REPORT OF TEST

FR 3956

JANUARY, 1985

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

PART 1 of 2

FINAL REPORT FOR

FEDERAL EMERGENCY MANAGEMENT AGENCY
WASHINGTON, DC 20472

Tests conducted under Interagency Agreement EMW-E-1239,
Task Order 4A FEMA Work Unit No. 6121A

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, MD 20899

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Water Spray Suppression of Fully-Developed Wood Crib Fires in a Compartment		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER FR 3956
7. AUTHOR(s) James Milke, Dave Evans, Warren Hayes, Jr.		8. CONTRACT OR GRANT NUMBER(s) Interagency Agreement EMW-E-1239, Task Order 4A FEMA Work Unit No. 6121A
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Bureau of Standards Gaithersburg, MD 20899		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Federal Emergency Management Agency Washington, DC 20472		12. REPORT DATE January 1985
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release: Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Crib fires; extinguishment; firefighting; room fires; sprinklers; water spray

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a fully-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model. The results illustrate the dynamics of compartment fire suppression using water sprays.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

SECURITY CLASSIFICATION OF THIS PAGE(*When Data Entered*)

FORM NBS—259
(REV. 12-78)

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

REPORT OF TEST

FR 3956

JANUARY, 1985

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

PART 1 of 2

James Milke, David Evans, Warren Hayes, Jr.
Center for Fire Research
National Bureau of Standards

FOR

FEDERAL EMERGENCY MANAGEMENT AGENCY

Tests conducted under Interagency Agreement EMW-E-1239,
Task Order 4A FEMA Work Unit No. 6121A

1.0 INTRODUCTION

A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a fully-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model.[1] The results illustrate the dynamics of compartment fire suppression using water sprays. This report is reproduced in two parts. Part 1 contains a description of the experiments and summary of results including graphical presentations of data. Part 2 contains tables of test data and test observations presented in four appendixes.

2.0 Experimental Parameters

The experimental parameters can be grouped into three categories: compartment, fuel, and water spray application. In these tests only the

[1] Pietrzak, L. M., Johnson, G. A., and J. Ball, "A Physically Based Fire Suppression Computer Simulation for Post-Flashover Compartment Fires", Mission Research Corporation, Santa Barbara, California, June 1984.

water spray drop size and flow rate were varied. The compartment geometry, wood crib fuel array, ignition method, and conditions to start water spray extinguishment were not varied. A full list of test parameters is provided in Table 1.

Total water spray flow rate and median volumetric droplet diameter were varied by choice of nozzle and operating pressure. The water flow rate and median volumetric droplet diameter for tests 2 through 5 are presented in Table 2 (no water was applied in Test 1). In each of the water spray tests, extinguishment was begun one minute after the top thermocouple in the room doorway reached a temperature of 478°C. This temperature in the doorway correlated with the beginning of the nearly steady burning rate of the wood crib in the room. Plan and elevation views of the room are provided in Figures 1 and 2, indicating the location of the cribs, water spray nozzle and measurement equipment.

2.1 Compartment Parameters

The compartment had inside dimensions of 2.44 m x 3.66 m x 2.44 m (height) with one ventilation opening (i.e. a doorway) measuring 0.44 m by 1.51 m (height). The wall, ceiling and floor were lined with a 0.019 m layer of Marinite I.* The Marinite panels were simply laid over a concrete slab floor. For the ceiling, the Marinite panels were attached to steel channels with a nominal 2 inch layer of Kaowool* insulation placed above the channels. For the walls, the Marinite panels were placed on steel channels attached to a concrete masonry block wall. This produced an air gap 0.0365 m wide between the marinite and concrete. The compartment doorway size was chosen to produce an air regulated, fully-developed compartment fire, when the wood crib fuel was burned.

2.2 Fuel Parameters

The fuel consisted of 7 clear white pine cribs, 10 layers in height and 3 sticks per layer. The crib was designed to have the free burning rate fuel-surface controlled and the fire duration of sufficient length to provide a long period for extinguishment studies unaffected by fuel depletion.

2.3 Water Spray Parameters

Several sizes of Bete* spiral, 60°, full cone nozzles were operated at selected pressures and were used to provide a particular flow rate and median volumetic droplet diameter for the spray. Flow rates and drop sizes were chosen to provide a range of extinguishment results. The water spray nozzle was located in the plane of the doorway, approximately 0.3 m from the floor, pointed in an upward direction at an angle of 15° above the horizontal axis. The water spray nozzle was rotated in a somewhat elliptic pattern (major axis (horizontal) 0.27 m, minor axis (vertical) 0.12 m) at a frequency of one cycle per second in a counter clockwise direction in an attempt to represent the action of firefighters.

---

*Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

A Bete Droplet Analysis System* was used to obtain droplet size distributions for the water spray nozzles. The Bete Droplet Analysis System consists of a strobe, camera and computer, as illustrated in Figure 3. The strobe and camera are positioned to obtain the droplet size distribution at a desired position within the water spray cone. Since the droplet size distribution is known to be a function of position in the cone, measurements must be taken at numerous positions to obtain a comprehensive representation of the droplet size distribution within the water spray cone. To reduce the number of measurements to be conducted to a reasonable level, the water spray pattern was assumed to be axisymmetric. A distance of 1.52 m was selected as the vertical distance of the nozzle to the analyzer strobe and camera as the droplets appeared to be well dispersed at this distance, and 1.52 m was the distance between the water spray nozzle and the front face of the wood cribs in the fire tests. Thus, measurements of droplet size distribution were only necessary at various radii at the selected height to characterize the spray. Radial measurements started at the inner edge of the overall spray cone and continued in two inch increments to the observed outer edge of the water spray cone.

The analysis of data by the system is performed in accordance with ASTM E799-81, "Standard Practice for Data Criteria and Processing for Liquid Drop Size Analysis."[2] Using a spatial sampling technique, the system accumulates drop size data from a sufficient number of frames such that the tolerable fractional error (the ratio of the volume of the largest drop in the sample to the cumulatitive volume of all the drops) is less than a selected value. For the purpose of this project a maximum tolerable fractional error of 0.05 was selected. The number of frames necessary to reduce this error to at least this value was observed to vary for each nozzle and radial position. The sampling time, which is proportional to number of frames exposed, was maintained constant for all radial positions measured in a single nozzle spray. This is a necessary condition so that separate radial measurements can be combined to obtain an overall average for the nozzle. The sampling time for each nozzle was selected such that an adequate number of frames were included to obtain a tolerable fractional error of less than 0.05 at all radial positions.

The smallest droplet recorded in the measurements had a diameter of 31.4 microns or 2 pixels on the monitor which displays in focus a measurement volume of 4 mm by 5 mm by 32 mm depth. Droplets on the border of the measurement field were excluded. Only droplets within the measurement volume (in focus) were counted. The manufacturer's data reduction program parameter slope was set at 4.0 and 6.0 for 1 pixel and 50 pixel droplets, respectively. The two slopes are used to increase the ability of the system to view both large and small droplets as being "in focus."

The cumulative distributions of water droplet diameters for the selected radial sample positions obtained for each of the spray nozzles are presented in Tables 3 - 6. Histograms of the cumulative distributions for each nozzle are presented in Figures 4 - 11. Distributions of water droplet diameter for each radial position for the four nozzles are presented in Appendix A (contained in Part 2 of this report).

---

[2] American Society for Testing and Materials, "Standard Practice for Data Criteria and Processing for Liquid Drop Size Analysis", E 799, ASTM, 1981.

3.0 Instrumentation

The instrumentation was designed to characterize the thermophysical aspects of the compartment fire. The number of temperature probes was selected for the experiments to ensure adequate characterization of the temperature distributions of the compartment gases and interior surfaces. Two oxygen probes were installed in the room, one in the upper and one in the lower portion of the room to measure oxygen vitiation in the room. A pressure probe was installed 0.61 m above the floor to help determine gas flow rates in and out of the room. Finally, mass loss of the cribs was monitored by a load cell.

A detailed description of the test instrumentation is presented in Table 7 in terms of the physical parameter being measured and the symbol and abbreviations used for each on diagrams and in test data listings. Each measurement position is shown in Figures 1 and 2.

Temperature Measurements

Thermocouples in Figures 1 and 2 are designated by the suffixes 'ST' and 'T.' The 'ST' designation is for the thermocouples used to measure the surface temperature of the compartment walls, ceiling and floor. These thermocouples were installed in a groove in the surface of the wall lining material. So that a portion of the junction bead was flush with the surface a caulking layer no more than 1.0 mm thick was then applied over the thermocouple to secure the thermocouple as well as shield it from radiation effects.

The 'T' designation for the thermocouple sensors refers to the aspirated probes. Aspirated probes were used to obtain a valid measure of the gas temperature, without being influenced by radiation effects. The tube in which the thermocouple was housed was custom designed for these test with two objectives in mind:

a) To provide shielding, and sufficient gas velocity flowing past the thermocouple bead to minimize radiation effects on the gas temperature measurement.

b) To provide shielding and a gas velocity that was insufficient to carry water droplets to the thermocouple bead.

Normally aspirated probes are designed with the thermocouple bead located in a straight, constant internal diameter tube. This type of probe was examined in the laboratory and found to draw water spray into the tube with a tube gas flow velocity of 7 m/s.

The final design of the tip of the aspirated probe is shown in Figure 12. The large diameter at the open end of the probe tip resulted in a low velocity which eliminated the drawing of water spray into the tube, the small diameter around the thermocouple produced the high 7 m/s gas flow velocity necessary to minimize radiation effects. The final tip design included a ceramic tube to anchor the thermocouple beam in the aspirated probe tip. In addition, radiation heating of the aspirated tube tip was reduced by wrapping the tip with reflective aluminum foil prior to each test.

Weight Loss Measurement

Weight loss of the cribs was measured by a water cooled, insulated load platform. A thermocouple was placed close to the load cell to observe any temperature variation. The weight loss measurement apparatus is shown in Figure 13. The purpose of the design of the apparatus was to avoid weight measurement of water not impinging on the cribs which could accumulate on the load platform. A box was formed of 12.7 mm thick Marinite I panels to shield the load platform with the crib basket frame placed through holes in the box to rest on the load platform.

4.0 Test Procedure

A water flow rate and median volume diameter droplet size for each test was selected, based on discussions with Dr. Larry Pietrzak, to assure the data would be useful for evaluation of the Fire Demand Model.[1] The appropriate nozzle to deliver the desired flow rate and droplet size was installed in an apparatus referred to as the iron firefighter (see Figure 14). This device was designed and constructed to rotate the nozzle in an elliptic pattern at a rate of 1.0 cps. to mimic the action of fire fighters and provide a broader distribution of spray in the compartment.

Of the four tests in which water was applied, two tests were performed with "large" droplets and two with "small" water spray droplets, i.e. median volumetric droplet diameters of approximately 0.6 mm and 0.5 mm respectively. In each of the tests with a specific median volumetric droplet diameter, different flow rates were used.

The wood cribs were conditioned at 23°C, 39% RH for at least 48 hours prior to the test until the moisture content stabilized. The weight and moisture content of the cribs used in the five tests are given in Table 8 . Immediately prior to the test, the cribs were placed in the burn compartment, on the crib weighing basket. A container with 50 ml of heptane was placed under each crib (but separated from the weight measurement system).

Ignition of the seven cribs was achieved by igniting the heptane in each container. This ignition process was done in less than 1 minute so that ignition of the cribs was almost simultaneous.

In test 1 the cribs were allowed to burn until they were completely consumed, without any water applied. This test was used to examine the fire development in the compartment and to determine the time available for water spray extinguishment studies before the fire would extinguishment naturally.

In tests 2 - 5, water was applied 60 seconds after the gas temperature exiting at the top of the doorway (as measured by the uppermost aspirated thermocouple just outside the doorway, number 20 in Figure 2) achieved 478°C. This criterion identified a specific point in the fire development, in test 1 in which no water was applied, at 8 minutes after ignition when the crib weight loss rate history reached a steady value sustained for nearly 5 minutes until fuel depletion caused the weight loss rate to decrease. This criterion used to start extinguishment should be independent of the ignition process. Water was applied in each of the four tests until all water was emptied from the 340ℓ (90 gallon) storage tank.

Data was collected for each measurement device approximately every four seconds. In addition, video tape records of each test were made.

5.0 Test Results

A complete set of data from the five tests is provided in Appendix B (contained in Part 2 of this report). Each measurement device is identified by a data recording channel number and abbreviation for type of measurement device, as defined in Table 7. Graphs are provided in Figures 15 - 29 of the pressure, oxygen concentration, mass loss and mass loss rate history for the five tests.

For illustrative purposes temperature data was combined into averages to show temperature trends in the upper and lower gas layers in the room and room surfaces. These averages are tabulated in Appendix C (contained in Part 2 of this report). Five mean temperatures for the room surfaces were calculated - floor only; walls only; ceiling only; ceiling and walls combined; and ceiling, walls and floor combined.

The lower edge of the upper layer was defined for calculating gas temperature averages as the position of the lowest thermocouple among 27 through 41 which measured a Celsius temperature numerically at least twice that of the lowest thermocouple, number 41, see Figure 2. The average temperature in each layer was calculated as a simple numerical average of measured temperatures from those thermocouples 27 through 41 within each layer.

Graphs of the illustrative mean temperature in the upper and lower layers, and interface height are shown in Figures 30 - 39.

Visual observations for the five tests are tabulated in Appendix D (contained in Part 2 of this report).

6.0 Summary

A series of five tests were conducted to examine the effect of water spray on a fully-developed compartment fire. One test was conducted without the application of water as a "control", two tests were performed applying a water spray with "small" droplets (0.5 mm median volumetric diameter), and two tests with "large" droplets (0.6 mm median volumetric diameter). For each pair of tests with a particular median drop size, the visual effect of the water spray was most pronounced using the greater water flow rate, and was visually not apparent in the other test with the lesser flow rate.

7.0 Acknowledgements

The authors wish to acknowledge the insight and constructive critique of the experimental plans provided by Jim Quintiere. In addition, the effort of R. Zile, W. Bailey and colleagues in preparing the room, constructing equipment, setting up the instrumentation, and assisting in the conduct of the tests at the NBS fire test facility in Building 205 should be recognized. Special thanks are extended to L. Buffington for characterizing the water spray nozzles, P. Martin for generating the tables in Appendices A and B, and C. Thompson for preparing the typed manuscript.

Table 1. Compartment and Fuel Parameters

COMPARTMENT DESCRIPTION	
Room Height	2.44 m
Floor Area	2.44 m x 3.66 m = 8.93 m^2
Area of Walls and Ceiling	37.72m^2
Door Area	0.67 m^2
Door Height	1.51 m
Wall Material	Marinite I
Wall Thickness	1.9 cm
Wall Properties	
Thermal conductivity	0.12 W/m °K
Specific Heat	1.25 kJ/kg °K
Density	738 kg/m^3
FUEL DESCRIPTION	
Fuel Type	White Pine Wood Crib
Crib Geometry	
Square Stick Thickness	4.0 cm
Stick Length	26.0 cm
Spacing Between Sticks	7.0 cm
Number Sticks per Layer	3
Number of Layers	10
Number of Cribs	7
Fuel Surface Area	7.59 m^2
Fuel Surface Area Exposed to Water	16%
Heat of Combustion	4440 kcal/kg
Fuel Density	370 kg/m^3
WATER APPLICATION DESCRIPTION	
Distance of Nozzle from Vent	0.0 m
Cone Angle of Hose Stream	60°
Sweep time to cover Compartment	2 sec
Volume Median Drop diameter	see Table 2
Flow Rate of Water	see Table 2

Table 2. Water Spray Parameters

Test	Drop Size (mm)	kPa(psi)	ℓ/s	$(\ell/s\text{-}m^2) \times 10^2$	Manufacturer's Nozzle Code
1	Free Burn (no extinguishment)				
2	0.627	123 (18)	0.46	5.2	TF 16NN
3	0.491	372 (54)	0.44	4.9	TF 12NN
4	0.595	117 (17)	0.35	3.9	TF 14NN
5	0.482	276 (40)	0.26	2.9	TF 10NN

Table 3. Cumulative Distribution of Droplets, Nozzle TF16NN, Test 2

```
COMPOSITE REPORT                            NOZZLE: TF 16 NN
TEST DATE        1/16/85                    TEST METHOD:   PLANE
TESTS INCLUDED:     118   121  122   123   124   125   126
SPRAY DIRECTION           VERTICAL
PRESSURE                  18.0 PSI
CENTERLINE COORDINATE     60.00 INCHES
RADIAL COORDINATE         14.00 -  26.00 INCHES
DISTANCE FROM NOZZLE      61.61 -  65.39 INCHES
AZIMUTHAL ANGLE           13.1 - 23.4   DEG
CYLINDRICAL ANGLE          270   DEG
```

DIAMETER (MICRONS)	DROPS	% OCCURRENCE	% SURFACE AREA	% VOLUME	CUM % VOLUME	CLASS CHECK
25.1 - 31.6	620	13.42	0.12	0.01	0.01	0.000
31.6 - 39.8	374	8.10	0.11	0.01	0.01	0.000
39.8 - 50.1	225	4.87	0.09	0.01	0.02	0.000
50.1 - 63.1	124	2.68	0.08	0.01	0.03	0.000
63.1 - 79.4	142	3.07	0.15	0.02	0.05	0.000
79.4 - 100.0	259	5.61	0.42	0.07	0.12	0.000
100.0 - 125.9	282	6.11	0.74	0.15	0.27	0.000
125.9 - 158.5	317	6.86	1.30	0.33	0.60	0.000
158.5 - 199.5	286	6.19	1.83	0.58	1.17	0.001
199.5 - 251.2	228	4.94	2.33	0.93	2.10	0.001
251.2 - 316.2	219	4.74	3.56	1.79	3.89	0.002
316.2 - 398.1	376	8.14	9.97	6.41	10.31	0.007
398.1 - 501.2	483	10.46	19.72	15.73	26.04	0.018
501.2 - 631.0	400	8.66	25.13	24.88	50.92	0.029
631.0 - 794.3	198	4.29	19.70	24.56	75.48	0.028
794.3 - 1000.0	68	1.47	10.34	15.91	91.39	0.018
1000.0 - 1258.9	17	0.37	4.07	7.85	99.24	0.009
1258.9 - 1584.9	1	0.02	0.34	0.76	100.00	0.001
	4619.	100.00	100.00	100.00	100.00	

AVERAGE DIAMETERS (MICRONS) :

```
ARITHMETIC MEAN =   241.54          MAXIMUM DIAMETER =  1287.00
SURFACE MEAN =      326.62          MINIMUM DIAMETER =    31.40
VOLUME MEAN =       392.22          TOTAL DROPS IN SAMPLE =   4619.
SAUTER MEAN =       565.56          TOTAL OUT OF FOCUS =       560
WEIGHT MEAN =       652.27          TOTAL FRAMES IN SAMPLE =  3545
VOLUME MEDIAN =     627.02          AVE. DROPS PER FRAME =    1.30
SAMPLE SIZE CHECK =  0.01           DEVIATION =  0.61

RELATIVE SPAN = (  981.73 -   395.28)/  627.02  =   0.94
```

Table 4. Cumulative Distribution of Droplets, Nozzle TF12NN, Test 3

```
COMPOSITE REPORT                                NOZZLE: TF 12 NN
TEST DATE        1/16/85                        TEST METHOD:    PLANE
TESTS INCLUDED:       94    95   127    97   128   129   130   131
SPRAY DIRECTION             VERTICAL
PRESSURE                    54.0 PSI
CENTERLINE COORDINATE       60.00 INCHES
RADIAL COORDINATE           16.00 -   30.00 INCHES
DISTANCE FROM NOZZLE        62.09 -   67.08 INCHES
AZIMUTHAL ANGLE             14.9 - 26.5   DEG
CYLINDRICAL ANGLE            270   DEG
```

DIAMETER (MICRONS)	DROPS	% OCCURRENCE	% SURFACE AREA	% VOLUME	CUM % VOLUME	CLASS CHECK
25.1 - 31.6	473	9.13	0.13	0.01	0.01	0.000
31.6 - 39.8	384	7.41	0.15	0.01	0.02	0.000
39.8 - 50.1	410	7.92	0.24	0.03	0.05	0.000
50.1 - 63.1	549	10.60	0.50	0.06	0.11	0.000
63.1 - 79.4	447	8.63	0.62	0.10	0.21	0.000
79.4 - 100.0	445	8.59	0.96	0.19	0.40	0.000
100.0 - 125.9	266	5.14	0.91	0.23	0.62	0.000
125.9 - 158.5	180	3.48	0.98	0.31	0.93	0.000
158.5 - 199.5	129	2.49	1.10	0.43	1.37	0.000
199.5 - 251.2	153	2.95	2.11	1.06	2.42	0.001
251.2 - 316.2	235	4.54	5.23	3.32	5.74	0.004
316.2 - 398.1	452	8.73	15.95	12.76	18.50	0.015
398.1 - 501.2	689	13.30	37.14	36.71	55.21	0.042
501.2 - 631.0	300	5.79	24.92	30.56	85.77	0.035
631.0 - 794.3	62	1.20	8.04	12.32	98.09	0.014
794.3 - 1000.0	5	0.10	1.01	1.91	100.00	0.002
	5179.	100.00	100.00	100.00	100.00	

```
AVERAGE DIAMETERS  (MICRONS) :

ARITHMETIC MEAN =     195.64          MAXIMUM DIAMETER =     927.62
SURFACE MEAN =        266.69          MINIMUM DIAMETER =      31.40
VOLUME MEAN =         313.41          TOTAL DROPS IN SAMPLE =   5179.
SAUTER MEAN =         453.90          TOTAL OUT OF FOCUS =        234
WEIGHT MEAN =         499.10          TOTAL FRAMES IN SAMPLE =   3775
VOLUME MEDIAN =       490.84          AVE. DROPS PER FRAME =     1.37
SAMPLE SIZE CHECK =     0.00          DEVIATION =    0.60

RELATIVE SPAN = (  685.3[illegible] -   352.71)/  490.84  =   0.68
```

Table 5. Cumulative Distribution of Droplets, Nozzle TF14NN, Test 4

```
COMPOSITE REPORT                                 NOZZLE: TF 14 NN
TEST DATE          1/16/85                       TEST METHOD:   PLANE
TESTS INCLUDED:        112    113   114   115   116
SPRAY DIRECTION               VERTICAL
PRESSURE                      17.0 PSI
CENTERLINE COORDINATE         60.00 INCHES
RADIAL COORDINATE             18.00 -  26.00 INCHES
DISTANCE FROM NOZZLE          62.64 -  65.39 INCHES
AZIMUTHAL ANGLE               16.6 - 23.4   DEG
CYLINDRICAL ANGLE              270   DEG
```

DIAMETER (MICRONS)	DROPS	% OCCURRENCE	% SURFACE AREA	% VOLUME	CUM % VOLUME	CLASS CHECK
25.1 - 31.6	208	7.72	0.06	0.00	0.00	0.000
31.6 - 39.8	107	3.97	0.05	0.00	0.01	0.000
39.8 - 50.1	55	2.04	0.03	0.00	0.01	0.000
50.1 - 63.1	61	2.27	0.06	0.01	0.02	0.000
63.1 - 79.4	75	2.78	0.11	0.02	0.03	0.000
79.4 - 100.0	124	4.60	0.29	0.05	0.08	0.000
100.0 - 125.9	166	6.16	0.65	0.14	0.22	0.000
125.9 - 158.5	195	7.24	1.16	0.30	0.52	0.000
158.5 - 199.5	211	7.84	2.01	0.67	1.19	0.001
199.5 - 251.2	154	5.72	2.31	0.96	2.15	0.001
251.2 - 316.2	184	6.83	4.53	2.42	4.57	0.003
316.2 - 398.1	322	11.96	12.53	8.38	12.95	0.010
398.1 - 501.2	449	16.67	26.76	22.17	35.12	0.025
501.2 - 631.0	227	8.43	20.68	21.18	56.30	0.024
631.0 - 794.3	99	3.68	14.45	18.74	75.04	0.021
794.3 - 1000.0	47	1.75	10.99	18.01	93.05	0.021
1000.0 - 1258.9	7	0.26	2.28	4.39	97.44	0.005
1258.9 - 1584.9	2	0.07	1.05	2.56	100.00	0.003
	2693.	100.00	100.00	100.00	100.00	

```
AVERAGE DIAMETERS  (MICRONS) :

ARITHMETIC MEAN =   284.17          MAXIMUM DIAMETER =   1347.82
SURFACE MEAN =      352.26          MINIMUM DIAMETER =     31.40
VOLUME MEAN =       406.72          TOTAL DROPS IN SAMPLE =   2693.
SAUTER MEAN =       542.20          TOTAL OUT OF FOCUS =        72
WEIGHT MEAN =       632.85          TOTAL FRAMES IN SAMPLE =  2262
VOLUME MEDIAN =     595.48          AVE. DROPS PER FRAME =    1.19
SAMPLE SIZE CHECK =   0.01          DEVIATION =  0.52

RELATIVE SPAN = (  964.95 -   376.03)/  595.48  =   0.99
```

