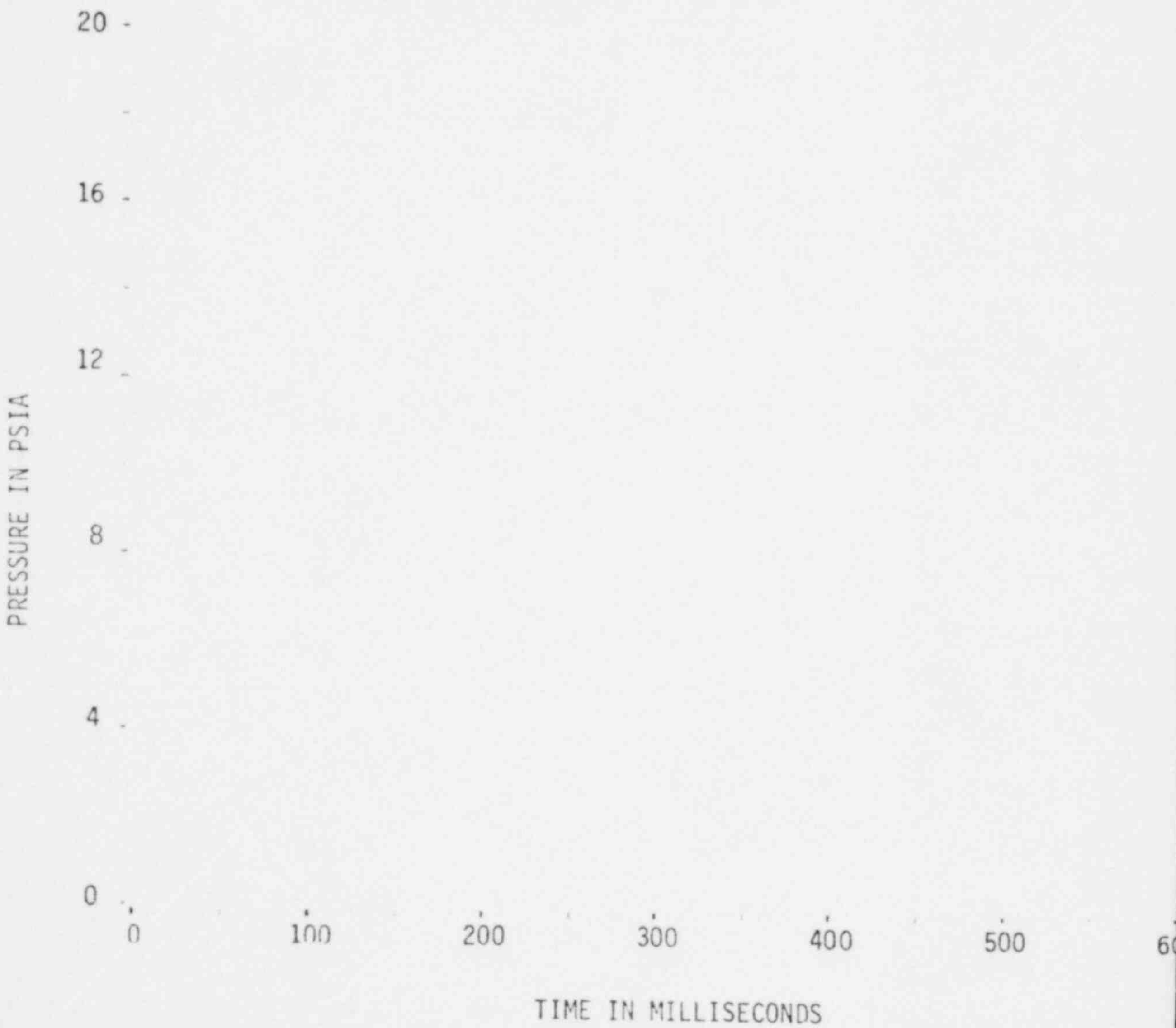


1350 304

FIGURE A-779

WETWELL PRESSURES

Task 5.5.3 Hope Creek Test 5

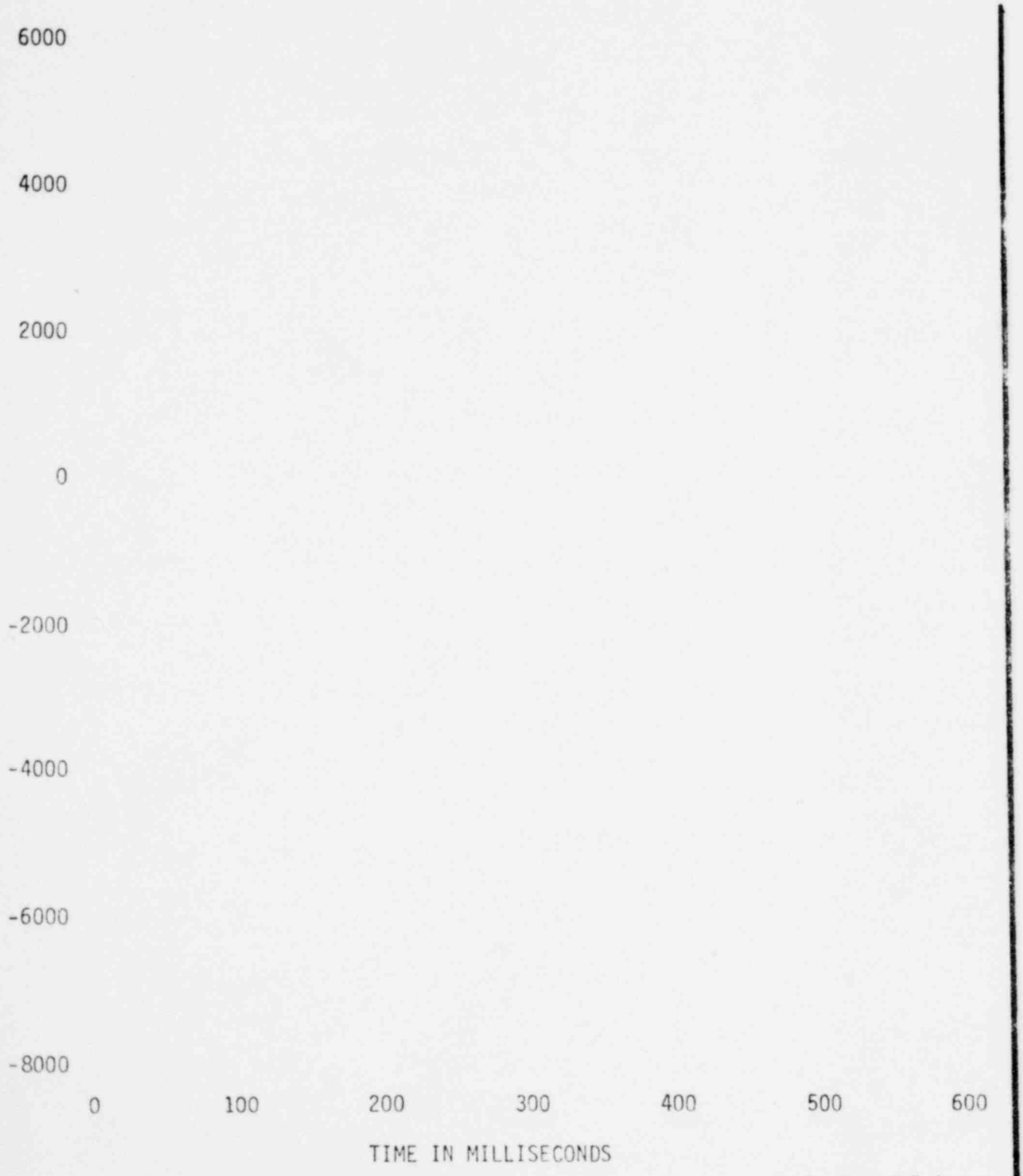


1350 305

FIGURE A-780

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Hope Creek Test 3



1350 306

FIGURE A-781

NET TORUS FORCE FROM PRESSURE INTEGRAL

Task 5.5.3 Hope Creek Test 5

FORCE IN LBF

6000

4000

2000

0

-2000

-4000

-6000

-8000

0 100 200 300 400 500 60

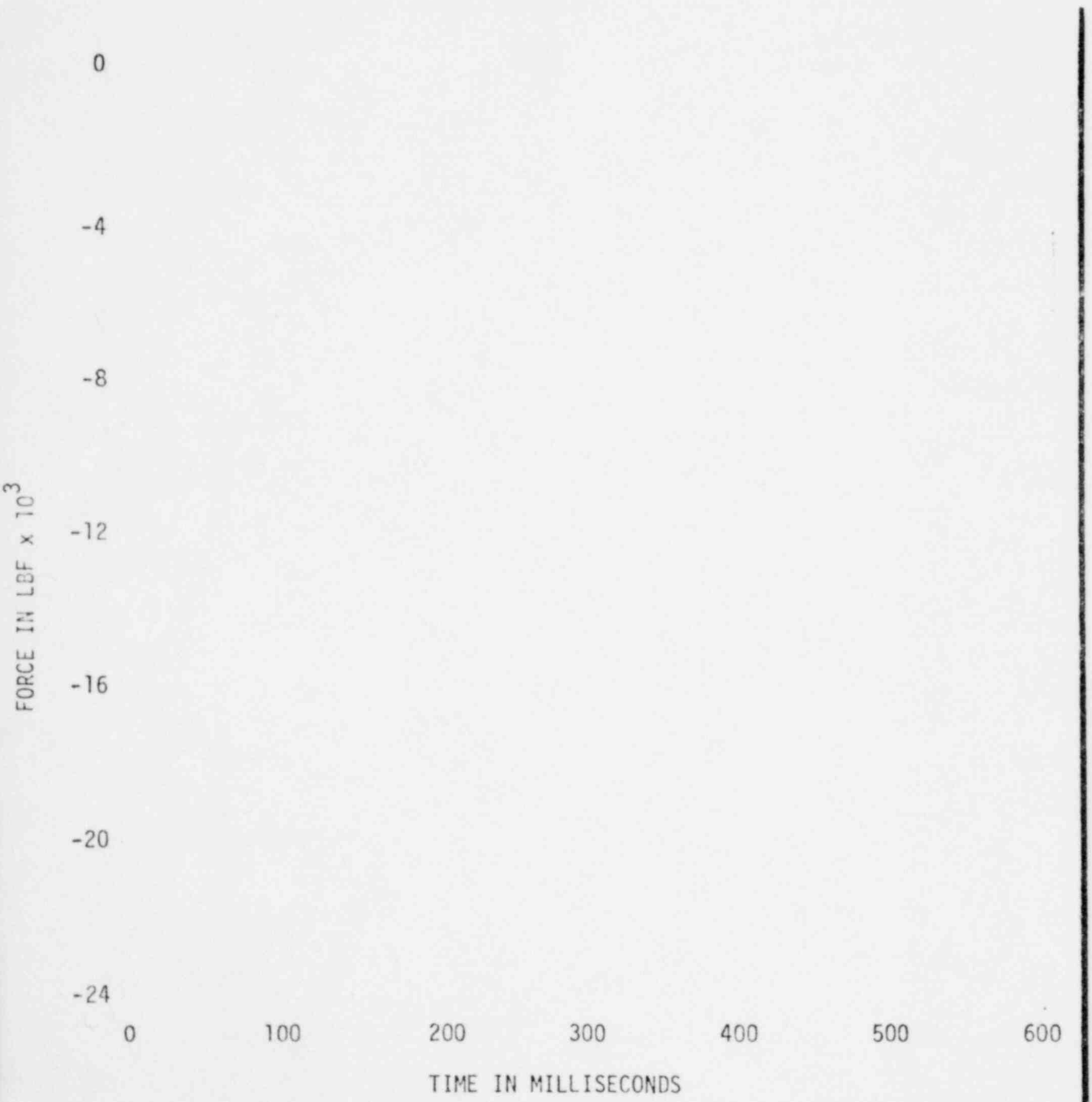
TIME IN MILLISECONDS

1350 307

FIGURE A-782

TORUS LOAD CELL

Task 5.5.3 Hope Creek Test 3



1350 308

FIGURE A-783

TORUS VERTICAL ACCELERATION

Task 5.5.3 Hope Creek Test 3

ACCELERATION IN G

2
1
0
-1
-2

0 100 200 300 400 500 600

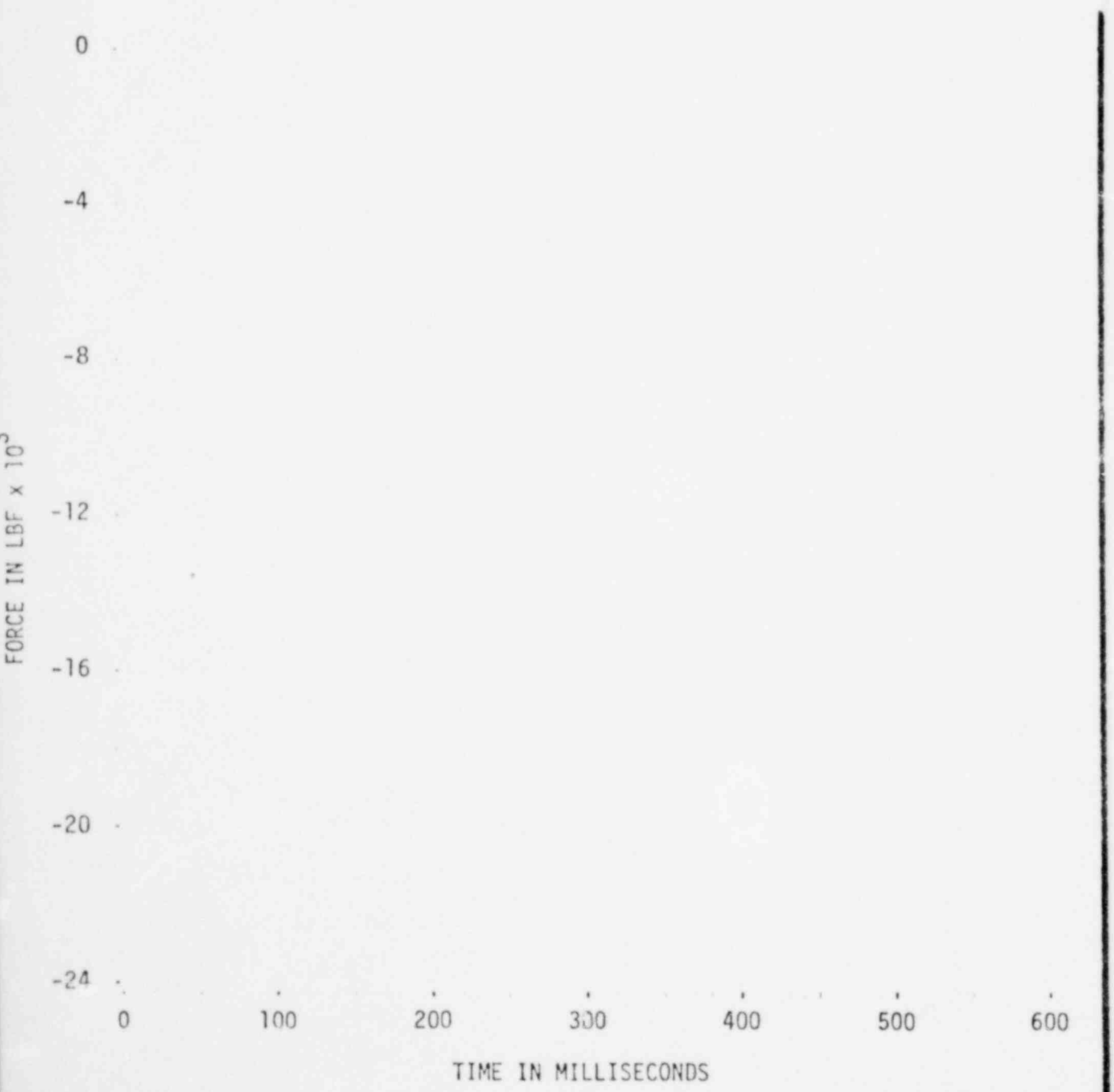
TIME IN MILLISECONDS

1350 309

FIGURE A-784

