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Slag Characterization and Removal Using Pulse Detonation Technology During Coal Gasification

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The research activities performed in this quarter (reporting period: 10/01/97-12/31/97) are summarized as follows:

The activities concentrated on:

- Partial analysis of the multi pulse test results
- Data analysis and comparison with that of the single pulse test data

Multi Pulse Test Results Analysis

Several experiments were performed with multi-cycle detonation wave at the Aerospace Research center at University of Texas at Arlington. The effects of tube banks and slag types were reported in the earlier quarterly report (reporting period: 06/01/97-09/30/97). The effects of slag reverberation, sample size, and sample configurations are discussed below.

Effects of slag reverberation

With medium soft slag, the test results show partial removal of slag from all positions of the fixture. Figure 1a and 1b show the picture of medium soft slag attached around the tube before and after the test. Test results show that almost all slag from the front row are chipped-off. Also observed are the shearing off of the slag from the tubes. Similar tests were also performed with hard slag with the same slag removal pattern observed. Some of the test runs with hard slag showed more removal. One of the possible reasons may be that the big chunks of hard slag removed from the front position collided with samples on the downstream positions and aided their removal. Figures 2a and 2b show the pictures of hard slag before and after the test. Pictures show more removal of hard slag from all positions.

Effects of Tube Orientation

Similar tests were performed with three different types of fixture. The results show that for the same type of slag, there is no considerable effect of the wave in removing slag with the axial and triangular configuration fixtures. But the wave have been found to be effective in removing slag with matrix configuration fixture. As explained earlier, wave reflections among tube bundles and collision of slag pieces are the factors which act in favor of removal. Figures 3a and 3b show the pictures of medium soft slag before and after the test using the axial position fixture. There was little effect on slag removal after the first run. But repeating the test for four more times resulted in shearing off of slag at the interface between the tube and the slag. This may be due to high temperature developed during the repeated test runs.

Data Analysis

Voltage readings from the pressure transducers are converted into pressure readings and plotted against time. The pressure plots were used to obtain an experimental wave diagram. The time interval between the observed abrupt rise in pressure from adjacent transducers was used to calculate wave propagation speed. The effect of the expansion wave generated behind the detonation wave was analyzed to determine how long it takes to die out and how it affects the next detonation wave in particular. Pressure data will be analyzed to determine basic system operating parameters such as pressure level, detonation velocity, expansion wave velocity, and cycle time in general.

The pressure developed within the test chamber in single pulse testing varied from 250-350 psi for weak and 450-650 psi for strong detonation wave. On the other hand, velocity varied from 1800-3000 ft/sec for weak and 2200-8000 ft/sec for strong detonation waves. Figures 4-7 show the typical pressure and velocity plots during single pulse slag removal test runs. Figure 7 indicates that the detonation waves inside the chamber follows a series of compression and expansion waves. The waves are converted into Chapmen Jouguet solution before exiting the detonation tube. Figure 8 shows the typical pressure plots in multi pulse testing. The pressure developed at the exit of detonation tube varied from 30 to 50 psia.

