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MEMORANDUM REPORT NO. 1894

AIR BLAST PARAMETERS FROM SUMMER AND WINTER 20-TON TNT EXPLOSIONS, OPERATION DISTANT PLAIN, EVENTS 3 AND 5

by

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Louis Giglio-Tos
George D. Teel
Daniel P. LeFevre

November 1967

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U. S. ARMY MATERIEL COMMAND
BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

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Terminal Ballistics Laboratory

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A B E R D E E N   P R O V I N G   G R O U N D,   M A R Y L A N D

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

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REReisler/LGiglio-Tos/GDTeel/
DPLeFevre/sjw
Aberdeen Proving Ground, Md.
November 1967

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ABSTRACT

Air blast was measured from the detonation of two 20-ton spherical TNT charges positioned with the center of gravity at the air-ground interface. The detonation occurred in an area having a silty-clay alluvium composition. One charge was fired in the summer and the other was fired in the winter when the ground was frozen. Strain-type pressure transducers with magnetic tape recording systems and mechanical self-recording gages were used to record the air blast parameters.

Differences in the air blast phenomena occurred in the pressure region greater than 200 pounds per square inch. These differences were manifested by a lower pressure under winter conditions than under summer conditions. No major differences were observed in the parameters of positive phase duration, positive phase impulse, dynamic pressure, and dynamic pressure impulse.

The data agree well with the modifications made to existing height-of-burst charts made after a similar test series at the Nevada test site in 1964 to show less reduction in overpressure for a charge on the surface.

TABLE OF CONTENTS

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LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

1. INTRODUCTION

During the years 1966 and 1967, The Technical Cooperation Panel (TTCP) N-2 sponsored a series of shock and blast experiments designated Operation Distant Plain. These experiments were conducted at the Defence Research Establishment Suffield (DRES), Ralston, Alberta and at a site near Hinton, Alberta, Canada. Two events in the series of experiments at DRES provided an opportunity for a comparison of air blast produced in the summer with that produced in a winter environment using the same charge design. The summer event was designated Event 3 in the Distant Plain series; the winter event was called Event 5.

A 20-ton TNT charge stacked in the shape of a sphere with its center in the plane of the air-ground interface was used. The charge was built up of specially cast TNT blocks approximately 12 x 12 x 4 inches weighing 33 pounds each. The ground at the site of the explosions had a silty-clay alluvium composition.

1.1 Objectives

The objectives of the Ballistic Research Laboratories (BRL) in Operation Distant Plain, Events 3 and 5, were to measure air blast parameters and to examine the effects produced by the difference in environmental conditions. Comparisons with data obtained on related past experiments were to be performed.

1.2 Background

In 1963 a series of three 20-ton TNT explosion experiments known as Operation Flat Top were carried out at the Nevada Test Site (NTS). The charges used in those experiments were built in the shape of a sphere with its center located in the plane of the air-ground interface. Soil was tamped around the base of the charge to a compaction comparable to that of the undisturbed surrounding soil. Flat Top Events II and III were detonated in a desert, dry lake-bed alluvium; Flat Top Event I was fired in limestone rock. Prior to Operation Flat Top very few large spherical charges had been fired with this configuration. The data provided by the

Flat Top experiments indicated that the existing height-of-burst charts for predicting overpressure should be modified; that is, to show less reduction in overpressure for a charge on the surface.[1*] The results from Operation Flat Top contributed to our knowledge of blast in the high pressure region, but also indicated the need for further measurements as close to the charge as possible. Such data would be especially valuable for comparison with detailed computer calculations of TNT explosions.

Events 3 and 5 of Operation Distant Plain were intended to duplicate the charge configuration, position, and weight of the Flat Top explosions in the alluvium of DRES, and to provide data on cratering, ground shock, and air blast. The choice of the Canadian site made it possible to conduct experiments where differences between winter and summer environmental conditions are large. In addition, considerable data on cratering, ground shock, and air blast have been obtained at DRES for hemispherical charges ranging in size from 5 to 500 tons; these data would be useful in interpreting the Distant Plain results.

The experimental results from the Flat Top series were used to make predictions of the air-blast parameters for Distant Plain Events 3 and 5.

2. EXPERIMENT DESIGN AND INSTRUMENTATION

2.1 Experimental Plan

The Drowning Ford range at DRES was chosen as the site for the summer and winter shots, Events 3 and 5 respectively. The soil composition of this area is a silty-clay alluvium. The voids between the earth and the charge were filled with silty-clay soil and the ground tamped to restore the pre-disturbance density and moisture content. The layout was planned so that the same recording bunker and "feeder cable" trenches could be used for both these events as well as Event 1 of the series, Figure 2.1. All of the instrument mounts and cabling for the events were installed prior to firing of the first shot in the area. Blast-line

Superscript number denotes references which may be found on page 71.

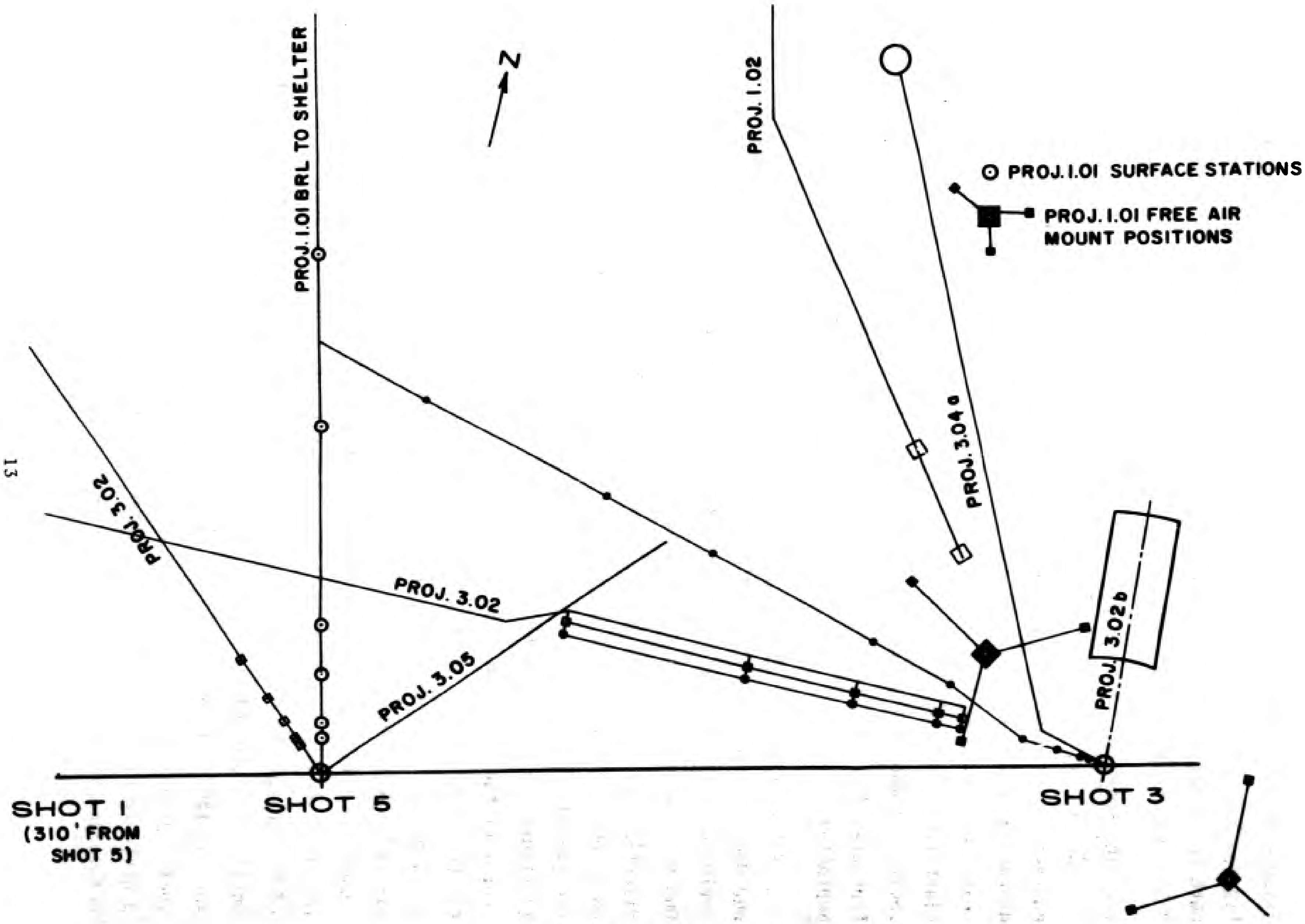

Figure 2.1 Field layout

layouts of the instrumentation for the two events are presented in Figures 2.2 and 2.3, and photographs of typical instrument stations for both the summer and winter shots are presented in Figure 2.4. Figure 2.5 shows the first 100 feet of the blast line for Event 3.

2.2 Instrumentation

2.2.1 Surface Sensor System. The sensors and mounts used for the surface measurements of overpressure, dynamic pressure, and drag are discussed in Reference 2. Self-recording gages were used to both supplement the electronic transducers at certain positions and to extend the blast line into the low pressure region. Magnetic tape recorders of commercial manufacture recorded the signal from the transducers. Strain-type transducer systems comprised the majority of the sensing instrumentation.

2.2.2 Free-Air Sensor System. Two free-air probes were developed and deployed on Event 3 to measure the overpressure in the free-air region near the charge. A suspended cable system positioned these probes. One vertical probe containing three instrument positions was located directly over the charge; and a second probe containing one instrument position was located on a radius at a 45 degree angle with respect to the ground. A scaled model of the probes and the support system is shown in Figure 2.6. Instrument stations were at 10, 20, and 35 feet from the center of the charge on the vertical probe and at 20 feet from the center of the charge on the 45 degree probe. The probes were fabricated in sections of 3-inch diameter aluminum tubing and assembled as they were erected. A pulley and cable guying system was used to align and guy the probes. A manually operated release system provided for the release of the displaced vertical probe to its vertical position after evacuation of the area. The displacement of the probe was required by the test range until after the charge was armed. Two 85-foot wooden support poles were located 180 degrees with respect to each other at a ground range of 65 feet. Signal cables, protected by flexible metal conduit, were kept at a distance of 65 feet from the charge to allow for signal transmission before the shock would strike the cables.

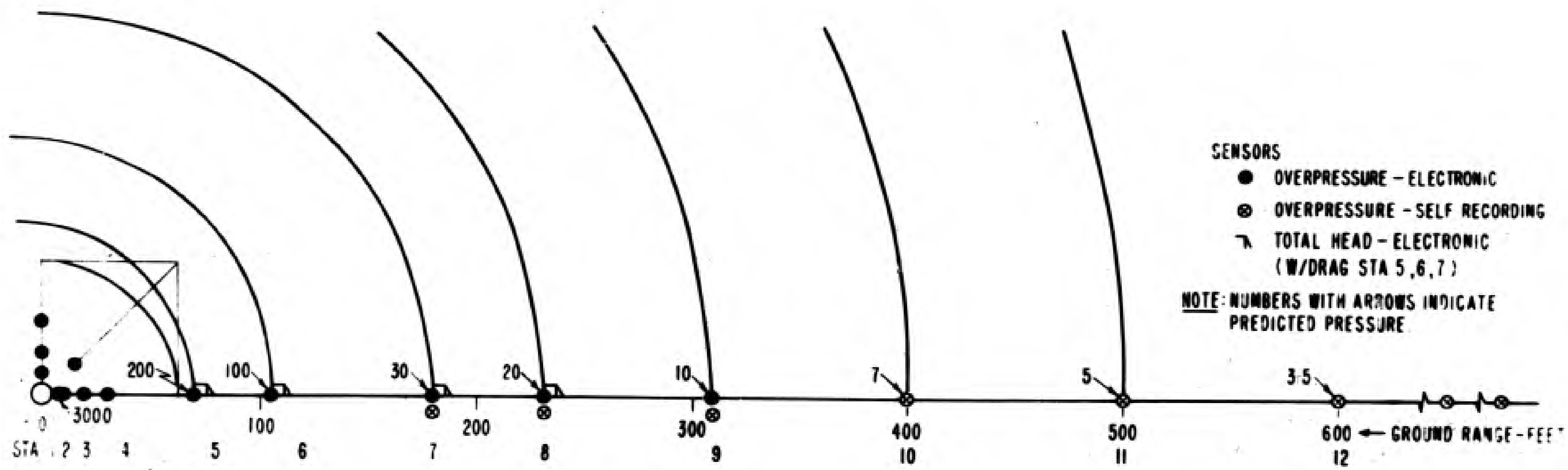

Figure 2.2 Blast line layout, Event 3.

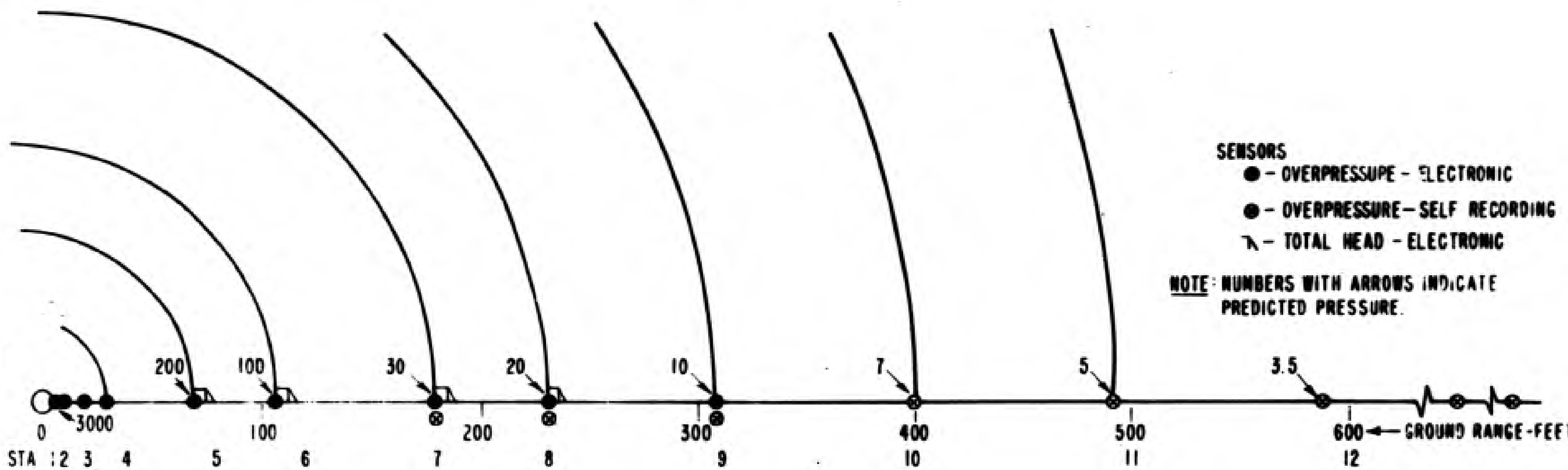

Figure 2.3 Blast line layout, Event 5

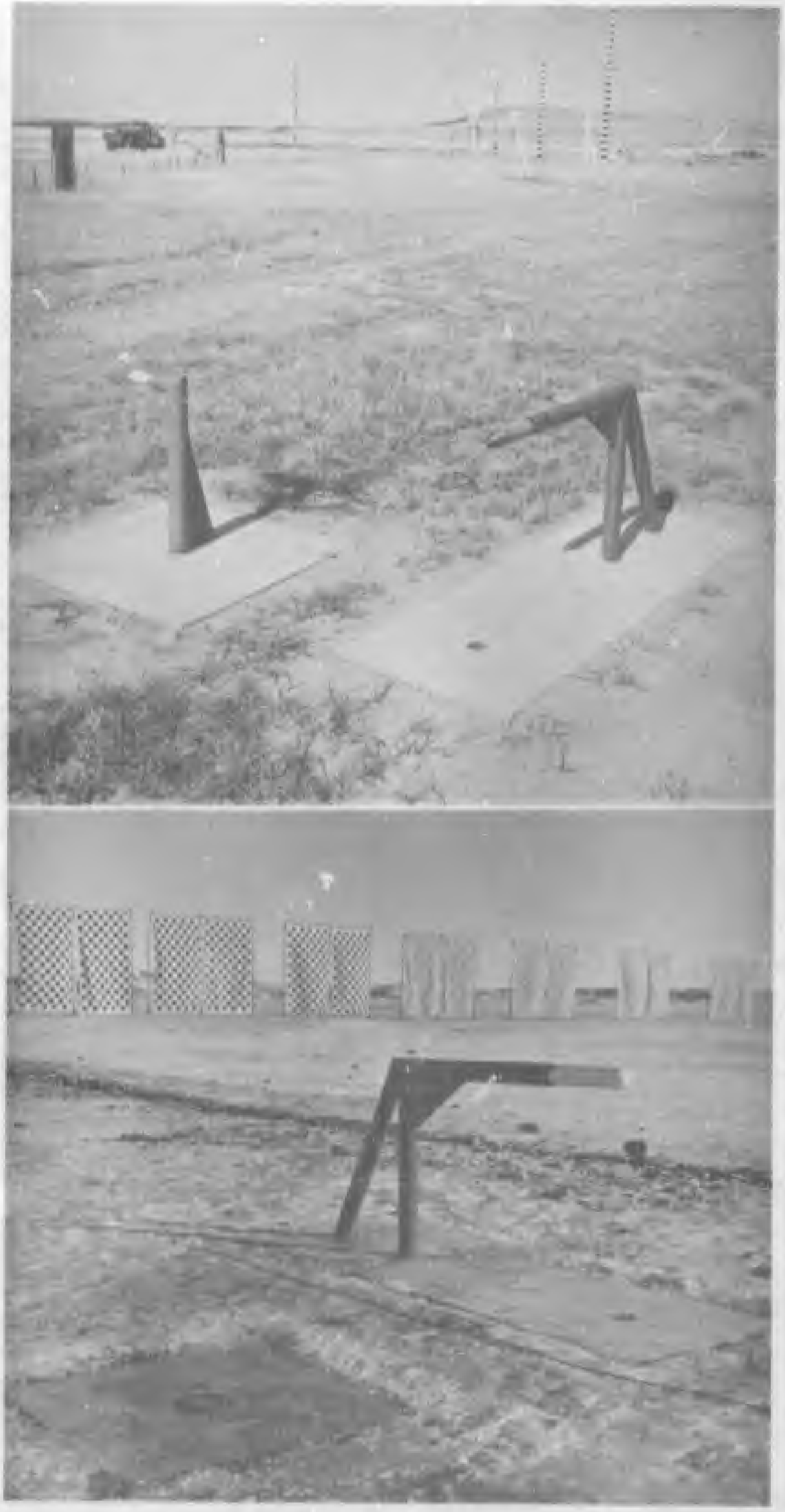

Figure 2.4 Typical instrument stations, summer and winter.

Figure 2.5 Blast line, Event 3

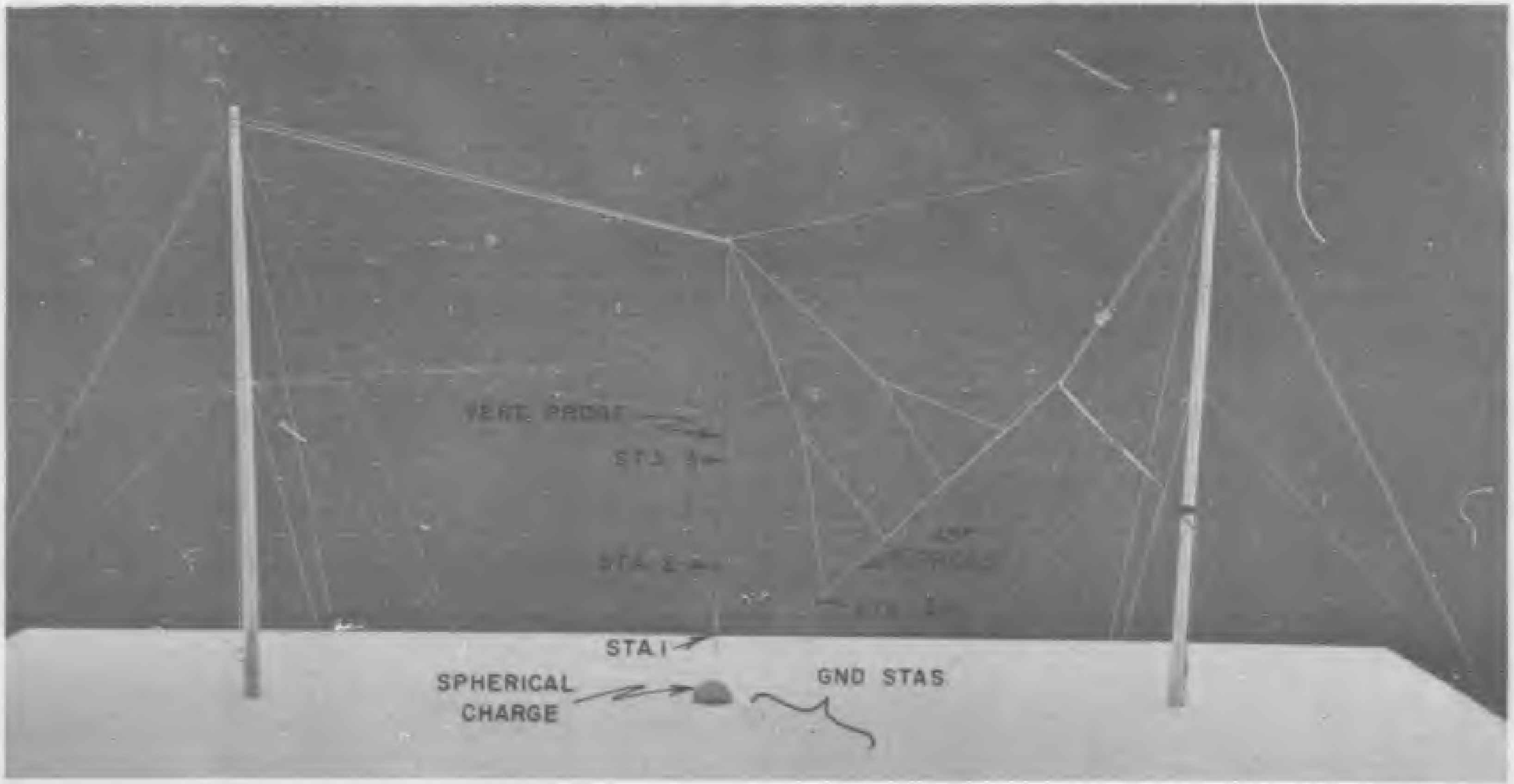

Figure 2.6 Model of free-air probe system

Transducers placed on the probes at each station were of two types. Piezoelectric gages of the bar-type, manufactured at BRL, were used to record arrival of the shock front and the maximum overpressure with its initial pressure decay. Dynisco strain-type gages complemented the piezo gages to provide the duration of the positive phase. Signals from the piezo gages were recorded by Project 3.04b, Stanford Research Institute (SRI), using single-sweep oscilloscopes backed up by raster oscilloscopes. The Dynisco gage outputs were recorded by magnetic tape recorders.

2.2.3 Gage Calibration During the Winter. During subzero temperatures in the winter, the transducers were installed with the aid of a specially equipped coach mounted on a 4 x 4, 3/4-ton truck. A portable manhole arranged in the rear floor section of the vehicle enabled project personnel to perform installation and calibration tasks in the relative comfort of a housed and heated facility. A photograph of the calibration vehicle is shown in Figure 2.7.

During the early phases of the field calibration, the temperatures stayed in the subzero range; however, a warming trend a week before the shot raised the temperatures to near 32°F. This weather change necessitated recalibration of the electronic instrumentation at above-zero temperatures. Hence, calibration data were obtained for above-zero and sub-zero firing conditions.

The method of operation for the self-recording gages was modified to permit locating the power-supply batteries for initiating the gages in the recording bunker.

3. RESULTS

3.1 Environmental Conditions

The environmental conditons prevailing at the time of detonation for each event are presented in Table 3.1. Although a snow cover of 1 to 4 inches is listed for Event 5, there were occasional small areas with no snow at all. Figures 3.1 and 3.2 show the explosions of Events 3 and 5 respectively.

Figure 2.7 Winter calibration vehicle
showing manhole and access hatch

Table 3.1 Environmental Conditions, Events 3 and 5

	Event 3 (Summer)	Event 5 (Winter)
Firing Time	28 July 66, 1245 MST	9 February 67, 1300 MST
Ambient Pressure	13.64 psi	13.51 psi
Temperature	Surface: 101.0 °F 2 meters: 84.5 °F	Surface: 33.2 °F 1.4 meters: 34.9 °F
Wind	0.6 meters: 8 mph at 220° 2 meters: 1.5 mph at 185° 8 meters: 1.3 mph at 120°	2 meters: 8.4 mph at 255° 9 meters: 10.8 mph at 255°
Relative Humidity	42 per cent	77 per cent
Sunshine	Bright	Bright
Surface Condition	Dry and Clean	1-4 in. snow and ice cover 9 in. depth of frost

Figure 3.1 Detonation of Event 3

Figure 3.2 Detonation of Event 5

3.2 Instrumentation Performance

All the gages and recording systems for Event 3 functioned except for one total-head channel which failed at time zero and one self-recording gage which did not run. The surface-level gage at 7 feet provided a record of arrival time and an initial peak, and then became erratic. Surface-level records from Station 2 at 10 feet through Station 5 at 70 feet show a sharp rise and a rapid decay, with the duration increasing with distance. The record at Station 6 at 105 feet shows a slow rise. Subsequent records at Stations 7 through 9 show multiple shocks. Self-recording gages as well as total-head and drag gages also recorded multiple shocks. We believe the instrumentation faithfully recorded the unusual phenomena that were present.

The design of the probes for the free-air measurements near the charge maintained gage and cable operation long enough to record the arrival time, peak overpressure, and a part of the positive phase.

The detonation of Event 5 occurred approximately 3.52 seconds before the planned zero time. Subsequent board of inquiry studies held by Suffield personnel revealed that a combination of circumstances in the timing and firing sequencer produced a situation that fired the shot when the last safety device was removed.

The magnetic tape recorders fortunately were running at that time and good records were obtained from each station where electronic gages were located. One of the two transducers at Station 9 was covered with an inch of water which resulted from thawing after personnel had left the area. Only peak pressure records were obtained from the self-recording gages, since gage turn-on was scheduled for -2 seconds.

