CONCRETE THICKNESS GAUGE (CTG-2)

System Reference Manual

PATENT PENDING
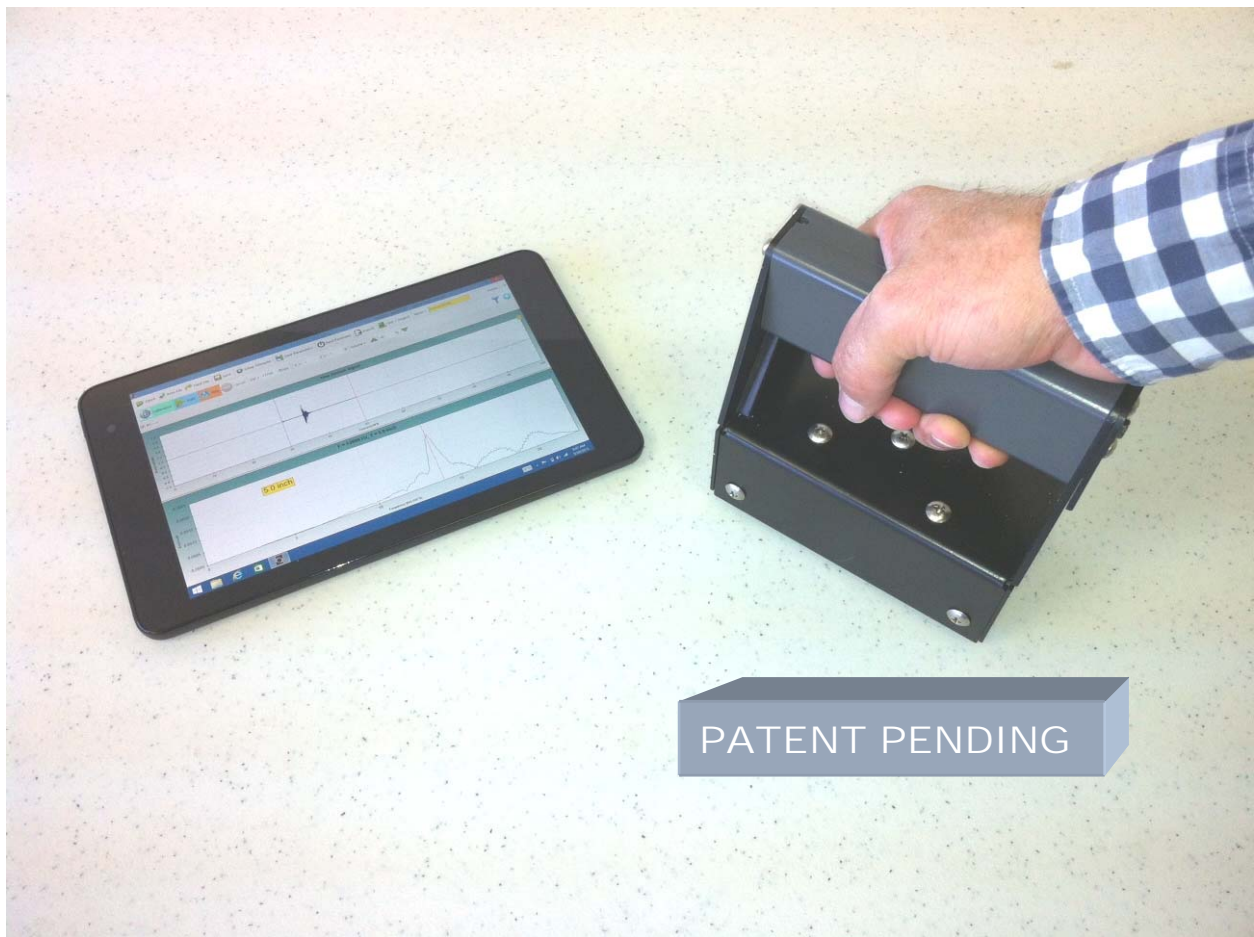
CTG-2 with WinCTG2 Software Version 1.7

Olson Instruments, Inc.

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INTRODUCTION

The Olson Instruments CTG-2 system is commonly used for thickness evaluation and rapid flaw detection on concrete and masonry structural materials. The method is normally applied to plate-like objects such as slabs and walls, but is also used on columns, mat foundations, and beams. The method requires access to only one side for testing.

The CTG-2 is a powerful, hand-held device meant to be used with most Windows 7 (and greater) laptop computers or tablets. The CTG-2 is designed to measure the thickness of concrete slabs and walls in the range of approximately 3.2 inches (8.1 cm) out to about 6 feet (1.8 m) without the need for drilling, coring, or other means. Test results are acquired and analyzed with Olson's WinCTG2 software, making the CTG-2 system a fully functional Impact Echo (IE) based thickness measuring system, capable of analyzing echoes from multiple cracks and other flaws. In addition, a summary of test results can be saved in comma separated format for use in an excel spreadsheet.

The WinCTG2 software features a graphical display of both the raw time signal as well as the received signal spectrum (which can be saved and recalled), which allows visual indication of data quality, easy differentiation of bad data, and even the location of partial cracking damage. This unit can also be used to determine relative concrete quality (by measuring concrete compression wave velocity) for test cylinders and other samples with known thicknesses. The device can also be used for thickness measurements of many materials other than concrete, such as plastics, stone, etc., depending on the properties and internal structure of the material being tested.

The CTG-2, when used with the default concrete velocity value of 12,000 fps, is accurate up to approximately 10%. This accuracy can be improved to approximately 2% when the unit is calibrated for velocity at a location of known thickness.

To confirm functionality of the CTG-2, it is advised to test the unit on a slab of known thickness or on a 6" x 12" concrete cylinder which can be readily obtained from a concrete supplier.

The CTG-2 with automated solenoid and displacement transducer comes with a phone-plug-to-phone-plug cable and USB Audio Adaptor used to connect the unit to a laptop or tablet. A USB jump drive is supplied with the necessary software and a microUSB-to-USB cable is included so the software on the USB jump drive can be downloaded onto Windows devices. The user must supply a Windows 7 (or greater) laptop/tablet. Details of the hardware and its usage are included in Section 2.0. Suggested Windows devices are listed in Appendix A.
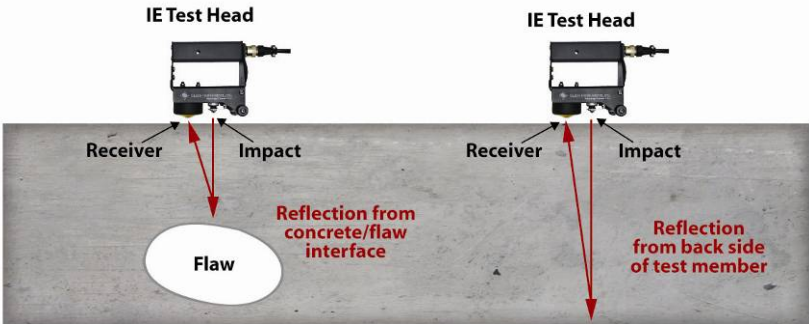
1.1   Organization and Scope of Manual

The CTG-2 is a sturdy battery powered unit designed for easy, fast, and reliable operation by anyone with no special training required for basic operation. This manual covers step-by-step hardware assembly, software setup, simplified operation instructions for data acquisition, data analysis, and output generation. If any problems with the system appear that are not covered in this manual, please call Olson Instruments at the number included in the front of this manual.

1.2   Test Methodology

The Impact Echo tests performed with the CTG-2 involve impacting the concrete/masonry member with an impactor solenoid and identifying the reflected wave energy with a displacement transducer as shown in the figure below. Note that the solenoid impactor and displacement transducer are built into the IE head. The test head is pressed against the top of the tested member and held while tests are performed at each test point. The resonant echoes of the displacement responses are usually not apparent in the time domain, but are more easily identified in the frequency domain. Therefore, amplitude spectra of the displacement responses are calculated by performing a Fast Fourier transform (FFT) analysis to determine the resonant echo peak(s). The relationship among the resonant echo depth frequency peak (f), the compression wave velocity (V_P) and the echo depth (D) is expressed in the following equation:

$$D = \beta V_p/(2*f) \hspace{3cm} (1)$$

where β is a geometric shape factor ranging in value from 0.8 for a pier/column shape to 0.96 for a slab/wall shape. A slab/wall shape has a single thickness resonance while beam and column shapes have multiple resonances due to their cross-sectional shape.

IE Test Head   IE Test Head

Receiver   Impact   Receiver   Impact

Reflection from concrete/flaw interface

Flaw

Reflection from back side of test member

Reflection from back side occurs at a lower frequency than that from shallower concrete/flaw interface.

2.0 HARDWARE

The CTG-2 system consists of a few basic components packaged into a carrying case. The carrying case with foam insert stores the CTG-2 IE test head and cables. It includes a small compartment to store four CR123A 3V spare batteries. A description of each of the included components as well as their connection and operation is included in the following sections.

2.1 Hardware Component Listing

COMPONENT NAME	QTY	DESCRIPTION
CTG-2 IE Test Head	1	The test head includes a solenoid impactor to create the impact and a displacement transducer sensor to receive the signal. Includes four CR123A 3V lithium photo batteries.
Phone-Plug-to-Phone-Plug Cable	1	To connect the IE Test Head to the USB Audio Adaptor.
USB Audio Adaptor	1	To connect the Phone-Plug-to-Phone-Plug Cable to the Windows device.
Olson Jump Drive	1	Jump Drive with Olson WinCTG2 Software.
USB to MicroUSB Adaptor	1	To connect Jump Drive with Olson WinCTG2 Software to Windows Device. To connect USB Audio Adaptor to Windows Device when only a MicroUSB port is available
Spare Batteries	4	Spare CR123A 3V lithium photo batteries

2.2 Location and Replacement of Batteries

The CTG-2 is provided with four CR123A 3V nonrechargeable long life lithium photo batteries to power the system. (If desired, rechargeable CR123A 3V batteries can be purchased and used with the unit.) The CTG-2 unit is designed to turn on when the toggle switch on the base of the unit is flipped into the on position, making the indicator light at the top of the handle illuminate green.

When the batteries are losing power, the green light will not illuminate. Instead, the red light will come on. To ensure accurate readings, the batteries must be replaced at this time. When light fails to illuminate (either green or red), the batteries have lost power and MUST be replaced.

Location of the Batteries: the four CR123A batteries that power the CTG-2 IE test head are located inside the handle of the test head.

> **i** *We recommend carrying spare batteries, and have provided a space for them in the carrying case.*

Battery Replacement: To replace the batteries, follow these steps:

1. Using the toggle switch located at the base of the IE head, turn off the unit and make sure the green light on the handle is not illuminated.

2. Use a Phillips screwdriver to remove the 2 screws at the rear of the handle as shown in the picture below. Remove the battery compartment cover.

3. Turn the front of the unit upward to allow the batteries to slide out.

4. Insert new batteries following the polarity diagram inside the handle as shown in the pictures below.

5. Replace the battery cover and screws.

Do not expose the CTG-2 system or the batteries to water.

2.3   Hardware Setup

1. Connect the Phone-Plug-to-Phone-Plug Cable to the IE Test Head as shown in the picture below.

2. Connect the other end of the Phone-Plug-to-Phone-Plug Cable to the USB Audio Adaptor. There are two jacks on the USB Audio Adaptor. One is identified with a microphone icon and is usually pink. The other is identified with a headphone icon and is usually green. Please use the pink microphone jack.

3. Connect the other side of the USB Audio Adaptor to the Windows Device. Or, if using a Windows device with only a MicroUSB port, use the provided USB to MicroUSB Adaptor to complete the connection.

4. Flip the toggle switch on the base of the IE test head to activate the unit. When the green light is illuminated, the IE test head is powered up and ready to collect data.

5. The picture below shows the complete CTG-2 system ready to acquire data. In this case, an 8" tablet is being used. We recommend a minimum 8" size tablet. We recommend that the tablet be used in "landscape" mode.

3.0   WinCTG2 SOFTWARE SETUP

This section covers the steps required to install the WinCTG2 software on a tablet, laptop or desktop computer from the supplied installation jump drive.

3.1   Prerequisite Software

Windows .Net Framework 4 is required for the WinCTG2 software and is installed automatically with the program. The software is fully compatible with Windows operating systems.