TORUS LOAD CELL

Task 5.5.3 Hope Creek Test 5



1350 310

FIGURE A-785

TORUS VERTICAL ACCELERATION

Task 5.5.3 Hope Creek Test 5

1350 311

FIGURE A-786

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Hope Creek Test 3

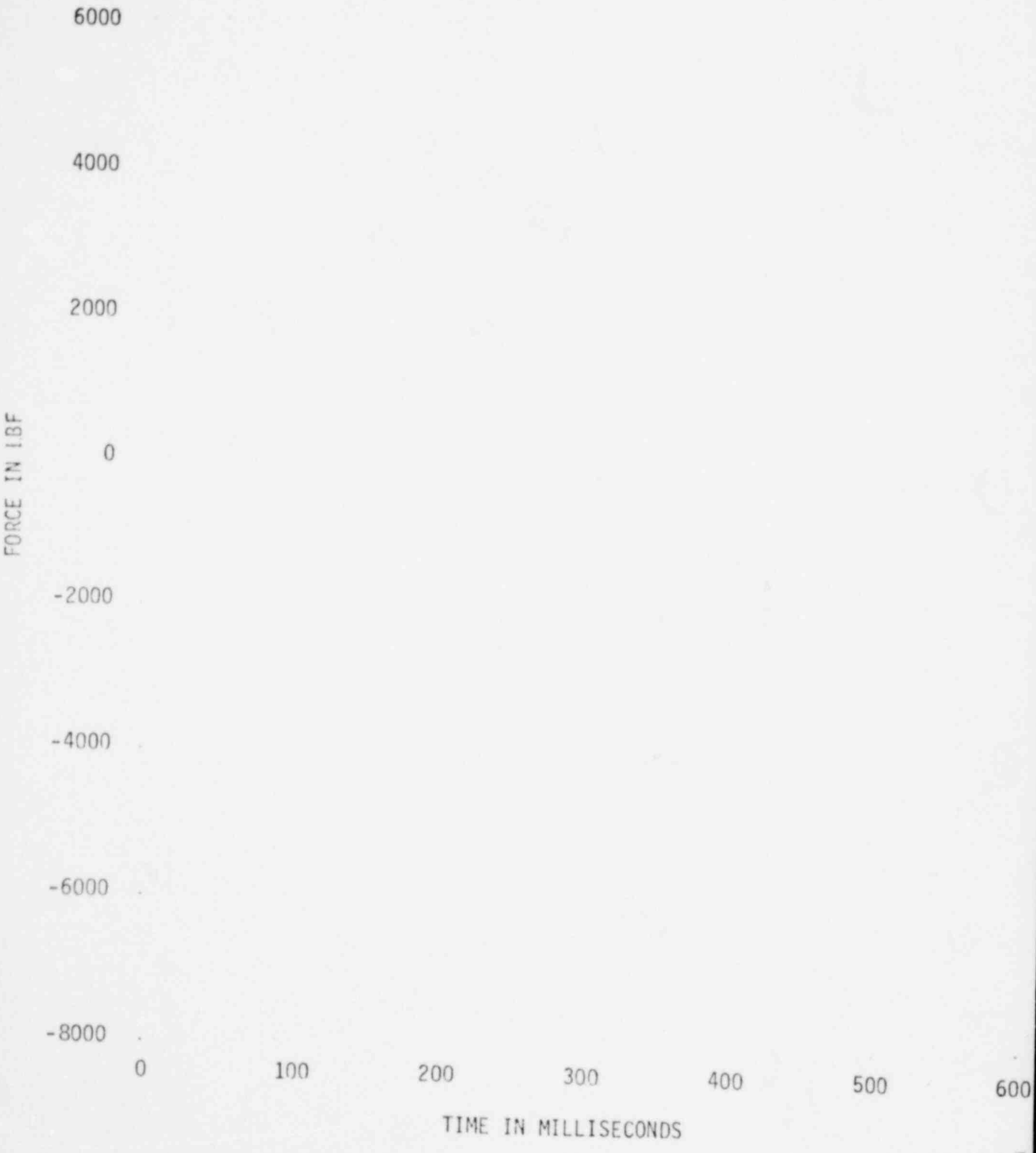
1350 312

FIGURE A-787

COMPARISON OF NET TORUS FORCE FROM PRESSURE INTEGRAL

WITH NET TORUS FORCE FROM LOAD CELL CORRECTED FOR TORUS INERTIA

Task 5.5.3 Hope Creek Test 5

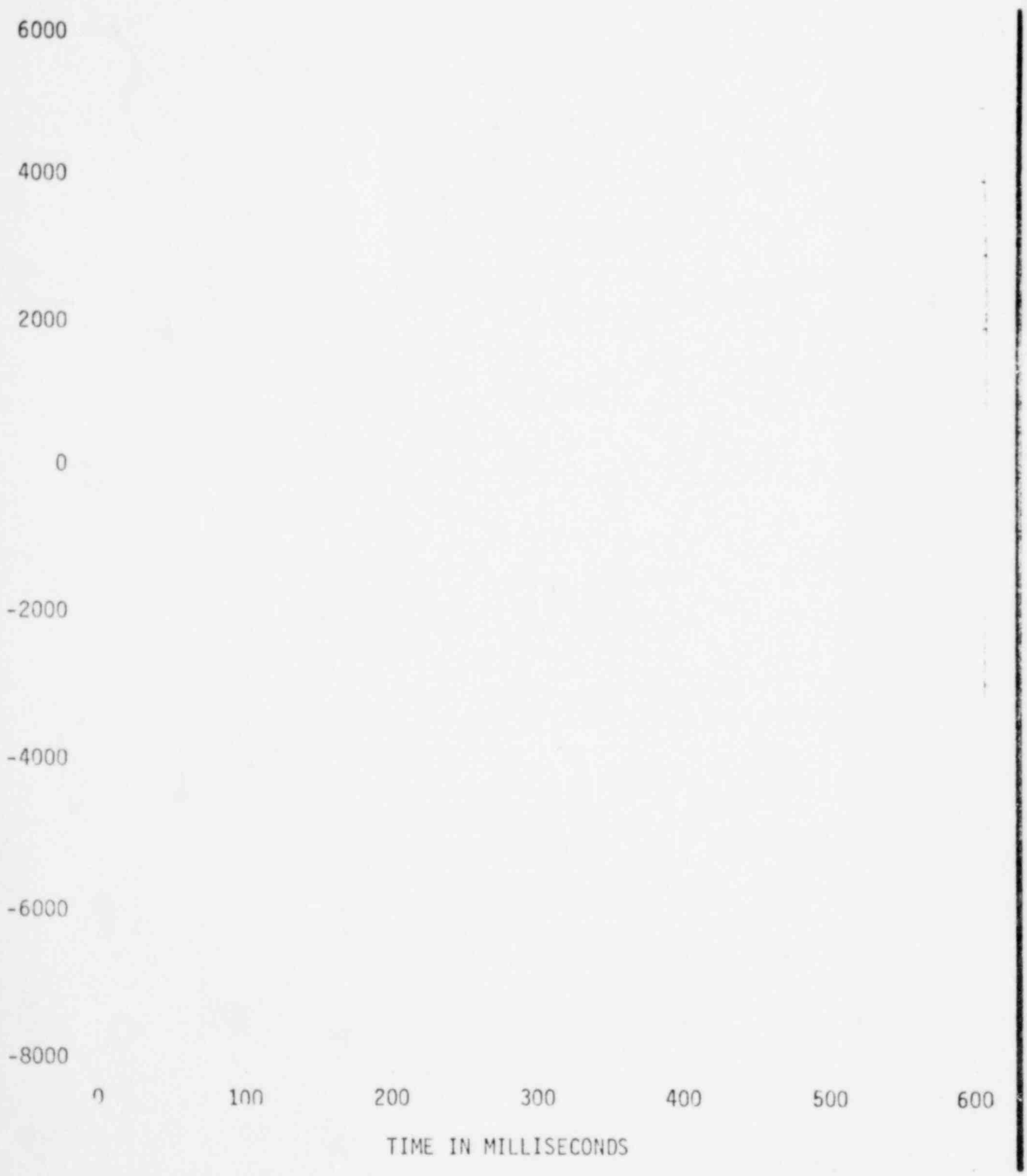


1350 313

FIGURE A-788

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hope Creek Test 3

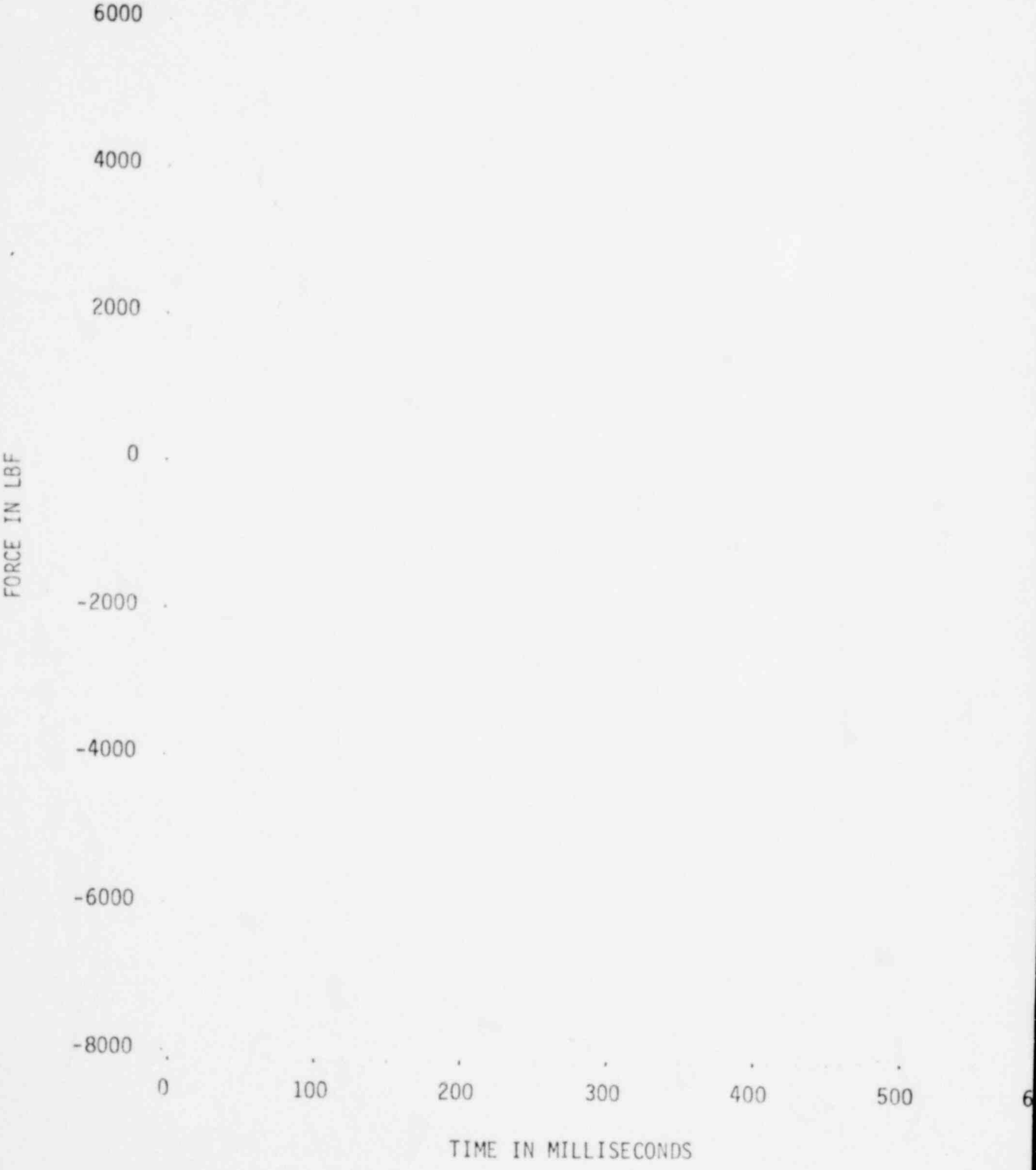


1350 314

FIGURE A-789

NET TORUS FORCE FROM PRESSURE INTEGRAL, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hope Creek Test 5



1350 315

FIGURE A-790