3.3 Method of Data Reduction

The data recorded by the magnetic tape systems was reproduced and recorded by an oscillograph with the use of a galvanometer driver. Digital data from these records was obtained by using a Gerber chart reader equipped with digital readout heads which feed electrical signals into a Telecordex Accumulator System. Self-recording records were read in a similar manner, however a microscope reader equipped with the read-out heads replaces the chart reader. The telecordex accumulator is accurate to ± 1 count. In the Gerber reader, 1 count is equivalent to 0.001 inch; with the microscope 1 count is equal to 0.025 mils. Overall reading error is considered to be less than 1 percent.

All of the digital data was reduced to pressure and time, and impulse, computed by the BRL Electronic Scientific Computer (BRLESC). A plot of the data was obtained with an automatic line plotter.

The dynamic pressure data were obtained from the side-on overpressure and total head pressure records. The records for each station were read independently and reduced, then plotted on the same axis on an expanded scale to emphasize any pecularities that were common to each record. After manually correcting for such things as total-head record spikes crossing the side-on pressure record, the two records were re-read. The BRLESC was used to process these final records and compute corrected dynamic pressure versus time, dynamic pressure impulse versus time, and Mach number versus time. The method of computation is described in Reference 3. An example of the resulting plots is shown in Figure A-5.

3.4 Presentation of Data

Air blast data for the two events are listed in Table 3.2 through Table 3.6. Maximum overpressure and positive duration were established by plotting the data on semi-logarithmic graph paper in accordance with the procedures described in Reference 4.

3.4.1 Air Blast Parameters, Event 3. Arrival time, maximum over-pressure, positive-phase duration and positive-phase impulse are shown plotted versus ground range in Figures 3.3 through 3.6; these figures also show curves constructed from predicted values. Overpressure values and arrival times of the free-air strain gages are presented with the surface measurements. Pressure-time records for this event are included in Appendix A.

Table 3.2 Instrumentation Results, Event 3

Sta. No.	Ground Range (ft)	Type Gage	Gage No.	Arrival Time (msec)	Maximum Overpressure (psi)	Positive Duration (msec)	Positive Impulse (psi-msec)
1	7	P_s*	7-2	0.36	4500		
2	10	P_s	8-6	0.56	2410	0.8	330
3	20	P_s	9-2	1.40	833	2.2	304
4	30	P_s	10 6	2.25	871	7.0	451
5	70	P_s	7-3	8.62	165	20.5	645
		P_t**	10-3	8.63			
6	105	P_s	8-5	18.32, 19.01***	110	48.0	576
		P_t	9-5	17.89, 19.13***			
7	180	P_s	9-3	46.44, 52.48***	33	64.0	420
		P_t	8-3	No Record			
		P_s	Self-Record	-	29	72.0	490
8	230	P_s	10-5	72.70, 81.01***	21	69.0	319
		P_t	7-5	71.48, 80.50***			
		P_s	Self-Record	Did Not Run			
9	310	P_s	10-2	126.46	10.0	85.0	272
		P_s	Self-Record	-	10.5	69.0	243
10	400	P_s	Self-Record	-	5.8	75.0	175
11	500	P_s	Self-Record	-	4.8	102.0	186
12	600	P_s	Self-Record	-	3.5	104.0	138
13	1000	P_s	Self Record	-	2.0	118.0	88
14	4680	P_s	Self-Record	-	0.23	220.0	22

*P_s = Overpressure

**P_t = Total-head pressure

***Time of second shock arrival.

Table 3.3 Dynamic Pressure Results, Event 3

Station No.	Ground Range (ft)	Max. Dynamic Pressure (psi)	Dynamic Pressure Impulse (psi-msec)
5	70	270	393.5
6	105	*	
7	180	No Record	
8	230	*	

* Analysis to determine dynamic pressure impossible due to multiple shocks.

Table 3.4 Results From Free-Air Instrumentation, Event 3

Sta. No.	Radial Distance (ft)	Type Gage	Gage No.	Arrival Time (msec)	Maximum Overpressure (psi)	Positive Duration (msec)	Positive Impulse (psi-msec)
Vert. 1	10	Strain	10-7	0.55	3200	-	-
		Piezo	522	0.53	2962	Good Record	
Vert. 2	20	Strain	9-7	1.19	1190	-	-
		Piezo	523	1.17	1950	Good Record	
45° 1	20	Strain	7-7	1.3	2100	-	-
		Piezo	525	1.28	1086	Fair Record	
Vert. 3	35	Strain	8-7	2.7	600	5.0	-
		Piezo	524	No Record			
Surf. 1	10	Strain	8-6	0.56	2410	0.8	330
		Piezo	526	0.52	3400	Questionable Record	
Surf. 2	20	Strain	9-2	1.40	833	2.2	304
		Piezo	527	1.56	890	Good Record	

Table 3.5 Instrumentation Results, Event 5

Sta. No.	Ground Range (ft)	Type Gage	Gage No.	Arrival Time (msec)	Max. Over-Pressure (psi)	Positive Duration (msec)	Postive Impulse (psi-msec)
1	7	P_s	2 - 3	0.20	3500	--	--
	7	P_s	3 - 4	0.19	3750	--	--
2	10	P_s	3 - 10	0.37	1400	0.85	350
3	20	P_s	2 - 9	1.03	1215	3.4	310
4	30	P_s	2 - 12	2.18	590	6.5	489
5	70	P_s	3 - 5	9.70	215	26.0	641
		P_t	2 - 4	9.67	--	--	--
6	105	P_s	3 - 9	20.2	93.5	46.3	620
		P_t	3 - 11	20.1	--	--	--
7	180	P_s	2 - 5	53.7	29.0	56.0	438
		P_s	Self-Record*	--	30.2	--	--
		P_t	3 - 6	53.5	--	--	--
8	230	P_s	3 - 3	83.2	17.5	64.8	340
		P_s	Self-Record	--	19.0	--	--
		P_t	2 - 10	83.5	--	--	--
9	310	P_s	2 - 11	137.7	10.2	77.6	258
		P_s	3 - 12	137.8	10.0	78.5	261
		P_s	Self-Record	--	10.7	--	--
10	400	P_s	Self-Record	--	7.4	--	--
11	493	P_s	Self-Record	--	5.8	--	--
12	589	P_s	Self-Record	--	4.04	--	--
13	930	P_s	Self-Record	--	1.86	--	--
14	4550	P_s	Self-Record	--	--	--	--

* All Self-Record Records Were Peak Pressures Only Due to the Detonation Prior to Scheduled Zero Time.

Table 3.6 Dynamic Pressure Results, Event 5

Station No.	Ground Range (ft)	Max. Dynamic Pressure (psi)	Dynamic Pres. Impulse (psi-msec)
5	70	340	449
6	105	103	378
7	180	16.5	152
8	230	2.9	26.4

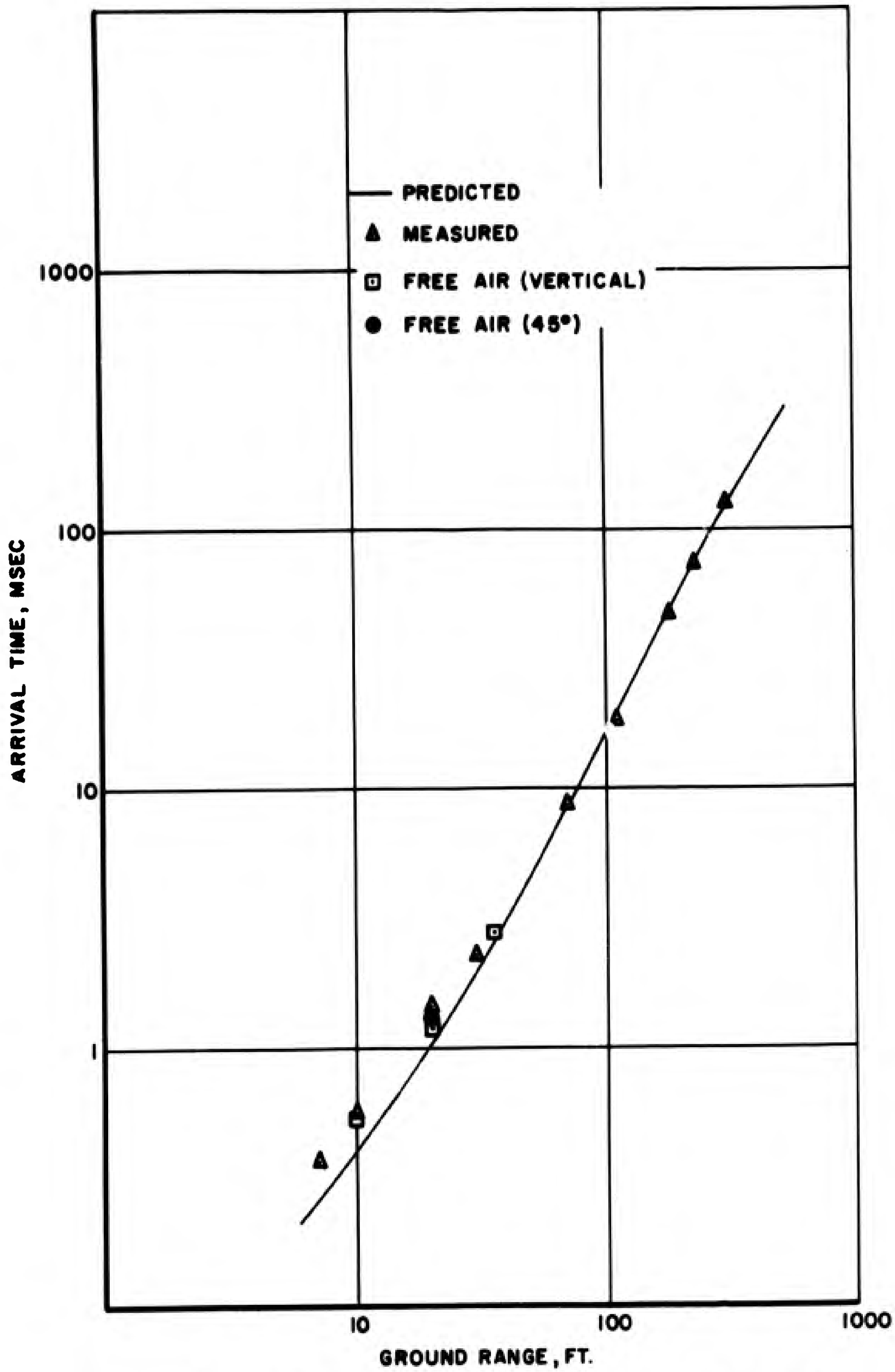

Figure 3.3 Arrival time versus ground range, Event 3

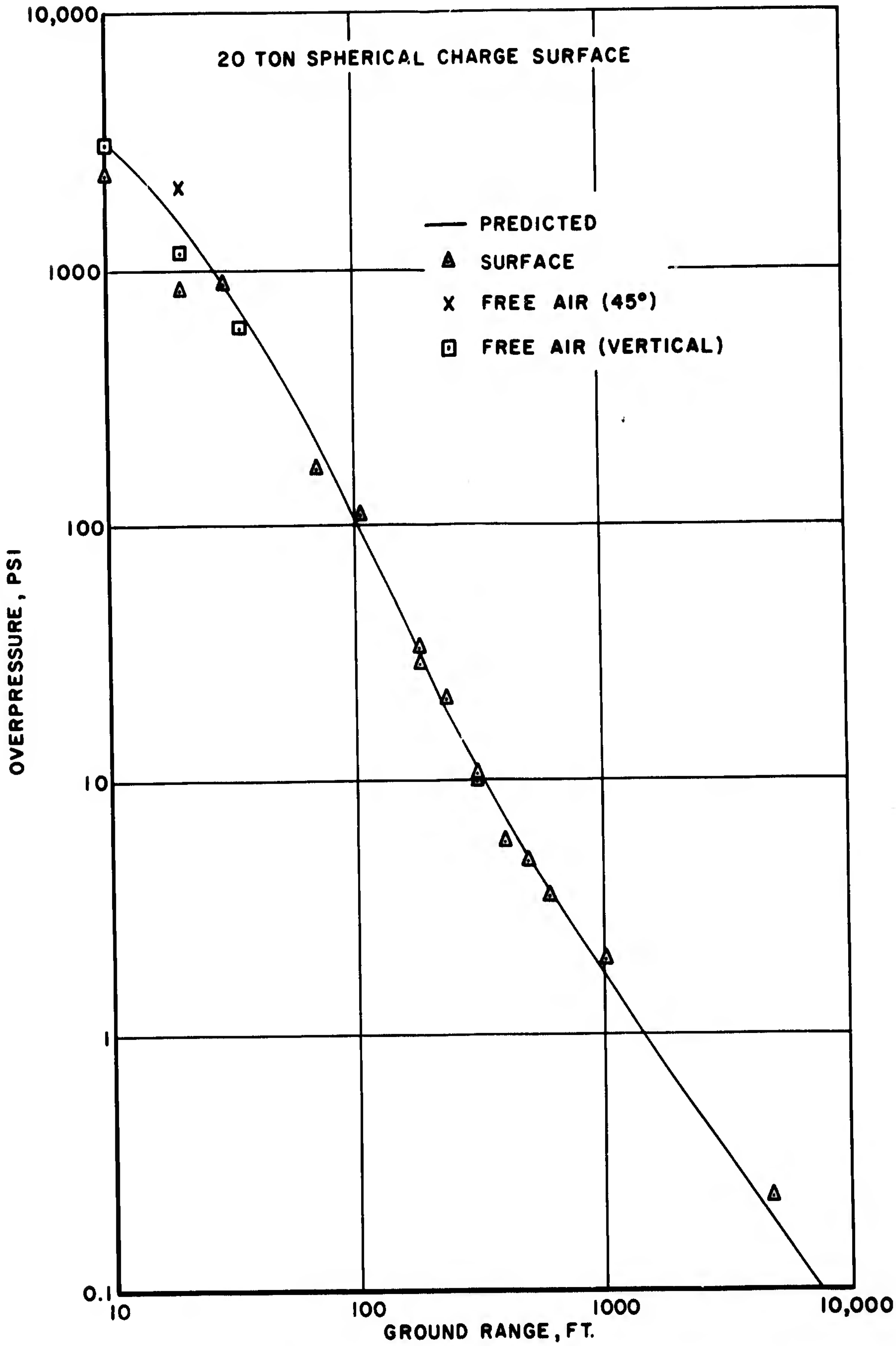

Figure 3.4 Maximum overpressure versus ground range, Event 3

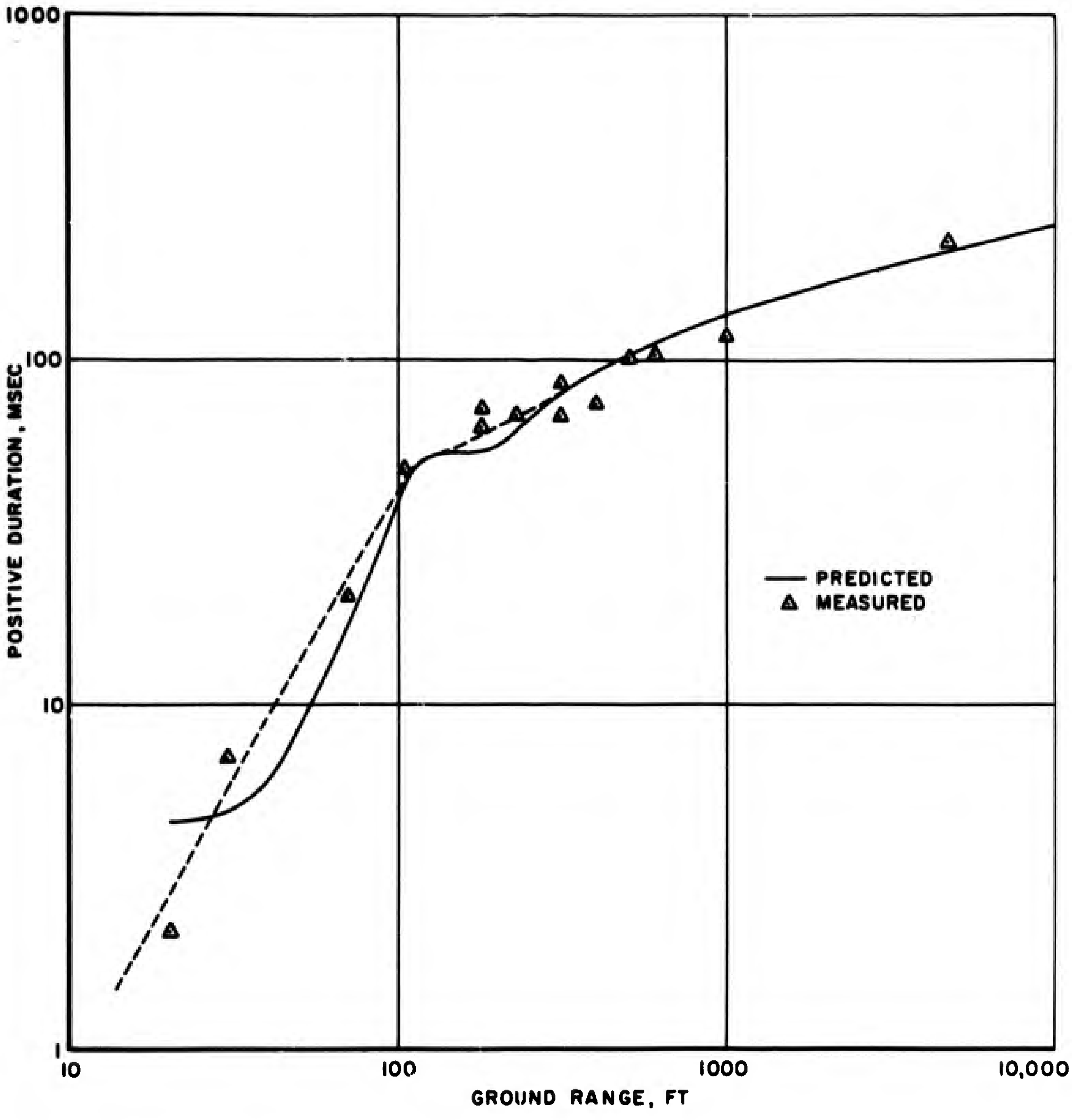

Figure 3.5 Positive phase duration versus ground range, Event 3

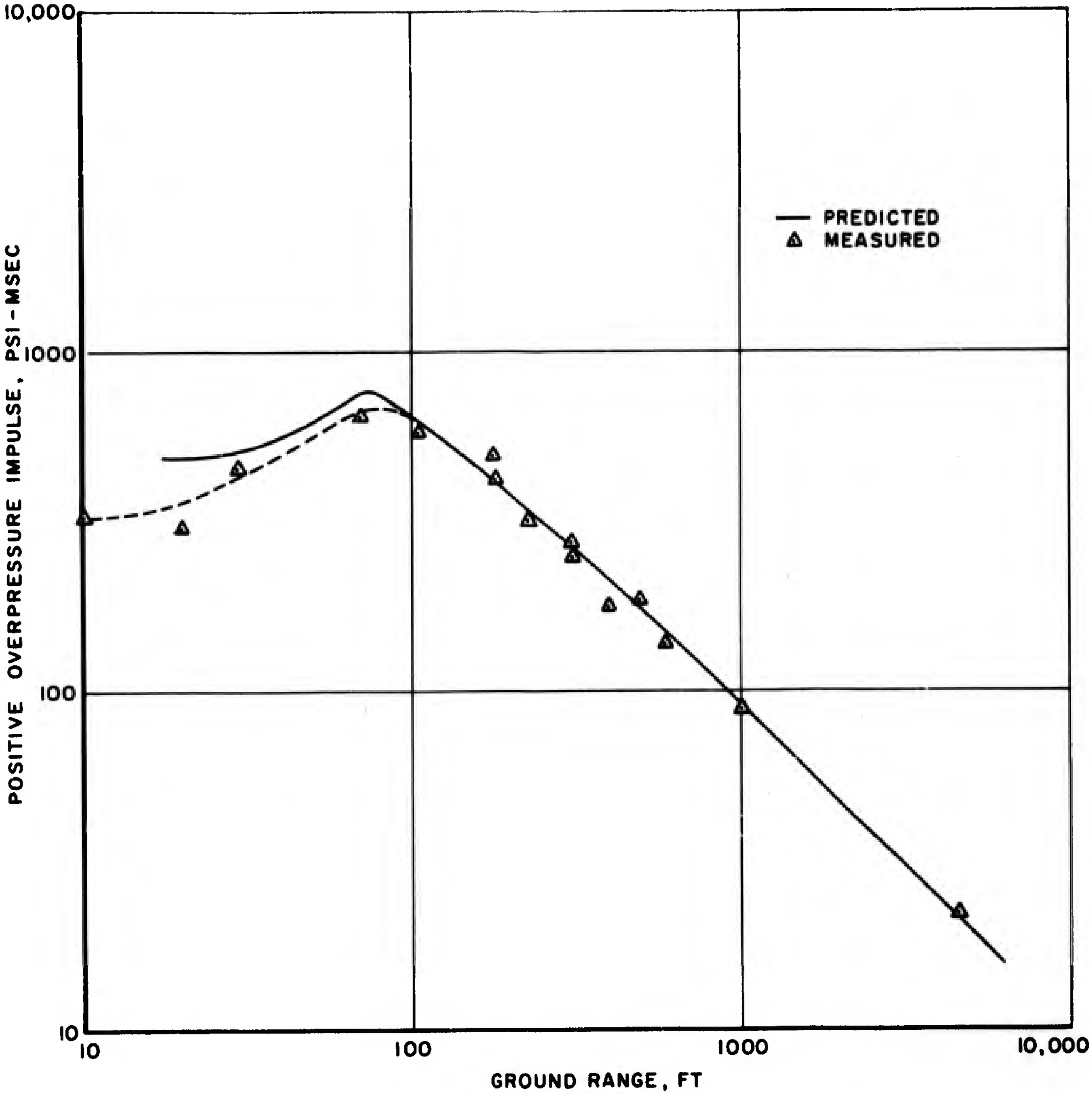

Figure 3.6 Positive Overpressure impulse versus ground range, Event 3

The unexpected multiple shocks recorded by the instrumentation may be explained by explosion details shown on the high speed photographs made by DRES. Figure 3.7 shows a bright, sharp-nosed jet emanating from the base of the fireball and proceeding ahead of the shock wave in the general direction of the gage line. A bow shock is clearly evident which makes a very sharp angle with respect to the body of the jet. As the jet moved outward, its luminous character became more diffuse and less bright, as can be seen in Figure 3.8. The bow wave traveled forward and became rounded, while the jet material appears to become smoke as if it had been a piece of burning explosive. The region behind the shock was very disturbed.

For stations experiencing multiple shocks the arrival times shown plotted in Figure 3.3 are arrival times of the first shock. For the same stations the overpressure plotted in Figure 3.4 is the maximum overpressure regardless of where it occurs in the record.

The pressure data realized from the piezoelectric transducers were in good agreement with the strain at stations 1 vertical and 2 surface. Considerable scatter was observed between the two systems for the other stations. Thermal shock and mechanical vibration undoubtedly had a deleterious effect on the piezoelectric transducers. One pressure-time record was obtained from the strain transducers. The gage was located at the 35-foot station on the vertical probe.

3.4.2 Air Blast Parameters, Event 5. The results of Event 5 are shown in Table 3.5 and Table 3.6. Arrival time, maximum overpressure, positive phase duration, positive phase impulse, dynamic pressure, and dynamic pressure impulse are plotted versus ground range in Figures 3.9 through 3.14. The records obtained were quite clean in appearance and exhibited a classical waveshape. No multiple shocks were recorded along the blast line. Pressure-time records for this event are included as Appendix B.

As noted in the table of environmental conditions, the snow and ice cover on the day of the event was rather thin and scattered and the depth of frost was shallow.

