MREL GROUP OF COMPANIES

Operations Manual

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Manufactured By:

MREL SPECIALTY EXPLOSIVE PRODUCTS LIMITED

1555 Sydenham Road • Kingston, Ontario K7L 4V4 • Canada

Tel: +1-613-545-0466 • Fax: +1-613-542-8029 • email: blasting@mrel.com • web site: www.mrel.com

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ABOUT THIS MANUAL

Congratulations on your acquisition of the SuperTrap High Resolution VOD/Data Recorder, manufactured by MREL Specialty Explosive Products Limited (MREL). The instructions in this Operations Manual serve as a reference for the operation of the SuperTrap. For your convenience, the Operations Manual is divided into the following six Chapters:

CHAPTER 1: INTRODUCTION

This Chapter addresses the general features of the SuperTrap; recalls some safety considerations related to the use of instrumentation in a blasting environment; and outlines the main field applications of the SuperTrap for recording explosives velocity of detonation (VOD) and DC voltages.

CHAPTER 2: SUPERTRAP HARDWARE

This Chapter covers issues related to the various hardware components of the SuperTrap; briefly describes the main features of the SuperTrap's front panel; provides details on the SuperTrap power source; and outlines instructions for recharging and long term storage of the SuperTrap. Also included are descriptions of the different types of VOD resistance probes available for use with the SuperTrap and a summary of the technical specifications of the SuperTrap.

CHAPTER 3: VOD FIELD OPERATIONS

This Chapter describes issues related to VOD testing of explosives in the field, and introduces the resistive wire technique for testing small explosive samples and down-the-hole explosive columns. Also presented are safety considerations, lay out and protection of the VOD resistance probes, the setup procedure for the SuperTrap and a detailed description of the SuperTrap's main features in preparation for field applications.

CHAPTER 4: DC VOLTAGE FIELD OPERATIONS:

SuperTrap setup considerations as applied to DC voltage recording are presented in this Chapter.

CHAPTER 5: SUPERTRAP SOFTWARE

This Chapter deals with the computer requirements and installation of the 32 bit Windows ’95 Advanced Analytical Software included with the SuperTrap. This Software allows the analysis and presentation of both VOD data and DC voltage information, and is the result of upgrading MREL’s proven MiniTrap^{II} and DataTrap-Scope Module Analytical Software. All the features and menu functions of the Software required for analysis and presentation are described.

CHAPTER 6: EXAMPLES OF DATA ANALYSIS

This Chapter provides a detailed analysis of available experimental VOD and DC voltage information, starting with the selection of the data and followed by its analysis and formatting for presentation. Several examples are discussed including VOD of small explosive samples and down-the-hole experiments as well as DC voltage analysis of experimental data generated from an acceleration transducer.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The SuperTrap High Resolution VOD/Data Recorder is the newest member of the family of velocity of detonation (VOD) and data recorders manufactured by MREL. The SuperTrap is a portable, 2 channel, high resolution data acquisition instrument specifically designed to record the continuous VOD of explosives. It has the added capability to simultaneously function as a digital oscilloscope, recording voltage signals generated from any type of DC voltage (VDC) sensor. This allows the SuperTrap to record transient events such as explosion pressures, air blast, etc. The SuperTrap has proven its reliability under the extreme temperature, weather, dust and rugged conditions which characterize mining environments around the world.

The associated SuperTrap Advanced Analytical Software allows the operator to analyze VOD traces and convert DC voltage signals recorded by the SuperTrap into the desired engineering units for analysis and presentation. The Software is used to retrieve, display, analyze, print and export VOD and VDC data. The Software runs under 32 bit Microsoft Windows '95, which facilitates extremely fast data handling and the ability to copy and paste SuperTrap graphics into any word processors and/or spreadsheets running under Windows '95.

The SuperTrap High Resolution VOD/Data Recorder is the result of merging and enhancing the most important features of the two most successful recording instruments manufactured by MREL: the 1 channel MiniTrap^{II} Explosives Continuous VOD Recorder and the 16 channel DataTrap Multi-Purpose Data Recorder.

In addition to many of the capabilities of the MiniTrap^{II} and DataTrap, the SuperTrap has the following features:

- Two channels capable of recording at 5 MHz (5 million points/sec) independently of the number of channels used. The channels can be used to simultaneously record VOD data, VDC data or both, without affecting the recording rate.
- A large circular memory bank (24 million data points) to store the recorded data. This allows the SuperTrap to record for relatively long periods (5.0 seconds when recording on one channel at a rate of 5 MHz; or 2.5 seconds when recording on two channels at a rate of 5 MHz).
- A high, 14 bit vertical resolution (2^{14} or 1 part in 16,384).
- The capability to store up to 16 events in its permanent (non-volatile) memory before having to download the recorded data to a computer.
- DC voltage recording capabilities, allowing the SuperTrap to perform as a digital storage oscilloscope.
- Capability to download information through the LPT1 parallel printer port using the PC's Enhanced Mode capability. Therefore, the downloading procedure is five times faster than with RS232 cable connections.

1.2 SAFETY CONSIDERATIONS

The SuperTrap is an easy and safe instrument to operate, however, one should be aware of the inherent risk associated with explosive's handling and with working in blasting environments. For this reason, it is always recommended that knowledgeable personnel, experienced in handling explosives and familiar with blasting procedures, operate the SuperTrap. The standard rules of safety used with explosives should apply when monitoring VOD or other explosive parameters. Persons not trained and/or authorized to handle explosives should not attempt to utilize the SuperTrap for monitoring explosive properties.

When recording VODs, the SuperTrap outputs a low voltage and an extremely low current (less than 50 mA) to the probes within the explosives. This low excitation signal ensures that the SuperTrap will not prematurely initiate explosives and/or detonators. When the SuperTrap is used to record DC voltage data (i.e. using the scope settings), no voltage or current is applied to the transducers. Note: any excitation signals required by the transducers must be supplied by gauge manufacturers or distributors.

Standard (and common sense) rules apply when it comes to the presence of electrical storms near the testing area. Due to the inherent hazards associated with blasting during these storms, in addition to the possibility of electrical interference causing false trigger signals to the SuperTrap, it is recommended to immediately suspend all blasting activities and evacuate the area. This is standard policy at most blasting operations.

1.3 MAIN FIELD APPLICATIONS OF THE SUPERTRAP

When used as an explosives continuous VOD recorder, the main applications of the SuperTrap include:

1.3.1 Testing of Explosive Samples

Test the performance of explosives against the quality control standards set by the manufacturers.
Measure the continuous VOD in any charge diameter under confined or unconfined conditions.
Determine the critical diameter and critical density of an explosive charge.
Determine the gap sensitivity of explosives.
Measure the timing accuracy of detonators.
Measure the continuos VOD of primers.
Determine the minimum primer size for any explosive by measuring run-up velocities.

1.3.2 Testing of Explosives Down-the-Hole

Measure the continuous VOD in any hole diameter.
Measure the continuous VOD in multiple holes per blast.
Determine whether full detonation, low order detonation or failure occurred and where in the explosive column it happened.
Check VODs against manufacturers' specifications in full scale blasting environments.
Determine the effects of detonating cord downlines on explosive columns.
Determine the minimum primer size for any explosive by measuring run-up velocities in full scale blasting environments.
Measure the timing accuracy of detonators in full scale blasting environments.
Measure the effects of water, drill cuttings, rocks, etc. trapped within the explosive mass.
Determine the length of explosive column to use in decking operations to evaluate the effect of stemming and drill cutting dilution, water pick-up, etc. on the explosive run-up requirements.
Determine the correct length and type of stemming material to be used between decks of explosives to prevent sympathetic detonation or explosive desensitization from occurring.

1.3.3 Recording DC Voltages from Gauges

As previously mentioned, the SuperTrap has the ability to function as a digital oscilloscope to record DC voltage signals from a wide variety of commercially available gauges. Typical applications of the SuperTrap when used as a voltage recorder include:

Measurement of detonation pressure using calibrated PVDF (polyvinylidene fluoride) gauges.
Measurement of air blast over-pressures using commercially available air blast pressure transducers.
Measurement of cross-borehole pressures using carbon composition resistors and/or commercially available tourmaline gauges.

Measurement of vibration parameters using commercially available displacement, velocity or accelerometer transducers.
Measurement of temperatures using commercially available thermocouples.
Measurement of strains using commercially available strain gauges.
Measurement of any phenomena that can be instrumented with gauges producing DC voltage signals in the range from -10 to +10 volts.

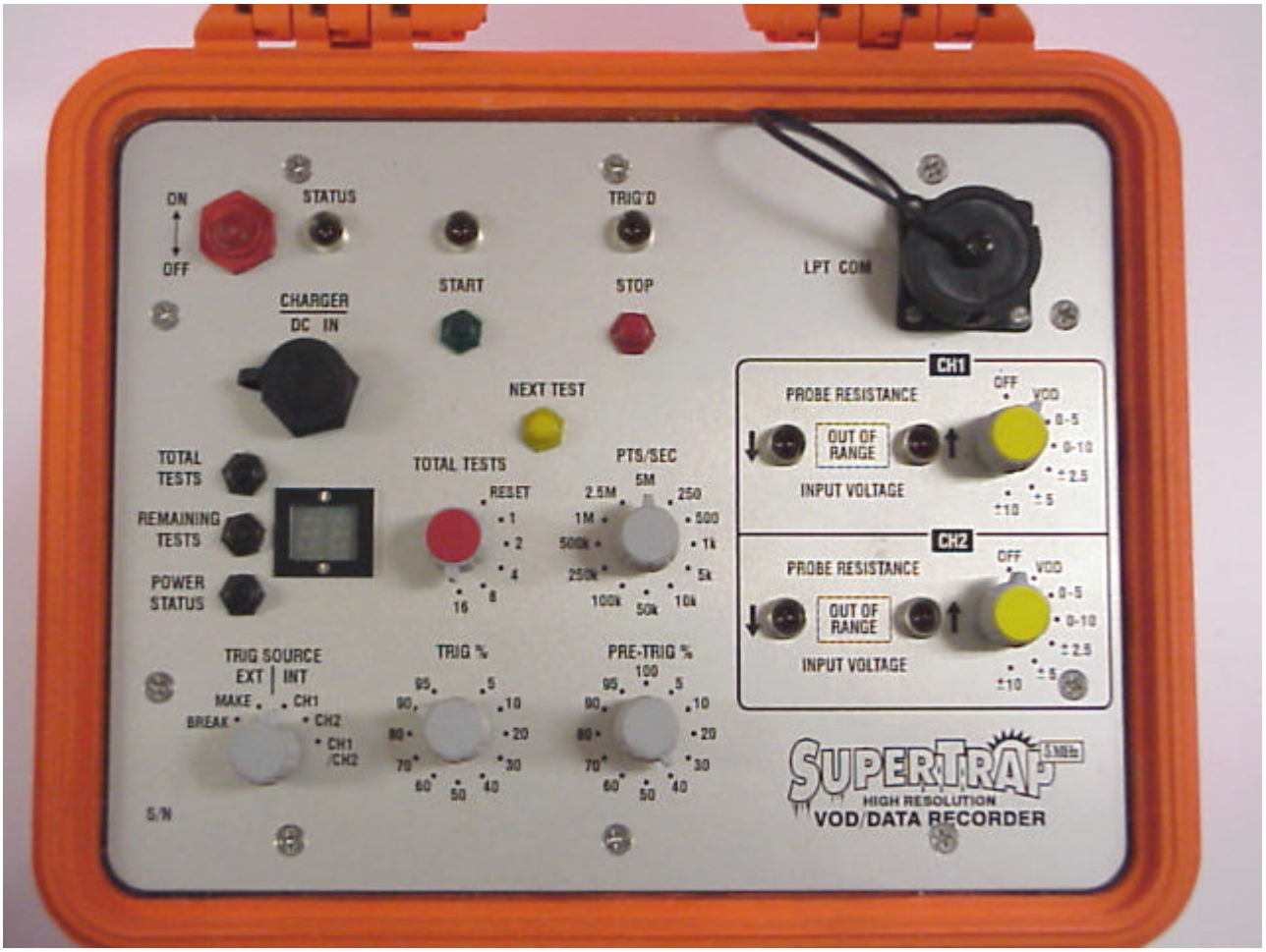
CHAPTER 2: SUPERTRAP HARDWARE

2.1 SUPERTRAP HARDWARE COMPONENTS

The hardware components of the SuperTrap System include the **SuperTrap** itself, a **Carrying Bag**, a **Battery Charger**, an LPT1 **Communications Cable**, three (3) **BNC Adapters** and two (2) **200 ohm BNC Adapters**. Also included with the SuperTrap are the **Operations Manual** and the SuperTrap Advanced Analytical **Software**. A brief description of each of the hardware components follows.

2.1.1 SuperTrap

The SuperTrap contains electronic circuitry and an internal rechargeable battery pack within a protective plastic case measuring 28x25x18 cm (11x10x7 in.) and weighing approximately 4 kg (8.8 lbs.). The protective case prevents damage from water, sand, snow, dust and similar harsh weather conditions. As well, the case offers resistance to high temperatures, shocks and vibrations. The SuperTrap's front panel is shown below.



The main features on the front panel of the SuperTrap are outlined below:

The **ON/OFF** switch is used to provide power to the SuperTrap.

The **STATUS** indicator light, which has three working modes:

In *Active* mode, the light is illuminated, indicating that the SuperTrap is ready for the operator to adjust the SuperTrap settings and press the **START** button. When the **START** button is pressed, the SuperTrap begins to monitor the event to be recorded while awaiting a trigger signal.

In *Stand-by* mode, the light flashes slowly, indicating that the SuperTrap has finished collecting and storing data. In *Stand-by* mode, the SuperTrap is waiting for the operator to either switch the SuperTrap power **OFF**; press the **NEXT TEST** button (to go to *Active* mode); or download the data to a computer.

In *Communications* mode, the light flashes quickly, indicating that the SuperTrap's **LPT COM** communications port is connected to a computer through the **Communications Cable** for downloading of data.

The **CHARGER/DC IN** port is used to connect the SuperTrap to the **Battery Charger** to recharge the internal battery pack of the SuperTrap. The **CHARGER/DC IN** port can also be used to power the SuperTrap from a regulated external VDC supply as detailed in **Section 2.5**.

The **LED screen** is a two-digit display to show information related to the power status of the internal battery pack and the total number of tests selected and the remaining number of tests.

The **POWER STATUS button** is pressed to display on the **LED screen** the remaining charge of the SuperTrap's internal battery pack. This one-digit value represents the percentage (%) charge remaining in the battery pack (i.e. 8 = 80% of full charge remaining).

The **TOTAL TESTS dial** allows the partitioning of the SuperTrap's memory so that up to 16 events, each event can use either 1 or 2 channels, can be recorded before the information must be downloaded to a computer. It controls both channels, thus, if the operator selects four tests, the memory will be allocated so that each channel can record four events. Care should be exercised when moving this dial to the **RESET** position when the SuperTrap is in *Active* mode (i.e. **STATUS** indicator not flashing). This action will reset the number of tests and overwriting of the data will occur upon subsequent recording of an experiment. However, if the dial is accidentally moved to the **RESET** position when the SuperTrap is in the *Active* mode, data will only be lost if subsequently an actual test is recorded. This will allow the operator to download existing information if it is considered necessary.
To reset the number of tests to be recorded, the operator has to position the **TOTAL TESTS dial** to the **RESET** position when the SuperTrap in the *Active* mode. The number 1 will begin flashing on the **LED screen**, prompting for action. The operator selects the desired number of tests and the LED screen flashes the new number of total tests. The operator must then press the **STOP** button.

The **TOTAL TESTS button** is pressed to display on the **LED screen** the total number of tests to which the SuperTrap was set.

The **REMAINING TESTS button** is pressed to display on the **LED screen** the number of tests that can still be recorded without having to download the data to a computer. This number will be the difference between the total number of tests as selected with the **TOTAL TESTS dial**, and the number of tests actually conducted and stored in the SuperTrap's memory.

The **TRIG SOURCE EXT/INT** dial allows the selection of internal (**INT**) or external (**EXT**) triggering of the SuperTrap. The internal trigger can be set for CH1, CH2 or CH1/CH2 as is standard with most oscilloscopes.

The external trigger allows the selection of two wire arrangements: BREAK circuit or a MAKE circuit. Triggering is described in **Sections 3.7 and 3.8**.

The **TRIG%** dial allows the setting of the trigger level, that is, the voltage value that a signal needs to cross to trigger the SuperTrap to begin recording post-trigger data. It is given as a percentage of the full-scale voltage range input. For example, if **TRIG%** is set at 90% and the monitoring channel is set to VOD (i.e. input voltage is factory preset at approximately 5 volts DC), the unit will trigger at 5 x 90% = 4.5 volts. Similarly, if used in a scope setting, say ± 10 volts, and the **TRIG%** is selected at 20%, the SuperTrap will be triggered and begin recording post-trigger data when the signal level crosses the 10 x 20% = ± 2 volt level.

The **PRE-TRIG%** dial is used to set the pre-trigger time. This represents the length of time, immediately before the trigger level is crossed, during which the SuperTrap will record data. It is given as percentage (%) of the total recording time. For example, if the recording rate is at 5 MHz with 2 channels and SuperTrap has been set to 4 events, the available recording time per event is ((5.0 seconds/2 channels)/4 events) = 0.625 seconds. Setting the PRE-TRIG% to 20% will then allot 0.625 x 20% = 0.125 seconds (125 msec) for recording pre-trigger data.

The **PTS/SEC** dial is used to set the recording rate of the SuperTrap. The SuperTrap's circular memory bank stores 25 million points. This means that at the maximum recording rate of 5 MHz (5 million points/sec) the SuperTrap can record 25/5 = 5.0 seconds of data. (when only one channel is used and the other channel is set to OFF).

NEXT TEST button is used to change the SuperTrap's mode from *Stand-by* to *Active*. When in *Active* mode, the SuperTrap waits for the operator to press the **START** button to instruct the SuperTrap to await a trigger signal.

The **TRIG'D** indicator light will illuminate when the trigger conditions are met. It will remain illuminated during collection of the data, which in turn depends on the recording rate selected for the test. Otherwise, the light will remain off.

The **START** button instructs the SuperTrap to wait for a trigger signal to occur. When the **START** button is pressed, the settings for the sampling rate, trigger level and pre-trigger time are accepted for the upcoming test. Otherwise, they can be changed at anytime between tests before pressing the **START** button.

The **STOP** button has several functions:

1. It is used to reset a new number of tests as previously described.
2. It is used to artificially trigger and fill the memory of the SuperTrap should the operator wish to abort a test after pressing the **START** button. The SuperTrap then reverts to *Stand-by* mode.
3. The **STOP** button is particularly useful when the SuperTrap has been set at a relatively slow sampling rate (for example - thermocouple measurements). Given the large memory bank available in the SuperTrap, if the lowest sampling rate is selected, a total recording time of 25 million data points / 250 Hz = 100,000 seconds (27.8 hours) will be available for recording. Pressing the **STOP** button, after the operator is satisfied that the data he requires has been recorded by the SuperTrap, fills the remaining SuperTrap memory with artificial data and the SuperTrap reverts to *Stand-by* mode. This saves the operator from having to wait for 27.8 hours for the SuperTrap memory to become full.

The **LPT COM** port is used to connect the **Communications Cable** to the SuperTrap. The other end of the **Communications Cable** is connected to the parallel printer port of the computer for retrieval of recorded information.

There are two **PROBE RESISTANCE/INPUT VOLTAGE OUT OF RANGE** warning lights for each channel. They will flash when the probe resistance is out of a factory-preset range. This is detailed in **Section 3.6**.

The **CH1** and **CH2 dials** are used to select the type of input signal connected to the channels. When VOD is selected, the SuperTrap is calibrated to supply approximately 5 volts across the resistance probe. The remaining dial positions are used to measure DC voltage signals generated from a variety of gauges. Two different uni-polar voltage ranges (0-5 and 0-10 volts) and three different bi-polar voltage ranges (± 2.5, ± 5 and ± 10 volts) are available for each channel. They should be selected according to the output specifications of the gauge being used.

The back of the SuperTrap with the 2 BNC input connectors for the VOD/VDC probes labeled **PROBE 1** and **PROBE 2** as well as the external trigger **EXT TRIG** input connector is shown below. Position of the input connectors may be different on your model of SuperTrap.

2.1.2 Carrying Case

The Carrying Case houses the **SuperTrap**, **Battery Charger**, **Communications Cable**, **BNC Adapters**, **Operations Manual** and **Software**.

2.1.3 Battery Charger

The **Battery Charger** has a manual selector switch that allows the charger to operate from any 115 VAC or 230 VAC voltage source.

2.1.4 Communications Cable

The **Communications Cable** is provided to connect the SuperTrap to a Personal Computer for downloading of the recorded data. The **Communications Cable** is connected between the **LPT COM** port on the front panel of the SuperTrap and the LPT1 parallel printer port of the computer.

2.1.5 BNC Adapters

Three **BNC Adapters** are provided to facilitate easy connection between the **PROBE 1**, **PROBE 2** and **EXT TRIG** connectors on the SuperTrap to the coaxial cable (preferably RG-58/U) leading to the VOD probes and/or VDC gauges and/or external trigger wire.

2.1.6 200 Ohm BNC Adapters

Two **200 ohm BNC Adapters** are provided to facilitate easy connection between the **PROBE 1** and **PROBE 2** connectors on the SuperTrap to the coaxial cable (preferably RG-58/U) leading to the VOD probes. They are to be used when the total resistance of the circuit (PROBECABLE + coaxial cable) is less than the minimum allowable resistance of 200 ohms.

2.2 SUPERTRAP INTERNAL RECHARGEABLE BATTERY PACK

The SuperTrap has an internal Ni-Cad rechargeable battery pack. The SuperTrap is supplied with a manually switchable 115/230 VAC Charger. When the internal battery pack is fully charged, the SuperTrap can operate for a 12 hour period (at maximum SuperTrap power consumption) before battery pack recharging is required. The SuperTrap is shipped from MREL fully charged. Since some time may elapse before the SuperTrap is actually put in use, the SuperTrap may not be charged fully, the first time it is used. Full operating time will be obtained when the SuperTrap is recharged.