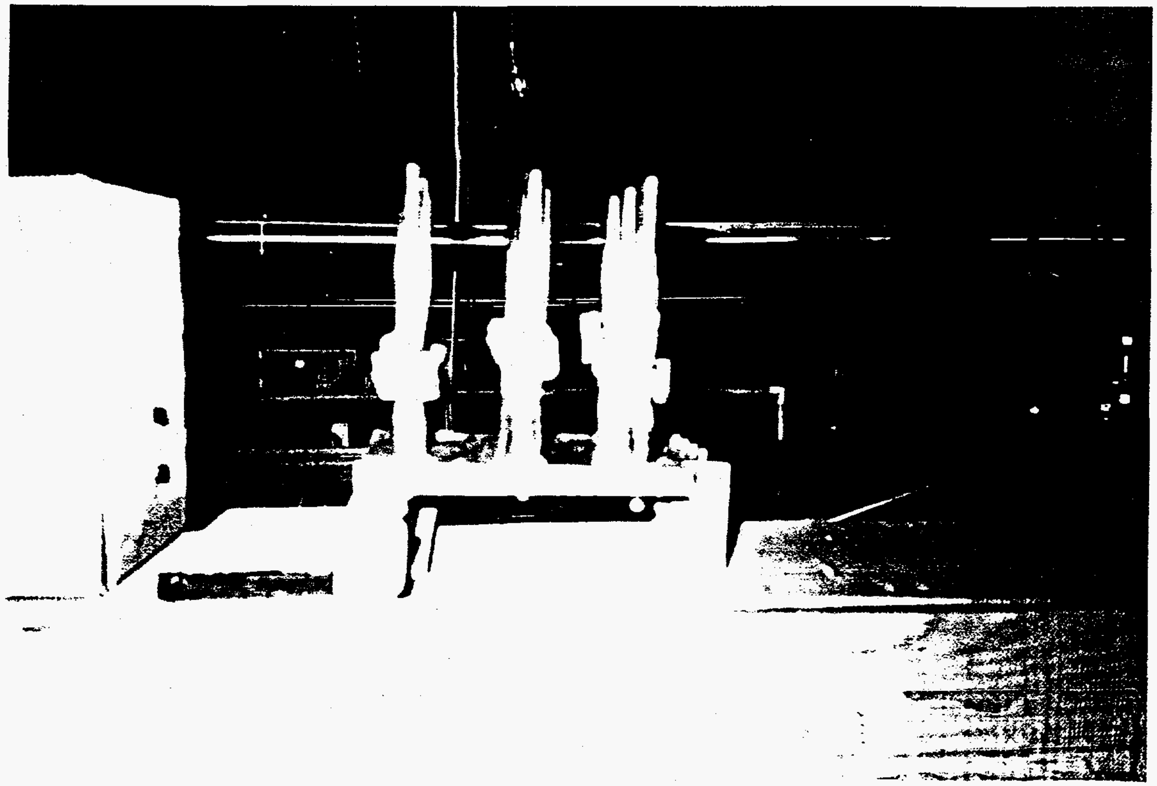

Figure 1a. Medium soft slag with matrix configuration before test

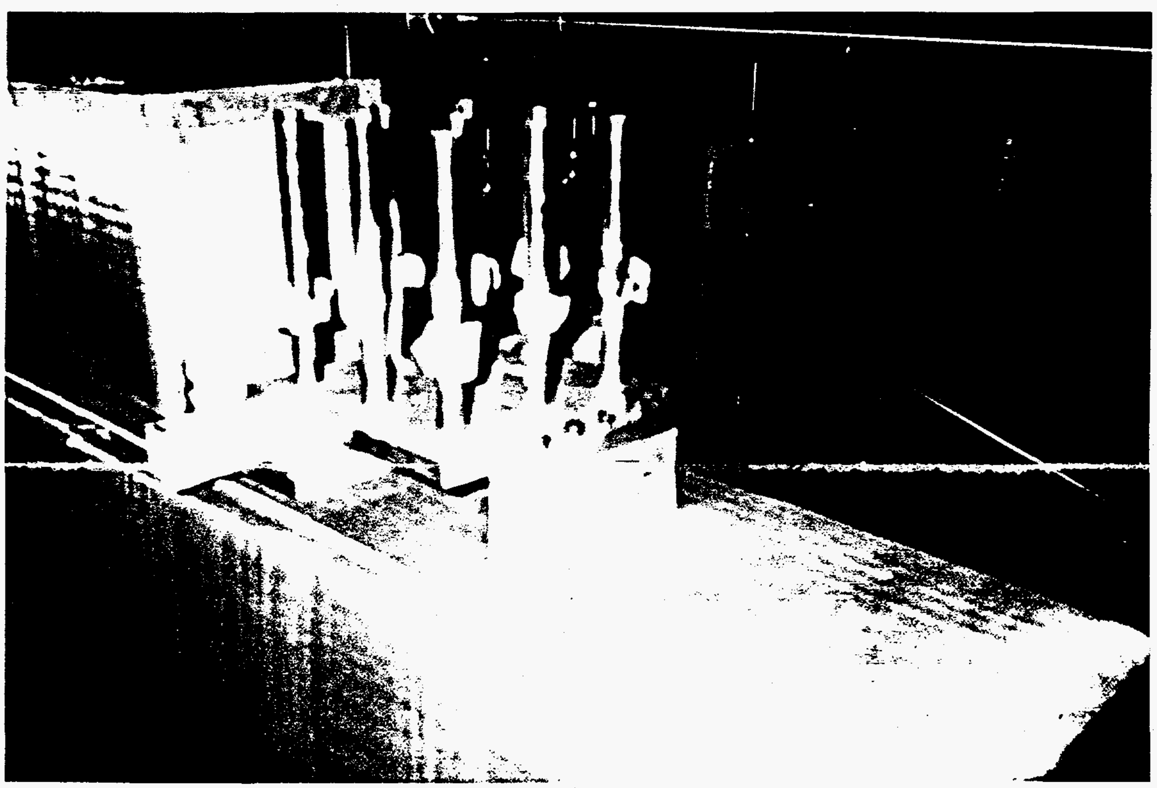