3.2   Software Installation

1. Uninstall any previous version of WinCTG2 software.

2. Using the USB to MicroUSB adaptor if needed, connect the provided jump drive to the Windows device. Copy the WinCTG2 Setup directory from the jump drive to the desktop on the device. On the Windows device, open WinCTG2 Setup/setup.exe. The software will be installed using a Setup Wizard. Select "Next" as appropriate. Select "Yes" when prompted to confirm changes. Select "Close" to exit. This should create a shortcut on your desktop. The default location for the software installation is "C:/Olson Instruments/WinCTG2" unless the user changes the location during the installation process.

3.3   Software Updates

To update the software, completely uninstall the WinCTG2 Setup software per Section 3.4 and install the new version of WinCTG2 Setup by selecting the "Setup" executable in the "WinCTG2" directory. The program will install a shortcut on your desktop.

3.4   Software Uninstallation

The following steps are required to uninstall the WinCTG2 Software.

1. Navigate to "Control Panel".
2. Select "Programs" or "Programs and Features" or "Add or Remove Programs".
3. Select "WinCTG2 Setup".
4. Select "Uninstall".
5. Select "Yes" to confirm uninstallation.
6. Select "Yes" to confirm changes.

The uninstall process will remove all installed components including shortcuts. This process might take up to five minutes. Do not exit the installation until it is completed.

4.0   DATA AQUISITION

This section includes instructions for data collection with the WinCTG2 Software. If you have an area of known thickness that can be used for velocity calibration, please refer to Section 4.3 before testing.

4.1   General Information about the WinCTG2 Software

The WinCTG2 software is comprised of 3 different panels: the Data Parameter panel, the Filter panel, and the Waveform Data panel. Each panel (except the waveform data panel) is collapsible if not needed (especially during the data acquisition process) to enlarge the waveform data panel. Figure 1 below shows an overview of the program layout. The shortcuts to turn on each panel are located on the upper right corner of the screen. The function of each shortcut is described below:

- Toggles the filter panel on/off
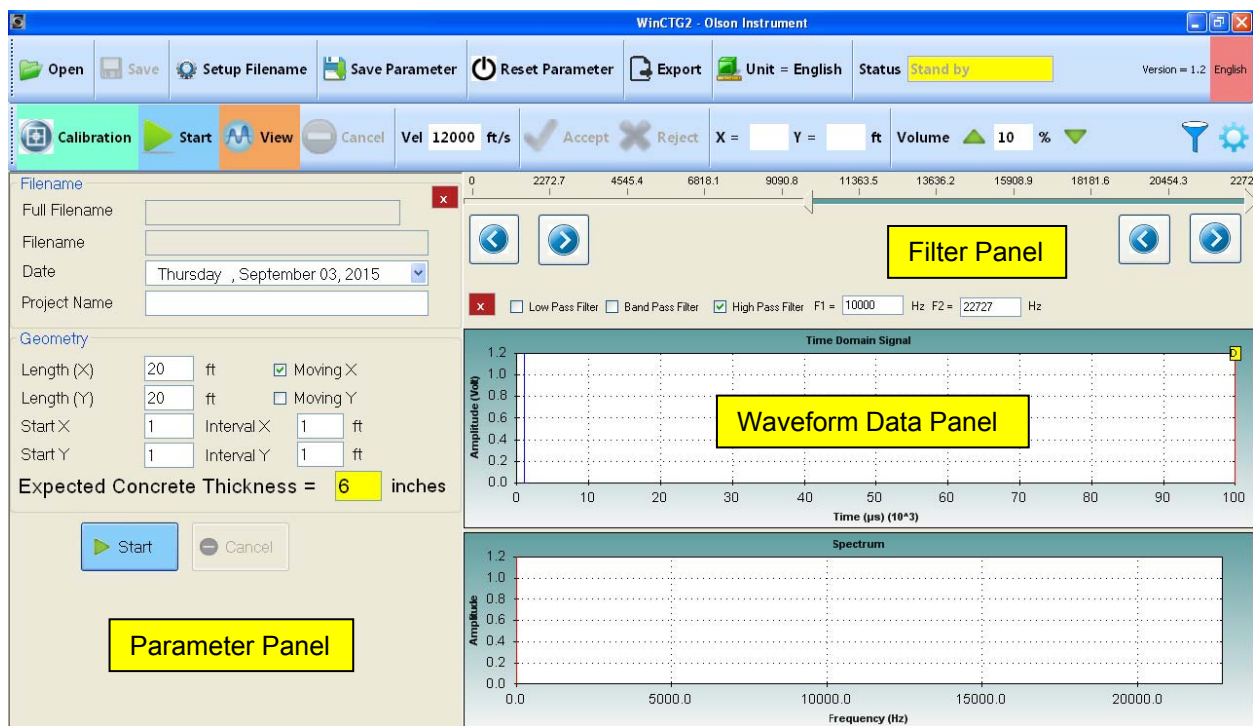
- Toggles the parameter panel on/off

Figure 1 – WinCTG2 Layout for IE Test Results

4.2   IE Data Acquisition without Velocity Calibration

It is not necessary to calibrate for velocity in order to perform the Impact Echo test and collect data using the system's default value of 12,000 fps (3,657 m/s) as an average velocity for sound concrete. But the operator should understand that using the default value results in up to approximately a 10% error in the results as compared to approximately a 2% error when the unit is calibrated for velocity at a location of known thickness.

1. Turn on your tablet or laptop (with the hardware connected and turned on as described in Section 2.0) and select the WinCTG2 shortcut on the desktop. The software will open as shown in Figure 2 below. Within the Waveform Data Panel, the top plot box shows the current time domain data and the bottom plot box shows the frequency spectrum. Per the "Status" field in the Main Menu, the program is currently in "Stand by" mode.
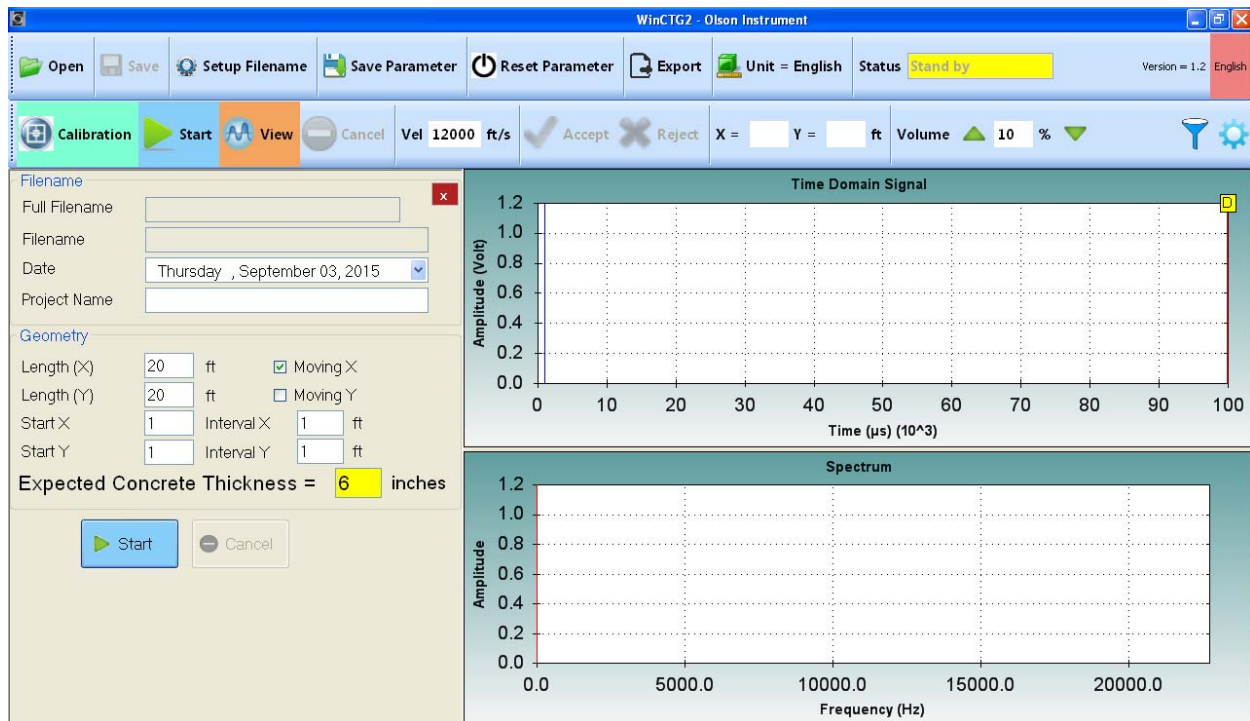

Figure 2 – Main Screen for WinCTG2 Software

2. **Filename Feature:** Fill in the "Date" field and "Project Name" field as desired.

3. **Geometry Feature:** If you have laid out a grid for data collection and want the software to keep track of your X and Y coordinates, use the Geometry Feature to document the coordinates. In the "Length (X)" field, enter the total length you plan to

test in the X direction and in the "Length (Y)" field, enter the total length you plan to test in the Y direction. Select the "Moving X" checkbox if you plan to move from test point to test point in the X direction. Select the "Moving Y" checkbox if you plan to move from test point to test point in the Y direction. In the "Start X" field, enter a value for the start point in the X direction as well as the "Interval X" (or distance between test points) in the X direction. Finally, in the "Start Y" field, enter a value for the start point in the Y direction as well as the "Interval X" (or distance between test points) in the Y direction.

Unless changed, a default value of 6 inches will be used for "Expected Concrete Thickness". This value is used to limit the amount of data analyzed and presented by the software so it is important to alter this number as appropriate, however, 6 inches is an appropriate value to use for slabs ranging in thickness from 4 inches to 8 inches.

4. At this point, the user has two options for collecting and saving data. The "Setup Filename" option in the Main Menu can be used to set up automatic file naming for files that will be saved (this is the suggested mode). Or the "Start" option in the Toolbar can be used to start testing without setting up automatic file naming. When using this mode, the user will be prompted to name each file individually. Note that the "View" option in the Toolbar can also be used as discussed in Section 4.4 to view data without saving or recording files.

Set up Automatic File Naming: First, position the IE head on the test member. To set up sequential numbering of the files to be collected, select the "Setup Filename" option found in the Main Menu. This will open a dialogue box as shown in Figure 3 below. Enter the directory where the data is to be saved along with an alphabetical prefix and a numerical suffix. (The alphabetical prefix will remain fixed and the numerical suffix will increase with each test.) When finished, select "Start" to close the dialogue box then select the "Start" option found on the Toolbar to start collecting data.
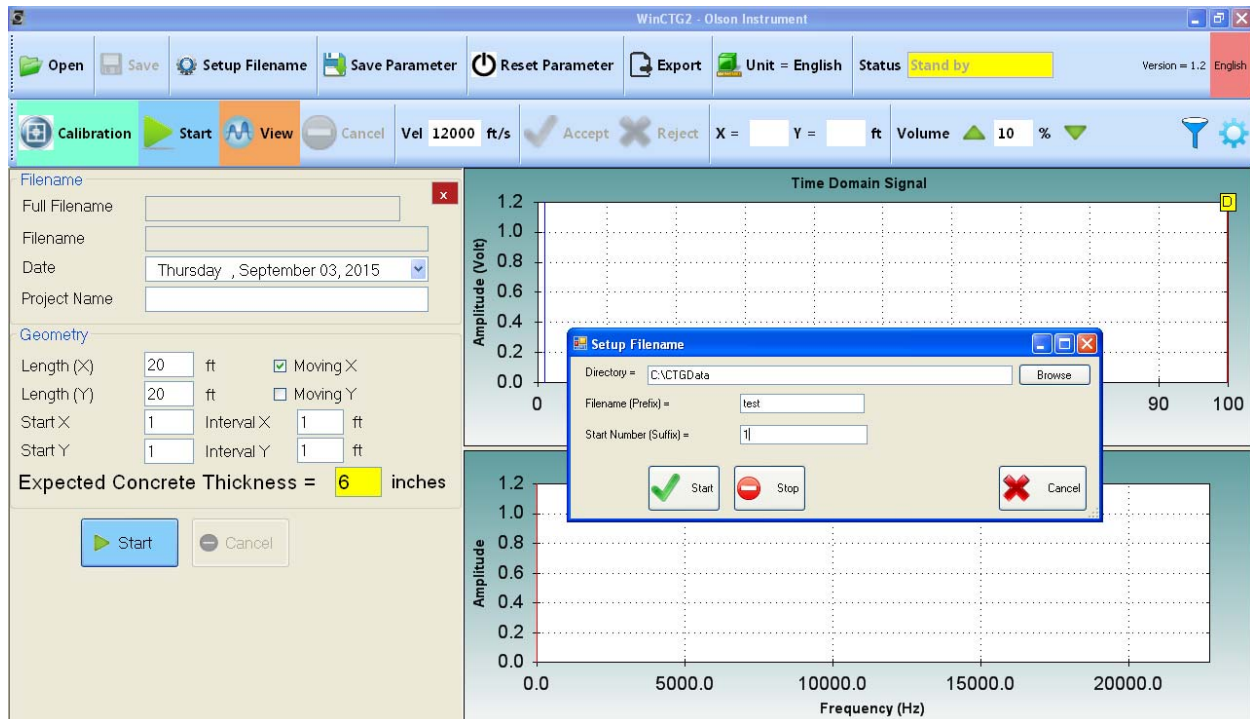