2.3 TESTING THE SUPERTRAP POWER STATUS

The procedure to check the power status of the SuperTrap is as follows:

1. With the SuperTrap switched **ON**, press the **POWER STATUS** button on the front panel. This button can be pressed at any time during operation of the SuperTrap.
2. The **LED screen** will display the energy remaining in the battery pack as a percentage of the full charge. For example, if the display shows the number 8, it means that 80% of the maximum charge remains in the battery pack. A display of **F** (full) is shown when the SuperTrap is fully charged. A display of **L** (low) is shown when the SuperTrap requires recharging.

NOTE: *The SuperTrap will operate appropriately at low power levels as indicated by* **L** *on the LED screen. When the* **L** *is indicated there is approximately 20 minutes of SuperTrap operating time remaining before the SuperTrap shuts itself* **OFF** *to help prevent complete discharging of the internal battery pack. It is important to note that the SuperTrap has a non-volatile memory, allowing the data to be stored safely regardless of the power status of the internal battery pack.*

2.4 RECHARGING THE SUPERTRAP

The procedure to recharge the SuperTrap is as follows:

1. Ensure that the **Battery Charger** AC voltage switch is in the correct position for the AC voltage mains power available, 115 or 230 VAC.
2. With the SuperTrap switched **OFF**, connect the **Battery Charger** between the **CHARGER/DC IN** port on the front panel of the SuperTrap and the wall outlet.
3. An indicator light on the **Battery Charger** will illuminate during the charging operation and will begin to flash once the SuperTrap is fully charged.

NOTE: *There is no risk involved in charging the SuperTrap for too long a period of time since it cannot be overcharged. According to the battery Manufacturer's specifications, full battery pack recharging will take up to 6 hours. The Manufacturer also recommends recharging the SuperTrap at temperatures from 20 to 30 °C (68 to 86 °F).*

2.5 OPERATING THE SUPERTRAP FROM EXTERNAL POWER SOURCES

The SuperTrap can be operated from an external DC power source connected to the **CHARGER/DC IN** port on the front panel of the SuperTrap. ***The source must have specifications: 9-18VDC, 10 Watts. The maximum output for the power source must not be higher than 30 VDC without a load.*** Use of any other supply may cause damage to the SuperTrap and will void the SuperTrap Warranty. Please contact MREL for further information on use of alternative power sources.

2.6 LONG TERM STORAGE CONSIDERATIONS

No special procedures, other than those pertaining to the internal battery pack, should be taken for long term storage of the SuperTrap. In the eventuality that the SuperTrap remains idle for long periods, it is recommended to recharge the SuperTrap once per month per the procedure in **Section 2.4**. This will maintain the internal battery pack.

2.7 VOD RESISTANCE PROBES USED BY THE SUPERTRAP

The following types of VOD resistance probes are available from MREL:

2.7.1 PROBEROD

The PROBEROD, shown below, is a rigid probe consisting of a high resistance insulated wire placed within a small diameter metal tube, which acts as the return lead of the circuit. PROBERODs are specifically designed to measure VODs of explosive cartridges and/or of short sample tubes of explosives, under confined or unconfined conditions. They are available from MREL in a standard length of 3 ft. (0.9 m) and are supplied with leads ready to be connected to the RG-58 coaxial cable, which connects to the **PROBE 1** or **PROBE 2** connector at the back of the SuperTrap. PROBERODs are also available in custom lengths (contact MREL for more details).

2.7.2 PROBECABLE

Two types of flexible resistance wire are available from MREL: PROBECABLE (green colour) and PROBECABLE-LR (blue colour) as shown below. PROBECABLE have the classical configuration of a standard RG-type coaxial cable, where the high resistance wire is the central conductor and the braided shield acts as the return lead. A dielectric material placed between the resistive wire and the return lead provides both electrical insulation and a physical barrier between them. The latter feature reduces the possibilities of short circuits during handling of the PROBECABLE. Moreover, a plastic outer layer protects the PROBECABLE from tearing actions during loading.

PROBECABLE and PROBECABLE-LR are used for measuring VODs of explosives in blastholes and the delay times between holes and decks. The selection of either PROBECABLE or PROBECABLE-LR is based on the total resistance of the circuit, which in turn depends on the number of holes being monitored. The only difference between these two cables relates to their nominal or unit resistance. PROBECABLE has a unit resistance of 11.5 ohm/m (3.5 ohm/ft) while PROBECABLE-LR (LR stands for Low-Resistance) has a unit resistance of 3.31 ohm/m (1.01 ohm/ft). The latter allows VOD recording for lengths up to 444 m (1,457 ft) per channel. Both types of flexible probes are available from MREL in boxes containing 2 x 1000 m spools (2 x 3,280 ft).

2.8 SUPERTRAP TECHNICAL SPECIFICATIONS

Number of Channels	2 channels. Either channel can be individually set to OFF, VOD, 0-5 VDC, 0-10 VDC, +/-5 VDC, or +/-10 VDC.
Resolution	14 bits, 1 part in 16,384.
Recording Rate	User selectable: up to 5 MHz, independent of the number of channels used.
Recording Time @ 5MHz	With 2 channels ON: 2.5 seconds (12.5 million data points per channel). With 1 channel ON: 5.0 seconds (25 million data points).
Pre-Trigger Time	User selectable: 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95 and 100% of the total recording time.
Trigger Modes	User selectable: Internal, on user selectable VOD/Voltage signal level - operator can select to use a trigger signal from CH1, CH2 or CH1 & CH2 from which to trigger. External, on a user selectable external wire make or break circuit.
Power	Internal rechargeable Ni-Cad battery pack providing up to 12 hours of active operation when fully charged. The non-volatile memory allows the data to be stored securely regardless of the status of the internal battery pack. The Battery Charger has a manual selector switch allowing it to operate from 115/230VAC. Recharging takes up to 6 hours.
Multiple Event Storage	User selectable: up to 16 tests stored in permanent memory.
Components Provided	SuperTrap, Battery Charger, Communications Cable, BNC Adapters, Operations Manual and Software for Windows '95 all in a Carrying Case.
Size and Weight	SuperTrap: 28 x 25 x 18 cm (11 x 10 x 7 in); 4 kg (8.8 lbs.). System in Carrying Case: 46 x 35 x 18 cm (18 x 14 x 7 in); 6 kg (13.2 lbs.).
Environmental	Operates at -40 to +80 C (-40 to +185 F). Snow, rain, dust and sand proof. System in Carrying Case is drop proof from at least a 1 m (3 ft) height.
PC Connection	After conducting the test(s), the SuperTrap connects to the PC LPT1 parallel printer port, allowing downloading of data 5 times faster than with an RS232 communication cable (assuming PC is configured to EPM).
Software	SuperTrap Advanced Analytical Software runs under 32 bit Windows '95 operating system. It provides fast downloading of data to the computer and automatically displays graphs of DISTANCE or VOLTAGE versus TIME, depending on the type of testing conducted. All software operations are "point and click". Unlimited Zoom capabilities on graphs and powerful conversion of voltage graphs to graphs of engineering units versus time. VOD and hole/deck delay time analysis capability of any part of the VOD trace. Annotating, printing, saving and exporting of graphs and data to other Windows applications. The SuperTrap Software is based on MREL's proven DataTrap-VOD, MiniTrap[II] and DataTrap-Scope Software being used around the world. User selectable: Metric or Imperial units.

VOD Excitation/Safety	The SuperTrap automatically adjusts its excitation voltage for the maximum 14-bit resolution across the VOD probe. All VOD operating parameters are recorded by SuperTrap with no requirements for additional instrumentation. For safety considerations, SuperTrap is designed to unable the output of more than 50 mA of current to a VOD probe.
VOD Probes	A complete line of VOD probes is available from MREL to record the VOD of explosive samples to multiple holes in large open-cast blasts. The SuperTrap can record VODs across PROBECABLE-LR (resistance cable) lengths of up to 444 m (1,457 ft) per channel.
Other Gauges	The SuperTrap has the capability to function as a scope and record DC voltages from a variety of gauges. The user can select different uni-polar and bi-polar input ranges. This allows the use of high frequency accelerometers, dynamic pressure transducers, displacement transducers, temperature measurement gauges and any gauge that outputs a DC voltage signal between -10 to +10 volts.

CHAPTER 3: VOD FIELD OPERATIONS

3.1 SAFETY CONSIDERATIONS FOR SELECTING AN EXPLOSIVE TESTING SITE

Care must be taken to select a good site for detonation and VOD recording of explosive samples. If convenient, permanent test sites may be constructed. A pit surrounded by an earth wall suffices as a simple detonation site. A similarly protected shelter for the SuperTrap and personnel can be constructed some distance away. The distance will depend on the amount of explosive being detonated at one time and whether the explosives are confined in steel pipes or not. Ensure that the area is well demarcated and that access is restricted.

If samples of explosives are to be detonated at an unprepared site, then the operator must be careful when deciding upon what type of ground the charges are to be placed. Avoid placement on ground with stones, rubble or anything that is likely to turn into a projectile. The best surfaces are fines, sand or tailings.

It is always good practice to have maximum control over the time of firing of the test, therefore safety fuse initiation is not recommended. Electric or shock tube initiation is best with the detonator either initiating the sample of explosives or initiating the primer/booster in the explosive sample. For site specific recommendations, contact MREL.

3.2 THE RESISTIVE WIRE TECHNIQUE FOR MEASURING VOD

The SuperTrap is capable of monitoring the continuous VOD profile along the entire length of an explosives column. The SuperTrap can measure the VOD of relatively short explosive samples such as cast primers or explosive cartridges, and of explosives loaded down-the-hole in surface and/or underground blasts, in single and multiple hole blasts. The SuperTrap provides a regulated constant excitation signal to the probes and monitors the drop in voltage across them.

The SuperTrap uses the proven continuous resistive wire technique for monitoring VODs. A probe of known linear resistance (i.e. ohm/m or ohm/ft) is placed axially in the explosive sample or explosive column. As the detonation front of the explosive consumes the resistive probe, the resistance of the circuit will decrease in proportion to the reduction in length of the probe. The SuperTrap records the resulting decrease in voltage across the probe versus time.

The SuperTrap's Advanced Analytical Software automatically converts the recorded data into a graph of distance versus time. The slope of this graph at any position is the VOD of the explosive at that particular position. The Software includes menu functions that will automatically calculate and display the VOD of an explosive at any selected location in the graph. Other functions allow the operator to calculate and display the delay time between selected blastholes or between selected explosive decks within a blasthole.

3.3 FIELD LAY OUT OF VOD PROBES

3.3.1 Testing of Explosive Cartridges/Samples Using PROBERODs

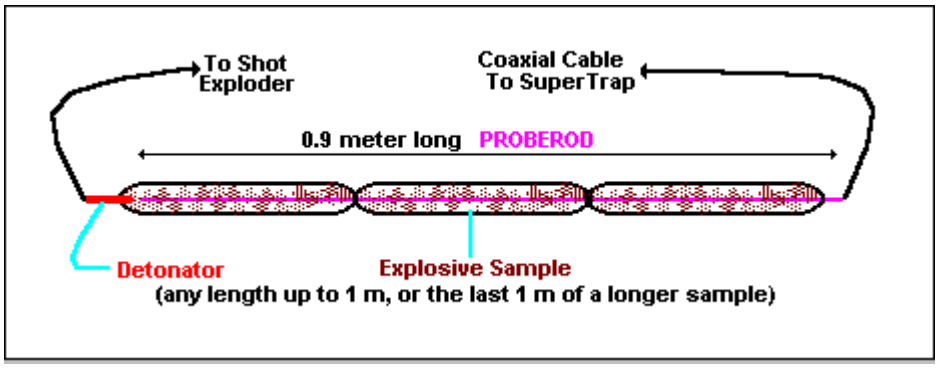
The equipment and supplies that are required to conduct VOD tests on samples of explosives or on explosive cartridges are:

1. The SuperTrap System.

2. PROBEROD (rigid resistive probes) - one (1) per explosive sample.
3. Coaxial cable (type RG-58 is recommended) - sufficient length to run between the SuperTrap location and the explosives.
4. Wire cutters and electrical tape.
5. Explosives, detonators and shot exploder.

The procedure for preparing a VOD test is as follows:

1. Demarcate the charge detonation area.
2. Place the SuperTrap in a protective shelter or at a safe distance away from the detonation area. This distance may be closer than what is considered safe for the operator. Once the setup is completed, the SuperTrap does not require an operator to collect the data; it does it automatically without operator assistance.
3. Run a length of coaxial cable from the SuperTrap to the detonation area with enough excess length to compensate for cable shortening or cable damage from each test area - run two lengths if both SuperTrap channels are to be used. Shorter lengths of coaxial cable may be connected together using the wire cutters and electrical tape. A male BNC connector should be attached to the end of the coaxial cable which is to be attached to the **PROBE** input at the back of the SuperTrap. Convenient **BNC Adapters** have been supplied with the SuperTrap for this purpose. They can be connected to the coaxial cable using the wire cutters and electrical tape.
4. For quality control purposes, select and test the resistance of a rigid PROBEROD with an ohmmeter or blaster's galvanometer. Do not use the PROBEROD if its resistance is outside the range of 290 to 305 ohms. MREL will replace any probe not complying with specifications.
5. Insert a rigid PROBEROD axially in the sample of explosives. Start at the opposite end from where the detonator will be placed as shown below.



If bulk explosives are being tested in paper tubes, plastic tubes or steel pipes which have been sealed at both ends, make a small central hole to allow the PROBEROD to be inserted. If a measurement of run-up to detonation is required, ensure that the PROBEROD is pushed well into the explosives so that it reaches the position of the detonator or primer. If the PROBEROD reaches the primer or protrudes past it, the effect of the primer will be recorded by the SuperTrap. The same holds true for cartridges of explosives.
To test the VOD of detonation cord, tape the detonation cord along the entire length of the PROBEROD.

6. Note the Unit Resistance of the probe by reading the value in ohm/m or ohm/ft from the factory label on the PROBEROD. Note the ohm/m value if the VOD is to be reported in m/s. Note the ohm/ft value if the VOD is to be reported in ft/sec. The Unit Resistance will be requested later by the SuperTrap Software.
7. Connect the PROBEROD to the coaxial cable using the wire cutters and electrical tape. Do not be concerned with the polarity of the connection.

8. At the SuperTrap end, connect the coaxial cable to the appropriate **PROBE 1** or **PROBE 2** connectors located on the outside and at the back of the SuperTrap as shown below. These connectors correspond with CH1 and CH2 respectively. Position of the input connectors may be different on your SuperTrap.

9. The probe setup aspects of the test are complete. The operator can now place the detonator and connect it to the shot exploder as per standard procedures. The SuperTrap is now ready to be set up to record the test.

3.3.2 Testing of Explosives Columns (Down-the-Hole) using PROBECABLE

The equipment and supplies that are required to conduct VOD tests on explosives down-the-hole are:

1. The SuperTrap System.
2. PROBECABLE or PROBECABLE-LR (flexible resistive wire).
3. Coaxial cable (type RG-58 is recommended) - sufficient length to run between the SuperTrap location and the last blasthole to be recorded.
4. Wire cutters and electrical tape.
5. Explosives, detonators and shot exploder.

The initial procedure for preparing a VOD test is as follows:

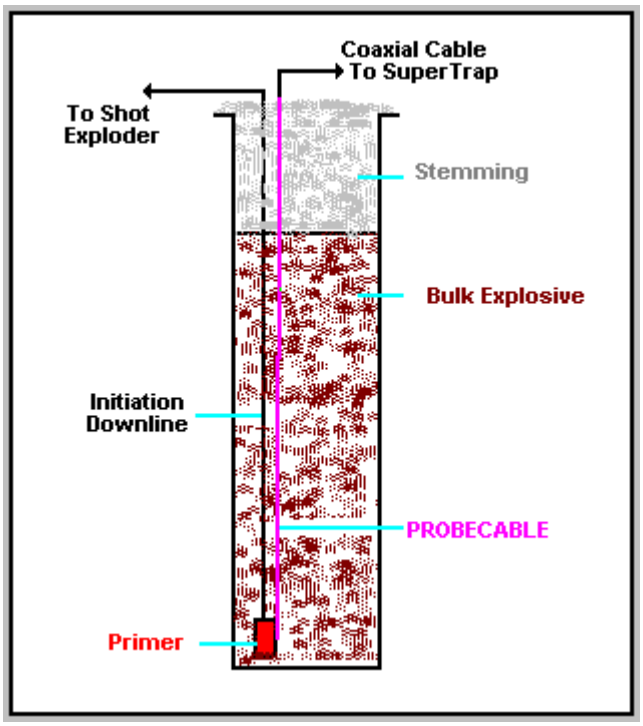
A. Demarcate the blast area.

B. Place the SuperTrap in a protective shelter or at a safe distance away from the blast area. This distance may be closer than what is considered safe for the operator. When setup, the SuperTrap does not require an operator to collect the data, the SuperTrap collects the data automatically without operator assistance.

C. Run a length of coaxial cable from the SuperTrap to the blast area - run two lengths if both SuperTrap channels are to be used. Shorter lengths of coaxial cable may be connected together using the wire cutters and electrical tape. A male BNC connector should be attached to the end of the coaxial cable which is to be attached to the **PROBE** input at the back of the SuperTrap. Convenient **BNC Adapters** have been supplied with the SuperTrap for this purpose. The **BNC Adapters** should be connected to the coaxial cable using the wire cutters and electrical tape. Somewhere along the length of the coaxial cable, loop the coaxial cable around a large rock. When the blast is fired and the ground moves, this will stop the blast from pulling the coaxial cable and the SuperTrap with the moving rock. Alternatively, leave sufficient slack in the coaxial cable to allow for ground movement.

Single hole recording may be performed as follows:

1. Prepare the end of the PROBECABLE by using the wire cutters to remove the insulation from the end and then short the wire by connecting the shielding wire to the center conductor wire and twist them together. Protect the connection with electrical tape.
2. Using tape or wire, attach this finished end of the PROBECABLE to the primer/booster or to a rock and lower the PROBECABLE into the hole as shown below. Detonation cord downlines may damage the PROBECABLE or cause side initiation of the bulk explosive. When initiating with detonation cord, attach the PROBECABLE to a rock and lower it on the side of the hole opposite to the detonation cord downline.

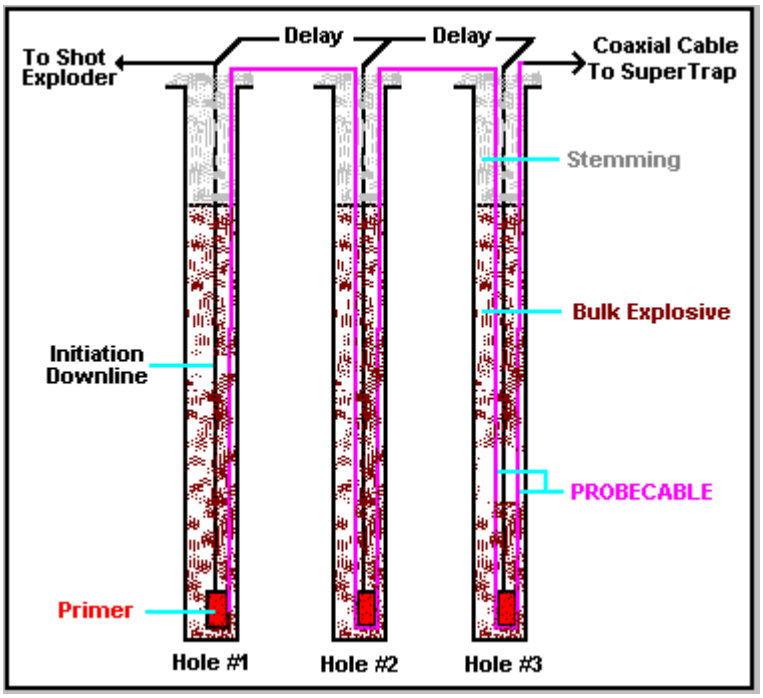


3. The PROBECABLE can then be cut at the top of the hole.
4. Note the Unit Resistance of the probe by reading the value in ohm/m or ohm/ft from the factory label on the reel of PROBECABLE. Note the ohm/m value if the VOD is to be reported in m/s. Note the ohm/ft value if the VOD is to be reported in ft/sec. The Unit Resistance information will be requested later by the SuperTrap software. When measured with a blaster's galvanometer, the Probe Resistance should compare favorably with the calculated resistance of the PROBECABLE, which is the Unit Resistance multiplied by its length. If this is not the case then remove the length of PROBECABLE and reload another length into the hole.
5. The hole can now be loaded per usual procedure. Hold the PROBECABLE taut during the loading of the explosive to avoid slack in the hole. In the absence of the operator, this may be accomplished by tying the PROBECABLE taut around a hole marker stake or around a rock at the top of the hole. After loading, the operator may wish to check the Probe Resistance to ensure that no damage has occurred. As the PROBECABLE is well protected with thick PVC coating, no problems are anticipated.
6. Connect the PROBECABLE to the coaxial cable using the wire cutters and electrical tape. The connection should be shielding to shielding and center conductor to center conductor. Ensure that the center conductor and the shielding connections do not touch each other.
7. At the SuperTrap end, connect the coaxial cable to the appropriate **PROBE 1** or **PROBE 2** connectors located on the outside and at the back of the SuperTrap as shown below. These connectors correspond with CH1 and CH2 respectively. Position of the input connectors may be different on your model of the SuperTrap.

8. The probe setup aspects of the test are complete. The SuperTrap can now be set up to record the test.

Multiple hole recordings may be performed as follows:

1. Prepare the end of the PROBECABLE by using the wire cutters to remove the insulation from the end and then short the wire by connecting the shielding wire to the center conductor wire and twisting them together. Protect the connection with electrical tape.
2. Using tape or wire, attach this finished end of the PROBECABLE to the primer or to a rock and lower the PROBECABLE into the hole that is anticipated will detonate first of all the series of holes to be recorded by the SuperTrap. Detonation cord downlines may damage the PROBECABLE or cause side initiation of the bulk explosive. When initiating with detonation cord, attach the PROBECABLE to a rock and lower it on the side of the hole opposite to the detonation cord downline.