Figure 3.7 Photograph of fireball, sequence 1, Event 3

Figure 3.8 Photograph of fireball, sequence 2, Event 3

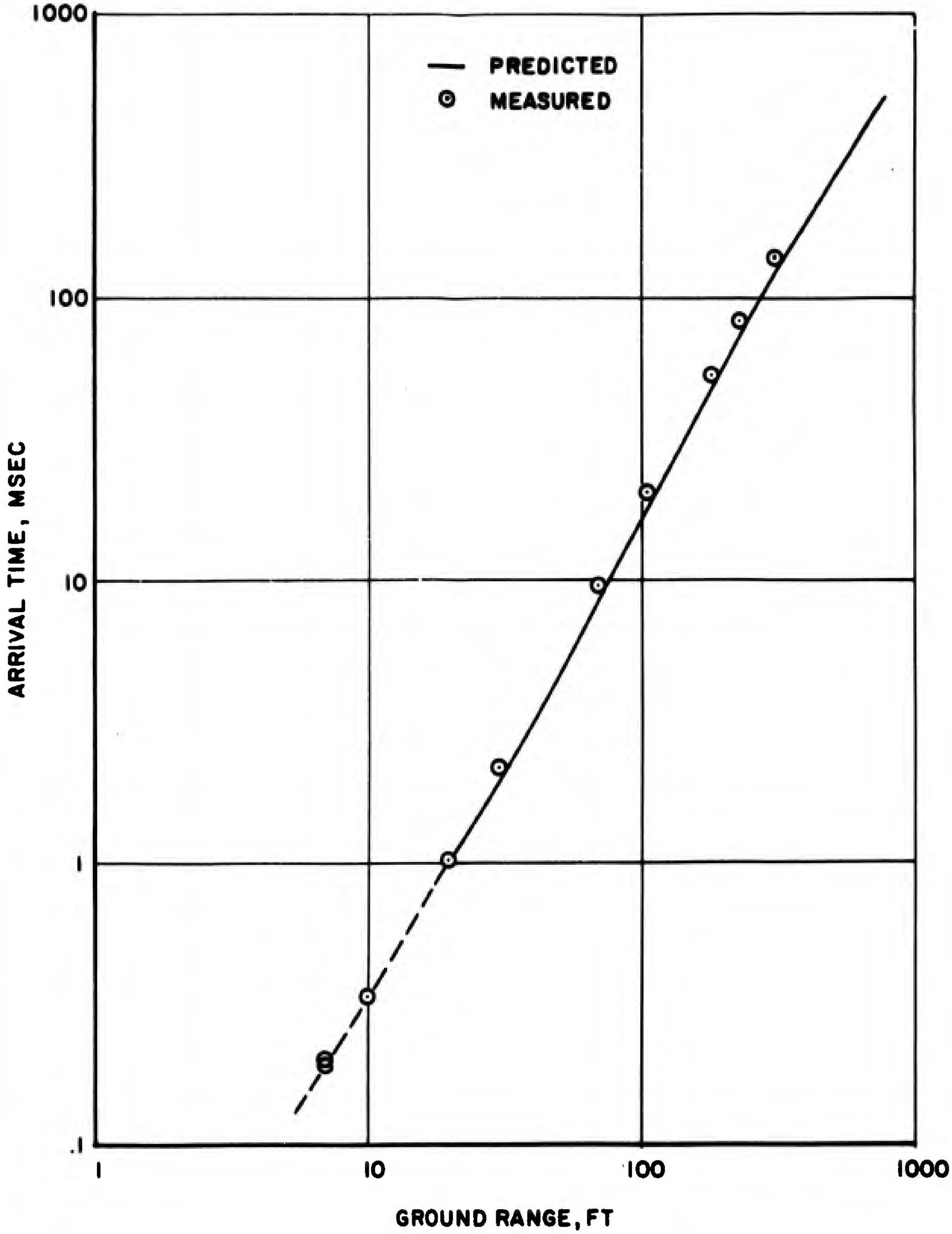

Figure 3.9 Arrival time versus ground range, Event 5

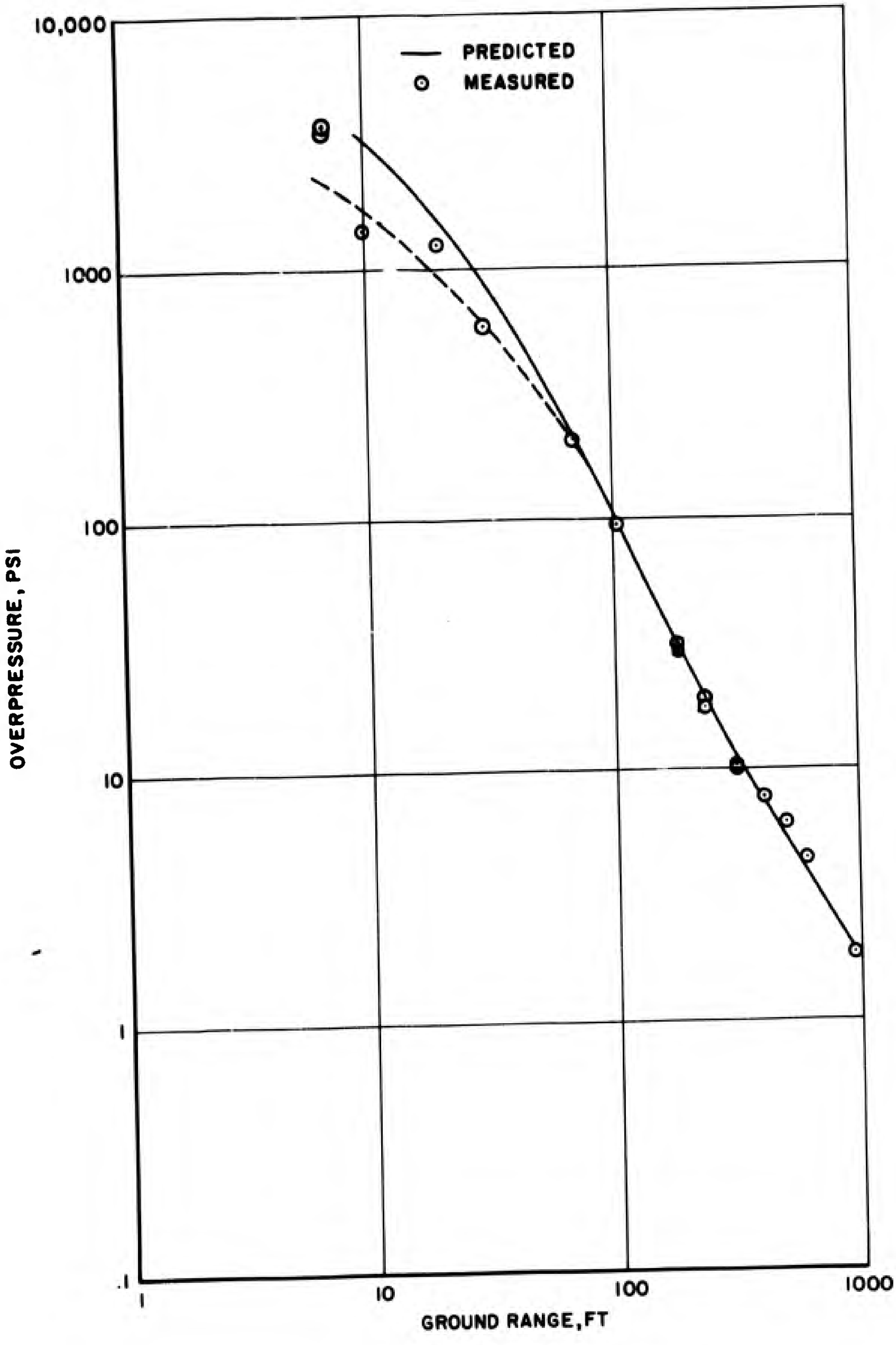

Figure 3.10 Maximum overpressure versus ground range, Event 5

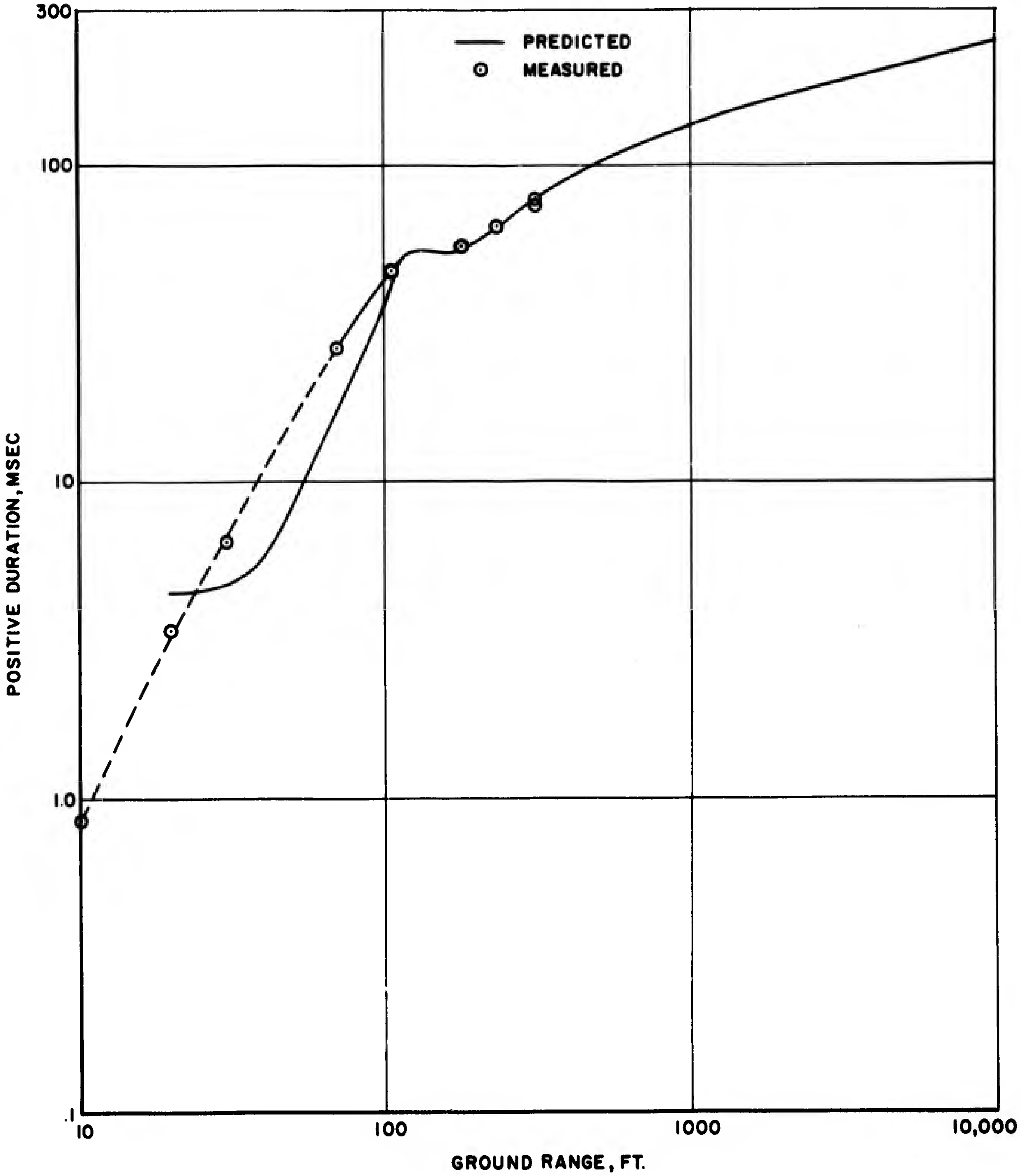

Figure 3.11 Positive phase duration versus ground range, Event 5

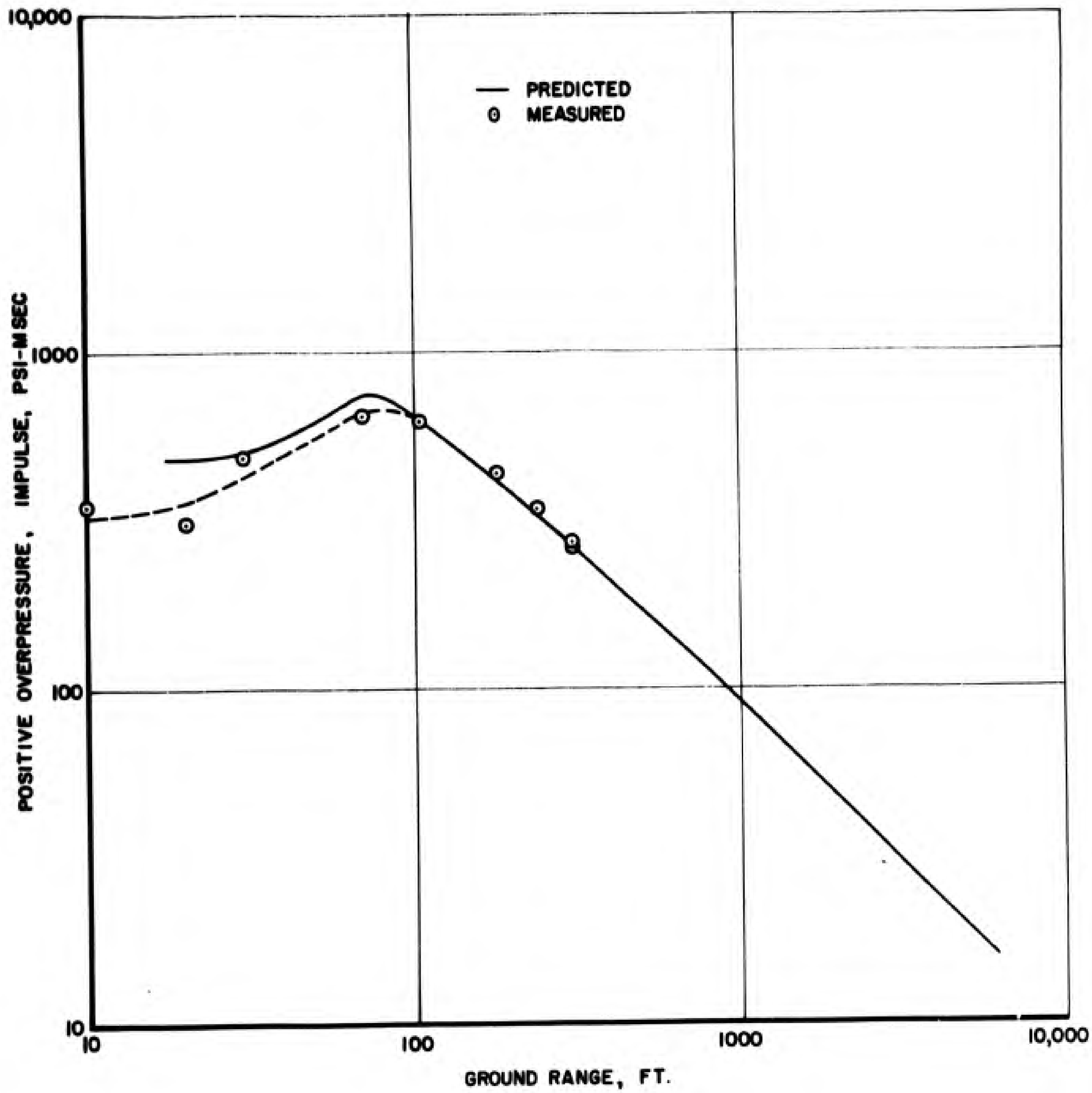

Figure 3.12 Positive Overpressure impulse versus ground range, Event 5

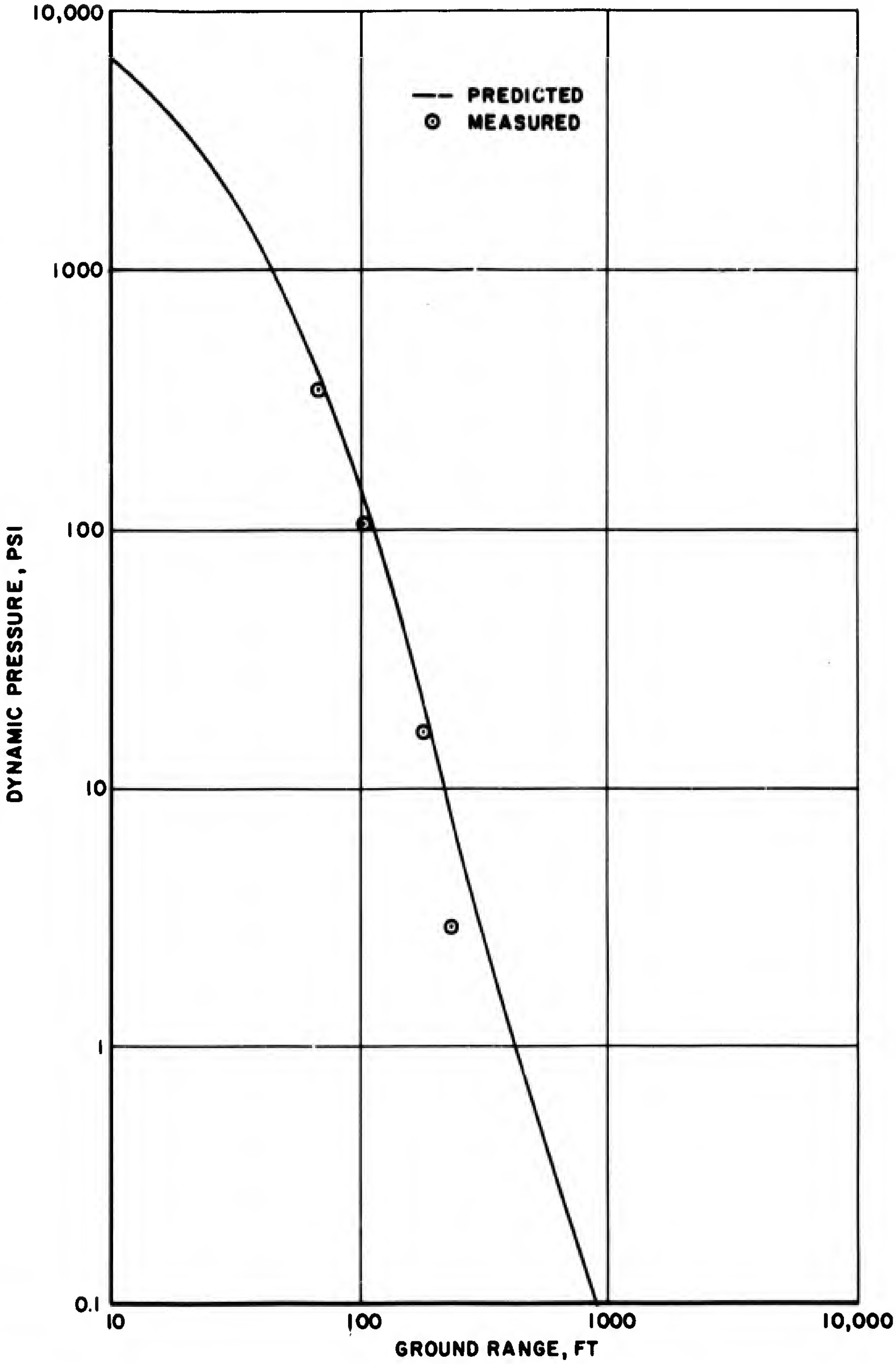

Figure 3.13 Dynamic pressure versus ground range, Event 5

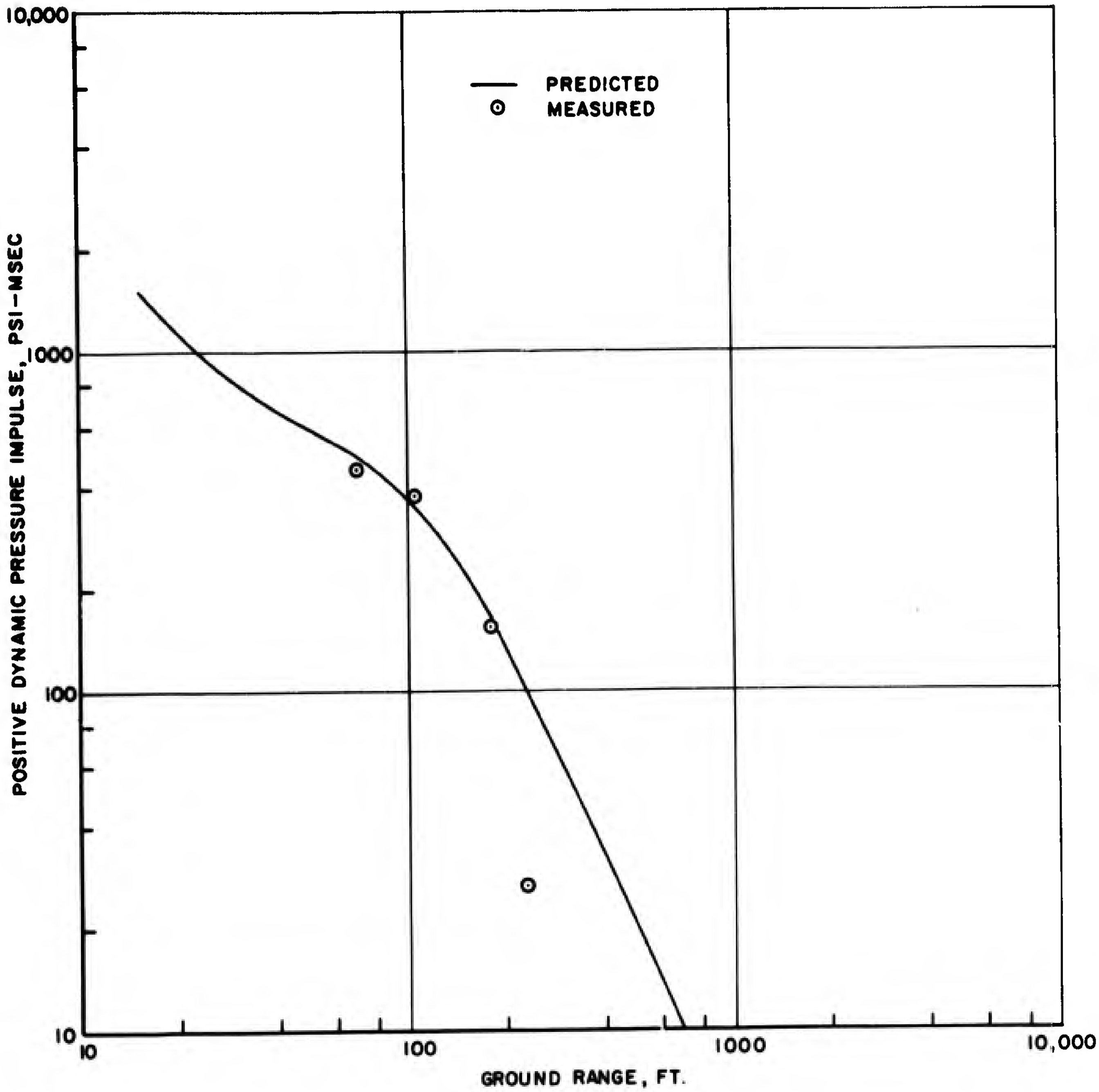

Figure 3.14 Dynamic pressure impulse versus ground range, Event 5

4. GENERAL DISCUSSION

The overpressure-time histories recorded on Event 3 over an alluvium surface in summer are compared with those of the same ground range on Event 5, a frozen alluvium surface condition, in Figures 4.1 through 4.3. The presence of multiple shocks and a disturbed shock wave on Event 3 is sharply evident when the records from that event are contrasted with the very clean, classical waveforms of Event 5. With the exception of the close-in region, very minor differences are seen in the values of the overpressure and duration between the records obtained during the winter conditions and those obtained during the summer conditions. Despite the presence of multiple shocks, the maximum overpressure at Stations 6, 7, and 8 on Event 3 are consistent with the other data.

4.1 Data Comparison With Operation Flat Top

The blast parameters measured on Events 3 and 5 are compared directly with Flat Top II and III data in this section; i.e., no scaling was performed. Flat Top II and III were detonated at about the same elevation above sea level as the shots at DRES.

The arrival times measured on Events 3 and 5 are shown compared to Flat Top II and III results in Figure 4.4. Event 5 times were longer than the other shots by a small amount. The cooler air temperatures on Event 5 were expected to lower sound velocity and increase the times for shock arrival. At 20 feet and 30 feet on Event 3 longer times occurred than were realized on either Flat Top or Event 5.

In Figure 4.5 a comparison of the overpressures measured on Flat Top II and III, Event 3, and Event 5 is presented. A least squares fit has been applied to the data. The overpressures measured close to the charge on Events 3 and 5 were lower than at the corresponding distances on Flat Top II and III. In a similar manner the overpressures measured on Event 5 are lower than those of Event 3. In the region from 100 pounds per square inch to 10 pounds per square inch the overpressures measured were essentially the same for all events. Below the 10 pounds per square inch level the overpressures over the frozen media were higher than those that occurred on the other events.

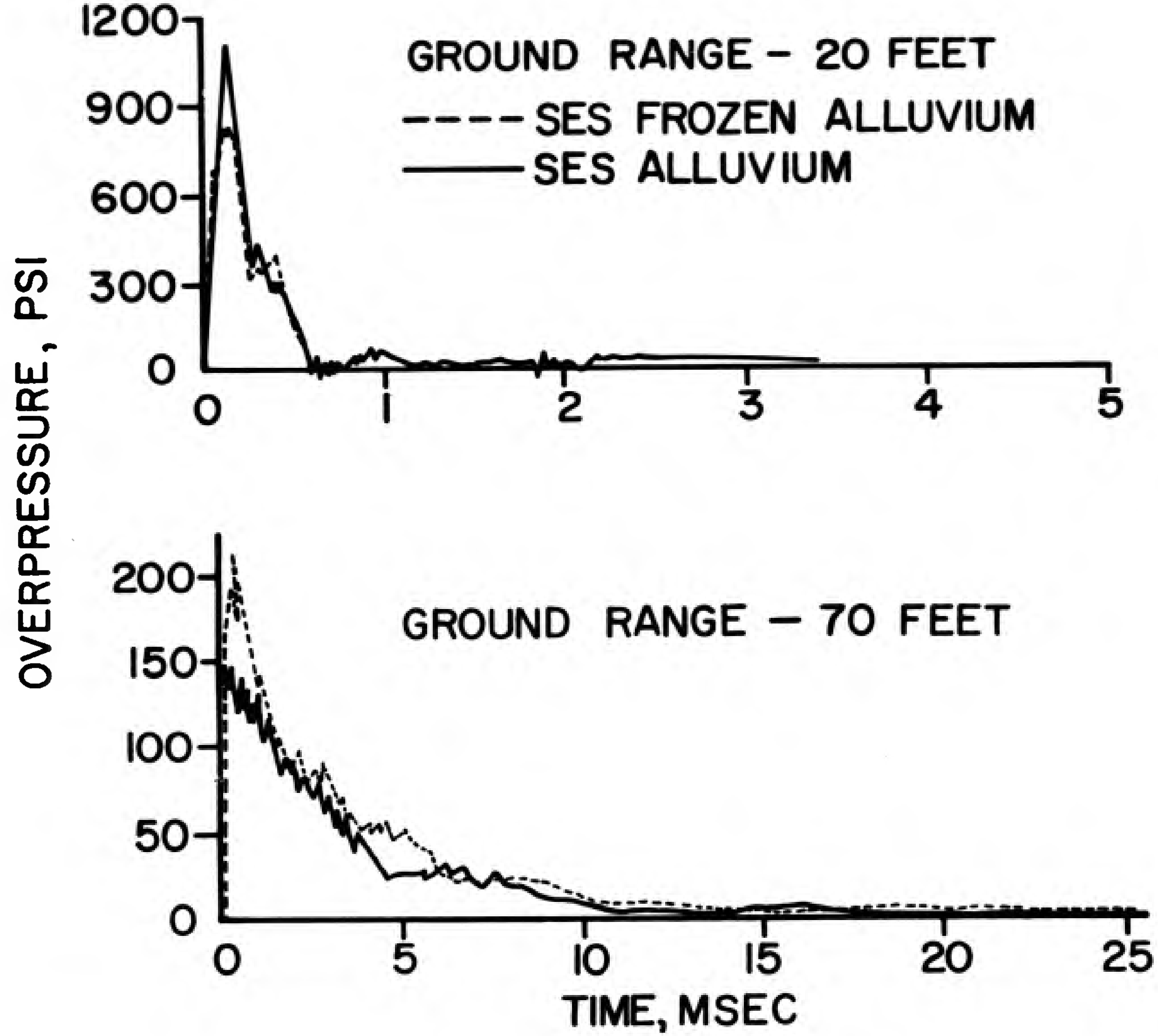

Figure 4.1 Comparison of pressure records, frozen alluvium versus unfrozen alluvium, stations 2 and 5