Table 6. Cumulative Distribution of Droplets, Nozzle TF10NN, Test 5

COMPOSITE REPORT
NOZZLE: TF 10 NN
TEST DATE 1/16/85
TEST METHOD: PLANE
TESTS INCLUDED: 86 87 106 107 108 109 110 111
SPRAY DIRECTION VERTICAL
PRESSURE 40.0 PSI
CENTERLINE COORDINATE 60.00 INCHES
RADIAL COORDINATE 14.00 - 28.00 INCHES
DISTANCE FROM NOZZLE 61.60 - 66.21 INCHES
AZIMUTHAL ANGLE 13.1 - 25.0 DEG
CYLINDRICAL ANGLE 270 DEG

DIAMETER (MICRONS)	DROPS	% OCCURRENCE	% SURFACE AREA	% VOLUME	CUM % VOLUME	CLASS CHECK
25.1 - 31.6	191	5.11	0.05	0.00	0.00	0.000
31.6 - 39.8	140	3.74	0.05	0.00	0.01	0.000
39.8 - 50.1	143	3.82	0.08	0.01	0.02	0.000
50.1 - 63.1	197	5.27	0.18	0.02	0.04	0.000
63.1 - 79.4	186	4.97	0.25	0.04	0.08	0.000
79.4 - 100.0	210	5.62	0.44	0.09	0.17	0.000
100.0 - 125.9	177	4.73	0.60	0.15	0.32	0.000
125.9 - 158.5	116	3.10	0.61	0.19	0.52	0.000
158.5 - 199.5	139	3.72	1.17	0.47	0.99	0.001
199.5 - 251.2	236	6.31	3.15	1.59	2.58	0.002
251.2 - 316.2	401	10.72	8.68	5.60	8.18	0.006
316.2 - 398.1	696	18.61	23.75	19.24	27.42	0.022
398.1 - 501.2	563	15.06	29.12	29.04	56.46	0.033
501.2 - 631.0	267	7.14	21.61	26.96	83.43	0.031
631.0 - 794.3	68	1.82	8.52	13.23	96.66	0.015
794.3 - 1000.0	9	0.24	1.74	3.34	100.00	0.004
	3739.	100.00	100.00	100.00	100.00	

AVERAGE DIAMETERS (MICRONS) :

ARITHMETIC MEAN = 264.89
SURFACE MEAN = 318.30
VOLUME MEAN = 356.35
SAUTER MEAN = 446.62
WEIGHT MEAN = 492.94
VOLUME MEDIAN = 482.14
SAMPLE SIZE CHECK = 0.01

MAXIMUM DIAMETER = 953.06
MINIMUM DIAMETER = 31.40
TOTAL DROPS IN SAMPLE = 3739.
TOTAL OUT OF FOCUS = 114
TOTAL FRAMES IN SAMPLE = 2882
AVE. DROPS PER FRAME = 1.30
DEVIATION = 0.45

RELATIVE SPAN = (710.45 - 328.53)/ 482.14 = 0.79

Table 7 Description of Instrumentation

Channel	Acronym	Description	Units	Location
16	PR	Differential Pressure	Inches H_2O	Rear of side wall, 2 ft. above floor
17	OX	Oxygen Concentration	Percent by Volume	Rear wall, 2 ft. below ceiling
18	OX	Oxygen Concentration	Percent by Volume	Rear wall, 2 ft. above floor
19	MS	Mass of Cribs	kg	Under crib assembly
20	GT	Gas Temperature	°C	Doorway
21	GT	Gas Temperature	°C	Doorway
22	GT	Gas Temperature	°C	Doorway
23	GT	Gas Temperature	°C	Doorway
24	GT	Gas Temperature	°C	Doorway
25	GT	Gas Temperature	°C	Doorway
26	GT	Gas Temperature	°C	Doorway
27	GT	Gas Temperature	°C	Room Center
28	GT	Gas Temperature	°C	Room Center
29	GT	Gas Temperature	°C	Room Center
30	GT	Gas Temperature	°C	Room Center
31	GT	Gas Temperature	°C	Room Center
32	GT	Gas Temperature	°C	Room Center
33	GT	Gas Temperature	°C	Room Center
34	GT	Gas Temperature	°C	Room Center
35	GT	Gas Temperature	°C	Room Center
36	GT	Gas Temperature	°C	Room Center
37	GT	Gas Temperature	°C	Room Center
38	GT	Gas Temperature	°C	Room Center
39	GT	Gas Temperature	°C	Room Center
40	GT	Gas Temperature	°C	Room Center
41	GT	Gas Temperature	°C	Room Center
42	ST	Surface Temperature	°C	Rear Wall
43	ST	Surface Temperature	°C	Rear Wall
44	ST	Surface Temperature	°C	Rear Wall
45	ST	Surface Temperature	°C	Left Wall
46	ST	Surface Temperature	°C	Left Wall
47	ST	Surface Temperature	°C	Left Wall
48	ST	Surface Temperature	°C	Front Wall
49	ST	Surface Temperature	°C	Front Wall
50	ST	Surface Temperature	°C	Front Wall
51	ST	Surface Temperature	°C	Right Wall
52	ST	Surface Temperature	°C	Right Wall
53	ST	Surface Temperature	°C	Right Wall
54	ST	Surface Temperature	°C	Ceiling
55	ST	Surface Temperature	°C	Ceiling
56	ST	Surface Temperature	°C	Ceiling
57	ST	Surface Temperature	°C	Floor
58	ST	Surface Temperature	°C	Floor
59	ST	Surface Temperature	°C	Floor

Table 8 Fuel Mass Data For Tests

Test #	Crib Mass (kg)	Crib Moisture Content (%)	Total Fuel Mass (kg)	Fuel Load* (kg/m^2)	Total Residual Fuel Mass (kg)
1	5.72	7.5	40.27	4.51	0
	5.62	8.3			
	5.76	8.0			
	6.03	7.8			
	5.53	8.2			
	6.12	7.8			
	5.49	8.2			
2	5.72	8.2	38.42	4.30	11.80
	5.61	8.5			
	5.39	7.5			
	5.17	9.3			
	5.66	9.5			
	5.59	9.5			
	5.28	8.0			
3	5.51	9.1	39.37	4.41	12.16
	5.86	9.0			
	5.62	9.0			
	5.62	8.5			
	5.15	9.1			
	5.82	8.6			
	5.79	9.2			
4	5.38	8.3	37.78	4.23	4.54
	5.60	9.2			
	5.51	9.0			
	5.42	7.2			
	5.55	7.2			
	5.67	9.5			
	5.65	8.0			
5	5.86	7.8	40.51	4.54	4.57
	6.09	8.4			
	5.70	8.0			
	5.89	8.8			
	5.41	8.8			
	5.86	8.5			
	5.70	8.5			

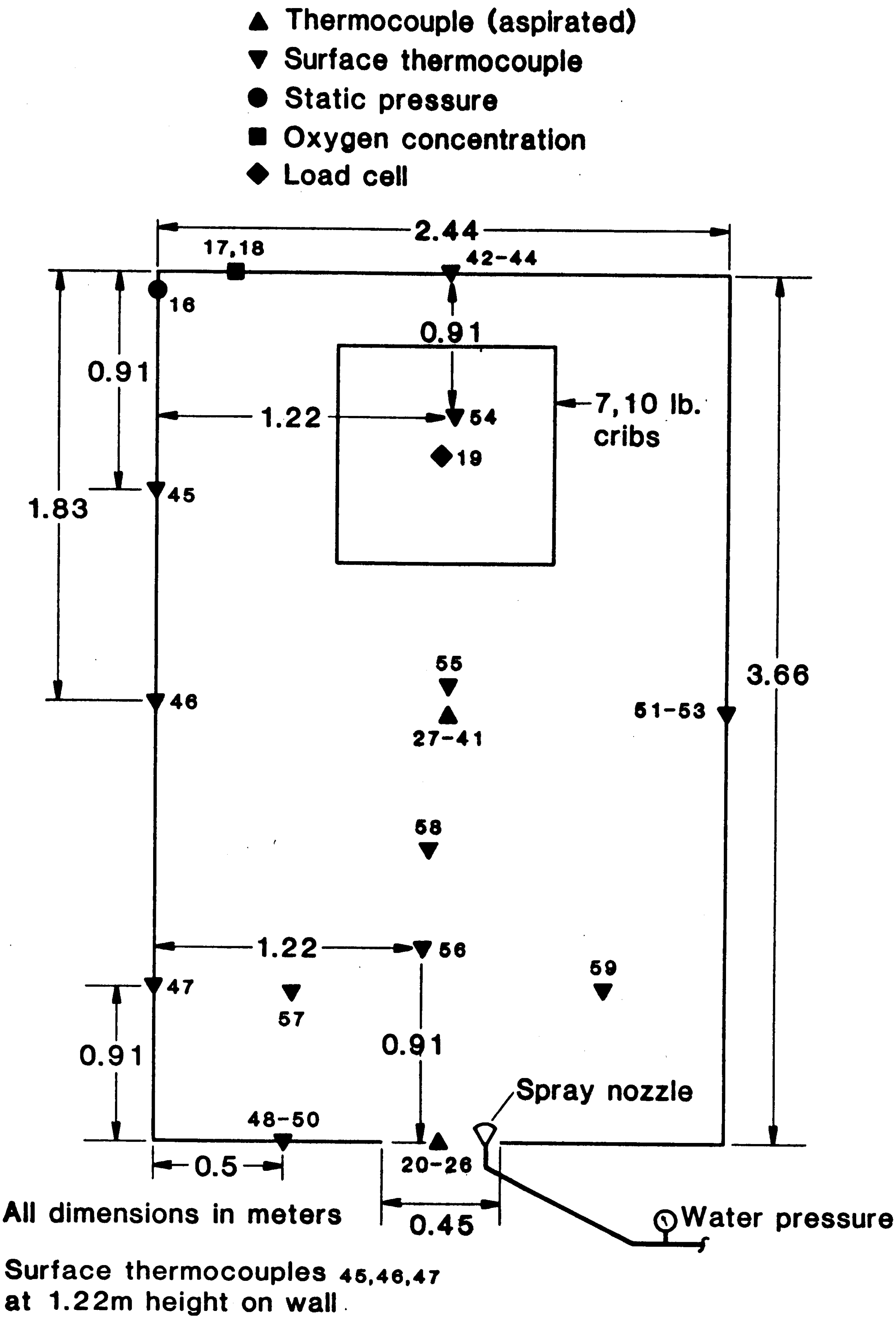


Figure 1. Plan View of Test Room and Instrumentation

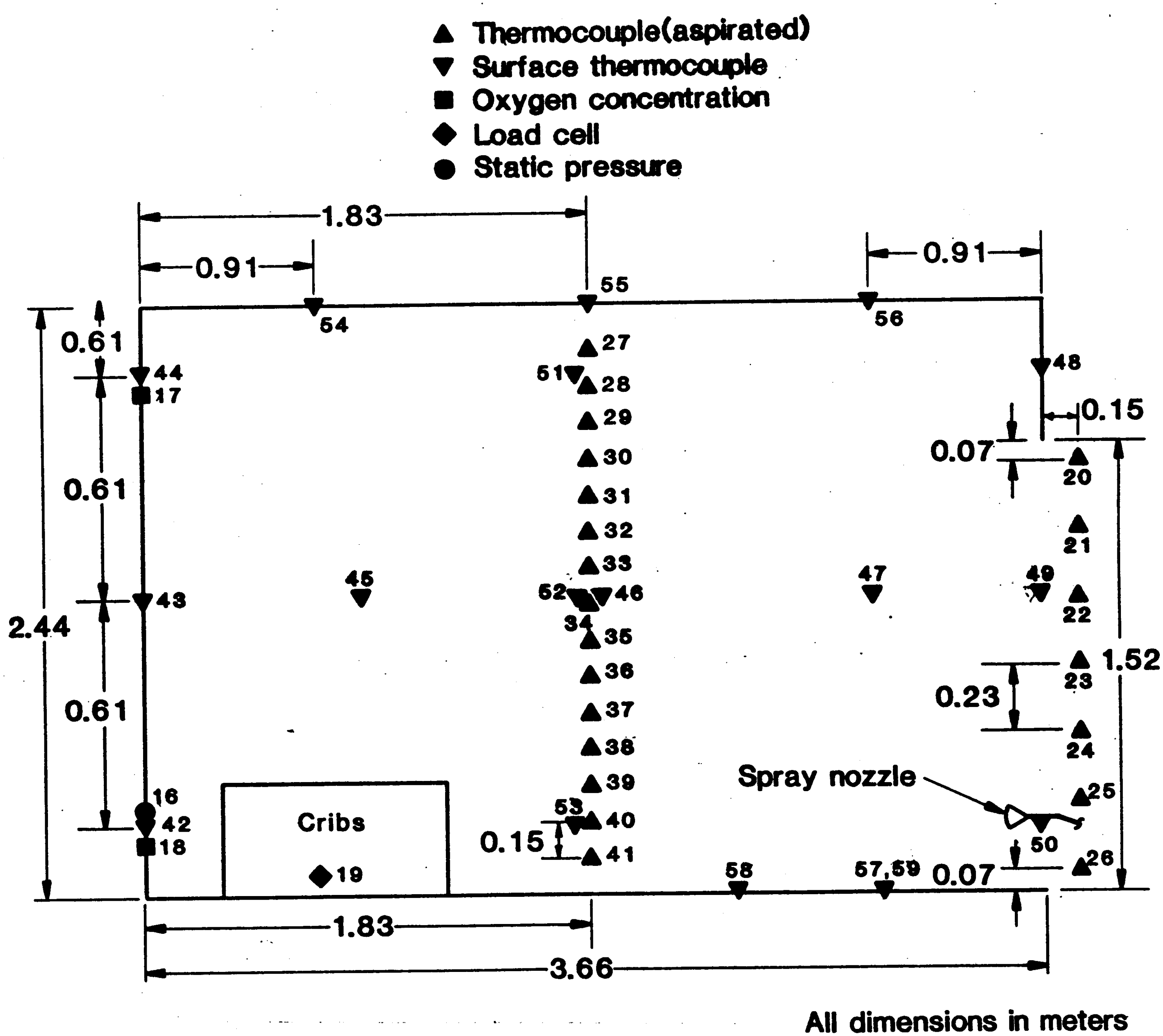


Figure 2. Elevation View of Test Room and Instrumentation

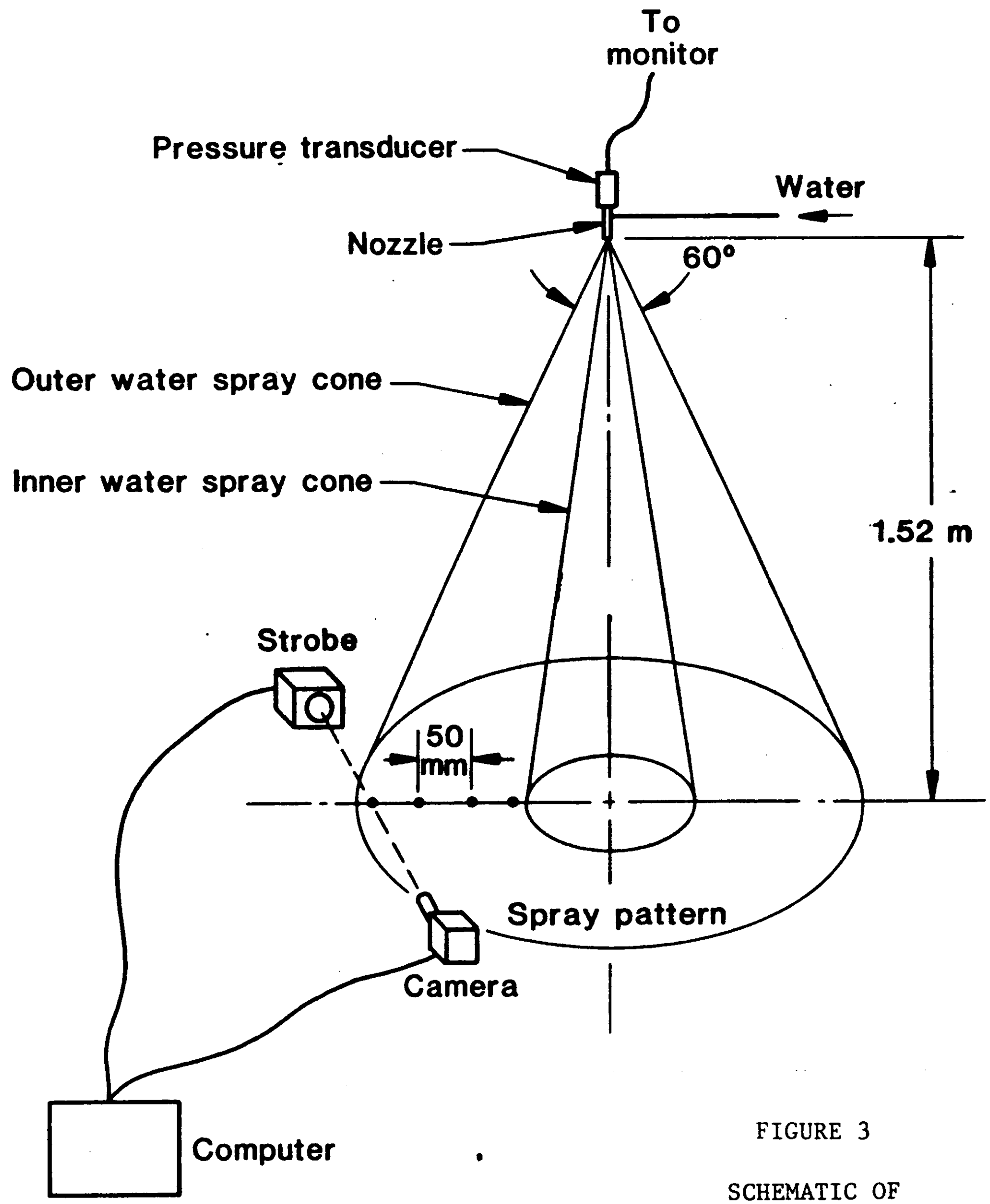


FIGURE 3

SCHEMATIC OF

DROPLET ANALYZER SYSTEM

Figure 4. Histogram of Droplet Diameter by Percent Volume and Cumulative Volume, Nozzle TF16NN, Test 2

```
COMPOSITE REPORT                             NOZZLE: TF 16 NN
TEST DATE       1/16/85                      TEST METHOD:    PLANE
TESTS INCLUDED:     118   121   122   123   124   125   126
SPRAY DIRECTION          VERTICAL
PRESSURE                 18.0 PSI
CENTERLINE COORDINATE    60.00 INCHES
RADIAL COORDINATE        14.00 -   26.00 INCHES
DISTANCE FROM NOZZLE     61.61 -   65.39 INCHES
AZIMUTHAL ANGLE          13.1 - 23.4   DEG
CYLINDRICAL ANGLE         270   DEG
```

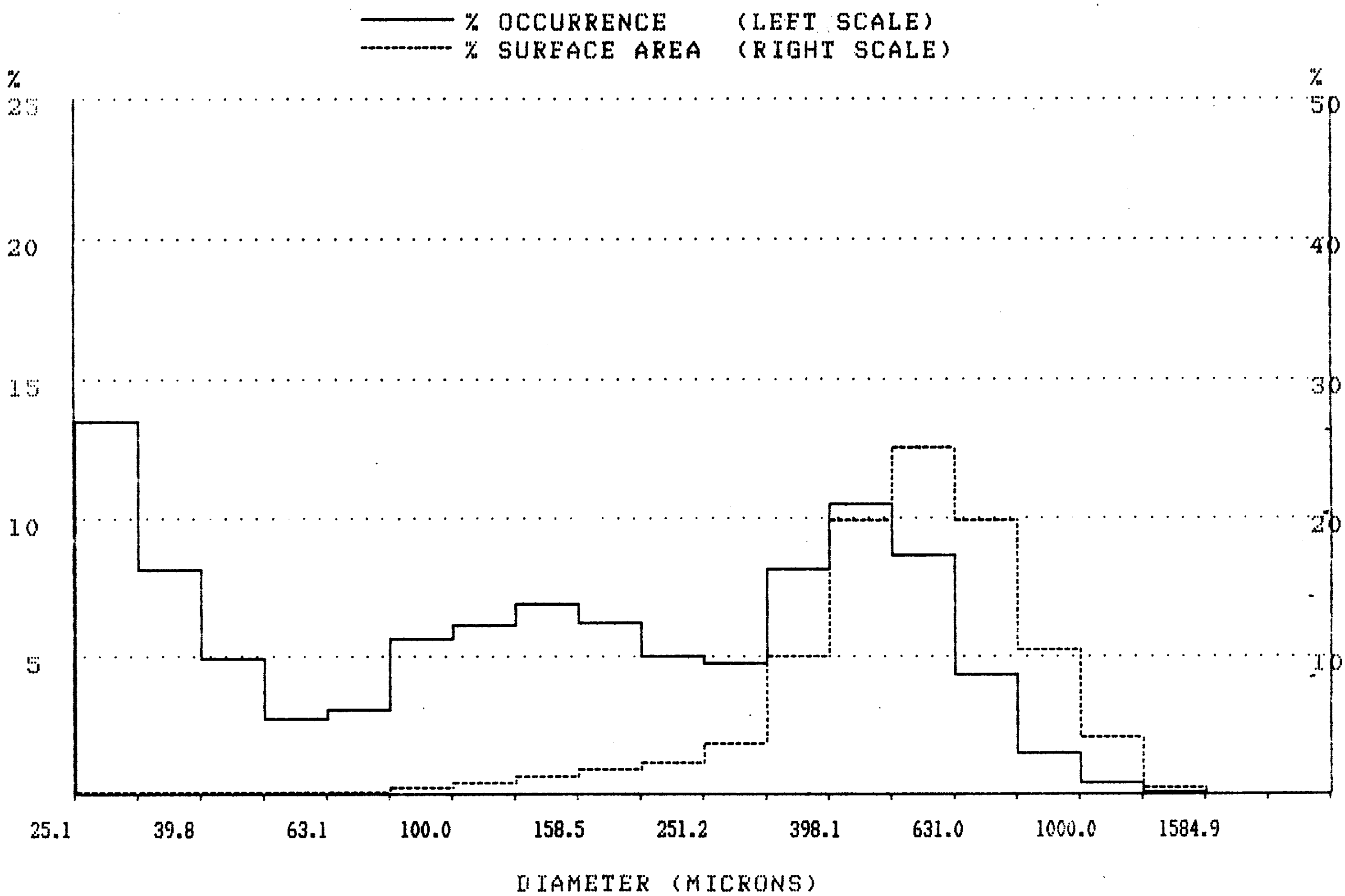


Figure 5. Histogram of Droplet Diameter by Percent Occurrence and Surface Area, Nozzle TF16NN, Test 2

```
COMPOSITE REPORT                         NOZZLE: TF 16 NN
TEST DATE      1/16/85                   TEST METHOD:   PLANE
TESTS INCLUDED:    118  121  122  123  124  125  126
SPRAY DIRECTION         VERTICAL
PRESSURE                18.0 PSI
CENTERLINE COORDINATE   60.00 INCHES
RADIAL COORDINATE       14.00 -  26.00 INCHES
DISTANCE FROM NOZZLE    61.61 -  65.39 INCHES
AZIMUTHAL ANGLE         13.1 - 23.4  DEG
CYLINDRICAL ANGLE        270  DEG
```