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hope Creek Test 3

1350 316

FIGURE A-791

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hope Creek Test 3

NET AVERAGE POOL PRESSURE IN PSIA

3

2

1

0

-1

-2

-3

-4

0 100 200 300 400 500 60

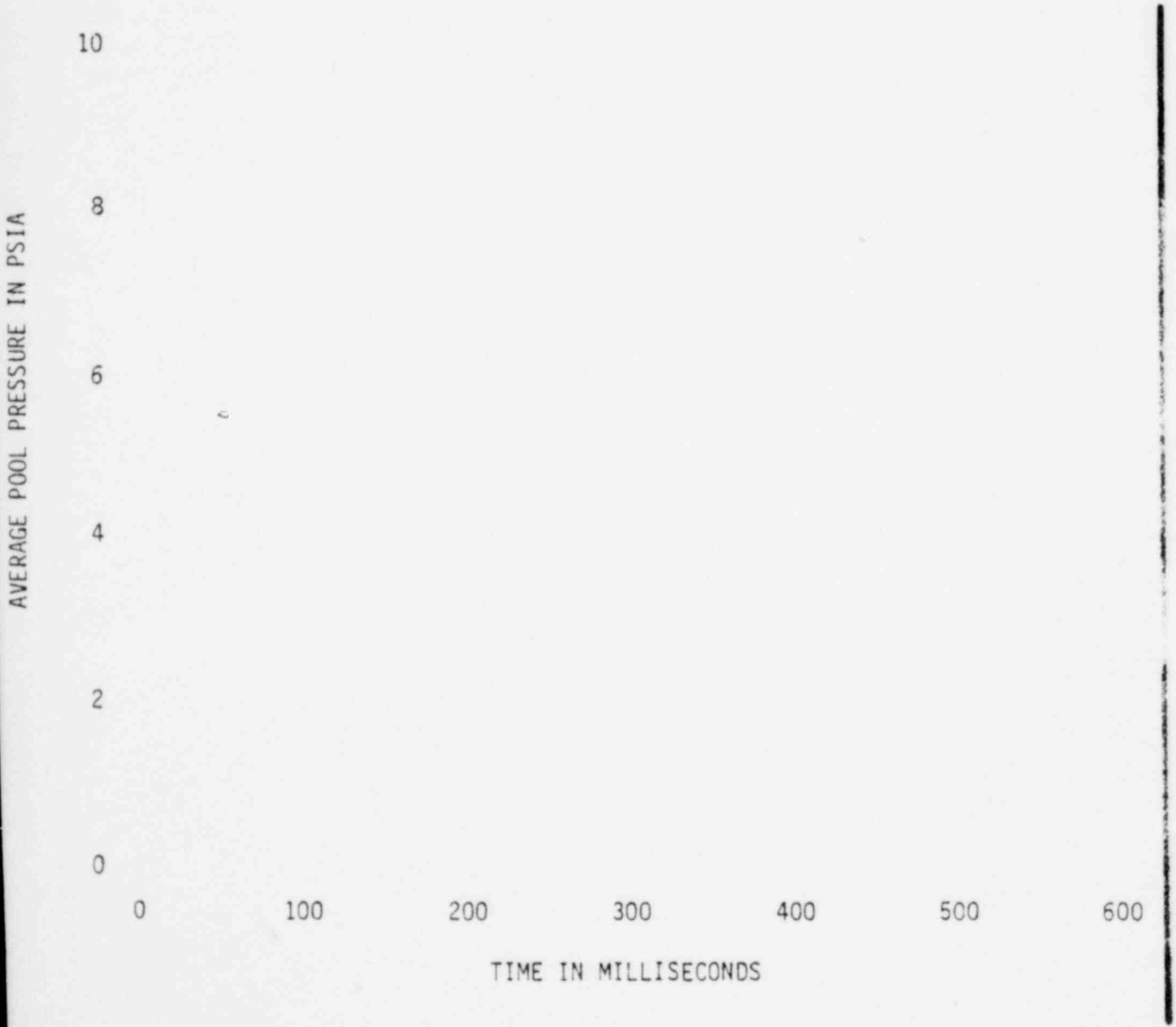
TIME IN MILLISECONDS

1350 317

FIGURE A-792

AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Task 5.5.3 Hope Creek Test 5



1350 318

FIGURE A-793

NET AVERAGE POOL PRESSURE, CORRECTED FOR WATER INERTIA

Tast 5.5.3 Hope Creek Test 5

NET AVERAGE POOL PRESSURE IN PSIA

3

2

1

0

-1

-2

-3

-4

0 100 200 300 400 500 60

TIME IN MILLISECONDS

1350 319

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hope Creek Test 3

FIGURE A-794

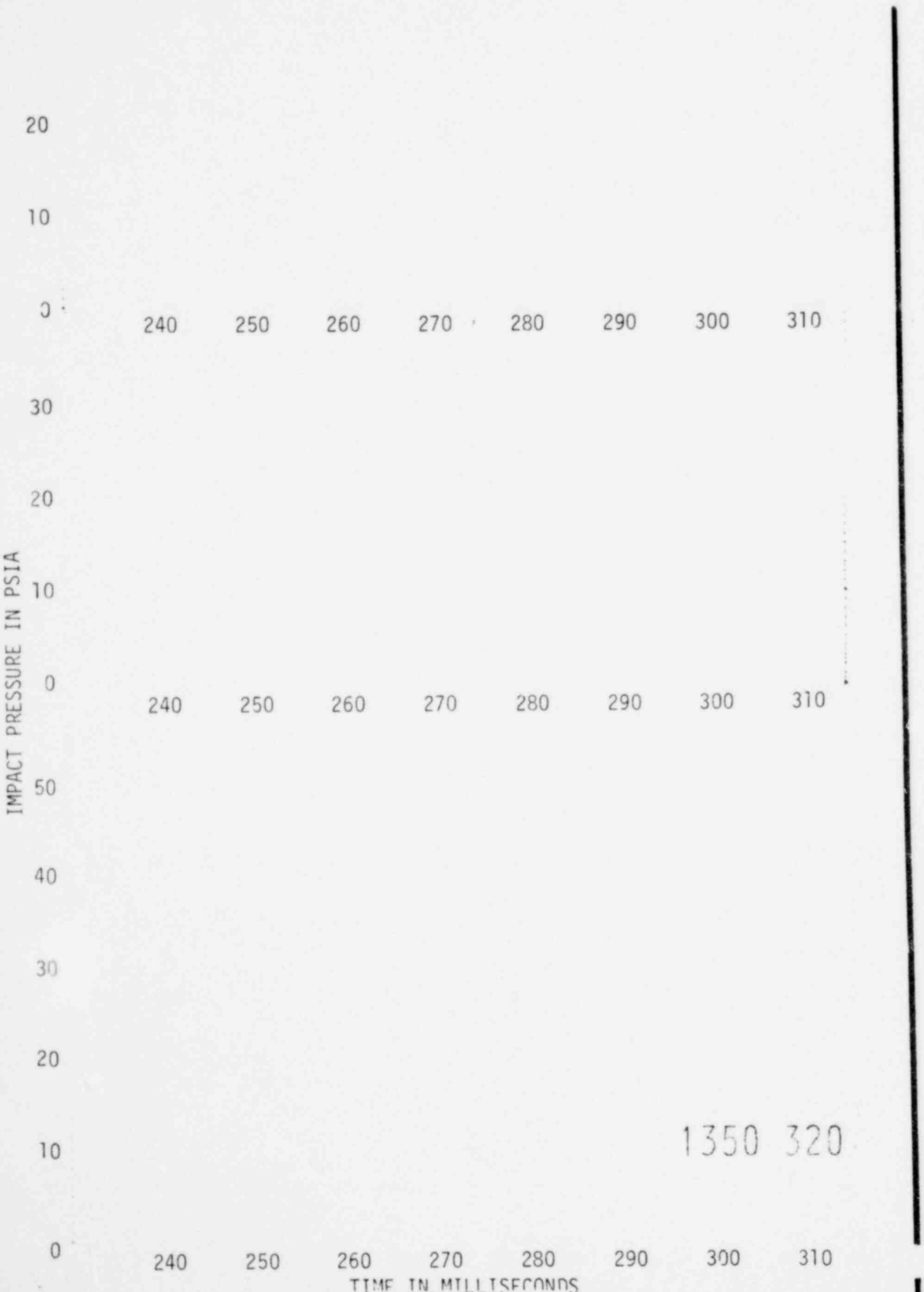
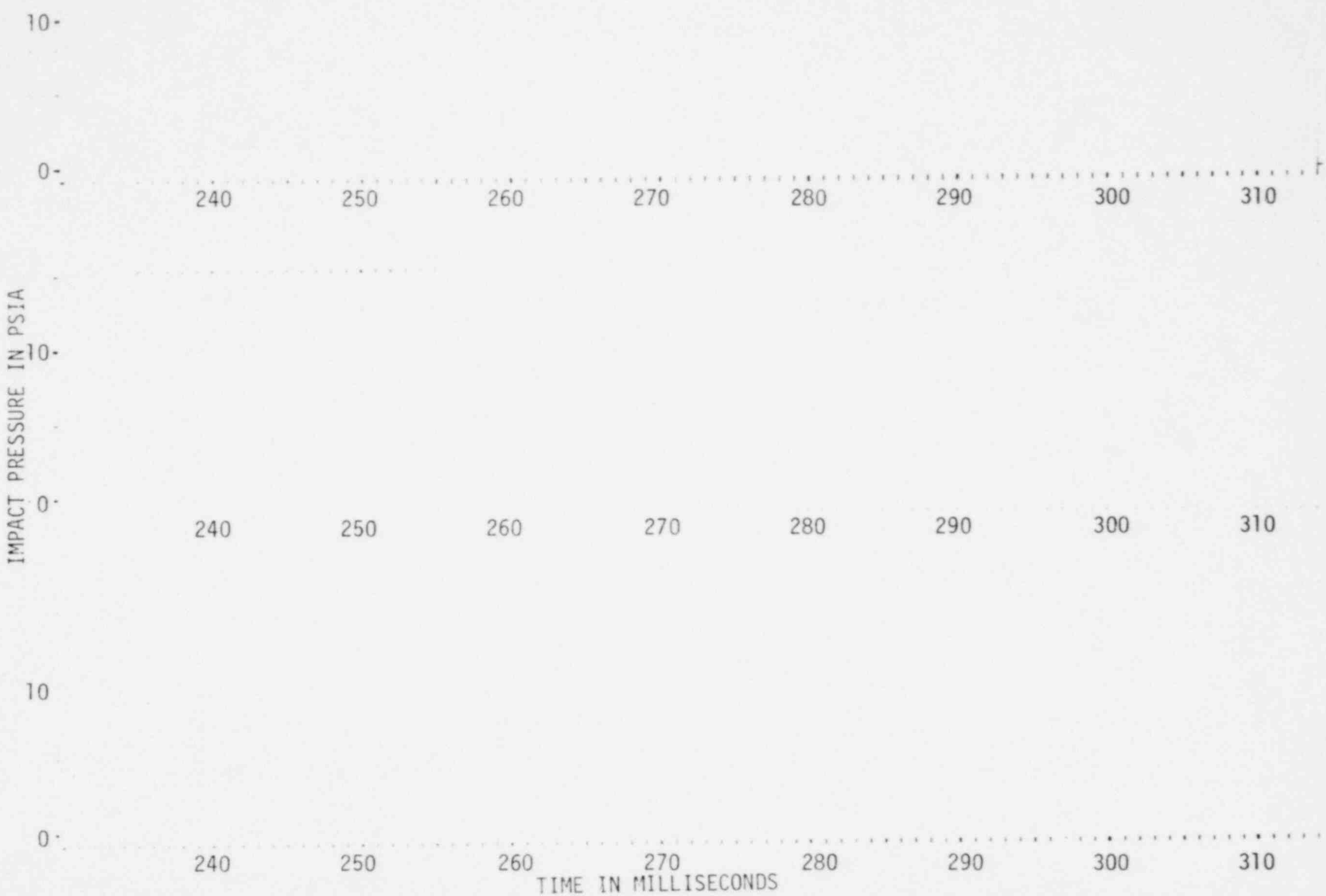