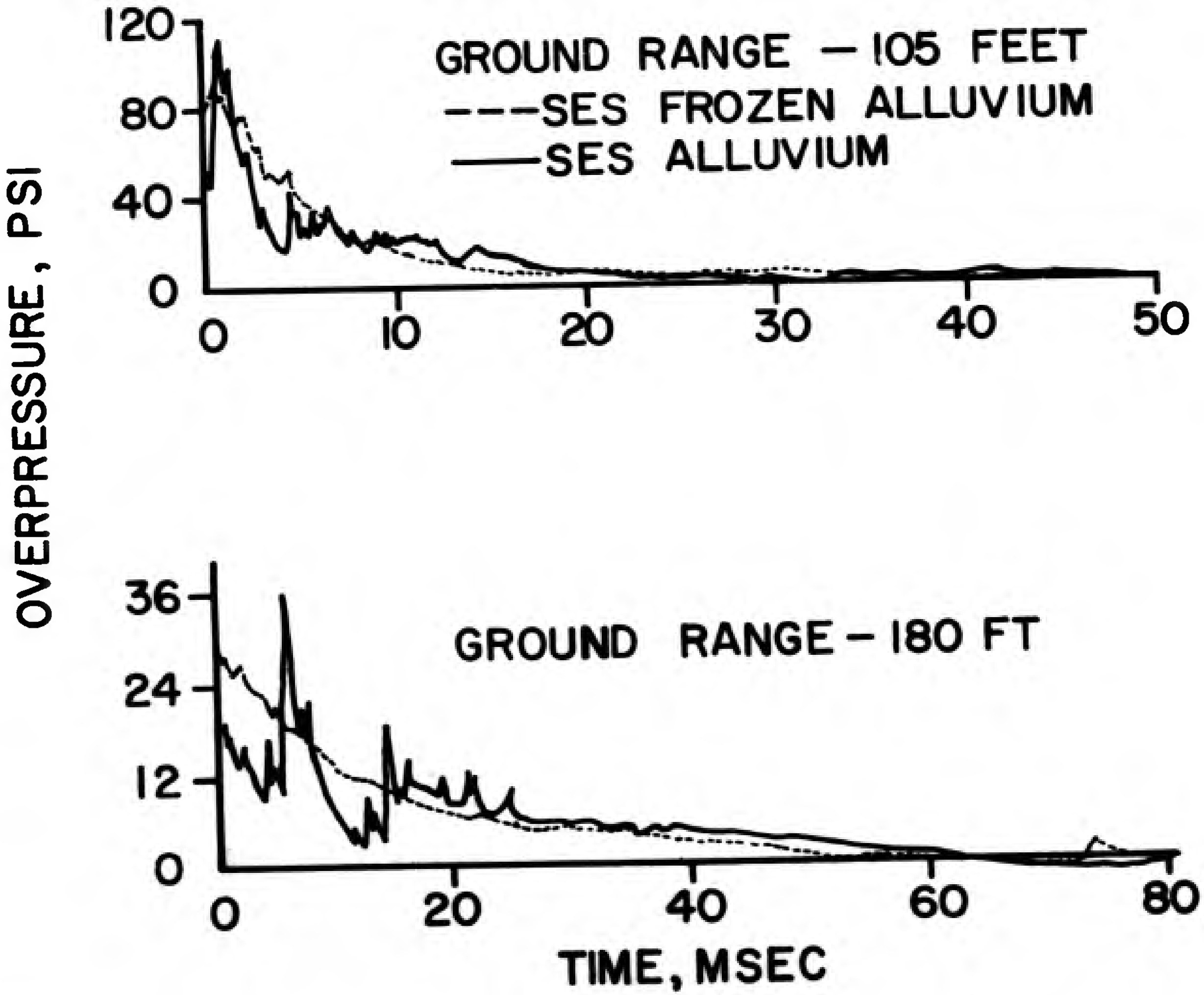

Figure 4.2 Comparison of pressure records, frozen alluvium versus unfrozen alluvium, stations 6 and 7

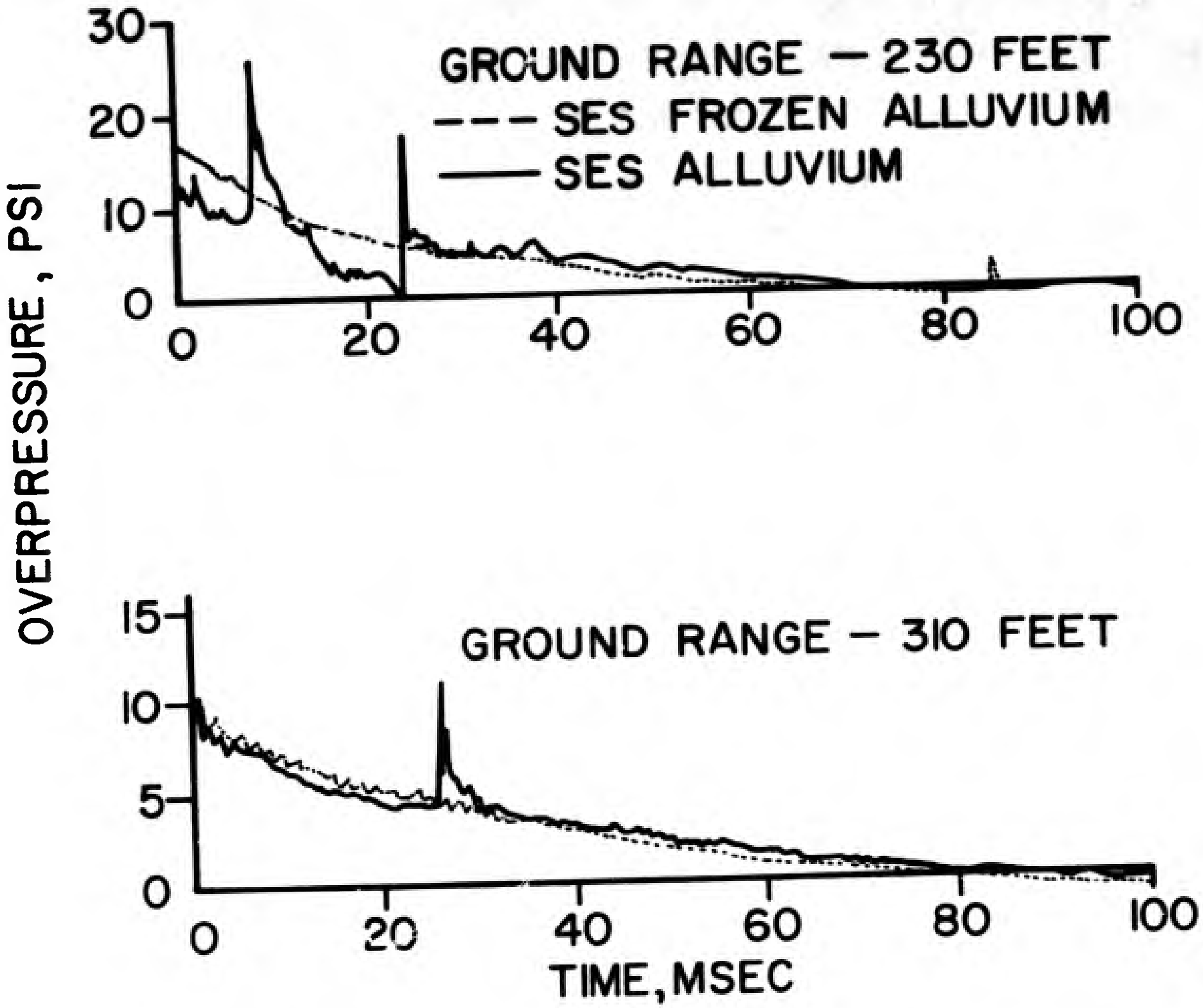

Figure 4.3 Comparison of pressure records, frozen alluvium versus unfrozen alluvium, stations 8 and 9

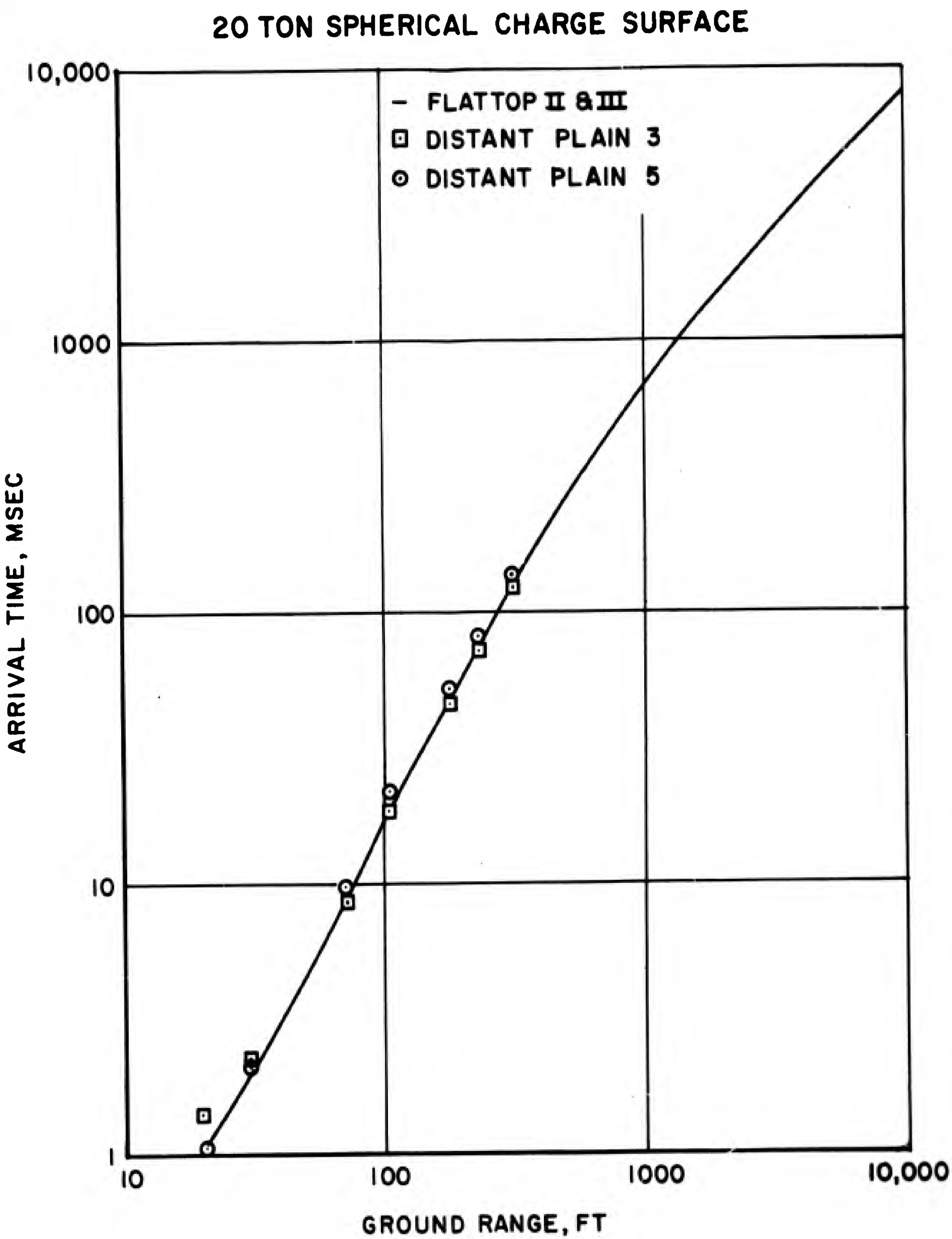

Figure 4.4 Measured arrival time compared with Flat Top II and III

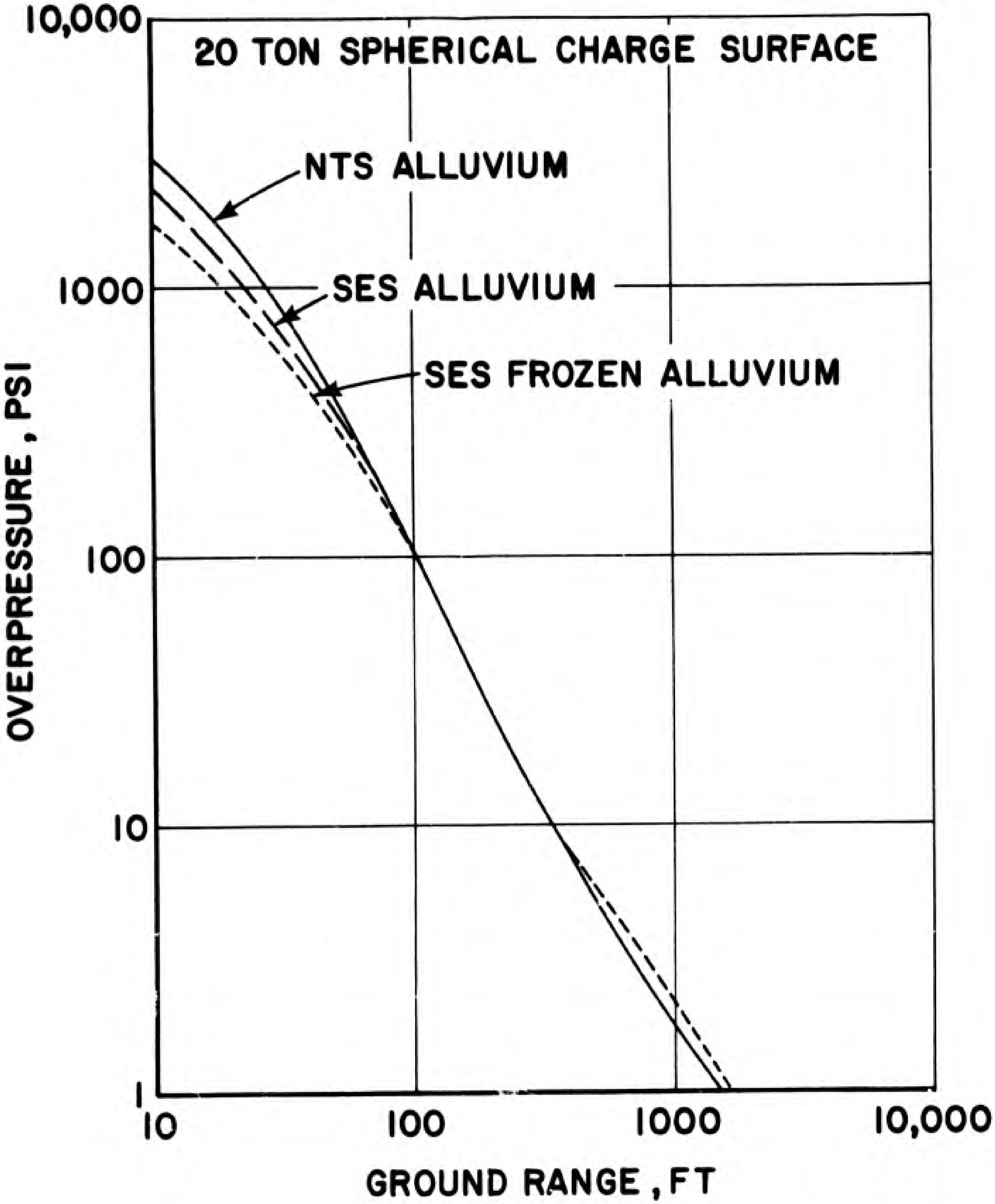

Figure 4.5 Measured overpressure compared with Flat Top II and III

Positive-phase duration and positive-overpressure impulse data are compared in Figures 4.6 and 4.7. Good agreement between the four tests, Flat Top II and III, Event 3, and Event 5, is seen in the region of 100 feet through 8000 feet. Longer durations were measured on Events 3 and 5 than on Flat Top II and III in the 10-to-100 foot region. On the other hand in the 10-to-100 foot region, the positive-overpressure impulse for the DRES tests was less than those of the Flat Top tests. Since the overpressures in this region were much less than on Flat Top, although the durations were greater, the impulses were lower than the Flat Top data.

The dynamic pressure and dynamic pressure impulse comparisons are presented in Figures 4.8 and 4.9. The parameters measured from each event were essentially the same. The data from the 230-foot station on Event 3 was low. However, errors associated with the dynamic pressure measurements in the low-pressure region may be large due to the small differences occurring between the total-head and side-on pressure records.

4.2 Scaling

In order to make other comparisons with previous air-blast data, scaling to a standard must be accomplished. The standard which has been established is a 1-pound charge at sea level conditions where the ambient pressure is 14.7 pounds per square inch and the ambient temperature is 15° C. The standard scaling relationships are as follows:

$$S_p = 14.7/P_o$$

$$S_d = (P_o/14.7W)^{1/3}$$

$$S_t = [(T_o + 273)/288]^{1/2} \cdot S_d$$

$$S_I = S_p \cdot S_t$$

where S_p = scaling factor for pressure

S_d = scaling factor for distance

S_t = scaling factor for time

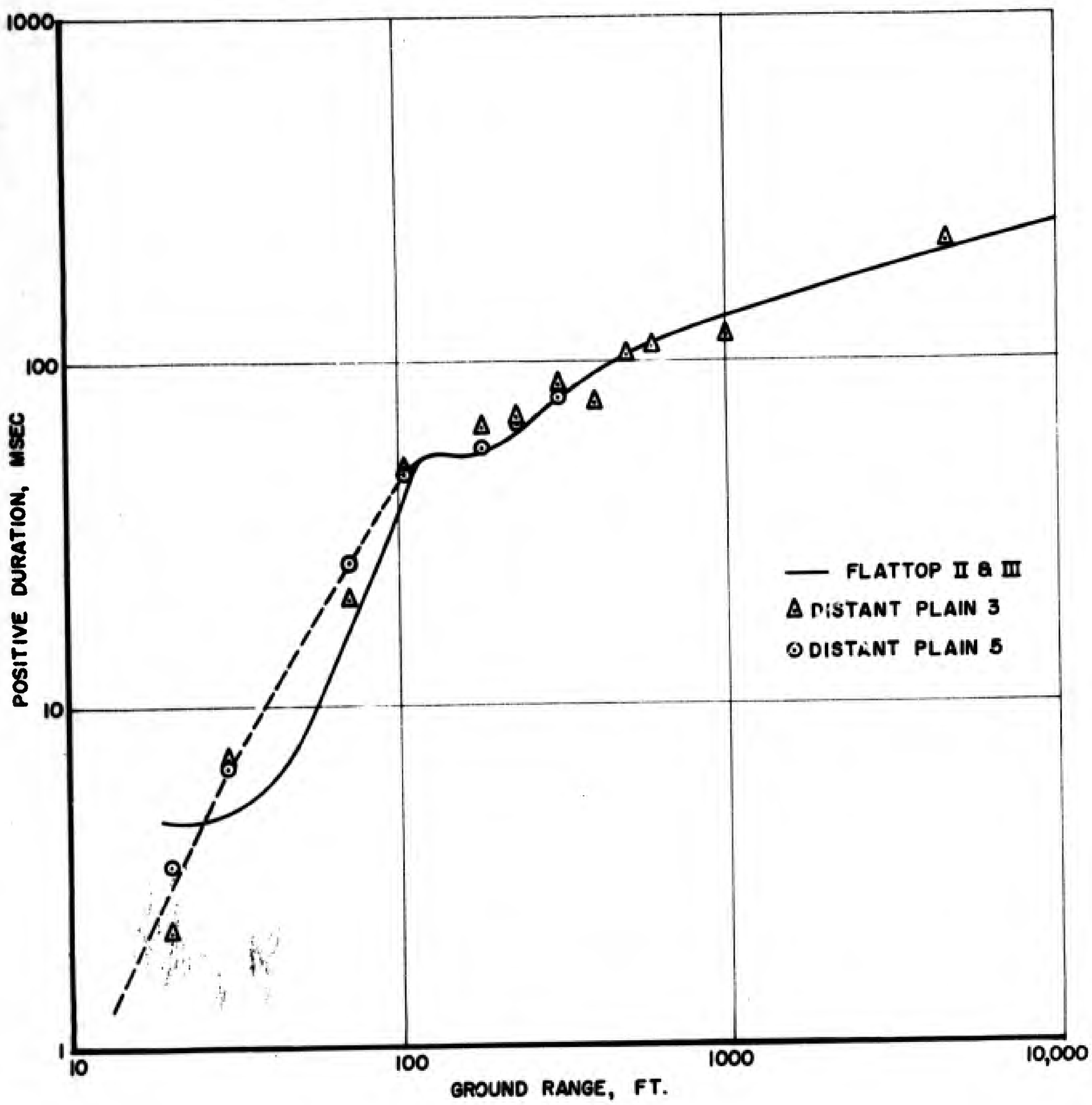

Figure 4.6 Measured positive phase duration compared with Flat Top II and III

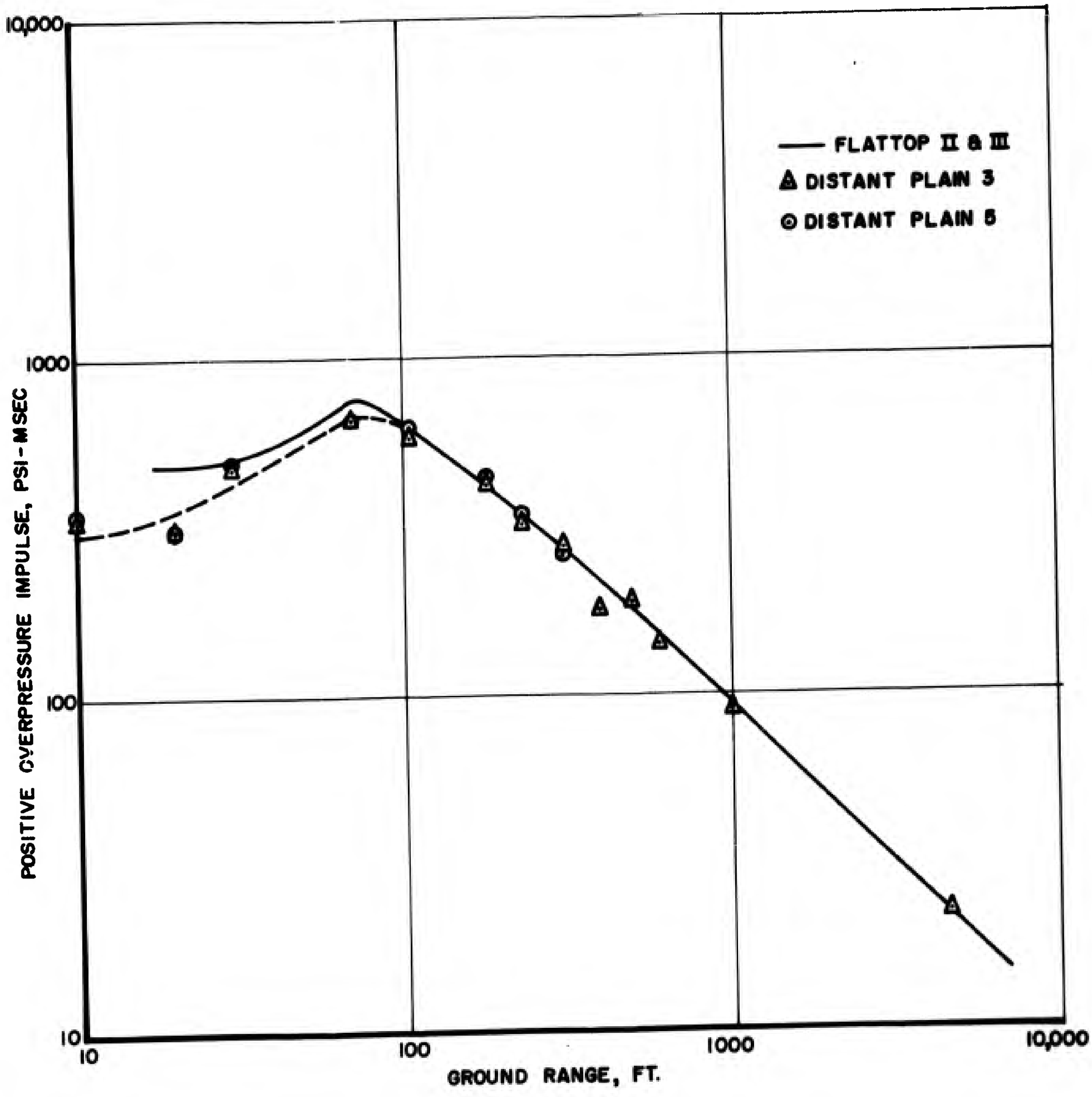

Figure 4.7 Measured positive-overpressure impulse compared with Flat Top II and III