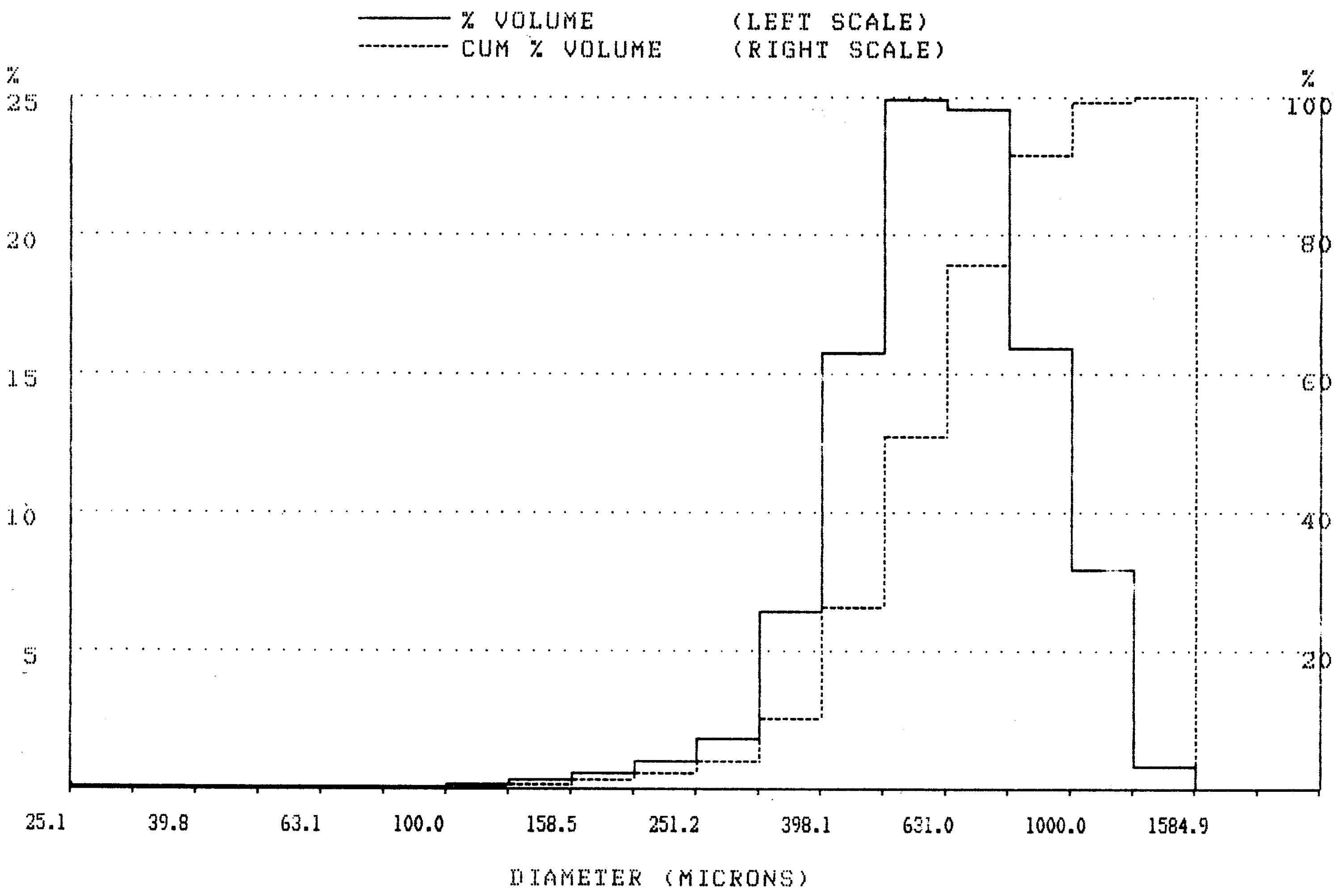


Figure 6. Histogram of Droplet Diameter by Percent Volume and Cumulative Volume, Nozzle TF12NN, Test 3

COMPOSITE REPORT		NOZZLE:	TF 12 NN
TEST DATE	1/16/85	TEST METHOD:	PLANE
TESTS INCLUDED:	94 95 127 97 128 129 130 131		
SPRAY DIRECTION	VERTICAL		
PRESSURE	54.0 PSI		
CENTERLINE COORDINATE	60.00 INCHES		
RADIAL COORDINATE	16.00 - 30.00 INCHES		
DISTANCE FROM NOZZLE	62.09 - 67.08 INCHES		
AZIMUTHAL ANGLE	14.9 - 26.5 DEG		
CYLINDRICAL ANGLE	270 DEG		

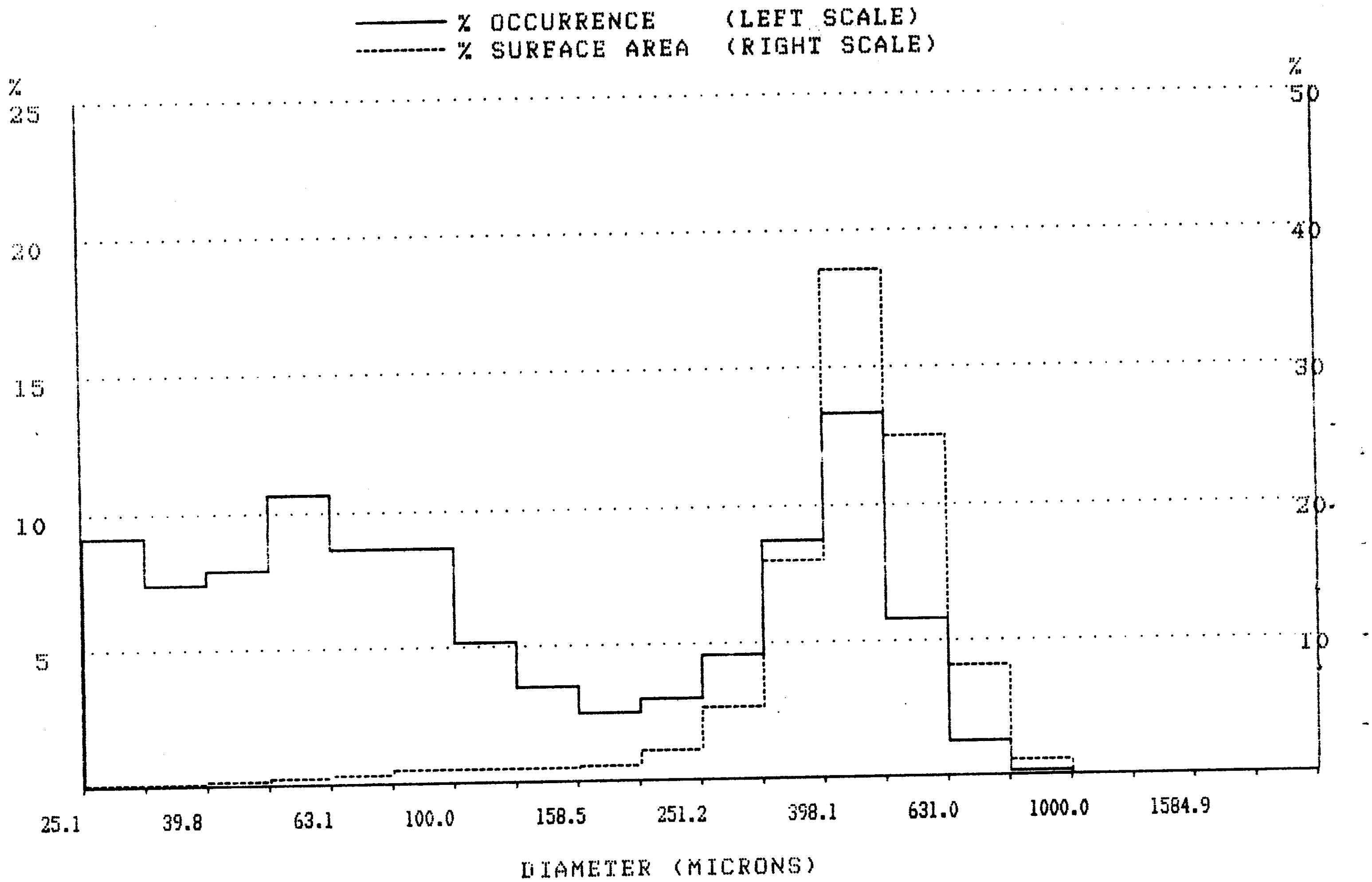


Figure 7. Histogram of Droplet Diameter by Percent Occurrence and Surface Area, Nozzle TF12NN, Test 3

```
COMPOSITE REPORT                          NOZZLE: TF 12 NN
TEST DATE      1/16/85                    TEST METHOD:   PLANE
TESTS INCLUDED:     94   95  127   97  128  129  130  131
SPRAY DIRECTION          VERTICAL
PRESSURE                 54.0 PSI
CENTERLINE COORDINATE    60.00 INCHES
RADIAL COORDINATE        16.00 -  30.00 INCHES
DISTANCE FROM NOZZLE     62.09 -  67.08 INCHES
AZIMUTHAL ANGLE          14.9 - 26.5  DEG
CYLINDRICAL ANGLE         270  DEG
```

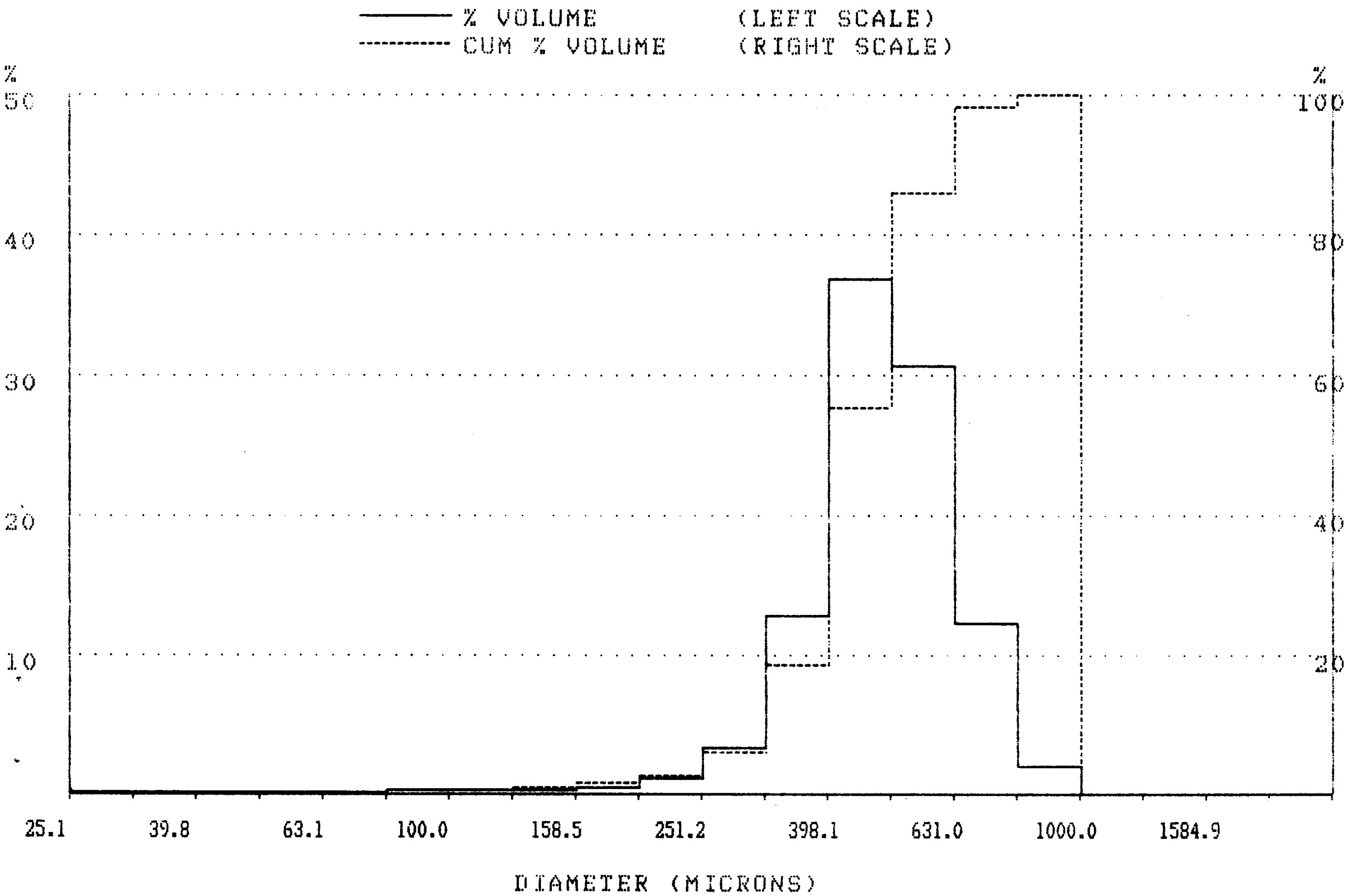


Figure 8. Histogram of Droplet Diameter by Percent Volume and Cumulative Volume, Nozzle TF14NN, Test 4.

```
COMPOSITE REPORT                              NOZZLE: TF 14 NN
TEST DATE        1/16/85                      TEST METHOD:    PLANE
TESTS INCLUDED:     112   113   114   115   116
SPRAY DIRECTION           VERTICAL
PRESSURE                  17.0 PSI
CENTERLINE COORDINATE     60.00 INCHES
RADIAL COORDINATE         18.00 -   26.00 INCHES
DISTANCE FROM NOZZLE      62.64 -   65.39 INCHES
AZIMUTHAL ANGLE           16.6 - 23.4   DEG
CYLINDRICAL ANGLE          270   DEG
```

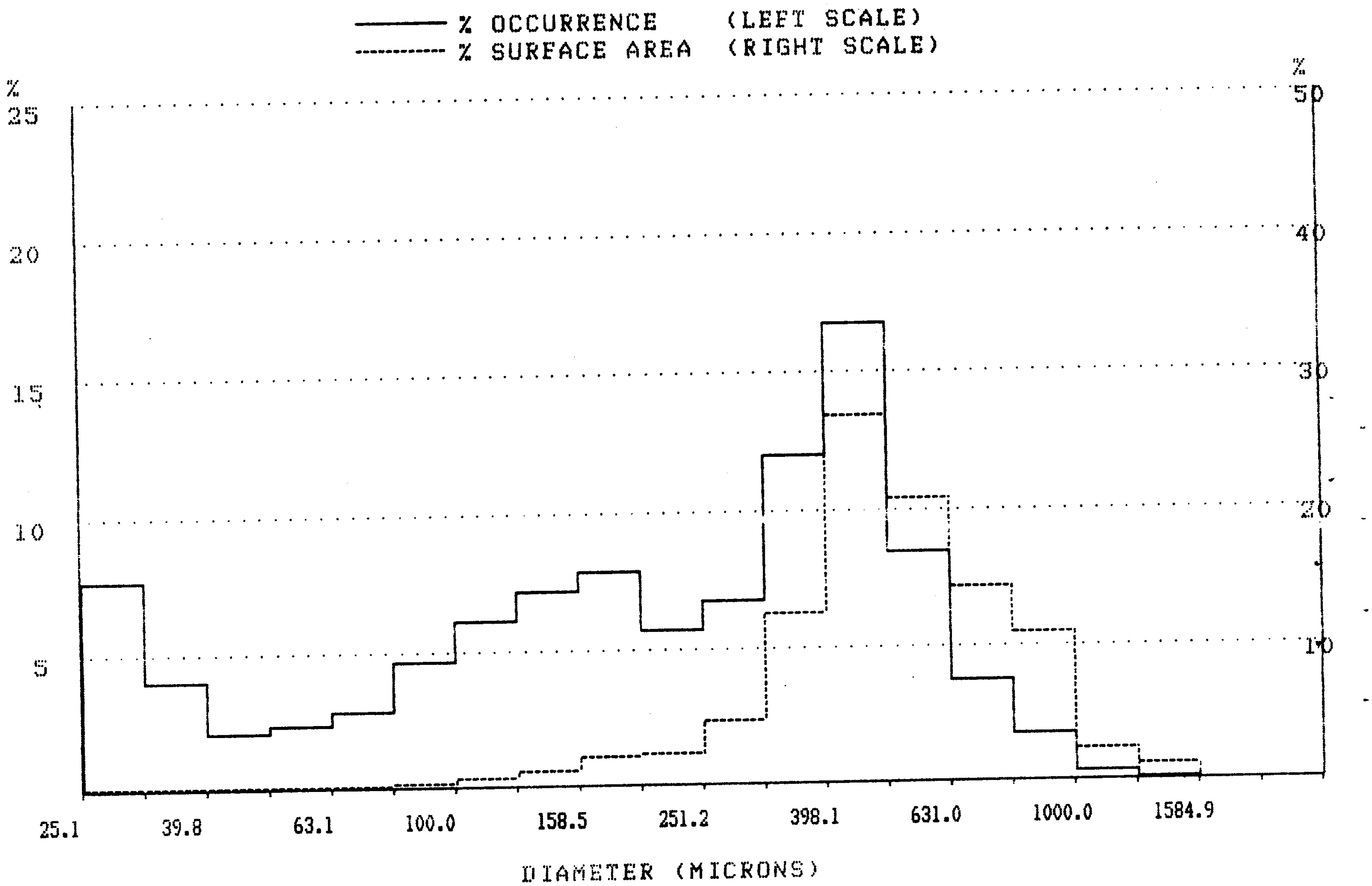


Figure 9. Histogram of Droplet Diameter by Percent Occurrence and Surface Area, Nozzle TF14NN, Test 4

COMPOSITE REPORT		NOZZLE: TF 14 NN	
TEST DATE	1/16/85	TEST METHOD:	PLANE
TESTS INCLUDED:	112 113 114 115 116		
SPRAY DIRECTION	VERTICAL		
PRESSURE	17.0 PSI		
CENTERLINE COORDINATE	60.00 INCHES		
RADIAL COORDINATE	18.00 - 26.00 INCHES		
DISTANCE FROM NOZZLE	62.64 - 65.39 INCHES		
AZIMUTHAL ANGLE	16.6 - 23.4 DEG		
CYLINDRICAL ANGLE	270 DEG		

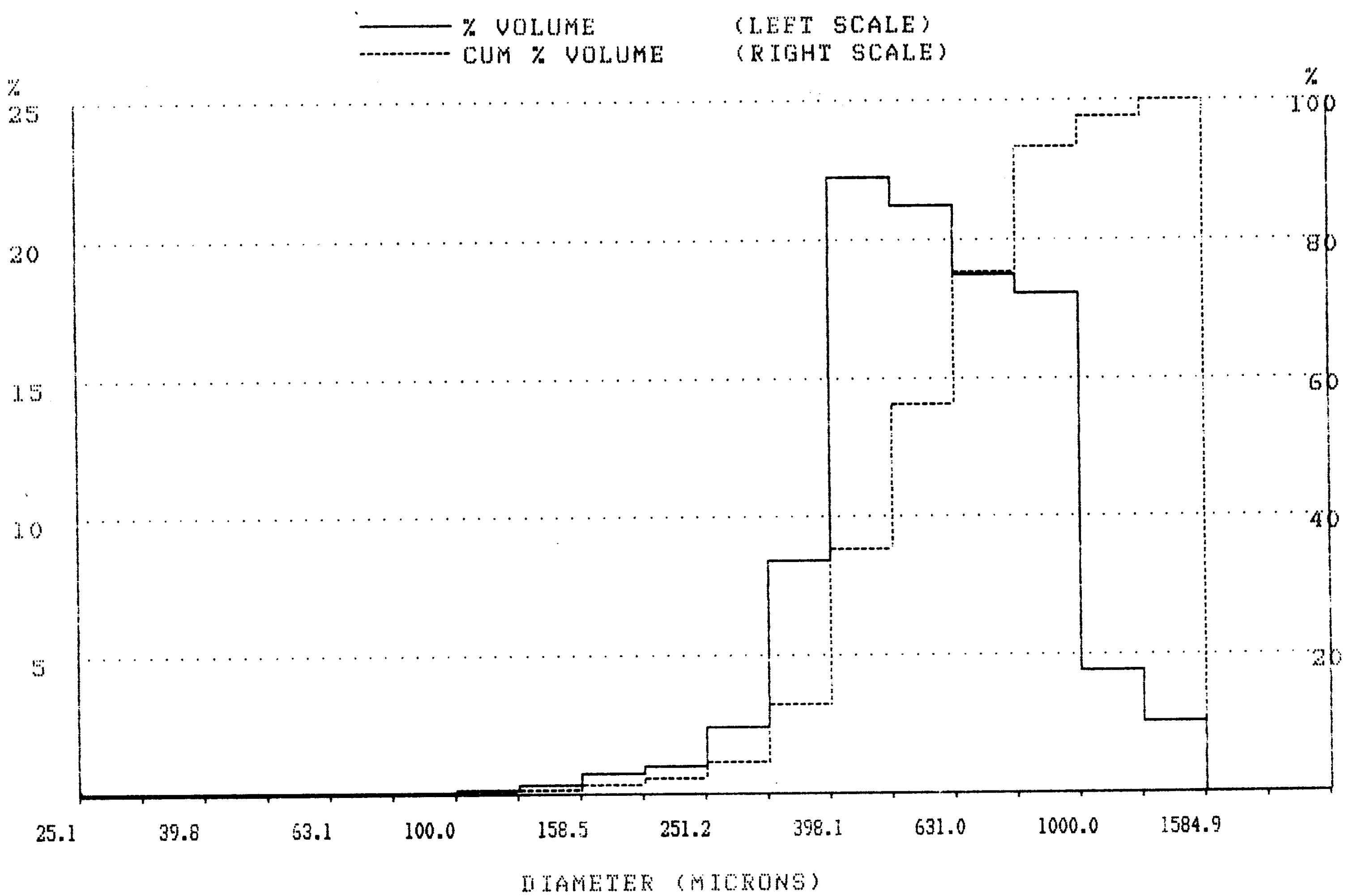


Figure 10. Histogram of Droplet Diameter by Percent Volume and Cumulative Volume, Nozzle TF10NN, Test 5.