Figure 3 – Set Up Filenames

Start Testing without Setting up Automatic File Naming: First, position the IE head on the test member. To start collecting data without using the "Setup Filename" option, select the "Start" option found on the Toolbar. A "Save As" dialogue box will open as shown in Figure 4 below. Enter the individual filename desired. When finished, select "Save" to close the dialogue box and proceed with testing.
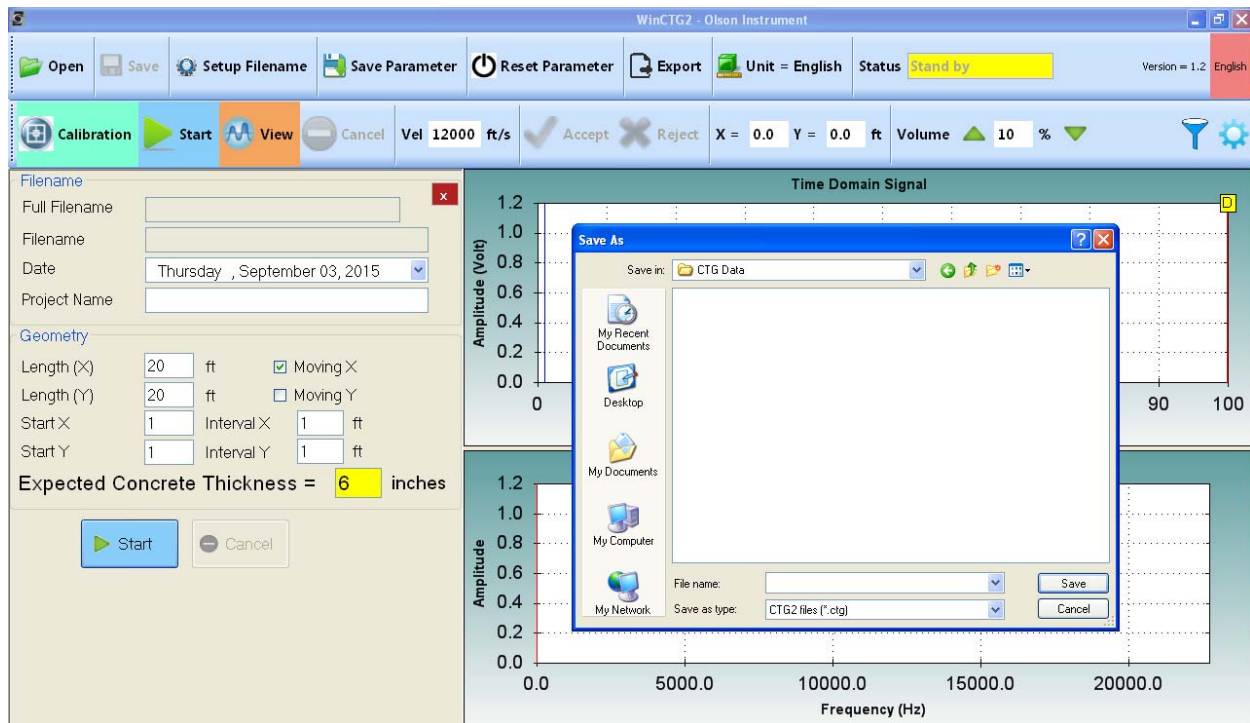

Figure 4 – Start Testing without Setting up Filenames

5. After following the instructions as described above for testing with or without file naming, the system is now waiting to receive data (in the form of an impact) as reported in the "Status" field which is currently in "Ready to Test" mode. (See Figure 5 below.) At this point, the user must be careful not to reposition the IE test head as this will trigger data collection before impact, resulting in invalid data.

> **i** *Some Windows devices will trigger when the "Start" or "View" option is selected. When this happens, reject the data and proceed with the testing instructions below.*

> **⚠** *If the IE head is repositioned after the "Start" or "View" option is selected, data acquisition will be triggered. When this happens, reject the data and proceed with the testing instructions below.*
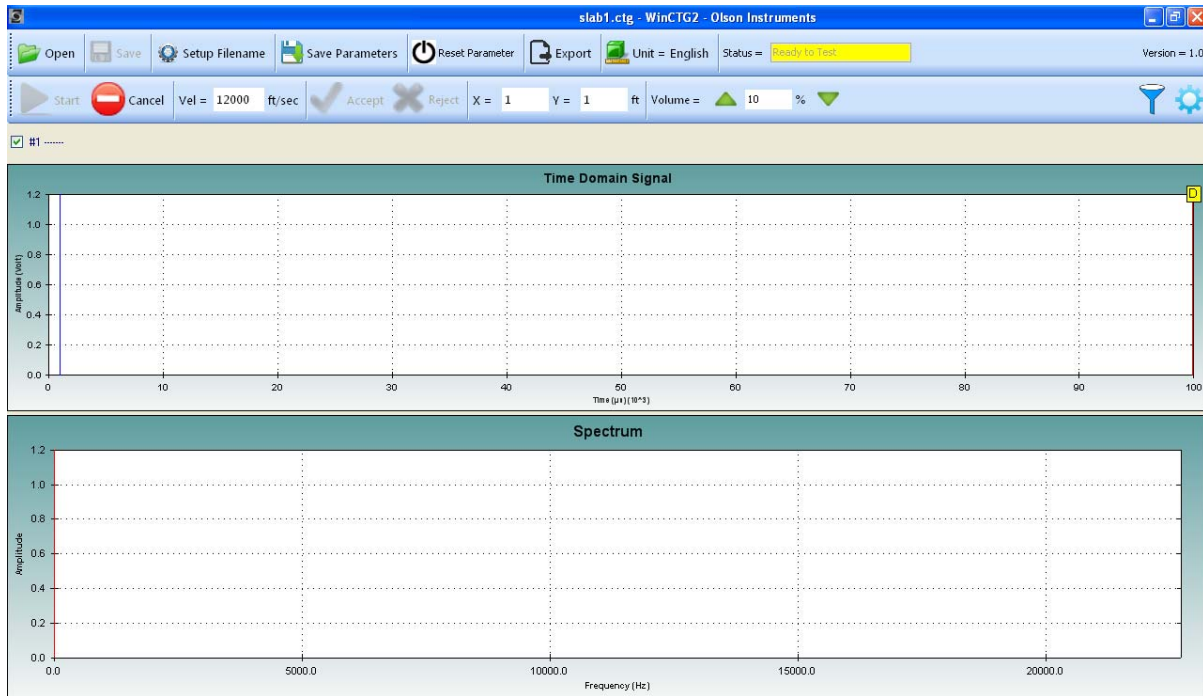
Figure 5 – System Waiting to Receive Data

6. With the IE head powered up and the green light on the top of the handle illuminated, press the trigger button on the underside of the handle. The unit will fire the solenoid on the CTG-2 head and create an impact. The displacement transducer sensor on the CTG-2 head will record the data and the software will display the data on the screen as shown in Figure 6 below. The program is now waiting for you to either accept or reject the data as reported in the "Status" field which is currently in "Accept or Reject" mode.

> **i** *When placing the CTG-2 on a test surface, place the rear feet down first then rotate the unit down into position. This will ensure proper contact between the sensor tip and the test surface.*

> **!** *Gently rotate the sensor tip onto the test surface as a sudden impact to the sensor might result in damage to the sensing element.*
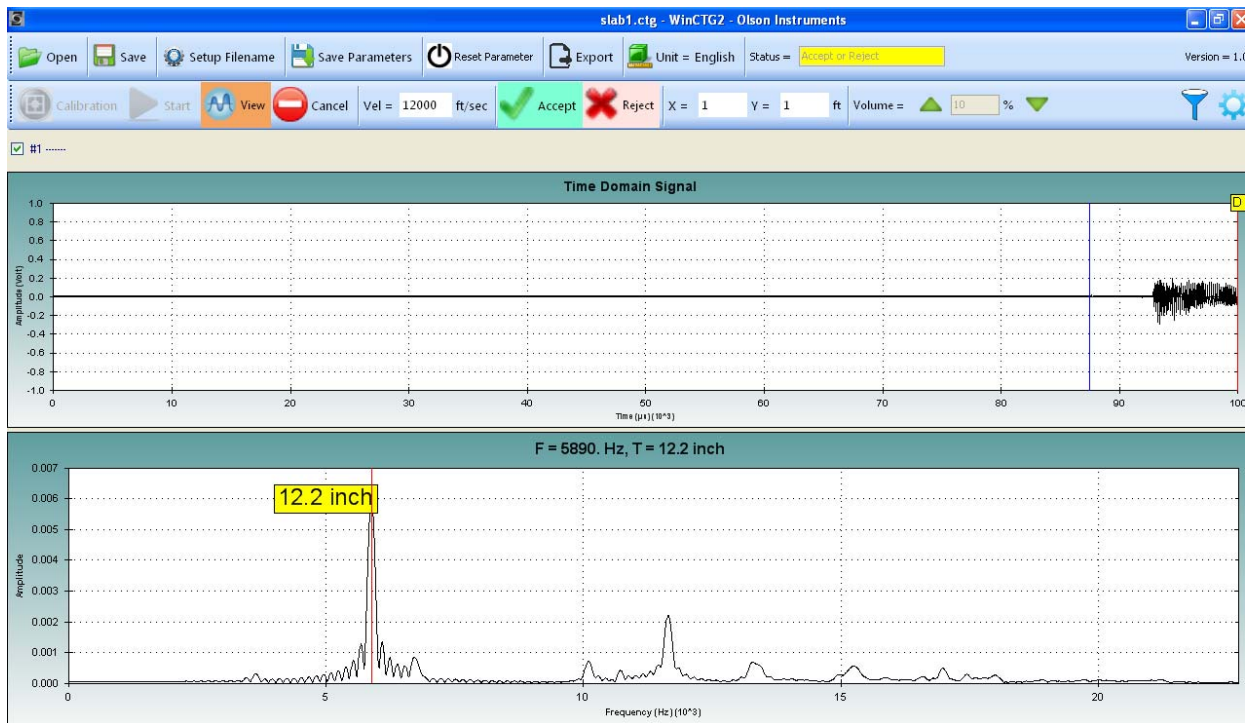
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Figure 6 – Data Displayed with Thickness Reported above the Frequency Spectrum Plot

7. Good data can be identified by a waveform signal in the Time Domain (top plot) that ranges from 0.1 volt to 0.8 volt AND the presence of a prominent peak in the Frequency Spectrum (bottom plot). (In Figure 6 above, the data was collected on a 6" x 12" cylinder so there are additional resonant peaks displayed in the data.) The following Figures 7A through 7D, demonstrate both acceptable and unacceptable data. It is recommended to verify repeatability of results by taking at least two tests at the same location.