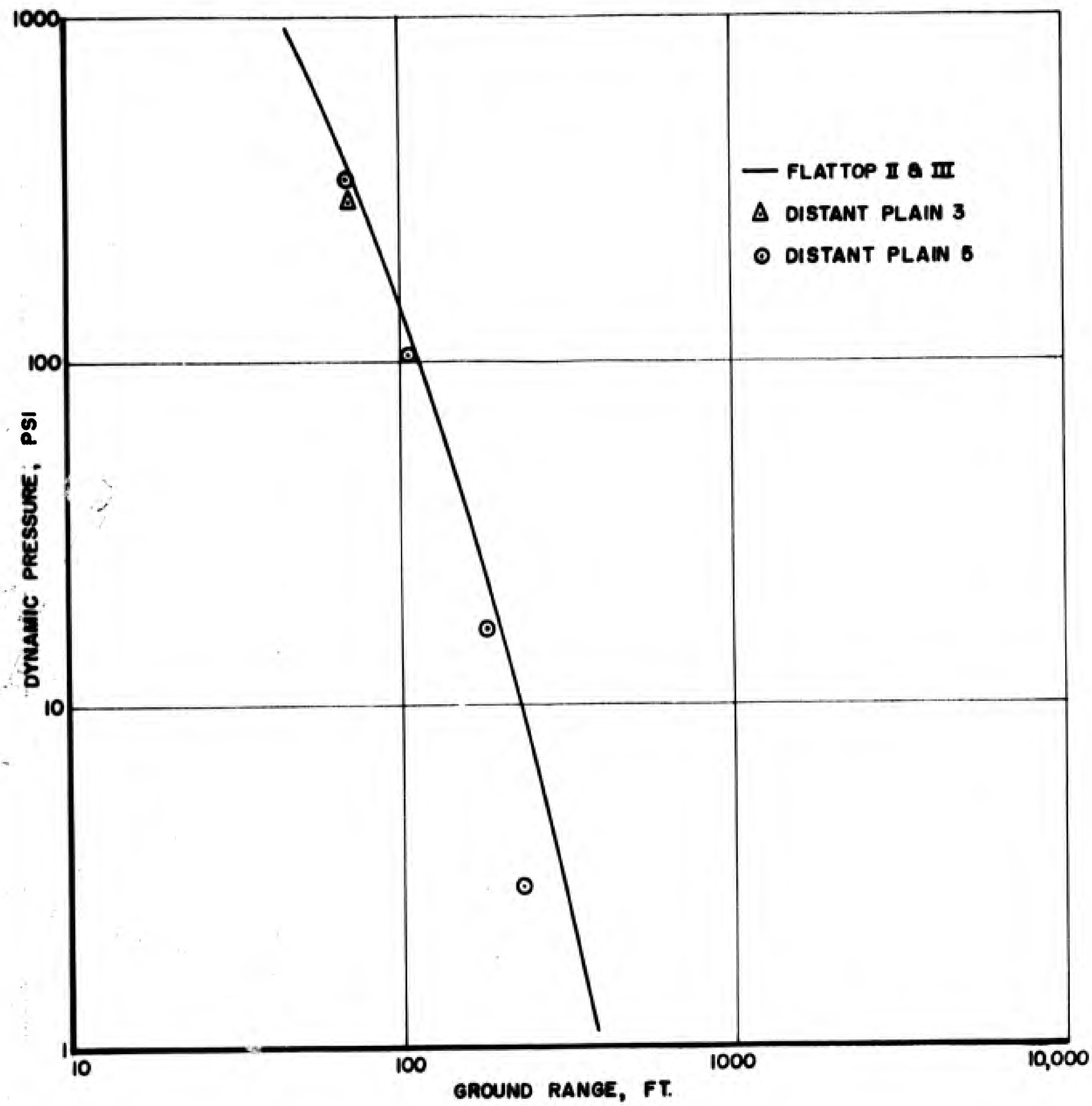

Figure 4.8 Measured dynamic pressure compared with Flat Top II and III

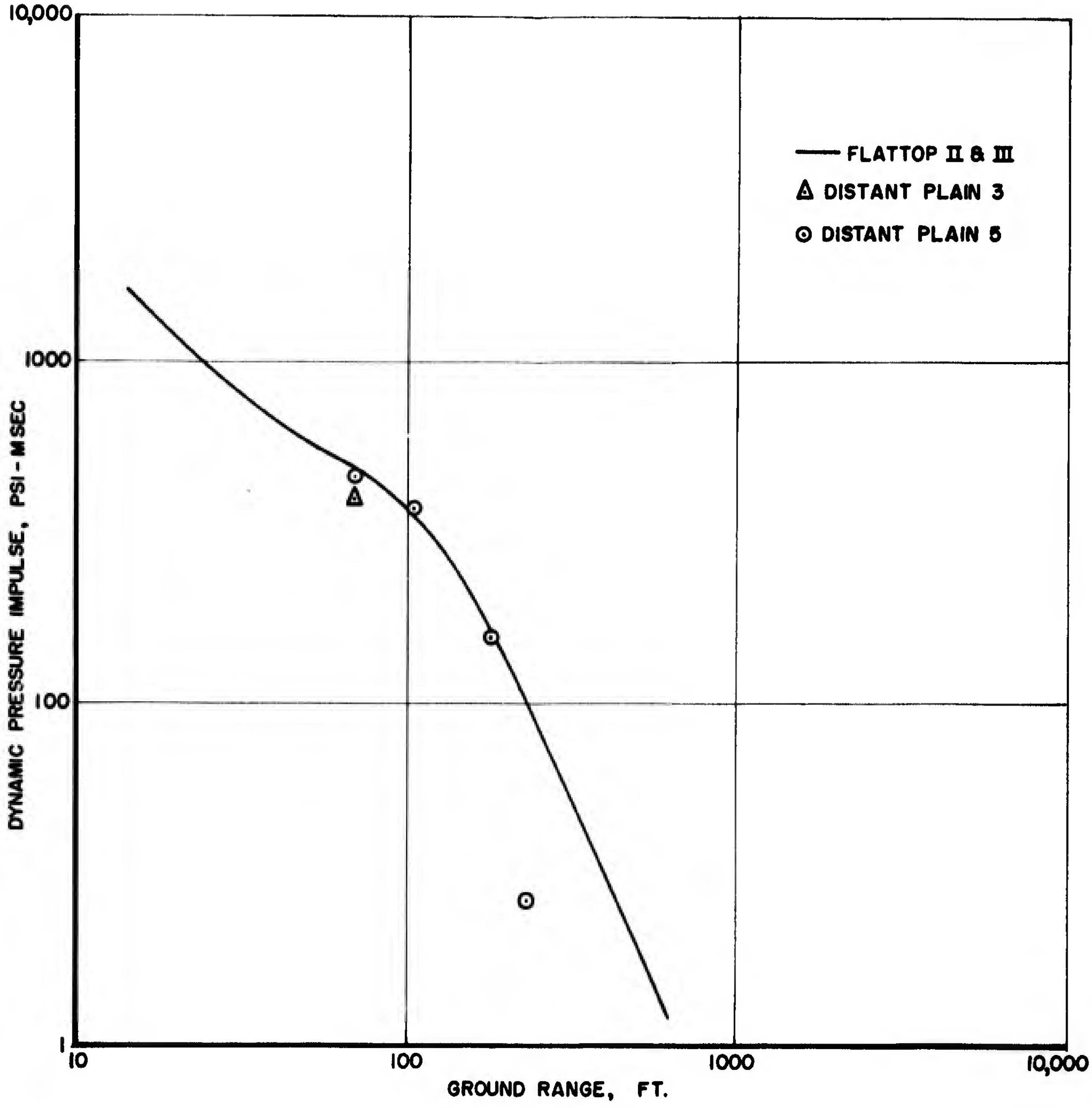

Figure 4.9 Measured dynamic pressure impulse compared with Flat Top II and III

S_I = scaling factor for impulse

P_o = ambient atmosphere pressure at the surface elevation of interest

W = yield in pounds

T_o = measured temperature in degrees Centigrade

The scaling factors for the two events are as follows:

Factor	Event 3	Event 5
S_p	1.078	1.088
S_d	0.0285	0.0284
S_t	0.0292	0.0277
S_I	0.0315	0.0301

The measured data obtained for Events 3 and 5 were scaled to sea level conditions, and the results are presented in Tables 4.1 through 4.3. Plots of the scaled data are shown in Figures 4.10 through 4.15.

4.3 Height-of-Burst Curves

The scaled Distant Plain results were plotted on height-of-burst curves as shown in Figures 4.16 through 4.22. The solid curves shown in the figures were obtained from Reference 5. The dashed curves near surface level are the modifications made to the height-of-burst curves as a result of the Flat Top series. These modifications are discussed in Reference 1.

5. CONCLUSIONS

Air blast measured under summer and winter environmental conditions as represented by the Distant Plain Events 3 and 5 did not indicate any major differences. Overpressure, duration and impulse were essentially the same, although Event 3 exhibited multiple shocks and a disturbed waveform. No differences were evident in the dynamic pressure data obtained. Maximum overpressures measured over the winter surface close-in to the charge were lower than for the summer condition out to 200

Table 4.1 Scaled Results from Event 3

Ground range (ft)	Arrival Time (msec)	Over-pressure (psi)	Positive Duration (msec)	Positive Impulse (psi-msec)
0.199	0.0105	4846	-	-
0.285	0.0163	2595	0.0233	10.4
0.570	0.0408	897	0.0642	9.6
0.855	0.0657	938	0.2044	14.2
1.99	0.252	178	0.599	20.3
2.99	0.535	118.5	1.401	18.1
5.13	1.36	35.5	1.87	13.2
5.13	-	31.2	2.10	15.4
6.55	2.12	22.6	2.01	10.0
8.83	3.69	10.8	2.48	8.57
8.83	-	11.3	2.01	7.65
11.40	-	6.2	2.19	5.51
14.25	-	5.17	2.98	5.86
17.10	-	3.77	3.04	4.35
28.5	-	2.15	3.45	2.77
133.4	-	0.248	6.42	0.69

Table 4.2 Scaled Results from Event 5

Ground Range (ft)	Arrival Time (msec)	Over-pressure (psi)	Positive Duration (msec)	Positive Impulse (psi-msec)
0.199	0.0055	3808	-	-
0.199	0.0053	4080	-	-
0.284	0.0102	1523	0.024	10.54
0.568	0.0285	1322	0.094	9.33
0.852	0.0604	642	0.180	14.72
1.99	0.269	234	0.720	19.29
2.98	0.560	101.7	1.28	18.66
5.11	1.49	31.5	1.55	13.18
5.11	-	32.8	-	-
6.53	2.30	19.0	1.79	10.23
6.53	-	20.7	-	-
8.80	3.81	11.1	2.15	7.76
8.80	3.82	10.9	2.17	7.86
8.80	-	11.6	-	-
11.36	-	8.05	-	-
14.00	-	6.3	-	-
16.73	-	4.4	-	-
26.41	-	2.02	-	-

Table 4.3 Scaled Dynamic Pressure Results

		Event 5		
1.98	0.261	370	-	13.51
2.98	0.542	112	-	11.38
5.11	1.44	17.9	-	4.58
6.53	2.25	3.2	-	0.795
		Event 3		
1.99	-	291	-	12.51

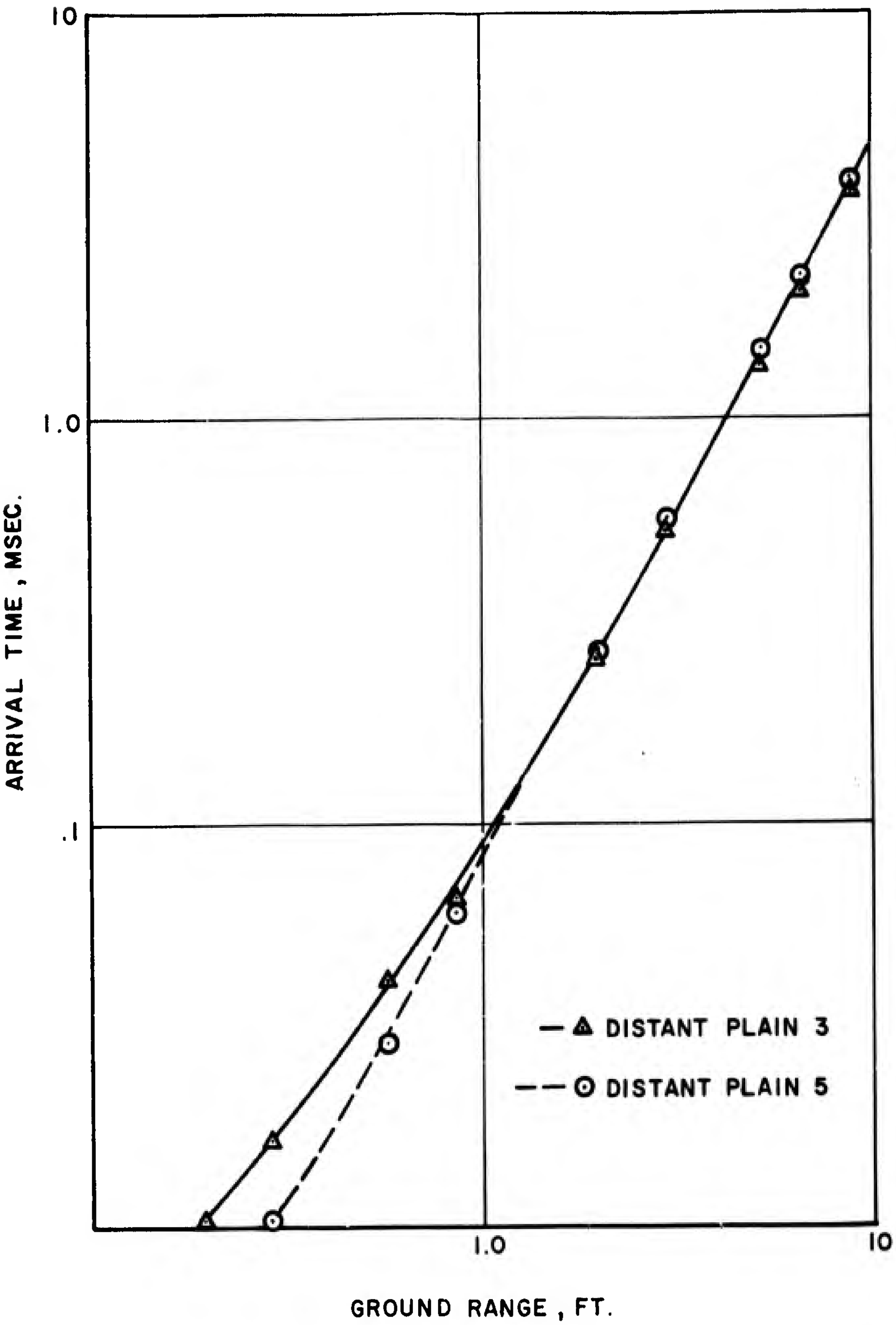

Figure 4.10 Measured arrival time for Events 3 and 5 scaled

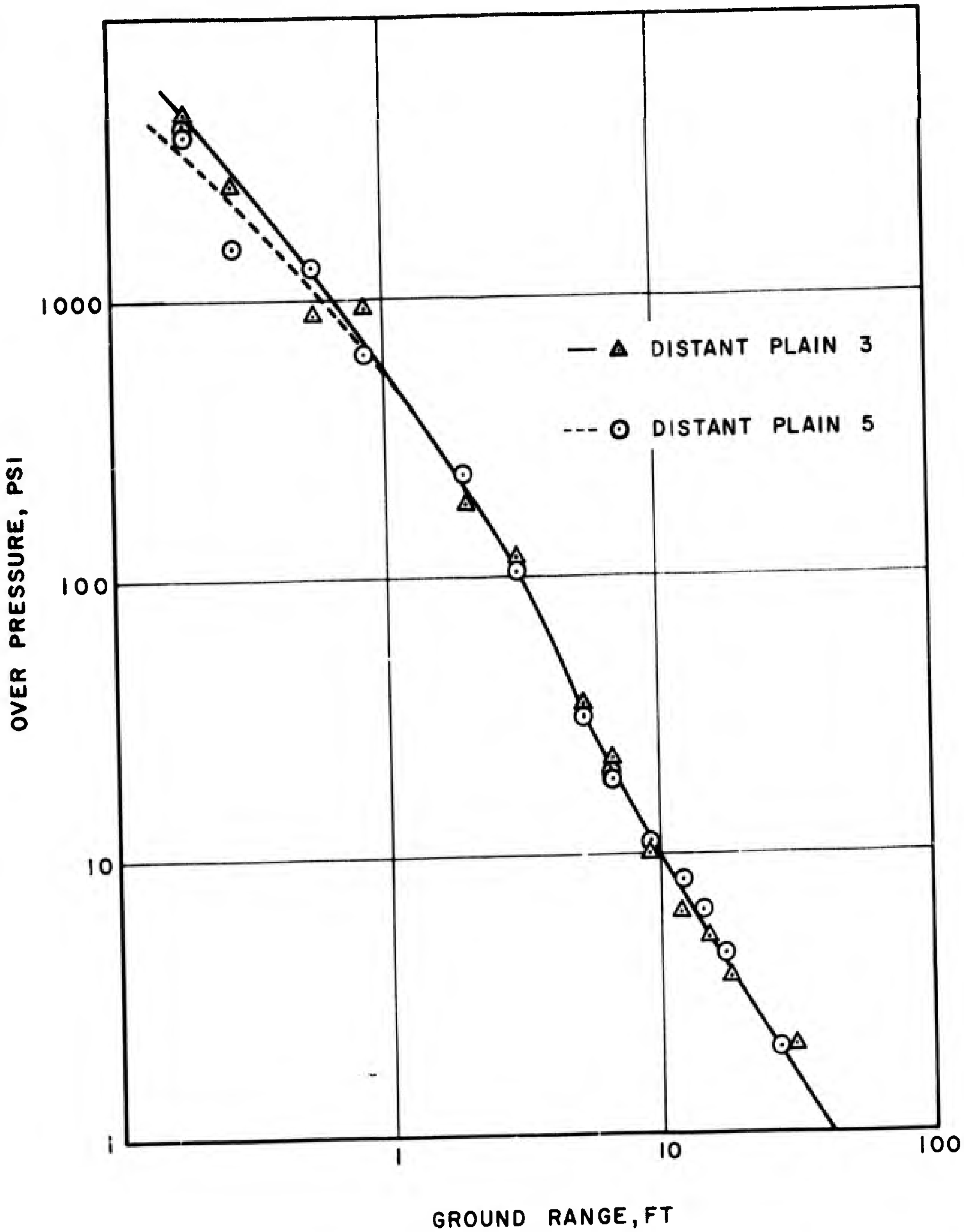

Figure 4.11 Measured overpressure for Events 3 and 5 scaled

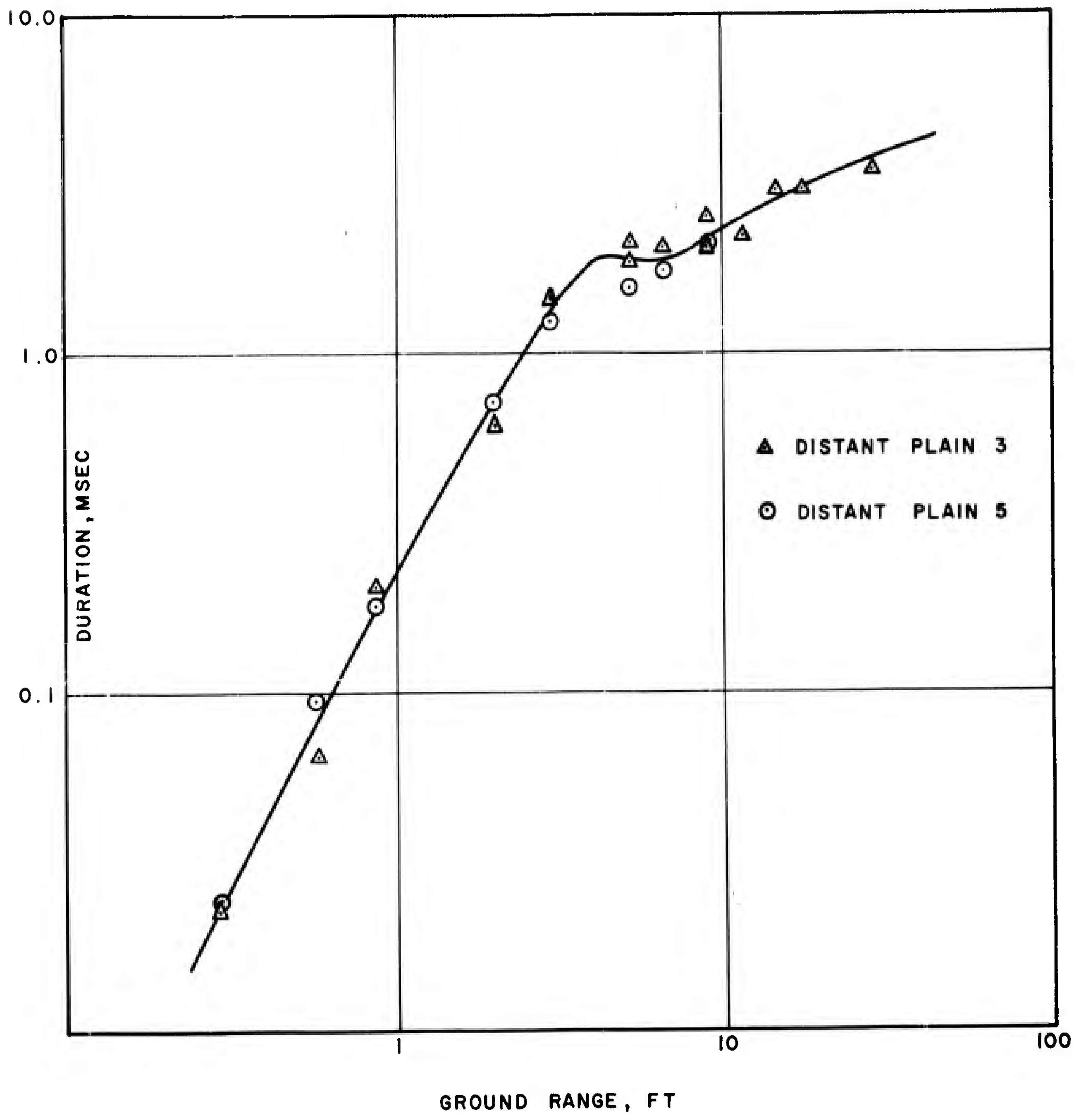

Figure 4.12 Measured positive duration for Events 3 and 5 scaled

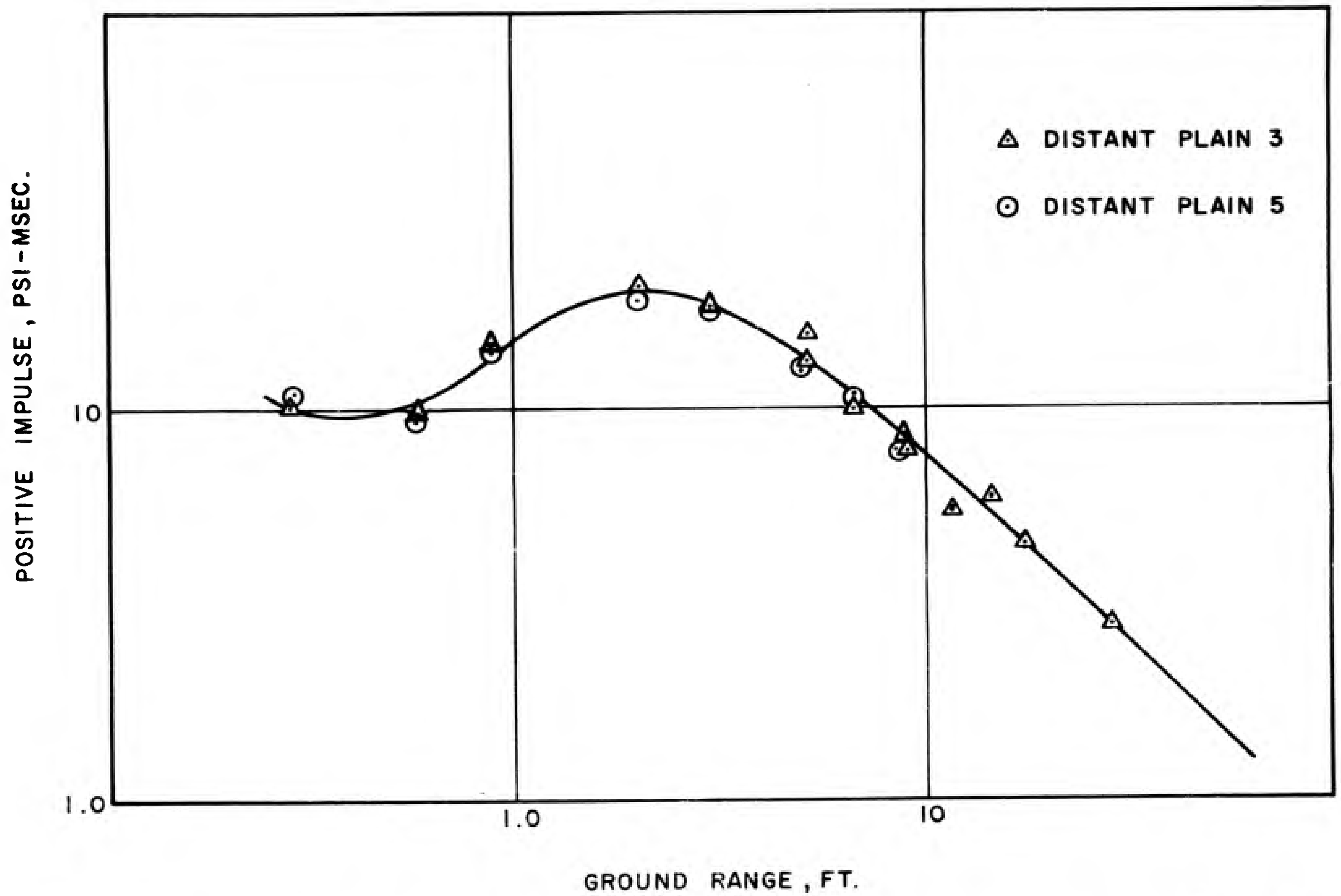

Figure 4.13 Measured positive overpressure impulse for Events 3 and 5 scaled

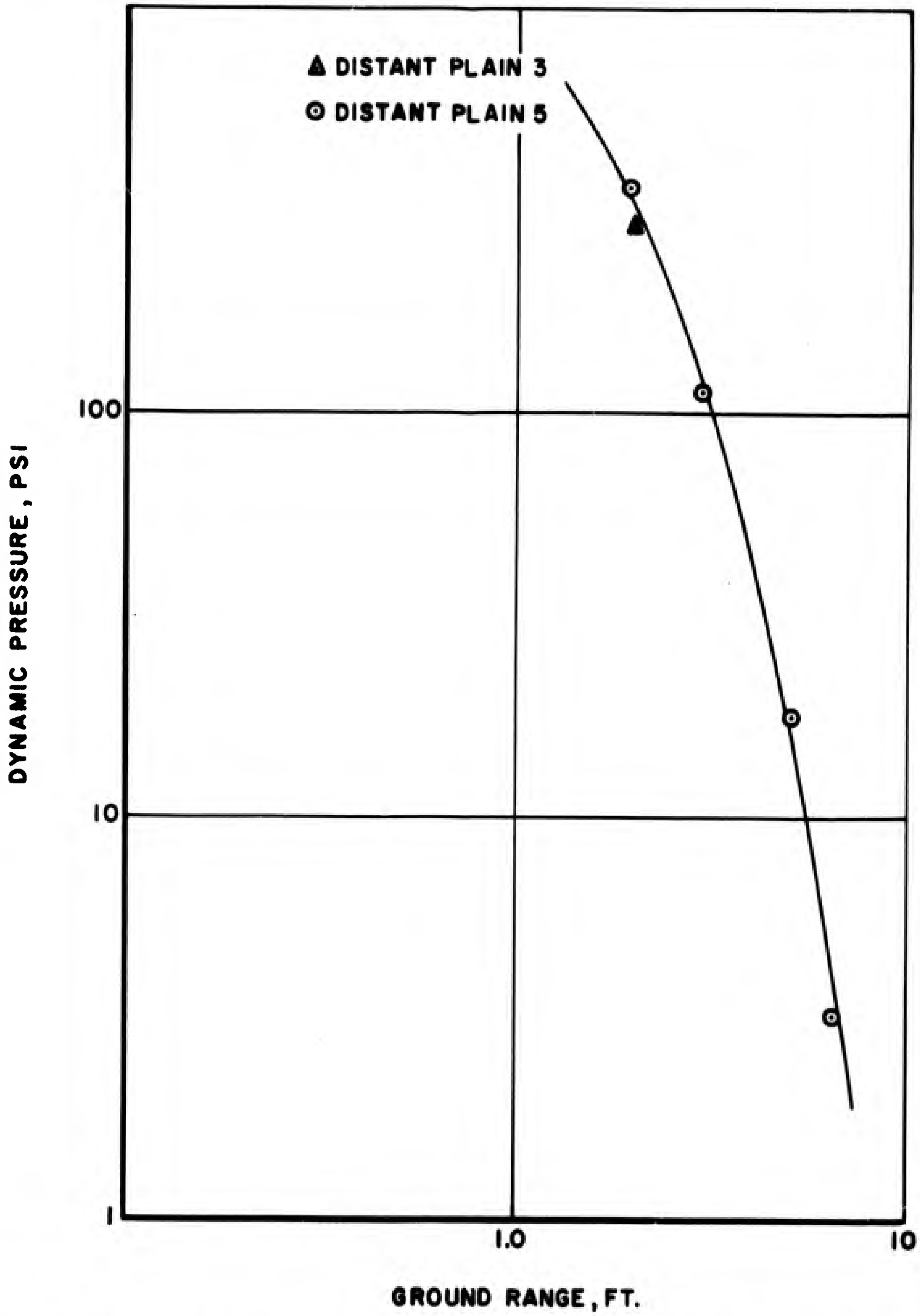

Figure 4.14 Measured dynamic pressure for Events 3 and 5, scaled.