3. Run the PROBECABLE between the first hole and the second hole leaving sufficient slack between the holes to allow for ground movement between the delayed holes.
4. There are two common methods of lowering a doubled length of PROBECABLE in the second and subsequent holes. The first method is to measure the correct length of PROBECABLE so that it reaches the bottom of the hole where the PROBECABLE has been doubled over and attached to the primer or a rock. Excess PROBECABLE between holes is not a problem. The second, and easiest method is to run the PROBECABLE through a wire loop which has been tied or taped around a rock. In this way the rock will slide along the PROBECABLE as the PROBECABLE is lowered into the hole until the rock reaches the bottom of the hole.
5. Note the Unit Resistance of the probe by reading the value in ohm/m or ohm/ft from the factory label on the reel of PROBECABLE. Note the ohm/m value if the VOD is to be reported in m/s. Note the ohm/ft value if the VOD is to be reported in ft/sec. The Unit Resistance information will be requested later by the SuperTrap software. When measured with a blaster's galvanometer, the Probe Resistance should compare favorably with the calculated resistance of the PROBECABLE which is the Unit Resistance multiplied by its length. If this is not the case then remove the length of PROBECABLE and reload another length into the hole.
6. The holes can now be loaded per usual procedure. Hold the PROBECABLE taut during the loading of the explosive to avoid slack in the hole. In the absence of the operator, this may also be accomplished by tying the PROBECABLE taut around a hole marker stake or around a rock at the top of each hole. After loading, the operator may wish to check the Probe Resistance again to ensure that no probe damage has occurred. As the PROBECABLE is well protected with a thick PVC coating, there should be no problems.
7. Connect the PROBECABLE to the coaxial cable using the wire cutters and electrical tape. The connection should be shielding to shielding and center conductor to center conductor. Ensure that the center conductor and the shielding connections do not short with each other.
9. At the SuperTrap end, connect the coaxial cable to the appropriate **PROBE 1** or **PROBE 2** connectors located on the outside and at the back of the SuperTrap as shown below. These connectors correspond with CH1 and CH2 respectively. Position of the input connectors may be different on your SuperTrap.

10. The probe setup aspects of the test are complete. The SuperTrap can now be set up to record the test.

3.4 PROBECABLE AND COAXIAL CABLE PROTECTION

It is important to protect the PROBECABLE and the coaxial cable from damage caused by personnel and machinery operating on the blast; detonation of other holes and/or surface accessories such as detonating cord, detonating relays, and shock tube bunch blocks.

The cables may be protected in many ways but experience has shown that it is best to lead the PROBECABLE and coaxial cable under the detonating cord and leave a barrier of sand or drill cuttings between them where they cross. A danger point is the collar area of the holes as the detonating cord or shock tube bunch blocks that initiate the downlines may cross directly over the PROBECABLE or coaxial cable. A good procedure is to protect the area where there is a cross over for about 1.5 m (5 ft) along the length of cable. Experience has shown that a sand barrier thickness of 15-30 cm (0.5-1 ft) suffices to protect the cables.

3.5 SUPERTRAP SETUP PROCEDURE FOR VOD MEASUREMENTS

Once the VOD probe(s) have been placed in the explosive and connected to the RG-58 coaxial cable(s) running to the signal input connectors on the SuperTrap, the operator can start setting the SuperTrap to record VOD experiments. The SuperTrap's setup procedure is accomplished entirely from the front panel. The procedure to record a new set of experiments consists of the following steps:

1. Ensure that the coaxial cable coming from the probe(s) is connected to the corresponding SuperTrap signal input connector(s) labeled **PROBE 1** and/or **PROBE 2** on the outside and back of the SuperTrap. These connectors correspond to CH1 and CH2 of the SuperTrap.
2. Turn the SuperTrap **ON**. The **STATUS** light indicator will illuminate, and may or may not flash depending on the status the SuperTrap prior to being switched OFF.
3. If the **STATUS** light is flashing (*Stand-by* mode), it is indicating that there are data from previous tests stored in the non-volatile memory and the SuperTrap is waiting for the operator to press the **NEXT TEST** button. Unless the data can be discarded, ensure it is downloaded before proceeding, otherwise the data will be overwritten.
4. If the **STATUS** light is not flashing, it is indicating that the unit is already in the *Active* mode and waiting for the operator to press the **START** button to await a trigger signal.
5. Select the number of events/tests to be recorded (1, 2, 4, 8 or 16) by setting the **TOTAL TESTS dial** in the **RESET** position. For enabling **RESET**, the SuperTrap has to be in the *Active* mode (i.e. the **STATUS** light illuminated and not flashing), thus, if the light is flashing, the **NEXT TEST** button needs to be

pressed to change the SuperTrap to the *Active* mode. Once in *Active* mode, when the **TOTAL TESTS dial** is set to the **RESET** position, the number 1 will flash on the **LED screen**. The operator should now switch the dial to the desired total number of tests as verified by the flashing number on the **LED screen**. The TOTAL TESTS is not set into the SuperTrap's memory until later in the procedure (Step 12) when the operator presses the **START** button.

TIP: *The SuperTrap has a massive data memory as discussed in **Section 3.8**. The SuperTrap can record at a speed of 5 MHz for 5.0 seconds when 1 Channel is used and 2.5 seconds per channel when 2 Channels are used. Unless there are large delays between multiple holes being recorded in a blast, then it is likely that the full memory of the SuperTrap will not be required to record 1 test. This is certainly the case when conducting tests on explosive samples with PROBERODs that take less than 0.2 msec to be consumed in the detonating explosive. To keep data download time and computer hard drive usage to a minimum, the operator should consider switching the **TOTAL TESTS** dial to **16** or 8 or 4, even if only one test is being performed. With the **TOTAL TESTS** dial on **16** this will provide 312.5 msec of total recording time per test when 1 Channel is used and 156.25 msec of total recording time per channel when 2 Channels are used. Of course, if more time is required, then consider doubling the time by switching the **TOTAL TESTS** dial to 8 etc. If fewer tests than 16 are performed before downloading the data to a computer, the SuperTrap Software recognizes this fact and only downloads the data from the test(s) actually conducted. This reduces data download time, minimizes the file size, and conserves computer hard drive space.*

6. Select the operating channel(s) by setting the **CH1** and/or **CH2** dials to the VOD position. Note that if only one channel is used, setting the other channel to the OFF position will maximize the recording time.
7. Look for the **PROBE RESISTANCE OUT OF RANGE** warning light indicators (LOW and HIGH). If there is a warning light flashing, then there is a problem with the resistance probe, the coaxial cable and/or the input connectors. If this is the case, the operator is referred to **Section 3.6** for how to solve the problem. It is worth noting that, as a safety feature, the **START** button will be blocked and the SuperTrap will be unable to record when an **OUT OF RANGE** condition exists, or when both **CH1** and **CH2** are **OFF**. If no warning lights are flashing, then the operator can proceed with the next step.
8. Select the sampling rate using the **PTS/SEC** dial on the front panel. It is recommended to always select as fast a recording rate as possible. For VOD recording, 5 MHz is the most likely choice. At 5 MHz, the recording time on 1 channel is 5.0 seconds and the recording time on 2 channels is 2.5 seconds. This should be sufficient time for the holes to be recorded, otherwise the recording rate must reduced from 5 MHz.
9. Select the trigger level using the **TRIG %** dial on the front panel. This sets the signal voltage level crossing value, which will trigger the SuperTrap and start the recording of data. When working in the VOD mode, the SuperTrap's voltage range is factory preset at approximately 5.0 volts. The TRIG% represents the percentage of this value that a signal needs to reach in order to trigger the unit and start recording post-trigger information. Typically, a setting value of 90% is recommended for VOD experiments. This means that the unit will be triggered when the signal level reaches the 5 x 90% = 4.5 volts mark.
10. Select the pre-trigger percentage time using the **PRE-TRIG %** dial on the front panel. This value represents the percentage of the available total recording time in which the SuperTrap will record pre-trigger information, that is, data that occurs immediately before the signal level crosses the trigger level setting and triggers the unit to start the post-trigger recording process. Typically, 20% pre-trigger time is sufficient for VOD monitoring.

    It is worth noting that the last three settings (**PTS/SEC**, **TRIG%** and **PRE-TRIG%**) can be changed at any time between tests, and only when the **START** button is pressed are the values accepted as the settings for the upcoming test.

11. Ensure the **TRIG SOURCE EXT/INT** dial is set to the CH1, CH2 or CH1/CH2 position. This selection will depend on which channel the operator wants the SuperTrap to look for a trigger signal - CH1, CH2 or both. Normally for 1 channel VOD tests, either the CH1 or the CH2 setting would be selected depending on the channel being recorded. Normally for 2 channel VOD tests the CH1/CH2 setting should be selected. The use of external EXT triggering will be discussed in **Section 3.7**.
12. Press the **START** button. The **START light** will illuminate steadily. During this time all of the positions of the SuperTrap's dials and switches (Steps 5-11 above) are written to the SuperTrap's memory. The SuperTrap then starts monitoring the blast, waiting for the trigger signal to start collecting VOD data. Personnel can now leave the SuperTrap unattended.
13. When the triggering condition is met (i.e. a sufficient length of resistance probe has been consumed by the detonation), the SuperTrap will trigger and start collecting VOD information. Upon triggering, the **TRIG'D**, **START** and **STATUS** light indicators will illuminate and remain illuminated during the collection of data (this time depends of the sampling rate selected).
14. Once data collection ends, the **TRIG'D** indicator goes off and the SuperTrap starts storing data into its non-volatile memory. During the storing period, the **START** indicator will flash, indicating that data is being transferred into memory (this period will depend of the number of tests selected). The **STATUS** indicator will remain illuminated. Do not switch the SuperTrap **OFF** at this point.
15. Upon finishing the storing process, the **START** indicator will go off and the **STATUS** indicator will commence flashing. At this point the SuperTrap returns to the *Stand-by* mode.
16. If testing has been completed then go to Step 17. Otherwise press the **REMAINING TESTS** button to confirm how many tests can be still hosted by the SuperTrap before downloading of the data to a computer is required. If there are 1 or more tests remaining in the memory then press the **NEXT TEST** button and go to Step 6. If there are 0 tests remaining in the memory, then either download the data to a computer (**Section 5.4**) and return to Step 1, or go to Step 17.
17. If no more experiments are to be conducted, and the data storing process has been finished (Step 15 above), turn the SuperTrap **OFF**; the data will remain in the SuperTrap's non-volatile memory.

3.6 PROBE RESISTANCE OUT OF RANGE

There are two **PROBE RESISTANCE OUT OF RANGE** warning lights for each channel of the SuperTrap. One is labeled LOW and the other is labeled HIGH. The LOW indicator illuminates when the total resistance (probe plus the coaxial cable) is less than 200 ohms. The HIGH indicator illuminates when this total resistance is greater than 1,500 ohms. The SuperTrap is only calibrated to perform VOD tests between these two initial resistance values.

There can be several reasons for total resistance to be LOW:

1. A short circuit somewhere in the coaxial cable and probe assembly, including the BNC connector or BNC Adapter;
2. A damaged PROBEROD;
3. An insufficient length of PROBECABLE.

Items 1 and 2 above can be tested using a blaster's galvanometer to test the resistance/continuity of the coaxial cable and probe assembly and solved by remaking the connections and/or replacing the damaged PROBEROD. If Item 3 is the cause, then replace the **BNC Adapter** used in the test with the supplied **200 ohm BNC Adapter**. The **200 ohm BNC Adapter** provides an additional 200 ohms to the probe circuit and does not affect the VOD results.

There can be several reasons for the total resistance to be HIGH:

1. An open circuit somewhere in the coaxial cable and probe assembly, including BNC connector or BNC Adapter;
2. A damaged PROBEROD;
3. Too long a length of PROBECABLE.

Items 1 and 2 above can be tested using a blaster's galvanometer to test the resistance/continuity of the coaxial cable and probe assembly and solved by remaking the connections and/or replacing the damaged PROBEROD. If Item 3 is the cause, then reduce the length of the PROBECABLE used in the test by cutting out excess PROBECABLE between holes and remaking the connections using the wire cutters and electrical tape. Alternatively, this can be achieved by reducing the number of holes being recorded by cutting the PROBECABLE and remaking the appropriate connection with the wire cutters and electrical tape. If PROBECABLE is being used in the test, then considering using PROBECABLE-LR for such tests in the future. The unit resistance of PROBECABLE-LR is approximately 1/3 that of PROBECABLE.

3.7 UTILIZING THE EXTERNAL TRIGGER

In some VOD applications, it may be desirable to have the SuperTrap begin to record exactly when a specific event occurs. For the specific event to start at time = 0 on the VOD graph, the **EXT TRIG** port connector, on the outside and back of the SuperTrap, is used.

Connect one of the **BNC Adapters** to the **EXT TRIG** port. Do not use the **200 ohm BNC Adapter**. Connect a duplex wire to the **BNC Adapter** using cutters and electrical tape. The polarity of the connection does not matter.

When the **TRIG SOURCE EXT/INT** dial on the front panel of the SuperTrap is set to MAKE, then the "test" end of the duplex wire is prepared as follows: remove the insulation from one of the wires and wrap it around the second insulated wire such that the circuit remains open. Upon the duplex wire circuit becoming shorted, the SuperTrap will begin recording data. Any explosive event such as a detonator firing, detonating cord firing or a primer firing will short such a circuit and cause the SuperTrap to collect data. Pre-trigger points will still be collected per the settings of the SuperTrap, but time=0 on the VOD graph will be the precise time when the external trigger circuit became shorted.

When the **TRIG SOURCE EXT/INT** dial of the SuperTrap is set to BREAK, then the "test" end of the duplex wire is prepared as follows: connect the two ends together such that the circuit is closed. Upon the duplex wire circuit becoming broken, the SuperTrap will begin recording data. Any explosive event such as a detonator firing, detonating cord firing or a primer firing will break such a circuit and cause the SuperTrap to collect data. Pre-trigger points will still be collected per the settings of the SuperTrap, but time=0 on the VOD graph will be the precise time when the circuit became broken.

3.8 ADDITIONAL INFORMATION ON MEMORY AND TRIGGERING

3.8.1 Memory

SuperTrap has a large circular memory containing 25 million sampling points which are allocated according to both the number of channels and the number of events (or tests) selected for the experiments. These values, for a given sampling rate, define the available recording time for each event. Selection of the operating channels and the number of events to be recorded is done using the corresponding **CH1/CH2** and **TOTAL TESTS** dials, while the sampling rate is selected with the **PTS/SEC** dial. All of these dials are located on the front panel of the SuperTrap.

A general equation to calculate the Total Recording Time (Pre-trigger Time + Post-trigger Time) is:

Total Recording Time (seconds) = 25,000,000/((# of channels)x(# of events)x(recording rate))

When the SuperTrap operates on one channel only (i.e. the other channel with the dial set to the OFF position), the 24 million points are allocated to that particular channel. If the number of events selected is one, the available recording time will be maximized for a given sampling rate. For example, at the maximum sampling rate of 5 MHz, the available recording time will be:

25,000,000/((1 channel) x (1 event)x(5,000,000 points/sec)) = 5.0 seconds

At a slower recording rate of 1 MHz (for example), the available recording time will become 25 seconds.

If two channels are used simultaneously, the SuperTrap will partition the memory allocating 12.5 million points to each recording channel. Following the previous example, the available recording times can be calculated as follows:

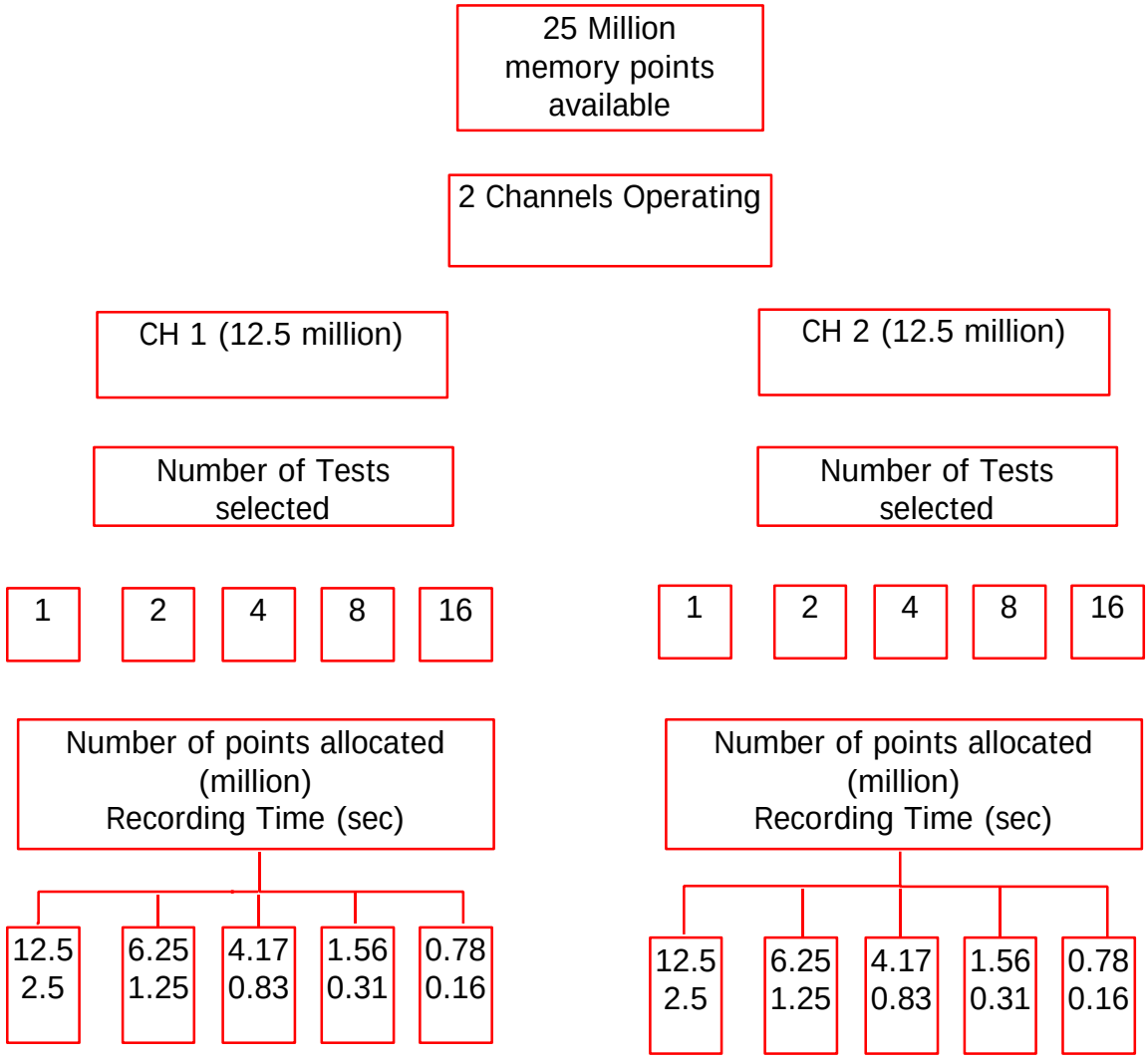
25,000,000/((2 channels) x (1 event)x(5,000,000 points/sec)) = 2.5 seconds

If the recording rate is reduced to 1 MHz, the available recording time will become 12.5 seconds.

If the operator were to record more than one event per channel, the available memory will be further partitioned proportionally to the number of events selected for recording. For example, if operating with 2 channels and selecting 4 tests per channel with the **TOTAL TESTS** dial, the available recording time for each event can be calculated as follows:

25,000,000/((2 channels) x (4 events)x(5,000,000 points/sec)) = 0.625 seconds

The flowchart on the following page is provided as an example to better understand the way the SuperTrap allocates its memory according to the number of channels and the number of tests selected. The example is valid when operating with 2 channels and sampling at 5 MHz.



3.8.2 Triggering

When setting the **TRIG SOURCE EXT/INT** dial in either the MAKE or BREAK setting of the EXT position, the trigger signal that the SuperTrap receives is from the trigger wire. This corresponds to time = 0 on the resulting VOD graph.

When the **TRIG SOURCE EXT/INT** dial is set the CH1, CH2 or CH1/CH2 of the INT position, then the SuperTrap is triggered by the signal received from the probe placed in the explosives. This trigger signal occurs according to the following principle: when the explosive detonates, the probe is consumed and the probe length is reduced. This in turn reduces the resistance and thus the voltage across the probe decreases from the initial 5.0 VDC (approximately) set automatically by the SuperTrap. When the voltage across the probe reaches the value corresponding to the trigger level selected with the **TRIG%** dial on the front panel, the SuperTrap is triggered. This represents time = 0 on the resulting VOD graph. For example, if the operator selects a trigger level setting of 90%, the SuperTrap unit will be triggered when the voltage signal coming from the probe crosses the 90% level of the full scale voltage (approximately 5.0 VDC), that is the 4.5 VDC level.

Once the SuperTrap receives the trigger signal, it stores the VOD information received immediately prior to the trigger signal into the pre-trigger memory; the VOD information received after the trigger signal is stored into the post-trigger memory. The recording time for each memory allocation (pre and post-trigger) will depend on the setting selected for **PRE-TRIG%**.

Pre-trigger Time = (Total Recording Time) x **PRE-TRIG%**
Post-trigger Time = (Total Recording Time) - (Pre-trigger Time)

The procedure for calculating the Total Recording Time is outlined in **Section 3.8.1**.

The Figures on the following two pages show the length of PROBECABLE (feet and metres) and length of PROBECABLE-LR (feet and metres) that must be consumed for the SuperTrap to receive the trigger signal, given the Probe Resistance of the test and the **TRIG%** setting of 95%, 90%, 80%, 70%, 60% and 50%. PROBECABLE-LR should be used for tests involving several holes where if PROBECABLE was used it would result in the Total Resistance exceeding the maximum resistance accepted by the SuperTrap (1,500 ohms).