> **i** *The default value for volume (or gain) is 10. The available volume varies in different tablets/laptops and the initial setting might not be appropriate to collect good data. If the waveform signal does not range from 0.1 volt to 0.8 volt, carefully adjust the volume as described in Section 4.6 and retest. Caution must be used when adjusting the volume as a high volume can result in noisy data.*
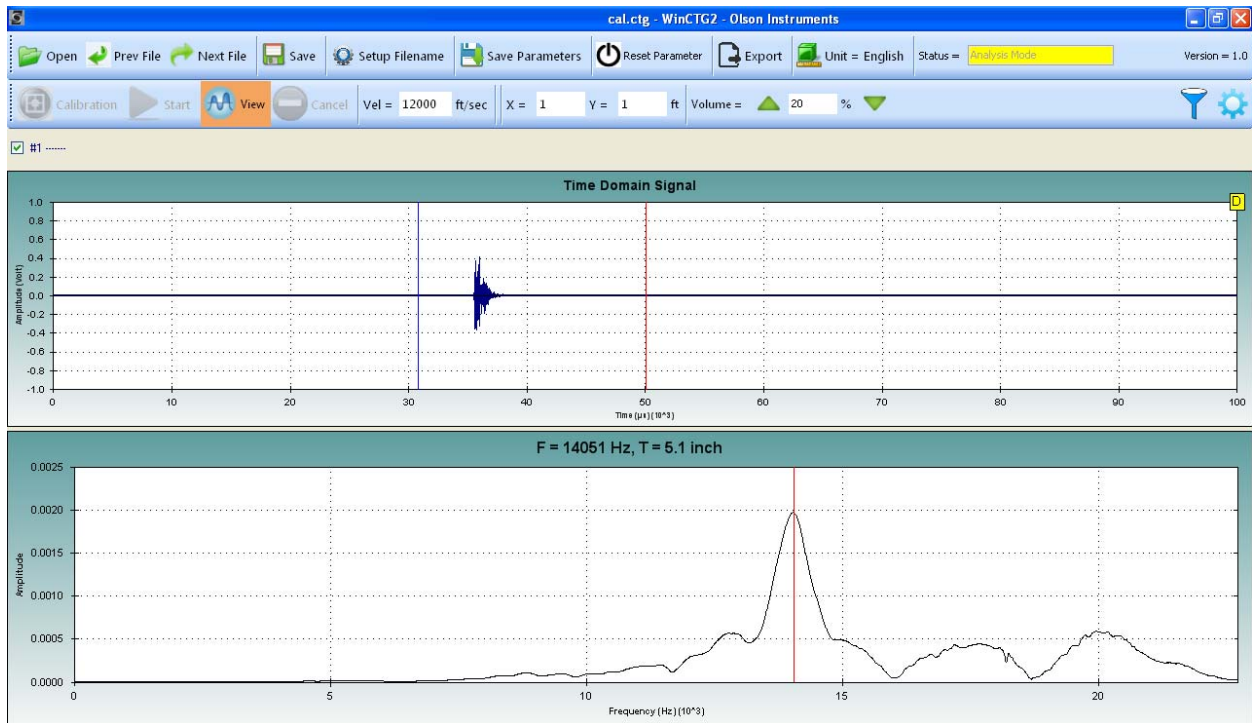
Figure 7A – Example of Good Data and a Single Prominent Peak in the Frequency Spectrum
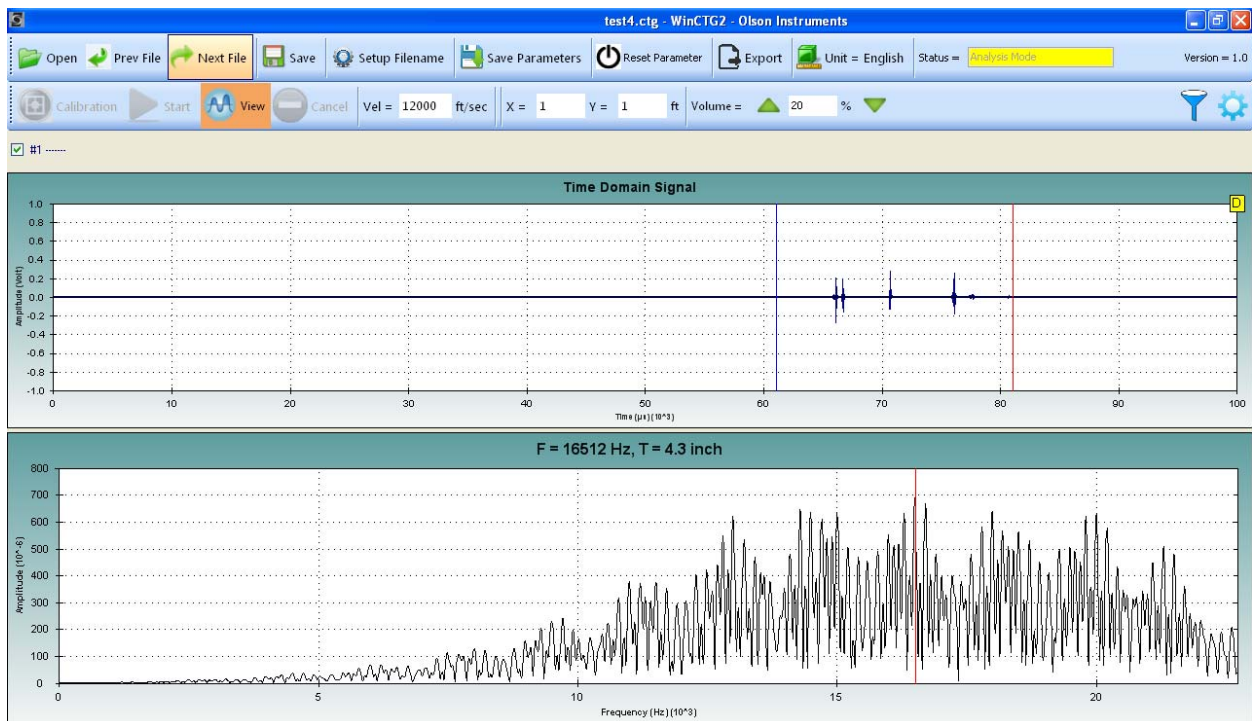

Figure 7B – Example of Poor Data (Noise) and many Peaks/Hash in the Frequency Spectrum
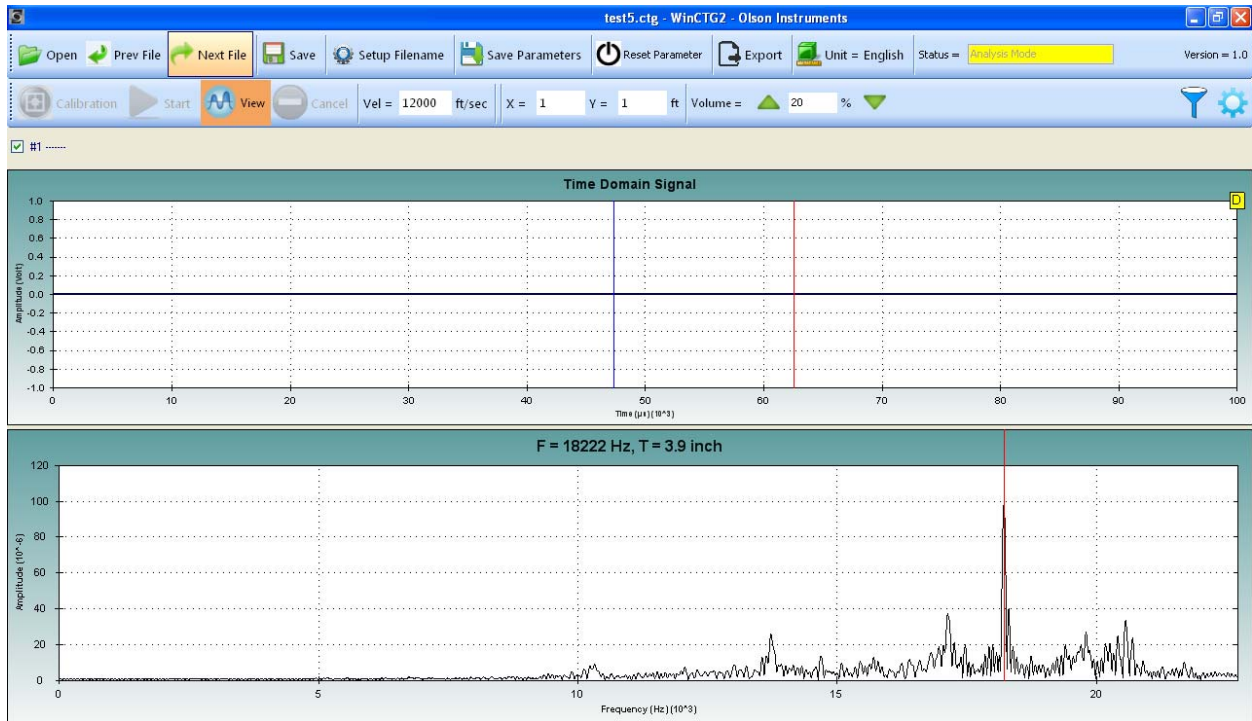
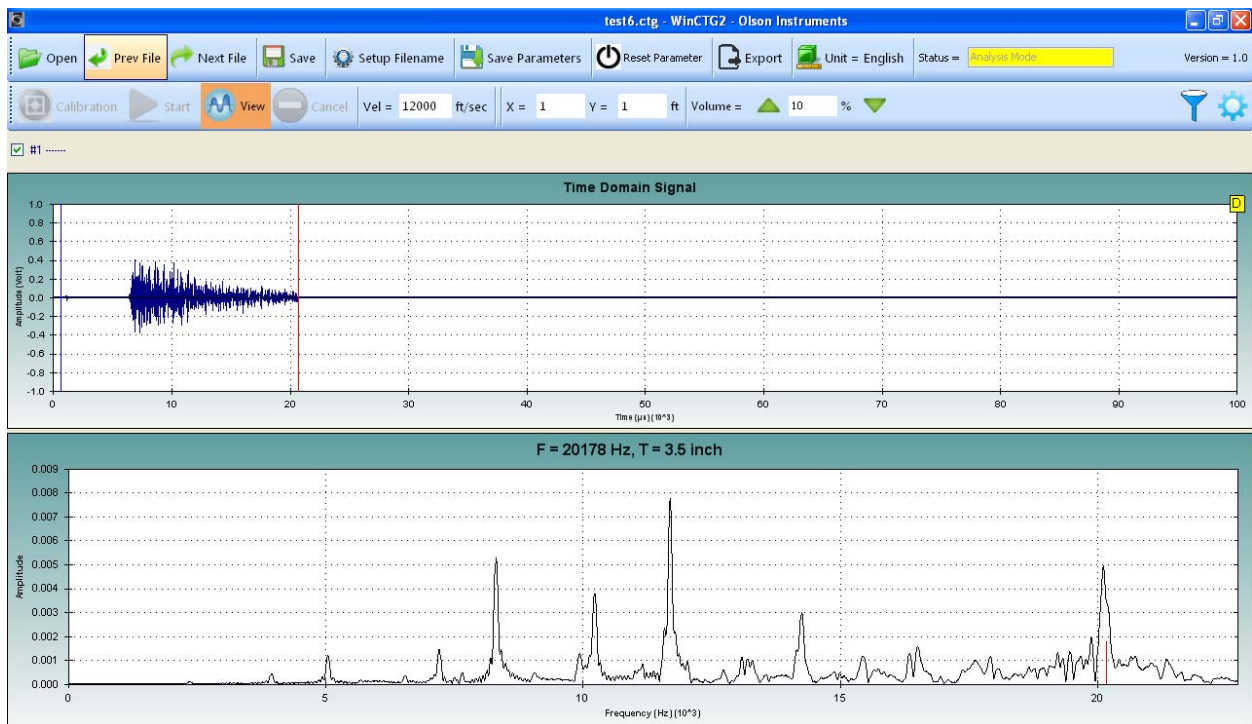Figure 7C – Example of Nonexistent Data and Noise Peaks in the Frequency Spectrum

Figure 7D – Example of Good Data and Multiple Peaks in the Frequency Spectrum that might Indicate the Presence of Multiple Cracks

8. If the data is acceptable, select the green box (with a checkmark) found in the Toolbar to accept and save the data. If the data is not acceptable, select the red box (marked with an X) found in the Toolbar to reject the data. After you have rejected the data, the program will wait for another impact. The program will continue to wait after every impact until you have accepted a record. Only then will it allow you to move on to the next test point.

9. Repeat the steps above until all the records are collected.

10. During the display of the data (before accepting or rejecting), several user options are available to allow additional data processing and display. First, a cursor function is available on the Frequency Spectrum (bottom plot) to allow the user to obtain the thickness values of peaks other than the largest one. Simply click on or touch the screen at the desired location. Next, the data can be windowed in or out by dragging the blue or red cursor to the desired location on the Time Domain plot (top plot). Finally, the frequency filtering can be changed by adjusting the filter bar in the Filter Panel located above the Waveform Panel.

11. After the data has been accepted (and saved), the data can be recalled by selecting the "Open" option found in the Main Menu then selecting the desired filename.