COMPOSITE REPORT		NOZZLE: TF 10 NN
TEST DATE 1/16/85		TEST METHOD: PLANE
TESTS INCLUDED: 86	87 106 107 108 109 110 111	
SPRAY DIRECTION	VERTICAL	
PRESSURE	40.0 PSI	
CENTERLINE COORDINATE	60.00 INCHES	
RADIAL COORDINATE	14.00 - 28.00 INCHES	
DISTANCE FROM NOZZLE	61.60 - 66.21 INCHES	
AZIMUTHAL ANGLE	13.1 - 25.0 DEG	
CYLINDRICAL ANGLE	270 DEG	

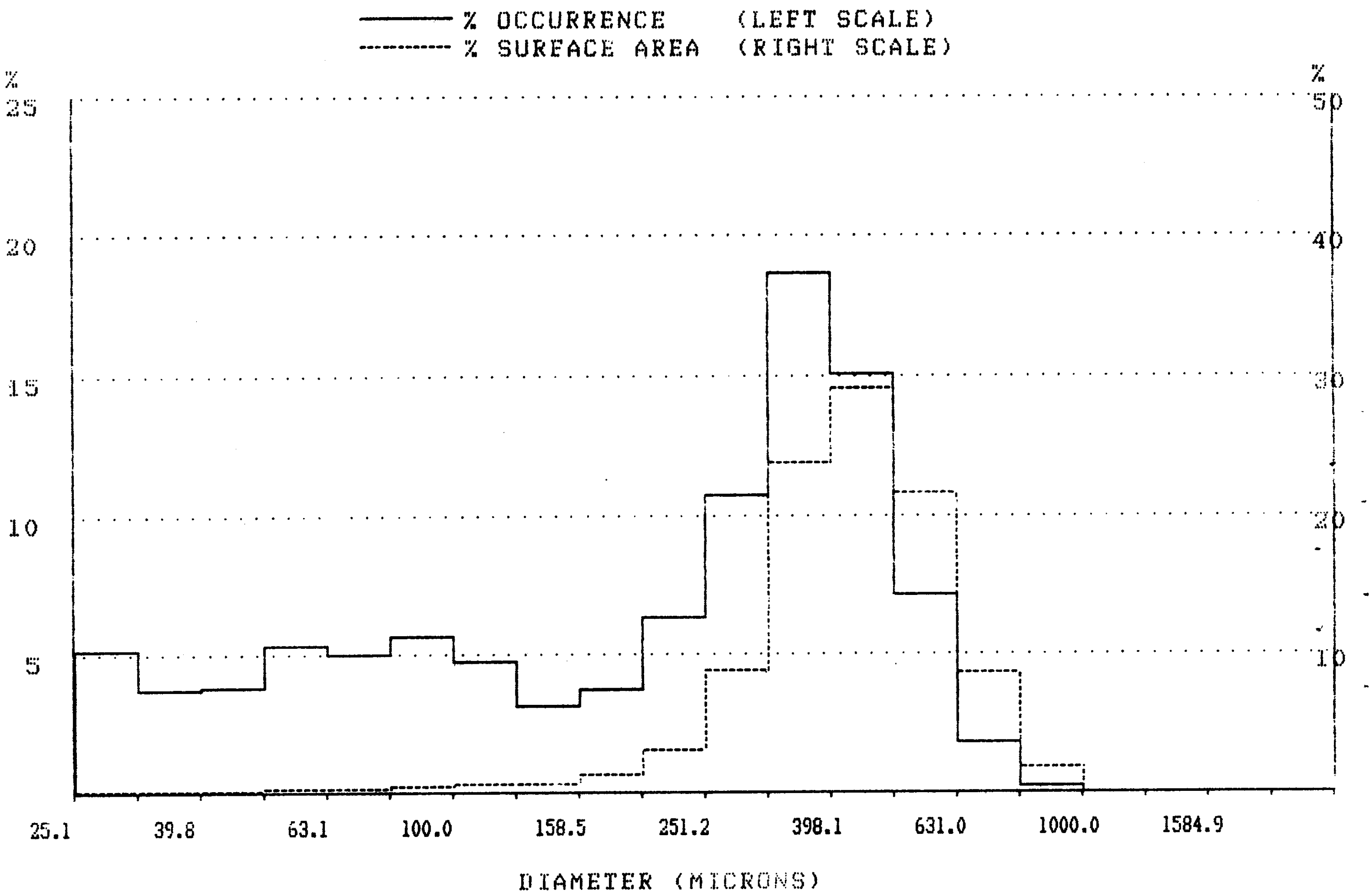
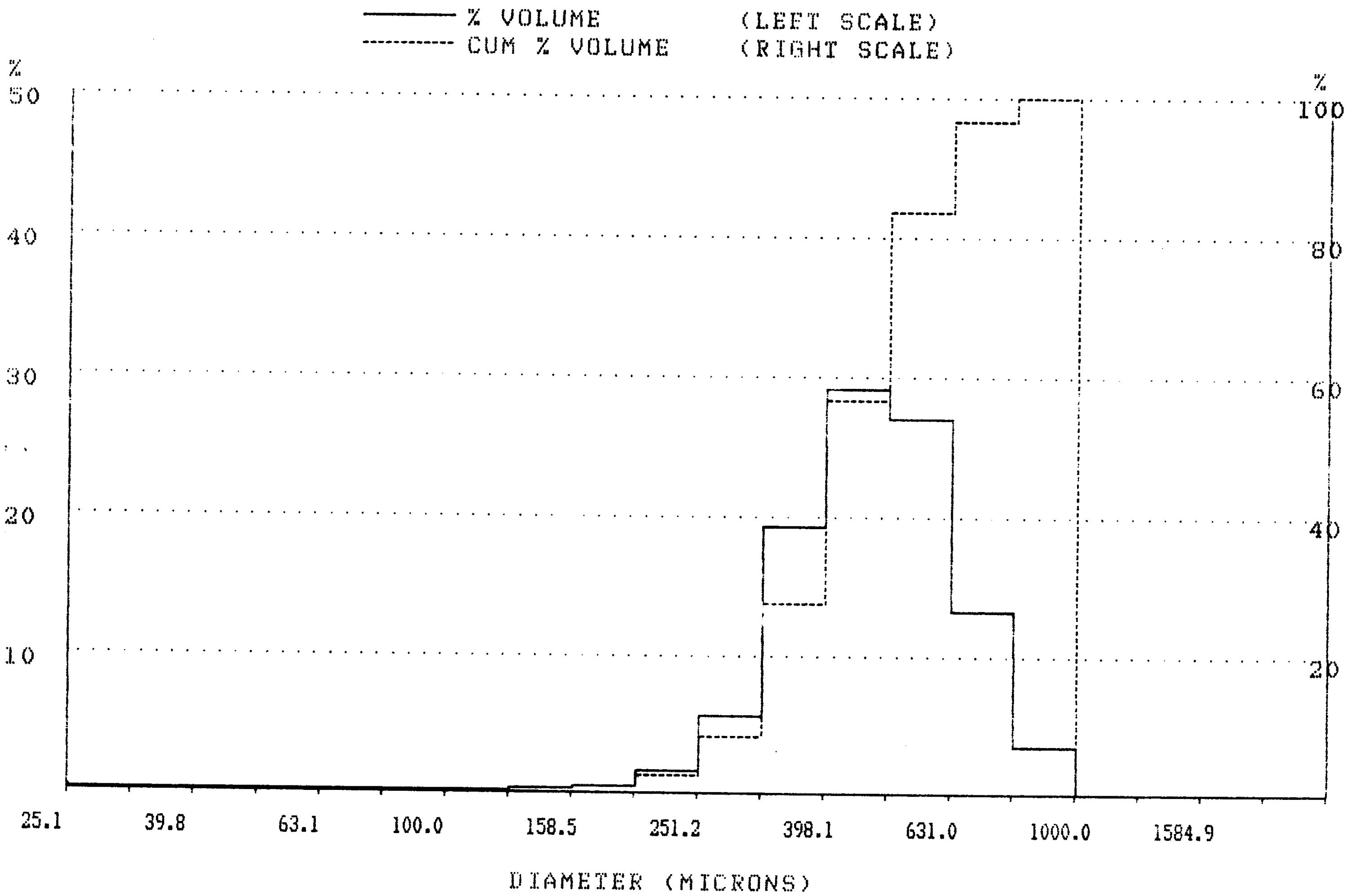


Figure 11. Histogram of Droplet Diameter by Percent Occurrence and Surface Area, Nozzle TF10NN, Test 5

COMPOSITE REPORT		NOZZLE:	TF 10 NN
TEST DATE	1/16/85	TEST METHOD:	PLANE
TESTS INCLUDED:	86 87 106 107 108 109 110 111		
SPRAY DIRECTION	VERTICAL		
PRESSURE	40.0 PSI		
CENTERLINE COORDINATE	60.00 INCHES		
RADIAL COORDINATE	14.00 - 28.00 INCHES		
DISTANCE FROM NOZZLE	61.60 - 66.21 INCHES		
AZIMUTHAL ANGLE	13.1 - 25.0 DEG		
CYLINDRICAL ANGLE	270 DEG		



