9. USING THE GRAPH SCREEN

Call Up Screen

Key to the Graph Screen as follows:

Press \textbf{ON ENTER} key.

If the Measure Screen or Data Screen appears, press \textbf{NEXT SCREEN} key once or twice until the Graph Screen appears. The Graph Screen, Measure Screen, and Data Screen appear in rotation. Or, alternatively press \textbf{PAST SCREEN} from the Measure Screen to arrive at the Graph Screen.

Select A Graph For Display

Graphs that have been stored can be selected for display from either the Data Screen or the Graph Screen. Select the storage area and the number of the moisture reading containing a graph directly or by selecting it in the Data Screen prior. Remember any reading displaying an “N” in the “P” category contains NO GRAPH. Enter the selected Storage Area and Reading Number directly in the Graph Screen and push \textbf{ON ENTER} to display the reading graph. Should the reading not contain an associated graph, a “NO GRAPH” will be displayed across the Graph Screen as shown in fig. 9.1.

Select From The Graph Screen

To make your selection directly from the Graph Screen, press the \textbf{ \textup{K}} key or the \textbf{ \textup{L}} key until the cursor is on the arrow next to the “Area” selection field.

Press the \textbf{ \textup{YES}} key or \textbf{ \textup{NO}} key to scroll to the storage area desired. The
“label” assigned to the particular storage area in the Setup Screen will be displayed for the storage area that is accessed.

To enter the number of the moisture reading, press the \( \text{ON} \) or \( \text{OFF} \) key until the cursor is in the “No.” field. Then key in the numeral keys corresponding to the number of the reading required and press \( \text{ON} \) \( \text{ENTER} \) key. If you make a mistake, press \( \text{DELETE} \) key and reenter.

Immediately the graph of the TDR pulse, corresponding to the moisture reading entered, is plotted on the screen. At the top of the screen, in the moisture data display field, the % of moisture, the Ka value, the waveguide lengths, and the Y axis scale associated with that particular moisture reading are displayed.

You can display other graphs stored in the same storage area simply by keying in the moisture reading numbers and pressing the \( \text{ON} \) \( \text{ENTER} \) key.

### Select From The Data Screens
To make your selection from the Data Screen, press \( \text{PAST} \) \( \text{SCREEN} \) key to bring up the Data Screen, and then follow instructions given under “USE CURSOR TO PICK GRAPH FOR DISPLAY” in Section 8 of these instructions.

### Review A Graph Before Storage
When making a moisture reading you can review the graph of the TDR pulse to determine whether you wish to store it. Each time you make a moisture reading the graph of the TDR pulse is temporarily stored in the process of calculating the moisture percentage. The graph remains temporarily stored until you make the next reading.

After making a moisture measurement in the Measure Screen, press the \( \text{PAST} \) \( \text{SCREEN} \) key to go immediately to the Graph Screen. The graph associated with the last reading taken will be plotted when 0 is entered in the “No. ”field.

If you now wish to store this graph, press the \( \text{NEXT} \) \( \text{SCREEN} \) key to return to the Measure Screen and press the \( \text{SAVE} \) \( \text{GRAPH} \) key as described under “STORE READING” in Section 7 of these instructions.

### “No Graph” Message
When a moisture reading number in the “No.” field of the Graph Screen for which there is no stored graph and the \( \text{ON} \) \( \text{ENTER} \) key is pressed, the message “NO GRAPH” will be displayed in place of the graph.

### Operate The Time Bars
Two “Time Bars” are provided in the Graph Screen for convenience in measuring the time between different features on the graph of the TDR pulse. Movement of these bars is controlled by the \( \text{YES} \) key and the \( \text{NO} \) key.
The \( t_0 \) Time Bar is used to set the time reference for features at the beginning of the graph and the \( t_1 \) Time Bar is used to set the time reference for the pulse reflection off the end of the waveguides. See “Principles & Techniques of Operation” Section 2.

To move the \( t_0 \) Time Bar, press the \( \text{up} \) key or the \( \text{down} \) key until the cursor is in the \( t_0 \) time display field. Then press the \( \text{yes} \) key or the \( \text{no} \) key to move the Time Bar in the direction desired. Pressing the \( \text{yes} \) key continuously causes the Time Bar to move at a maximum rate.