4.3   IE Data Acquisition with Known-Thickness Velocity Calibration

The CTG-2 measures thicknesses of concrete by measuring the time required for an echo to bounce off the back side of the concrete member being tested. The thickness is then computed by using this travel time along with the speed of sound in the concrete. The speed of sound in concrete can vary over a range of 10,000 to 14,000 feet per second (or 3,000 to 4,300 meters per second) depending on the mix design, aggregate type, and age of the concrete. Lower strength mixes typically have velocities in the lower range, while high strength mixes have higher velocities. The default velocity used in the WinCTG2 software is 12,000 ft/s (3,657 m/s) which is a typical value found in normal slabs and walls with 3,000 – 4,000 psi concrete mixes. Using this velocity with no additional calibration should give thicknesses within 10% or less of the actual value for most concrete structures. To increase accuracy, the unit can be calibrated.

The WinCTG2 software includes a feature that allows accurate calibration of the concrete velocity at any location where the user knows the actual concrete thickness and can collect good-quality data. This allows the user to improve the accuracy of readings from approximately a 10% error to approximately a 2% error. Typical locations for calibration include next to coreholes, cutouts, slab edges, etc. It can also be done on walls near holes or edges, or other known-thickness features that were placed with the same concrete mix as the structure being tested.

To use, first position the IE head on the concrete to be tested at a distance 6" – 12" from the known thickness location. Select the "Calibration" option on the Toolbar. This will open a "Calibration Form" dialogue box as shown in Figure 8 below.
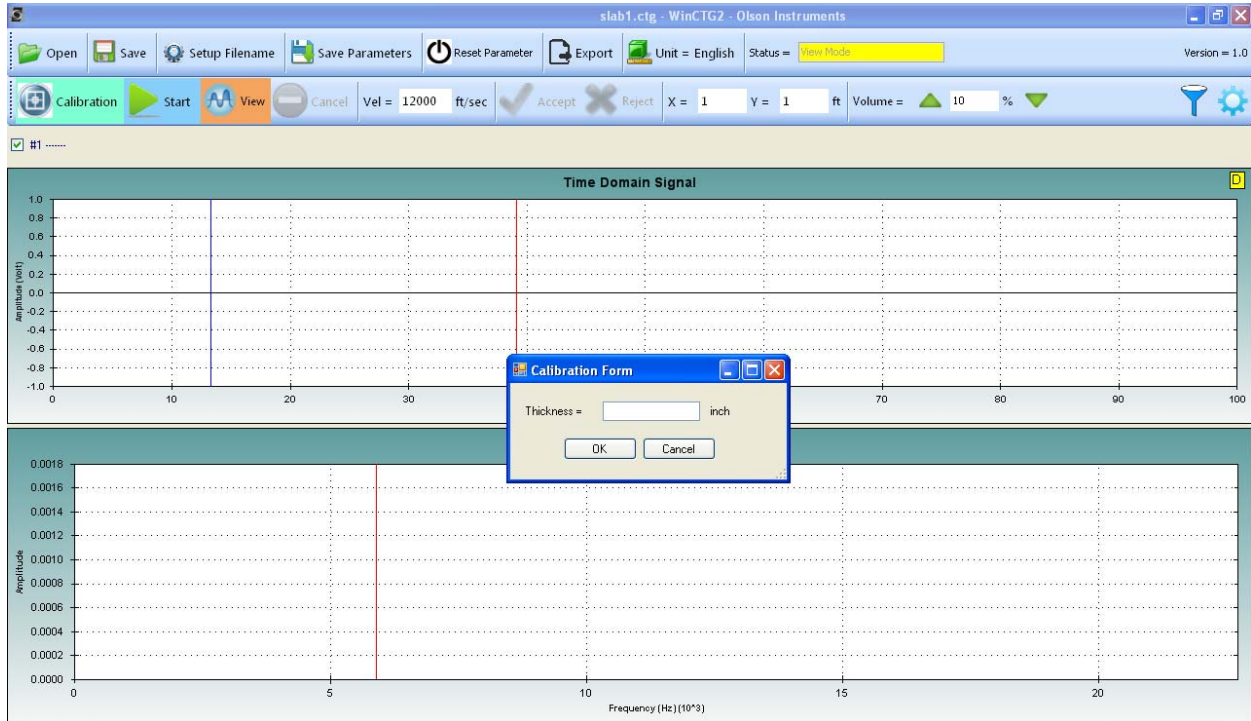

Figure 8 – Calibrate for Velocity at Location of Known Thickness

Enter the value of the thickness measured at the test location then click on "OK". This will generate a dialogue box asking if you want to save the calibration file. If you want to save the calibration file, select "Yes" and save the file, giving it a name like "cal1". Otherwise, select "No" if you don't want to save the file.

The system is now waiting to receive data (in the form of an impact) as reported in the "Status" field which is currently in "Ready to Test" mode. Now, press the test head firmly against the test surface and press the trigger button on the underside of the handle. The solenoid in the test head will immediately fire and a waveform will be collected. The data should show a clear, prominent IE echo peak and corresponding velocity. When you accept the data, a small dialogue box will appear and report the velocity as shown in Figure 9 below. (Note: the program will not display a corrected thickness measurement at this time.) If you want to accept the calibrated velocity value, select "Yes" and the velocity will be changed in the "Vel" field. If you don't want to accept this value, select "No" and the velocity will not be changed. Note: The calibrated velocity value is valid only for the specific pour of concrete on which it is calibrated. It should not be used on any other pours.
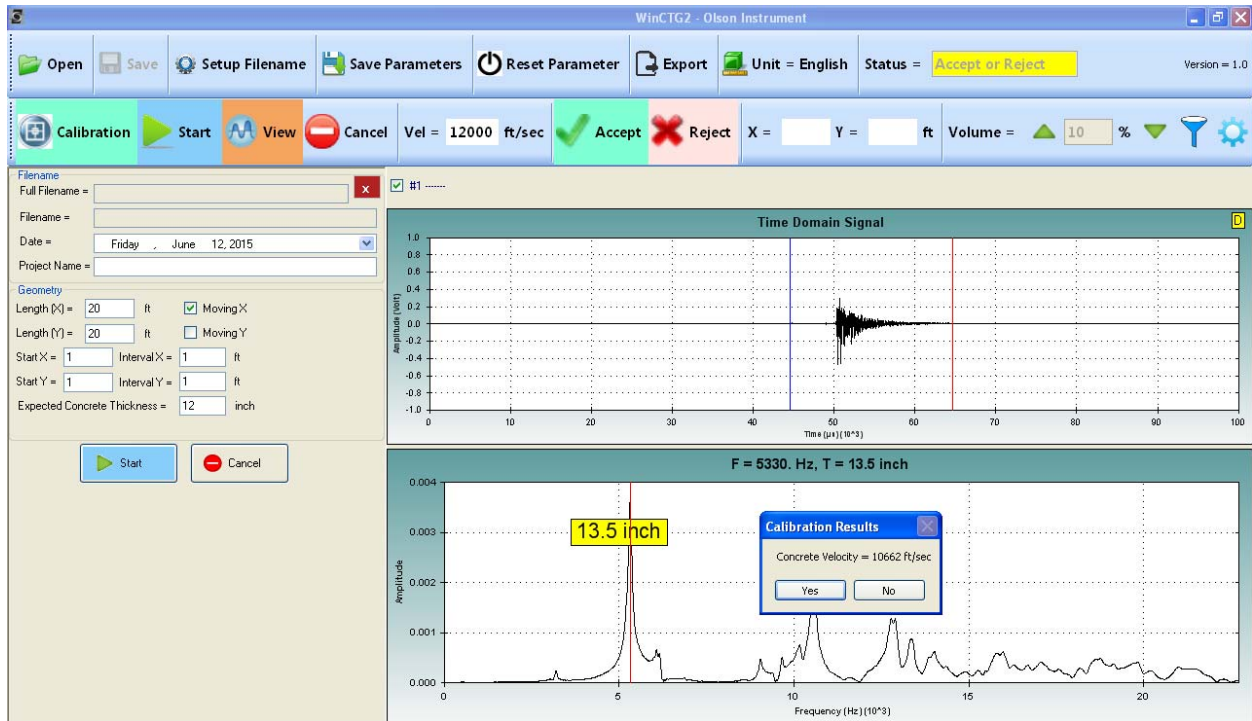
Figure 9 – Calibrate for Velocity at Location of Known Thickness

The velocity calibration mode can also be used to measure relative velocities of concrete in a member with known thicknesses (such as a wall) to find degraded or low-strength zones.

4.4   View Mode

View mode can be used when it is not necessary to save your data files or if you want to perform a quick succession of tests to scope out a job before you start saving data. To use, first position the IE head on the test member. Select the "View" option on the Toolbar. Note that the "Status" field will report that it is in "Ready to Test" mode. The system is now waiting to receive data (in the form of an impact). With the IE head powered up and the green light on the top of the handle illuminated, press the trigger button on the underside of the handle. The unit will fire the solenoid on the CTG-2 head and create an impact. The displacement transducer sensor on the CTG-2 head will record the data and the software will display the data on the screen as shown in Figure 10 below. The program is now waiting for you select the "View" option again for further testing. When you are ready to start saving data, select the "Start" option or "Setup Filename" option and proceed with testing according to Section 4.2 or 4.3.
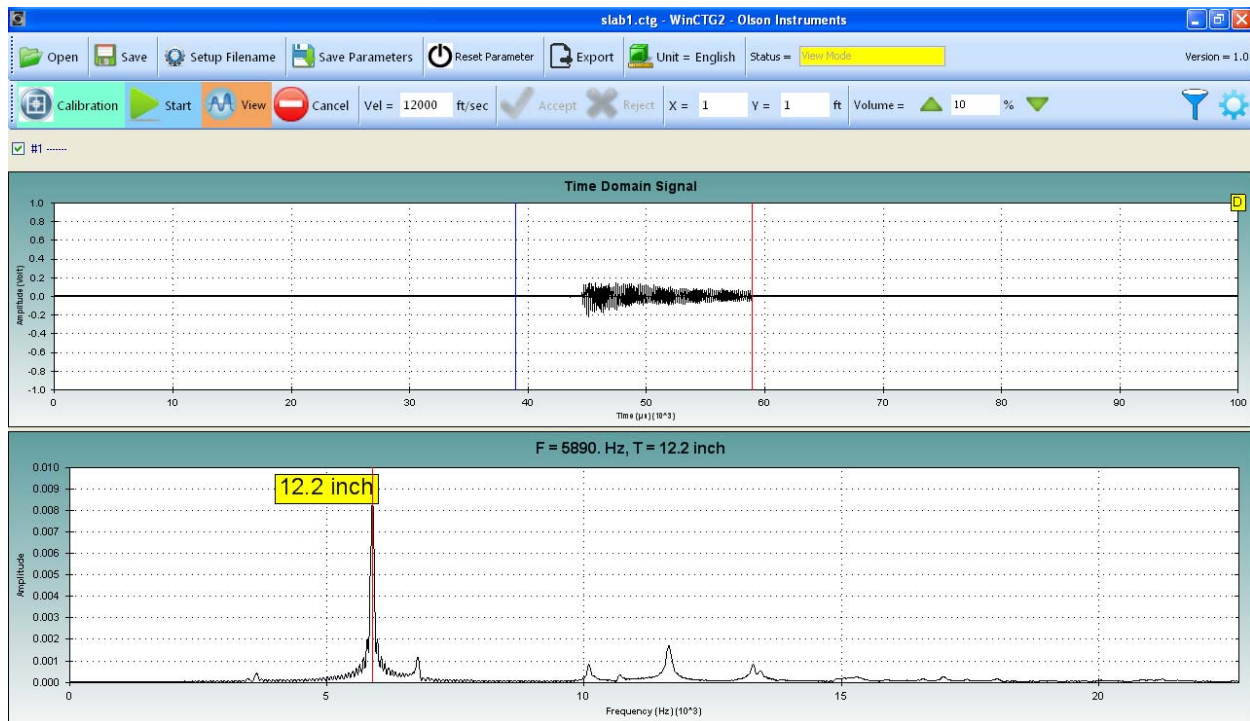
Figure 10 – Testing in View Mode

4.5 Thick Concrete Testing

The CTG-2 is primarily designed to measure concrete thicknesses ranging from approximately 3.2 inches (8.1 cm) to about 20 inches (50.8 cm), however, it is possible to measure thicknesses up to 6 feet (2 m) by using the following procedure:

First, change the "Expected Concrete Thickness" Value (found in the Geometry Feature on the Parameter Panel) from the default value of 6 inches (152.4 mm) to a number that represents the approximate expected thickness of the member you are testing.

Next, position the IE head on the test member. Now, start the testing using one of the three test mode options (Setup Filename, Start or View). With the IE head powered up and the green light on the top of the handle illuminated, press the unit firmly against the concrete member to be tested and use a small external hammer to impact the top of the concrete. The displacement transducer sensor on the CTG-2 head will record the data and the software will display the data on the screen.