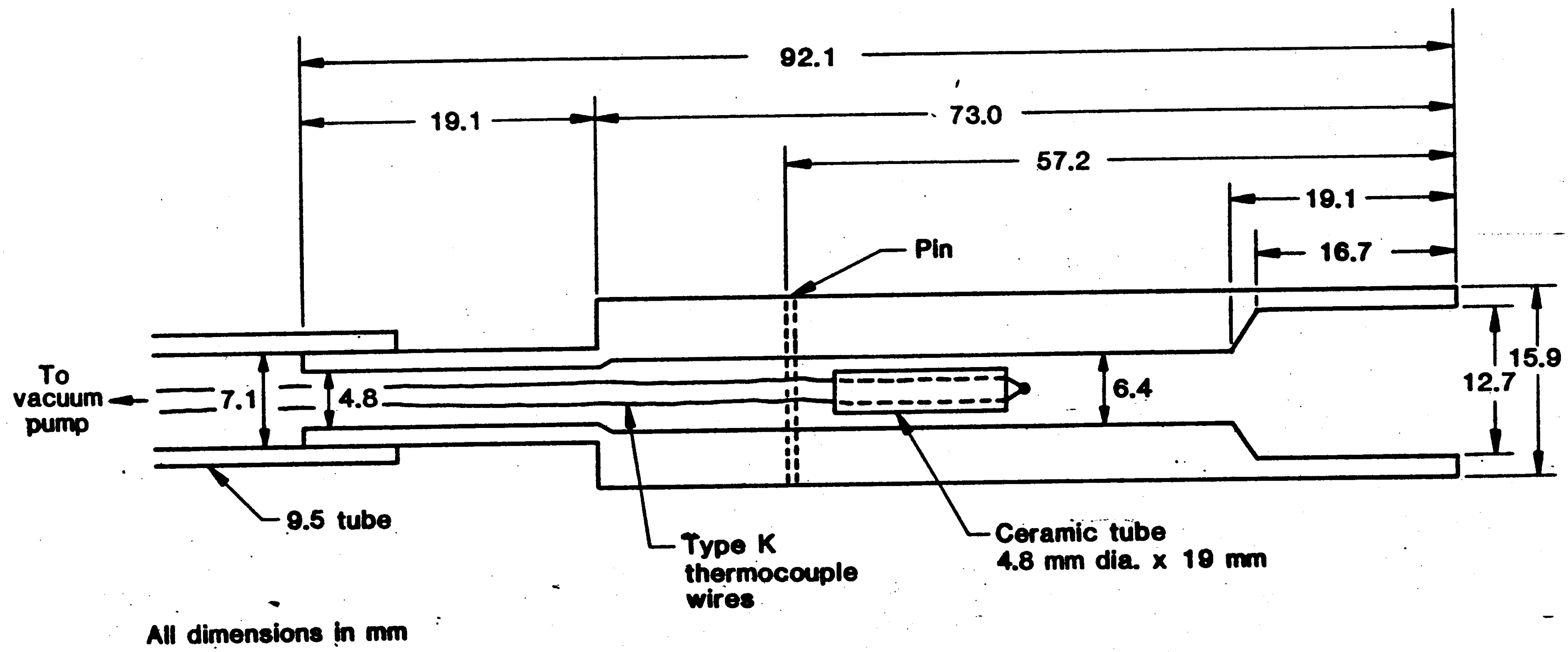


FIGURE 12

SCHEMATIC OF

ASPIRATED THERMOCOUPLE PROBE TIP

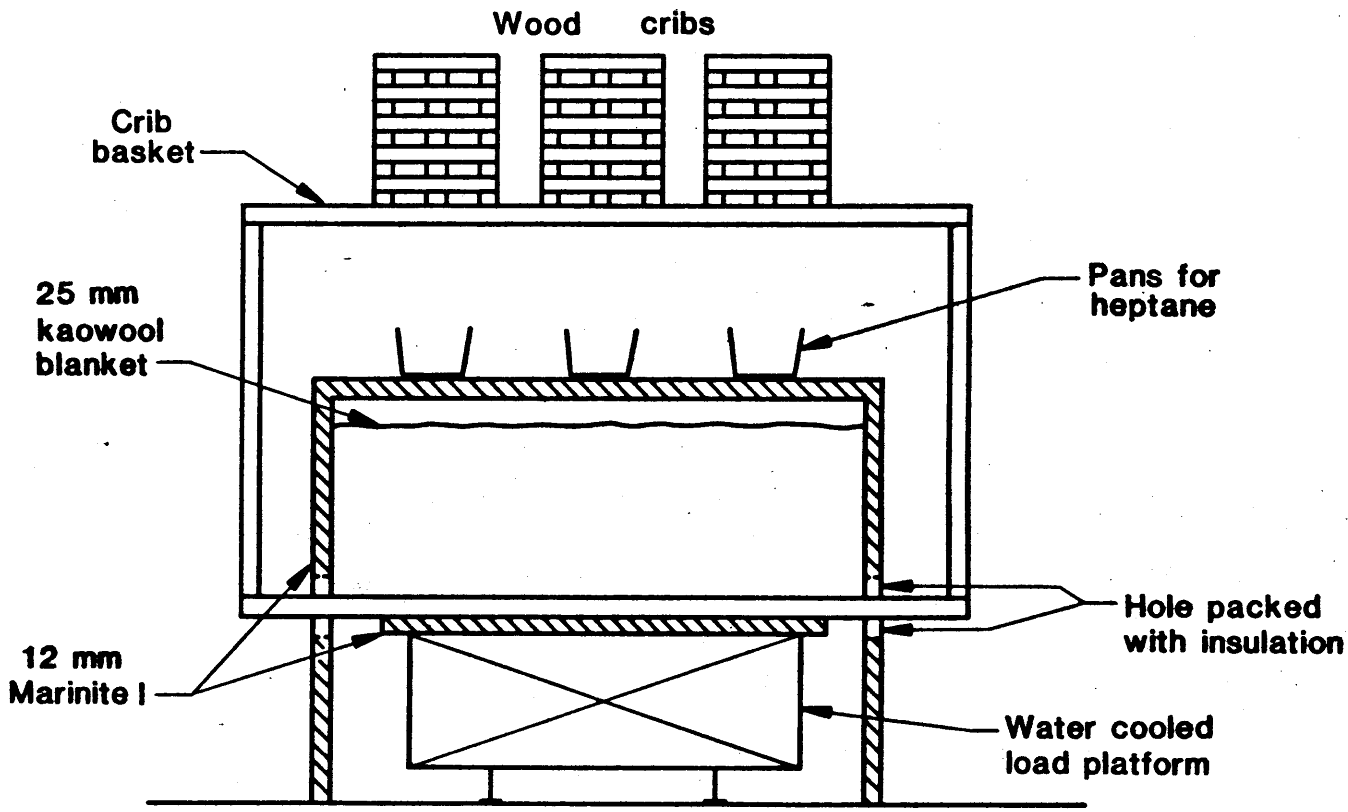


FIGURE 13

SCHEMATIC OF MASS LOSS

INSTRUMENTATION

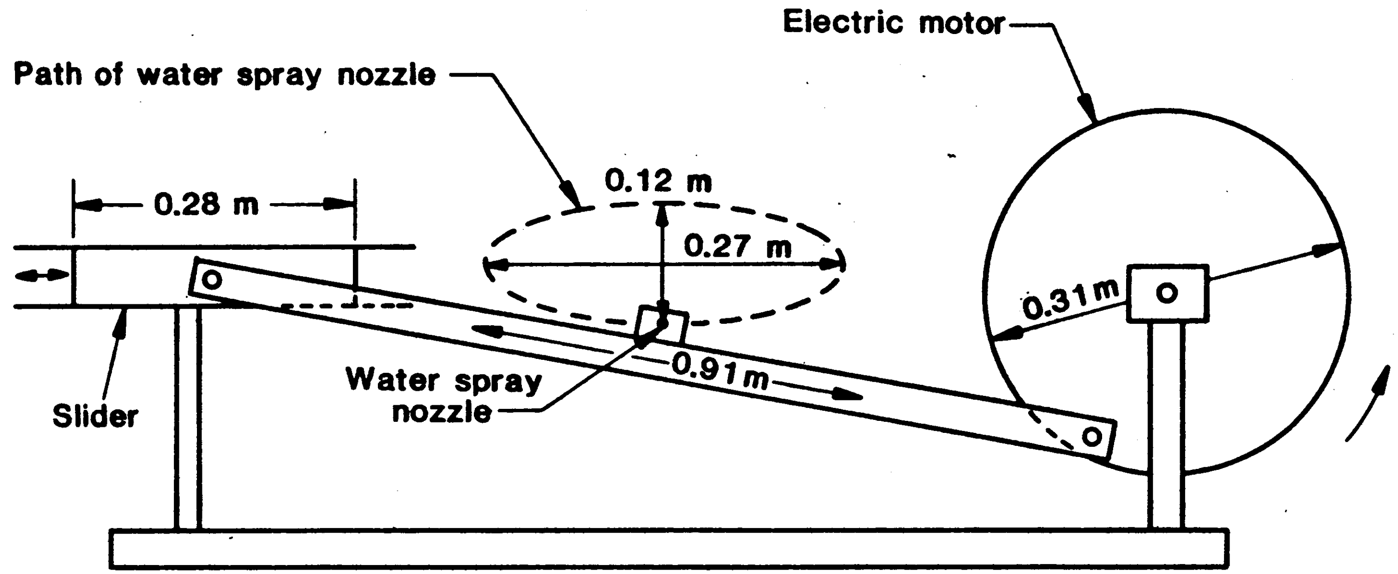


FIGURE 14

SCHEMATIC OF

IRON FIRE FIGHTER

Figure 15. Static Room Gauge Pressure

Test Number 1

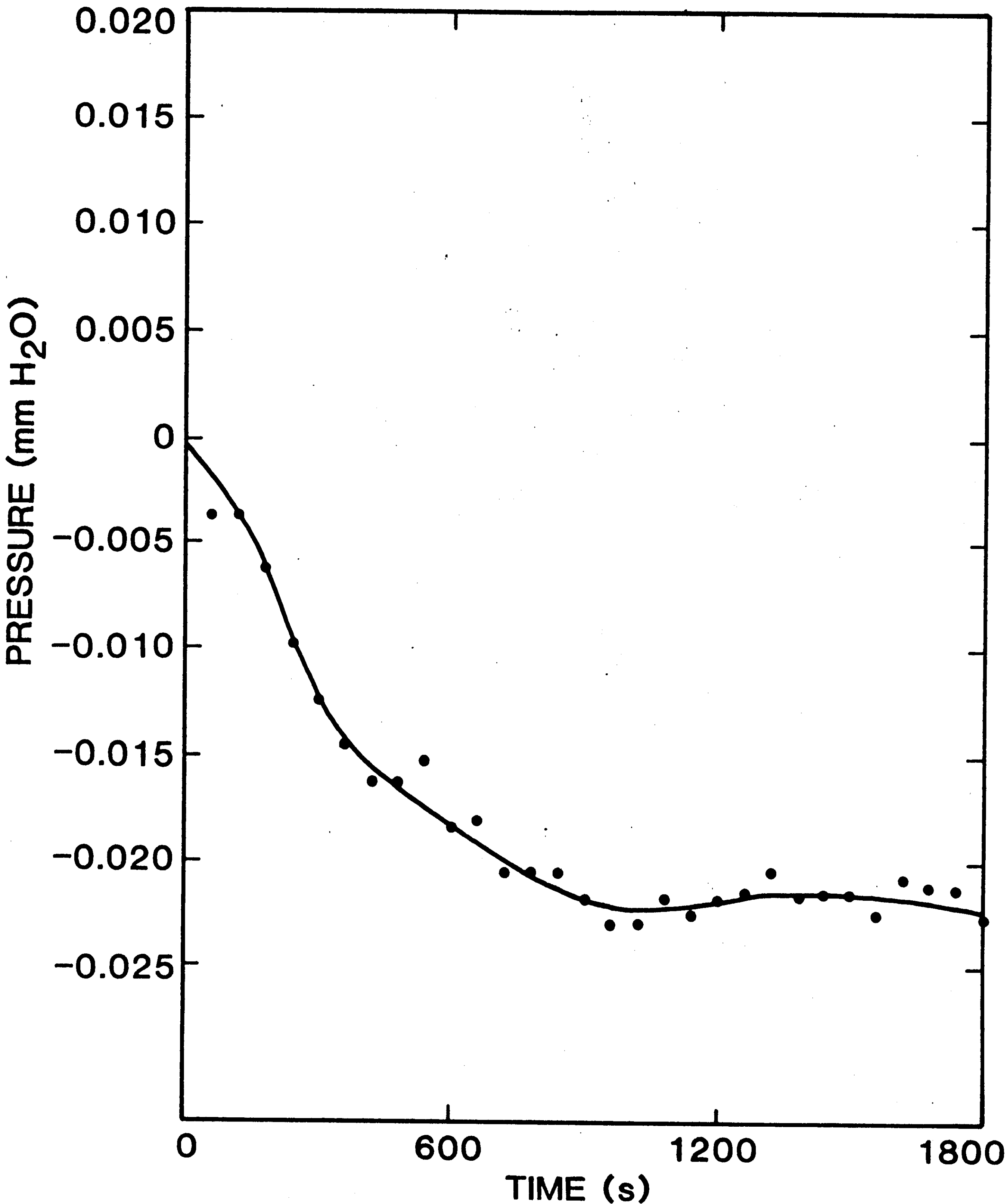


Figure 16. Static Room Gauge Pressure

Test Number 2

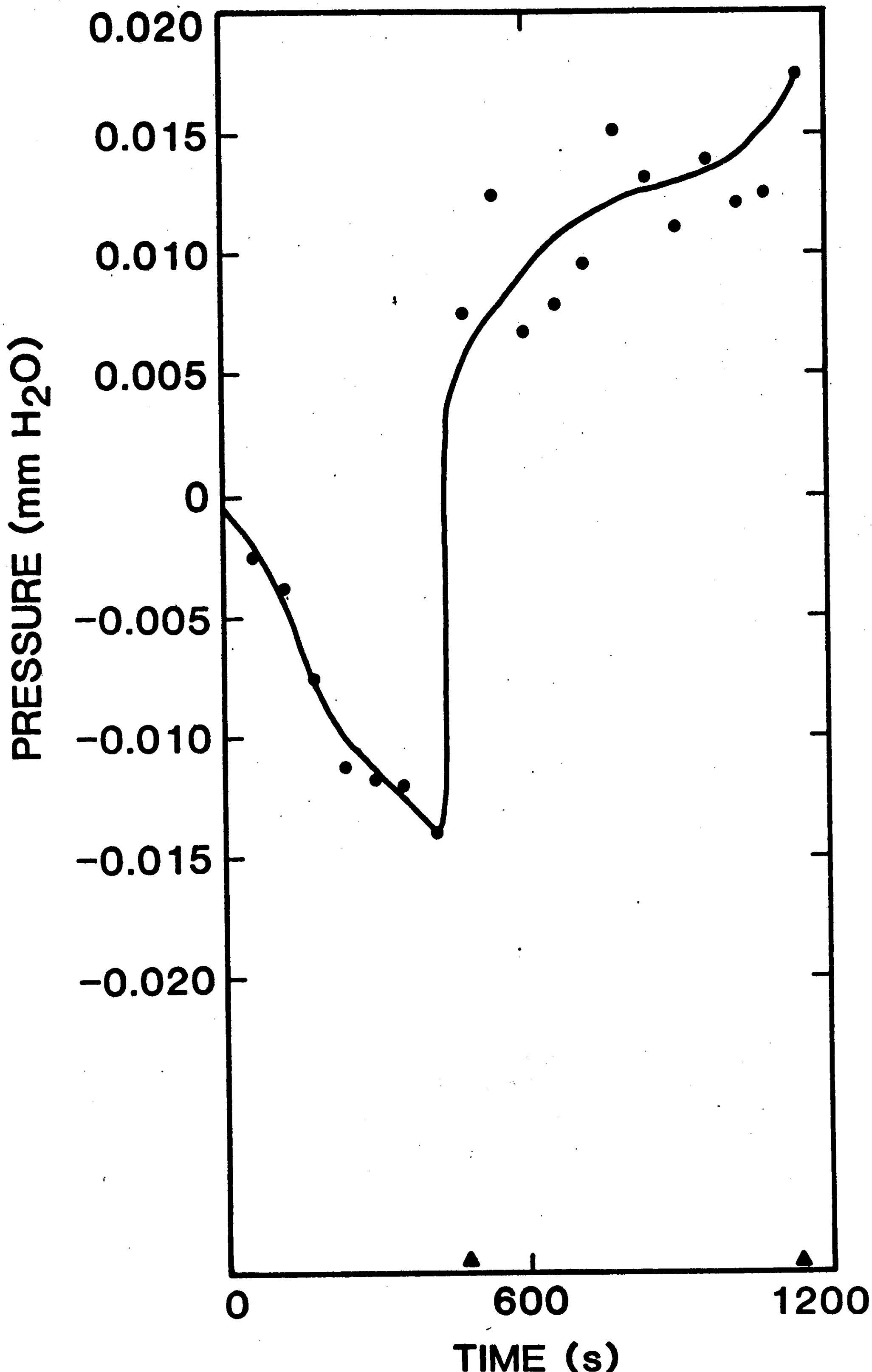


Figure 17. Static Room Gauge Pressure
Test Number 3

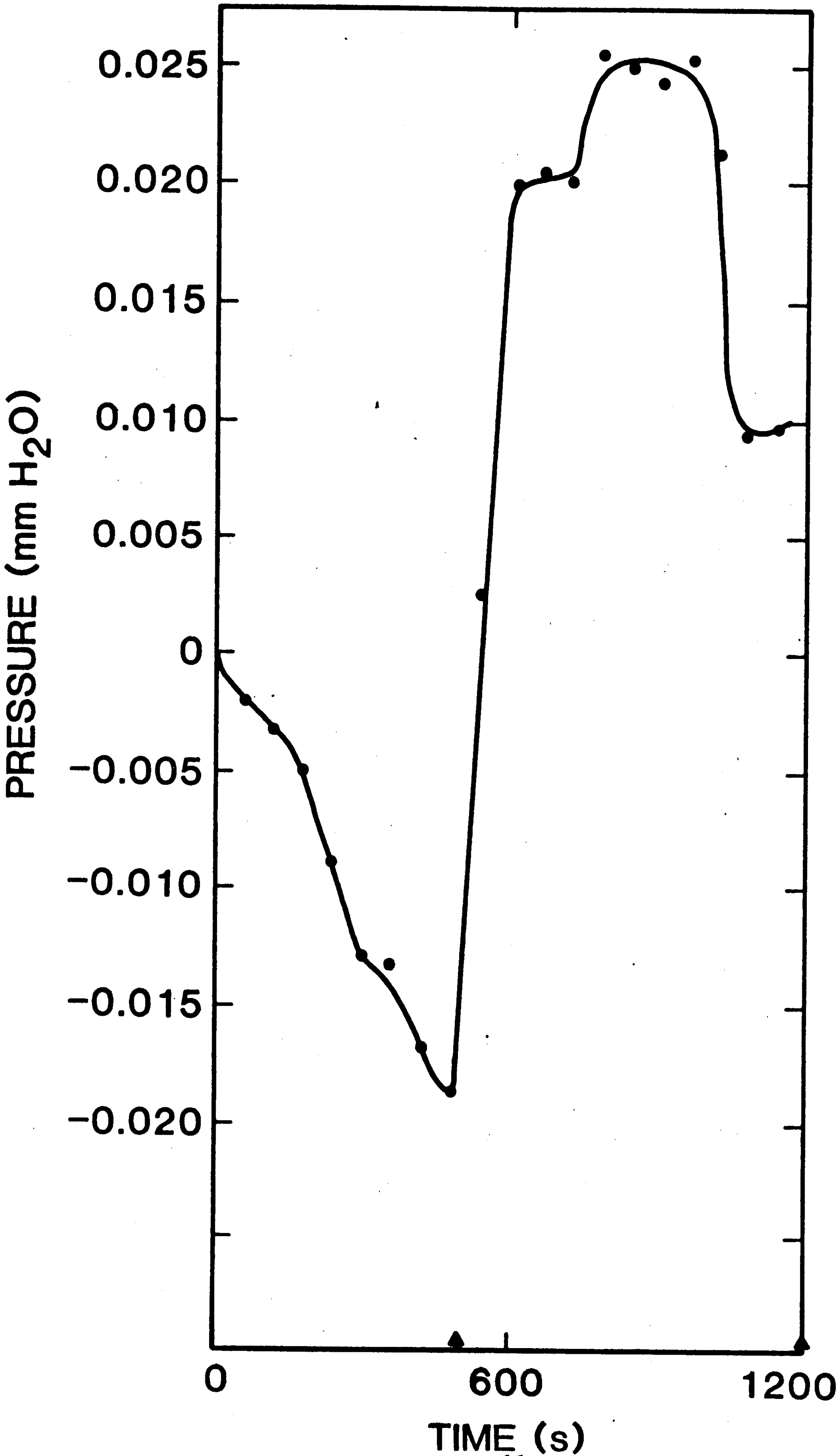


Figure 18. Static Room Gauge Pressure

Test Number 4

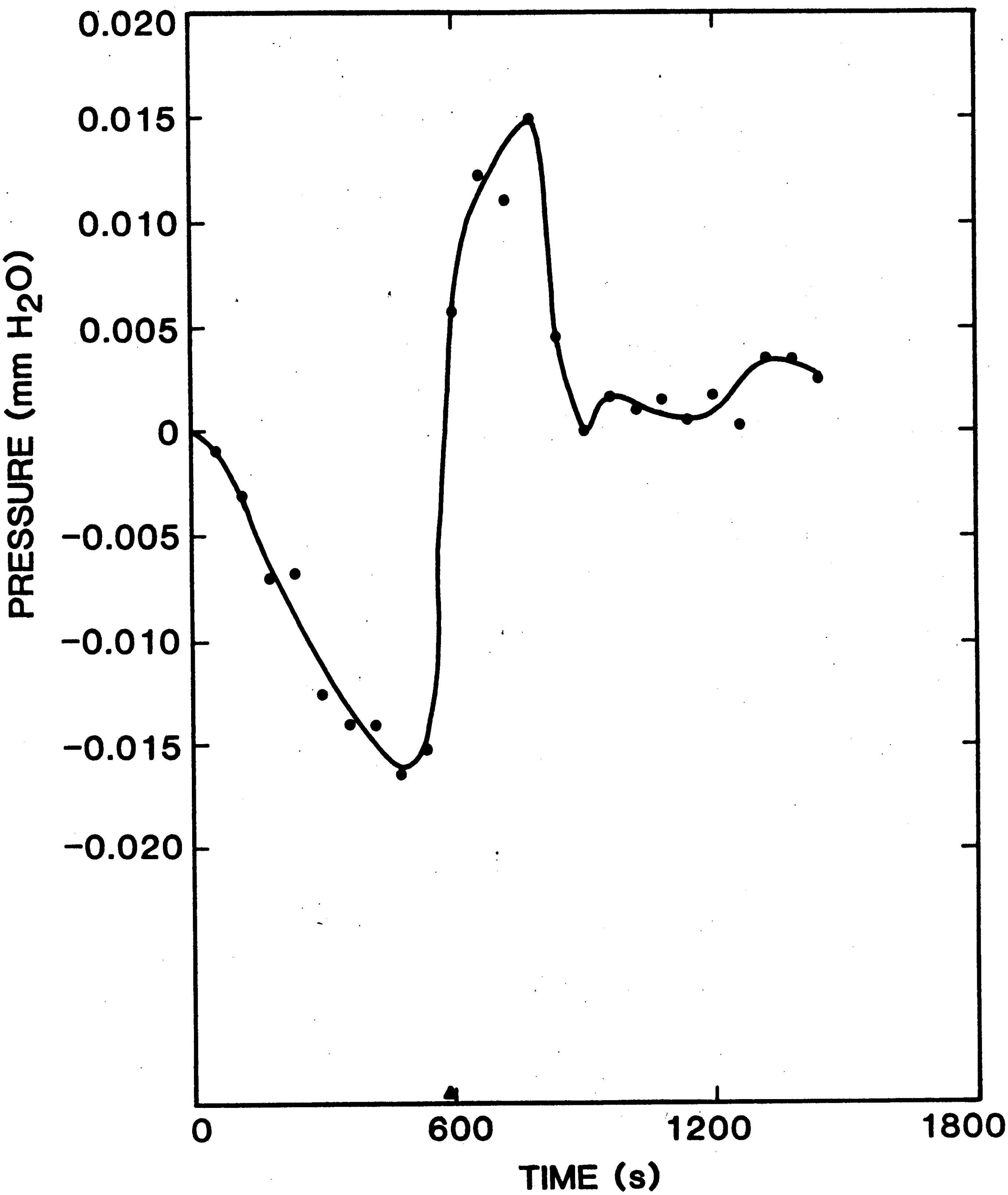
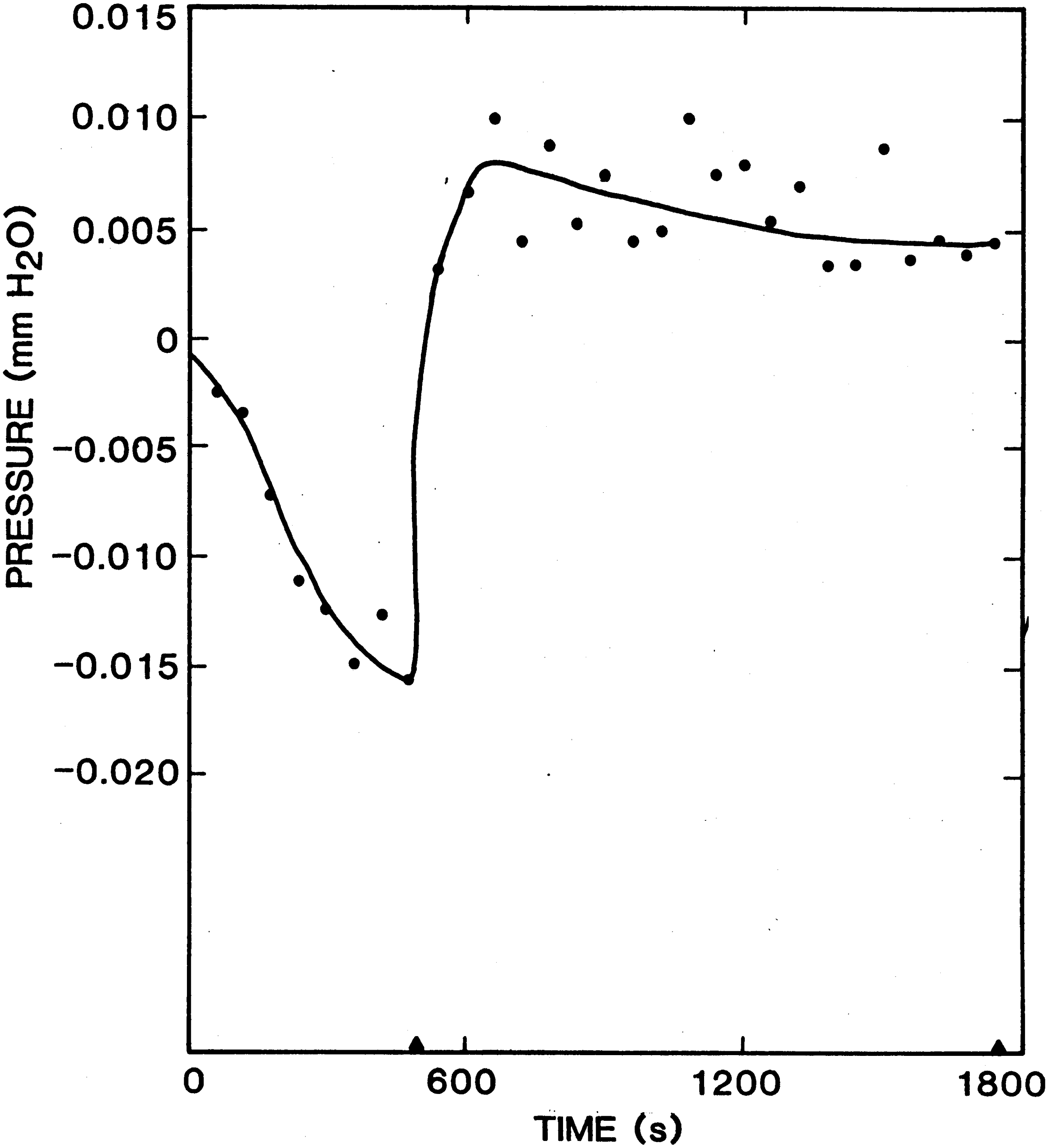