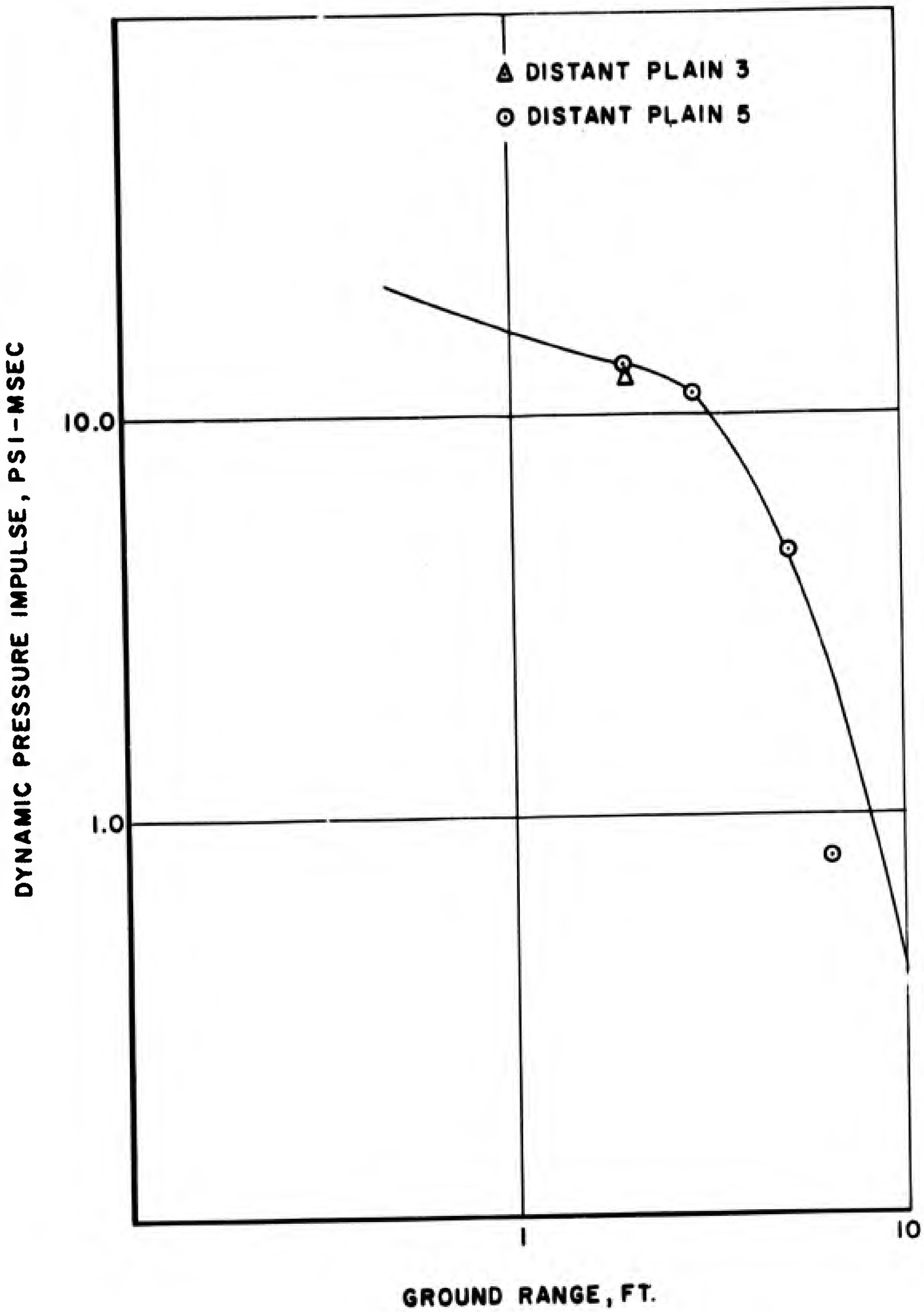

Figure 4.15 Measured dynamic pressure impulse for Events 3 and 5, scaled.

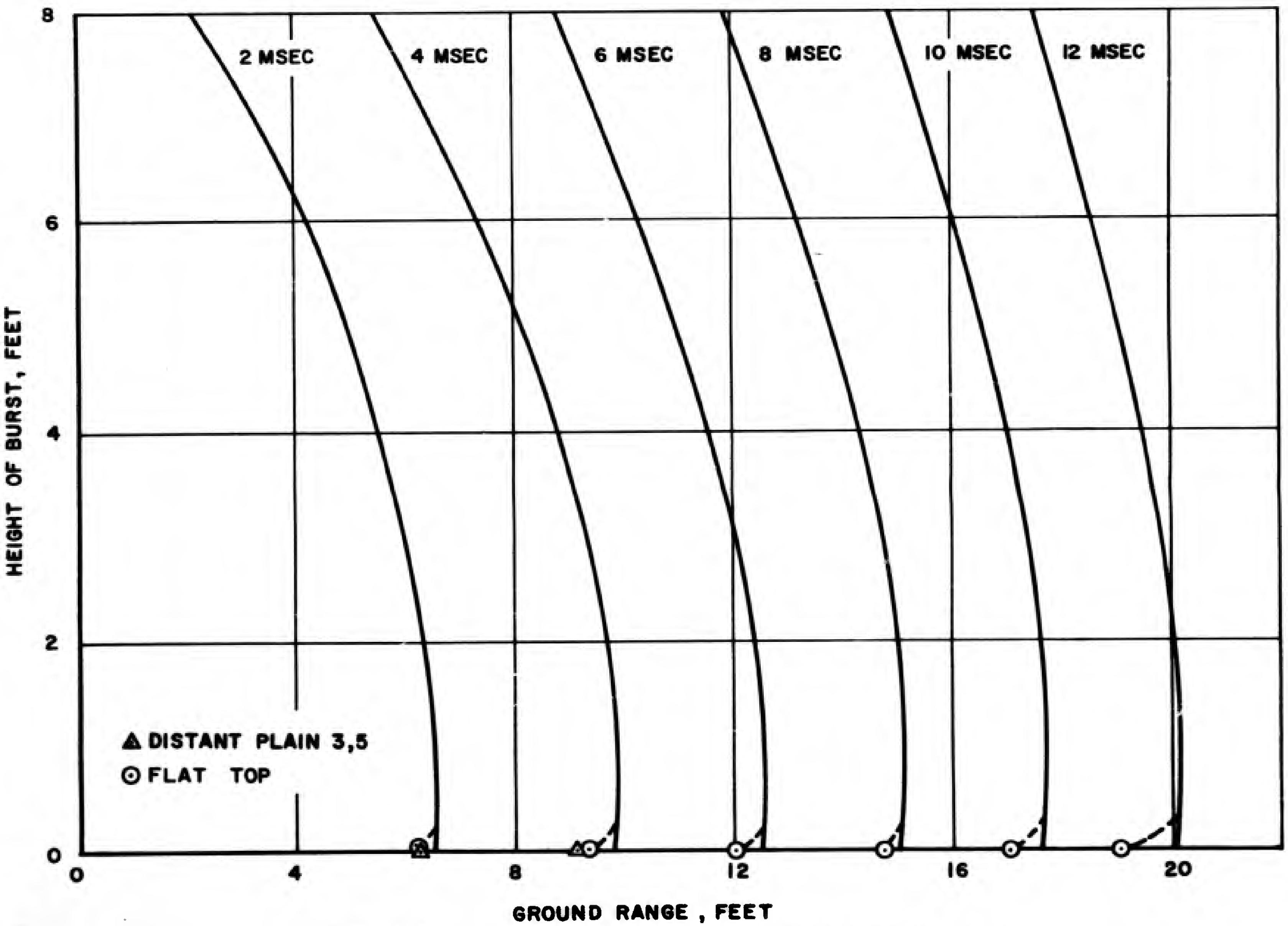

Figure 4.16 Scaled arrival time data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves

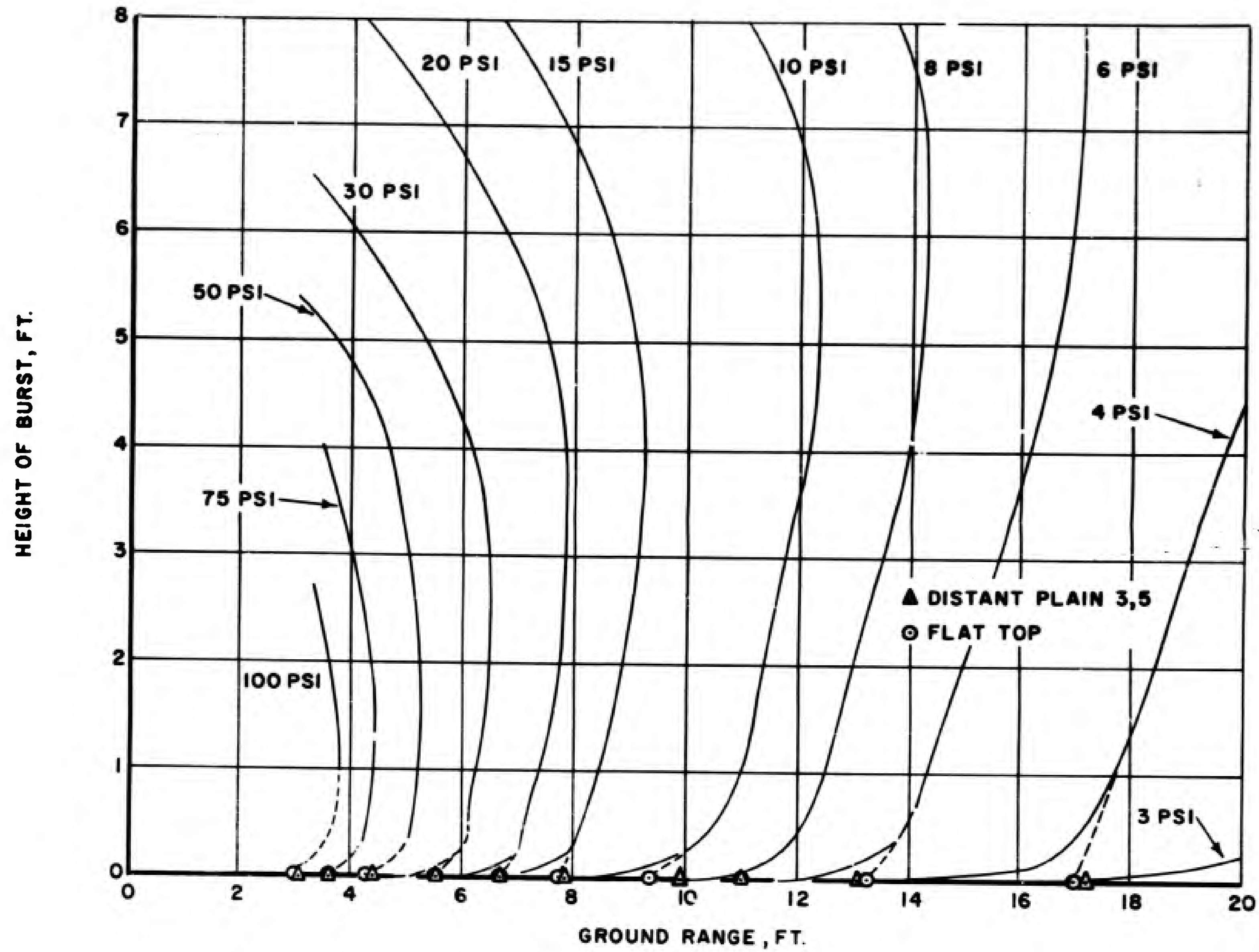

Figure 4.17 Scaled overpressure data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves.

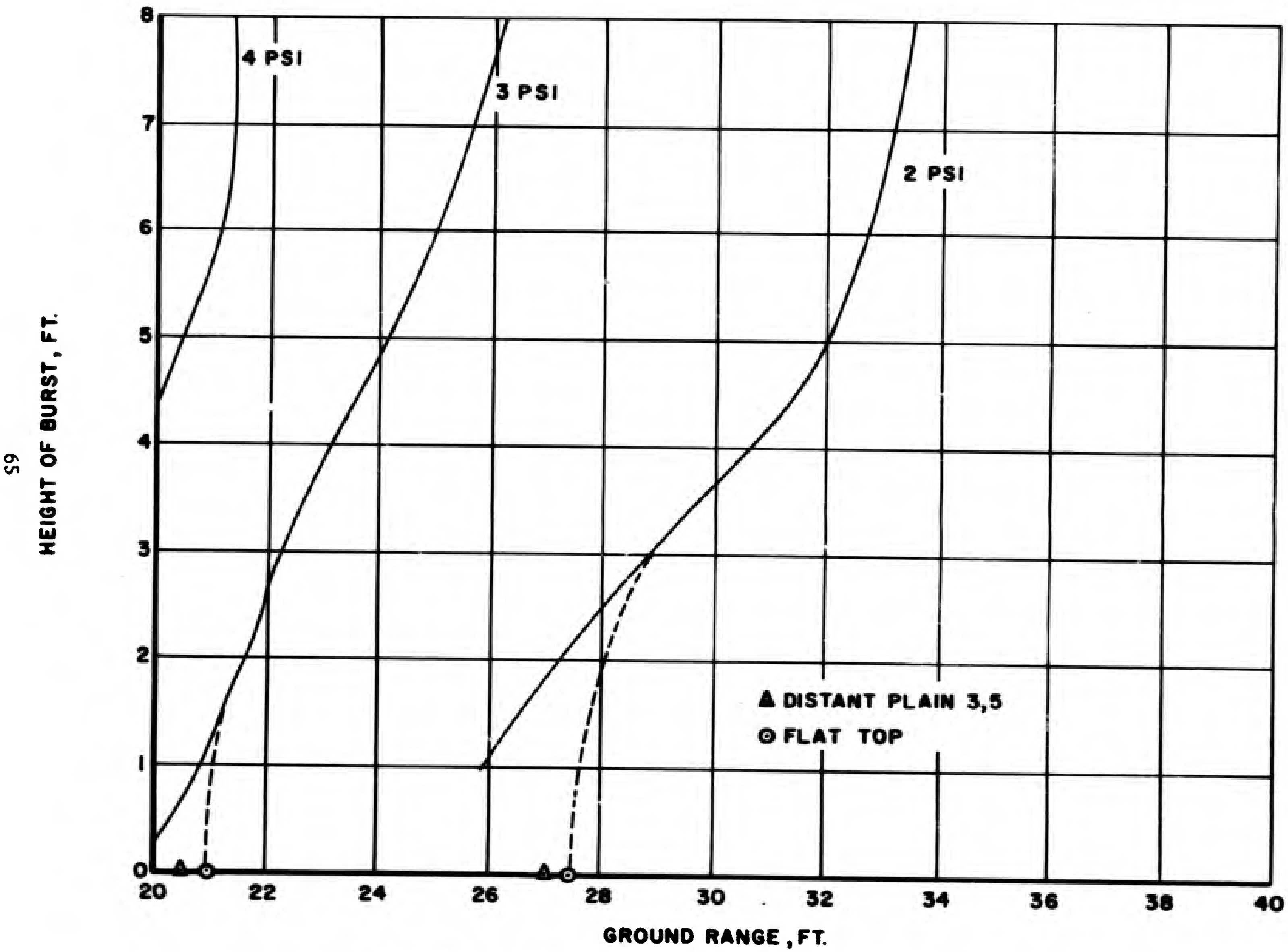

Figure 4.18 Scaled overpressure data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves continued.

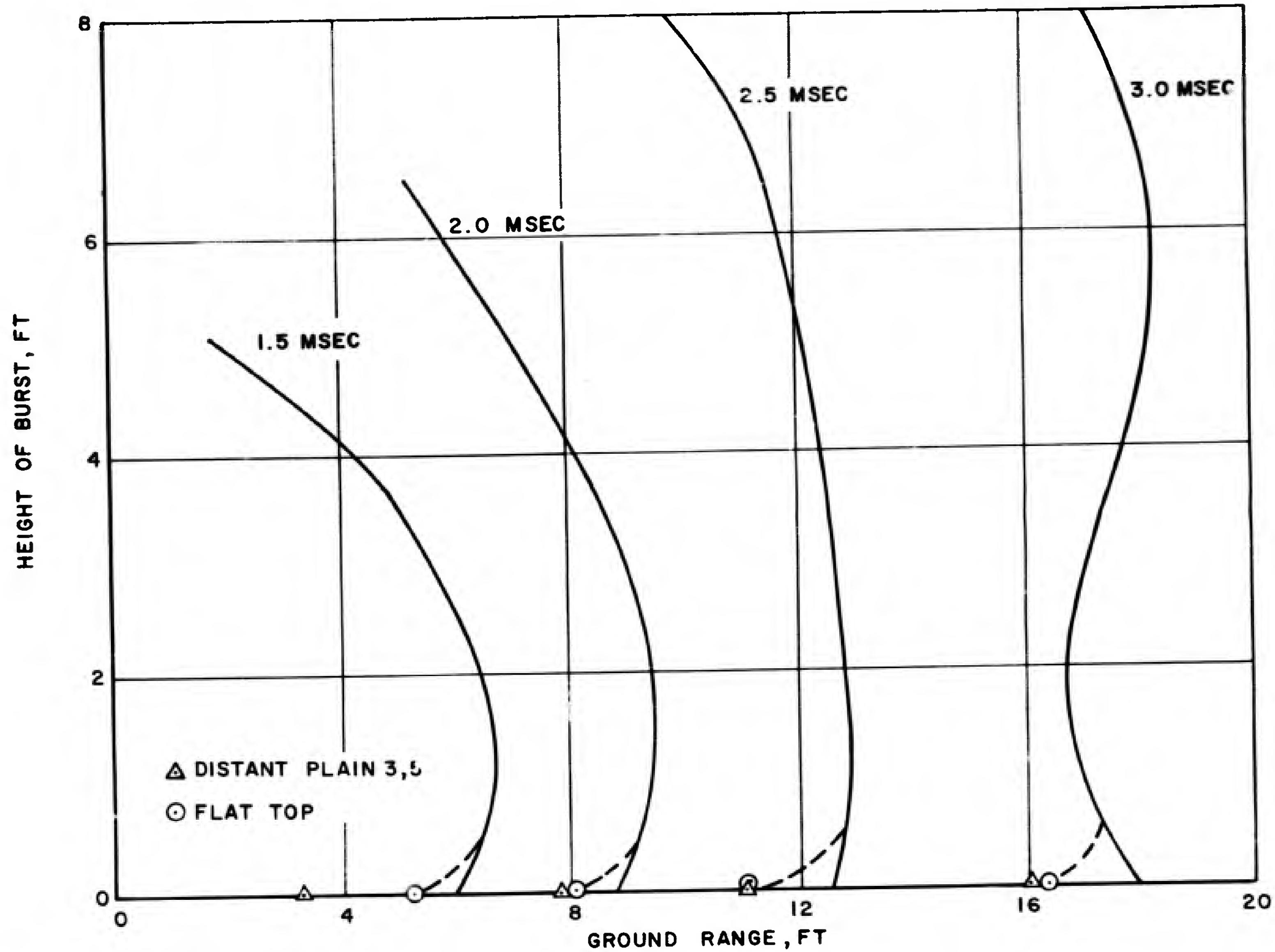

Figure 4.19 Scaled positive phase duration data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves.

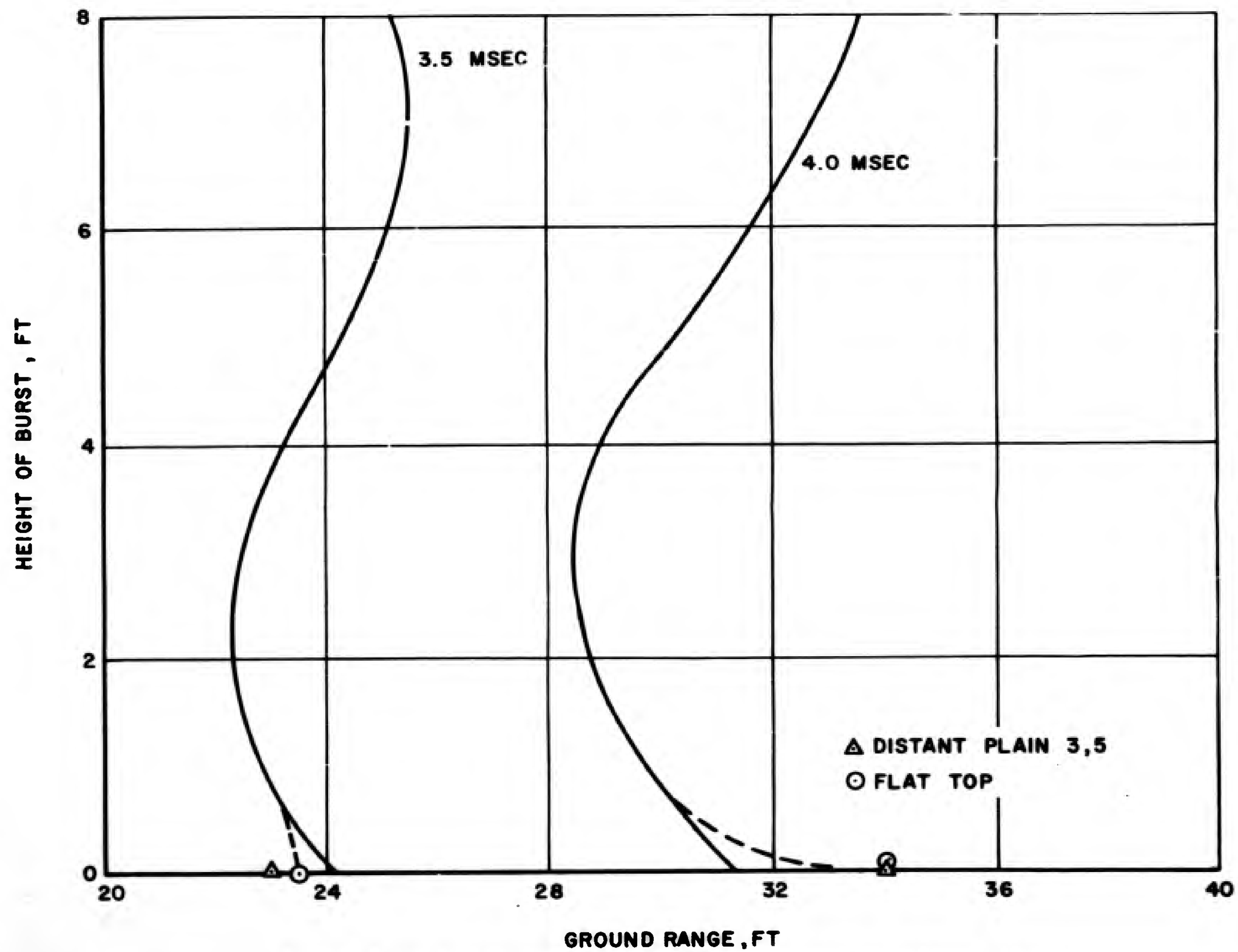

Figure 4.20 Scaled positive phase duration data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves continued.

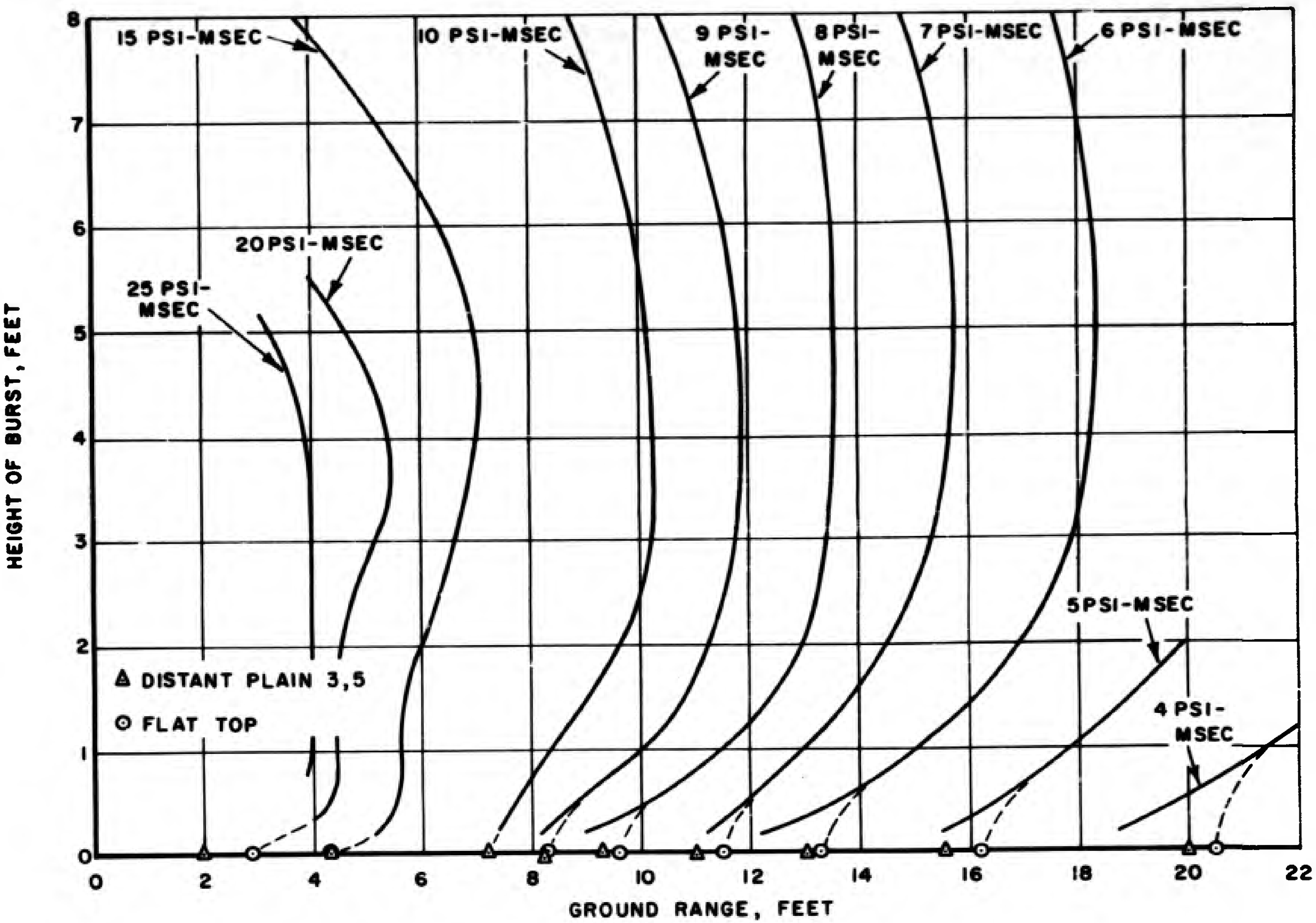

Figure 4.21 Scaled overpressure impulse data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves.