When testing thick concrete, it is important to select the proper hammer to obtain the best quality data. For tests on concrete expected to be between 2 and 3 feet (0.6 to 1m) thick, a 1 pound (0.5 kg) steel hammer is the best choice. For thicker structures, use of a 3 pound (1.5 kg) or larger hammer will result in clearer data.

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4.6   Units

The units can be changed from Metric to English or vice versa during data collection. Select the "Unit" option found on the Main Menu, as shown in Figure 11 below, to change the units.
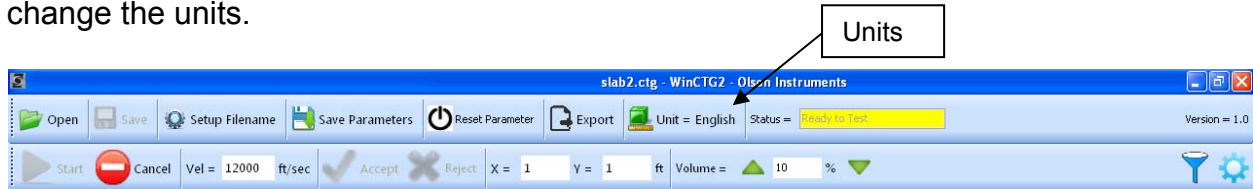

Figure 11 – Units

4.7   Volume

The volume (or gain) can be changed during data collection by adjusting the green "Volume" option arrows upward or downward or by typing a new value in the "Volume" field found on the Toolbar, as shown in Figure 12 Below.
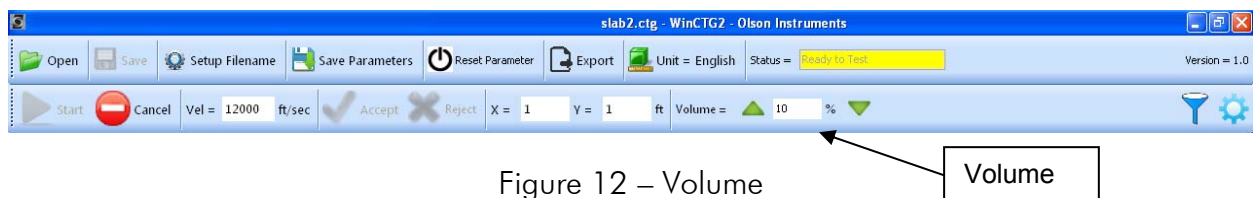

Figure 12 – Volume

4.8   Save Parameters

The parameters (such as "Expected Concrete Thickness" and "Velocity") can be saved by selecting the "Save Parameters" option found in the Main Menu as shown in Figure 13 below. Upon exiting the program, you will get another opportunity to save parameters. Be careful when you save parameters; they will be saved by the program for future use the next time you open the software. If you have calibrated for velocity, for instance, this velocity may not be valid for your next job.
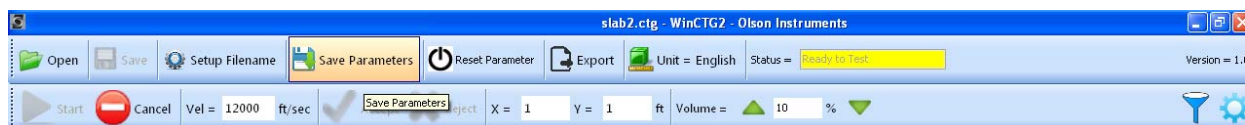

Figure 13 – Save Parameters

4.9   Reset Parameters

To return the parameters to the factory settings, select the "Reset Parameter" option found in the Main menu as shown in Figure 14 below.
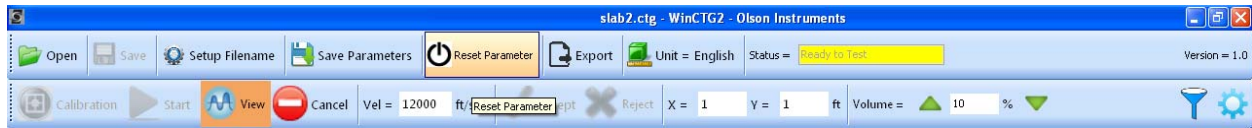

Figure 14 – Reset Parameters

4.10   Operation Notes and Tips

Concrete Thickness Readings: The CTG-2 is primarily designed to work on plate-like structures with dimensions that are at least 6 times the thickness. Structures which are block-like will give unreliable readings due to additional resonances present in the structure. When testing slabs or walls, it is important to check the Frequency Spectrum plot to assure that a prominent peak has been selected by the software.

Expected Concrete Thickness: Within any concrete structure, there might be additional resonances present. To minimize the chance for false readings, the CTG-2 requires an "Expected Concrete Thickness" value from which the default filter frequency value is computed. This limits the thickness range of the CTG-2 and attenuates frequencies outside the range of interest. When changing this value, be certain to exit the field to ensure that the value is accepted (use tab to exit or click on another field).

Solenoid Positioning: The automatic solenoid impactor must be positioned on an even concrete surface. If the solenoid is positioned over a hole/depression or over a bump/high spot, unreliable results may occur.

Delamination Conditions: If the user attempts to measure thin concrete that is outside the range of the CTG-2 unit (indicated by a hollow, drummy noise at the time of impact), multiple peaks will be displayed in the Frequency Spectrum plot. Delamination conditions may be a result of thin concrete or damaged, cracked concrete. These sorts of results will also appear if a test is attempted on a table top or metal surface, or if a test is done through unbonded tile or other topping material.

Thick Concrete: If the user attempts to measure thick concrete that is outside the range of the CTG-2, multiple invalid peaks might be displayed in the Frequency Spectrum plot.

Typical Velocity Ranges: If a location of known thickness is not available, the accuracy of the thickness readings can still be improved over the default velocity of 12,000 fps by inputting a typical value from the table below based on the estimated strength of the concrete.

2,000 – 3,000 psi:	11,000 fps
3,000 – 4,000 psi:	12,000 fps (default value)
4,000 – 6,000 psi:	13,000 fps
6,000 – 8,000 psi:	14,000 fps

Note that these values are general guidelines which will increase the accuracy of the measurements to 5% of full scale for cases where a direct calibration cannot be done. Note that the accuracy of the unit improves to 2% if a direct calibration can be done.

Pan Pour: When testing a corrugated pan pour slab, test in a straight line that is transverse to the direction of the corrugations, making note of the "thinner" concrete zones and the "thicker" concrete zones. Note that the areas between the thin zones and thick zones may produce data with two peaks or more. Data from these areas will probably not be useful. After the thick zones have been identified, test parallel to the corrugations in the thick zone if you want to identify the maximum thickness of the pan pour. Position the axis of the CTG-2 unit parallel to the direction of the corrugations.

Calibration of the CTG-2 on slab on metal deck (pan deck) concrete: The CTG-2 has the greatest accuracy (typically 2%) if a test at a known-thickness location is conducted and used to calibrate the concrete velocity. However, for the special case of pan-deck slabs, it is also possible to obtain a reasonable calibration (typically about 4% or better) by using the known dimensions of the metal deck pan.

To measure the velocity of the concrete in a pan deck slab, take a minimum of two thickness readings using the default velocity value of 12,000 ft/sec. One should be centered over a "Thick" part of the slab (D1 below) and the other centered over a "thin" part of the deck (D2 below). Find these locations by performing a series of close-spaced (0.5 to 1 inch) tests along a line to find points which are at the centers of typical thick and thin sections of the slab. Then, using the known deck height variation (H1 as shown below, from specifications or from direct measurement on the slab bottom), use the following equation to compute the calibrated velocity (Vc):

$$Vc = 12,000 * (H1/(D1-D2))$$

(where 12,000 fps is the default velocity and Vc is the new calibrated velocity)
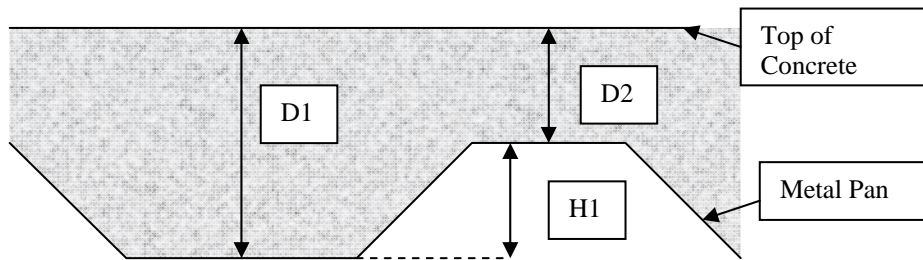
Software Troubleshooting: If the software does not work as expected, the best recourse is to reset the parameters, close the program and restart the program.

Signal Troubleshooting: If the CTG-2 unit is operating correctly (with the green light illuminated on the handle) and 'no data' or 'noisy data' is being received when the status bar reads "Ready to Test", check for the following:

1. Make sure you are using the USB Audio Adapter per the instructions.

2. If your data does not show a clear, prominent peak in the Frequency Spectrum (bottom plot), check to make sure your volume is not set too high. Try lowering it to 10 and work your way up in intervals of 10 if necessary.

4. A noisy signal without a prominent peak in the Frequency Spectrum may indicate that the concrete is too thin to test (less than ~ 3.2 inches). Verify that your unit is working correctly by returning to a previous location that has been successfully tested.

5. A noisy signal without a prominent peak in the Frequency Spectrum may indicate that the concrete is thicker than the range specified in "Expected Concrete Thickness". Try increasing this value to see if the results improve.

General Tips: Practice with your CTG-2 on a location of known concrete thickness before you take the unit to the first jobsite. Get familiar with your equipment and know what to expect from its performance.

General Troubleshooting: If the CTG-2 unit does not impact after pressing the trigger button (or if the impact is not hard/loud enough), the solenoid impactor might be stuck. Carefully pull the impactor out with your fingernails and clean with a Q-tip dampened with alcohol.

5.0   WinCTG2 SOFTWARE ANALYSIS

This section includes instructions for data analysis with the WinCTG2 Software.

5.1   Start Program

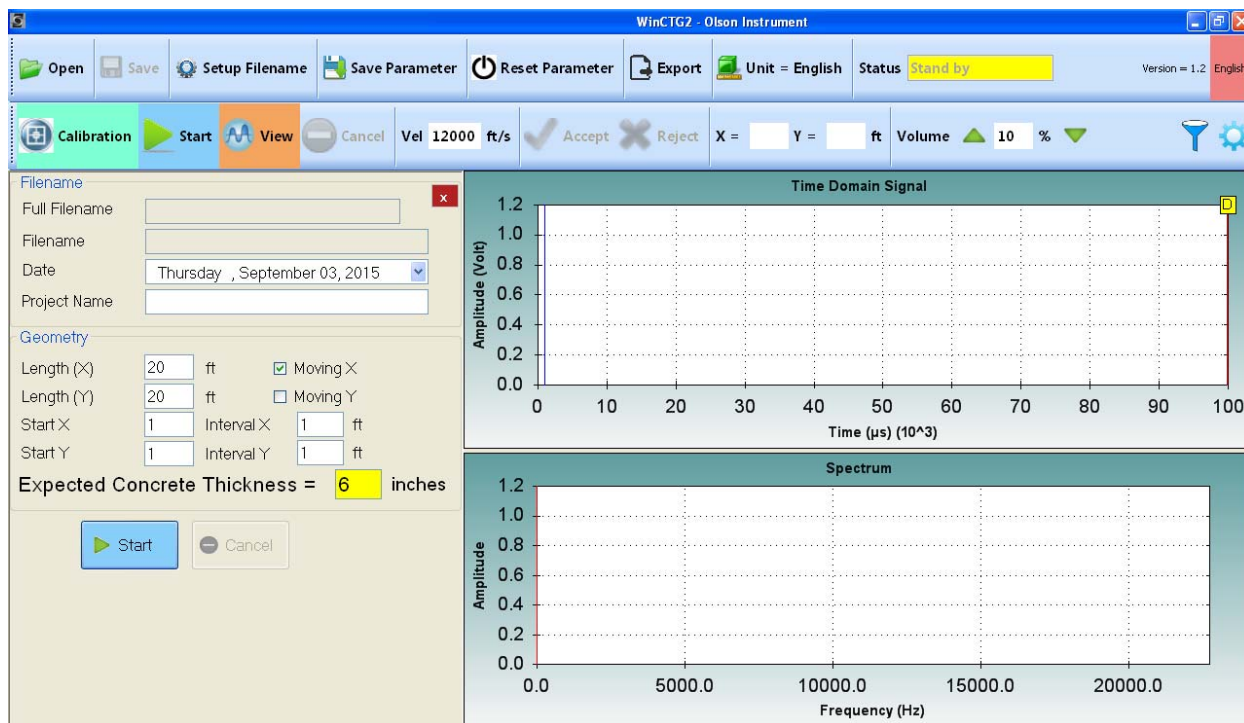Select the WinCTG2 shortcut on the desktop. The software will open as shown in Figure 15 below.