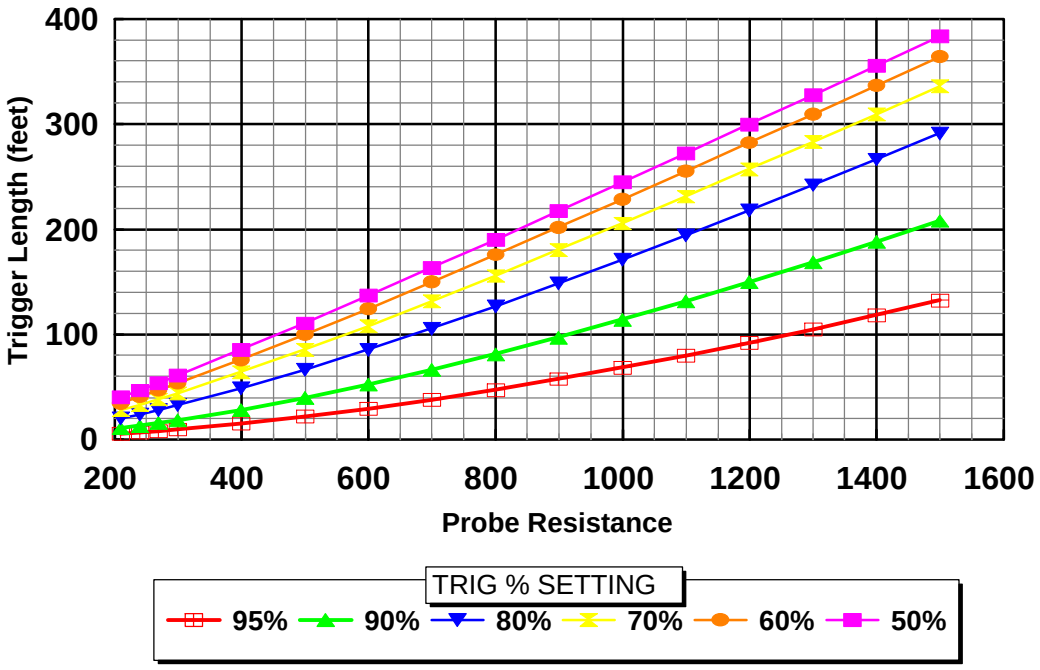
Notice on the graph that if a large resistance (such as 1,300 ohm) is used in a test, then (at the preferred 90% TRIG% setting for VOD tests) 50 metres of PROBECABLE (or approximately 175 metres of PROBECABLE-LR) must be consumed to trigger the SuperTrap. If the first hole does not consume a sufficient length of PROBECABLE to trigger the SuperTrap, then all of the VOD data for the first hole will be before time = 0.

The operator should ensure that there is sufficient pre-trigger time to record the time it takes for the trigger length of PROBECABLE to be consumed in the blast - particularly if several delayed holes must be detonated in order for sufficient PROBECABLE to be consumed. This is not as important with the SuperTrap as it has been in the past with the MiniTrap[II] and DataTrap, because the SuperTrap normally records for such a long time that the pre-trigger time is also very large when compared to delay times between blastholes.

If there is insufficient pre-trigger time, the best procedure is for the operator to re-configure the SuperTrap using the **PRE-TRIG%** dial to increase the amount of pre-trigger time to suit the test. Alternatively, the operator can reduce the recording speed to increase the amount of both pre and post-trigger time.

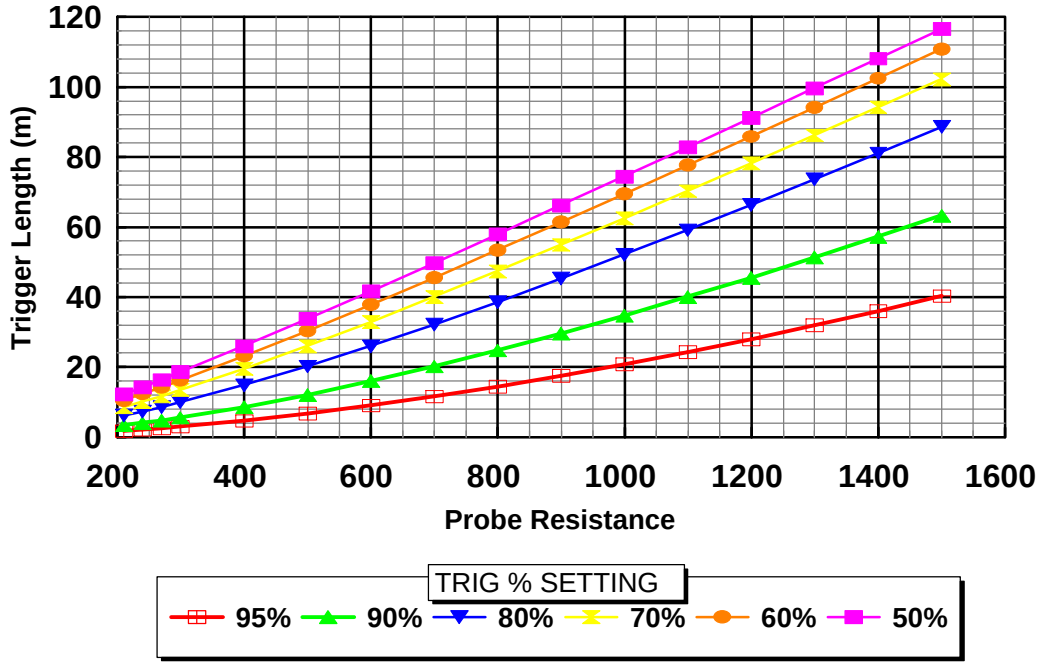
PROBECABLE

SuperTrap Trigger Length Determination



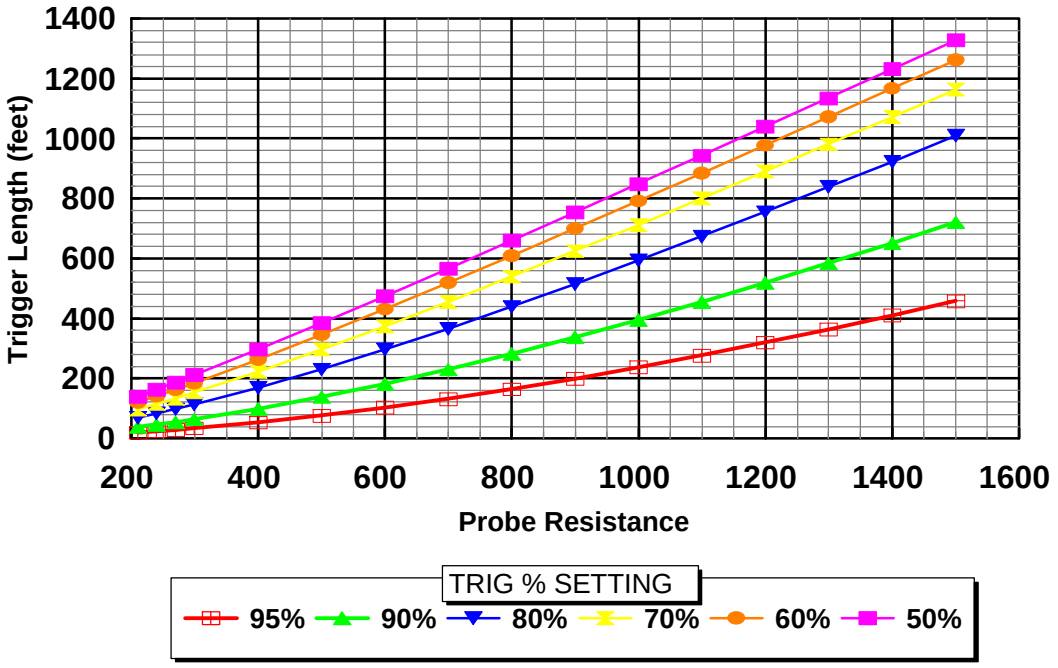
PROBECABLE

SuperTrap Trigger Length Determination



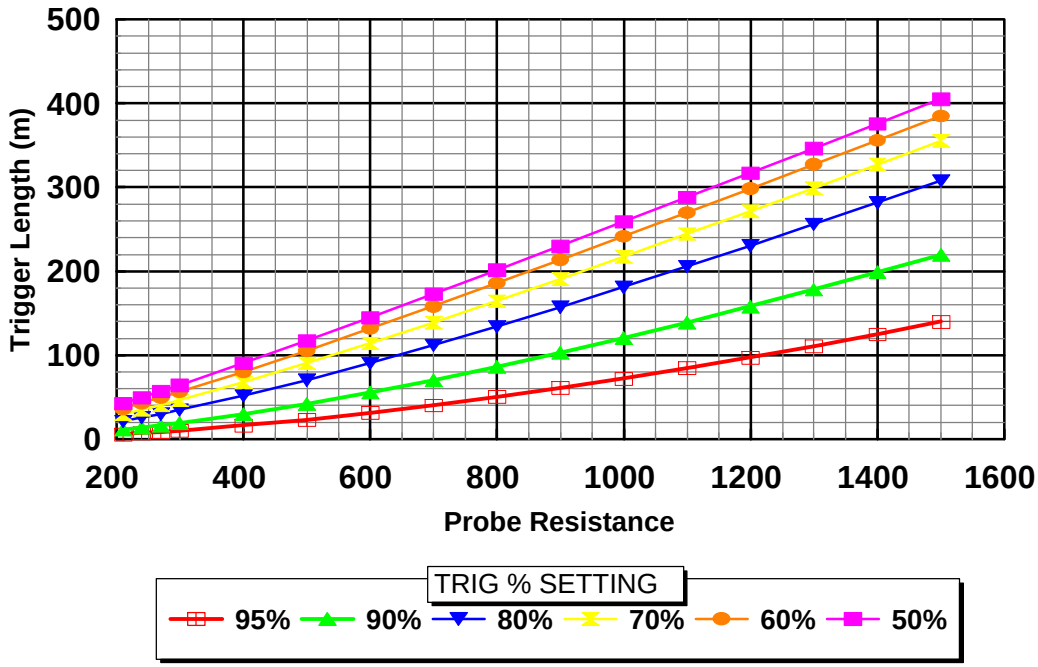
PROBECABLE-LR

SuperTrap Trigger Length Determination



PROBECABLE-LR

SuperTrap Trigger Length Determination



CHAPTER 4: RECORDING DC VOLTAGES

4.1 INTRODUCTION TO DC VOLTAGE RECORDING

All the information that has been provided on the use of the SuperTrap to monitor VOD remains valid when monitoring DC voltage inputs. Memory allocation remains a function of the number of channels being operated and the number of events being recorded, while the available recording time will also depend on the sampling rate selected. The **OUT OF RANGE** light will now indicate an out of range voltage input either HIGH or LOW.

The SuperTrap can be operated using one channel to record the VOD and the other to record a DC voltage output simultaneously, or any other combination thereof. The SuperTrap and associated Software are specifically designed to be used with gauges, power supplies and signal conditioning equipment producing DC signals in the -10 to +10 voltage range or lower. The CH1 and CH2 settings for DC voltage recording allow the selection of different voltage ranges for both uni-polar and bi-polar modes. The 0-5 and 5-10 volt ranges refer to the uni-polar setting commonly used to measure slow changing events such as temperature recordings. The ±2.5, ±5 and ±10 volt ranges refer to the bipolar mode which is frequently used to record faster events such as explosion & detonation pressures, blast vibrations, over-pressures, air blast, strains, etc.

Gauges or transducers used to measure the previous parameters are commercially available. Examples are the tourmaline and carbon resistor gauges to measure cross-borehole propagation, the PVDF transducers to measure detonation pressures, various PCB gauges which can be used to measure vibrations and blast over-pressures as well as various types of thermocouples to measure temperature changes. It is worth noting that when the SuperTrap is used in any VDC setting (i.e. any other than the VOD mode), the SuperTrap does not apply any voltage or current to the gauges or transducers. Should they require excitation signals to operate, the appropriate power supply(s) should then be acquired from the gauge manufacturers or suppliers.

4.2 SUPERTRAP SETUP PROCEDURE FOR VDC MEASUREMENTS

Once the VDC gauges have been placed and connected to the RG-58 coaxial cable(s) running to the signal input connectors on the SuperTrap, the operator can start setting the SuperTrap to record VDC experiments. The SuperTrap's setup procedure is accomplished entirely from the front panel. The procedure to record a new set of experiments consists of the following steps:

1. **ENSURE THAT THE GAUGES ARE NOT YET ATTACHED TO THE SUPERTRAP. OTHERWISE GAUGE DAMAGE AND/OR SUPERTRAP DAMAGE CAN OCCUR WHEN SWITCHING THE CH1 AND/OR CH2 DIAL FROM THE *OFF* SETTING TO A *VDC* SETTING THROUGH THE *VOD* SETTING.**
2. Turn the SuperTrap **ON**. The **STATUS** light indicator will illuminate, and may or may not flash depending on the status the SuperTrap prior to being switched OFF.
3. If the **STATUS** light is flashing (*Stand-by* mode), it is indicating that there are data from previous tests stored in the non-volatile memory and the SuperTrap is waiting for the operator to press the **NEXT TEST** button. Unless the data can be discarded, ensure the data are downloaded before proceeding, otherwise the data will be overwritten.
4. If the **STATUS** light is not flashing, it is indicating that the unit is already in the *Active* mode and waiting for the operator to press the **START** button to await a trigger signal.

5. Select the number of events/tests to be recorded (1, 2, 4, 8 or 16) by setting the **TOTAL TESTS dial** in the **RESET** position. For enabling **RESET**, the SuperTrap has to be in the *Active* mode (i.e. the **STATUS** light illuminated and not flashing), thus, if the light is flashing, the **NEXT TEST** button needs to be pressed to change the SuperTrap to the *Active* mode. Once in *Active* mode, when the **TOTAL TESTS dial** is set to the **RESET** position, the number 1 will flash on the **LED screen**. The operator should now switch the dial to the desired number of tests as verified by the flashing number on the **LED screen**. The TOTAL TESTS is not set into the SuperTrap's memory until later in the procedure (Step 13) when the operator presses the **START** button.

TIP: *The SuperTrap has a massive data memory as discussed in **Section 3.8**. The SuperTrap can record at a speed of 5 MHz for 5.0 seconds when 1 Channel is used and 2.5 seconds per channel when 2 Channels are used. Unless the event being recorded is of a long duration, then it is likely that the full memory of the SuperTrap will not be required to record 1 test. This is certainly the case with high-speed transitional events. To keep data download time and computer hard drive usage to a minimum, the operator should consider switching the **TOTAL TESTS** dial to **16** or 8 or 4, even if only one test is being performed. With the **TOTAL TESTS** dial on **16** this will provide 312.5 msec of total recording time per test when 1 Channel is used and 156.25 msec of total recording time per channel when 2 Channels are used. Of course, if more time is required, then consider doubling the time by switching the **TOTAL TESTS** dial to 8 etc. If fewer tests than 16 are performed before downloading the data to a computer, the SuperTrap Software recognizes this fact and only downloads the data from the test(s) actually conducted. This reduces data download time, minimizes the file size, and conserves computer hard drive space.*

6. Select the operating channel(s) by setting the **CH1** and/or **CH2** dials to the full scale VDC position of choice: 0-5, 0-10, +/- 2.5, +/- 5 or +/- 10 VDC. This selection will depend on the gauge being used in the test and the VDC signal expected. Note that if only one channel is used, setting the other channel to the OFF position will maximize the recording time.
7. Connect the coaxial cable coming from the gauge(s) to the corresponding SuperTrap signal input connector(s) labeled **PROBE 1** and/or **PROBE 2** on the outside and back of the SuperTrap. These connectors correspond to CH1 and CH2 of the SuperTrap.
8. Look for the **INPUT VOLTAGE OUT OF RANGE** warning light indicators (LOW and HIGH). If there is a warning light flashing, then the voltage being produced by the gauge is out of the VDC range selected in Step 6. If this is the case, the operator should test the cable connections to the gauge and power supply, as well a voltmeter should be used to verify the baseline output voltage of the gauge. It is worth noting that, as a safety feature, the **START** button will be blocked and the SuperTrap will be unable to record when an **OUT OF RANGE** condition exists or when both **CH1** and **CH2** are **OFF**. If no warning lights are flashing, then the operator can proceed with the next step.
9. Select the sampling rate using the **PTS/SEC** dial on the front panel. At 5 MHz, the recording time on 1 channel is 5.0 seconds and the recording time on 2 channels is 2.5 seconds. A reduction in recording rate proportionally increases the recording time. Additional information on memory is in **Section 3.8**.
10. Select the trigger level using the **TRIG %** dial on the front panel. This sets the signal voltage level crossing value, which will trigger the SuperTrap and start the recording of data. When working in the VDC mode, the TRIG% represents the percentage of the full scale VDC (set in Step 6) that a signal needs to reach in order to trigger the unit and start recording post-trigger information. For example, when set at +/-10 VDC, a **TRIG %** setting of 10% will cause the SuperTrap to trigger when the voltage from the gauge reaches either +1 VDC or - 1 VDC.
11. Select the pre-trigger percentage time using the **PRE-TRIG %** dial on the front panel. This value represents the percentage of the available total recording time in which the SuperTrap will record pre-trigger information, that is, data that occurs immediately before the signal level crosses the trigger level setting and triggers the unit to start the post-trigger recording process. Additional information on triggering is in **Section 3.8**.

It is worth noting that the last three settings (**PTS/SEC**, **TRIG%** and **PRE-TRIG%**) can be changed at any time between tests, and only when the **START** button is pressed are the values accepted as the settings for the upcoming test.

12. Ensure the **TRIG SOURCE EXT/INT** dial is set to the CH1, CH2 or CH1/CH2 position. This selection will depend on which channel the operator wants the SuperTrap to look for a trigger signal - CH1, CH2 or both. Normally for 1 channel VDC tests, either the CH1 or the CH2 setting would be selected depending on the channel being recorded. Normally for 2 channel VOD tests the CH1/CH2 setting should be selected. The use of external EXT triggering is discussed in **Section 3.7**.
13. Press the **START** button. The **START light** will illuminate steadily. During this time, all of the positions of the SuperTrap dials and switches (Steps 5-12 above) are written to the SuperTrap's memory. The SuperTrap then starts waiting for the trigger signal to start collecting VDC data. Personnel can now leave the SuperTrap unattended.
14. When the triggering condition is met (i.e. the voltage signal has crossed the trigger level set in Step 9), the SuperTrap will trigger and start collecting VDC information. Upon triggering, the **TRIG'D**, **START** and **STATUS** indicator lights will illuminate and remain illuminated during the collection of data (this time depends of the sampling rate selected).
15. Once data collection ends, the **TRIG'D** indicator goes off and the SuperTrap starts storing data into its non-volatile memory. During the storing period, the **START** indicator will flash, indicating that data is being transferred into memory (this period will depend of the number of tests selected). The **STATUS** indicator will remain illuminated. Do not switch the SuperTrap **OFF** at this point.
16. Upon finishing the storing process, the **START** indicator will go off and the **STATUS** indicator will commence flashing. At this point the SuperTrap returns to the *Stand-by* mode.
17. If testing has been completed then go to Step 17. Otherwise press the **REMAINING TESTS** button to confirm how many tests can be still hosted by the SuperTrap before downloading of the data to a computer is required. If there are 1 or more tests remaining in the memory then press the **NEXT TEST** button and go to Step 6. If there are 0 tests remaining in the memory, then either download the data to a computer (**Section 5.4**) and return to Step 1, or go to Step 17.
18. If no more experiments are to be conducted, and the data storing process has been finished (Step 16 above), turn the SuperTrap **OFF**; the data will remain in the SuperTrap's non-volatile memory.

CHAPTER 5: SUPERTRAP SOFTWARE

5.1 COMPUTER REQUIREMENTS

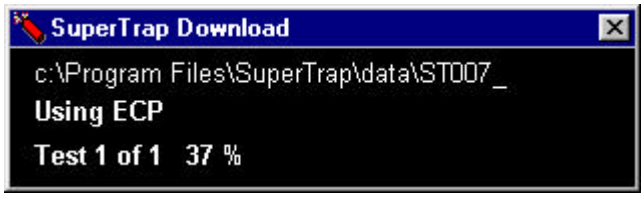
The SuperTrap Advanced Analytical Software for Windows '95 has been provided on 3.5 inch computer disks. This software can be installed on any PC system with the following minimum specifications:

1. Pentium 100 or higher processor.
2. 32 Mb RAM.
3. 10 Mb hard drive space for Software installation and up to an additional 50 Mb for each uncompressed data file. It is recommended that 100 Mb of hard drive space be available on the computer.
4. Windows '95 operating system. Windows '98 and Windows NT are not supported at this time.

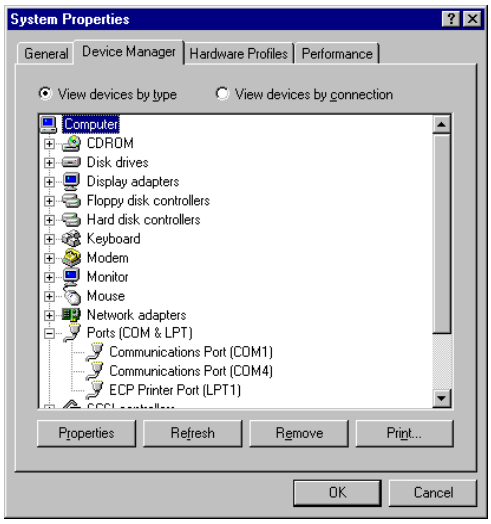
5.2 INSTALLATION

To install the SuperTrap Software, start Windows '95 and insert the first installation disk (Disk 1) in to the 3.5 inch drive (usually A:). Choose Start-Run, then type **A:\setup**. Follow the instructions on the screen. If a message appears mentioning "*msvcrt*" just click **ignore**. When the installation is complete, re-boot Windows '95. The SuperTrap icon will be visible. You may need to restart the computer, insert the first disk, and run setup.exe again. The installation program will tell you this if it is required. To start the SuperTrap Software, double click on the SuperTrap icon or Start-Programs-SuperTrap.