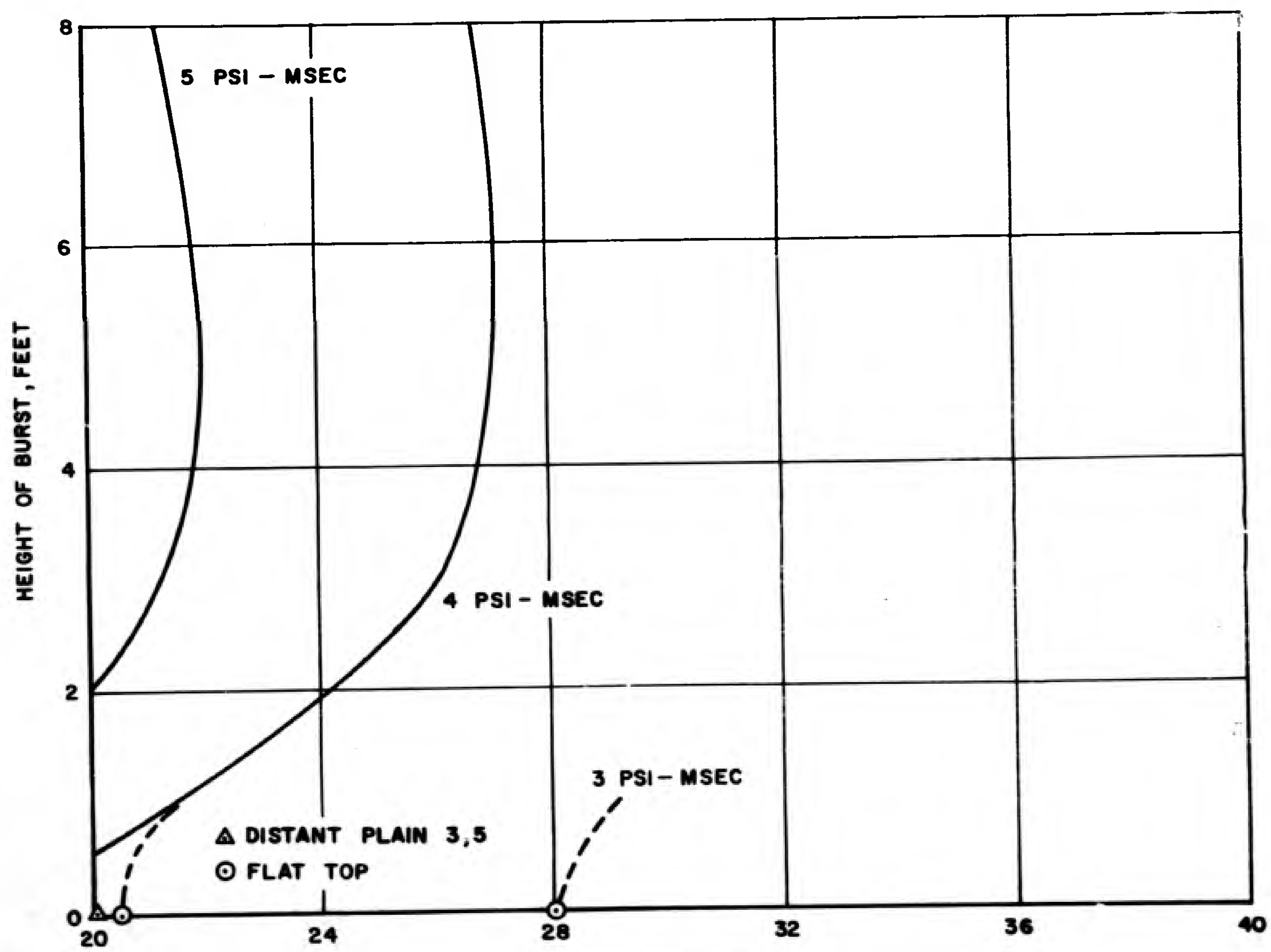

Figure 4.22 Scaled overpressure impulse data of Distant Plain 3, 5 and Flattop plotted with height-of-burst curves continued.

pounds per square inch, then were equal to the 10 pounds per square inch level, where overpressures for the winter condition became and continued slightly higher than for the summer condition.

The Distant Plain data agree well with the Flat Top desert alluvium shots. The larger number of close-in instrument stations on Distant Plain obtained data which define more clearly this particular region of interest.

The Distant Plain data further verify the modifications made to existing height-of-burst charts after Operation Flat Top to show less reduction in overpressure for a charge on the surface.

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The excellent advice and technical assistance of Mr. John H. Keefer, Program One Director, and Mr. Noel H. Ethridge are gratefully acknowledged.

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2. L. Giglio-Tos, *et al*, "Air Blast Instrumentation Operation Distant Plain," Ballistic Research Laboratories Memorandum Report in Publication.

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4. N. H. Ethridge, "A Procedure for Reading and Smoothing Pressure Time Data from HE and Nuclear Explosions," Ballistic Research Laboratories Memorandum Report No. 1691, September 1965.

5. L. J. Vortman and J. D. Shreve, "The Effects of Height of Explosion on Blast Parameters," Sandia Corporation Report SC-3858 (TR).