Figure 1b. Medium soft slag with axial configuration after test

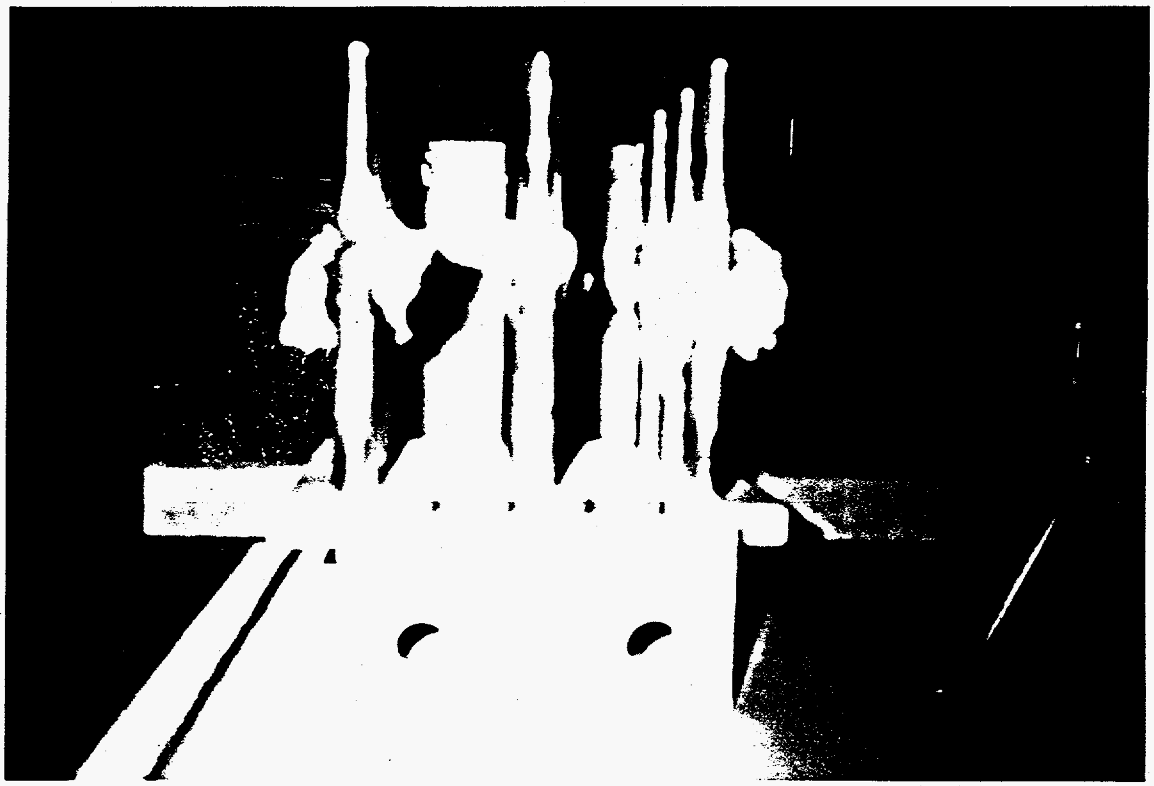

Figure 2a. Hard slag with matrix configuration before test