To move the \( t_1 \) Time Bar press the \( \text{up} \) key or the \( \text{down} \) key until the cursor is in the \( t_1 \) time display field. Then press the \( \text{yes} \) key or the \( \text{no} \) key to move the Time Bar, as indicated above.

The Time Bar, \( t_0 \) will not overlap the \( t_1 \) and vice-versa.

**Note**

The Time Bars appear in the last position set you have set.

The Graph Screen has a background grid that is a very accurate time reference.

The broken vertical grid lines divide the width of the screen or “Time Window” into 10 equal parts. The Time Window is explained under the section “The Measurement System” in Section 2, “Principles and Techniques of Operation”. The width of the Time Window set at the factory is 10.00 nanoseconds (a nanosecond is 1 billionth of a second, and is abbreviated as nS). The time between each vertical line is therefore 1.00 nS.

The first broken vertical grid line on the left is heavier than the other lines in the grid and easily distinguishable. When making moisture measurements, the Trase software displays the waveform, where the pulse enters the waveguide.

The horizontal broken background lines provide a reference for comparing energy levels as the pulse travels along the waveguides.

The spacing between horizontal lines is measured in millirhos, abbreviated mp, and is a automatically scaled by Trase software. This is only an approximate value and is displayed for your convenience.

Since the strength of the return signal varies considerably depending on a number of factors, such as length of cable used, the Trase software was configured to amplify the signal so the displayed graph would be as large as possible to fill the screen. This automatic feature provides great operator convenience. For each graph displayed, the approximate number of mp per division between the two horizontal lines, is displayed in the upper right hand corner of the screen.

To obtain extremely accurate Millirho measurements it is suggested that a “reference cable to short” millirho scale be obtained using the same cables and multiplexer arrangements shorting the cable end. The scale is arrived at by taking the average incoming cable level in A/D values and the average short signal level in A/D values. If the average cable level input was A/D=2120 and the
average short level A/D = 120, a difference of 2000 A/D is arrived at. Relative reflectance can then be determined precisely by taking a reflectance level in A/D values, for example 1567 A/D, and determining the exact ratio 1567/2000 = 0.7835 x 1000.

To obtain our “cable to short” Millirho factor, you will need to cause a short using your current cables and Multiplexer arrangements. It will be necessary to make an electrical short at the very end of the cable. The “short” scale factor is arrived at by taking the average incoming cable signal level in A/D values (associated with Trase Graphs) and the average short signal level in A/D values. If, for instance, the average cable level input was A/D = 2120 and the average short level A/D = 120, the difference would be 2000 A/D. Relative reflectance can then be determined precisely by taking a return reflectance level in A/D, for example 1567 A/D, and using the “shorting” factor 1567/2000 = 0.7835, to determine the exact Millirho value (0.7834 x 1000) = 783. Since this is a negative going signal level compared to the cable value it would be considered -783 Millirho.

To obtain the factor for those reflective values that occur at higher values than cable values, in our example an A/D value of 2121 or greater, the “cable to open” scale factor is determined by allowing an electrical “open” at the very end of the cable. In this type of condition, we may achieve an average A/D value of, say, 3920. As before, the cable value is subtracted from the open value, in our example 3920 - 2120 = 1800. If we now measure a dry material and find the average A/D reflectance value 3220, some 1100 A/D values above the cable value, the “open” factor would be 1100/1800 = 0.6111; or an exact Millirho value of (0.6111 x 1000) = 611.1 Millirho.

The Time Window has three available widths, namely 10 nS, 20 nS, or 40 nS that the user can select. If the Time Window is changed to 20 nS, then the spacing between the vertical grid lines is 2 nS per division. Likewise, if the Time Window is changed to 40 nS, then the spacing between the lines is 4 nS per division.

When making moisture measurements, no matter what choice of Time Window is made, that portion of the TDR waveform that represents the start of the pulse down the Waveguides is always aligned to the first heavy broken vertical grid line.

When a moisture measurement is made, a fast rise pulse of microwave energy, generated by Trase, is sent down the connecting cable to the Waveguides buried in the soil. This pulse of energy is referred to as the “incident pulse”. Time measurements that are displayed on the Graph Screen begin at the “Start of Timing”. The incident pulse occurs several nanoseconds after timing starts. See the section “The Measurement System” under Section 2, “Principles and Techniques of Operation” for details.