FIGURE A-795 VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hope Creek Test 3

1350 321

FIGURE A-796

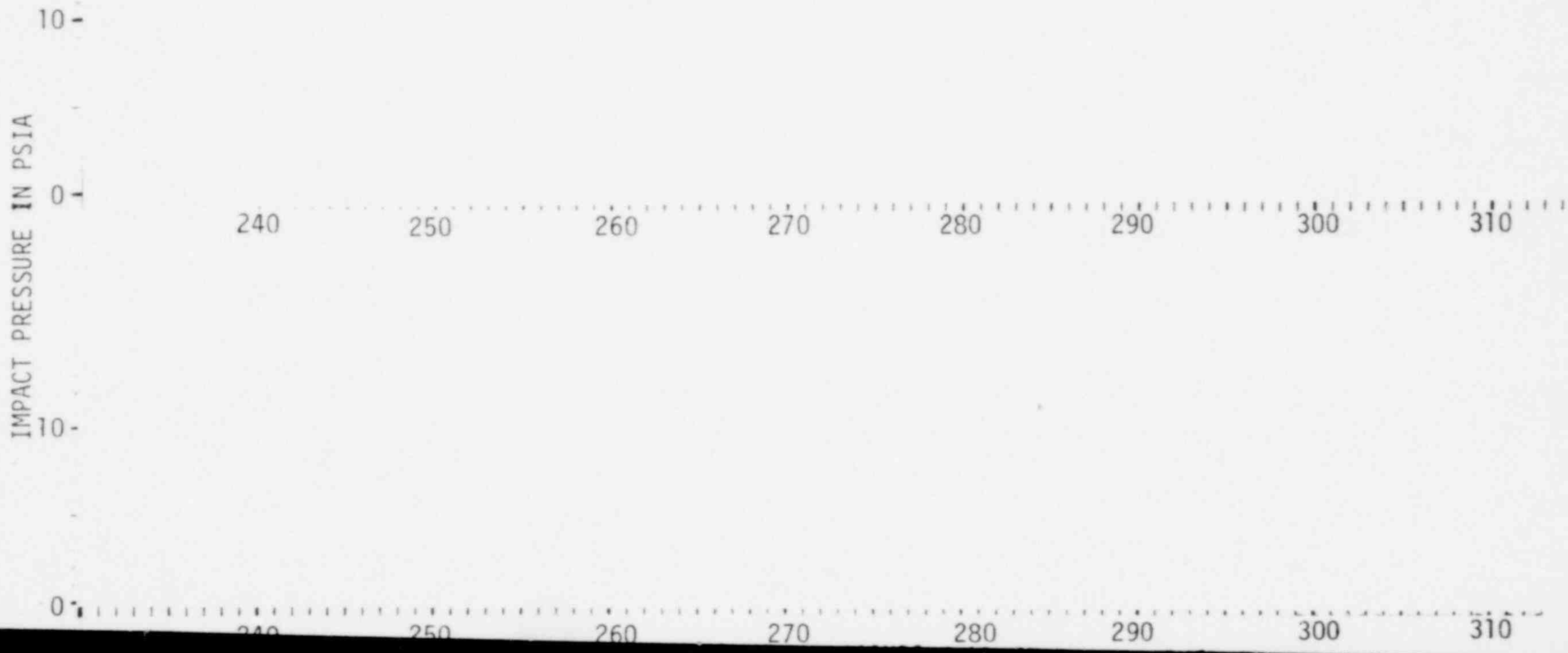


1350 322

FIGURE A-797

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hope Creek Test 3



VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hope Creek Test 5

FIGURE A-798

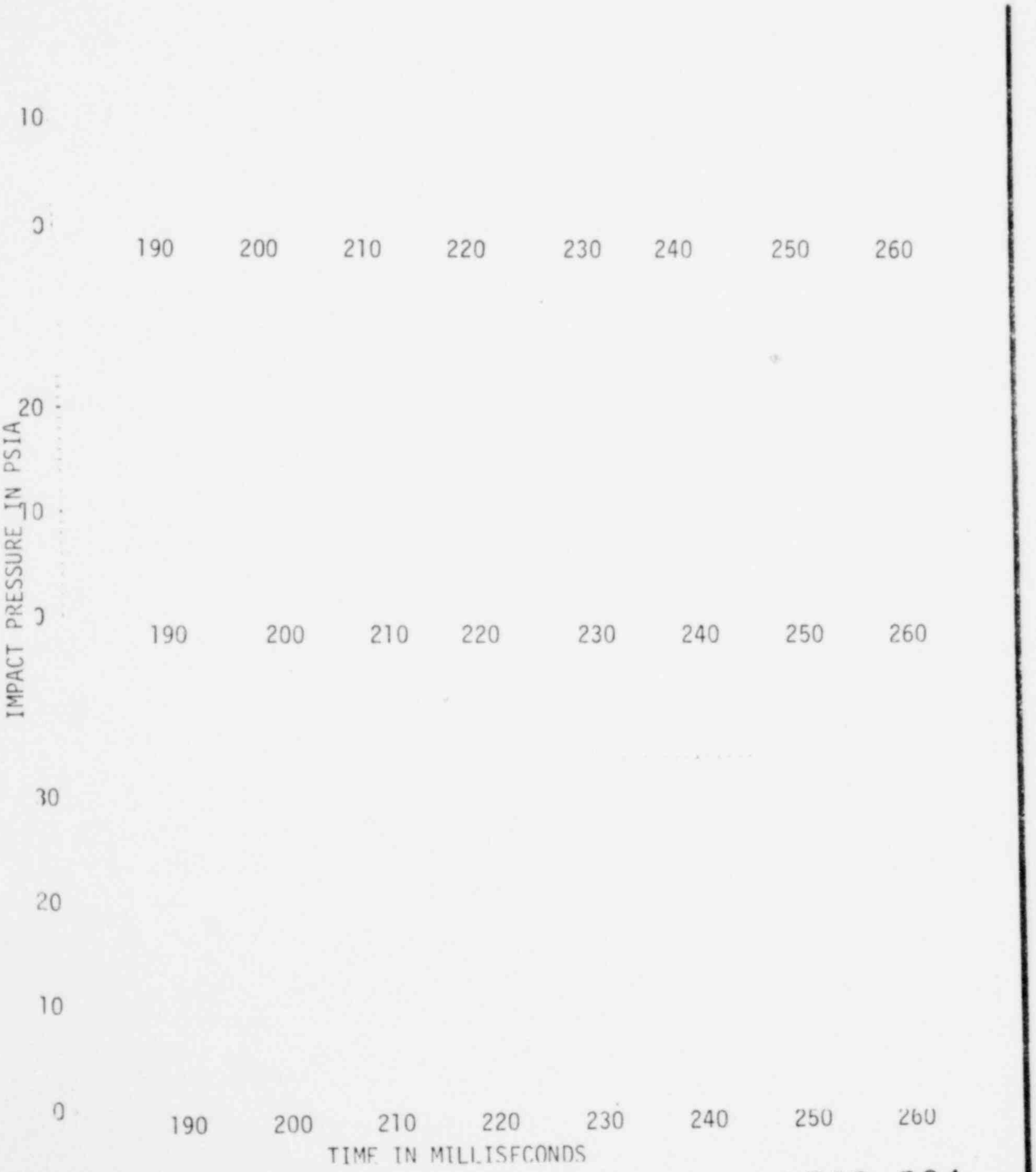


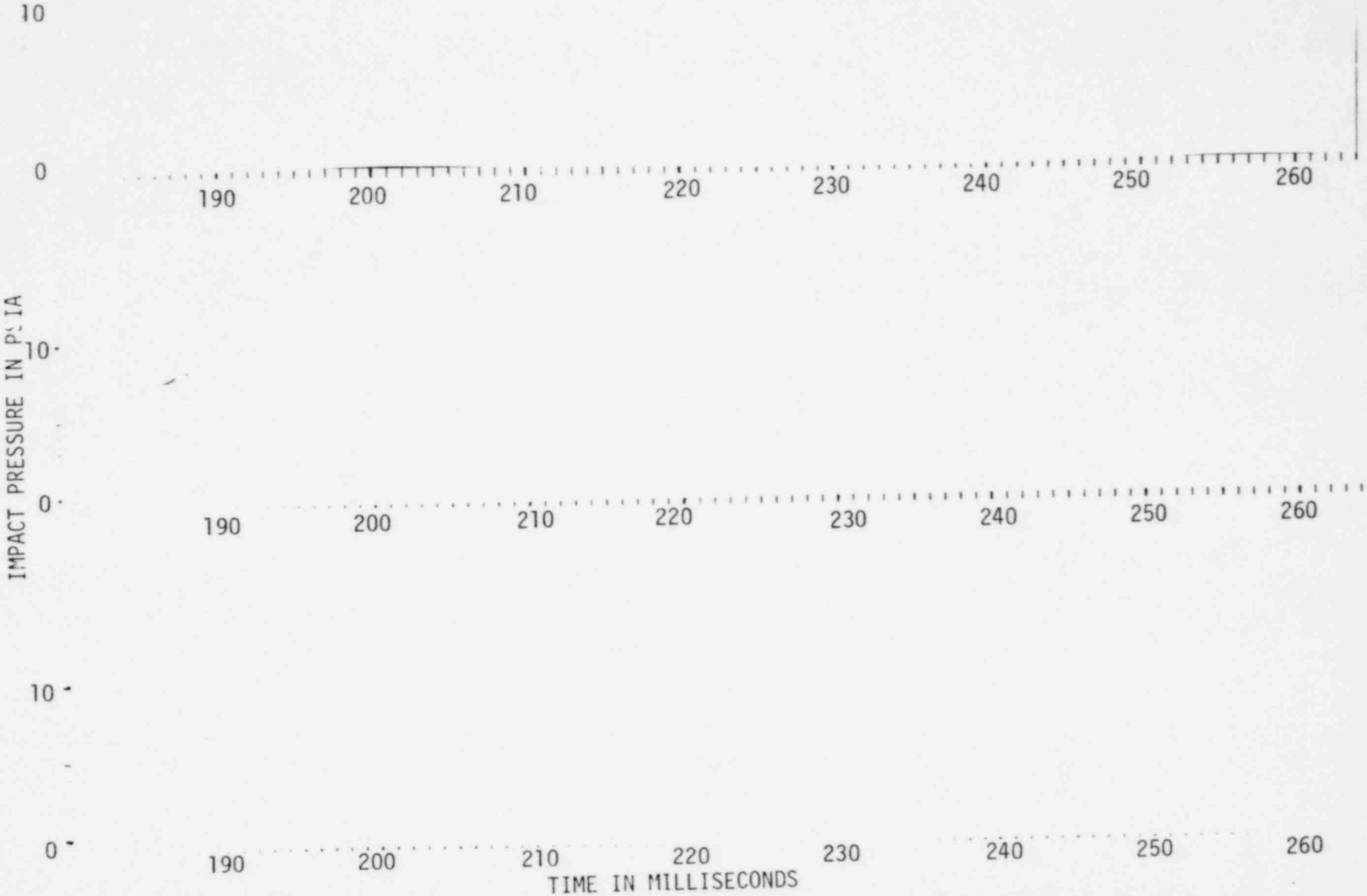
FIGURE A-799

VENT HEADER IMPACT PRESSURES

Task 5.5.3 Hope Creek Test 5

1350 32

Task 5.5.3 Hope Creek Test 5

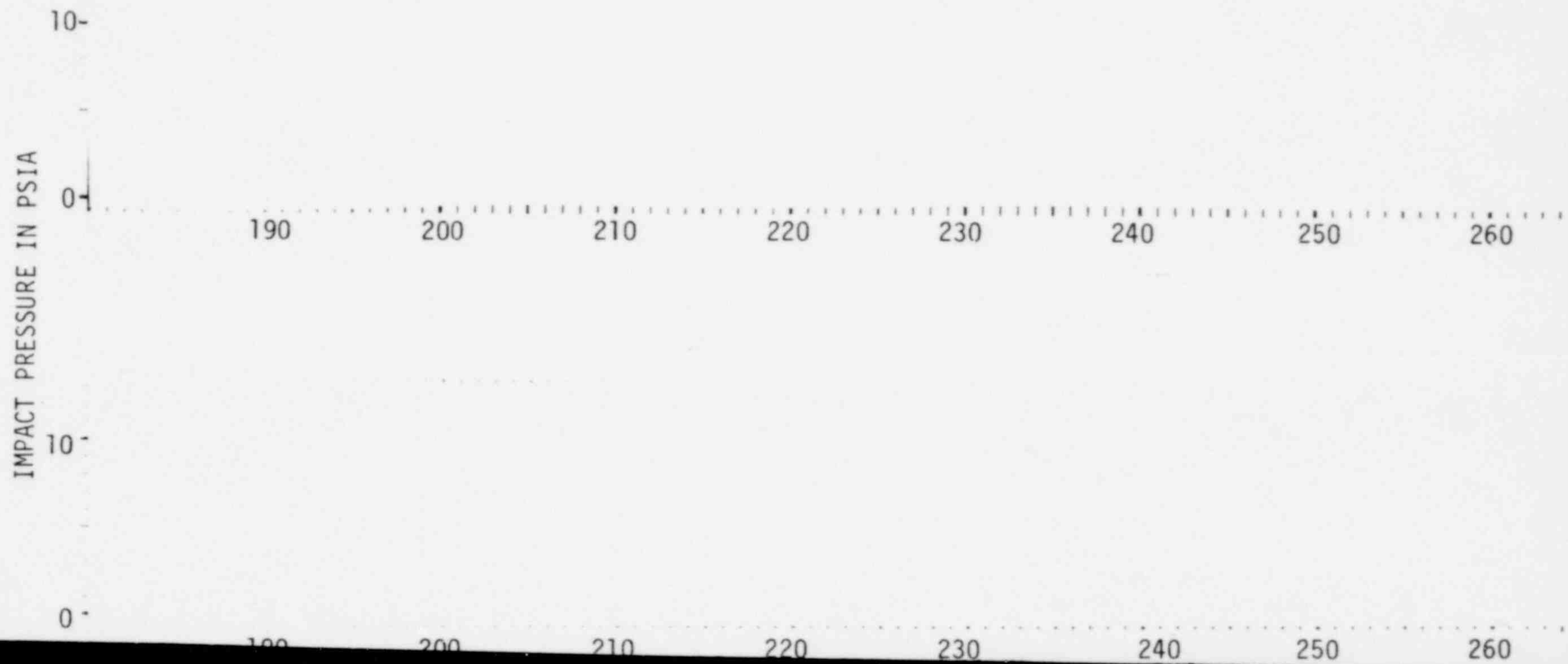