Figure 2b. Hard slag with matrix configuration after test

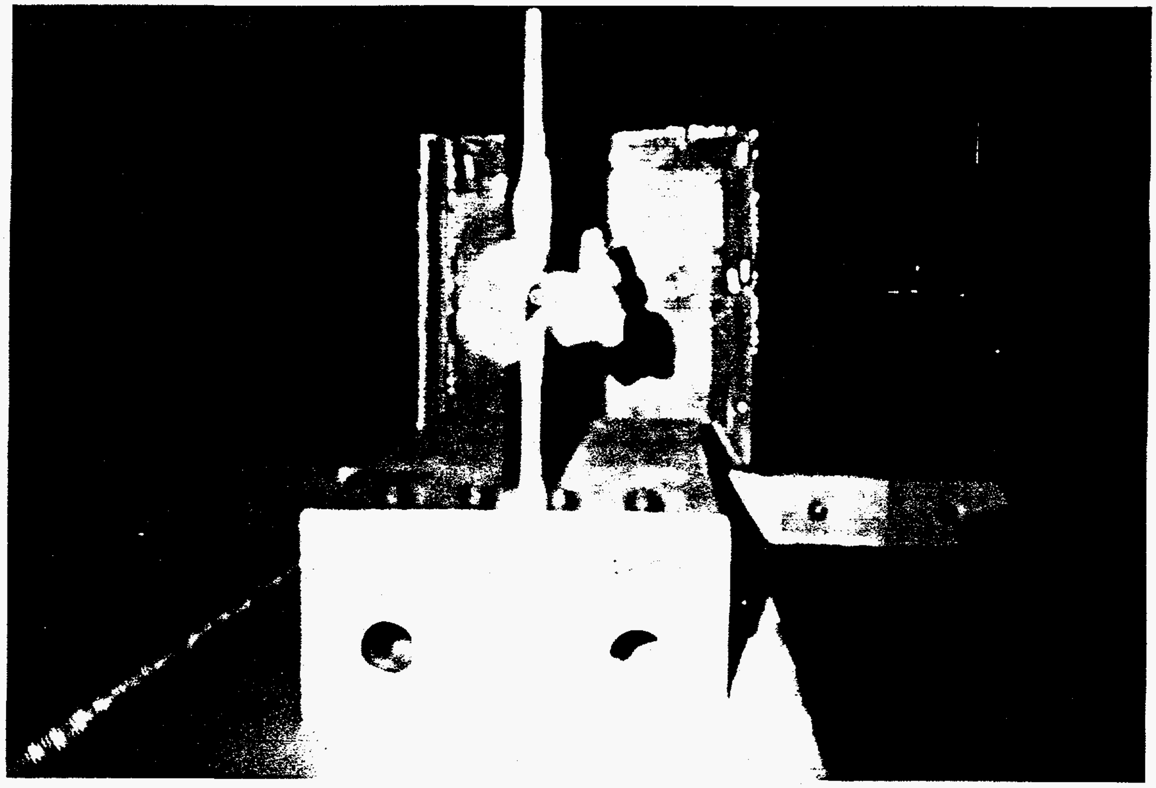

Figure 3a. Medium soft slag with axial configuration before test