When reviewing graphs associated with moisture measurements and making independent time measurements on the graphs, the heavy vertical grid line represents the beginning of the Waveguide and is a zero reference for the time required for the pulse to move down the Waveguides.

The t0 time display field continuously displays the time in nanoseconds from the “Start of Timing” to the position of the t0 Time Bar.
Similarly the t1 time display field continuously displays the time in nanoseconds from the “Start of Timing” to the position of the t1 Time Bar.

The dt time display field continuously displays the time between the t0 Time Bar and the t1 Time Bar.

To measure the time required for the pulse to move down the Waveguides, key the t0 Time Bar until it is directly over the heavy vertical grid line. This corresponds to the top or start of the Waveguides.

Then key the t1 Time Bar to the desired point on the graph at the point of reflection at the end of the Waveguide. The dt time display field will show the time required for the pulse to move from the start of the Waveguide at t0 to the feature on the graph where the t1 Time Bar is located.

Section 2, “Principles and Techniques of Operation”, gives detailed information on the interpretation of features on the graph and the manner in which the volumetric moisture percent can be determined from the graph.

The y coordinates of the graph being displayed can be transferred to an external printer or computer. The RS-232 Serial Port on the control panel is used for this purpose. For details on the procedure, refer to Section 14, “Technical Interface Information”.

For additional information on the use of this screen, press HELP key and follow instructions given on the screen.
The Autolog Screen allows you to program when to start a series of moisture readings, the time interval between readings, and the total number of readings to be taken. You can store just the reading or the reading and the graph associated with the reading.

Be sure the battery is fully charged before starting an autolog series of measurements. See Section 4, “Requirements Prior to Use” for detailed information on checking and charging the battery.

**Call Up Screen**

Key to the Autolog Screen as follows:

Press \[ \text{ON ENTER} \] key.

If the Graph Screen or Data Screen appears, press \[ \text{NEXT SCREEN} \] key once or twice until the Measure Screen appears. The Graph Screen, Measure Screen, and the Data Screen appear in rotation.

The Autolog Screen is accessed directly from the Measure Screen by pressing the \[ \text{SAVE GRAPH} \] key and then the \[ \text{NEXT SCREEN} \] key.

**Set Starting Date**

When you key to the Autolog Screen, the cursor automatically defaults to the Starting Date input field. Key in day of the month, the abbreviation of the month, and the last two digits of the year in strict conformance to the pattern described under Section 6, “Using the Setup Screen”.

After keying in the entry, press \[ \text{ON ENTER} \] key. The date keyed in will now be displayed in the Autolog Data Display field. Trase will automatically switch between ALPHA and NUMERIC modes when entering the date, month, and year.
Invalid entries will cause the error message “NOT VALID” to flash in the lower right corner of the screen. Press the Delete key to reenter correct data.

**Set Starting Time**

To set the starting time, press the \( \text{on } \text{enter} \) key to bring the cursor in the Starting Time input field. Key in the hour, minute, and second when readings are to start in conformance to the pattern described under Section 6, “Using the Setup Screen”.

After keying in the entry, press \( \text{on } \text{enter} \) key.

The time keyed in will now be displayed in the Autolog Data Display field. Invalid entries will cause the error message “NOT VALID” to flash in the lower right corner of the screen. Press the Delete key to reenter correct time.

**Set Interval**

To set the time between readings, when using a single set of Waveguides or time between readings when using multiple waveguides in a multiplexer array, press the \( \text{on } \text{enter} \) key to bring the cursor in the Cycle Interval input field.

Key in the hours and/or minutes desired between readings in conformance to the pattern described under Section 6, “Using the Setup Screen”. A minimum interval of 1 minute or a maximum interval of 23 hours and 59 minutes can be entered.

After keying in the entry, press \( \text{on } \text{enter} \) key.

The interval entered will now be displayed in the Autolog Data Display field.

**Set Number Of Cycles**

To set the number of reading cycles, press the \( \text{on } \text{enter} \) key to bring the cursor to the Number of Cycles field.

**Note**

Key in the number of cycles required, however, be sure that the total number of readings to be made does not exceed the “Storage Remaining” as displayed on the Measure Screen.

After keying in the entry, press \( \text{on } \text{enter} \) key.

The number of cycles keyed in will now be displayed in the Autolog Data Display field.