APPENDIX A

PRESSURE-TIME RECORDS, EVENT 3
SUMMER CONDITIONS

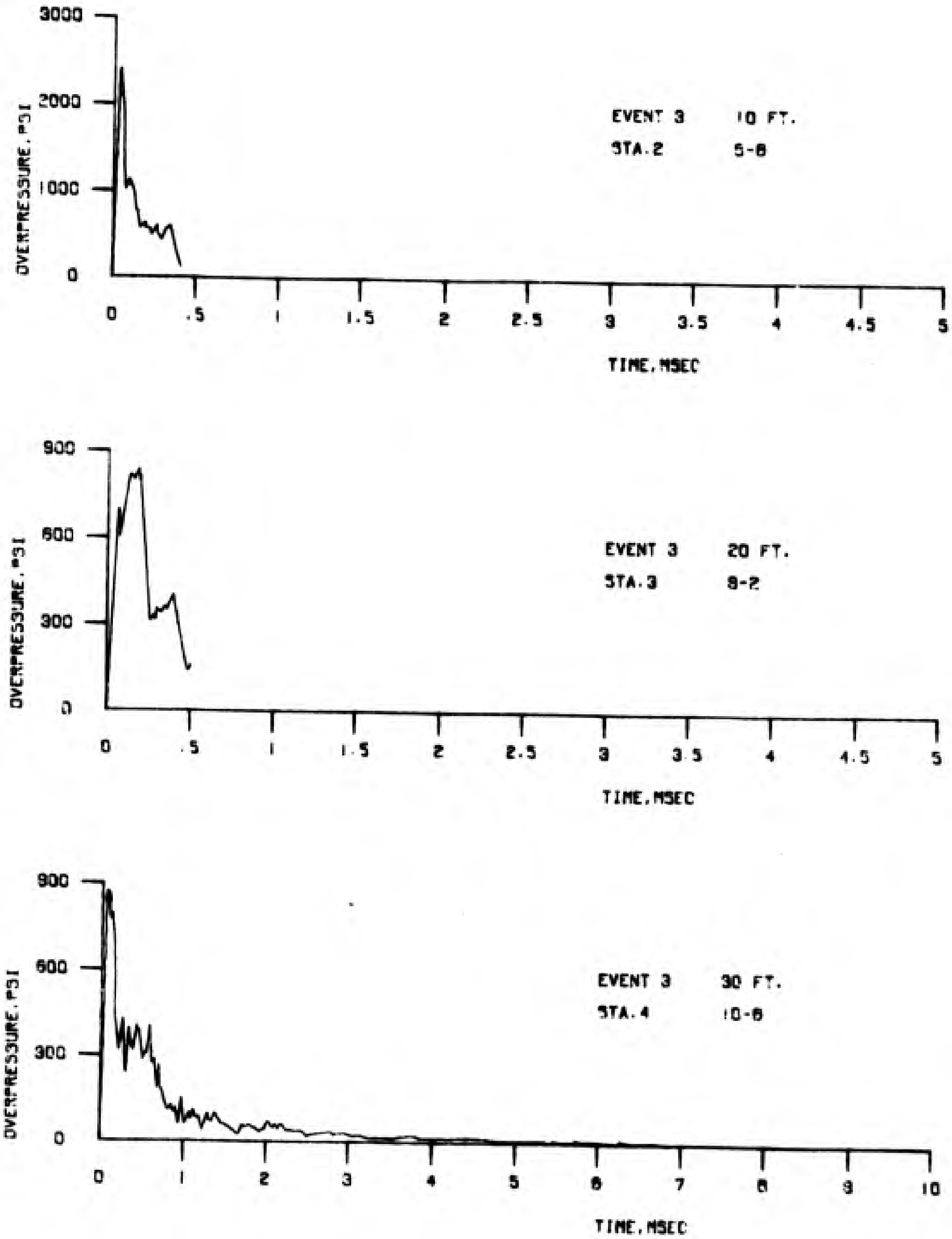

Figure A.1 Overpressure-time records, Stations 2-4, Event 3

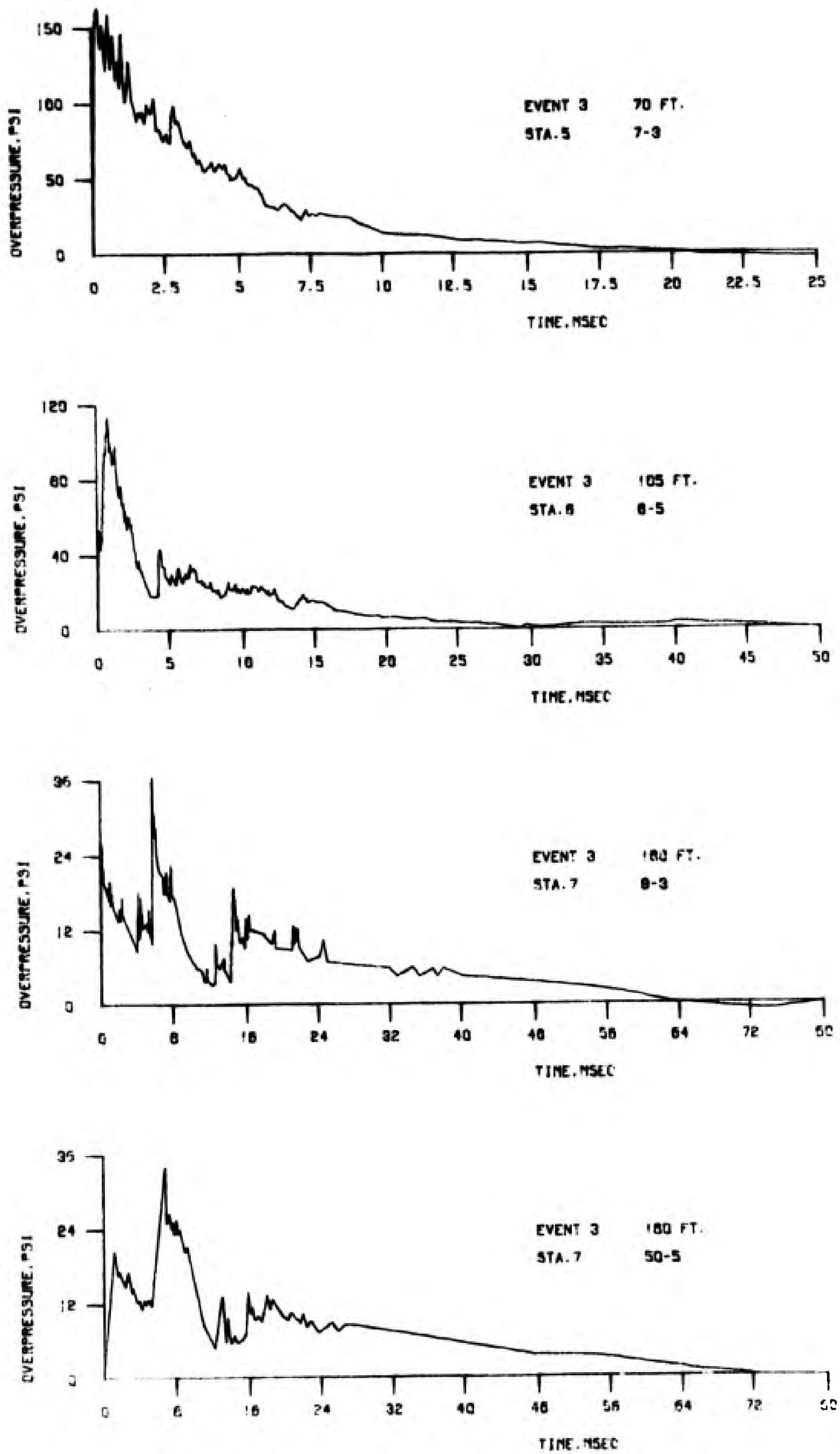

Figure A.2 Overpressure-time records, Stations 5-7, Event 3

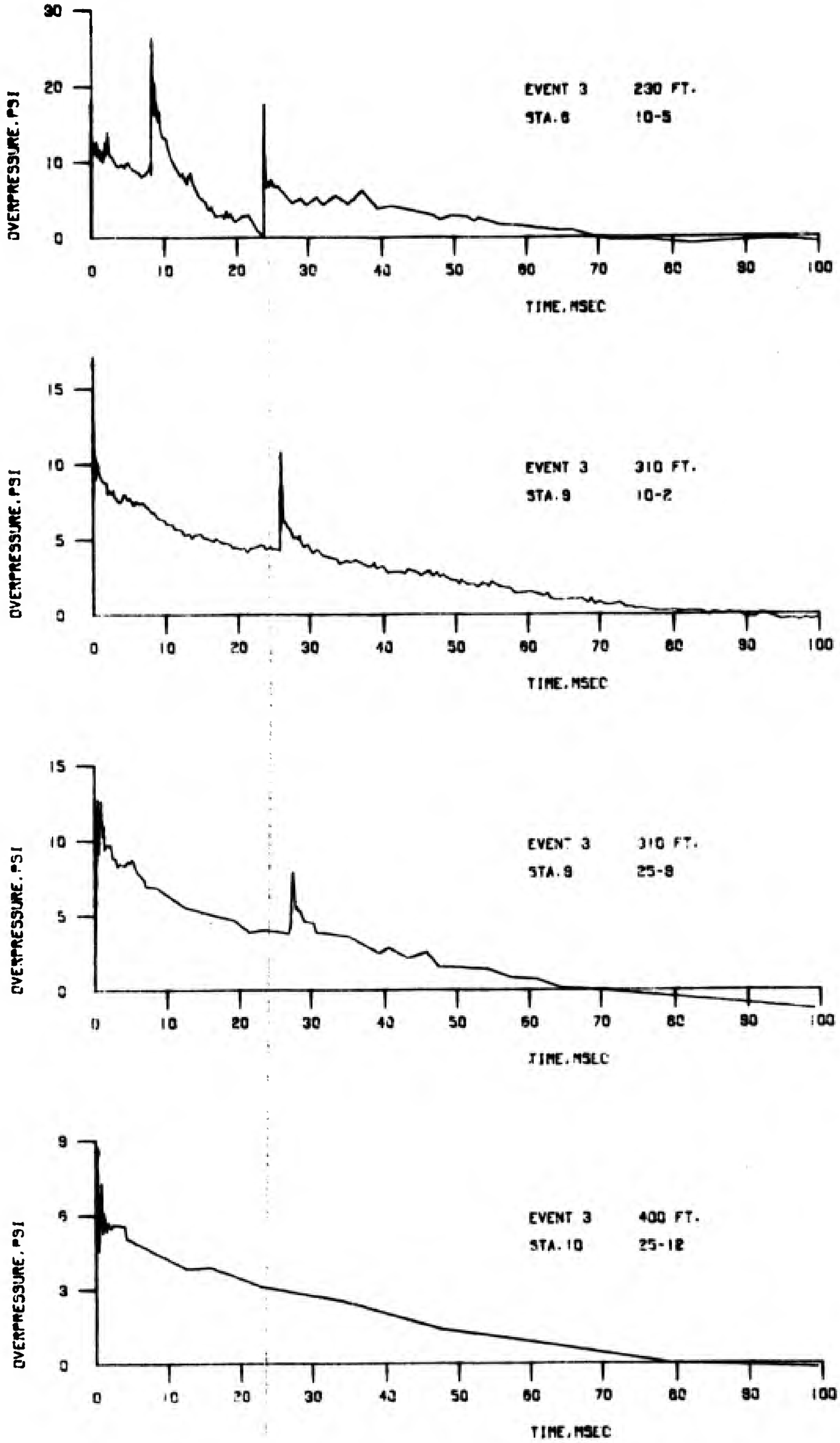

Figure A.3 Overpressure-time records, Stations 8-10, Event 3

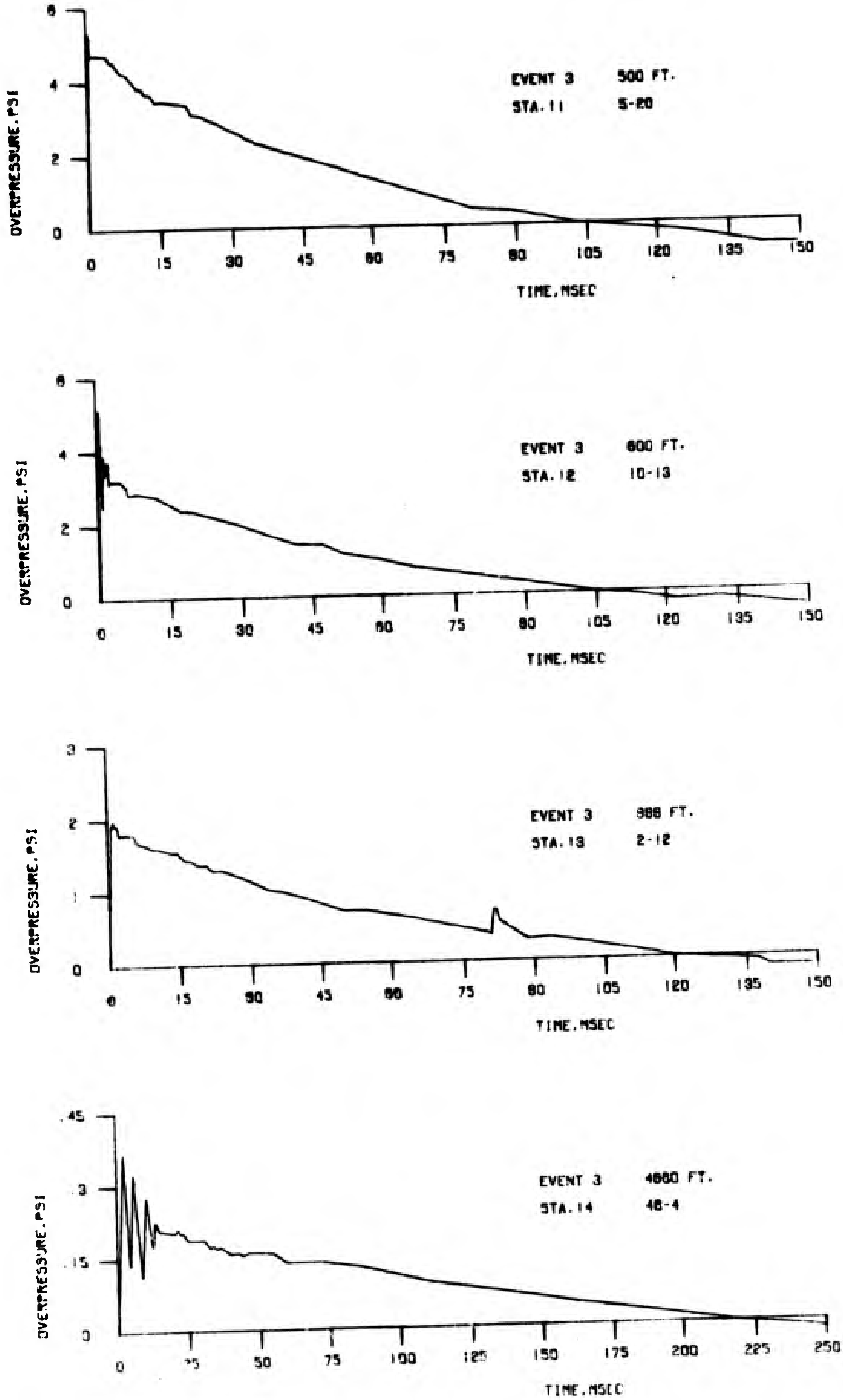

Figure A.4 Overpressure-time records, Stations 11-14, Event 3

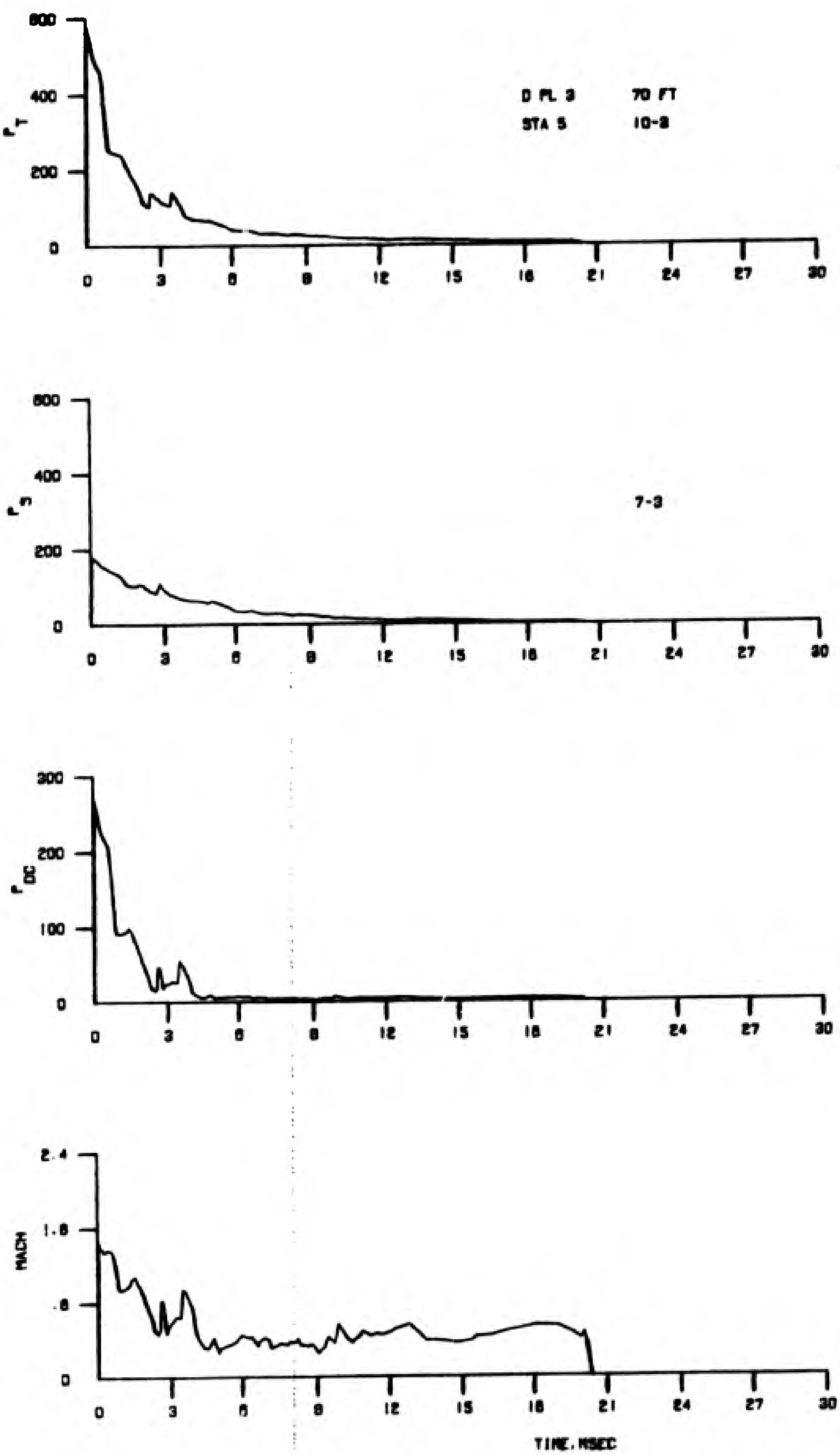

Figure A-5 Dynamic pressure-time data, Station 5, Event 3

APPENDIX B

PRESSURE-TIME RECORDS, EVENT 5
WINTER CONDITIONS

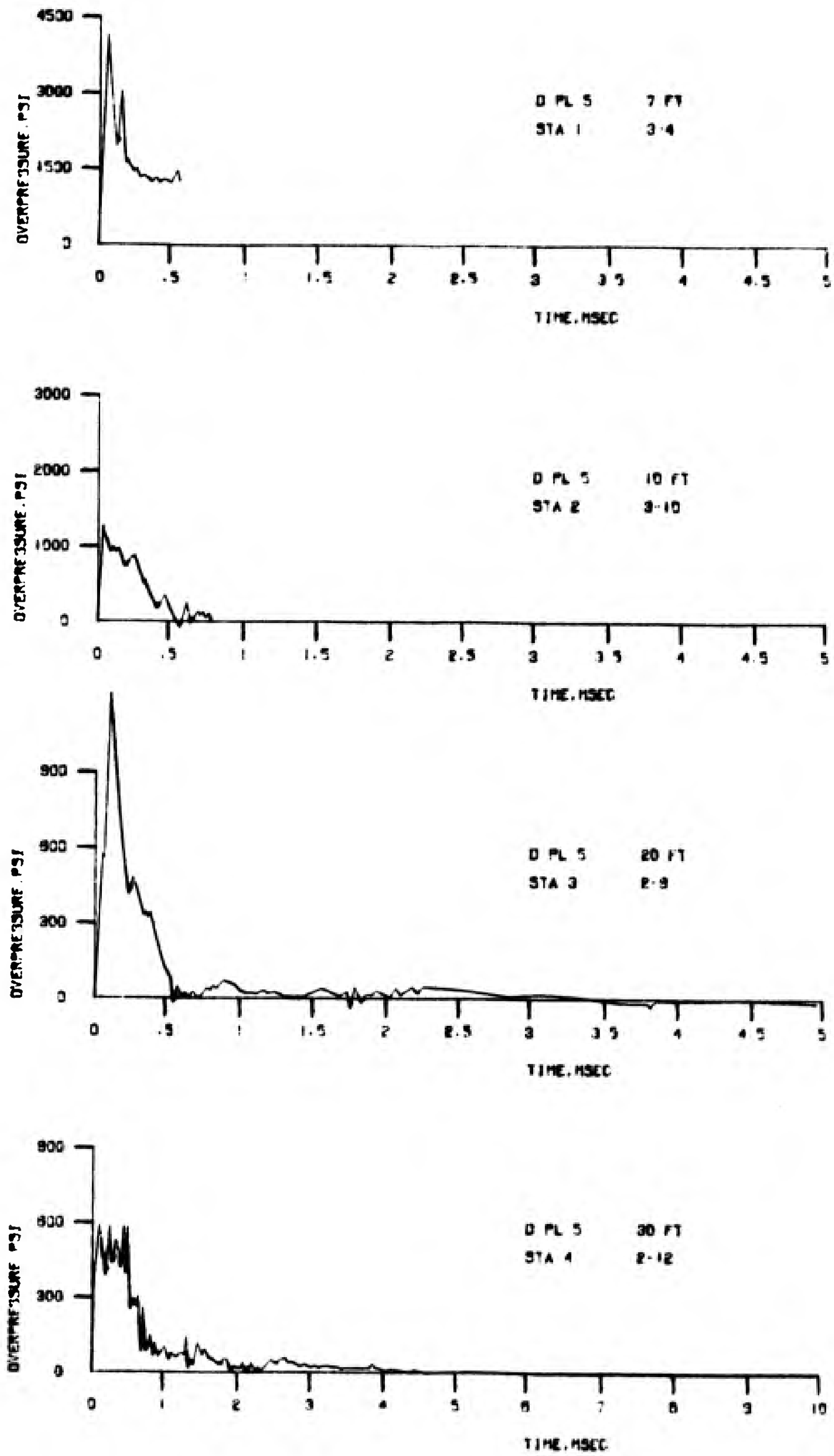

Figure B.1 Overpressure-time records, Stations 1-4, Event 5

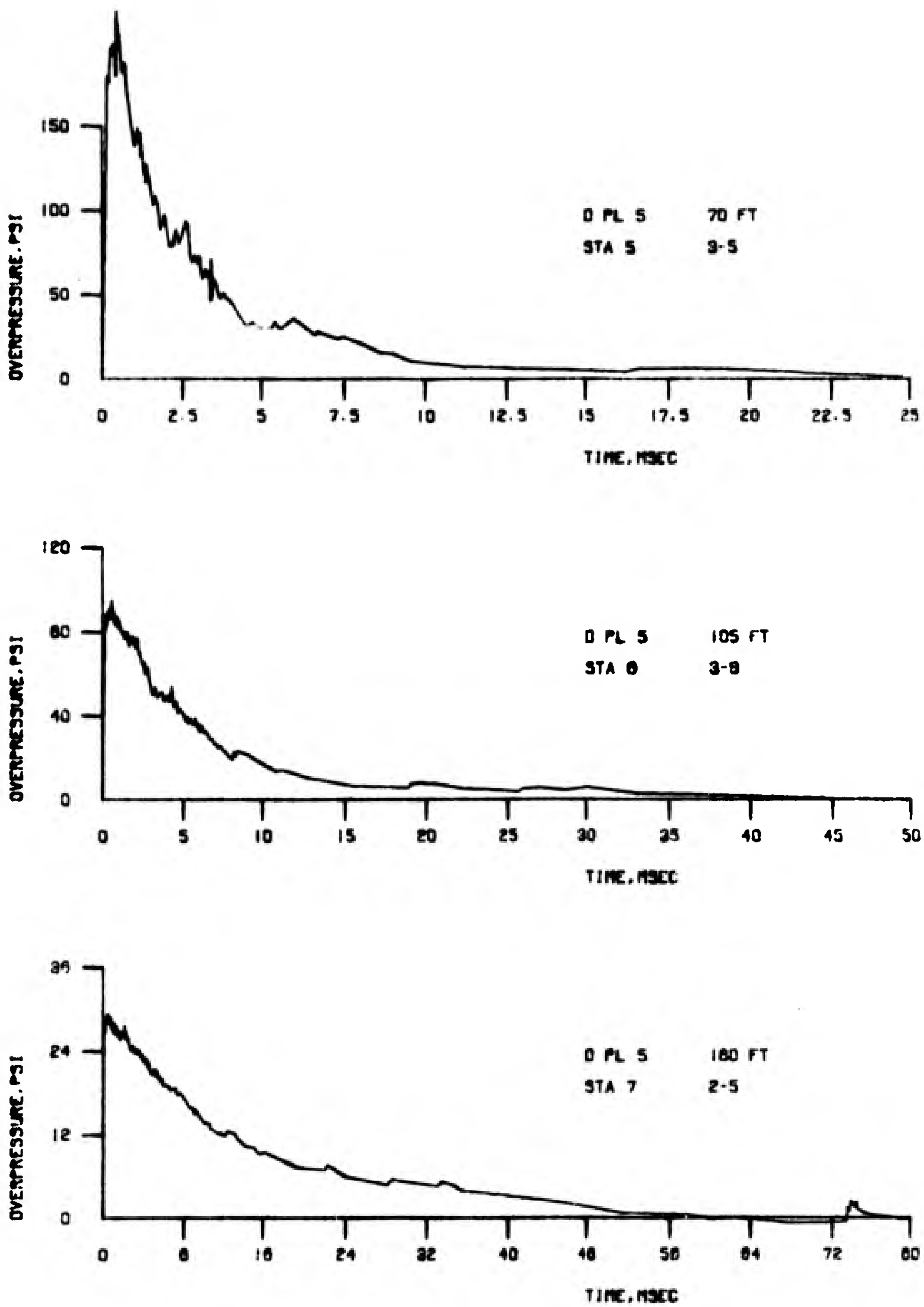

Figure B.2 Overpressure-time records, Stations 5-7, Event 5

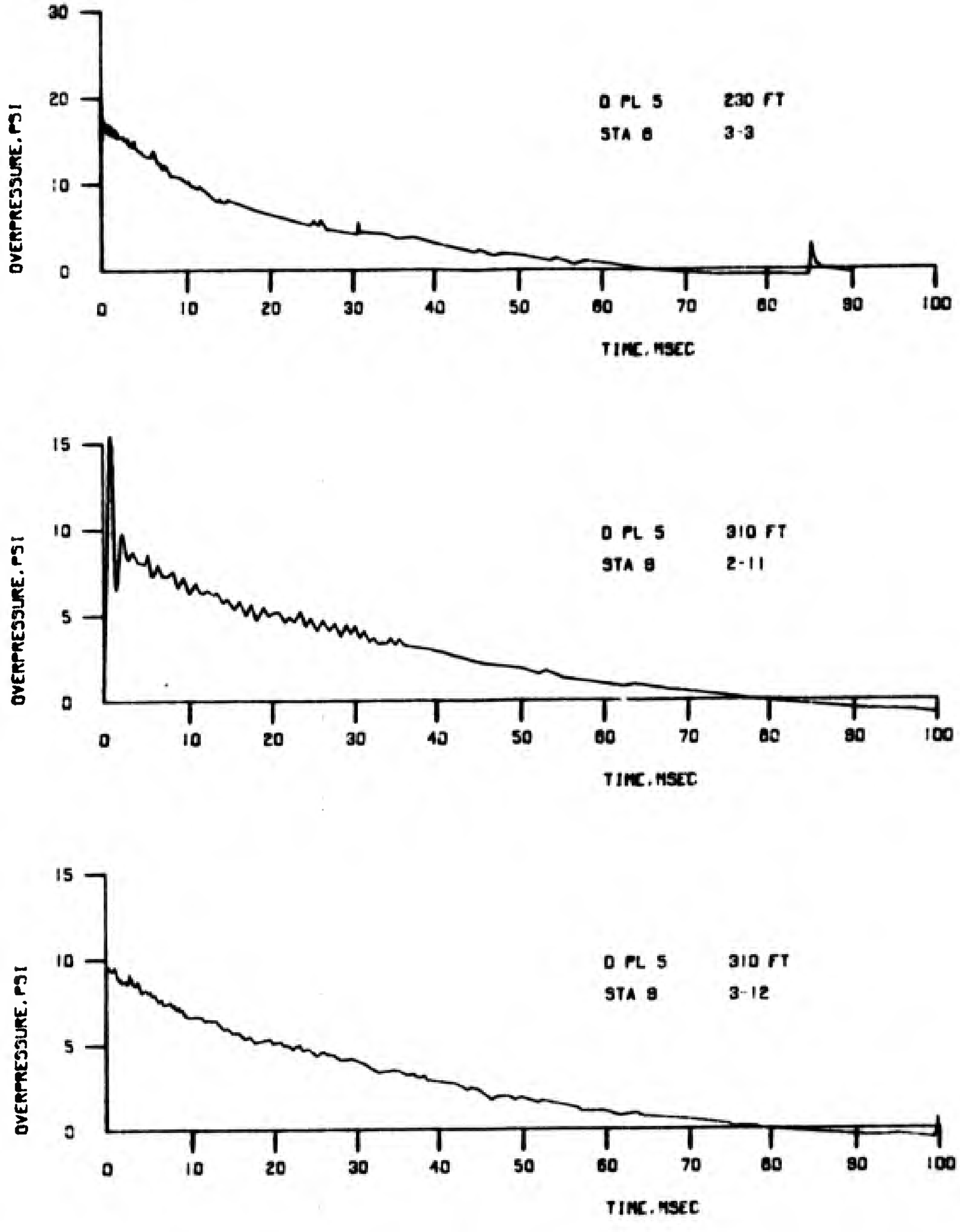

Figure B. 3 Overpressure-time records, Stations 6-9, Event 5

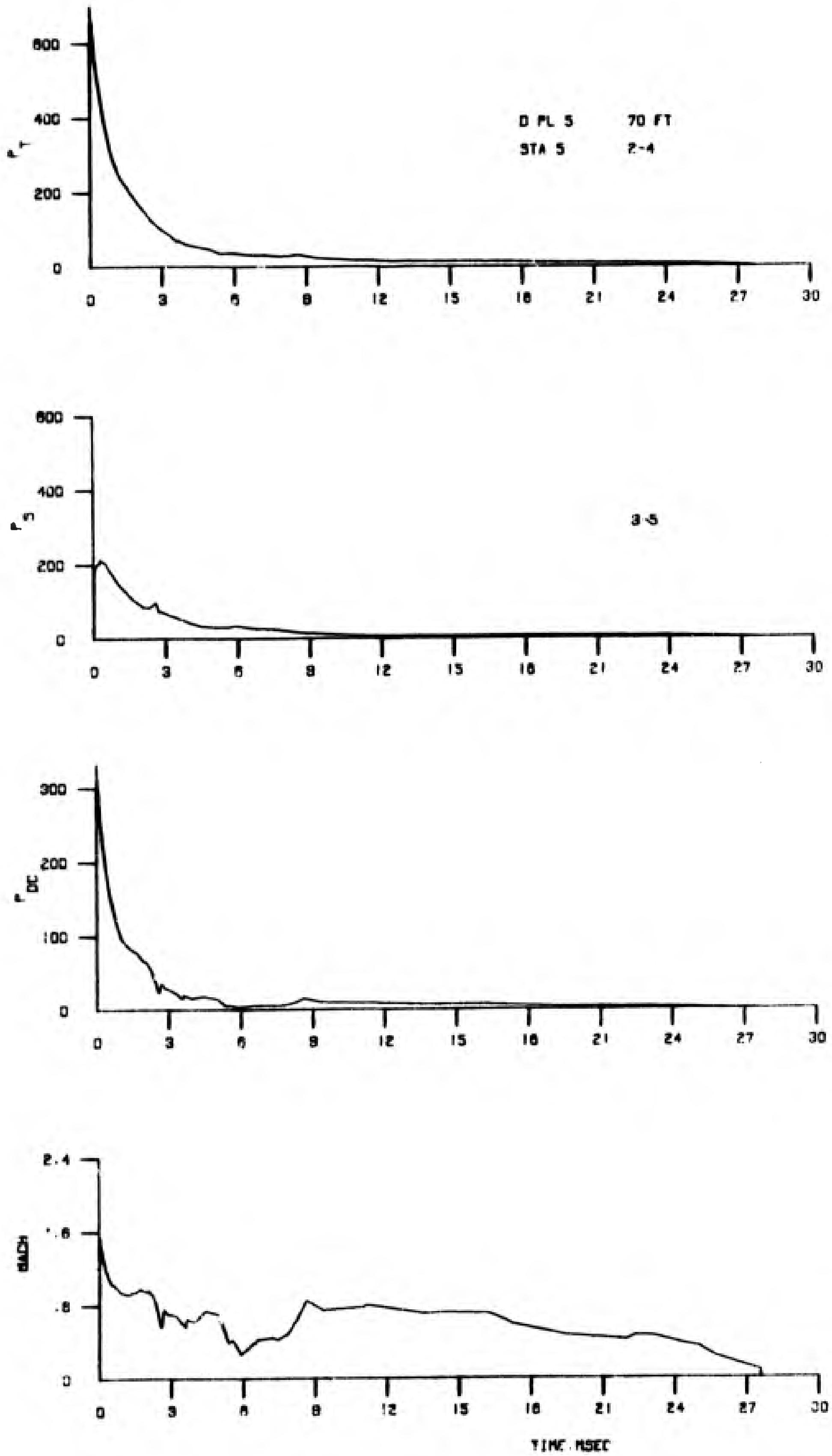

Figure B.4 Dynamic pressure-time data, Station 5, Event 5

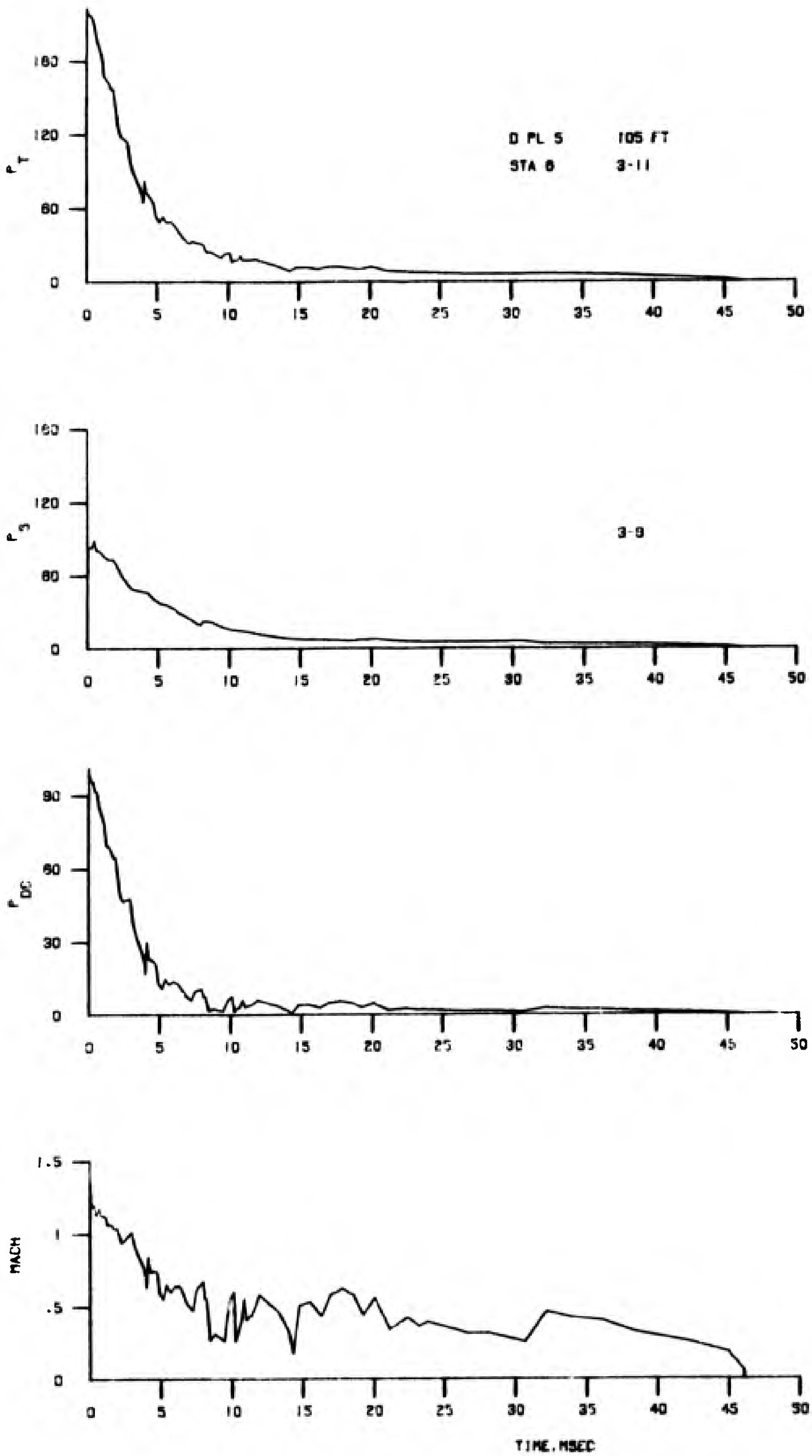

Figure B. 5 Dynamic pressure-time data, Station 6, Event 5

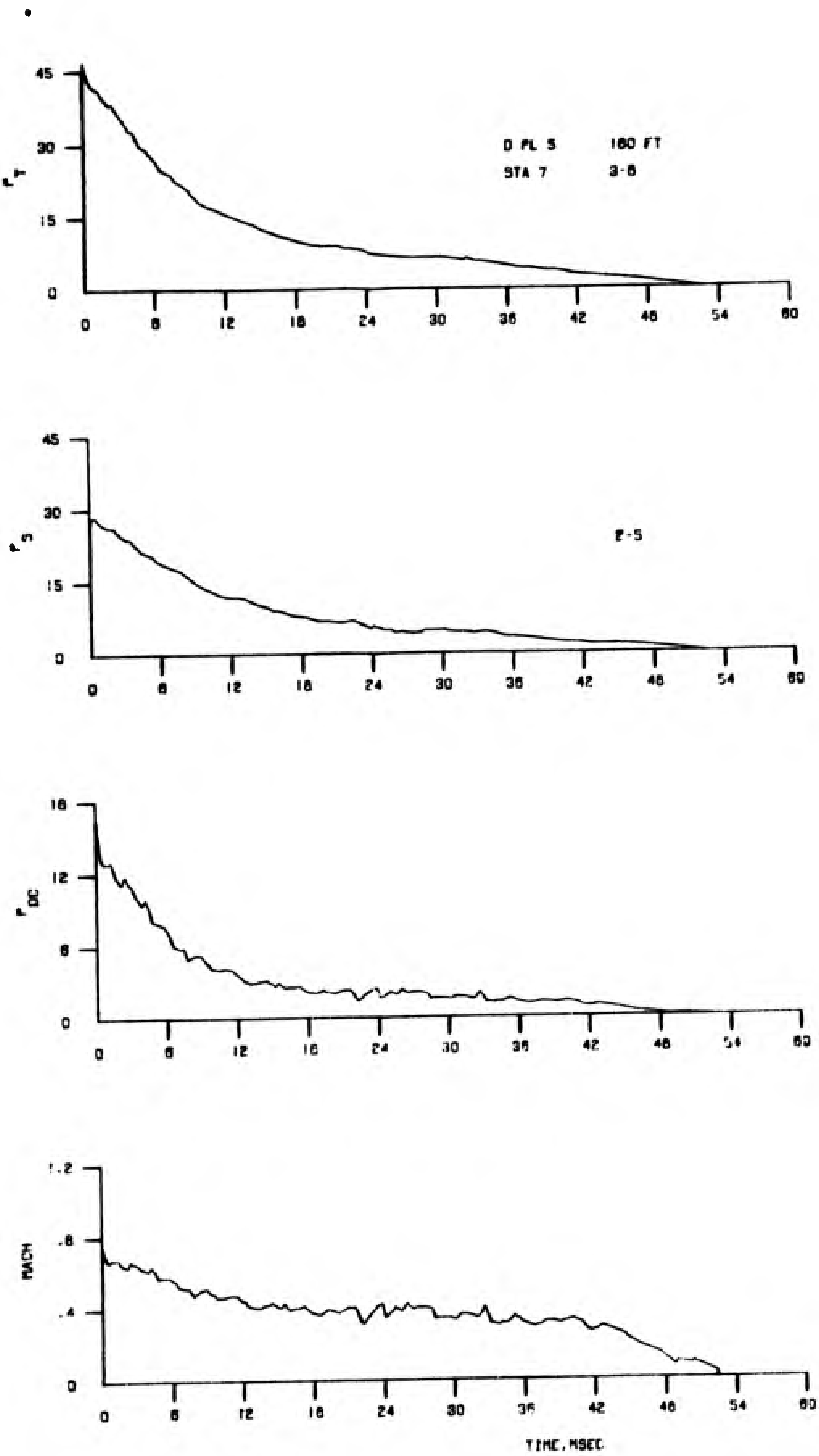

Figure B.6 Dynamic pressure-time data, Station 7, Event 5

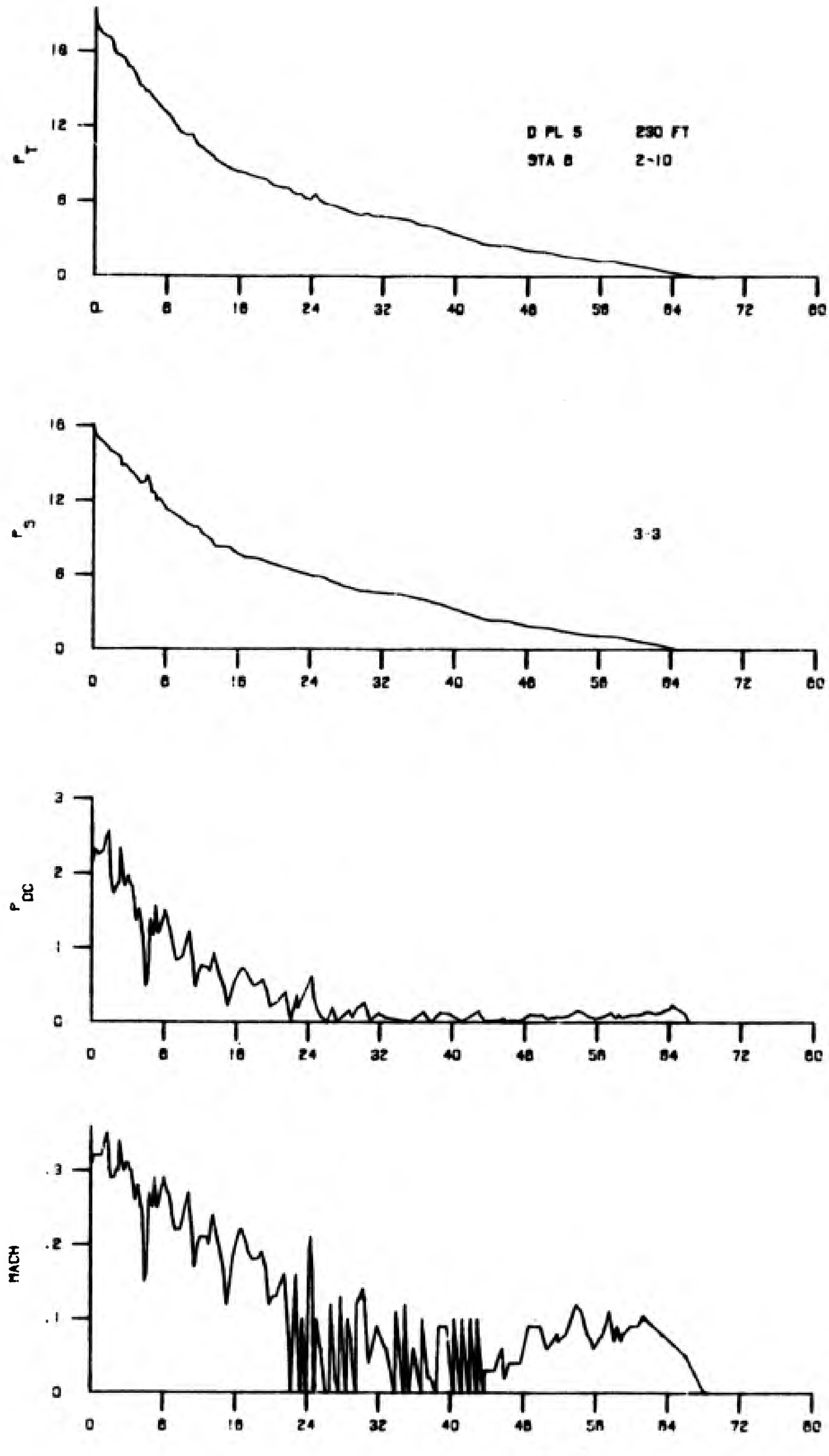

Figure B.7 Dynamic pressure-time data, Station 8, Event 5

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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13. ABSTRACT

Air blast was measured from the detonation of two 20-ton spherical TNT charges positioned with the center of gravity at the air-ground interface. The detonations occurred in an area having a silty-clay alluvium composition. One charge was fired in the summer and the other was fired in the winter when the ground was frozen.

Differences in the air blast phenomena occurred in the pressure region greater than 200 pounds per square inch. These differences were manifested by a lower pressure under winter conditions than under summer conditions. No major differences were observed in the parameters of positive phase duration, positive phase impulse, dynamic pressure and dynamic pressure impulse.

The data agree well with the modifications made to existing height-of-burst charts made after a similar test series at the Nevada test site in 1964 to show less reduction in overpressure for a charge on the surface.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Transducers						
Dynamic Pressure						
Air-Blast Parameters						
Overpressure						
Instrumentation						
Overpressure Impulse						
Height-of-Burst Charts						

Unclassified

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