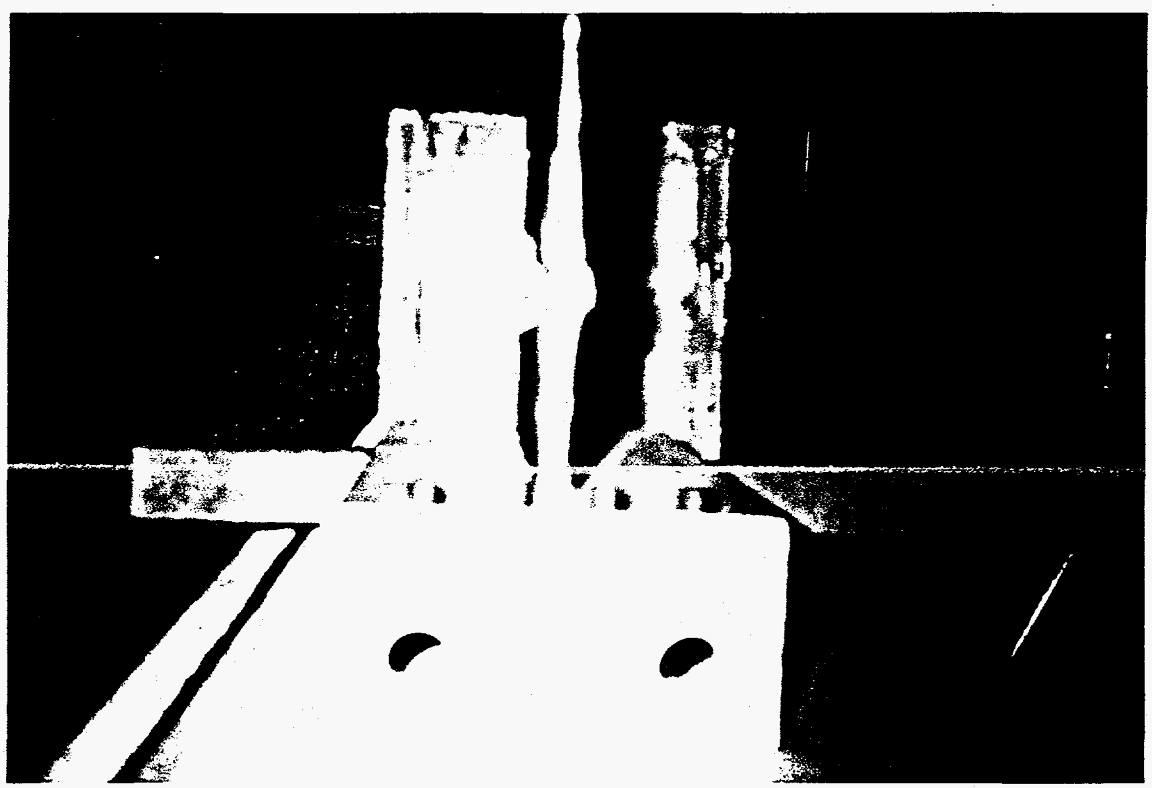

Figure 3b. Medium soft slag with axial configuration after test

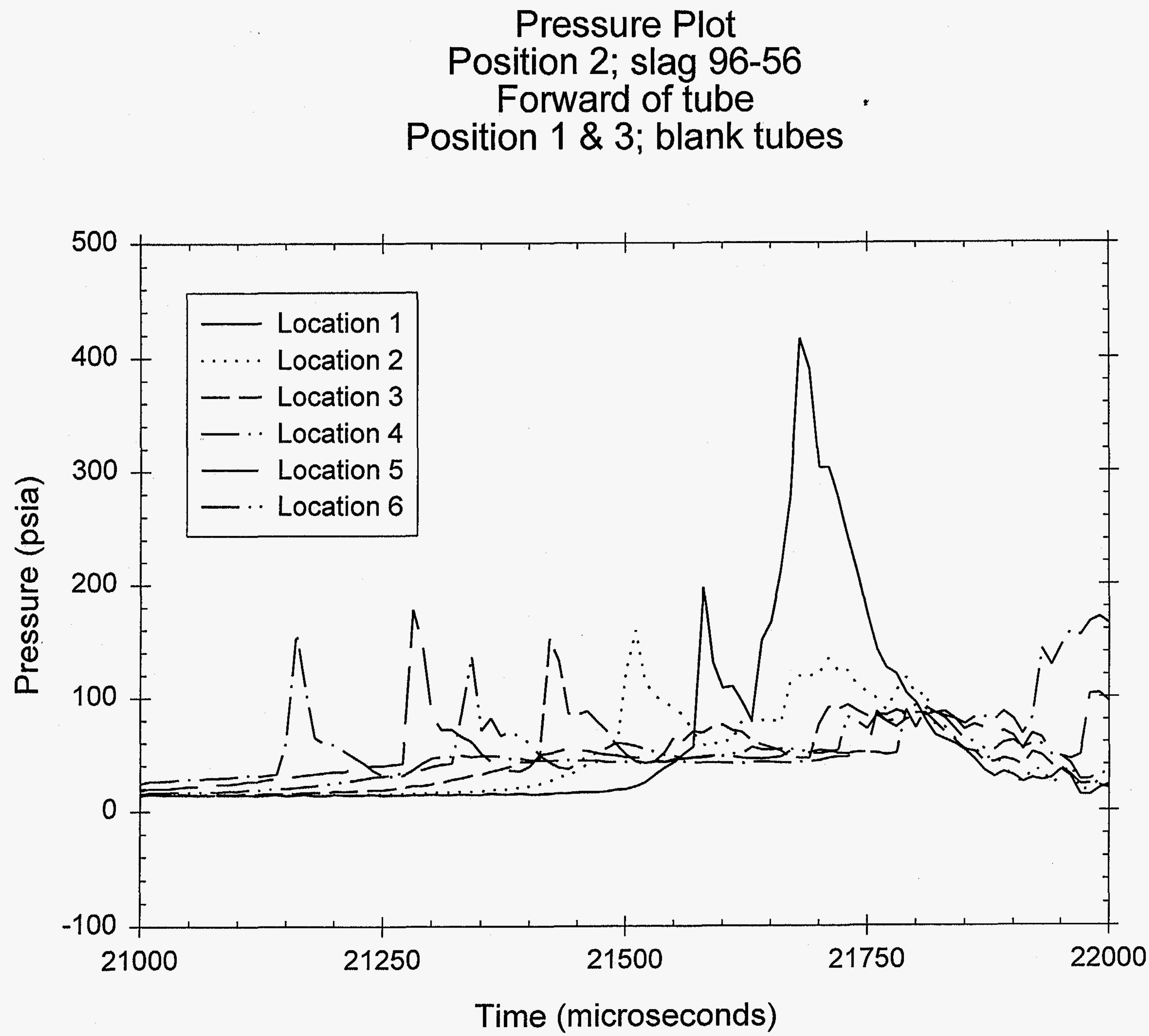