Figure 15 - Main Screen for WinCTG2 Software

5.2   Open Data Files

1. Select the "Open" option found in the Main Menu. The "Open" dialogue box will appear as shown in Figure 16 below. Navigate to the .ctg data files saved earlier and select the data file you want to open. After you have opened a file, the "Status" field will report that you are in "Analysis Mode"
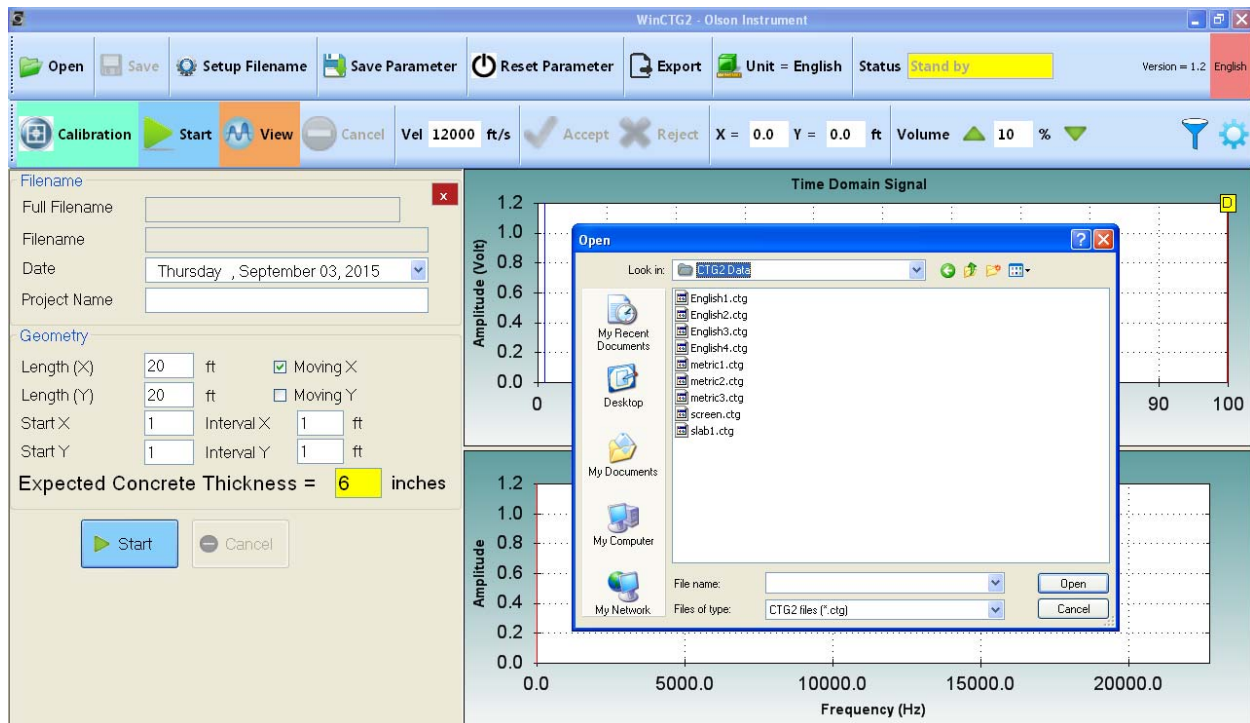

Figure 16 – Open File for Analysis

5.3   Filtering

Interactive filtering is implemented in this software. A Butterworth filter of 4th order is used. The type of pass-band can be selected in the Filter Panel. The default pass-band filter for IE data is "Highpass" which is the recommended filter for most IE situations. The frequencies can be set using the arrows below the slider bar as shown in Figure 17 below or can be typed into the filtering fields (F1 and F2). There are three options for pass-band filtering:

- Lowpass – Passes the frequencies below the right mark. This type of pass-band is NOT recommended for general Impact Echo data analysis.

- Highpass – Passes the frequencies above the left mark. This type of pass-band is recommended for Impact Echo data analysis.

- Bandpass – Passes the frequencies between the left and right mark. This type of pass-band can be used for Impact Echo data analysis if there is interference from low frequency noise.

The following guidelines can be used for selecting appropriate filters:

1. When the expected concrete thickness is less than 3 inches, a bandpass filter of 10,000 to 50,000 Hz is appropriate
2. When the expected concrete thickness is between 3 inches and 6 inches, a highpass filter of 6000 Hz is appropriate.
3. When the expected concrete thickness is between 6 inches and 12 inches, a highpass filter of 3000 Hz is appropriate.
4. When the expected thickness is greater than 12 inches, a highpass filter of 1000 Hz is appropriate.
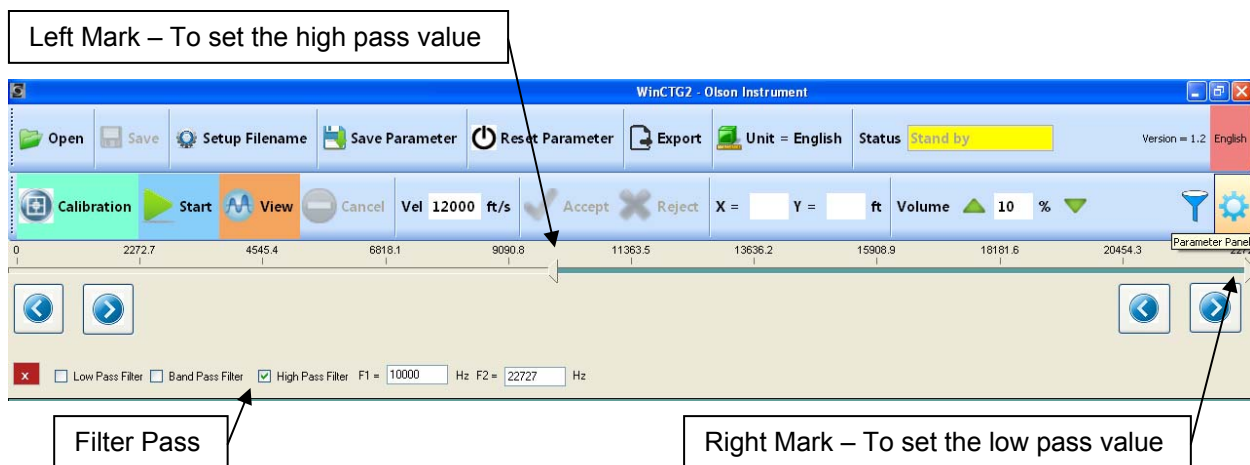

Figure 17 – Filter Panel

5.4   Windowing

Interactive time-domain windowing is implemented in this software. Two cursors (left blue and right red) found on the top plot box can be dragged into the data to window the front and back of the time domain waveform. This feature is useful to eliminate any front interference from the solenoid (front end) and/or the interference from double hitting or other noise (back end). Figures 18A and 18B show the effect on the frequency spectrum before and after windowing is applied to a typical time domain data waveform with noise present. Notice that the spectrum from the windowed time domain data in Figure 18B is smoother than the un-windowed data in Figure 18A.
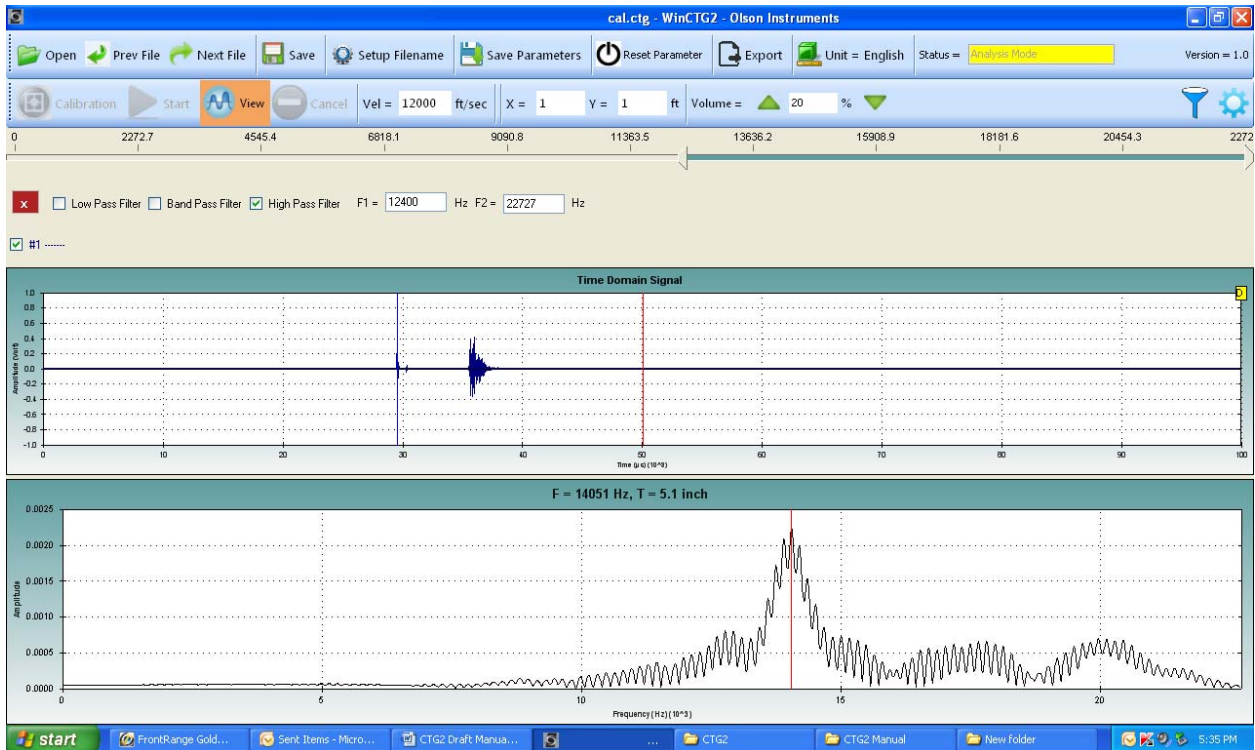
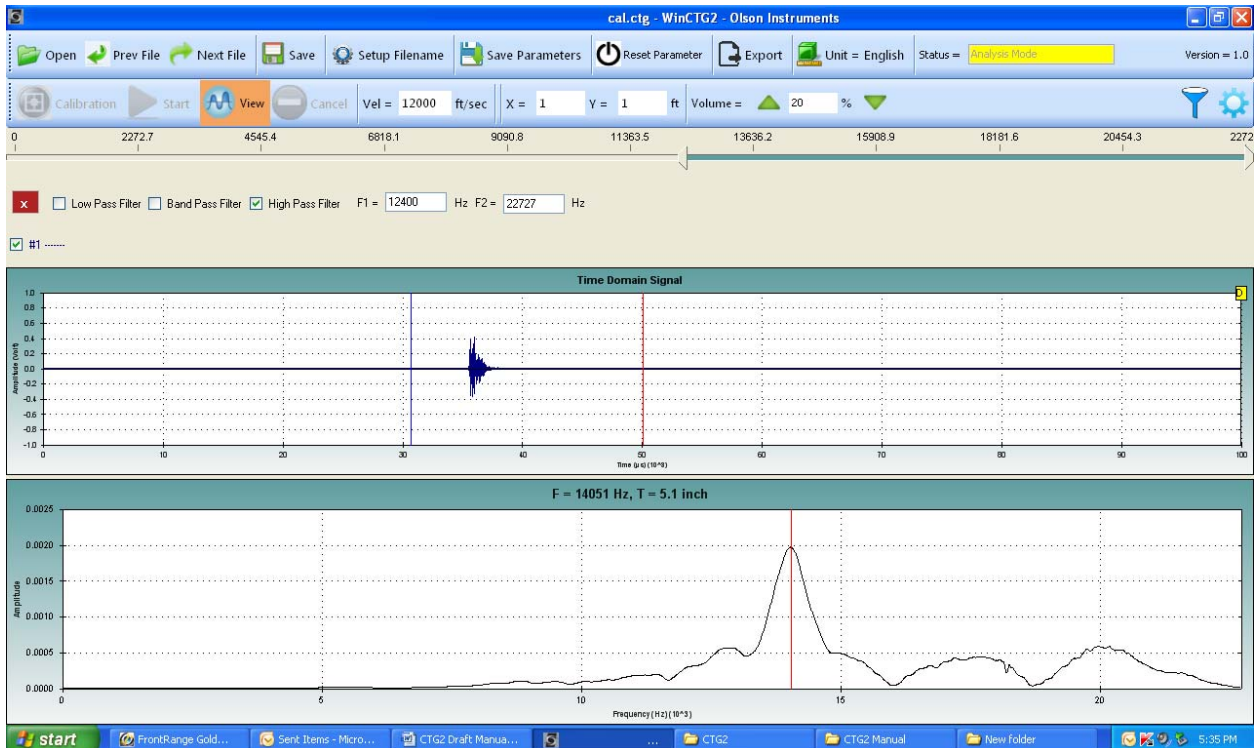Figure 18A – Time domain and Spectrum before Windowing is Applied