1350 326

FIGURE A-801

VENT HEADER IMPACT PRESSURES

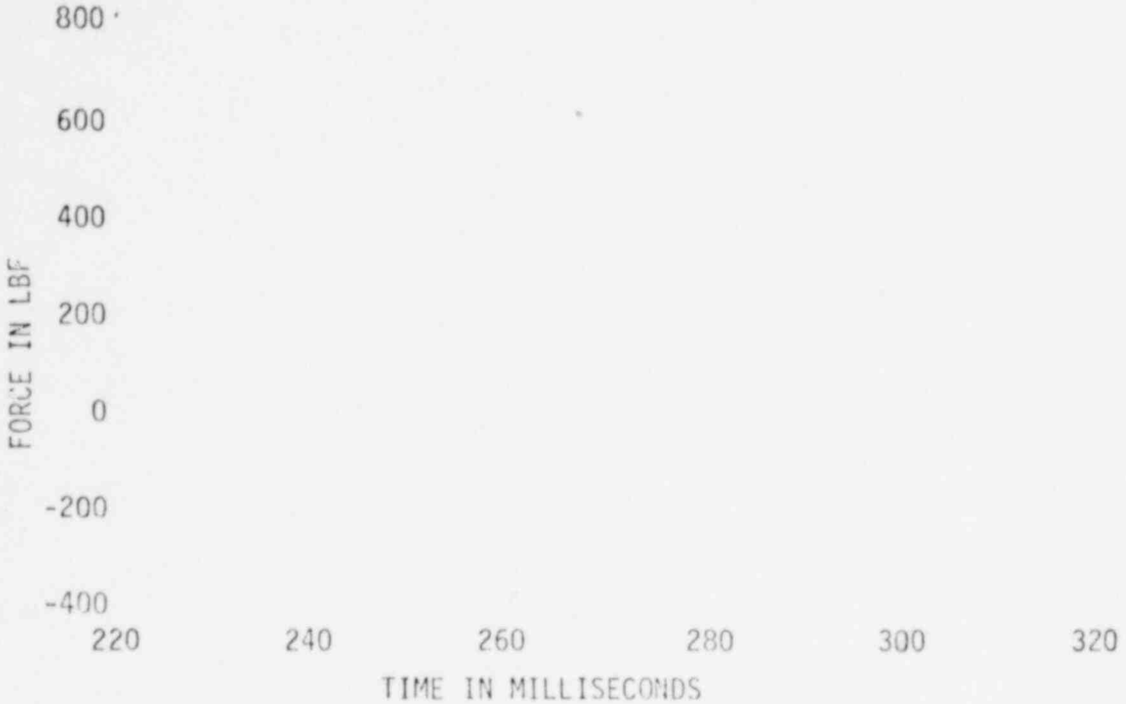
Task 5.5.3 Hope Creek Test 5



1350 327

FIGURE A-802

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



1350 328

FIGURE A-803

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3- Hope Creek Test 3

ACCELERATION IN G

12
8
4
0
-4
-8

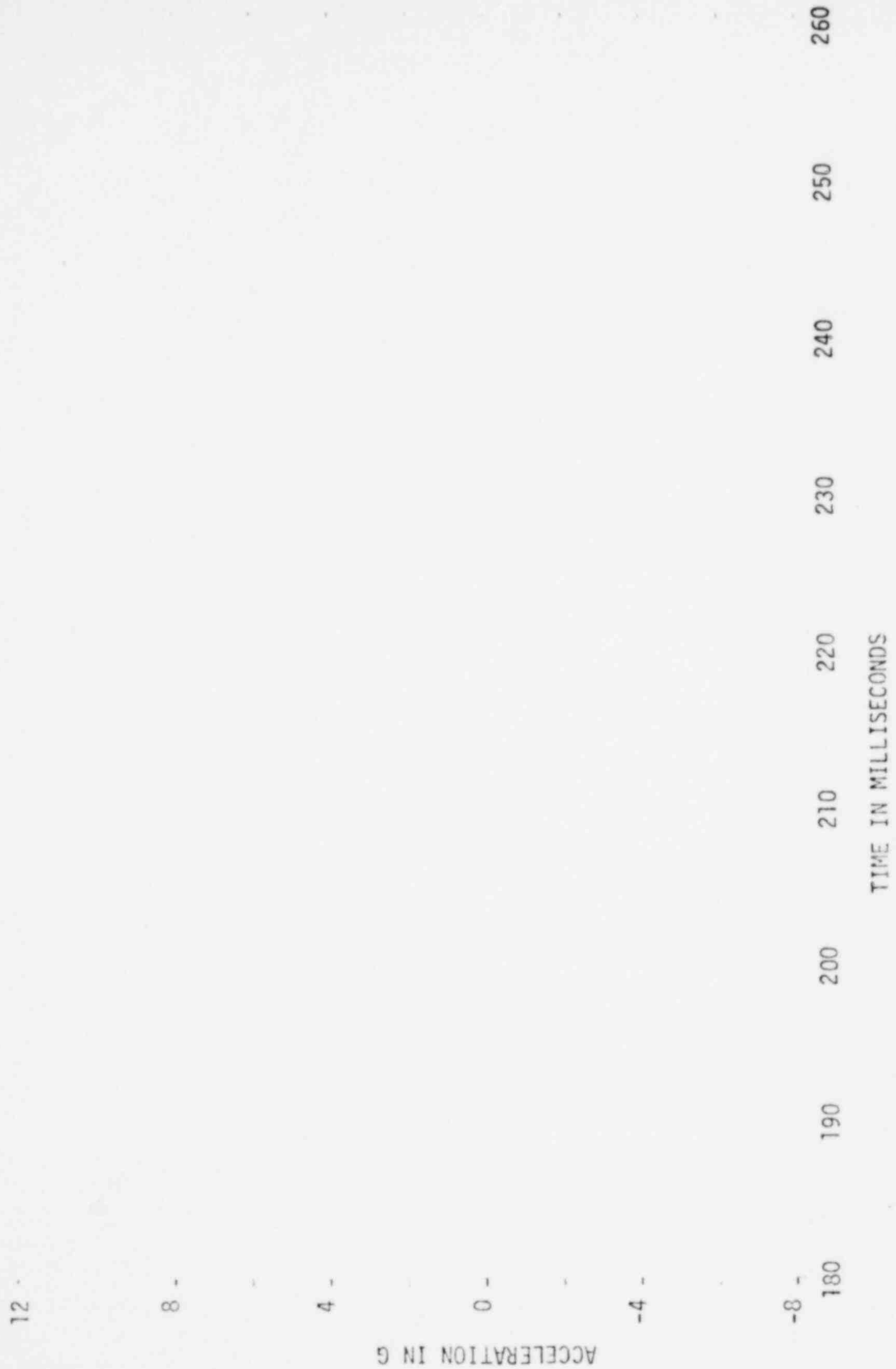
230 240 250 260 270 280 290 300 310

1350 329

FIGURE A-804

VENT HEADER VERTICAL ACCELERATION

Task 5.5.3 Hope Creek Test 5



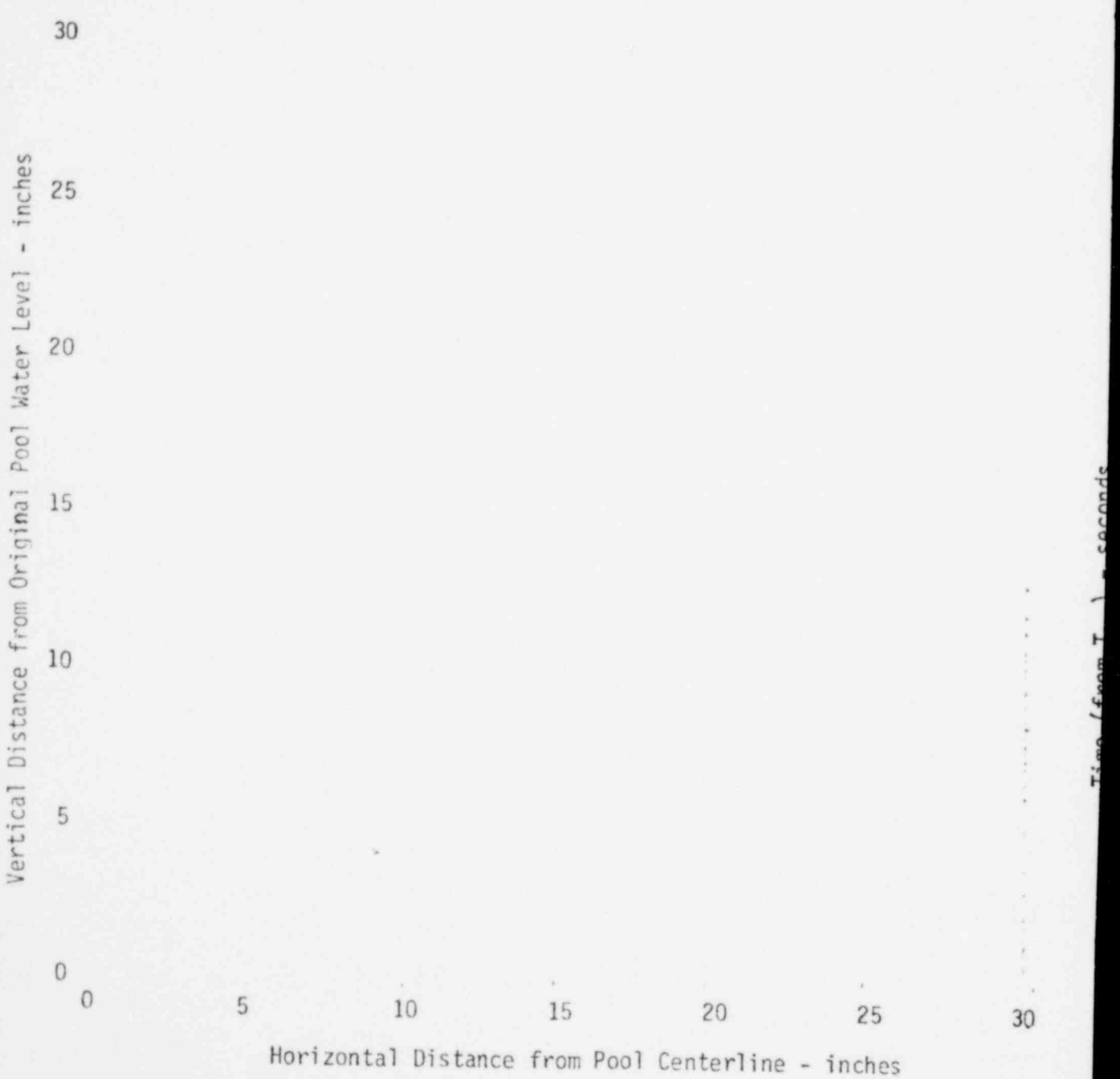