Figure 4. Pressure plot with single pulse detonation wave

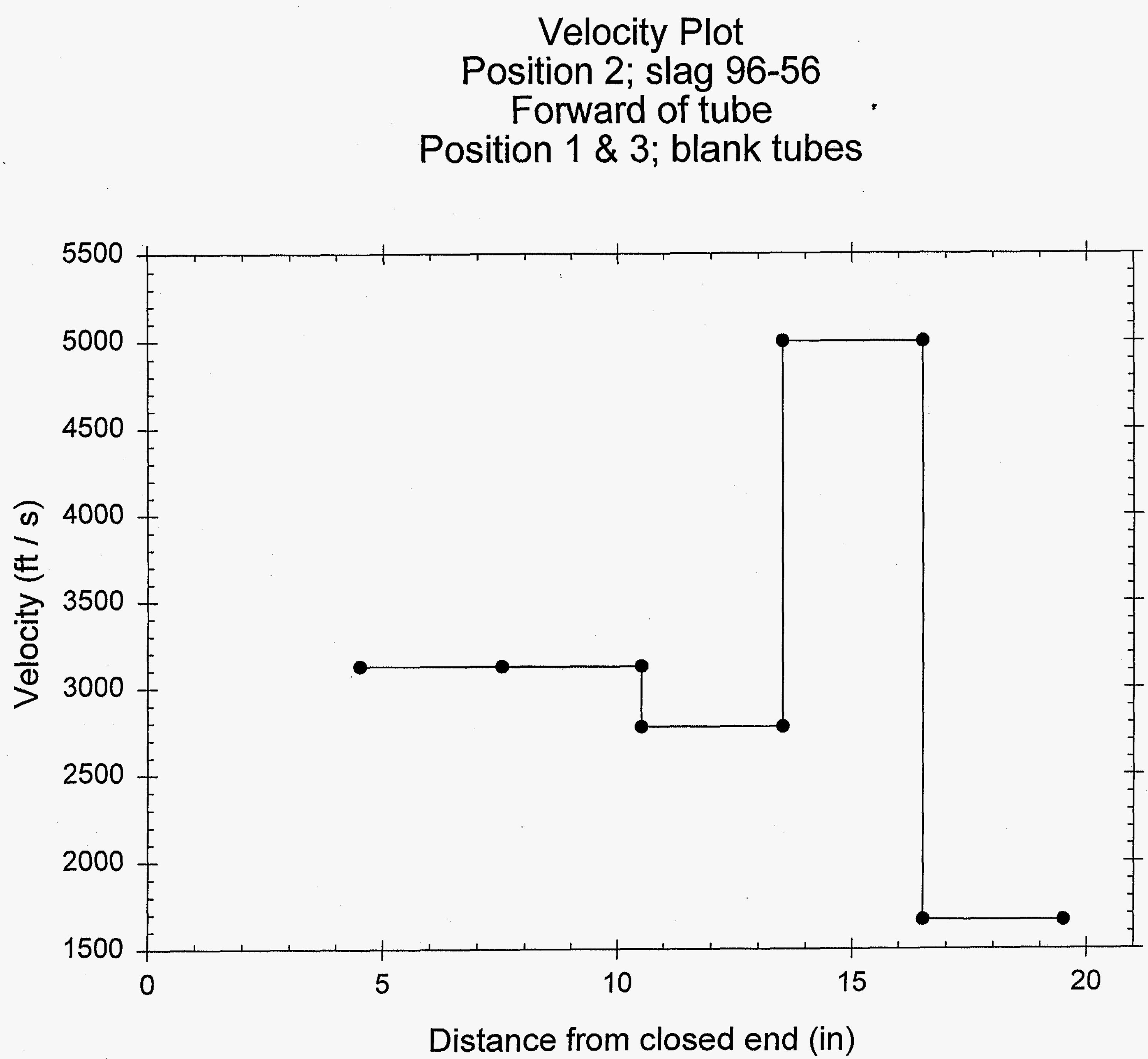

Figure 5. Velocity plot with single pulse detonation wave