5.3 THE PRINTER PORT



The SuperTrap can download data through 3 parallel port types - Standard (SPP), Enhanced (EPP), and Extended Capabilities (ECP). If the port is SPP or EPP, it uses SPP mode. If the port is ECP, it uses the faster ECP mode. The mode used is shown while downloading. Downloading is usually about 10 times faster in the ECP mode. If downloading a full-length SuperTrap test takes 3-4 minutes or downloading a short test takes less than 30 seconds, then you can assume that the computer has an ECP port. If a full test takes 20-30 minutes to download, then your computer is in SPP mode. You may wish to use a different computer or attempt to change the computer's printer port to a different mode.



Port information can be viewed in Windows 95 by clicking on Control Panel - System Properties and clicking on "Ports" to view the current type of printer port.

Most computers built in the last few years have either ECP or EPP or both. Some computers, however, are shipped with the BIOS set so that the parallel port is in SPP mode since this is the motherboard default. Most desktop computers allow the parallel

port to be changed in the BIOS setup mode, which can be entered during the first few seconds after starting the computer. Care must be taken while in this mode since changing certain settings can prevent the computer from starting. On some computers this mode is password protected and only a computer support person can access it.

Some laptops may provide only some of the above modes in BIOS setup mode. Some do not have a BIOS setup mode at all and use a custom program from within Windows, such as "Toshiba Utilities", to view and change laptop parallel port modes. Note that parallel ports can be added to laptops with PCMCIA cards or USB to parallel port adapters.

It cannot be guaranteed that the SuperTrap will be able to download on a specific computer on the first attempt. The parallel port is an evolving standard and certain active printer and scanner drivers may interfere with downloading. Usually such problems can be solved with support from MREL or local computer support. The fastest solution may be to use a different computer, then reconfigure the original computer when data is not waiting to be downloaded and analyzed. **It is good practice to ensure that a specific computer will download data from the SuperTrap before conducting a field test in which the data needs to be analyzed immediately.** The data will be held permanently in the SuperTrap's memory for later downloading.

Notes:

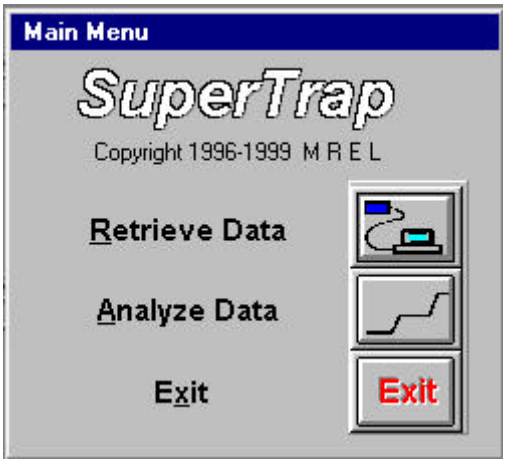
1. Most versions of Windows 95 do not have a native EPP driver, so if the BIOS is set to EPP, the printer port will show up as SPP. Also, some computers have an ECP/EPP driver, which allows both modes.
2. After changing from SPP to ECP mode, the printer port mode in "System Properties" may not change unless you remove the current driver, restart Windows 95, then allow plug-and-play to install the ECP driver. The SuperTrap can download with ECP speed regardless of the driver.
3. Some older printers will not work in ECP or EPP mode. Some printers will start working faster if the port is changed from SPP to ECP or EPP.
4. Some computers, particularly those made by IBM, have a mode called "Bidirectional" or "PS/2" which appears as "Printer Port" in the Windows 95 control panel. The computer may need to be changed to either SPP or ECP for downloading to work.
5. The current software allows the SuperTrap to be downloaded through LPT1, LPT2, or LPT3.
6. After downloading, the files are compressed if the compression tick box is on, which can add significantly to the time of the entire download operation depending on the speed of the computer. If a computer is slow at compressing files, the operator may wish to download the files uncompressed, view them, then save them as compressed files later.
7. Once the file retrieval box shows a compression message such as "Compressing file 2 of 16" the communication between the SuperTrap and the computer is over, and the SuperTrap can be detached and turned off or prepared for a new test.
8. If the Supertrap is connected to a parallel port switch box, ensure that the total length of all cables is less than 10 feet (3 m).
9. Do not connect the SuperTrap through a "dongle" or "pass-through port" in a Zip Drive, scanner, printer, or other such device.
10. It is worth repeating: Making a particular computer download data with high speed ECP mode (or download at all) can be a trial and error process. Over 80% of computers made in recent years will download in fast ECP mode on the first attempt. Often the best solution to a download problem is to try a different computer. Contact MREL for technical support.

5.4 RETRIEVING DATA

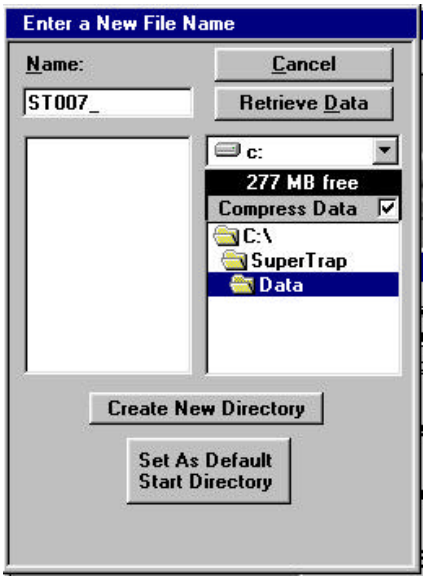
The procedure to retrieve data from the SuperTrap to a computer is as follows:

1. Connect the **Communications Cable** supplied with the SuperTrap between the LPT1 (parallel printer port) on the computer and the **LPT COM** port on the front panel of the SuperTrap. Do not connect to a "pass through" port such as on a ZIP drive or a "dongle" since incorrect data will result. Connection to a printer switching box will not cause a problem.
2. Turn the SuperTrap power **ON**.
3. Start the SuperTrap Software by double clicking on the SuperTrap icon or **Start-Programs-SuperTrap**.

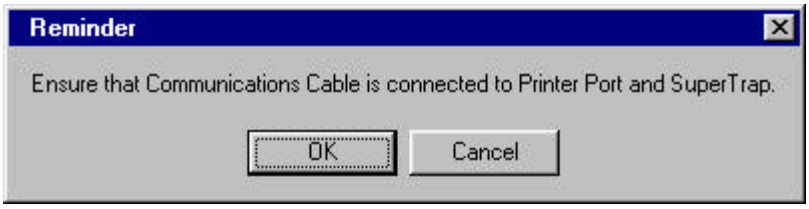
4. At the Main Menu click on the **Retrieve Data** button or with the keyboard press Alt-R. Data retrieval can be accomplished without the use of a computer mouse by pressing "tab" to move between data entry fields.



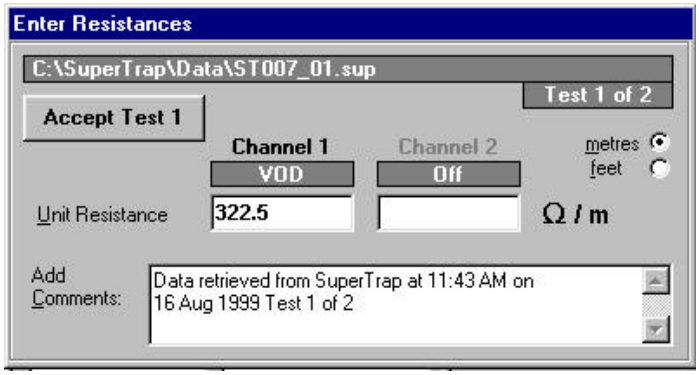
5. Choose a drive, directory and file name in which the SuperTrap data will be stored. The directory defaults to C:\SuperTrap\Data. The file name, in this case, is ST007_ . The numbers from 01 to 16 will be added to the name in case of multiple events in the SuperTrap memory. Other SuperTrap files already stored in the directory are also displayed. Clicking on the Compress Data tick box turns the file compression on or off. With Compress Data on, the retrieval from the SuperTrap takes longer for some computers but the file size is reduced conserving computer disk space. New directories can be created from this window using the **Create New Directory** button. Note that the current directory can be **Set as Default Start Directory** for saving files. When all information is entered, click on the **Retrieve Data** button. Otherwise, click on the **Cancel** button to return to the Main Menu.



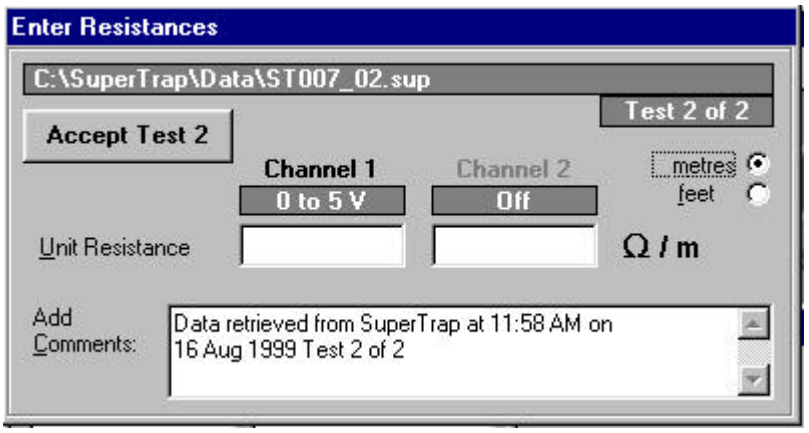
6. A reminder message window is then displayed. Click on **OK**. Refer to **Section 5.3** if data downloading appears to take a long time.



7. The following example shows the dialog window when data has been downloaded from the SuperTrap. In this example, the SuperTrap had recorded 2 events in its memory as indicated on the window ***(Test 1 of 2***). In the first test, Channel 1 was used to record a VOD and Channel 2 was OFF. For the VOD test, the operator can click on the preferred units of measurement (meters or feet). The **Unit Resistance** of the probe used in the VOD test must be entered. This value was noted when on the blast (**Section 3.3**). Channel 2 requires no data as it was OFF during the test. The operator can also **Add Comments** about the data so that the file can be easily recalled. Notice that this file will be saved as ***ST007_01.sup***. Click on the **Accept Test 1** button when the resistance information has been entered for the first test.



8. A window will open for the 2nd test (***Test 2 of 2***) in the SuperTrap's memory. Notice that this file will be saved as ***ST007_02.sup***. In this test, Channel 1 recorded voltage in the range from **0-5 VDC**. Channel 2 was **OFF**. Since neither channel was recording VOD during the second test, then no data needs to be inputted into the **Unit Resistance** fields. The operator can also **Add Comments** about the data so that the file can be easily recalled. Click on the **Accept Test 2** button to finalize the saving of data to the computer in the two file names: ST007_01.sup (Test 1) and ST007_02.sup (Test 2).

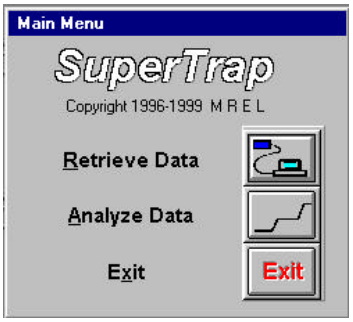


9. The **Communications Cable** can be detached from the computer and the SuperTrap and the **NEXT TEST** button may be pressed if another test is to be conducted.

5.5 SELECTING DATA FILES FOR ANALYSIS

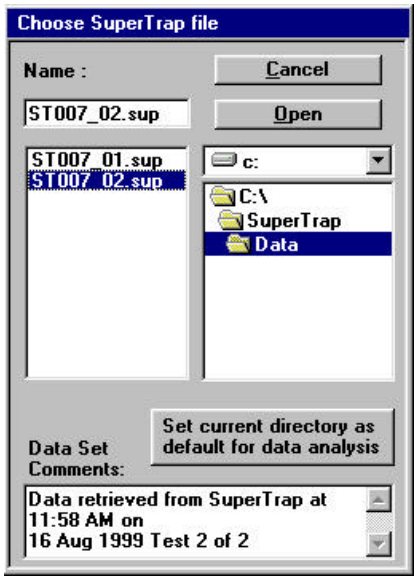
The procedure to select a SuperTrap file is as follows:

1. From the **Main Menu**, click on the **Analyze Data** button or press Alt-A.



2. Click on the file name of interest, use the **Data Set Comments** box as a guide to each file's content.

3. Click on the **Open** button when a file has been selected, otherwise click on the **Cancel** button to return to the **Main Menu**. Note that the current directory can be set as the default directory for opening files.

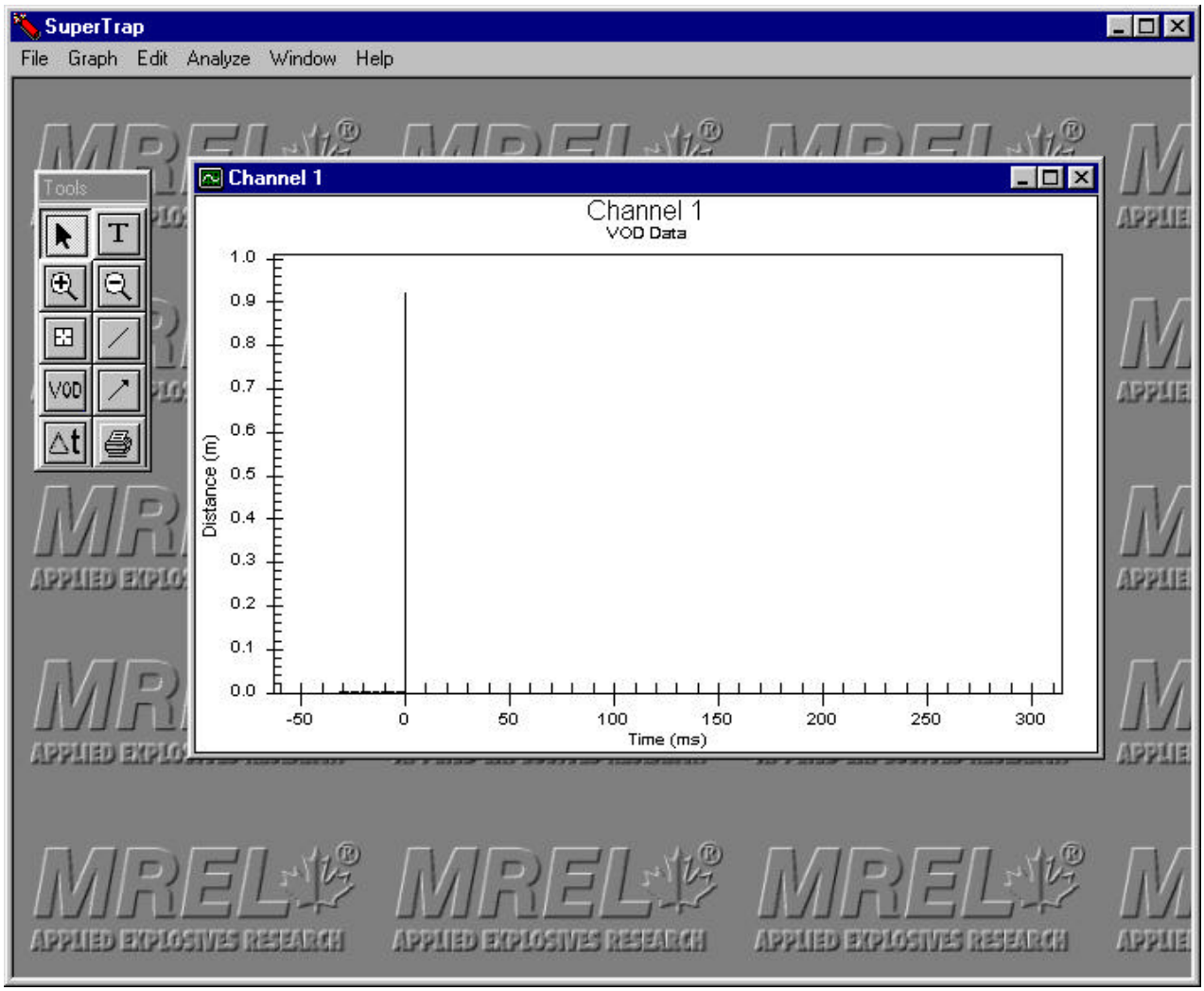


For this example, ***ST007_01*** is chosen to illustrate the results of a VOD test on a sample of explosives. ***ST007_01*** and ***ST007_02*** are data files which have all been included as examples with the SuperTrap Software. **Chapter 6** provides the detailed procedures for analyzing the data in each of these files.

Clicking on the **Open** button automatically starts the SuperTrap Analytical Software with the chosen data file. The following section outlines the capabilities of the Analytical Software.

5.6 INTRODUCTION TO ANALYSIS

The following screen is displayed when a VOD file has been chosen for analysis:



The screen contains three main areas that are summarized below and discussed in more detail in the following Sections as well as in **Chapter 6**:

Desktop: the area having the MREL logo as background. One or more graphs can be displayed in maximized, normalized or minimized size states in the area.

Tools Bar: a moveable menu of icons, which allows the operator to access analysis and graphics tools.

Menu Bar: located across the top of the screen. It includes pull down menus for File, Graph, Edit, Analyze, Window and Help.

If the file had been a VDC file, then the **Formula Bar** would also have been displayed on the Desktop. The Formula Bar is a moveable menu of pull down menus which allows the operator to easily apply a formula to convert voltage data to engineering units in the active graph.

5.7 DESKTOP

When a data file is initially opened, the Desktop area of the software, which has as a background the MREL logo, shows the original **Channel 1** and/or **Channel 2** data graph in a normalized state. The data and graphics on the "Channel" graphs can not be changed. New graph names must be given to the modified graphs (or sub-graphs). In this way, the original data for the test can never be lost. In the example in **Section 5.6**, the ***ST007_01*** data file at this point in the analysis has only 1 graph, which is the original **Channel 1** graph.

From this original graph, other graphs, known as sub-graphs can be made and saved by the operator under new graph names. These sub-graphs can include some or all of the data in the original graph and can include graphics, text and analysis information as added by the operator. The next time the data file is chosen for analysis, the original graph and all sub-graphs will be opened. There is no limit to the number of sub-graphs, which can be created from an original graph. The procedure for creating sub-graphs is discussed in **Chapter 6**.

By clicking on either the normalize icon or on the maximize icon on any minimized graphs (per normal Windows procedures), the data can then be viewed and analyzed.

5.8 TOOLS BAR

The Tools Bar contains a selection of ten (10) tool buttons used to add or modify the graph's characteristics, text and graphics and to apply analysis procedures to the data in the graphs to calculate VODs and delay times between holes. The Tools Bar can be moved anywhere on the Desktop. The basic functions of each of the tool buttons are outlined below:


The **Select Tool** has many functions including: selecting, moving, minimizing, maximizing and normalizing graphs; selecting and modifying any component of the graphs by double clicking on the component (i.e. x-axis, y-axis, data, text, titles).


The **Text Tool** allows the operator to add new text/titles/comments to graphs.


The **Zoom In Tool** allows the operator to zoom in on any part of the data and graph.


The **Zoom Out Tool** restores the data to the range before zooming in was performed.


The **Data Value Tool** displays the digital x, y (time, distance) value of any data point on the graph.


The **Line Tool** allows the operator to add a straight line to graphs.


The **Arrow Tool** allows the operator to add a straight arrowhead line/pointer to graphs.


The **VOD Tool** allows the operator to automatically calculate the VOD for any part of the VOD graph by doing a linear regression on all of the data between any two data points on the graph.

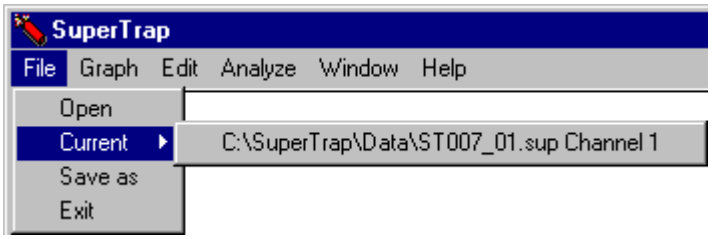

The **Delay Tool** allows the operator to automatically calculate the delay time between any two data points on the graph.


The **Print Tool** allows the operator to print the active graph.

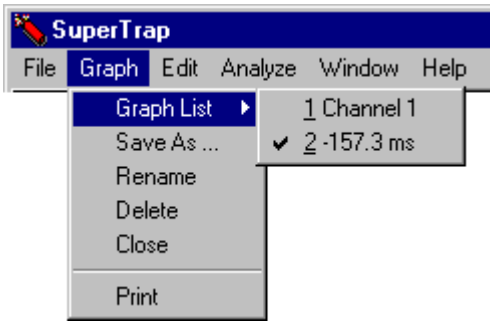
5.9 MENU BAR

The Menu Bar contains a selection of six (6) pull down menus used to open data files and their associated graphs, save sub-graphs, print graphs, export data and graphics, move and erase bad data points, arrange graphs on the Desktop and provide access to the online Help. The Menu Bar is always located at the top of the Desktop. The basic functions of each of the pull down menus are outlined below:

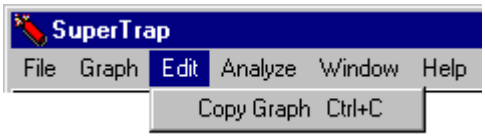
The **File** menu allows the operator to **Open** data files, display the name of the **Current** data file, **Save** the current data file including the associated graphs and **Exit** the Analysis section of the Software.