1350 330

FIGURE A-805

TIME HISTORY OF

POOL DISPLACEMENT

HOPE CREEK, TEST 1



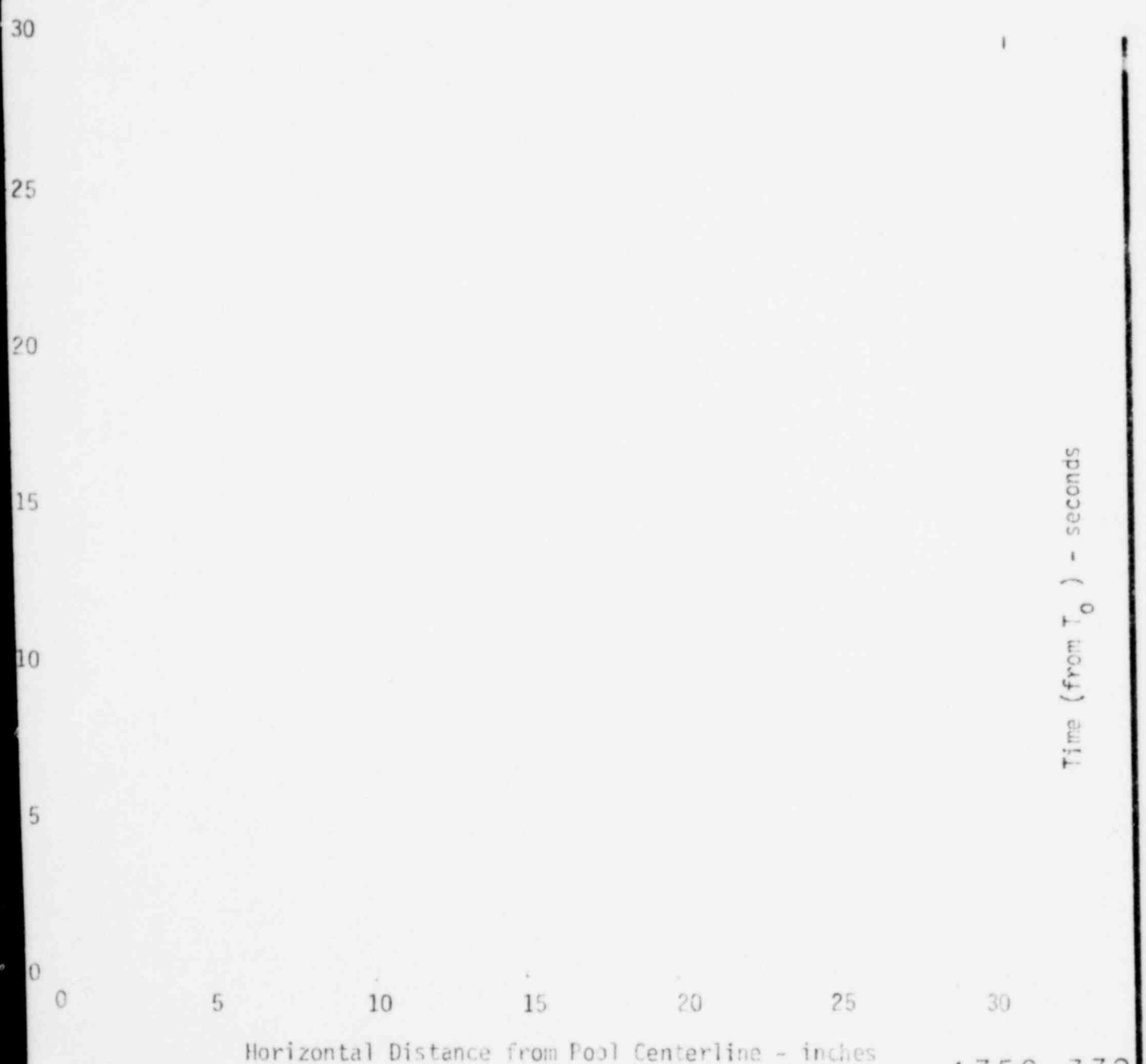
1350 331

FIGURE A-806

TIME HISTORY OF

POOL DISPLACEMENT

HOPE CREEK, TEST 2



1350 332

FIGURE A-807

TIME HISTORY OF
POOL DISPLACEMENT

HOPE CREEK, TEST 3

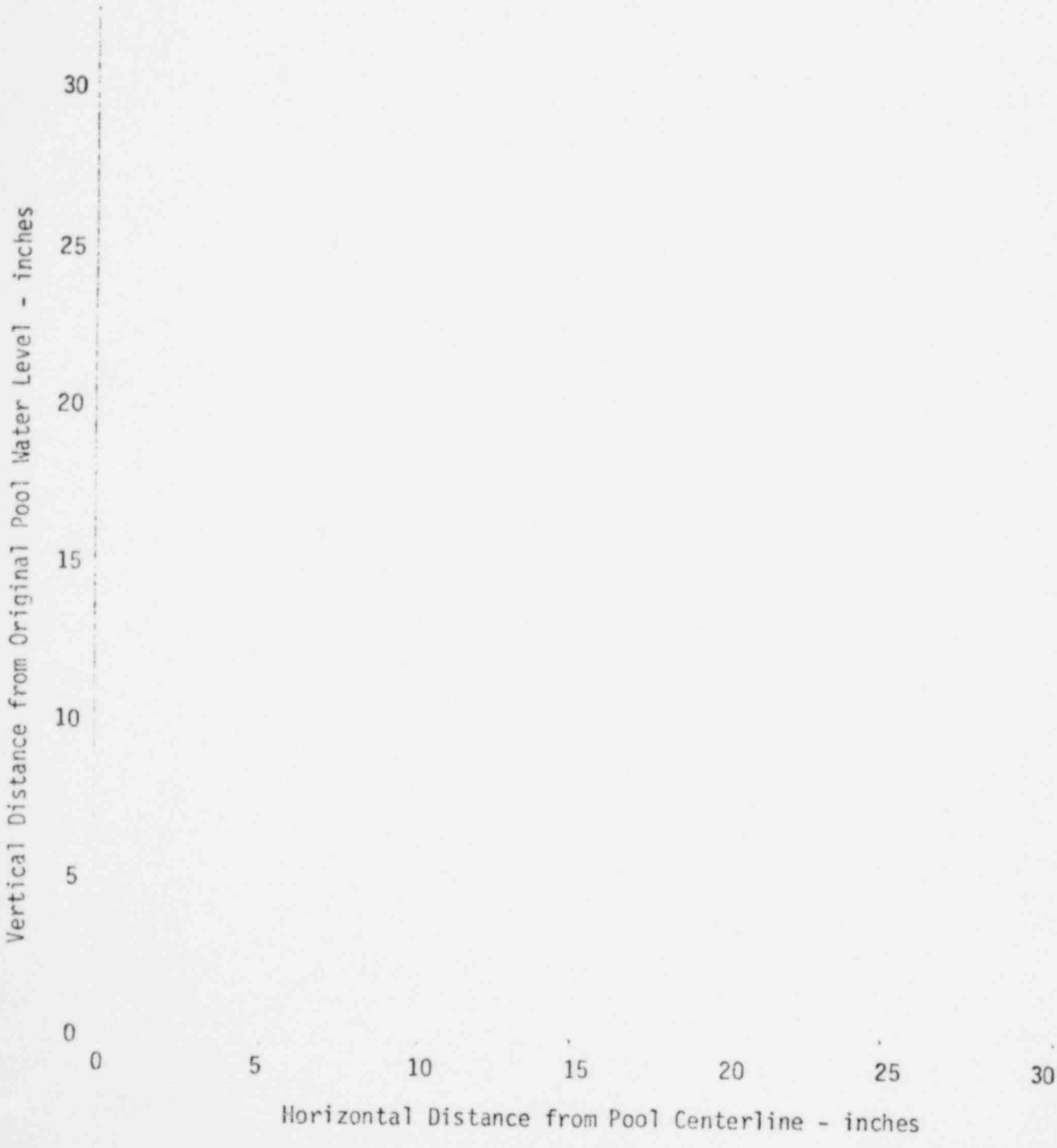


FIGURE A-808

TIME HISTORY OF
POOL DISPLACEMENT

HOPE CREEK, TEST 5

30

5

0

5

Time (from T_o) - seconds

1350 334

0 5 10 15 20 25 30

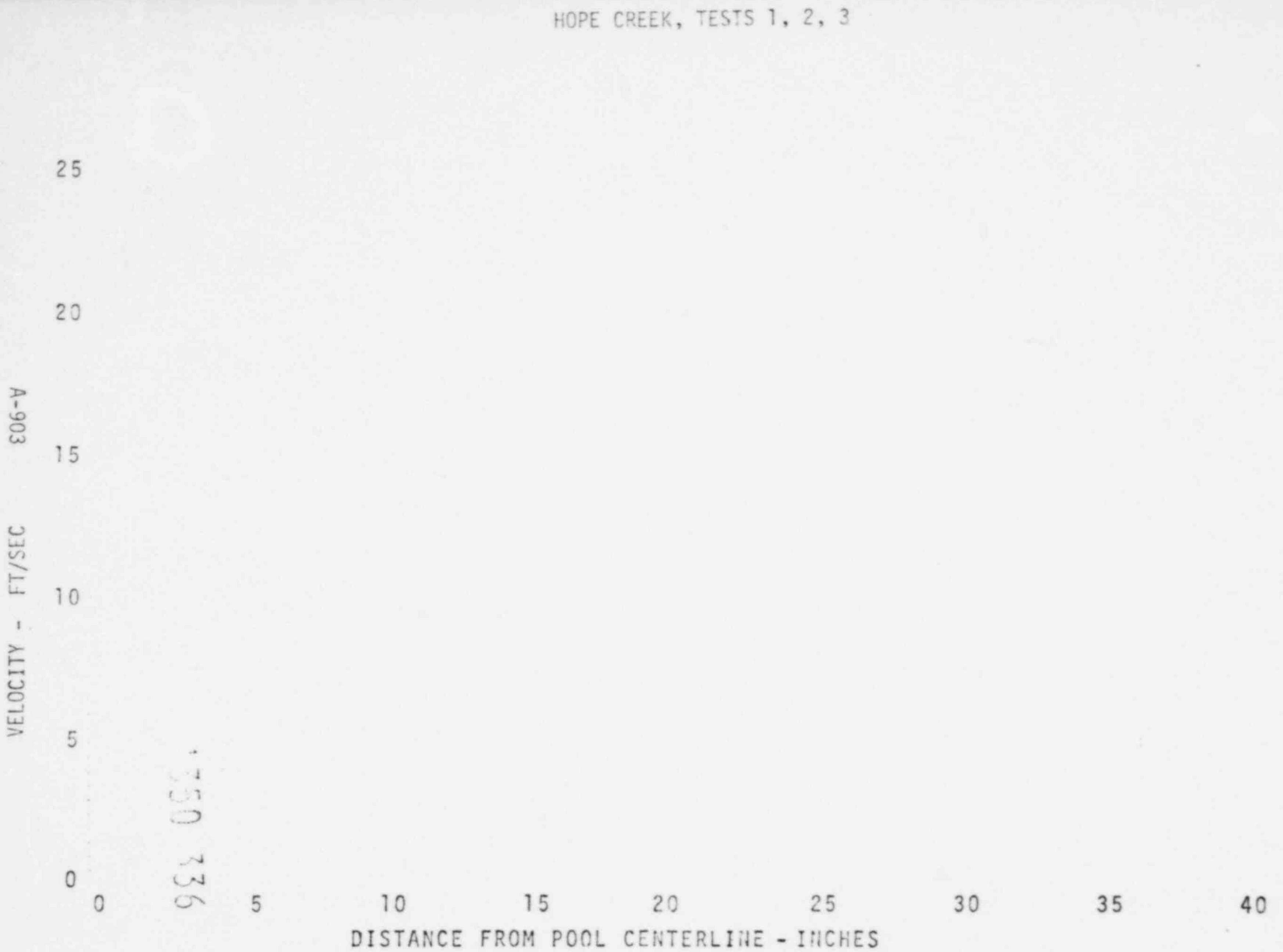
Horizontal Distance from Pool Centerline - inches