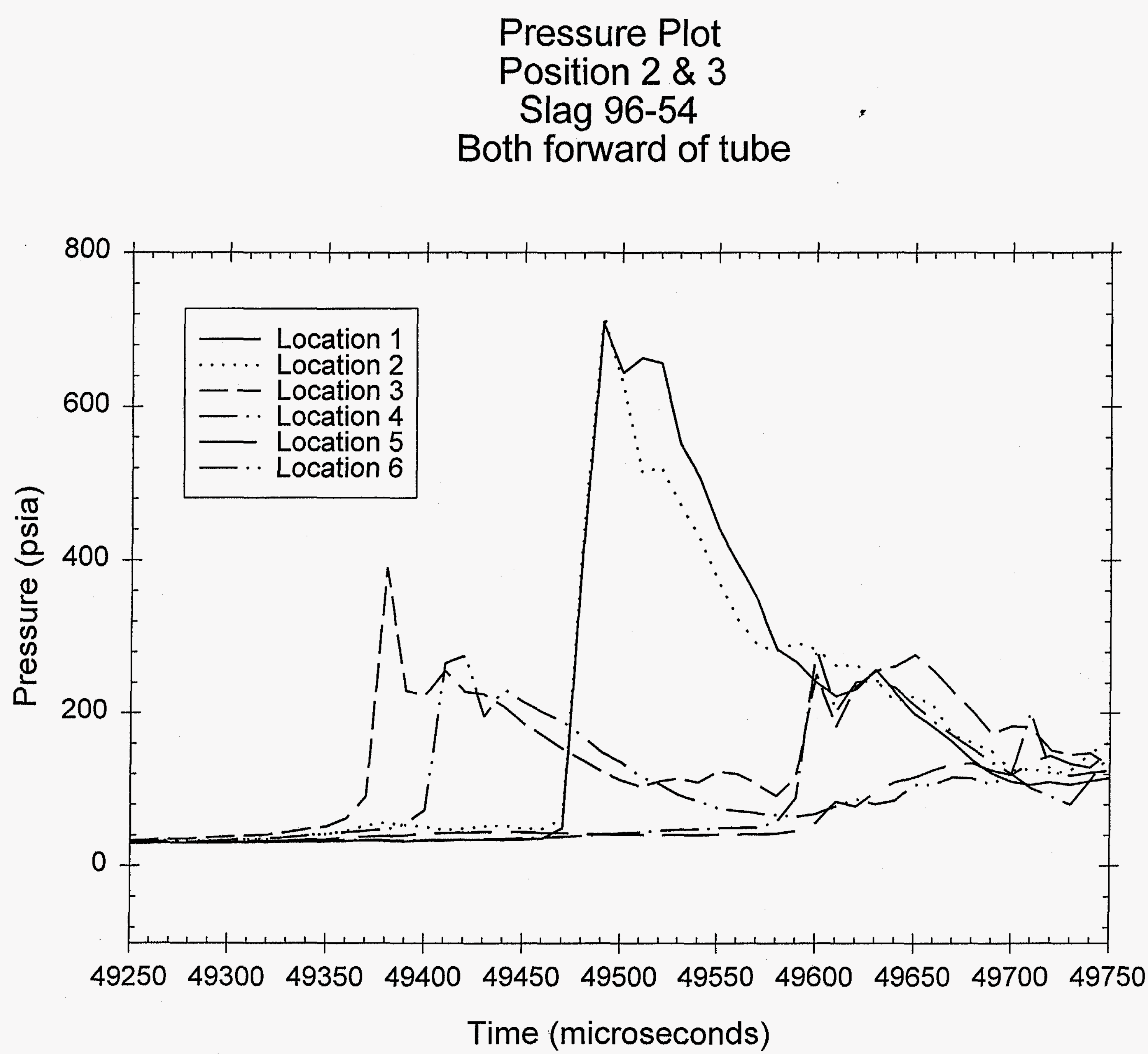

Figure 6. Pressure plot with single pulse detonation wave

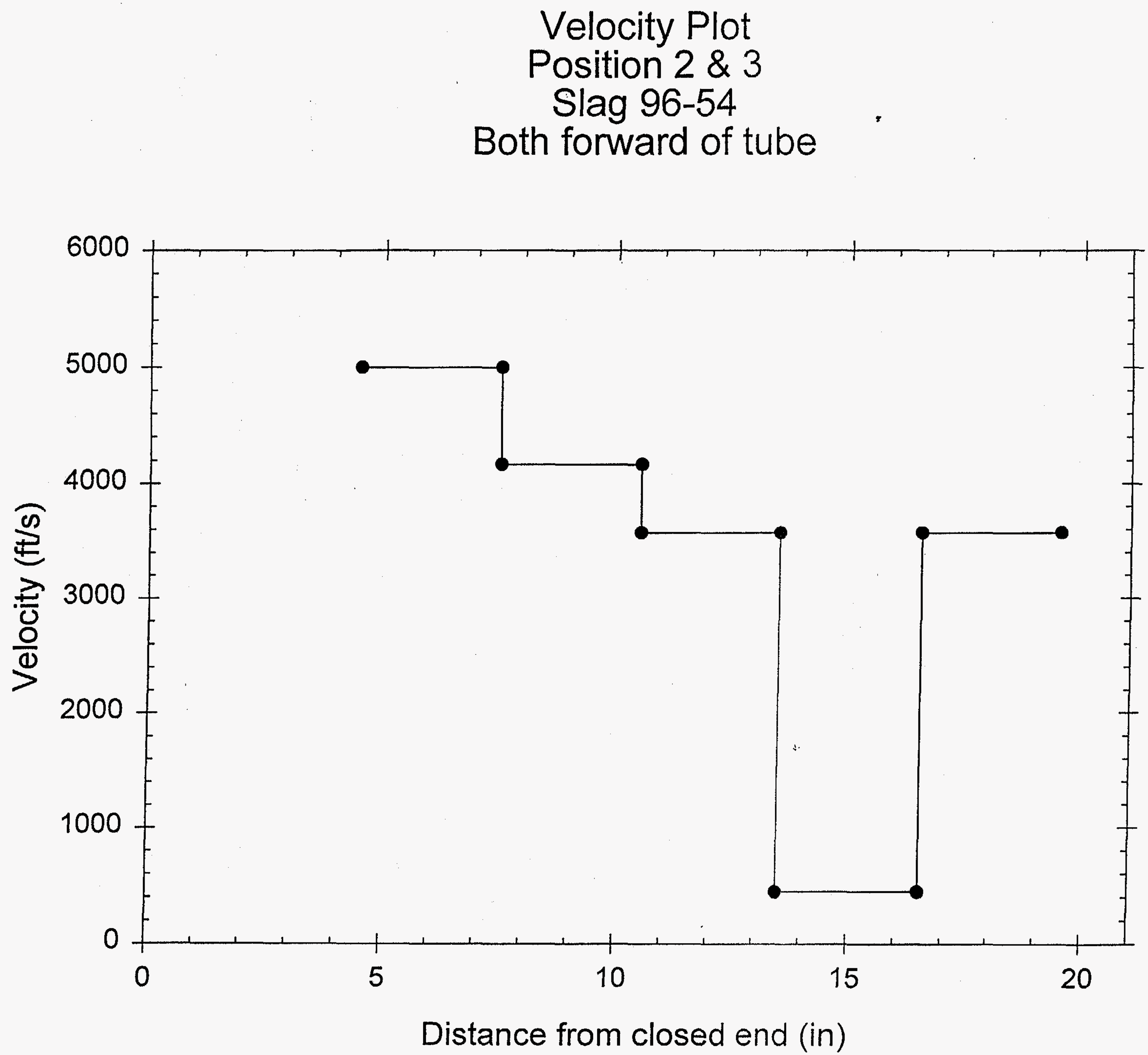