**The Trap Percentage Field**

The “Trap Percentage” field is used for troubleshooting purposes only. Its use is covered in Section 14, “Maintenance and Troubleshooting”.
Select
Readings Or
Graphs

To select whether Readings Only or Graphs and Readings will be stored, press the (U) key to bring the cursor to the arrow next to the “Save” selection field.

This selection field scrolls between “Readings” and “Graphs”.

To change the category, press (YES) key or (NO) key to select the category desired.

Caution

The storage of graphs requires considerable memory. Make sure your proposed Autolog program does not exceed the “storage remaining” as displayed on the Measure Screen.

Prepare
Connections
For Series
Of Reading
Cycles

After completing the entries in the Autolog Screen, press (PAST SCREEN) key to go directly to the Measure Screen.

The Information display field will now show the message “AUTOLOG ACTIVE”. Be sure to follow instructions at the bottom of the Autolog Screen before autologging begins.

Note

If the Waveguide connector is used in AUTOLOG, attach the Waveguide Connector, “Zero Set” the TDR processor, enter the Waveguide length, and insert the Waveguides in the soil as described under Section 7, “Using the Measure Screen”.

If Buriable Waveguides are used it is not necessary to “Zero Set” the TDR processor.

The reading series will now start as programmed.

Accessory items are available to bring the Waveguide Connector cable and auxiliary power through the Trase Cover when required to seal against the environment. See Section 12, “Field Measurements”.

To Abort
The
Autolog
Cycle

To abort the Autolog Series of readings at any time, key to the Autolog Screen, key the cursor to the “Number of Cycles” input field, and press the (0) key. Entering “0” cycles nullifies the program. All stored readings are retained.

Note

The “Starting Date” and other measurements parameters, originally entered, will be displayed on the Autolog Screen until new or modified entries are made. This feature provides a record of the Autolog sequence and minimizes entry requirements when similar sequences are used.

Apply The
Sequence
Switch

The Autolog Screen controls a “Sequence Switch” which is activated momentarily immediately after each reading is made when autologging a series of readings. The Sequence Switch is activated for a set interval of time ranging from .1 second to 9.9 seconds. Connection to the switch is made through the Multiplex Port as covered in the section, “Multiplex Port Pin Assignments”, under Section 13, “Technical Interface Information”.

USING THE AUTOLOG SCREEN 10-3
The purpose of the Sequence Switch is to sequence or control external devices which may be involved in the measuring process. It can also be used to coordinate the moisture measurement to the measurement of other physical properties with other external devices.

To engage the Sequence Switch, press the \( \text{UP} \) or \( \text{DOWN} \) key to bring the cursor to the arrow next to the “Sequence Switch” field. This selection field scrolls between “ON” and “OFF”. The default setting is “OFF”. To turn the Sequence Switch “ON” or “OFF”, press \( \text{YES} \) key or \( \text{NO} \) key.

To set the time interval that the Sequence Switch is activated, press the \( \text{UP} \) key to bring the cursor to the “Time” field. Key in the number of seconds desired from .1 second to 9.9 seconds.

After keying in the entry, press \( \text{ENTER} \) key.

Electrical connections can now be made through the Multiplex Port to coordinate external equipment to each Autolog reading that is made.

Caution

Manual operation of Trase, using the Measure Screen, overrides the Autolog cycle. Using the Measure Screen while Trase is autologging may interfere with Trase’s ability to make proper autolog readings.

Autologging With The Multiplexer

If your Trase unit incorporates multiplexing capabilities, there are additional instructions for preparing connections and operation of your unit. See Section 16 on Multiplexing.

Help Screen

For additional information on the use of this screen, press \( \text{HELP} \) key and follow instructions given on the screen.
11. USING THE TDR SCREEN

The TDR Screen provides capabilities similar to a cable tester that can be used
to check the continuity of connecting cables and to isolate breaks or discontinuities
in cables.

The TDR Screen also provides the means of making measurements with all types
of specialized waveguides and displaying the resultant graph of the TDR pulse on
the Graph Screen where time measurements can be made.

When making measurements in the TDR Screen the times entered are measured
from the system “start of timing”.

Call Up Screen

Key to the TDR Screen as follows:

Press the key.

If the Measure Screen does not appear, press the key once or twice until it
appears. The Data Screen, Graph Screen, and Measure Screen appear in rotation.

The TDR Screen is accessed directly from the Measure Screen by pressing
the key and then the key and then again the key and
the key.