FIGURE A-809

POOL SURFACE DISPLACEMENT

HOPE CREEK, TESTS 1,2,3

1350 335

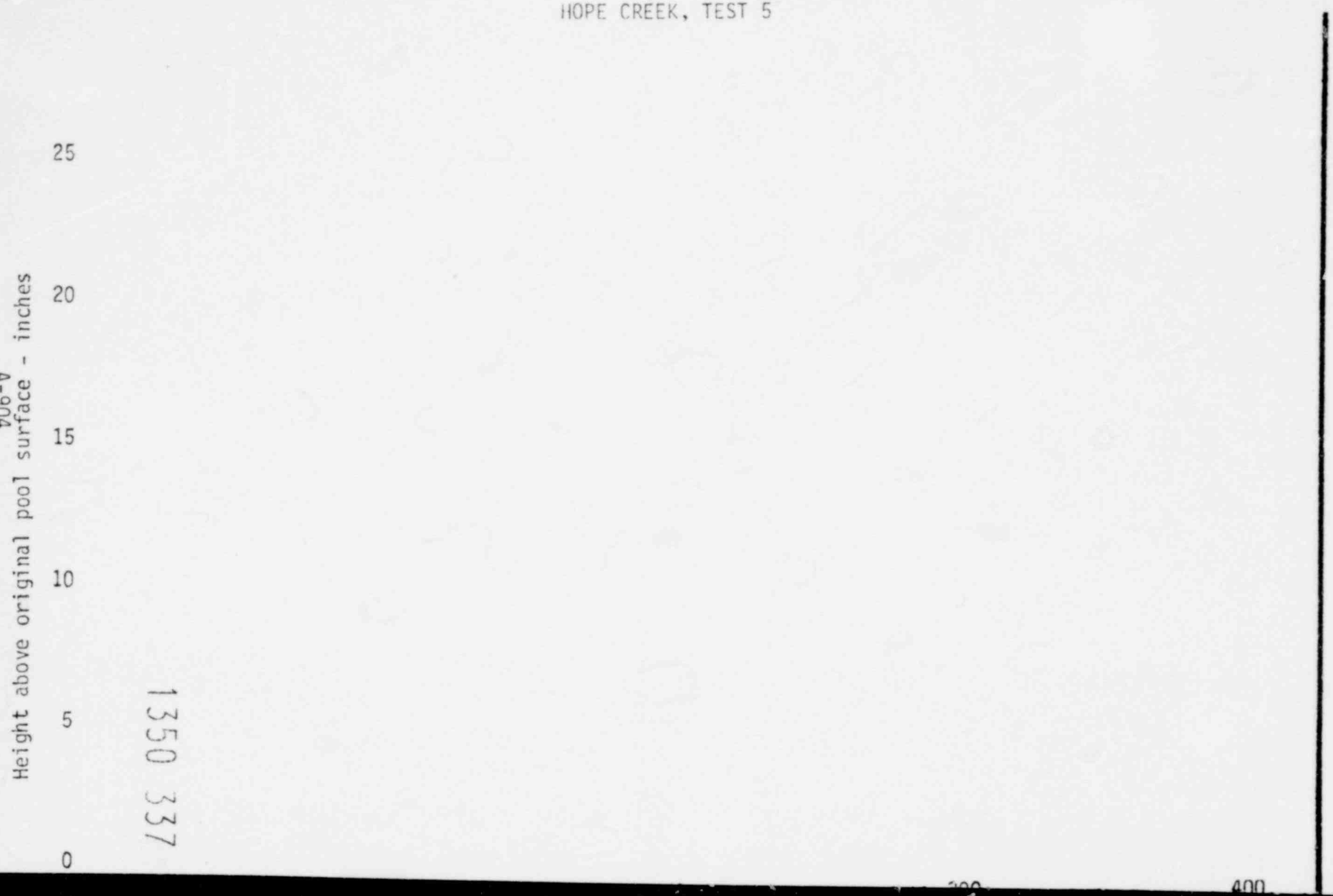

HOPE CREEK, TESTS 1, 2, 3
VELOCITY - FT/SEC
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
DISTANCE FROM POOL CENTERLINE - INCHES

1350 336

FIGURE A-811

POOL SURFACE DISPLACEMENT

HOPE CREEK, TEST 5



1350 337


HOPE CREEK, TEST 5
VELOCITY - FT/SEC
0
5
10
15
20
25
DISTANCE FROM POOL CENTERLINE - INCHES
0
5
10
15
20
25
30
35
40

1350 338

FIGURE A-813 SIDE WINDOW DISPLACEMENT AND VELOCITY PROFILES

HOPE CREEK, TEST 4

VERTICAL DISPLACEMENT - INCHES

10
8
6
4
2
0
-2

.150 .200 .250 .300 .350 .400 .450

VERTICAL VELOCITY-FT/SEC

15.
10.
5.
0.