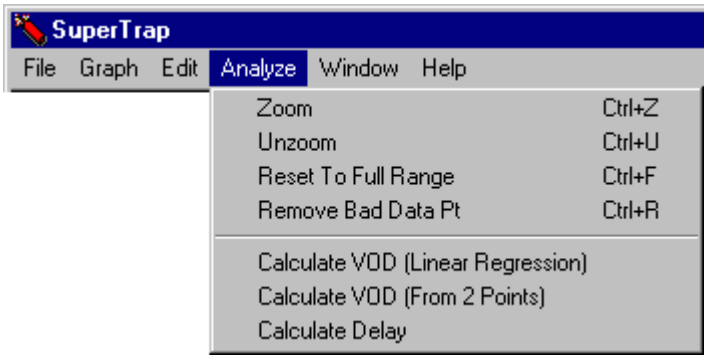
The **Graph** menu allows the operator to **List** the graphs associated with the current data file, **Save** and **Rename** the sub-graphs, **Delete** the sub-graphs, **Close** the sub-graphs for the current analysis session, and **Print** the active graph.



The **Edit** menu allows the operator to **Copy** the **Graph** to the computer's memory for pasting into other Windows applications such as word-processors. Later releases of the SuperTrap Software will allow the operator to Copy the Data, which comprises the graph, for subsequent pasting into Windows spreadsheets, and Export the data to an ASCII file for use by other graphics/analysis software.

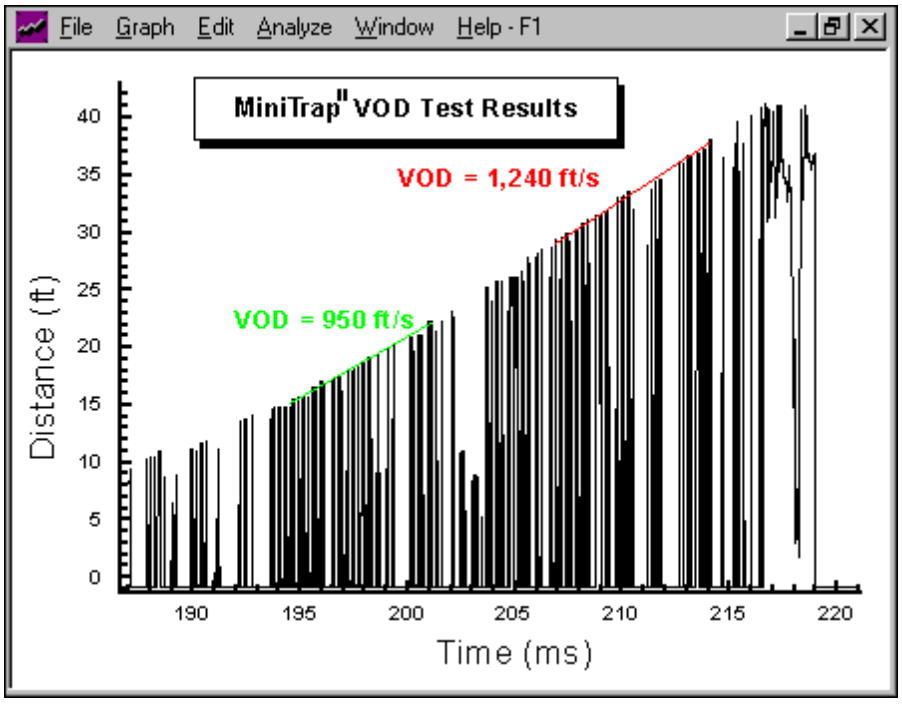


The **Analyze** menu allows the operator to **Zoom** in on the graph, **Un**do the last **Zoom**, **Reset** the graph to full range, **Remove** bad data points, calculate a **VOD** using **Linear Regression**, calculate a **VOD** from **2 Points** on the graph, and calculate a **Delay**. Later releases of the SuperTrap Software will allow the operator to Remove Negative Distance Changes on a VOD graph.



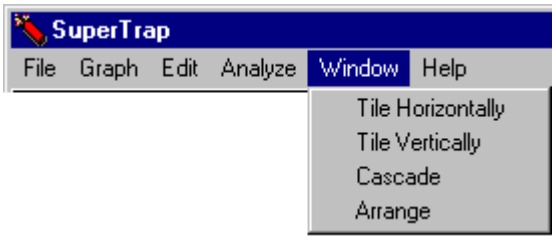
The **Remove** and Remove Negative Distances Changes (to be included in later Software releases) menu items can be used on data points that sometimes result from inefficient shorting of the probe, causing downward spikes in the data.

When explosives react very slowly, there may be inefficient shorting of the probe. This may result in a graph similar to that shown below which is a VOD record from a MiniTrap[II] Explosives Continuous VOD Recorder. The trend of the VOD is apparent, however there are many downward spikes on the trace which make the normal Calculating VOD using the regression inaccurate. In such cases the operator can Calculate VOD from 2 Points from the Analyze menu.

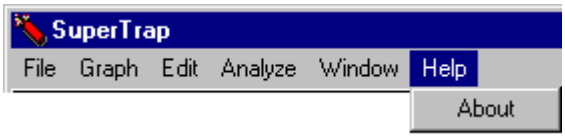


In the next release of the SuperTrap Software, using the Remove Negative Distance Changes will allow the operator to improve the appearance of the graph for presentation purposes in an automated fashion.

The **Window** menu allows the operator to automatically arrange the non-minimized graphs on the Desktop in three (3) ways: **Cascade**, tile **Vertically**, and tile **Horizontally**. This menu also allows the operator to automatically **Arrange** the minimized graph icons.



The **Help** menu displays information **About** the SuperTrap Software, including contact information for MREL. The next release of the SuperTrap Software will allow the operator to access a digital copy of the Operations Manual (through Adobe Acrobat) while the Operator is using the Software.



5.10 FORMULA BAR

The Formula Bar is originally minimized and becomes full-size when one of the function tabs is clicked.

To access the current formula, click on the Y(V) tab.

To minimize it again, click on the 

APPLY BUTTON

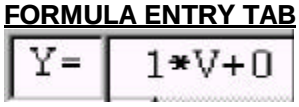
The **Apply** button applies the typed formula to the data currently in view. It also updates the y-axis if new units have been entered. This button is not available for original graphs (the ones labeled Channel 1 or Channel 2). For these graphs, the formula and units are entered and the **Apply to New Graph** button is pressed.

APPLY TO NEW GRAPH BUTTON

This creates a new graph with the same time range as the graph currently in view. It applies the formula to the original voltage data. It also labels the y-axis with any new units entered in the **Y-axis** tab.

NOTE FOR BOTH APPLY BUTTONS: Before implementing the Apply or Apply to New Graph, the Software checks the formula for syntax errors (such as unbalanced brackets) and evaluation errors (such as division by zero or square root of a negative number). If there is an evaluation error, the program will ask for confirmation that a "missing point" for that value should be plotted (i.e. no point visible). Later actions such as integration and exporting of data will leave this point out. If you receive continual requests for missing points, the formula may be invalid for a large range, such as Sqr(V) when V ranges from -5 to +5 VDC.

FORMULA ENTRY TAB



The formula for the current graph is displayed in a text box to the right of "Y=". The formula is entered using normal mathematical notation and can contain spaces. The formula is applied to the data as Volts if "V" is used or as milliVolts if "mV" is used. Numbers must use a period as a decimal separator, so "0,5" will cause an error and should be entered as "0.5". Numbers cannot be expressed in some notations, for example "4.74e-06", but these numbers can be entered as "0.00000474" or the more readable "4.74*10^-6".

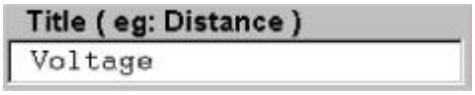
The formula operators available are:
Sin, **Cos**, **Tan**, **Atn** (uses radians)
Log10, **Exp**, **Log** (natural logarithm)
Abs (absolute value), S**qr** (square root)
+,**-**, ***** (plus, minus, multiply)

/ (real number division i.e.: 7/2=3.5), **** (integer division i.e.: 7/2=3)
^ (to the power of)

Also, the constant **Pi** and user-defined constants can be used in a formula. Some examples are:

mV	Plot the data as milliVolts instead of Volts.
15.302 * V	Apply a conversion factor of 15.302 units per V.
mV * (1/2.873)	Apply a conversion factor of 1/2.873 mV per unit.
(mV-0.051)^(7/8)	Apply a formula after applying an offset.
ArmLength3 * sin(mV * mvToDegrees * 2 * Pi/360)	Use user-defined Constants (see **Constant Value** box) to create a formula.

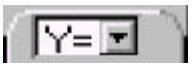
Y-AXIS TAB 

Axis Title box: 

Unit Entry box: 

Entering a new Y-axis title or unit, then clicking Apply or Apply to New Graph changes the Y-axis title from "Voltage (V)" to "New Title (New Unit)" ie: "Distance (cm)". These names are used in other Software functions.

Note that simply changing the formula "Y=1*V+0" to "Y=1*mV+0" or "Y=mV" will not automatically change the Y-axis units to mV.

Y=LIST TAB 

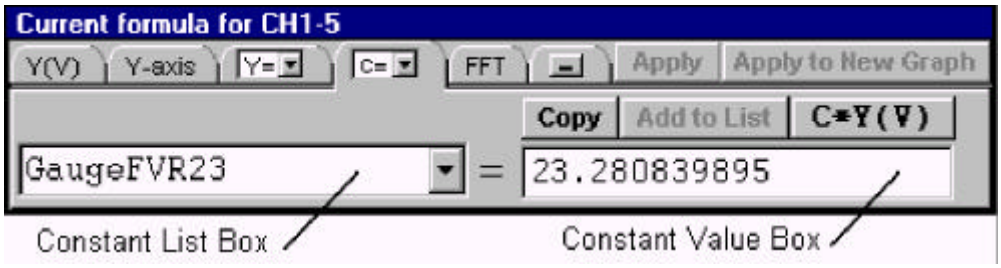
Formula List box: 

This is a read-only list of formulas previously stored by the operator. Clicking on the down arrow shows the list. Selecting one of the formulas makes that formula active.

To apply the active formula to the current graph, the operator then clicks **Set as Current Formula, Units**. Then click the **Apply** or **Apply to New Graph** button. This also sets the Y-axis to the unit and title used with that formula.

The **Add Current Formula, Units to List** button saves the current formula, title, and units to a permanent list. It can be recalled later by selecting it and clicking the **Set as Current Formula, Units** button.

CONSTANT TAB 



Constant List Box: This is a combination text entry and list box. The list function allows the operator to choose from a list of any constants previously stored. A new constant name can also be entered in this box.

Constant Value Box: If a constant is being created by the operator, its value is entered in this box. If a constant has been chosen from a list, its value is displayed in this box. Once a new constant name and value have been entered, the **Add to List** button stores it in a permanent list of constants.

Copy Button: This copies the current constant name into the clipboard. It can then be entered in the formula by pressing Ctrl-V. The constant name can simply be typed in the formula, but since it is often not a real word, it can be difficult to remember its exact spelling.

Add to List Button: This adds the currently entered constant to the permanent list of constants.

C*Y(V) Button: This button automates the most common use of a constant - multiplying it by the current formula. This occurs when using a conversion factor from Volts to the desired unit. It also occurs when changing units by multiplying by a constant such as "psiToMPa".

Using this button places brackets around the current formula, so no unexpected order of operations error occurs. For example, if the current formula was "V-0.0366" and this button was used, the resulting formula would become (GaugeFVR23 * (V-0.0366)) not (GaugeFVR23 * V -0.0366) which would have given an incorrect result.

If the Gauge value was in units of "psi/V" and units of MPa were desired, the constant "psiToMPa" could be chosen from the constant list, the C * Y(V) button checked, and the formula would become (psiToMPa * (GaugeFVR23 * (V-0.0366))).

Note that to complete the conversion, the operator must change the units in the **Y-axis** tab, then click on the **Apply** button.

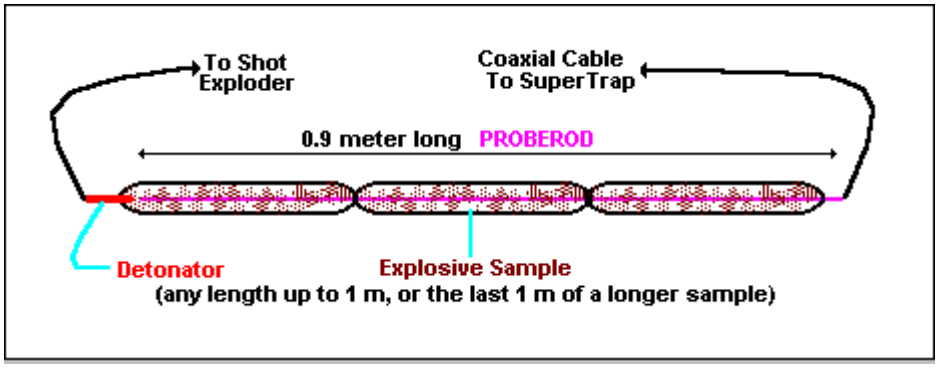
CHAPTER 6: EXAMPLES OF DATA ANALYSIS

6.1 VOD ANALYSIS

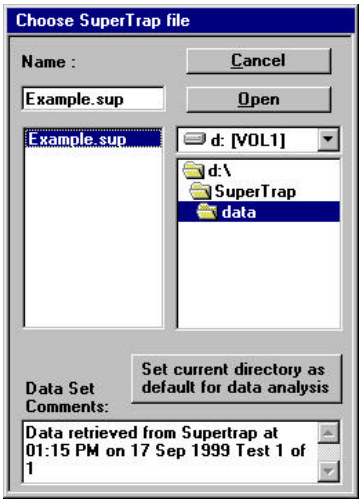
This Section presents a detail analysis conducted on a VOD test performed on a sample of explosives using a PROBEROD. The operator is encouraged to follow the example using the Analysis Software. Graphics are also provided to illustrate the analysis of VOD tests on other explosive samples and on explosives loaded in blastholes.

6.1.1 Sample of Explosives (*Example*)

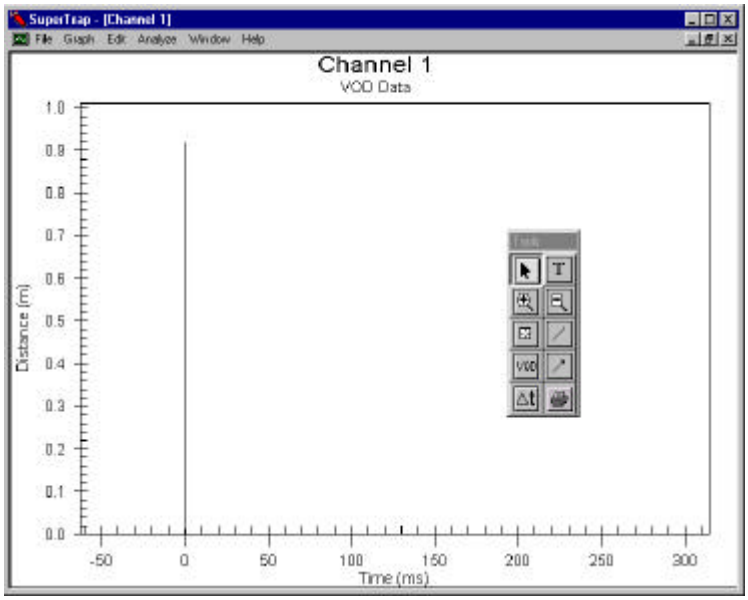
As detailed in **Section 3.3.1**, a typical VOD test of an explosive sample is shown below.



From the Main Menu, select the Analyze Data button (**Section 5.5**) and open the *Example* file.



Maximizing the Channel 1 original data graph and moving the Tools Bar results in the screen shown below:

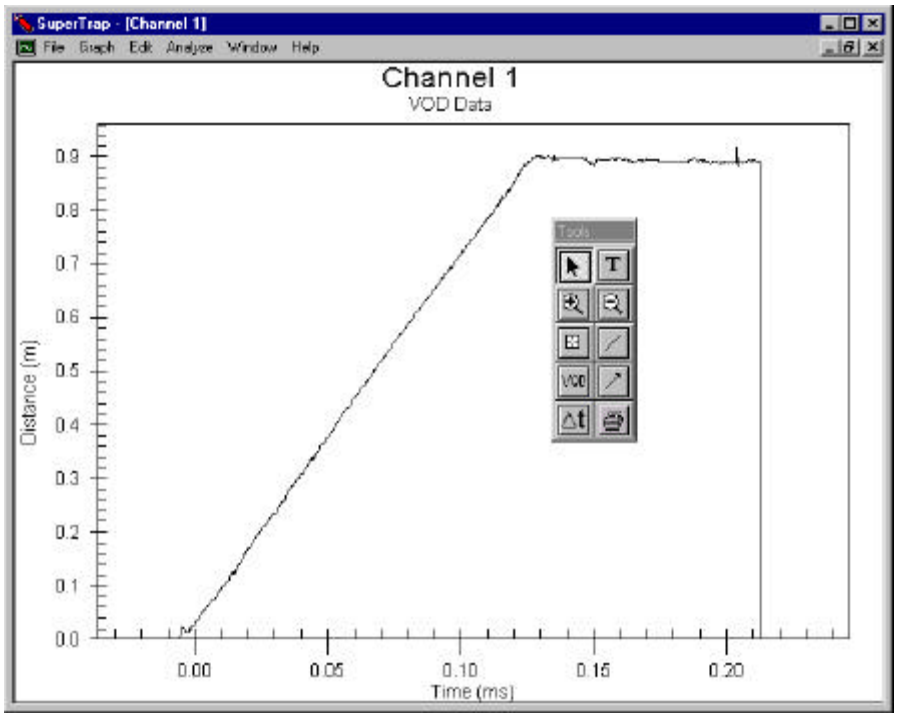


The graph shows a line plot of distance versus time for the complete duration of a VOD test. The test configuration was similar to that of the one sample of explosives test set up shown above. The length of the explosive column is approximately 0.9 m.

The graph has two time areas: before time = 0 (pre-trigger time) and after time = 0 (post-trigger time). In all VOD tests, the SuperTrap is triggered to begin recording at time = 0 but has a pre-trigger data memory before time = 0 (**Section 3.8.2**). This allows the SuperTrap to record the information from the probe as it is being consumed to the probe length at which the SuperTrap will trigger. The SuperTrap records post-trigger data after time = 0.

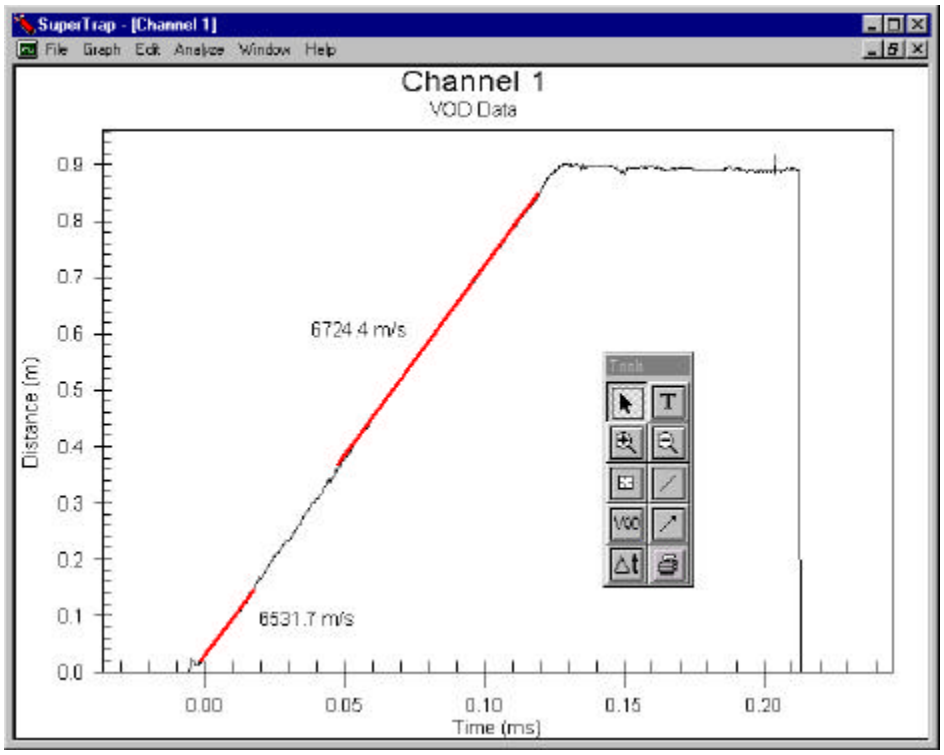
Since only a sample of explosive was tested, and the time for the explosive to detonate (approximately 0.15 ms) is far less than the total time that the SuperTrap records, a large amount of extra data was recorded after the detonation in the hole was complete. Using the **Zoom In Tool** (**Section 5.8**), the operator can focus on the area of interest: the part of the graph that shows the explosive detonating.

The following screen shows results from zooming in several times on the data of interest. If the wrong area is chosen, use the **Zoom Out Tool** to undo the Zoom In.



To change the format of the graph, the x and y-axis, plot type etc... use the **Select Tool** (**Section 5.8**) to double click on the graph window. Double clicking with this tool on the graph window, axis titles and other objects allows some changes to be made to the attributes of these items. The **Text Tool** (**Section 5.8**) can be used to add additional comments on the graph.

To analyze the data for VOD, choose the **VOD Tool** (**Section 5.8**). The software calculates the VOD by conducting a linear regression on the data contained between two data points chosen by the operator. The software prompts the operator to click on the "first" data point and then on the "second" data point, thus defining a data range for the VOD calculation. The operator will know when he is on a data point as the arrow will change to a hand. The VOD result is automatically shown with a colored straight VOD line over the data range of interest. The operator can perform an unlimited number of VOD analyses on a graph. The VOD text and line can be chosen with the **Select Tool** for moving. By double clicking on the VOD text and VOD line with the **Select Tool**, the operator can change the properties of these items or delete them.