Note

The “Mux channel” field, shown in italic face, appears only if your Trase unit incorporates multiplexing capabilities. If your Trase unit is connected to your assembled Multiplexer enclosure it will read “Mux connected”. If no connection has been established, it will read “Mux not connected”. See Section 16 on Multiplexing.
The pulse of microwave energy, generated by Trase, travels in the coaxial cable and in the Waveguides at approximately the speed of light. The speed of light is $3 \times 10^{10}$ cm per second or 30 cm per nanosecond (1 nanosecond is 1 billionth of a second). The speed in the cable depends also on the dielectric constant of the materials used in the construction of the cable. The “velocity of propagation” in the average coaxial cable is actually about 70% of the speed of light.

The “velocity of propagation”, or “Vp” as it is abbreviated, is available for different types of coaxial cable. Multiplying the Vp of the cable by the speed of light gives the speed that the pulse will travel in the cable. The coaxial cable, such as used in the Trase connecting cables, has a Vp of approximately .70. This means that in 1 nanosecond the pulse will travel (.70)(30 cm), or 21 cm, or about 8 inches down the cable.

The above relationship between nanoseconds of time and length of cable can be used in estimating the “Start time” and the “Range” to be entered in the TDR screen.

The section “The Measurement System” in Section 2, “Principles of Techniques of Operation” explains the manner in which the graph of the TDR pulse is created and describes the “Capture Window” in which it is displayed.

The graphs of the TDR pulse made from measurements in the TDR Screen are displayed in the Graph Screen. The “Start time” entered corresponds to the left side of the Graph Screen and the “Range” corresponds to the desired time range to be examined.

The width of the screen will then correspond, in nanoseconds, to the “Range” specified.
**Large Capture Window**

If a “Start Time” of 0 nS (abbreviation for nanoseconds) is entered and a “Range” of 100 nS were entered, then the width of the Graph Screen is 100 nS, and events from the “Start of Timing” to 100 nS after the “Start of Timing” count are displayed.

**Small Capture Window**

If, in contrast, a “Start Time” of 20 nS is entered and a “Range” of 10 nS is entered, then the width of the Graph Screen is 10 nS, and only events that occurred between 20 nS and 30 nS after the “Start of Timing” are displayed.

You may select 10, 20, 40, 80, 160, or 320 nS for the “Range” values. The total of the Start Time and Range cannot exceed 610 nS.

The flexibility of the TDR Screen makes it possible to look at the continuity of long connecting cables.
Making a TDR Measurement

Press the \[ \text{[1]} \] key until the cursor is in the “Start Time” field. Enter the nanoseconds desired and press the \[ \text{[ENTER]} \] key.

Press the \[ \text{[U]} \] key to bring the cursor to the “Range” field. Scroll to the capture window & nanoseconds desired and press the \[ \text{[ENTER]} \] key.

Press the \[ \text{[MEASURE]} \] key to initiate the measurement.

During the measuring process the message “Digitizing...” will flash in the top left corner of the screen.

After the measurement is completed, the Graph Screen is automatically displayed.

The Time Bars can now be used to locate features on the graph, as explained in Section 9, “Using the Graph Screen”. The \( t_0 \) and \( t_1 \), displayed in nanoseconds on the Graph Screen, can be converted to centimeters or feet, as outlined above, when troubleshooting connecting cables.

The graph of the TDR pulse, made from the TDR Screen, can also be stored. To do so, key to the Measure Screen before the next reading is made. “Tag” the reading, if desired, as covered under Section 7, “Using the Measure Screen”, and then store the graph in any storage area as described under the same section.

Finding Cable Breaks

When looking for cable breaks it is advisable to set the “Start Time” at 0 nSec. With reference to the relationship of time and cable length, the “Range” can be set so that it covers the entire length of the cable used. In this way, the graph will display the position of a break in the cable.

The screen below displays a typical graph showing a cable break.

With reference to the graph, the beginning of the cable is at 4 nS and the break is at 22 nS. This means that the break is \( (18 \text{ nS}) \times (8 \text{ inches/nS}) = 144 \text{ inches} \) from the beginning of the cable. In practice, using the Graph Screen, you would set the \( t_0 \) time bar at the position corresponding to the beginning of the cable and the \( t_1 \)
time bar at the position of the break in the cable. The time difference would then be displayed in the dt time display field of the Graph Screen. This time value can then be readily converted to distance.