Figure 19. Static Room Gauge Pressure
Test Number 5



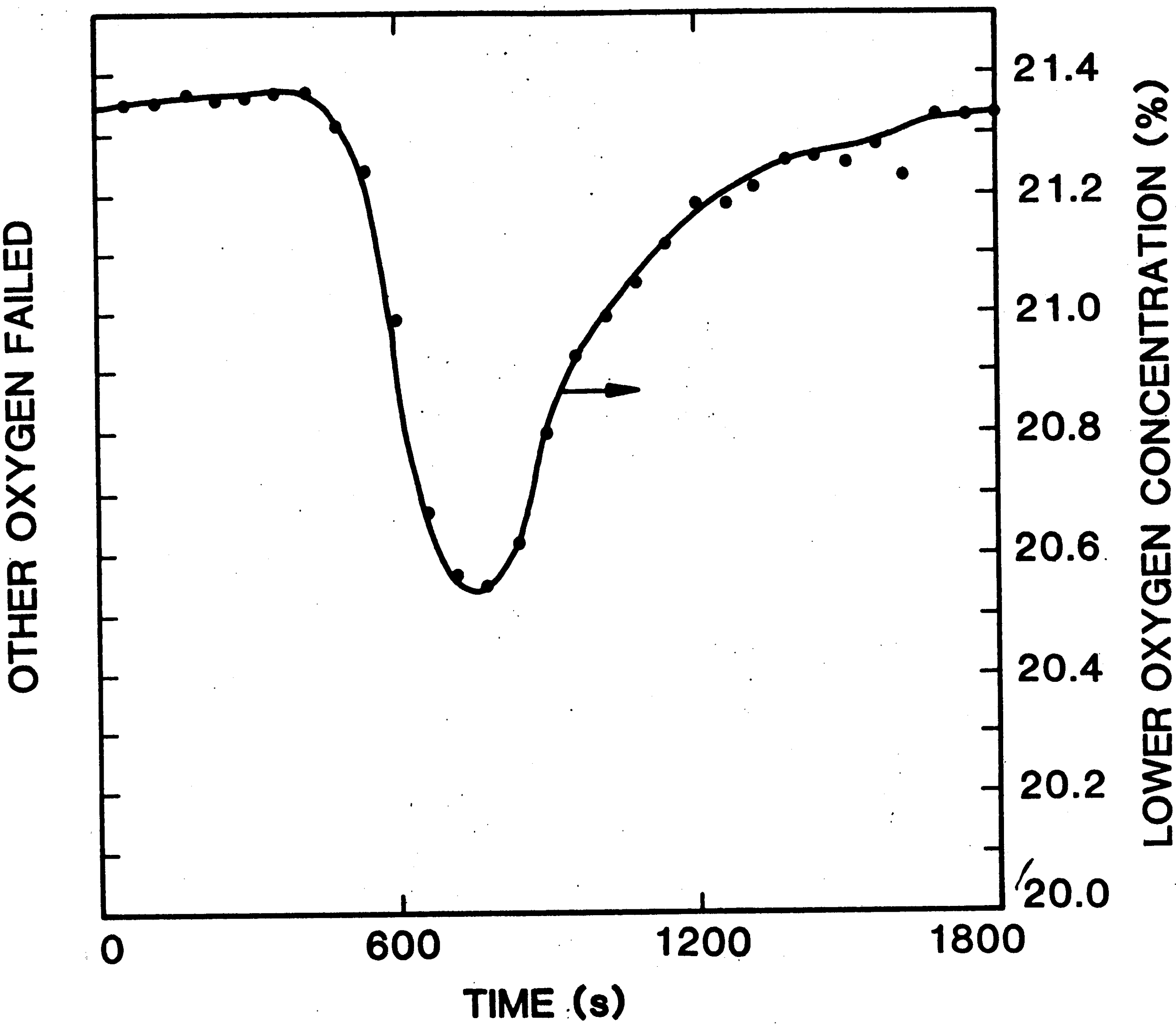


Figure 20. Upper and Lower Layer Oxygen Concentration

Test Number 1

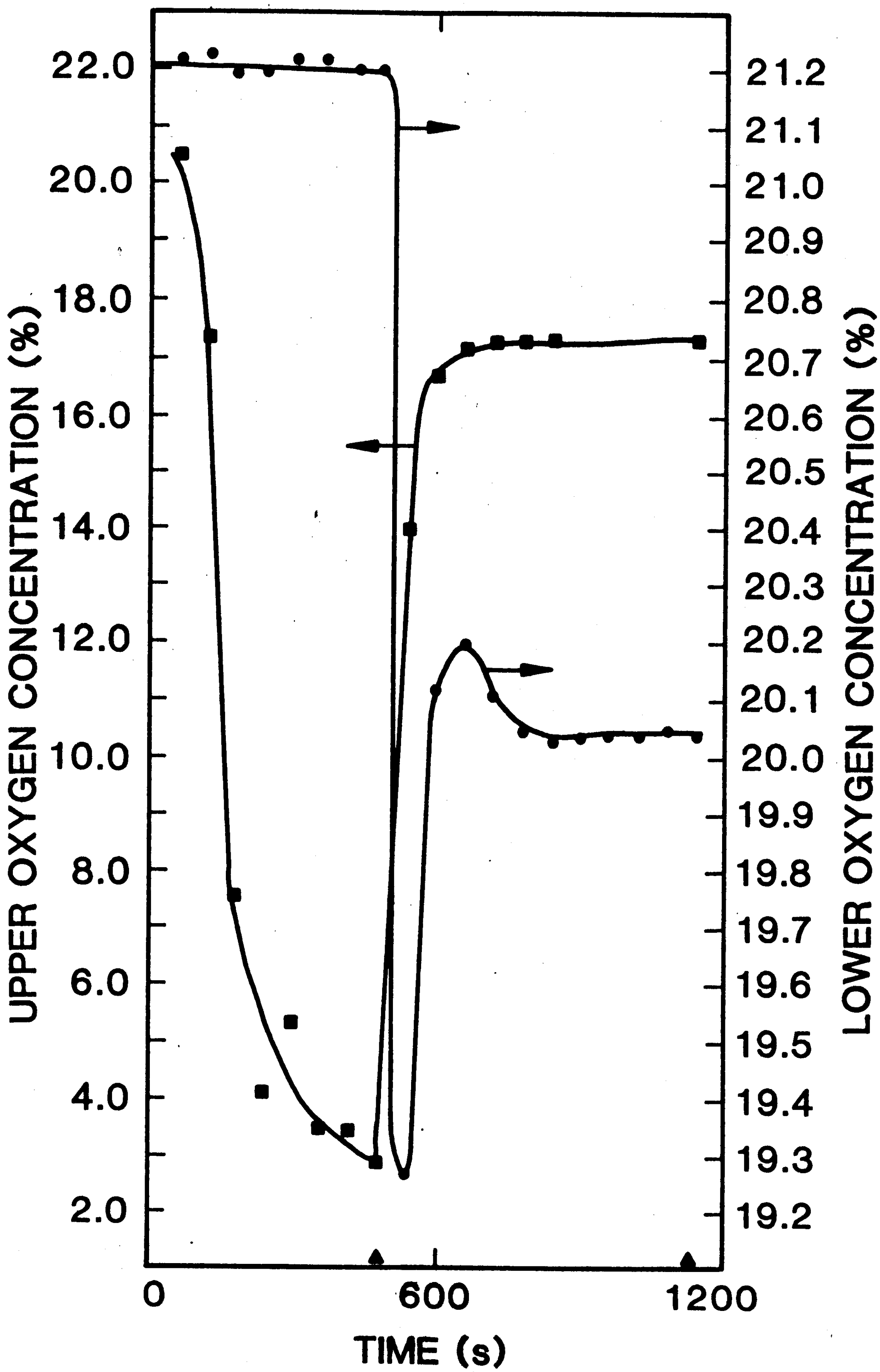


Figure 21. Upper and Lower Layer Oxygen Concentration

Test Number 2

Figure 22. Upper and Lower Layer Oxygen Concentration

Test Number 3

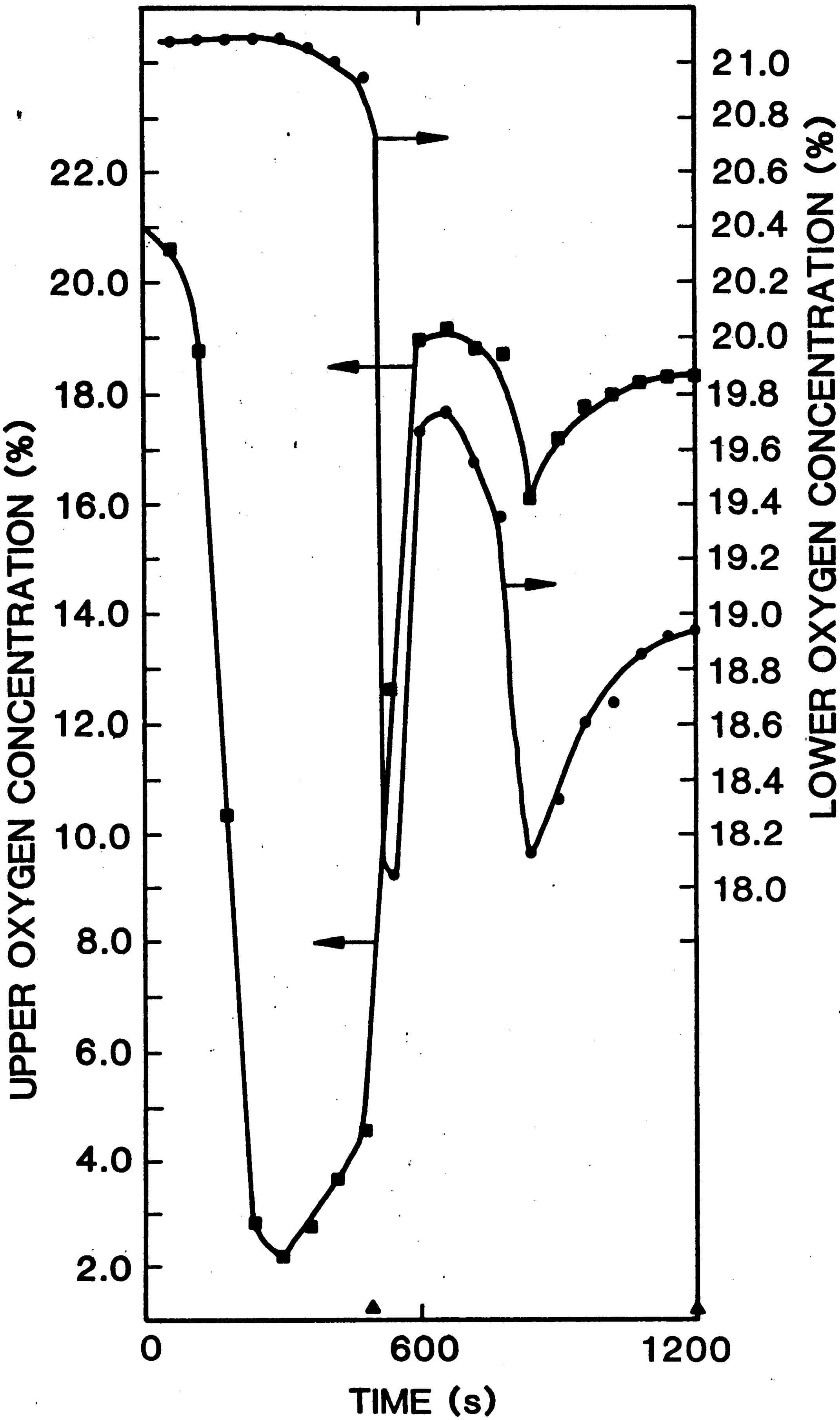


Figure 23. Upper and Lower Layer Oxygen Concentration

Test Number 4

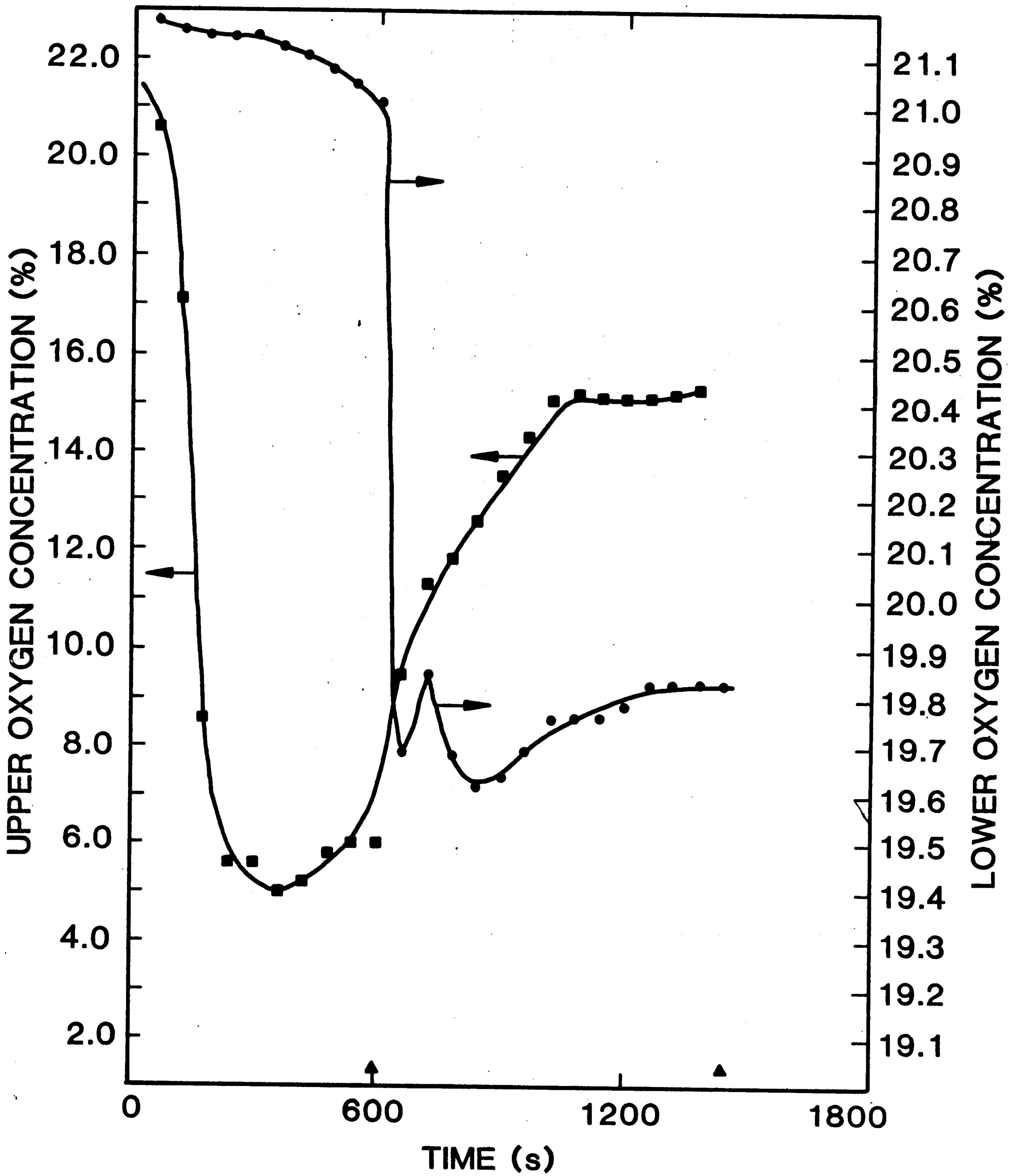


Figure 24. Upper and Lower Layer Oxygen Concentration

Test Number 5

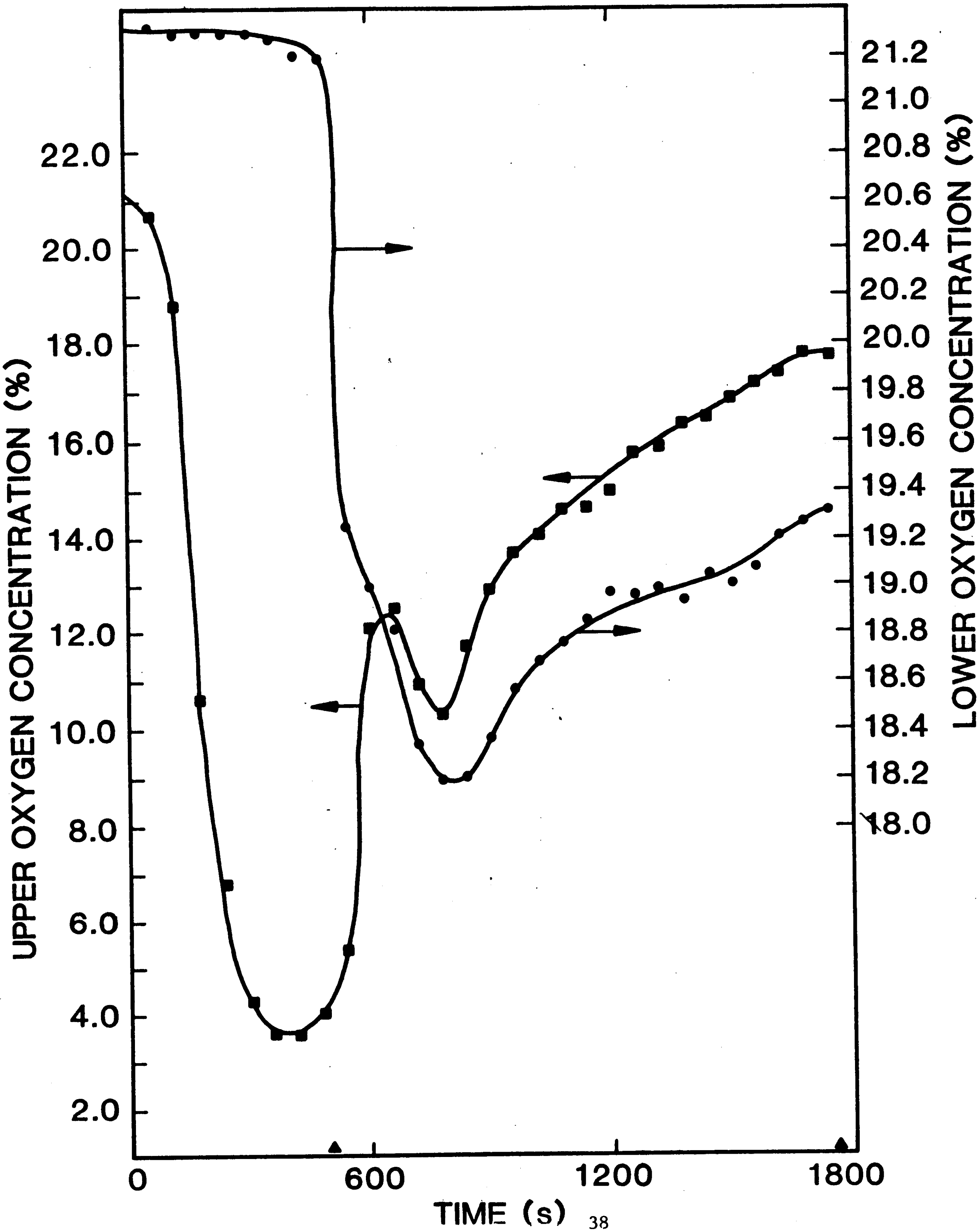


Figure 25. Fuel Mass and Mass Loss Rate
Test Number 1

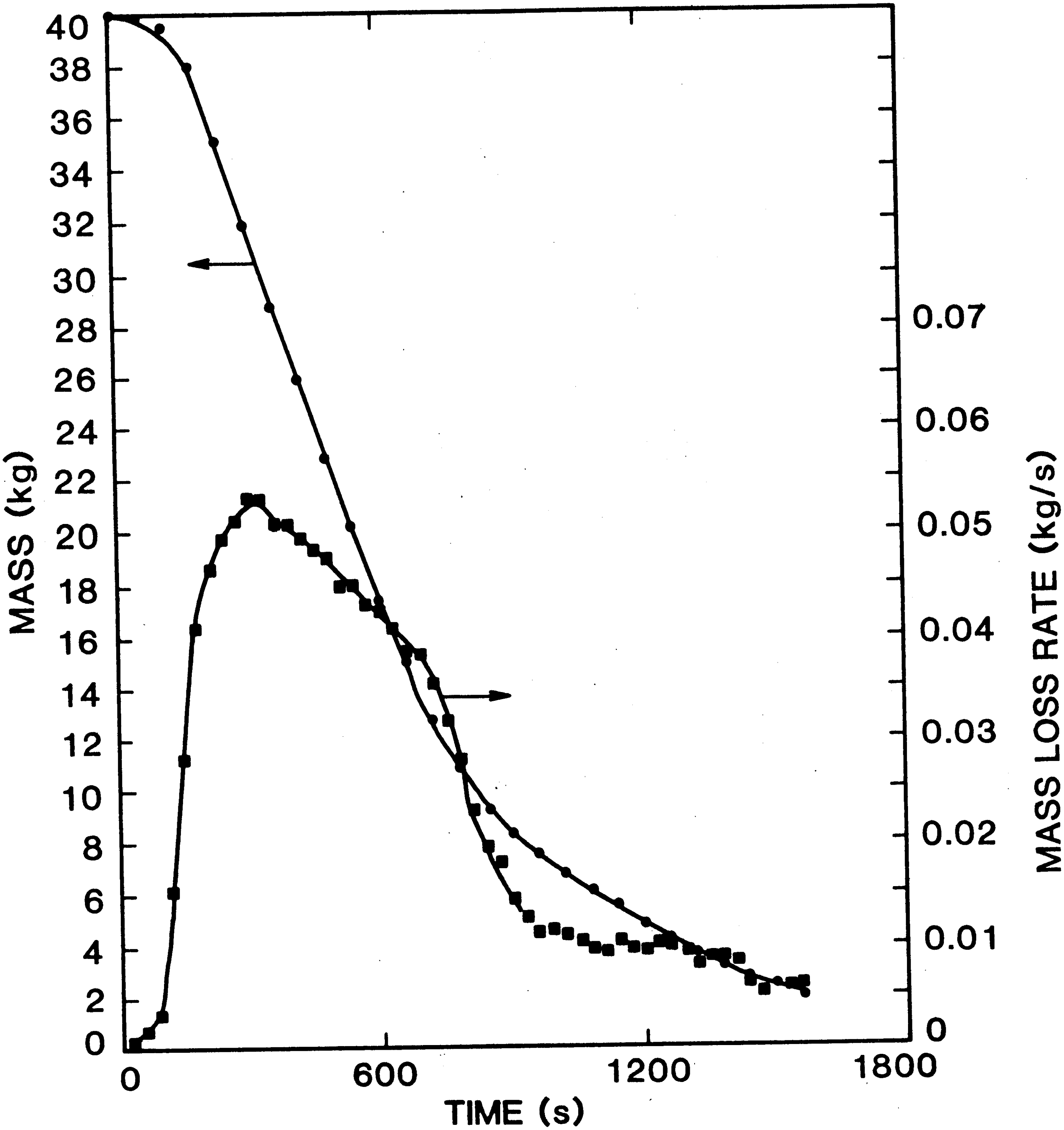


Figure 26. Fuel Mass and Mass Loss Rate
Test Number 2

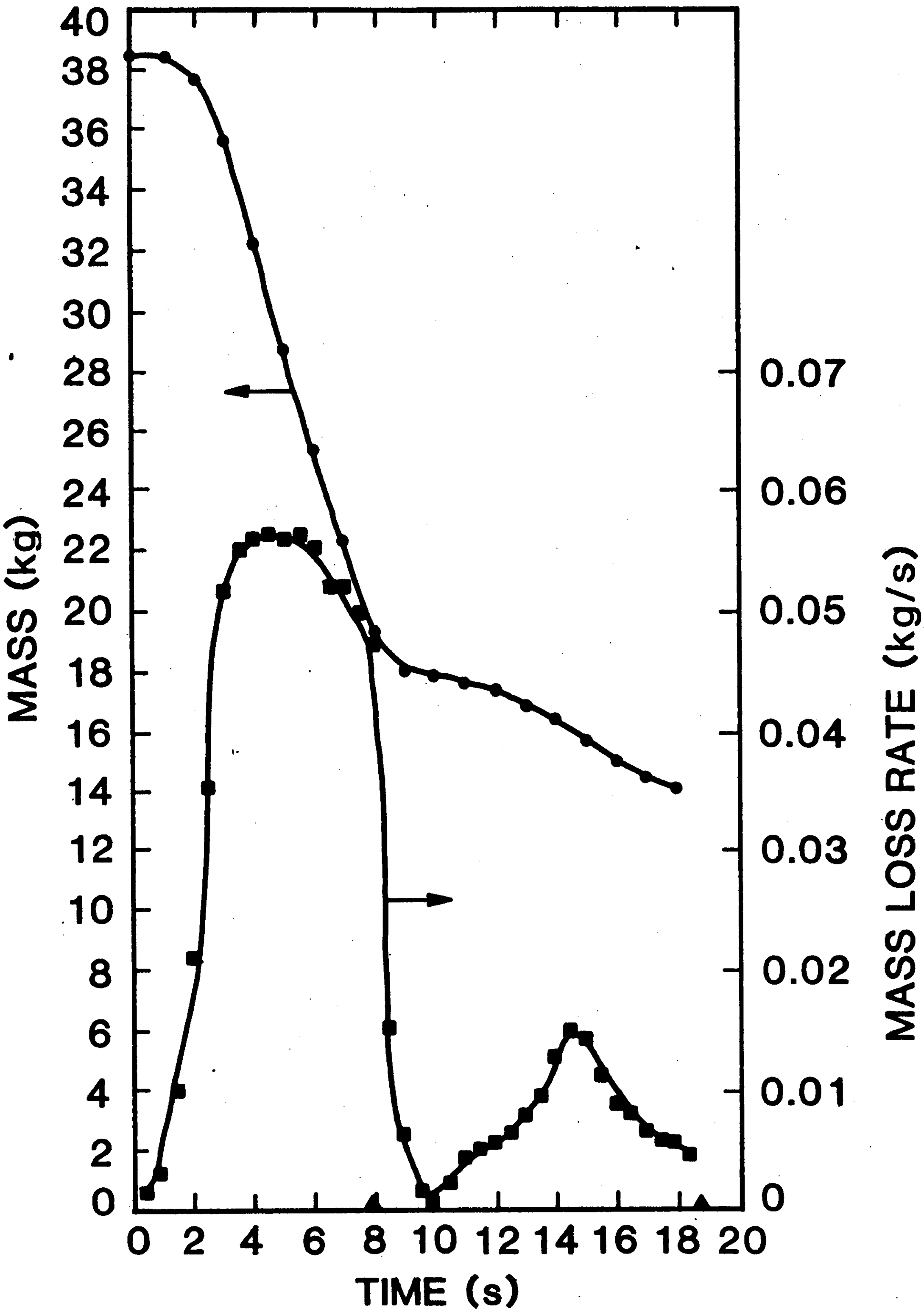


Figure 27. Fuel Mass and Mass Loss Rate

Test Number 3

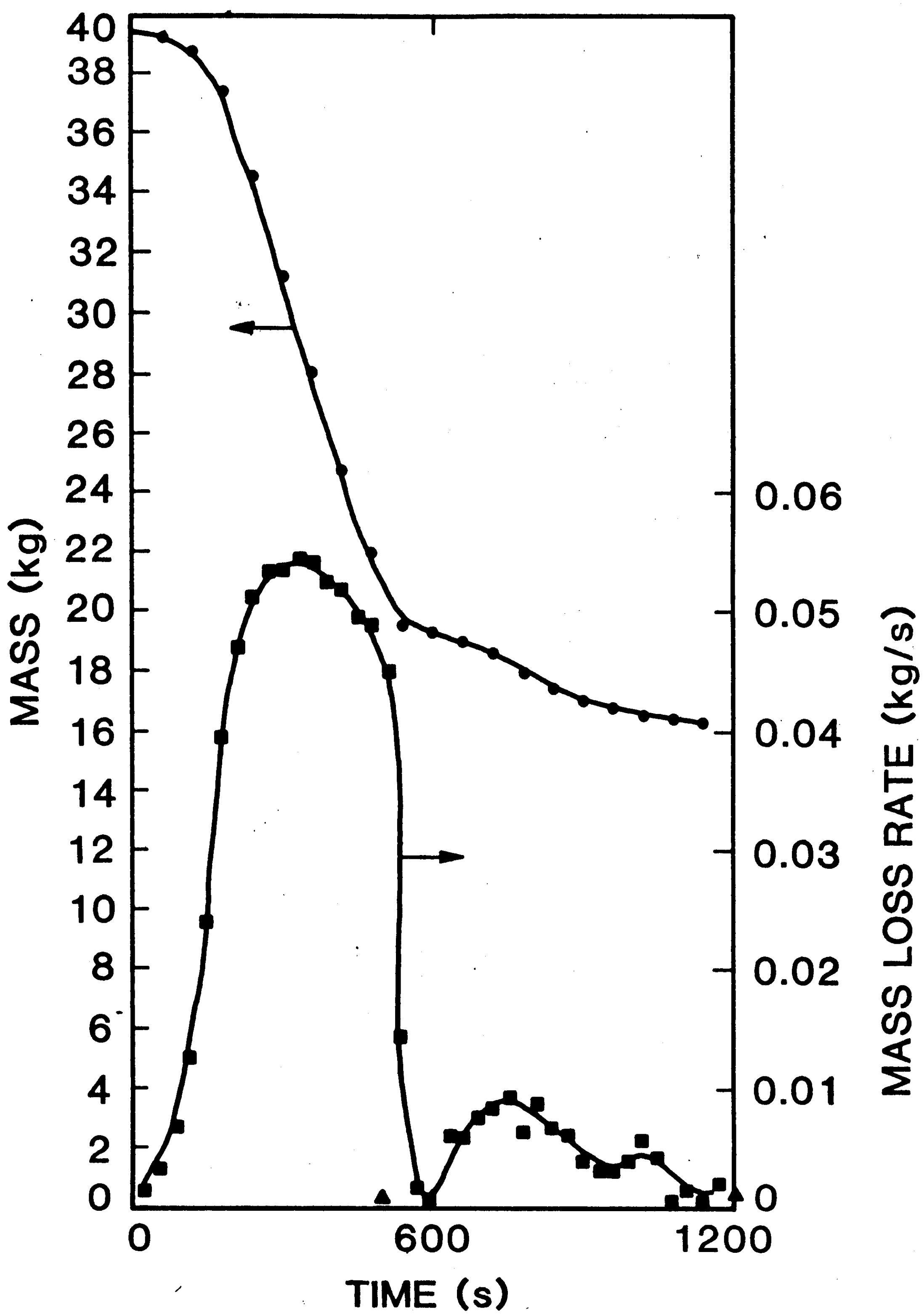


Figure 28. Fuel Mass and Mass Loss Rate

Test Number 4

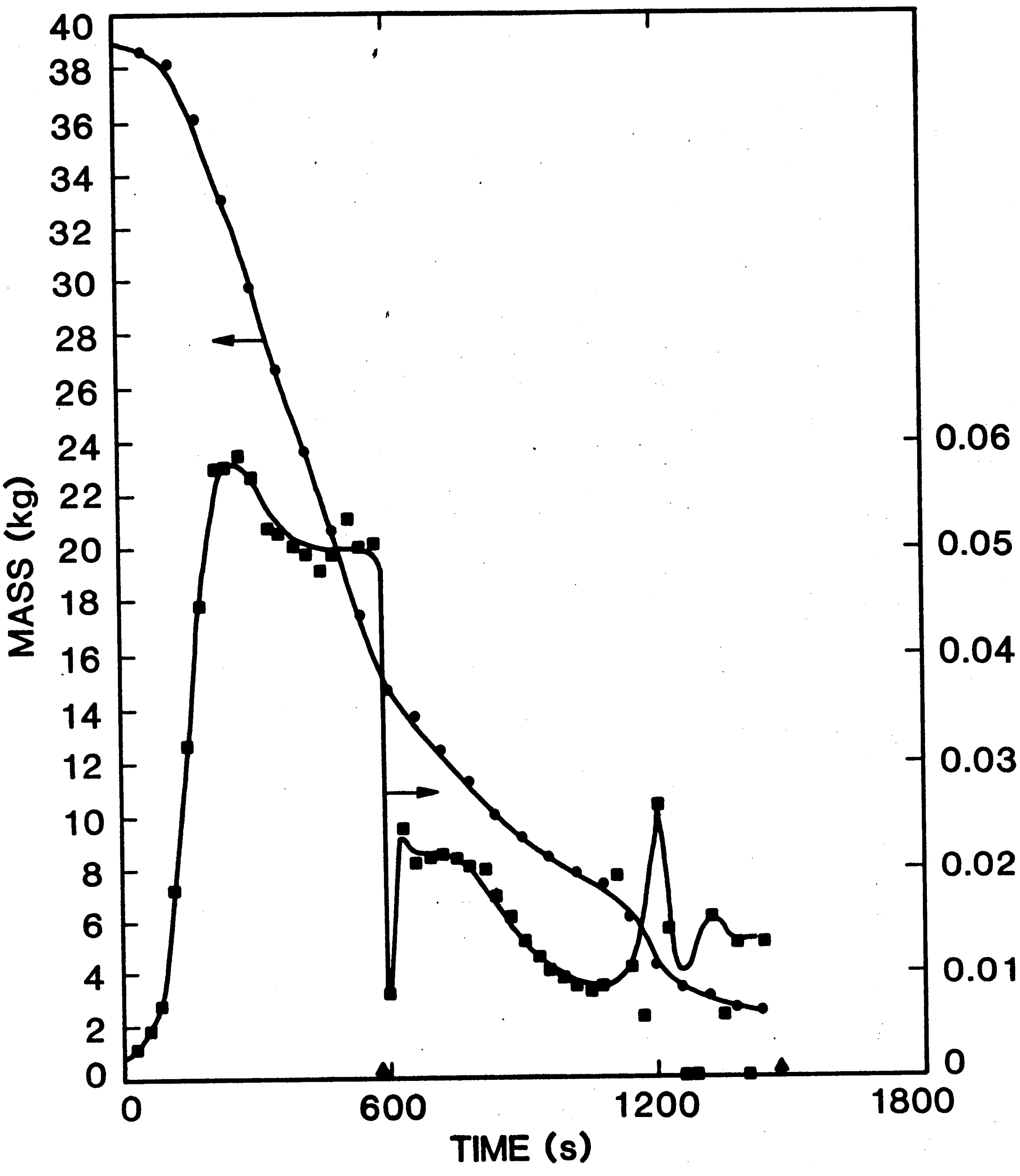


Figure 29. Fuel Mass and Mass Loss Rate
Test Number 5

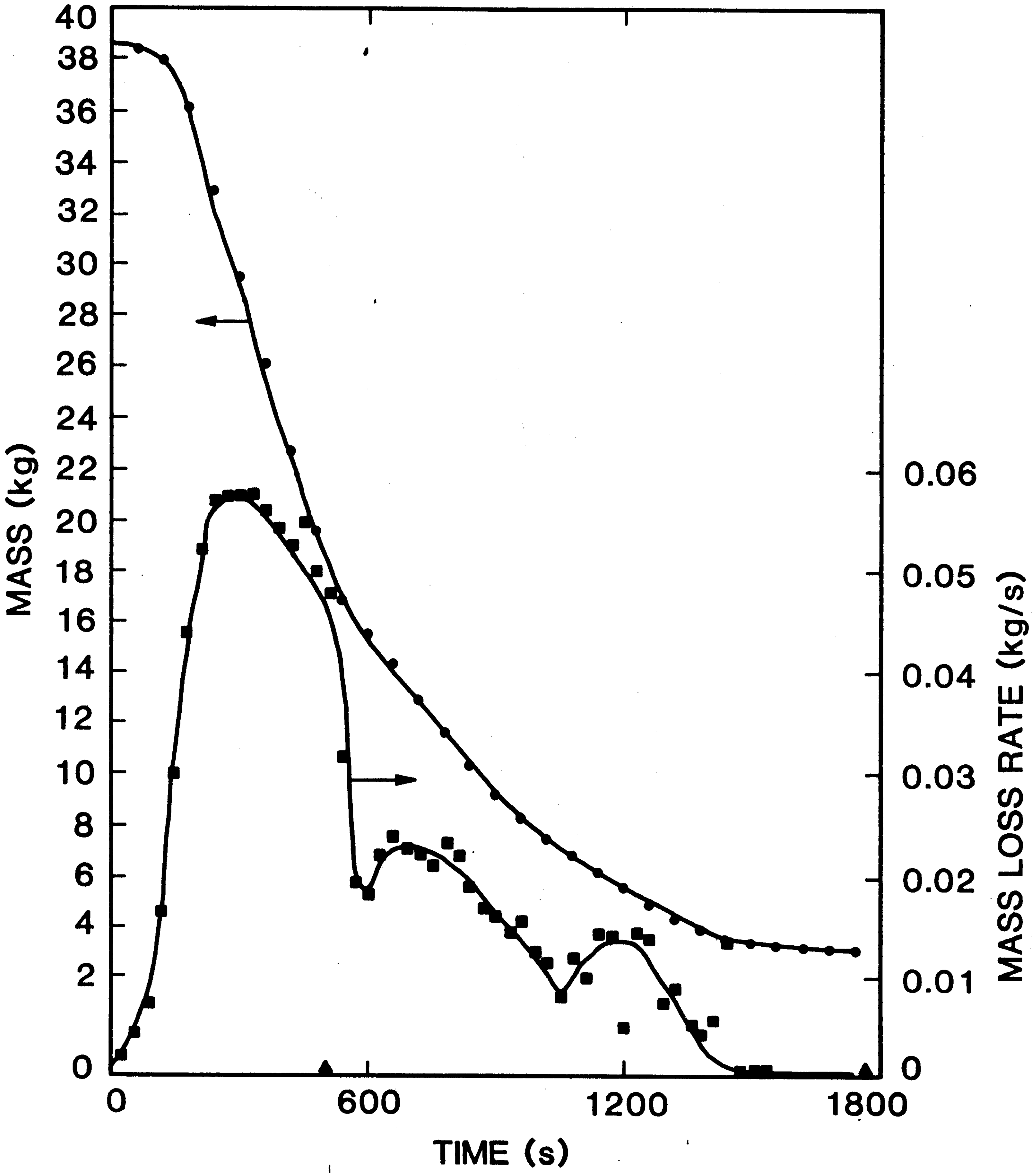


Figure 30. Depth of Lower Layer
Test Number 1

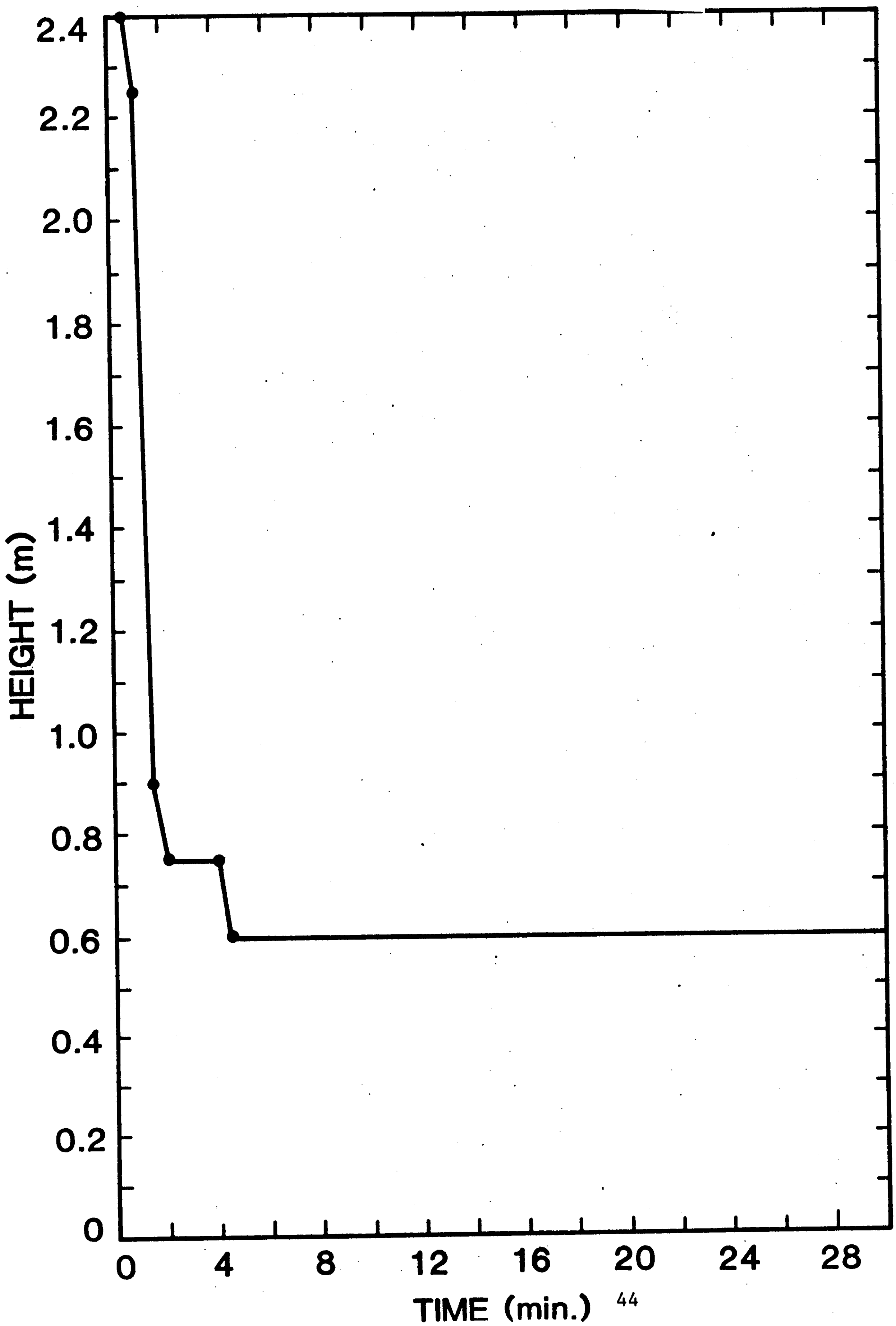


Figure 31. Depth of Lower Layer
Test Number 2

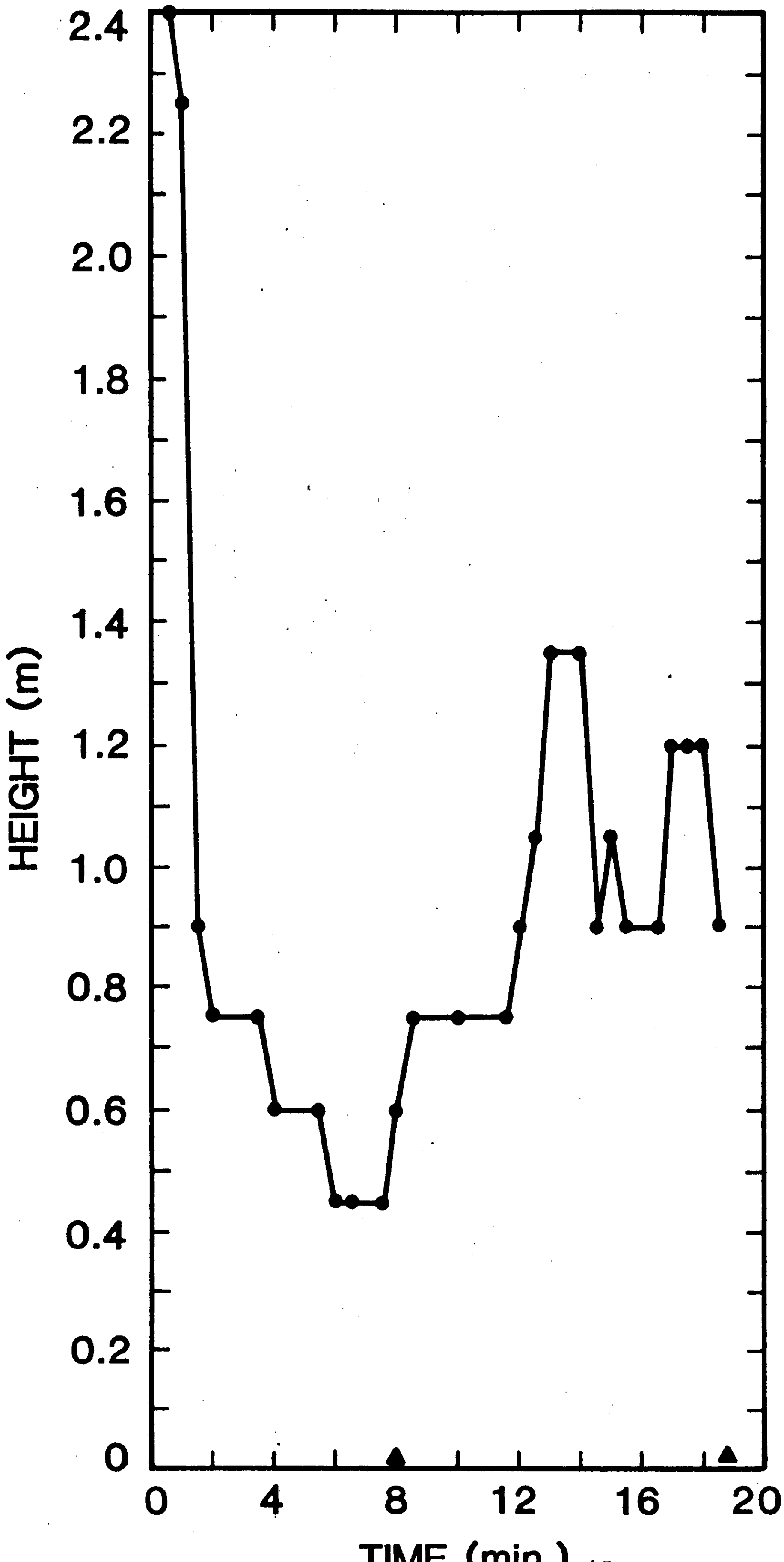


Figure 32. Depth of Lower Layer
Test Number 3

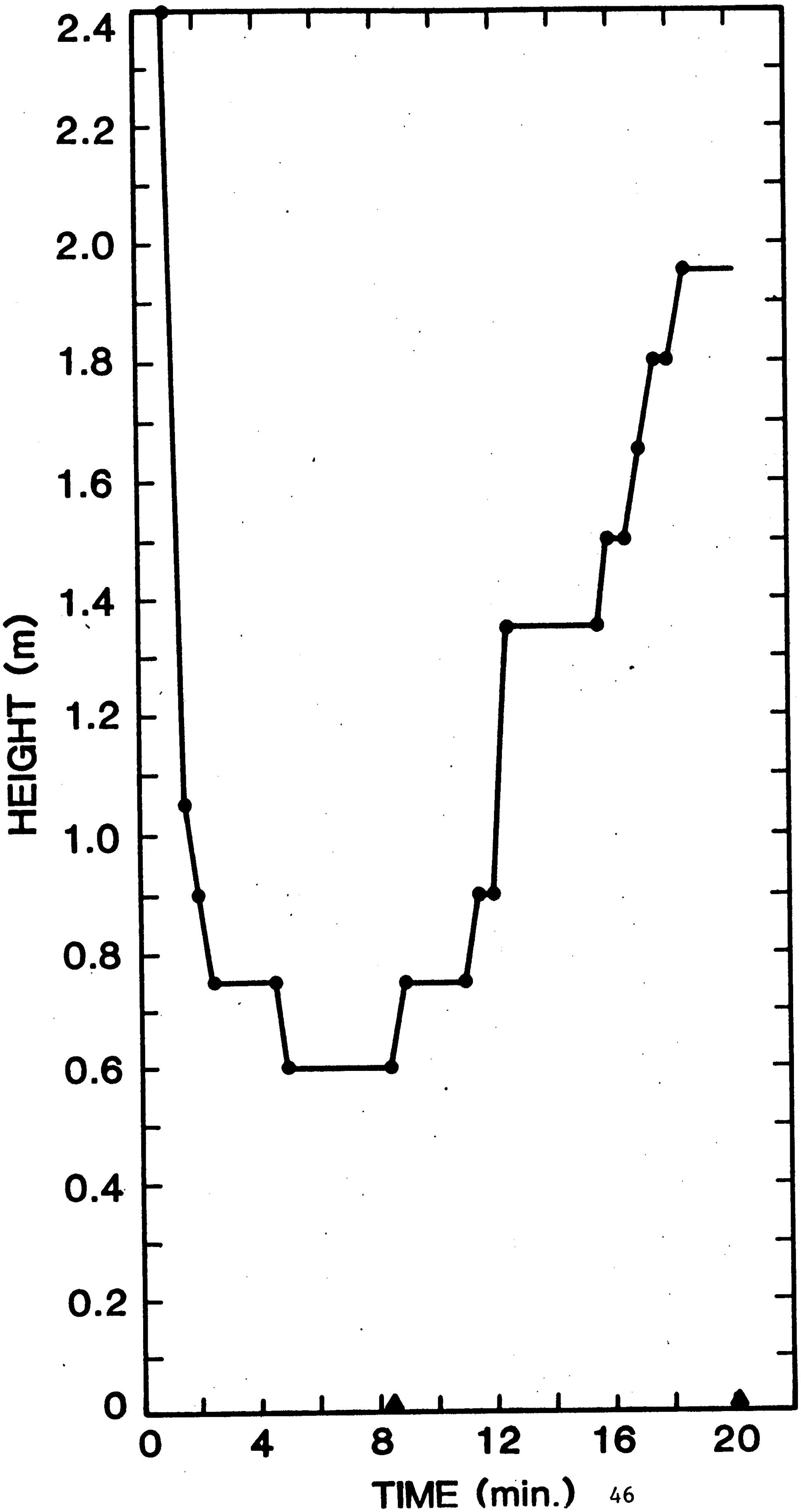


Figure 33. Depth of Lower Layer
Test Number 4

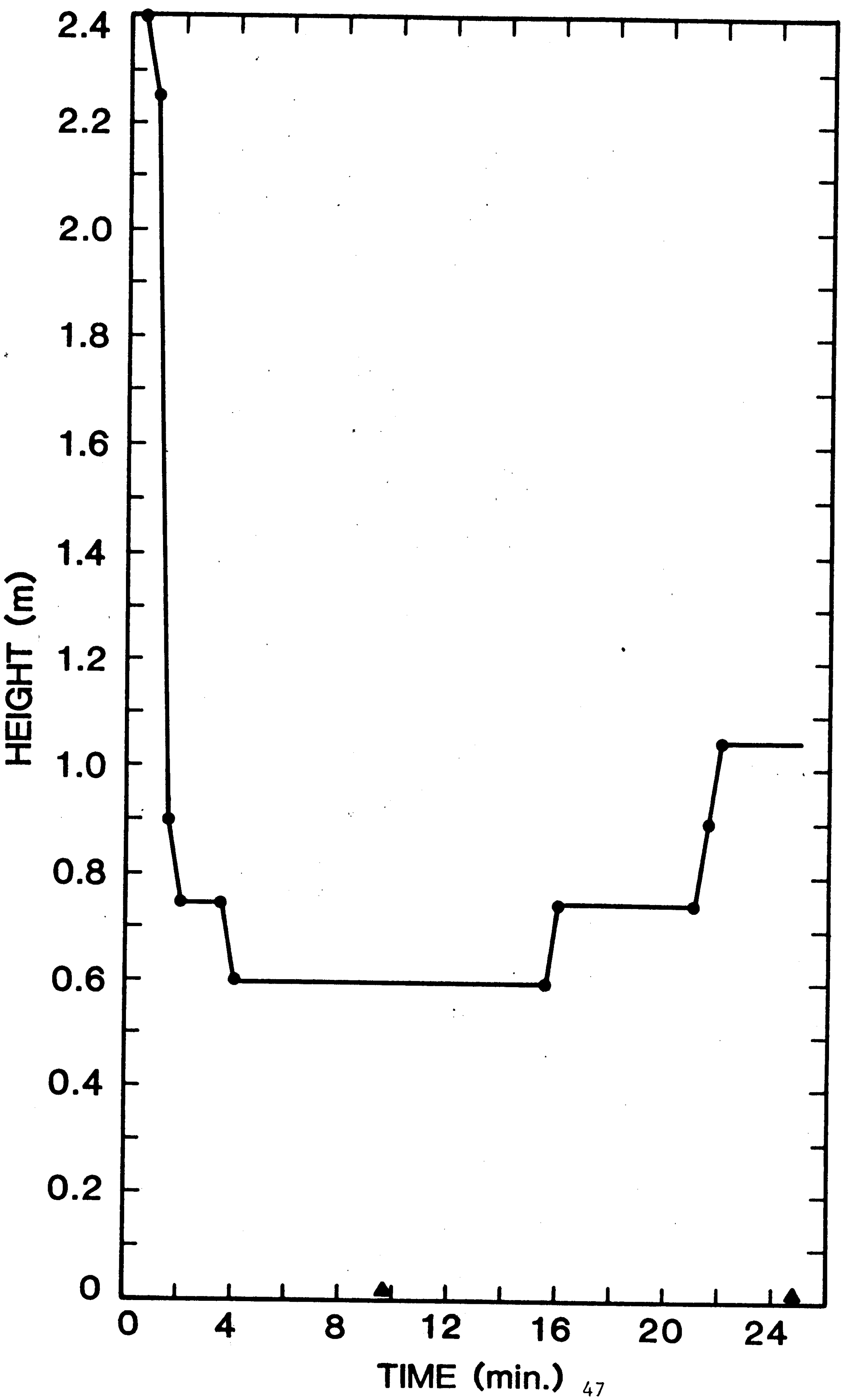


Figure 34. Depth of Lower Layer
Test Number 5

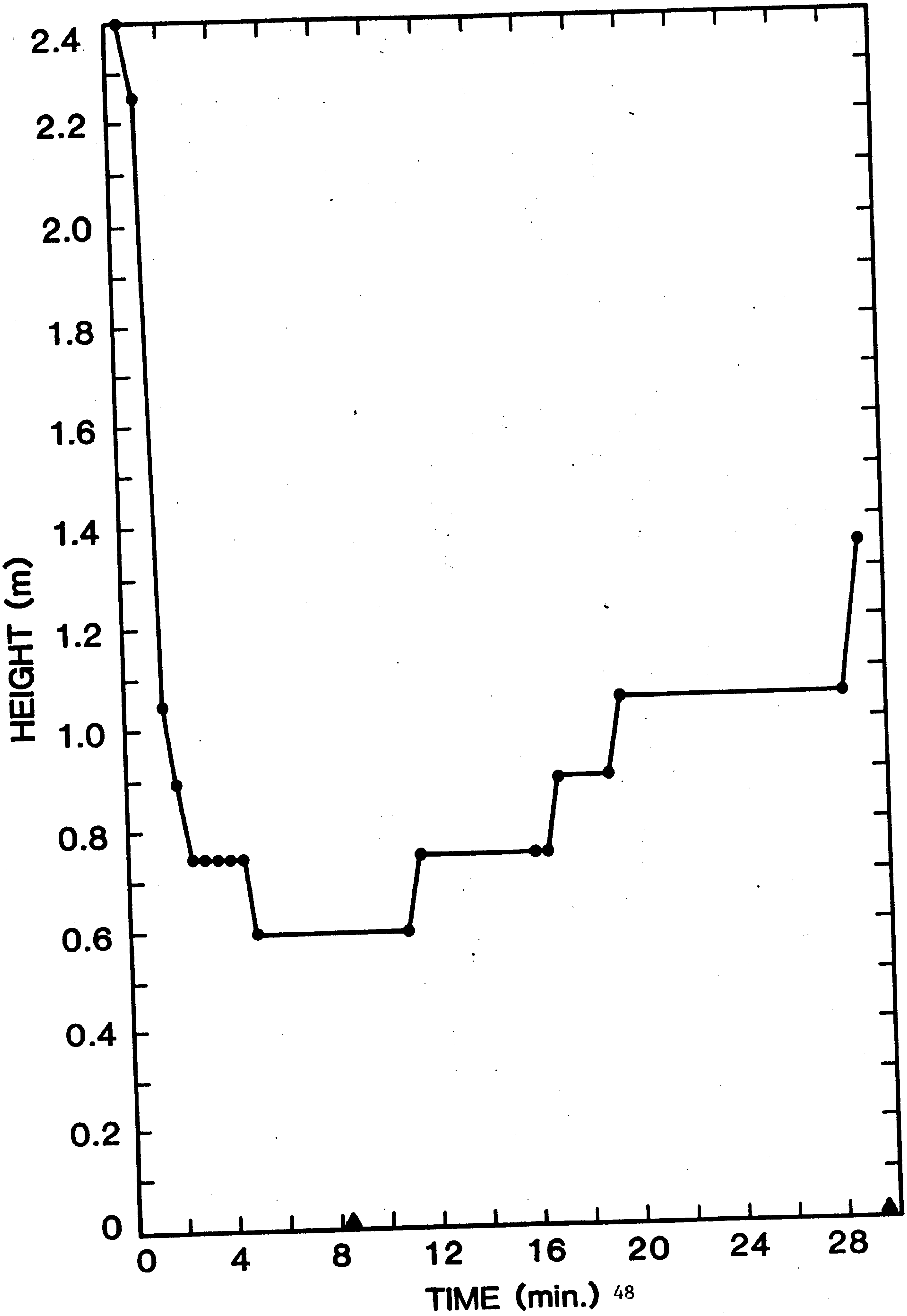


Figure 35. Upper and Lower Layer
Average Temperature
Test Number 1

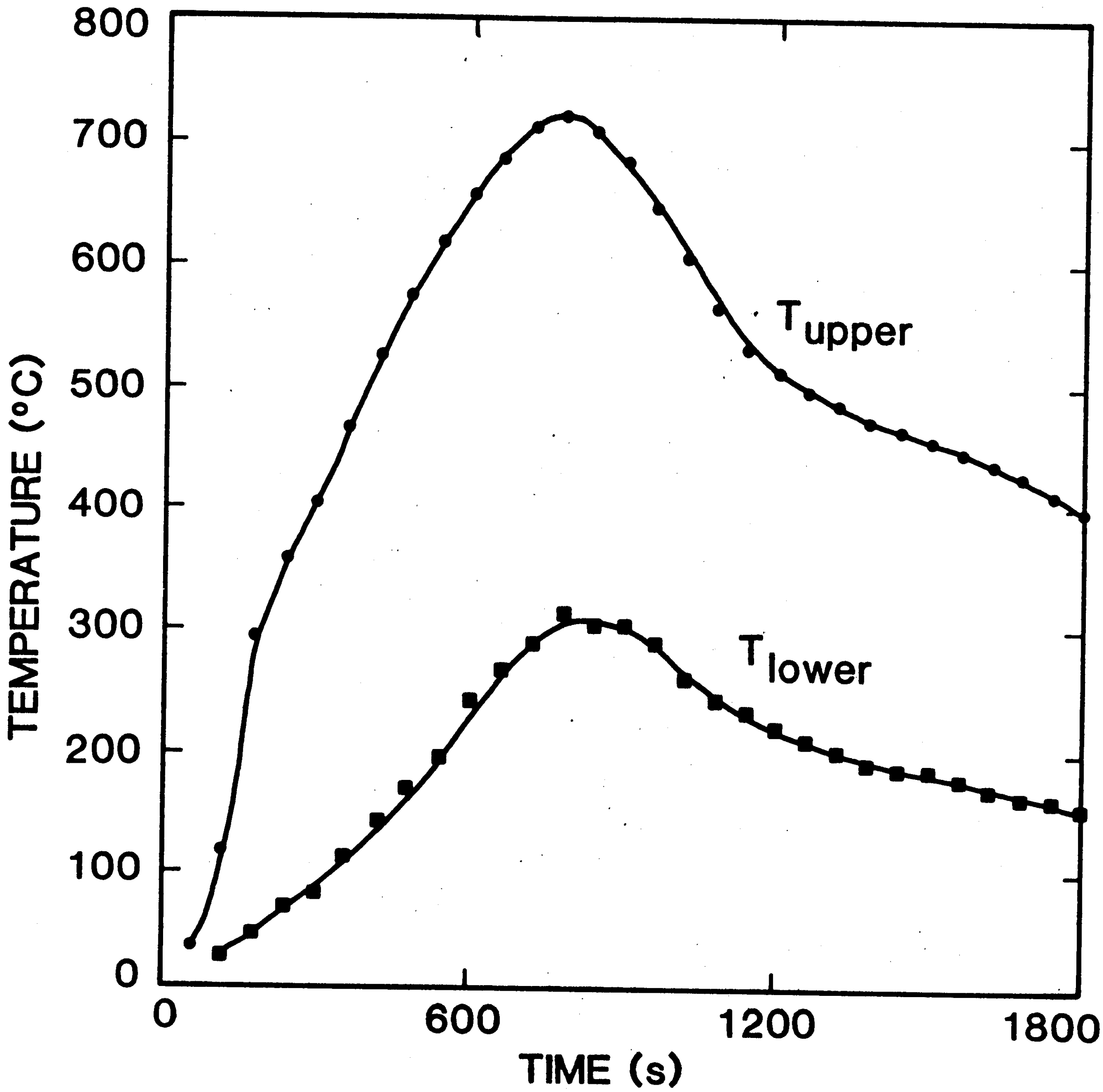


Figure 36. Upper and Lower Layer Average Temperature

Test Number 2

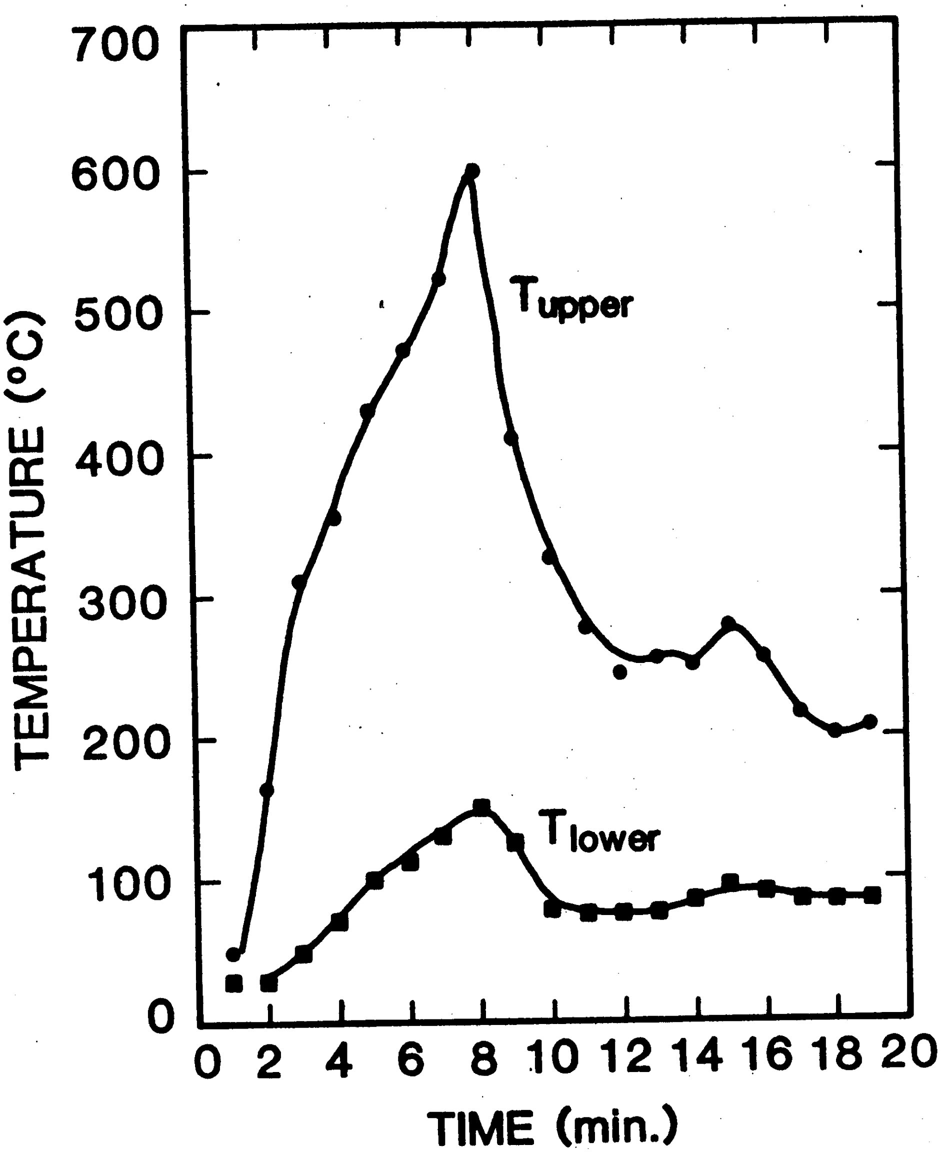


Figure 37. Upper and Lower Layer
Average Temperature
Test Number 3

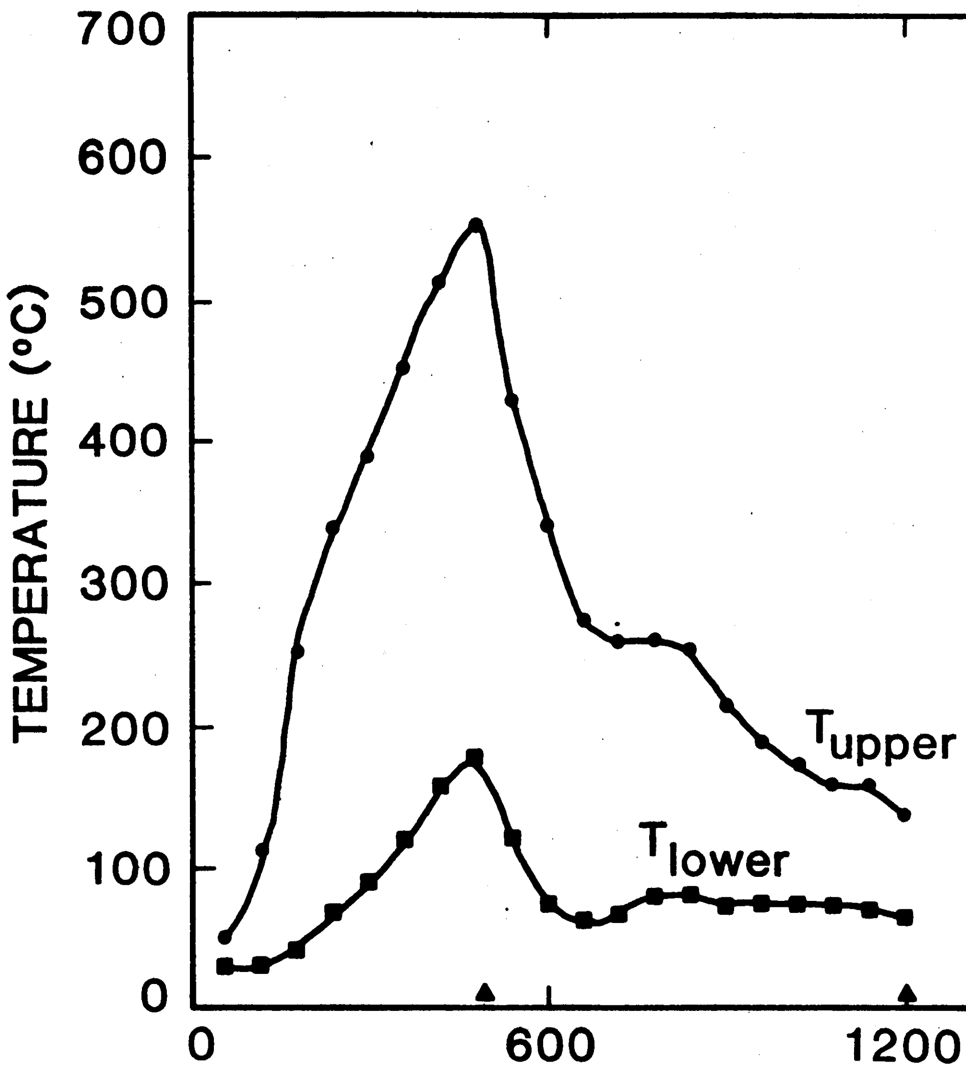


Figure 38. Upper and Lower Layer Average Temperature

Test Number 4

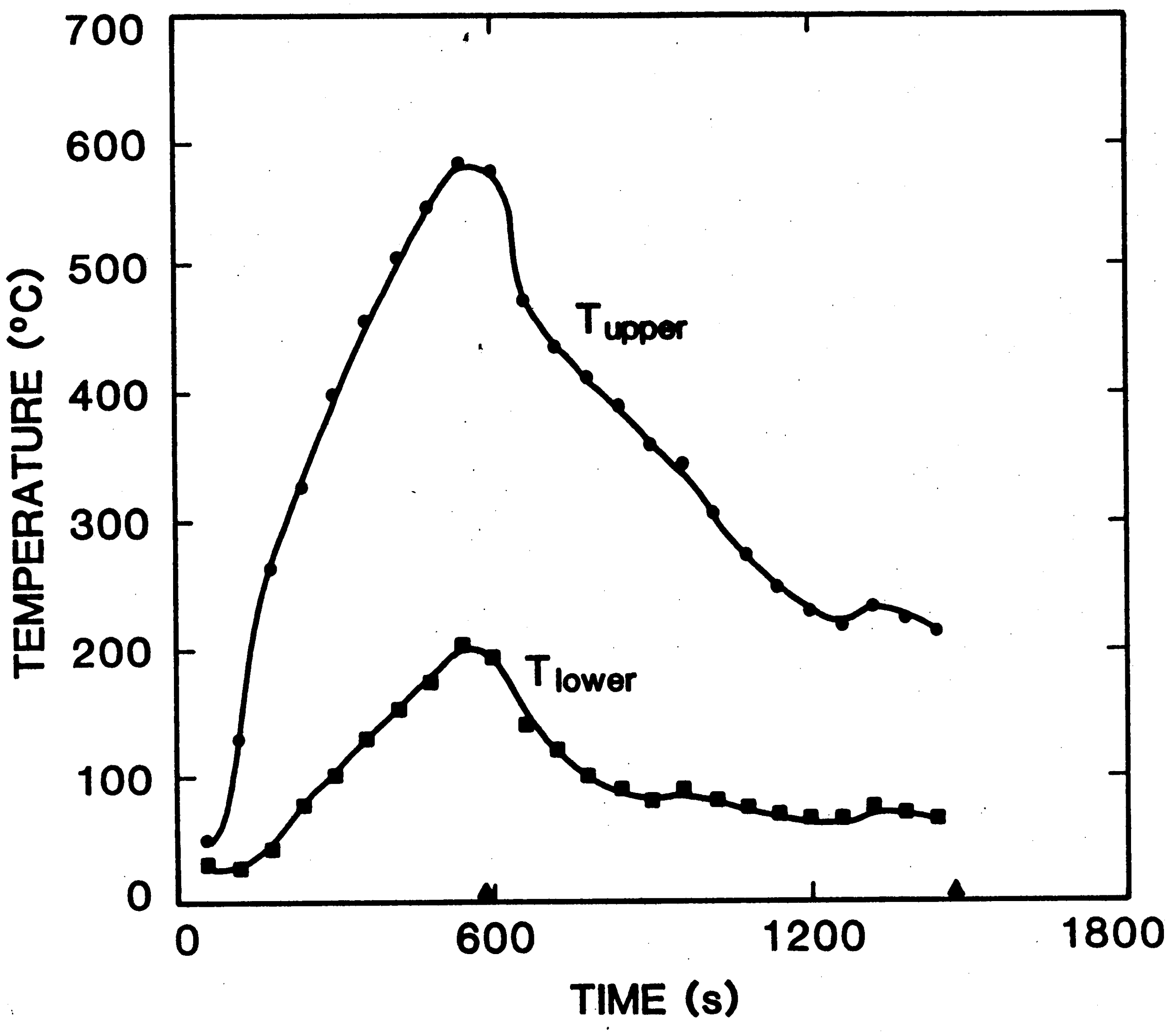
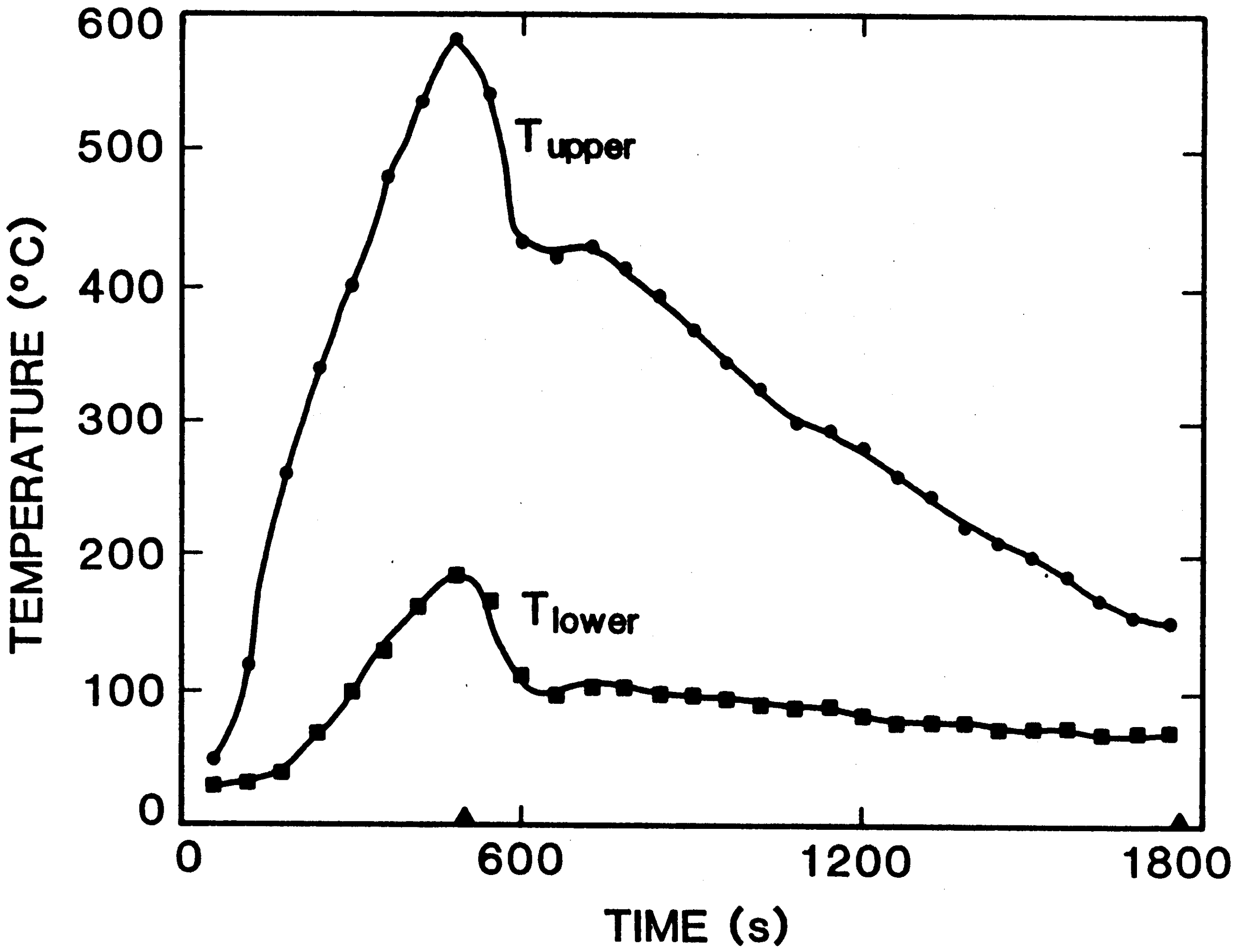


Figure 39. Upper and Lower Layer Average Temperature

Test Number 5



DISTRIBUTION LIST

1 copy unless otherwise noted

Federal Emergency Management Agency
Attn: Henry Tovey - Room 619
Emergency Management Research Division
Office of Civil Preparedness
National Preparedness Programs Directorate
Washington, D.C. 20472 (43 copies)

Federal Emergency Management Agency
Attn: Chief, Emergency Management Research Div. Rm. 619
Office of Civil Preparedness
National Preparedness Programs Directorate
Washington, D. C. 20472 (3 copies)

National Emergency Training Center
Attn: Learning Resource Center - Building N
Federal Emergency Management Agency
16825 South Seton Avenue
Emmitsburg, MD 21727 (2)

Defense Technical Information Center (DTIC)
Cameron Station
Alexandria, VA 22314 (12 copies)

Oak Ridge National Laboratory
Attn: Emergency Technology Division Librarian
Post Office Box X
Oak Ridge, TN 37830

Los Alamos Scientific Laboratory
Attn: Document Library
Los Alamos, NM 87544

The RAND Corporation
Attn: Document Library
1700 Main Street
Santa Monica, CA 90406

Assistant Director
Energy and Natural Resources
Office of Science and Technology Policy
Executive Office Building
Washington, D. C. 20500

Assistant Secretary of the Army (RD&A)
Attn: Deputy ASA for (RD&S)
Washington, D.C. 20310

Chief of Engineers
Department of the Army
Attn: DAEN-RDZ-A
Washington, D.C. 20314

U.S. Army Training and Doctrine Command
Fort Monroe
Hampton, VA 23651

U.S. Army Combined Arms Combat
Development Activity
Fort Leavensworth, KA 66027

Air Force Weapons Laboratory
Attn: SUL Technical Library
Kirtland Air Force Base
Albuquerque, NM 87117

Air Force Weapons Laboratory
Attn: Civil Engineering Division
Kirtland Air Force Base
Albuquerque, NM 87117

Director, U.S. Army Ballistic
Research Laboratory
Attn: Document Library
Aberdeen Proving Ground, MD 21006

Director, U.S. Army Ballistic
Research Laboratory
Attn: Mr. William Taylor
Aberdeen Proving Grounds, MD 21005 (2 copies)