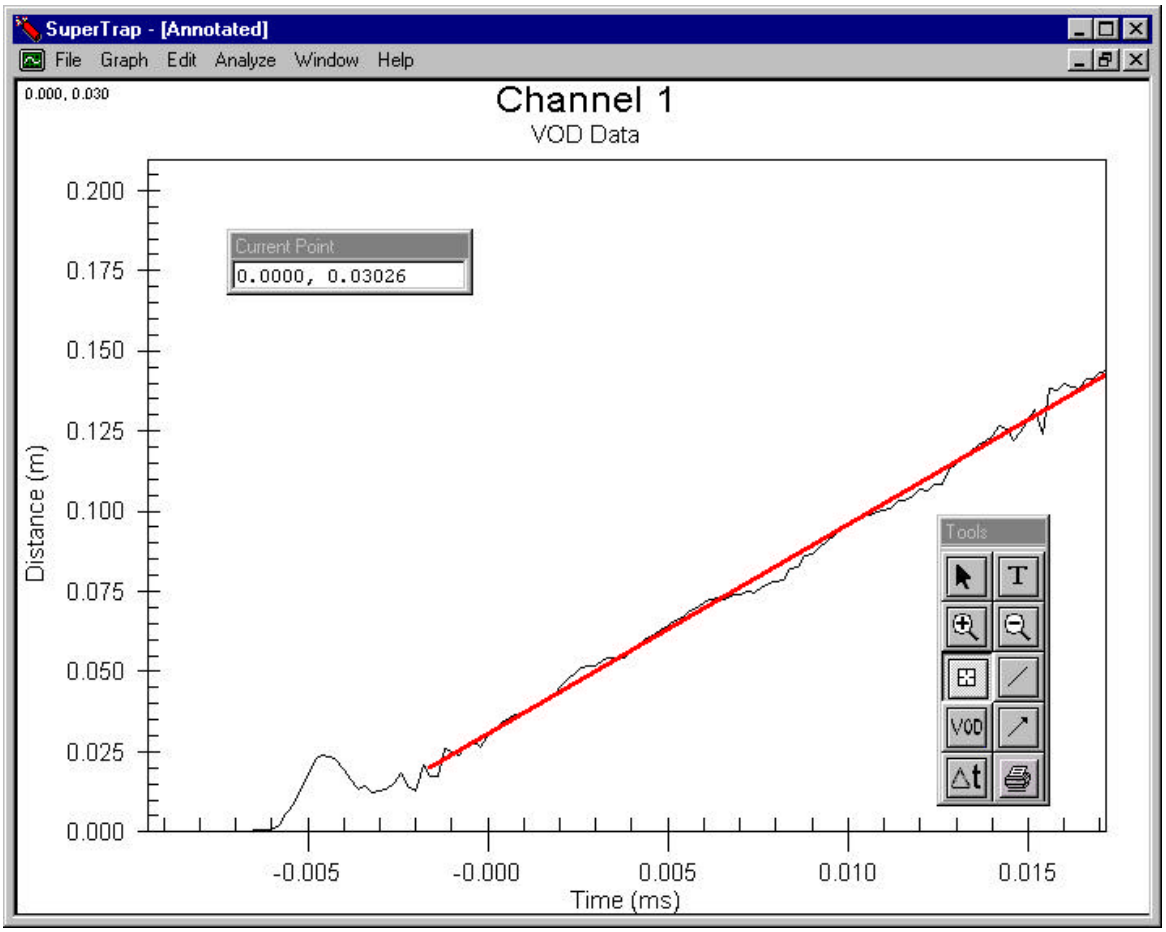


When the graph has been annotated to the satisfaction of the operator, using the Menu Bar, the graph can be saved as a sub-graph. The operator cannot overwrite the Channel original data graph name that contains the original data and graphics. The operator chooses **Graph-Save As** and then types in a name for the sub-graph. This sub-graph will be stored with the Example file and will be automatically opened along with the Channel 1 original data graph the next time the *Example* file is chosen for analysis.

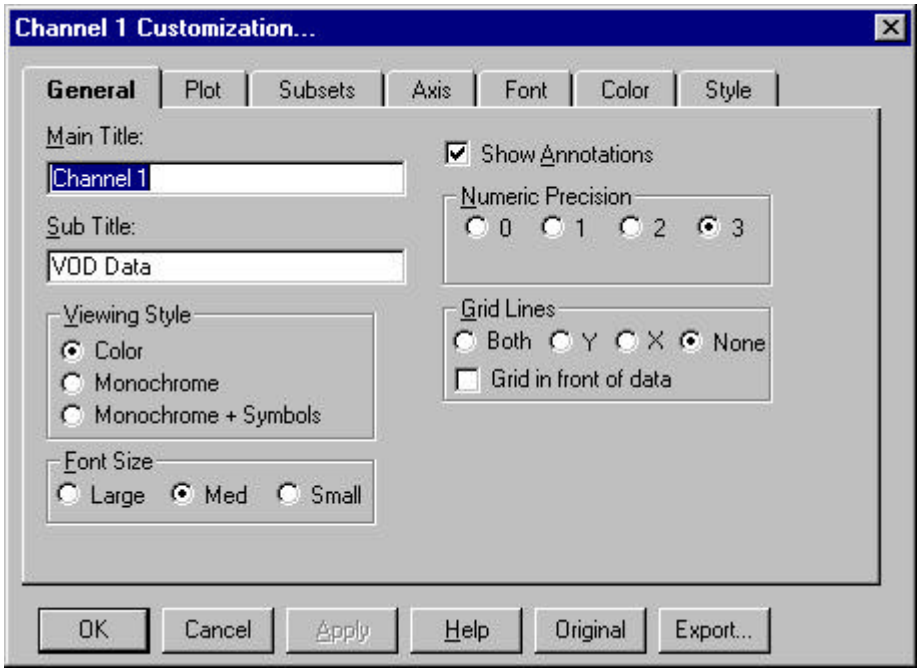
The operator may wish to copy the graph into a Windows word-processor for a report. To do this the operator chooses **Edit-Copy Graph** from the Menu Bar. The operator can then minimize the SuperTrap Software, open the word-processor and Paste the graph.

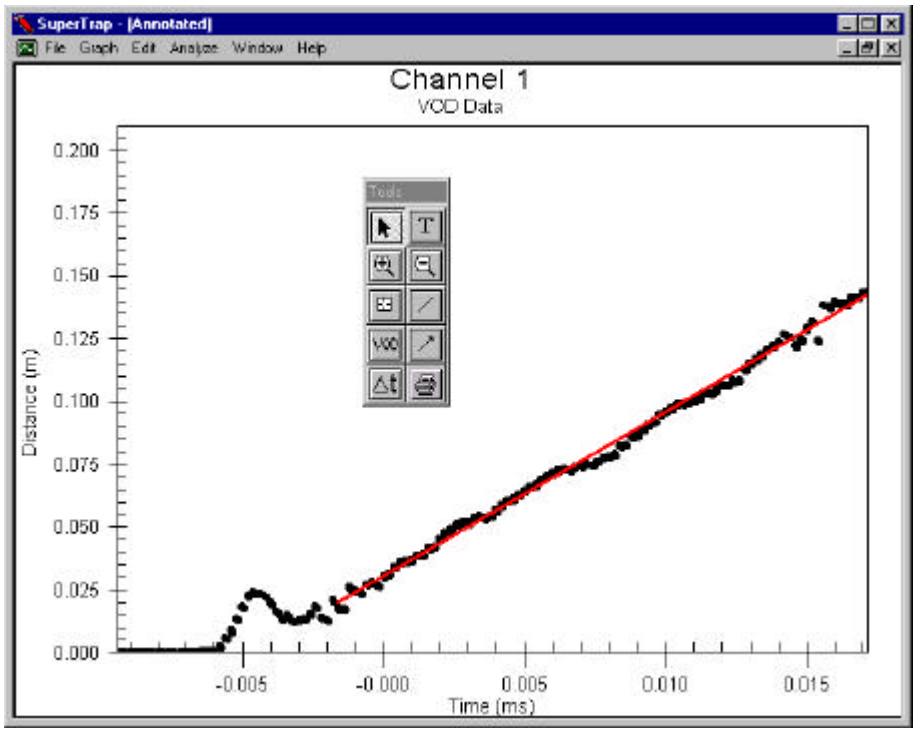
To print directly from the SuperTrap Software, the operator can either use the **Print Tool** or select **Graph-Print** from the Menu Bar.

On the next screen, for interest only, the graph with the VOD analysis has been enlarged further using the **Zoom In Tool** and the **Data Value Tool** has been used to click on the graph to find the distance at which time = 0. The x, y (time, distance) coordinates of this point are shown in the **Current Point Window**. Notice that when the **Data Value Tool** is chosen, an arrow appears and in the upper left corner of the graph, the position of the arrow on the graph window is displayed (x, y). When the arrow is placed over the graph line, the arrow changes to a hand. When the operator clicks on the graph line then the **Current Point Window** displays the value of the data point on the graph line. Note: the arrow and hand cursors are not shown on the screen below.



In the screen below, the **Select Tool** was used to double click on the graph window. The following window is displayed. Under the Plot tab, the property of the graph was changed to display data points only.



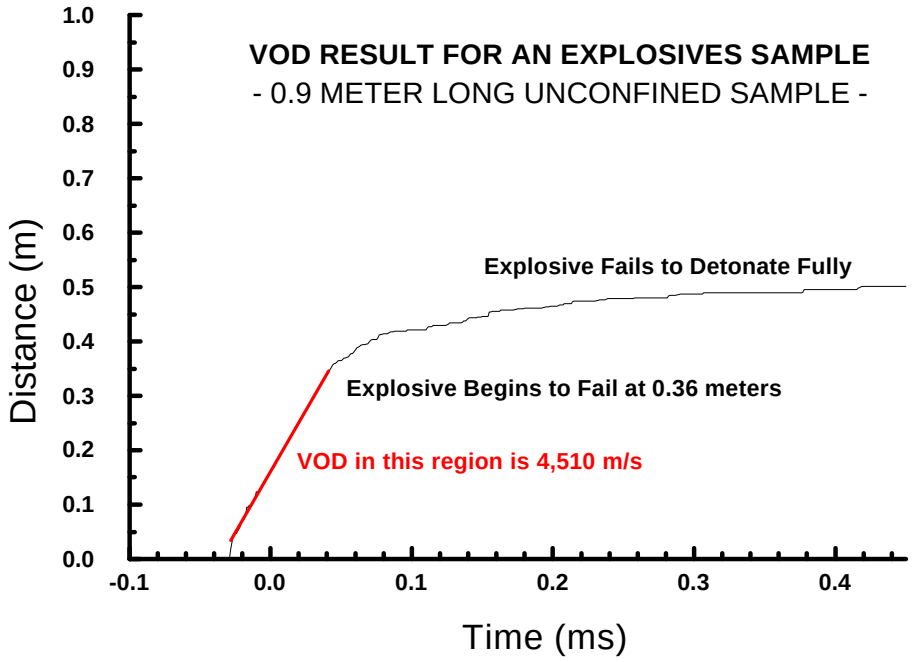


The operator is encouraged to experiment with analyzing, formatting and printing the data and graphs contained in the *Example* file. No matter what changes are made to the data in the sub-graphs, the Channel original data graph cannot be changed and will always be available for subsequent analyses.

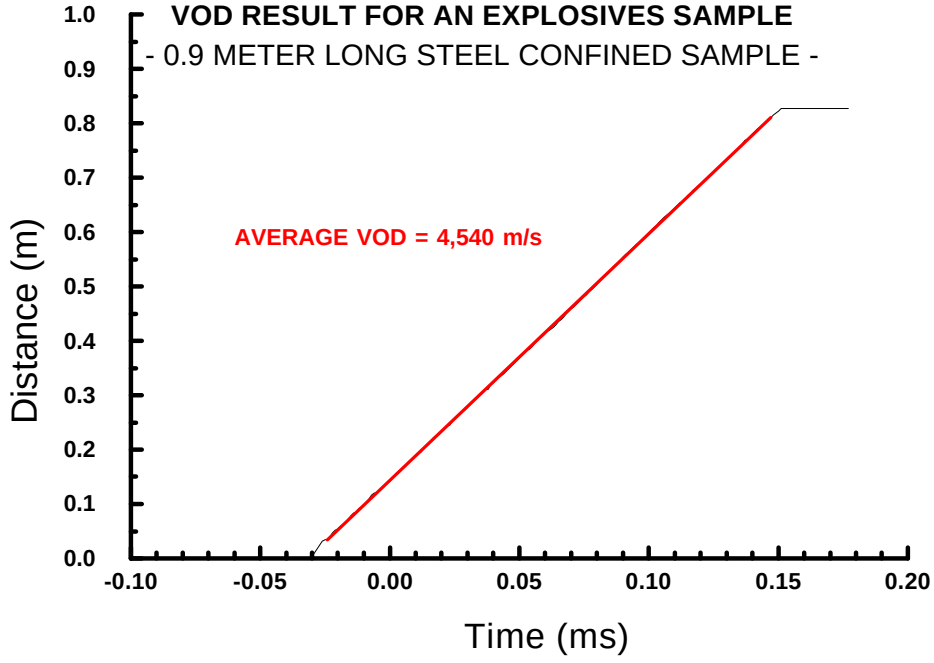
6.1.2 Other Results from Samples of Explosives

The following examples are provided as an illustration of the VOD analysis capabilities of the SuperTrap when the operator is testing samples of explosives.

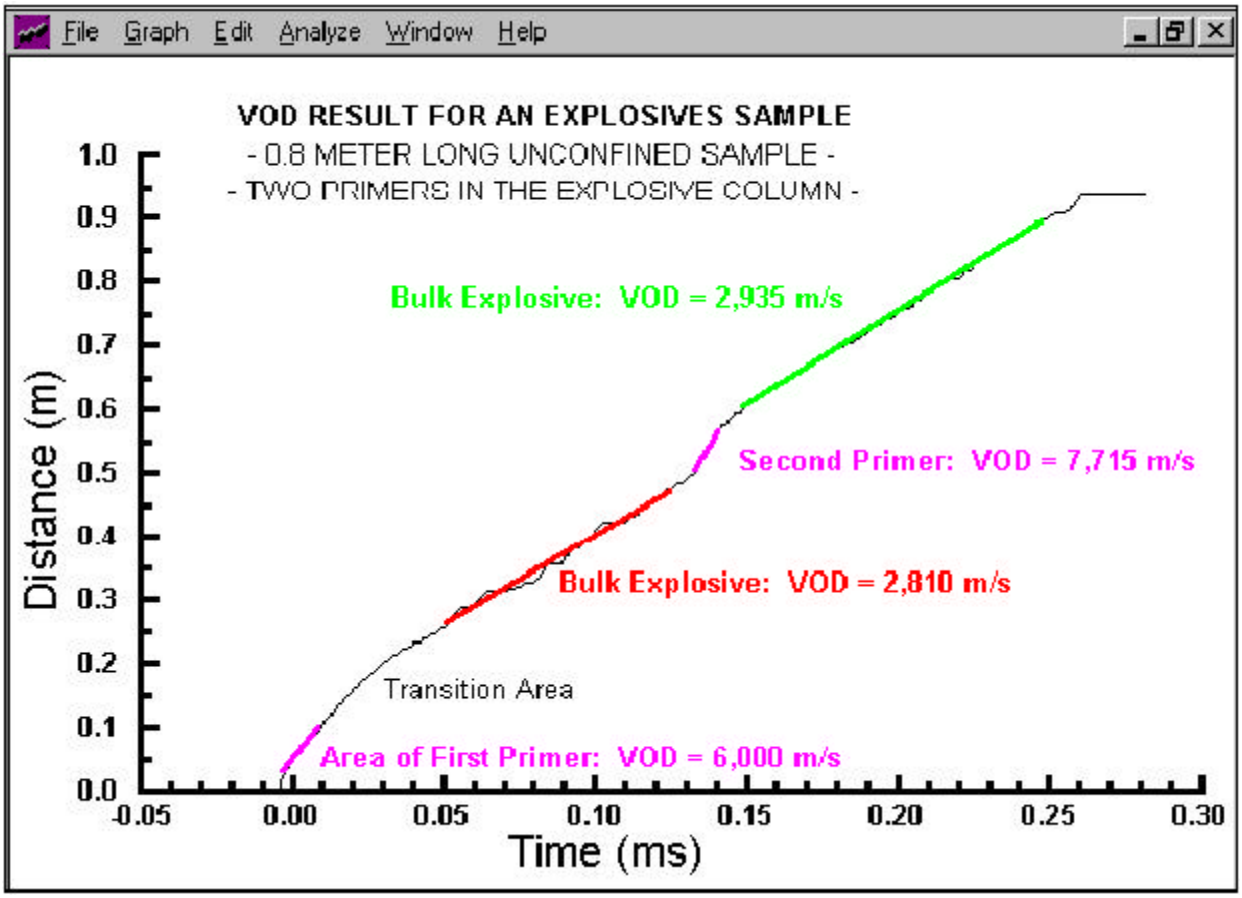
This result is typical for an unconfined explosive failing to detonate completely.



This result illustrates the effect of confining the explosive in Schedule 40 steel pipe (a standard substitute for rock). The explosive detonates fully when loaded in steel pipe but fails when unconfined as shown in the previous graph.

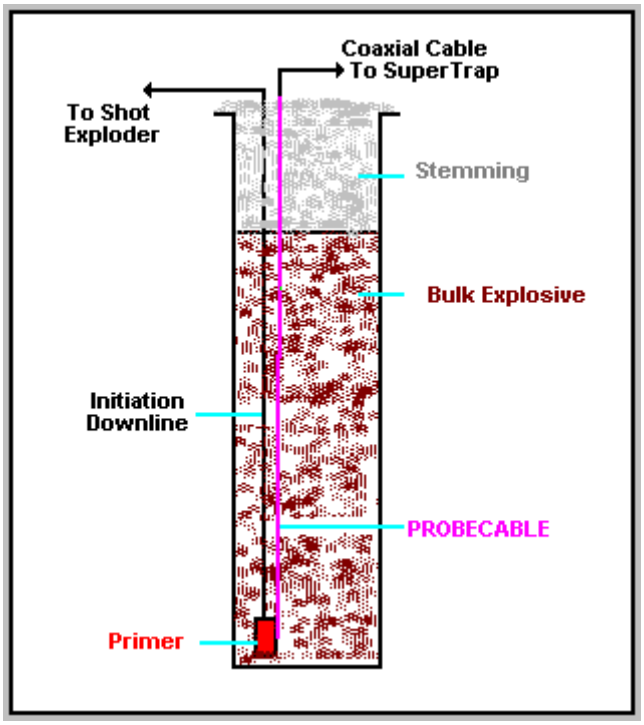


The following is the result of a VOD test on unconfined bulk explosive. It can be observed that a second primer was placed in the explosive column that had not been tied into the shot exploder. As can be seen, the operator can determine the VOD anywhere along the 0.8 m long unconfined sample.



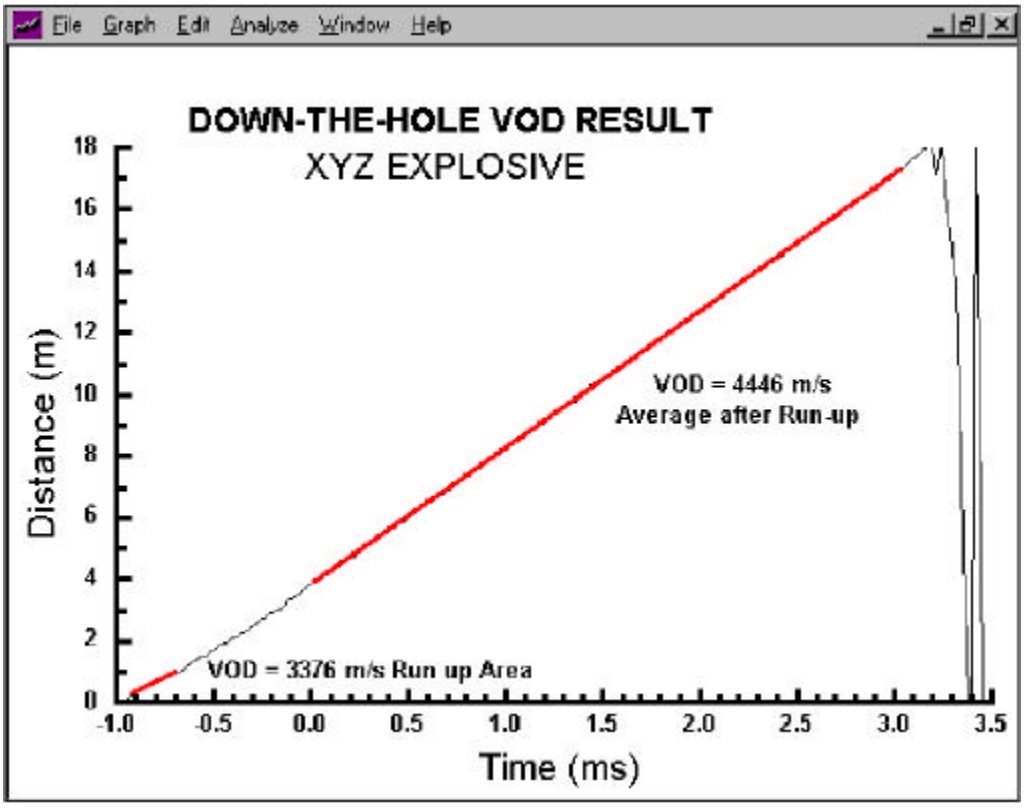
6.1.3 Explosives in Blastholes

As detailed in **Section 3.3.2**, a typical VOD test on a single blasthole using PROBECABLE is shown. The length of the explosive column is approximately 18 m.