**Help Screen** For additional information on the use of this screen, press HELP key and follow instructions given on screen.
12. FIELD MEASUREMENTS

12-A. Field Measurements Using the Standard Waveguide Connector

Insertion In Loose, Friable And Wet Soils

Using Short Waveguides in Spot Measurements: The standard Waveguide Connector and Waveguides, in conjunction with accessory items, are capable of measuring moisture in virtually all types of soils.

When the soil can be readily penetrated, the measuring Waveguides, are commonly 15 cm, 30 cm or 45 cm long. After “zero setting”, mount the Waveguides in the connector and insert the Waveguides in the soil. Always make sure that the Waveguides are fully inserted in the soil to obtain an accurate moisture measurement.

The Waveguide Connector is ruggedly built and considerable force can be used to push the Waveguides into the soil.

Caution: Do not hammer or stamp on the Connector since sharp blows can disturb internal electronic components. Contact our Sales Department regarding our heavy duty “Slammer” Waveguide Connector.

Proper spacing between the two Waveguides is necessary to obtain accurate moisture measurements.

Using Long Waveguides: When longer Waveguides, such as 45 cm and 60 cm long, are mounted in the Waveguide Connector, the ends of the Waveguides can be flexed considerably during the insertion process. When using long Waveguides, it is important to guide the ends of the Waveguides when they enter the soil. Our accessory Model No. 6012, Alignment Block, should be used for this purpose.
The ends of the Waveguides are inserted into the Alignment Block as they start to enter the soil.

This procedure starts the Waveguide entry into the soil with exactly the same spacing as in the Waveguide Connector and helps assure that they will be paralleled as they move down into the soil.

When the Waveguides are well into the soil, the Alignment Block can be twisted to free it from the Waveguides and removed.
Insertion In Dense Soils

Soils of high plasticity, compacted soils, very dry soils, and cemented soils require the use of our Model No. 6010, Installation Tool.

The Installation Tool is made from steel and plated for corrosion resistance. A wrench is provided with the Installation Tool. The Waveguides are mounted in the installation tool by first loosening the hex head bolt, slipping the grooved end of the Waveguides all the way down to the bottom of the holes, and then tightening the bolt securely.

Use the Alignment Block to space the Waveguides, as shown. Drive the Waveguides into the soil. A mallet or similar heavy tool can be used.
When the Waveguides are mostly driven into the soil, remove the Alignment Block.

Drive the Waveguides all the way into the soil until the bottom of the Installation Tool is in contact with the soil surface.

Disconnect the Installation Tool by loosening the hex bolt with the wrench and lifting the tool off the Waveguides. The ends of the Waveguides will project slightly above the soil surface.
Align the Waveguide Connector over the ends of the Waveguides, as shown, and press down until the Waveguides are fully seated in the Waveguide Sockets of the connector. Then tighten the clamping knob on the Waveguide connector to secure contact with the Waveguides. The moisture reading can now be made.

To remove the Waveguides, loosen the Clamping Knob on the Waveguide Connector and remove. Fit the protruding ends of the Waveguides into the holes of the Installation Tool. Make sure the Waveguides seat on the bottom of the holes in the Installation Tool. Tighten the hex bolt securely with the wrench. Use the Installation Tool to pull or pry the Waveguides out of the soil, as shown.

After installing Waveguides in the soil, as described above, they can be left in the field and tagged for identification and returned to for subsequent readings. The Waveguides are made of stainless steel and can be left in the field indefinitely.

In order to obtain accurate results when making measurements in containers or pots, caution must be exercised regarding the size of the container. The Waveguide spacing (5 cm) is such that a volume of soil approximately the shape of a cylinder with radius of 4 cm is sampled.

Inserting the Waveguides too close to the wall of the container will introduce error in the moisture measurement. Measuring too close to the wall of the container will average, not only the soil, but, the dielectric of the container and the air outside the container. It is recommended that the Waveguides be inserted at least 2-3 cm (approx. 1 inch) from the wall of the container.

**Caution**

**Repeat Readings At The Same Location**

**Insertion In Containers**
12-B. FIELD MEASUREMENTS USING BURIABLE WAVEGUIDES

Installing Buriable Waveguides

The Buriable Waveguide can be installed near the surface.