Figure 7. Velocity plot with single pulse detonation wave

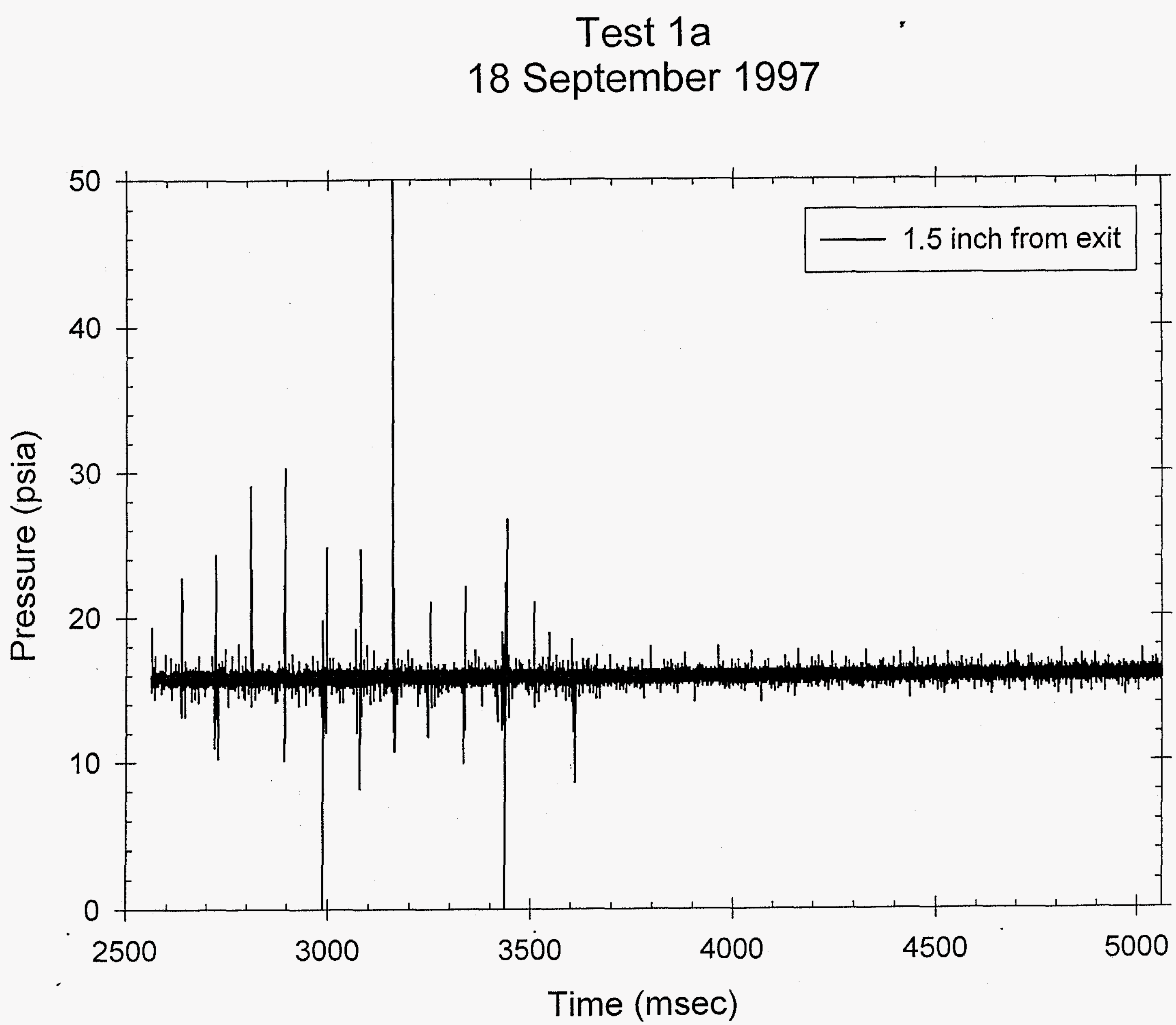

Figure 8. Pressure plot with multi pulse detonation wave