.150 .200 .250 .300 .350 .400 .45

TIME - Seconds

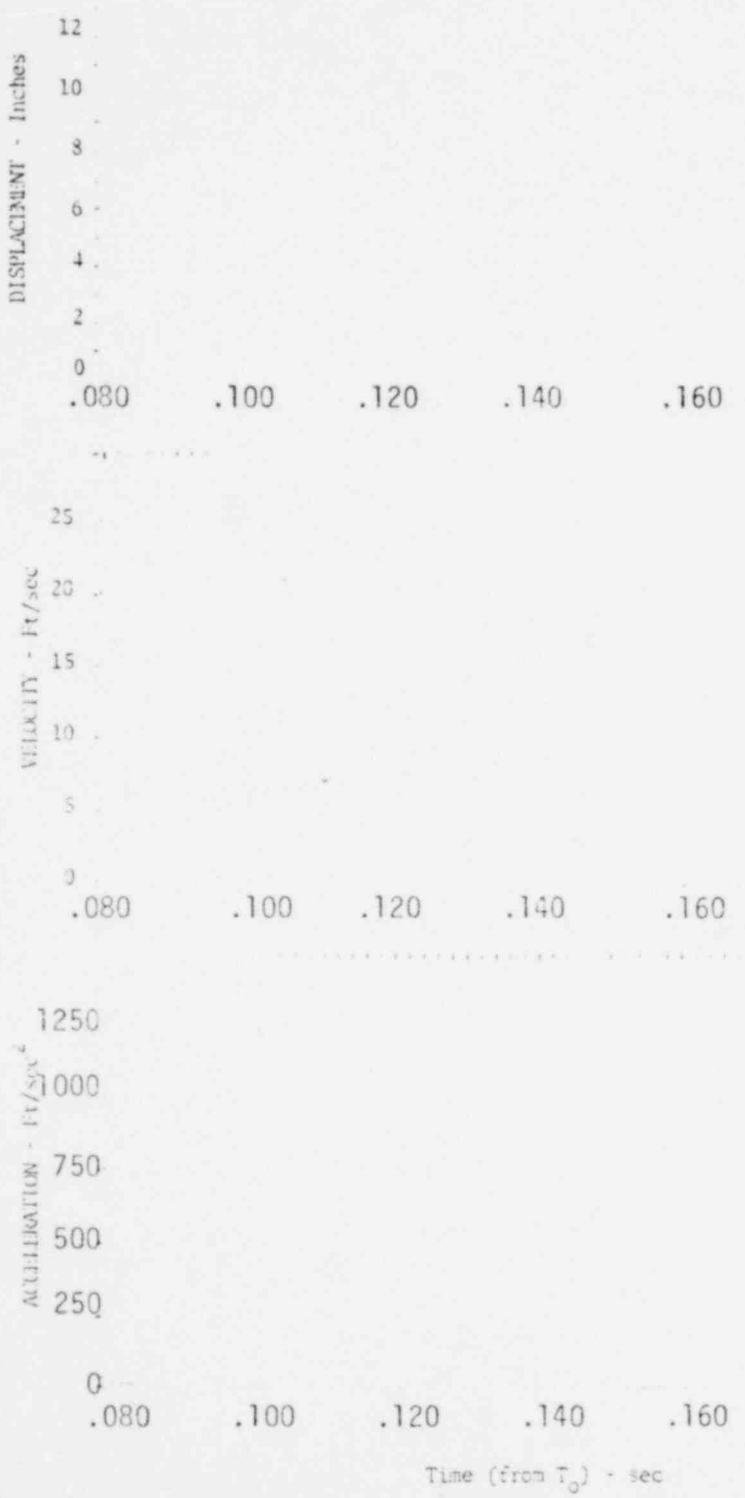
1350 339

NEDO-21944

FIGURE A-814

DOWNCOMER WATER SLUG EJECTION

HOPE CREEK, TEST 3

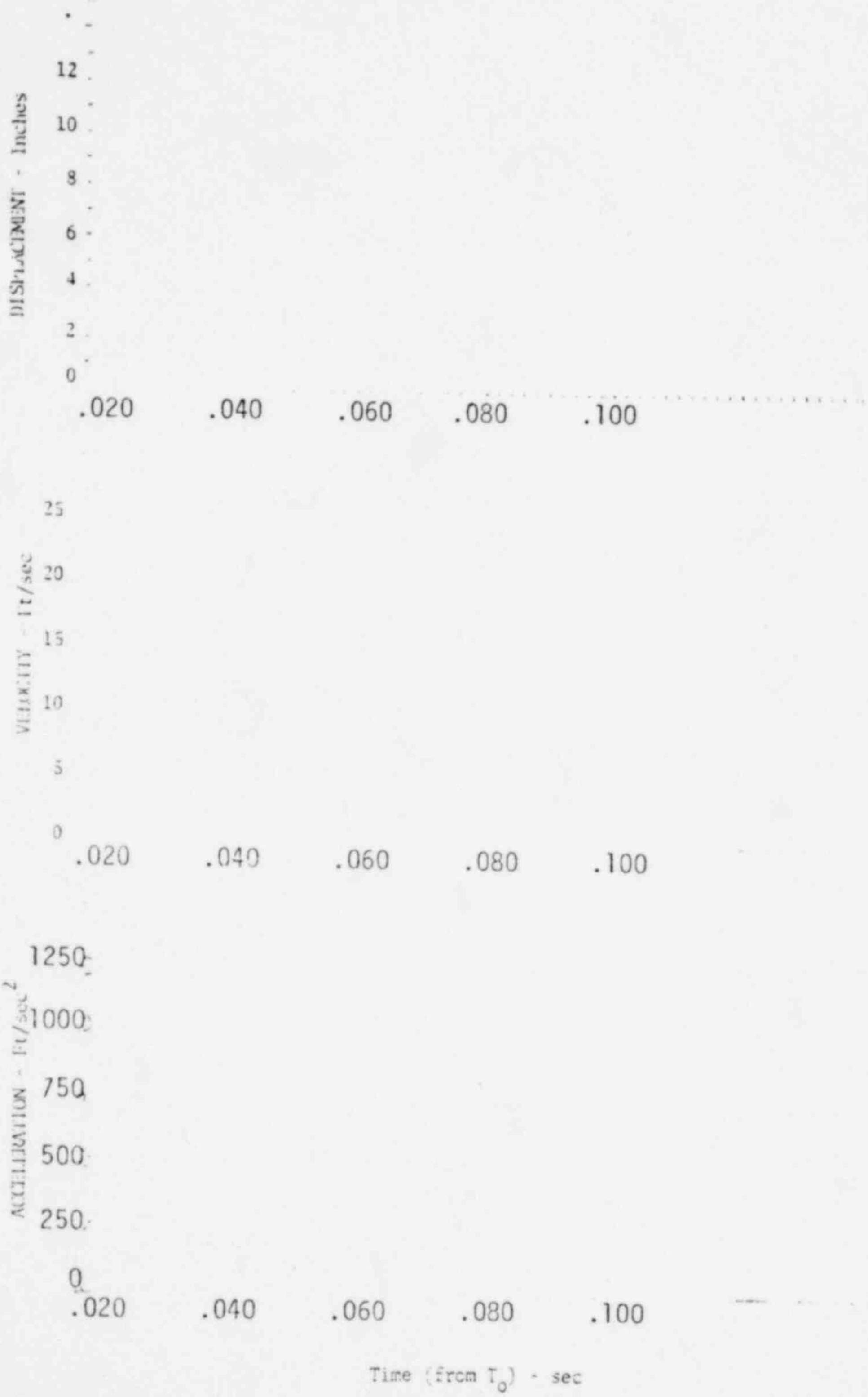


1350 340

FIGURE A-815

DOWNCOMER WATER SLUG EJECTION

HOPE CREEK, TEST 5



1350 341

FIGURE A-816

EFFECT OF DRYWELL/WETWELL ΔP ON

ENTHALPY FLOW INTO POOL

Hope Creek Tests

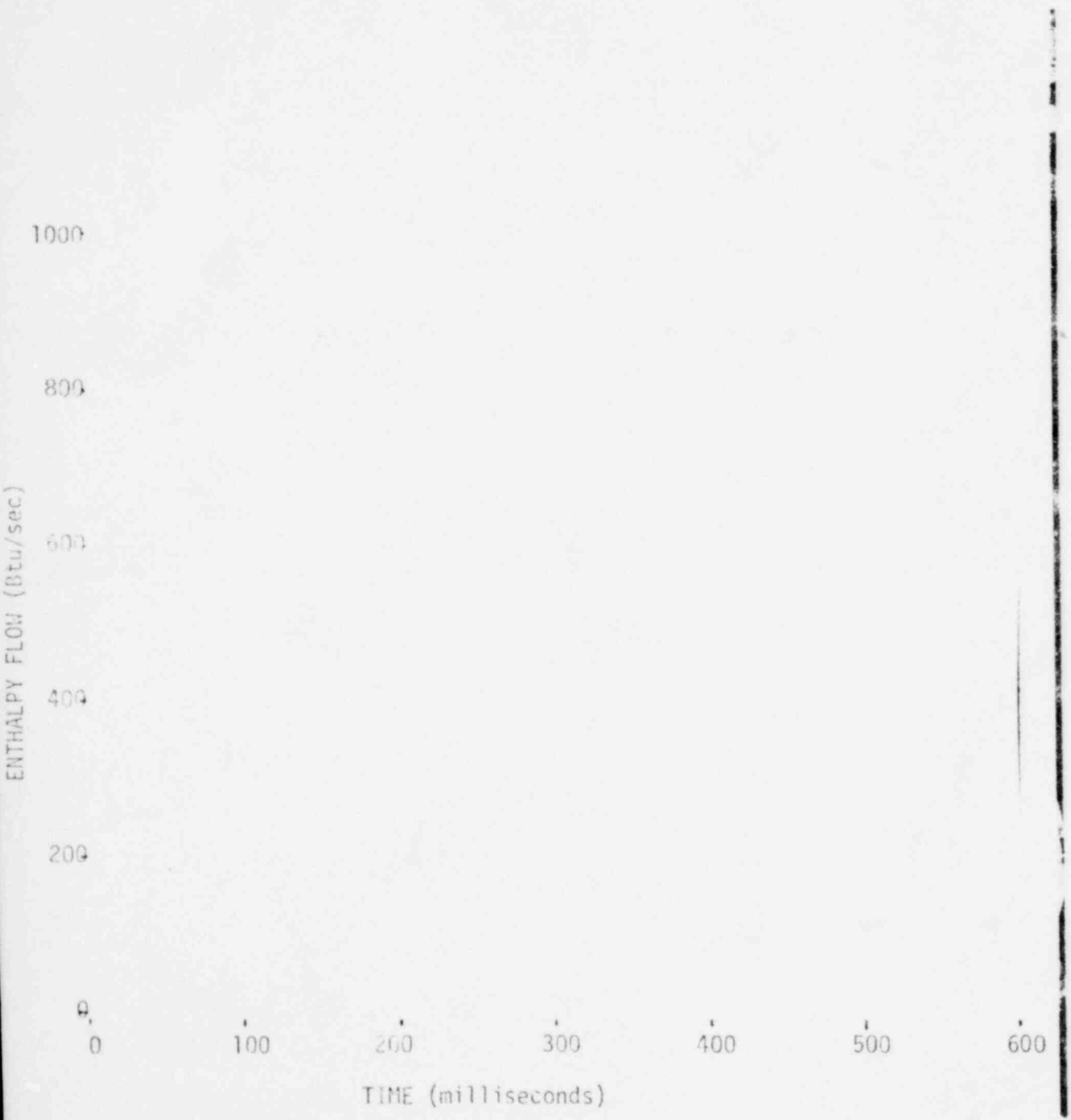
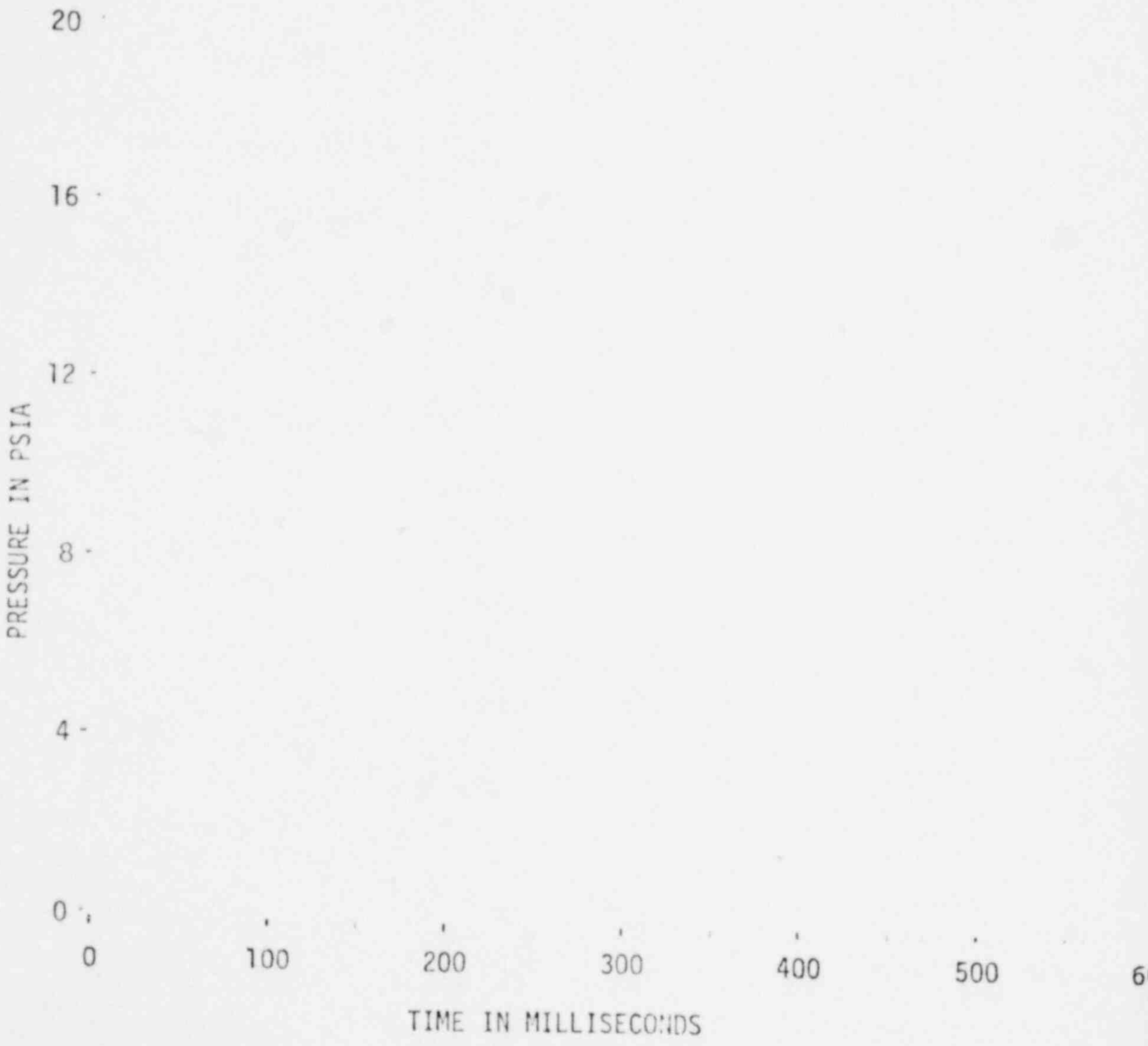


FIGURE A-817

EFFECT OF DRYWELL/WETWELL ΔP ON

DOWNCOMER INTERNAL PRESSURE

Hope Creek Tests



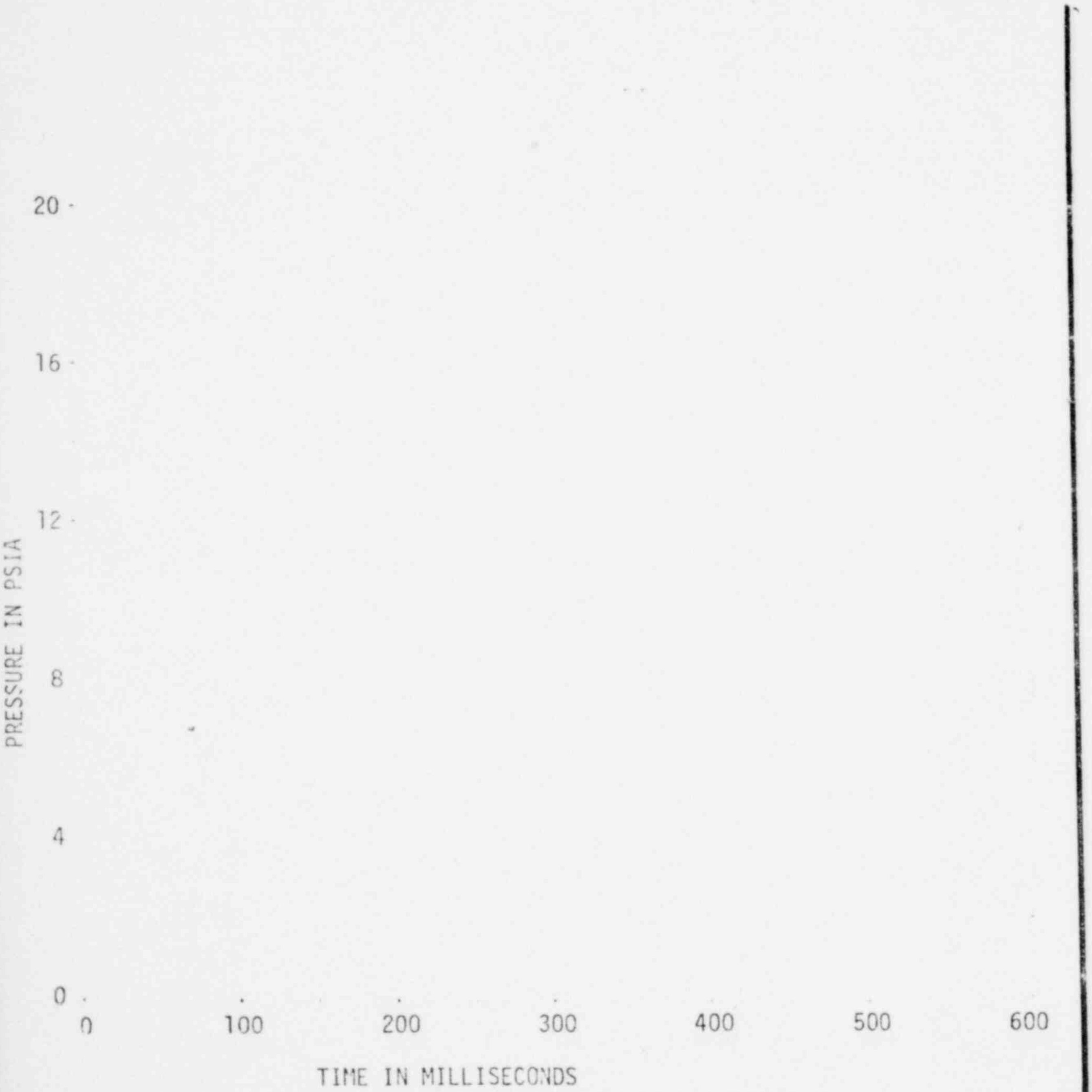
1350 343

FIGURE A-818

EFFECT OF DRYWELL/WETWELL ΔP ON POOL PRESSURE

AT 180 DEGREE AND FREESPACE PRESSURE

Hope Creek Tests



1350 344

TABLE A-33

DATA FOR WETWELL VERTICAL LOADS

Task 5.5.3 Hope Creek Tests

Parameter \ Test No.		0" ΔP, No Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	7.0" ΔP (5)
T_o +	(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)							

+ = Start of test reference time

* = Vent clearing time (from T_o) determined from the movie films

** = Time difference from T_o to time of zero downforce

1350 345

TABLE A-33

DATA FOR WETWELL VERTICAL LOADS (continued)

Task 5.5.3 Hope Creek Tests

Parameter \ Test No.	0" ΔP, No Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	7.0" 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)							

*** = Time at force is zero (from T_o)

1350 346

TABLE A-34

DATA FOR VENT HEADER IMPACT LOADS

Task 5.5.3 Hope Creek Tests

Parameter \ Test No.		o" ΔP, No Deflector (1)	(2)	(3)	(4)	Mean	Std. Dev.	7" 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

1350 347