A group of Buriable Waveguides can be installed at various depths to monitor moisture in the soil horizon to program irrigation frequency and amount.

In light soils, and in many containers used in the nursery business and in research work, the Buriable Waveguide can be inserted from the surface by hand to its full depth for rapid evaluation of the moisture content.
To secure an accurate moisture measurement it is essential that the metal rods of the Buriable Waveguide be in tight, intimate contact with the soil. This means that rods be inserted directly into the soil to retain bulk density characteristics or tightly packed around with native soil taken from the hole. In deep installations, a heavy slurry of water and native soil may be poured down the hole after inserting the Buriable Waveguide. Sufficient slurry should be used to completely cover the Buriable Waveguide. This should be followed by a small amount of soil which is then tamped in place with a small diameter rod.

**Caution**

When packing around the Buriable Waveguide, never use silica flour or other materials that differ in dielectric or volumetric character from the native soil in your location, since this can result in readings that are not representative of your soil.

When installing one Buriable Waveguide above another, make sure that the coaxial cable from the lower unit is kept at least 2 inches away from the metal rods of the upper unit.

When installing Buriable Waveguides horizontally near the surface, such as in seed beds, make sure that the metal rods are at least 2 inches below the surface in order to obtain accurate volumetric moisture content readings.
When autologging and it is necessary to leave Trase out in the field, it is desirable to bring the coaxial cable from the Waveguide and perhaps a power cable through the hole in the side of the Storage Cover so that the cover can be closed to protect the Trase unit.

Accessory Cable Grommets are available for this purpose. The solid Cable Grommet in the Storage Cover is first removed by pushing from the inside as pictured and described under the section “Storage Cover and Contents” in Section 3, “Acquaint Yourself With The Parts”. The Waveguide Mount is also removed, as described in the same section. The accessory Cable Grommets with lead-thru holes can then be fitted into the Storage Cover. The photo below shows how the coaxial cable of the Waveguide Connector is mounted through the slot in the accessory Cable Grommet.

The BNC connector can then be fed through the hole in the Storage Cover and the grommet pushed into place, to seal the hole and the coaxial cable, as pictured below.

The BNC connector is then fed through the rectangular hole in the Cover Lid and connected to the BNC Port on the Control Panel. The Storage Cover can now be latched closed to seal the Trase unit while connection is maintained to the Waveguide Connector in the field.
In similar fashion, an accessory Cable Grommet with two holes can be used to seal the coaxial cable from the Waveguide Connector, as well as the power cable from the Battery Charger or other power source to provide long term operation.

The photo below shows how the two cables are mounted through the slots in the accessory Cable Grommet.

The photo below shows the accessory Cable Grommet with the two cables in place, with the Storage Cover closed to seal the Trase unit.

**Note**

When your work involves the use of long coaxial cables, refer to the section “Use of Long Coaxial Cables” in Section 13, “Technical Interface Information”. Cable lengths up to 40 meters are available on special request.
13. CUSTOM LOOKUP (MOISTURE) TABLES

Standard Moisture Table

The Trase software incorporates 4 Standard Moisture Tables (CUN, CCT, BUN, and BCT) which are used to convert the measured apparent dielectric constant, Ka, to volumetric moisture content, as explained in Section 2, “Principles and Techniques of Operation”.

The Standard Moisture Tables are located in a fixed place in memory and cannot be modified. The tables can be transferred, however, to an external terminal for review.

Custom Moisture Tables

When moisture measurements are required in materials or unusual soils, where the relationship of Ka to percent of moisture is radically different from conventional soils, a Custom Moisture Table can be prepared and entered into the Trase software. The Trase system provides a separate place in memory to store 4 Custom Moisture Tables (T01, T02, T03, and T04) which are separate from the Standard Moisture Tables.

To make up a Custom Moisture Table it is necessary to prepare a series of samples of the material with known volumetric moisture contents to span the range of moisture content that is of interest. The samples must be of sufficient volume so that the dielectric constant, Ka, of the samples can be measured using Trase with standard waveguides inserted into the samples.

The development of the table relating the known volumetric moisture content to the dielectric constant, Ka, at a series of increasing moisture contents must be done carefully to maintain measurement accuracy in the field.

A Custom Moisture Table needs to consist of a series of volumetric moisture content values and the corresponding Ka values.