Director, U.S. Army Engineer
Waterways Experiment Station
Attn: Document Library
P.O. Box 631
Vicksburg, MS 39180

Director, U.S. Army Engineer Waterways
Experiment Station
Attn: Mr. W. L. Huff
P.O. Box 631
Vicksburg, MS 39180

Civil Engineering Center/AF/PRECET
Wright Patterson Air Force Base, OH 45433

Mr. Carl Wiehle
Defense Intelligence Agency
Attn: WDB-4C2
Washington, D.C. 20301

Director
Defense Nuclear Agency
Attn: Michael Frankel
Washington, D.C. 20305

Director
Defense Nuclear Agency
Attn: Lt. Col. David H. Thomas, USAF
Washington, D.C. 20305

Command and Control Technical Center
Department of Defense
The Pentagon
Washington, D.C. 20301

Oak Ridge National Laboratory
Attn: Emergency Technology Division
Librarian
P.O. Box X
Oak Ridge, TN 37830

Dr. Conrad Chester
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Dr. Lewis V. Spencer
National Bureau of Standards
Center for Radiation Research
Building 245 - Room C-313
Washington, D.C. 20234

Director
Department of Military Application
Department of Energy
Washington, D.C. 20545

Director, Army Materials and Mechanics
Research Center
Attn: Technical Library
Watertown, MA 02172

National Council on Radiation
Protection and Measurements
7910 Woodmont Avenue
Bethesda, MD 20014

Director
Lovelace Foundation
5200 Gibson Boulevard, S.E.
Albuquerque, NM 87108

Dr. Forman Williams
Department of the Aerospace and
Engineering Sciences
University of California San Diego
La Jolla, CA 03027

Mr. Joseph Minor
Texas Technological College
Lubbock, TX 79408

Mr. Robert Fristrom
Johns Hopkins Applied Physics
Laboratory
Johns Hopkins Road
Laurel, MD 20707

Chief, Robert G. Purington
Lawrence Livermore Laboratories
Laboratory
University of California
P.O. Box 808 - L-519
Livermore, CA 94550

Dr. Clarence R. Mehl
Sandia National Laboratories
Division 7112
P.O. Box 5800
Albuquerque, NM 87185

Mr. Donald Drzewiecki
Calspan Corporation
P.O. Box 400
Buffalow, NY 14225

Mr. Richard Laurino
Center for Planning and Research
2483 East Bayshore, Suite 104
Palo Alto, CA 94303

Mr. John Rempel
Center for Planning and Research
2483 East Bayshore, Suite 104
Palo Alto, CA 94303

Mr. Walmer E. Strope
Center for Planning and Research, Inc.
5600 Columbia Pike, Suite 101
Bailey's Crossroads, VA 22041

The Dikewood Corporation
1613 University Boulevard, N.E.
Albuquerque, NM 87101

Hudson Institute
Quaker Ridge Road
Croton-on-Hudson, NY 10520

Dr. Anatole Longinow
IIT Research Institute
10 West 35th Street
Chicago, IL 60616

Mr. Thomas Watermann
IIT Research Institute
10 West 35th Street
Chicago, IL 60616 (2 copies)

Mr. Leo A. Schmidt
Institute for Defense Analyses
Program Analysis Division
1801 N. Beauregard Street
Alexandria, VA 22311

Dr. Donald Sachs
Kaman Sciences Corp.
1911 Jefferson Davis Highway
Arlington, VA 22202

Mr. Peter S. Hughes
Los Alamos Technical Associates, Inc.
P.O. Box 410
Los Alamos, NM 87544 (2 copies)

Mr. Laurence Pietrzak
Mission Research Corporation
P.O. Drawer 719
Santa Barbara, CA 93102

Mr. Fred Sauer
Physics International Company
2700 Merced Street
San Leandro, CA 94577

Dr. Dennis Holliday
R&D Associates
P.O. Box 9695
Marina del Ray, CA 90291

Mr. Edward L. Hill
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

Mr. Harvey G. Ryland
Ryland Research, Inc.
5266 Hollister Avenue, Suite 324
Santa Barbara, CA 93111

Dr. Jana Backovsky
SRI International
Menlo Park, CA 94025

Mr. Dick Foster
SRI International
1611 Kent Street
Arlington, VA 22209

Mr. Marvin Drake
Science Applications, Inc.
1200 Prospect Street
La Jolla, CA 92037

Mr. C. Wilton
Scientific Service, Inc.
517 East Bayshore Drive
Redwood City, CA 94060 (2 copies)

Technology & Management Consultants
330 Washington Street
Suite 613
Marina del Ray, CA 90291

Dr. Don Scheuch
430 Golden Oak Drive
Portola Valley, CA 94025

Brigadier I.G.C. Gilmore
Director, Australian Counter Disaster College
Mount Macedon, Victoria 3441
Australia

Secretaire d'Administration
Ministere de l'Interieu
Direction Generale de la
Protection Civile