Figure 18B – Time domain and Spectrum after Windowing is Applied

5.5   Concrete Velocity

The default concrete velocity used for concrete thickness calculation (or depth of the echo) is 12,000 fps. This is an average velocity value for typical sound concrete. But sound concrete velocity values range from 10,000 fps (weaker concrete) to 14,000 fps (strong concrete). If this velocity needs to be modified, simply enter the new velocity value in the "Vel" field found on the Toolbar as shown in Figure 19 below.
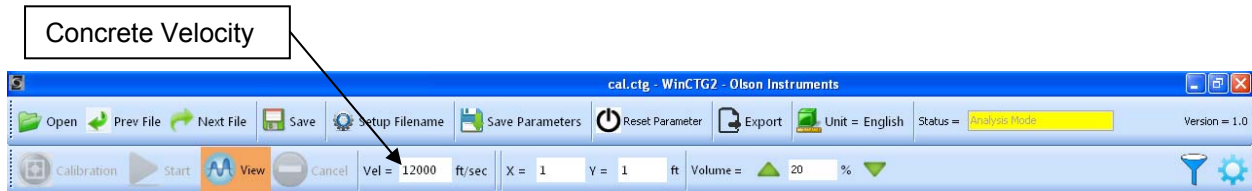
Concrete Velocity

Figure 19 – Concrete Velocity

> **i**
>
> *Typical concrete velocity is 12,000 – 13,000 ft/sec or 3,600 – 4,000 m/s. Higher strength concrete may have a higher velocity. Young concrete (less than 7 days old) may have a slower velocity. Poor concrete may also have a slower velocity.*

5.6   Open Next Data File

If the data filenames have a fixed alphabetical prefix and are numbered sequentially in the suffix, it is possible to scroll quickly through the data. Note that this is the normal way files are saved on the CTG-2. Use the buttons "Next File" and "Prev File" to quickly open the files, as shown in Figure 20.
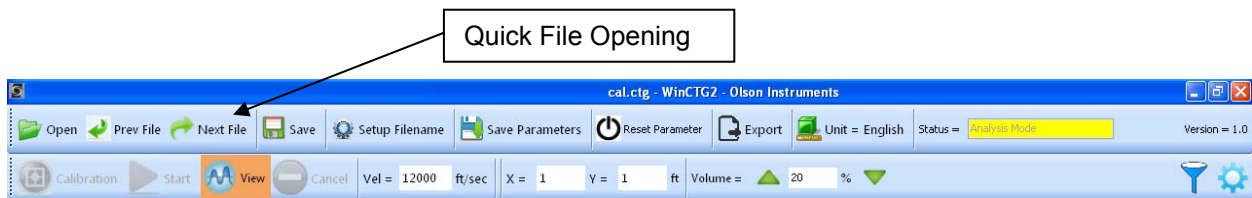
Quick File Opening

Figure 20 – Quick File Opening

6.0   WinCTG2 SOFTWARE EXPORTING OPTIONS

This section describes options for exporting images and a summary table of test results.

6.1   Copy or Save Image

After the IE file is opened, either the top or bottom plot (Time Domain or Frequency Spectrum) can be copied to the clipboard for easy pasting into reports or other documents. Just right click on the desired plot (hold your finger on the screen if using a tablet) then select "Copy" to save to your clipboard or select "Save Image As" and use the "Save as Type" dropdown menu to save as an .emf, .png, .gif, .jpg, .tif, or .bmp for later use.

6.2   Export Test Results to Comma Separated Format

The WinCTG2 software allows the export of test results to comma separated format which can be entered into an Excel Spreadsheet. Select the "Export" option found in the Main Menu and the "Export Output" dialogue box will appear as shown in Figure 21 below. Enter the desired directory then enter the alphabetical filename prefix, the first numerical suffix, the total number of records collected under that filename setup and the name you want to give to the file.
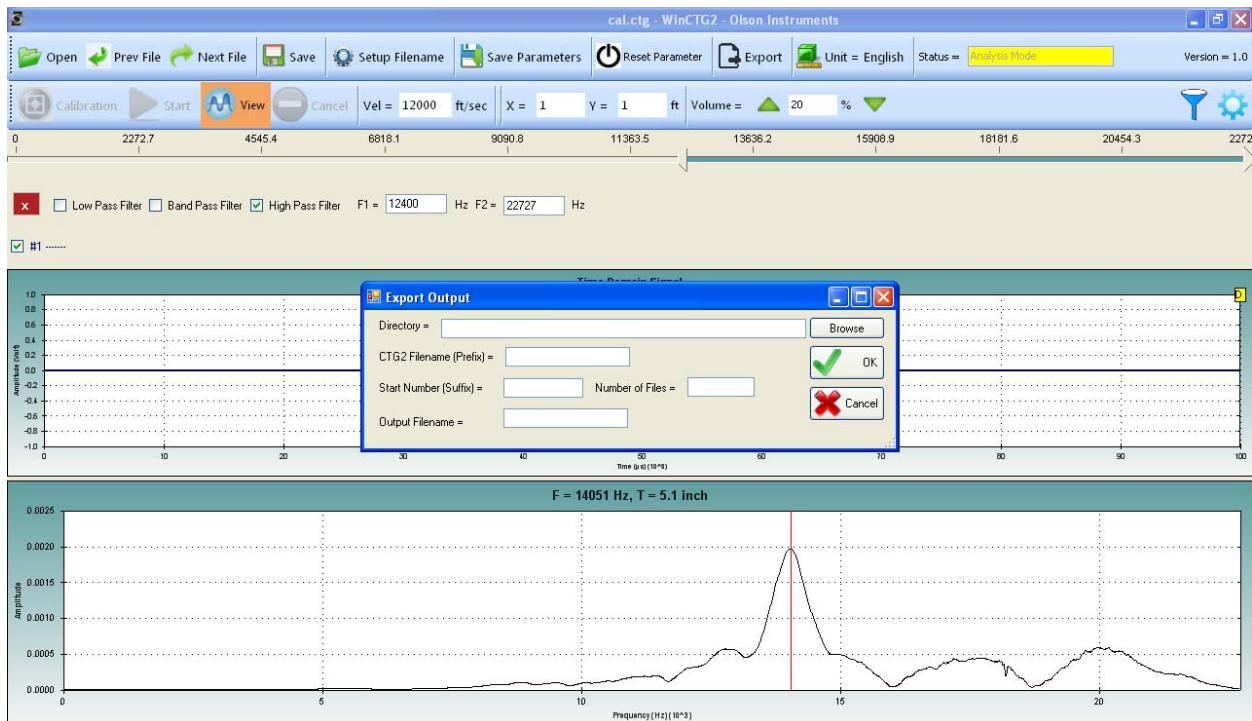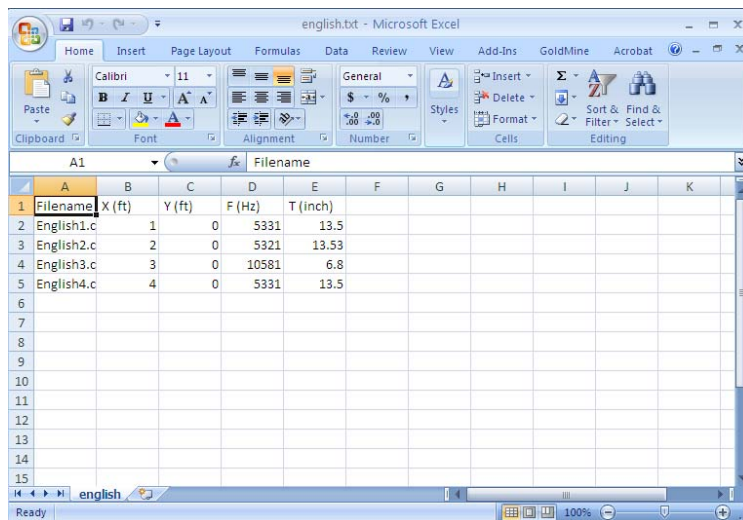

Figure 21 – Export Test Results to Comma Separated Format

A summary table of test results will be saved in a .txt file with data arranged in columns as shown in Figure 22 below. The column format is as follows:

1. File Name
2. X location of the test (ft or m)
3. Y location of the test (ft or m)
4. Frequency associated with the measured thickness (Hz)
5. Measured thickness (inches or mm)

The columns of information are separated by commas, so when importing the data into a spreadsheet, be sure to click on the "commas as delimiters" checkboxes.

Figure 22 – Results Exported to Excel Spreadsheet

6.3   Export Raw Data to Comma Separated Format

The WinCTG2 software allows the export of individual waveform (raw) data in comma separated format to an Excel Spreadsheet. After opening an existing file, click anywhere on the waveform plot then use the hot key "W" to export. A "Save As" dialogue box will appear on the screen. Name the .csv file and click on "Save". The .csv file will be saved in the same directory as the data file.

7.0   WinCTG2 SOFTWARE LANGUAGE OPTIONS

The WinCTG2 Software can be operated in several different languages. To browse for different languages, select the "Language" option located at the far right of the Main Menu as shown in Figure 23 below.
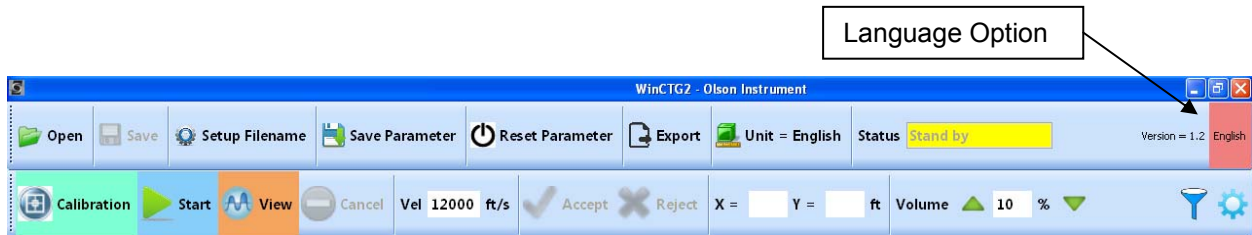

Figure 23 – Language Options

8.0   CARE AND MAINTENANCE

The CTG-2 unit is rugged but it is not indestructible. Certain precautions should be taken to ensure the reliable operation of the unit.

1. Take care not to drop the CTG-2 as damage might result.

2. Do not slide sensor tip or rubber feet along the test surface.

3. Use the toggle switch on the base of the IE head to turn the unit off when not in use. This will prolong battery life.

4. The CTG-2 should be kept clean and free of mud and dirt, as mud can interfere with the operation of the automatic solenoid impactor and small rocks or other objects on the sensor can result in poor data or low signal amplitudes.

5. The CTG-2 should not be exposed to direct rain or other moisture. Do not submerge the CTG-2. If the unit falls into water, immediately remove the batteries, disconnect the cable, remove the bottom cover, clean off any mud or dirt, and allow the unit to dry out.

APPENDIX A

SUGGESTED WINDOWS DEVICES

The Olson Instruments CTG-2 unit should work with most desktops, laptops and better-quality tablets.

The following is a list of tablet manufacturers that have been used at our facility with the CTG-2. This list will change over time so contact us at info@olsoninstruments.com with questions and to report tablets you have found to work.

Toshiba
Dell
Microsoft Surface Pro
Acer

We recommend a minimum 8" size tablet for the best software display. We recommend that the tablet be used in "landscape" mode.