To Enter A Custom Moisture Table By Hand

To enter a Custom Moisture Table you must first have a terminal, or a computer used as a terminal, connected to the RS-232 Serial Port on the Trase unit with the baud rate set to match the Trase setup [the default is 9600]. See “Setting the Data Transfer Parameters” in this section for further details.

Steps:
1. Key to the Setup Screen.
2. Press the key.
3. The following prompt will appear on the terminal:
   “Type each table entry as Ka, moisture. Press after each entry. Example: 15.3,.351<ENTER>. Press again after last entry. Begin!”

   1 = T01
   2 = T02
   3 = T03
To Enter a Custom Moisture Table From a File

Steps:

1. Prepare the file. The file should contain one entry per line. Each entry is the Ka value, a comma, then the moisture value. The moisture value is expressed as a three place decimal. For example, 5.0% is written .050, and 27.5% is written as .275. Ka is carried to a one place decimal. The following example of the first four lines of our standard table are: (see GRAPH 2.1 & 2.2)

   2.0, 0.000  
   3.8, 0.050  
   6.0, 0.100  
   7.8, 0.150

2. As with entering a custom moisture table by hand, you must have a terminal, or a computer used as a terminal, connected to the RS-232 Port of the Trase unit with the baud rate set to match the Trase setup - the default is 9600. See “Setting the Data Transfer Parameters” in this section for further details.

3. Key to the Setup Screen.

4. Press the \[\text{SAVE READING}\] key.

5. The following message will appear on the terminal:

   “Type each table entry as Ka, moisture. Press \[\text{ON ENTER}\] after each entry.

Example: 15.3,.351<ENTER>. Press \[\text{ON ENTER}\] again after last entry. Begin!”

6. Using the ASCII upload feature of your communication program, send the file to Trase.

7. After the file has been uploaded to your Trase unit the following message will appear on your terminal:

   “XX entries.  
Enter the table destination.  
1 = T01

4. Type in the entries. After the last entry, press the \[\text{ON ENTER}\] key again.

5. The following prompt will appear on the terminal:

   “XX entries.  
Enter the table destination.  
1 = T01  
2 = T02  
3 = T03  
4 = T04  
Selection (default = 1): (You will enter either 1,2,3, or 4 to select the destination for your new custom table).

6. After you have entered the table number, you will be prompted as follows:

   “Enter table label (8 characters alphanumeric maximum): (You will now enter the name for your custom table).

7. The following message will confirm that your custom table has been entered:

   “New table values stored in table TXX (the x’s designating the table number selected).
2 = T02  
3 = T03  
4 = T04
Selection (default = 1): (You will enter either 1, 2, 3, or 4 to select the destination for your new custom table).

8. After you have entered the table number, you will be prompted as follows:
   “Enter table label (8 characters alphanumeric maximum): (You will now enter the name for your custom table).

9. The following message will appear on the terminal confirming your custom table has been entered:
   “New table values stored in table TO# (the #’s designating the table number selected).

**Note**

If you have problems transferring data, you may have to set your communication program upload to “line at a time”. The communication program will not send the next line until it has received the echo from the previous line.

**Transfer A Moisture Table From Trase**

To transfer a Moisture Table you must have a terminal or a computer, used as a terminal, connected to the RS-232 Serial Port with the baud rate set to match the Trase setup - the default is 9600. See “Setting the Data Transfer Parameters” in this section for further details.

Steps:
1. Key to the Setup Screen.

2. Select either one of the 4 Standard or one of the 4 Custom Tables in the “Moisture Table” field.

3. Press the **SEND DATA** key.

4. The table will be displayed on the screen in the same format as used in entering a moisture table.

**Note**

When the Trase software calculates the moisture content it considers that there is a linear relationship of Ka to moisture content between two adjacent Ka values in the table.

If the Custom Moisture Table you are entering only covers a part of the full range of moisture, for example 0-40%, where, say, 40% corresponds to a Ka value of 26.0, then, if in the course of making measurements a Ka value of greater than 26.0 is encountered, Trase will always report 40% moisture. If you want to know that a measurement exceeds the range of your moisture table, you can assign a Ka value of, for example, 26.5 just slightly above 26.0, and relate this to 99.9% moisture. Then when making a reading, if Trase reports 99.9% moisture, you will know that the moisture value measured is beyond the range of your Custom Moisture Table.