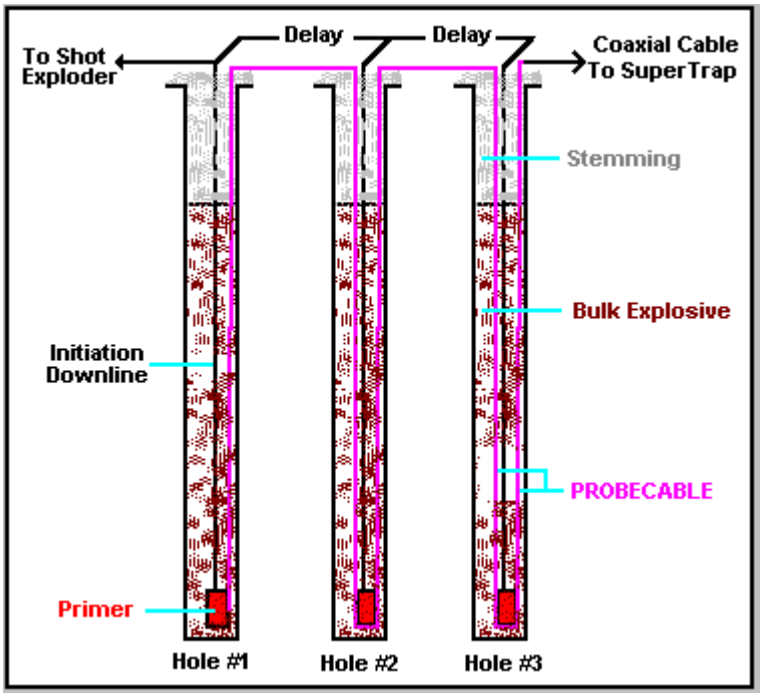
The resulting graph has two time areas: before time = 0 (pre-trigger time) and after time = 0 (post-trigger time). In all VOD tests, the SuperTrap is triggered to begin recording at time = 0 but has a pre-trigger data memory before time = 0 (**Section 3.8**). This allows the SuperTrap to record the information from the probe as it is being consumed to the probe length at which the SuperTrap will trigger. The SuperTrap records post-trigger data after time = 0.

Since only one hole was tested, and the time for the explosive to detonate (approximately 5 ms) is far less than the total amount of time the SuperTrap records, a large amount of extra data was recorded after the detonation in the hole was complete. Using the **Zoom In Tool**, the operator can focus on the area of interest: the part of the graph that shows the explosive detonating.

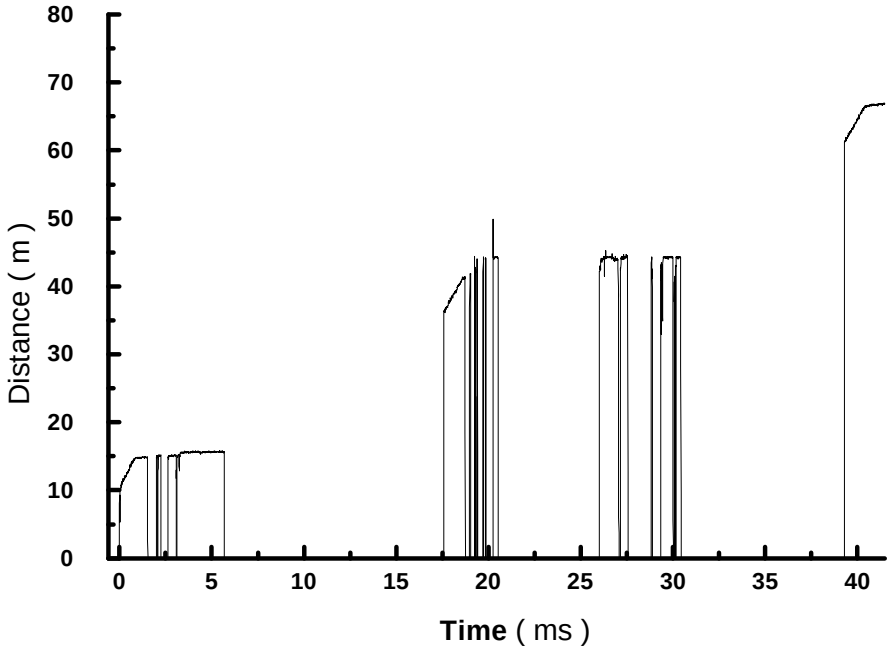


As detailed in **Section 3.3.2**, a typical VOD test on a multiple (3 in this case) blastholes using PROBECABLE is shown. Three 10 m deep holes were monitored. Each hole contained a column of approximately 5 m of explosives and the blast was tied in with a 17ms delay between holes.

Notice on the diagram that the PROBECABLE in Hole 1 was not terminated at the primer but was run down and out of the hole in a method similar to Holes 2 and 3. In this way, the detonation of the primer in Hole 1 immediately cuts off or shortens the PROBECABLE by 10 m thereby assuring that the SuperTrap will be triggered to record (time = 0) upon the primer in Hole 1 firing. This is evident on the graph. Also notice that if Hole 2 fired before Hole 1 then approximately 35 m of PROBECABLE (comprised of 20 m in Hole 1 + 5 m spacing between holes + 10 m in Hole 2) would have been cut off. Of course, in that case no data would have been recorded for Hole 1, only for Holes 2 and 3.

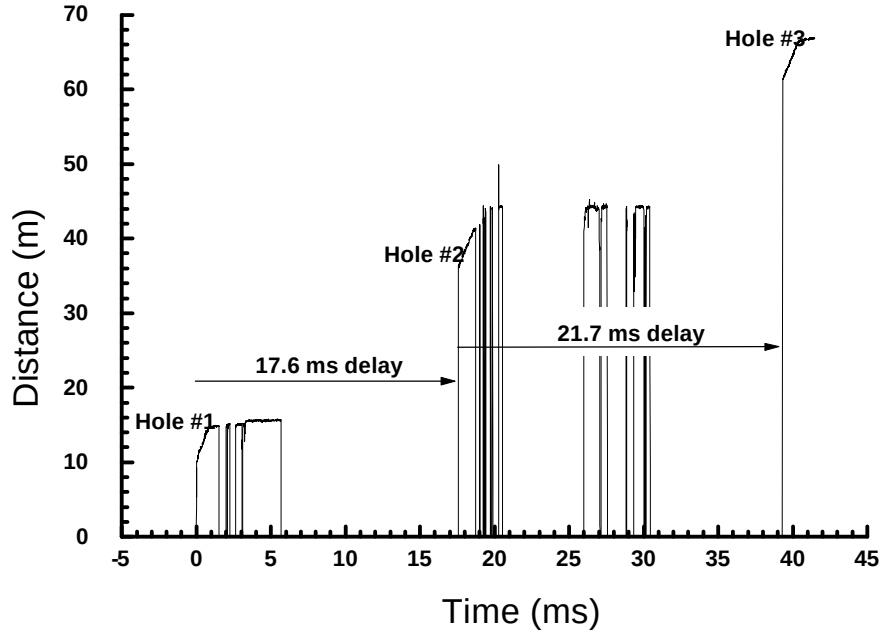


The data can be analyzed to determine the actual delays between holes and the VODs of the explosives in each of the holes.

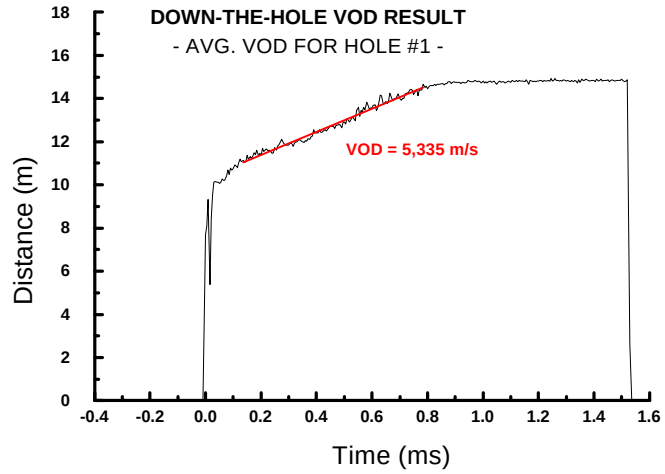


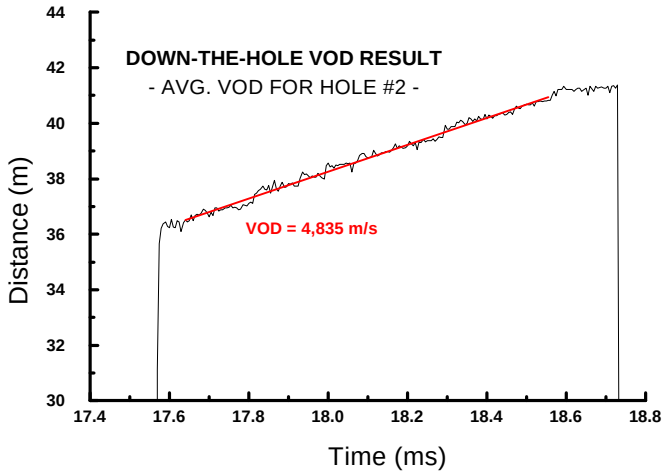
The **Delay Tool** is used to determine the delays between holes (**Section 5.8**). The software calculates the delay time by measuring the difference in time between two data points chosen by the operator. The software prompts the operator to click on the "first" data point and then on the "second" data point, thus defining a data range for the delay calculation. The delay result is automatically shown with a colored line over the data range of interest. The operator can perform an unlimited number of delay analyses on a graph. The delay text and line can be chosen with the **Select Tool** for moving or deleting. The colours and properties of these items can be changed or the item can be deleted by double clicking with the **Select Tool**.

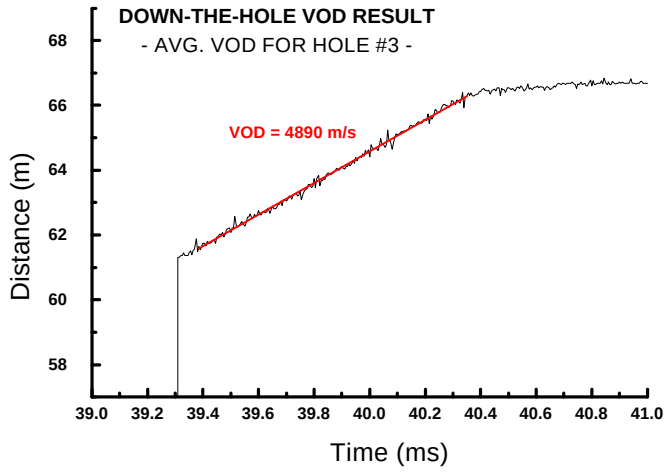
Delay times between Holes 1 and 2, and 2 and 3 are shown on the graph.



The operator can zoom in on each of the three holes to calculate the VODs in each hole and save the zoomed VOD results for each hole as sub-graphs as illustrated on the following page.

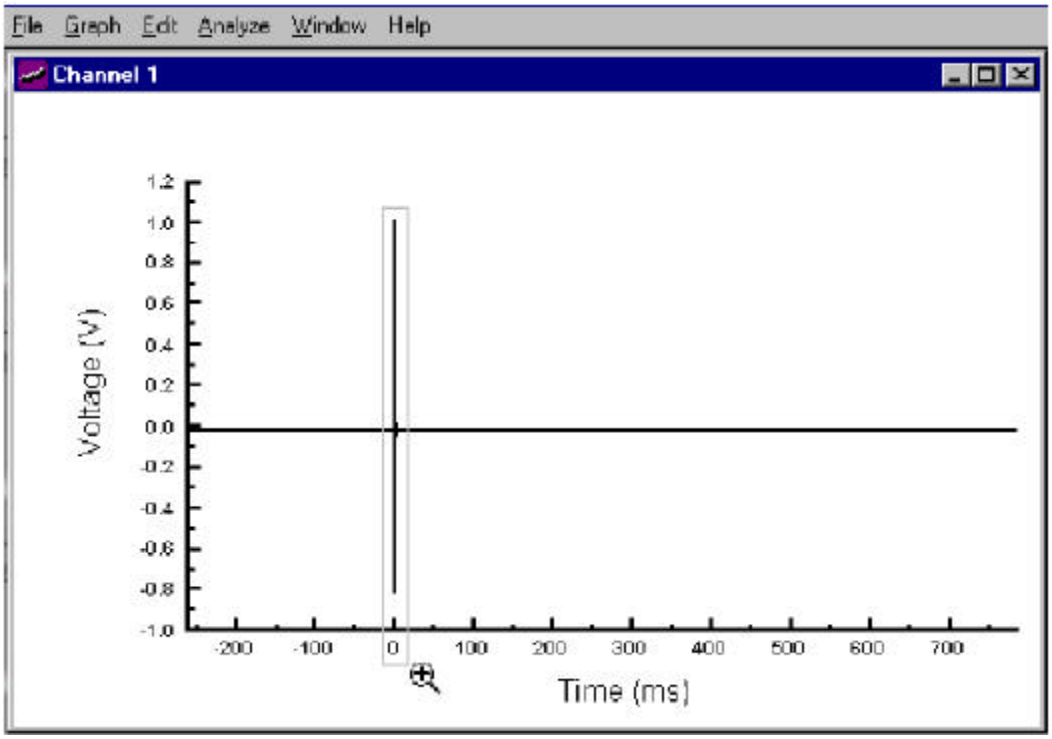

DOWN-THE-HOLE VOD RESULT
- AVG. VOD FOR HOLE #1 -
VOD = 5,335 m/s
Distance (m)
Time (ms)
18
16
14
12
10
8
6
4
2
0
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6


DOWN-THE-HOLE VOD RESULT
- AVG. VOD FOR HOLE #2 -
VOD = 4,835 m/s
Distance (m)
Time (ms)
44
42
40
38
36
34
32
30
17.4
17.6
17.8
18.0
18.2
18.4
18.6
18.8

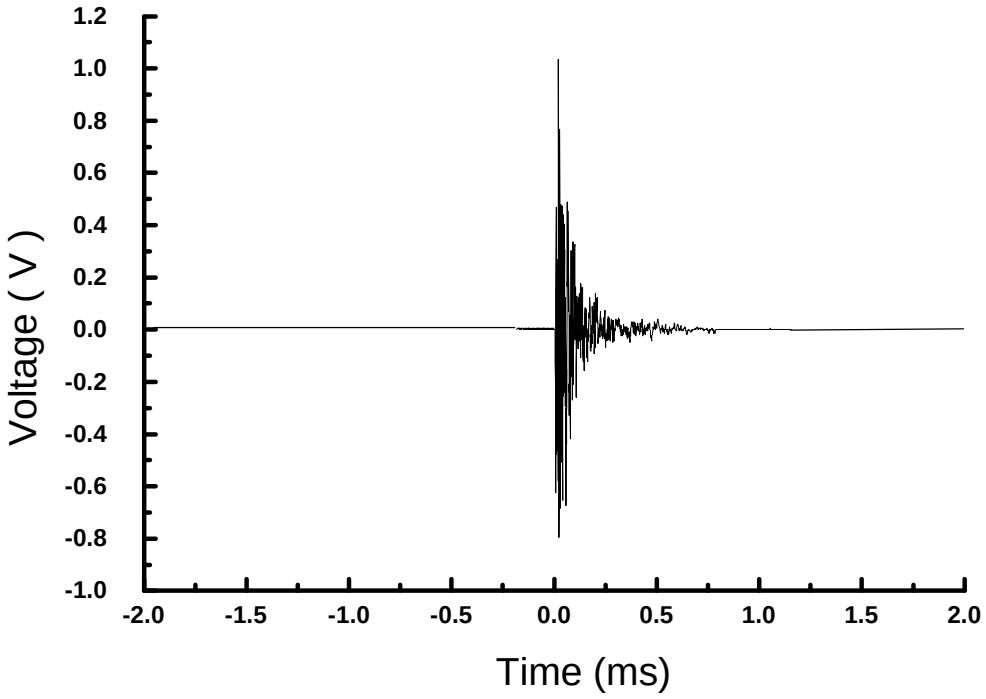

DOWN-THE-HOLE VOD RESULT
- AVG. VOD FOR HOLE #3 -
VOD = 4890 m/s
Distance (m)
Time (ms)
68
66
64
62
60
58
39.0
39.2
39.4
39.6
39.8
40.0
40.2
40.4
40.6
40.8
41.0

6.2 VOLTAGE ANALYSIS EXAMPLES

This Section presents and example of an analysis of an accelerometer recording. When the file is opened, a graph of Voltage versus Time is displayed on the Channel 1 original data graph. The graph shows a line plot of voltage versus time from an accelerometer. The graph has two time areas: before time=0 (pre-trigger time) and after time=0 (post-trigger time). Time=0 corresponds to the internal voltage crossing the trigger voltage or the shorting of the external trigger. This test was conducted with the external trigger.
Using the **Zoom In Tool** (Section 4.7), the Operator can focus on the area of interest: the part of the graph that shows non-zero acceleration.



The following graph shows the result of zooming in on the data of interest. If the wrong area is chosen, use the **Zoom Out Tool** to restore the graph to full range.

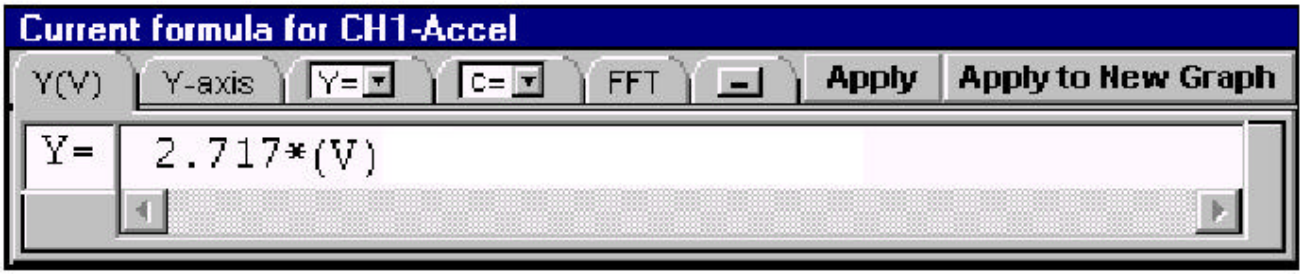


The graph can then be saved as a sub-graph named ***Accel*** (Graph-Save As) and it is now ready to be converted into engineering units. This requires 4 steps. The first 3 can be carried out in any order. They are:

1. Enter new title;
2. Enter new units;
3. Enter the formula.

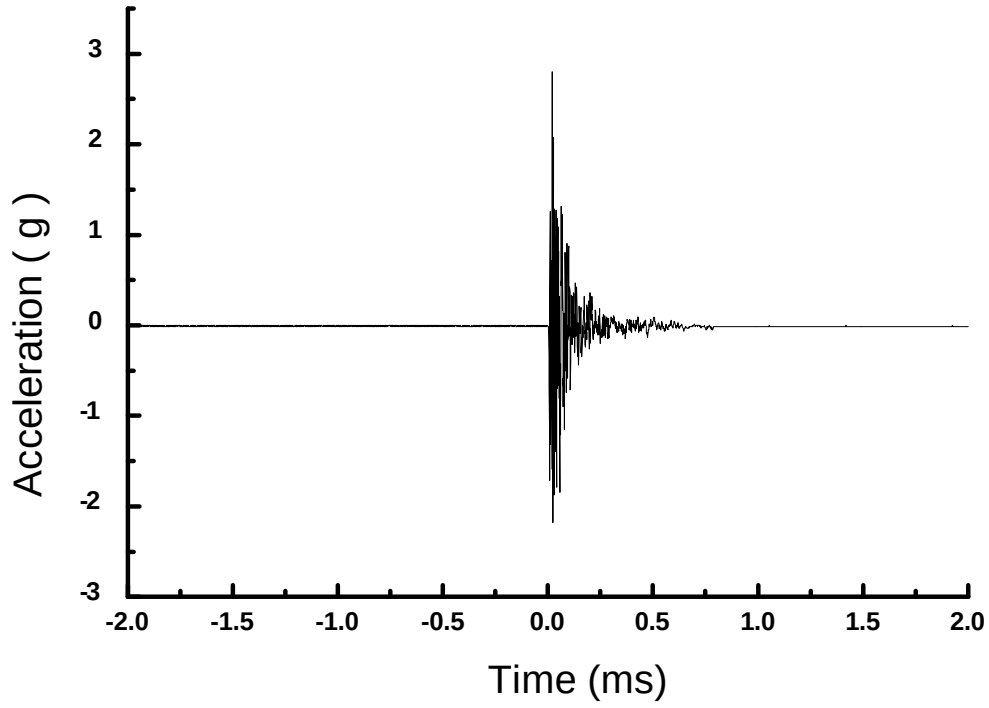
After this, click **Apply** or **Apply to New Graph** to convert to the new units.

To enter the formula, click on the **Y(V)** tab and enter the formula, using standard mathematical notation. In this example, the formula comes from the conversion factor of the gauge 2.717 **g's** per volt.



Next, click on the **Y-axis** tab and enter the units and title.

Next, to apply these to the current graph, click on the **Apply** button to change the graph to the following:



The Operator may now be interested in the value and location of the maximum acceleration. Using the **Data Value Tool**, this can be viewed and also labeled on the graph. Click the **Data Value Tool** and click on the data point of interest.

The final graph can be copied and pasted into a Windows word processor by choosing **Edit-Copy Graph** from the Menu Bar. The operator can then minimize the SuperTrap Software, open the word-processor and Paste the graph. The graph can be printed from within the SuperTrap Software by using the **Print Tool** or **Graph-Print** from the Menu Bar.

6.3 E-MAILING SUPERTRAP FILES

It is straightforward to send a SuperTrap file for its analysis/review by another operator who also has the SuperTrap Software.

When a file is saved on a computer, the file name takes the form of filename.filetype, otherwise known as root.extension. When a SuperTrap file is saved using a name chosen by the operator (for example: test), several files with different filetypes are automatically created by the SuperTrap Software all with the same filename, test.

To email a SuperTrap file called "Example", attach the entire SuperTrap files with the same filename, to the email. It is better if all of the files are contained in one ZIP file for transfer by email, particularly if the SuperTrap data were not compressed when downloaded to your computer.

For example:

Example.sup (the SuperTrap settings file, which is a readable text file)

Example.raw (the SuperTrap data file if the data were not compressed)

Example.cmp (the SuperTrap data file if the data were compressed)

Example.plot001, Example.plot002 etc... (the series of sub-graph files the operator saved during analysis)

Example.r01 (the data points removed from a sub-graph by the operator)

As part of MREL's ongoing commitment to Customer Satisfaction, MREL VOD Specialists will be pleased to review your analysis of your SuperTrap data. If you would like to have a "second opinion" from MREL on your analysis of a specific test, send an email to VOD@mrel.com with a brief description of the test and attach all of the files.