Rue de Louvain, 1
1000 Brussells
Belgium

Canadian Defence Research Staff
Attn: Dr. K. N. Ackles
2450 Massachusetts Avenue, N.W.
Washington, D.C. 20008 (2 copies)

The Head of
Civilforsvarsstyrelsen
Stockholmsgade 27
2100 Copenhagen 0
Denmark

Direction de la Securite Civile
Ministere de l'Interieur
18 Rue Ernest Cognac
92 Levallois (Paris)
France

Bundesministerium des Innern
Graurheindorfer Strasse 198
5300 Bonn 1
West Germany

Ministry of Social Services
11 Spartis Street
Athens
Greece

Office of Civil Defence
Almannavarnir Skirfstofa
Reykjavik
Iceland

Santo Maggiore Difesa Civile
Centro Studi Difesa Civile
Rome
Italy

Civil Emergency Planning Directorate
North Atlantic Treaty Organization
1110 NATO
Belgium

Jefe, Seccion de Estudios y Planification
c/Evaristo San Miguel, 8
Madrid-8
Spain

Ministero dell Interno
Direzione Generale della
Protezione Civile
00100 Rome
Italy

Directeur de la Protection Civile
Ministere de l'interieur
36 Rue J.B. Esch
Grande-Duche de
Luxembourg

Directeur Organisatie
Bescherming Bevoling
Ministry of Interior
Schedeldoekshaven 200
Postbus 20011
2500 The Hague
Netherlands

The Head of Sivilforsvaret
Sandakerveien 12
Postboks 8136
Oslo-dep
Oslo 1
Norway

Servico National de
Proteccao Civil
Rua Bela Vista a Lapa, 57
1200 Lisbon
Portugal

Civil Defense Administration
Ministry of Interior
Ankara
Turkey

Home Office
Scientific Research and
Development Branch
Home Defense Research Section
Horseferry House
Dean Ryle Street
London SWIP 2AW
England

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

UNCLASSIFIED

National Bureau of Standards
Department of Commerce
Gaithersburg, MD 20899

January 1985

pages 53

FR 3956

Abstract: A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a fully-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for
(over)

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

UNCLASSIFIED

National Bureau of Standards
Department of Commerce
Gaithersburg, MD 20899

January 1985

pages 53

FR 3956

Abstract: A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a fully-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for
(over)

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

UNCLASSIFIED

National Bureau of Standards
Department of Commerce
Gaithersburg, MD 20899

January 1985

pages 53

FR 3956

Abstract: A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a fully-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for
(over)

WATER SPRAY SUPPRESSION OF FULLY-DEVELOPED WOOD CRIB FIRES IN A COMPARTMENT

UNCLASSIFIED

National Bureau of Standards
Department of Commerce
Gaithersburg, MD 20899

January 1985

pages 53

FR 3056

Abstract: A series of five experiments examining the effects of a simulated fire fighting water spray introduced into a full-developed compartment fire were conducted for the Federal Emergency Management Agency by the Center for
(over)

Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model. The results illustrate the dynamics of compartment fire suppression using water sprays.

Key Words: Crib fires; extinguishment; firefighting; room fires; sprinklers; water spray

Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model. The results illustrate the dynamics of compartment fire suppression using water sprays.

Key Words: Crib fires; extinguishment; firefighting; room fires; sprinklers; water spray

Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model. The results illustrate the dynamics of compartment fire suppression using water sprays.

Key Words: Crib fires; extinguishment; firefighting; room fires; sprinklers; water spray

Fire Research at the National Bureau of Standards per Interagency Agreement (EMW-E-1239 Task Order 4A). Data from these tests were intended to be used as a check of predicted results from the Mission Research Corporation Fire Demand Model. The results illustrate the dynamics of compartment fire suppression using water sprays.

Key Words: Crib fires; extinguishment; firefighting; room fires; sprinklers; water spray