



RT-1

Resonant Frequency Test Software Version 1.0

User Guide



12401 W 49thAve.
Wheat Ridge, Colorado 80033-1927 U.S.A.

Phone: 303/423-1212
Fax: 303/423-6071
www.olsoninstruments.com

The Olson Instruments Model RT-1, Version 1.0 series of test kits are complete units designed primarily to conduct and supplement ASTM C215 (Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens) and ASTM C666 (Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing) respectively. The test kit comes in a portable case and is easy to set up in the laboratory or field.

The RT-1 test kit includes three main components: (1) a small hammer to impact the concrete specimen, (2) an accelerometer to measure the vibration response of the concrete specimen, and (3) a handheld data acquisition unit which includes a processor to perform calculations as well as a graphical display of the received signal spectrum allowing the user to immediately review test data as well as save, recall, and later download the data to a PC. Additional equipment in the RT-1 test kit includes all necessary cables, sensor mounting brackets and adhesives, and a rubber pad for specimen support. The RT-1 test kit also includes a CD with an Excel spreadsheet programmed with all calculations and tables found in ASTM C215.

The RT-1 test kits are simple, rugged, battery powered units designed for easy, fast, and reliable operation. There is no special training required. This operation manual begins with a description of the hardware and simplified operating instructions then continues on to a more detailed explanation of the various features and functions available.

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BASIC OPERATION

Hardware and Setup

The RT-1 system consists of three basic parts:

Main body acquisition and display unit



Accelerometer (with magnetic base)



Ball-Peen Hammer (0.2lb)

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Also included in the test kit are:

- (2) White BNC Cables
- (1) Steel Block (mounting the accelerometer for torsional testing of cylinders)
- (2) Mounting Washers
- (1) Rubber Pad (for specimen support)
- (1) Can Marine Grease/Spatula
- (1) High Frequency Hammer (for small specimens)
- (1) CD Data Download
- (1) User Guide
- (1) RS-232 Download Cable
- (1) Power Supply/Charger
- (1) Equipment Case

The steel mounting block should be used to mount the accelerometer to cylinder or core specimens for Torsional testing. Attach the steel block to the cylinder/core with the marine grease. Next attach the accelerometer to the steel block (using the magnetic base) so that the accelerometer will measure vibration in the tangential direction. Note the accelerometer measures vibration in only one direction.

The high frequency hammer supplied in the kit is intended for testing of very small concrete or rock core samples (diameter ≤ 2 inches). These small samples have higher resonant frequencies and therefore need to be excited at a higher frequency range, which can not be done with the 0.2 lb hammer. Experimentation by the user may also find that for other non-standard specimens, such as cores

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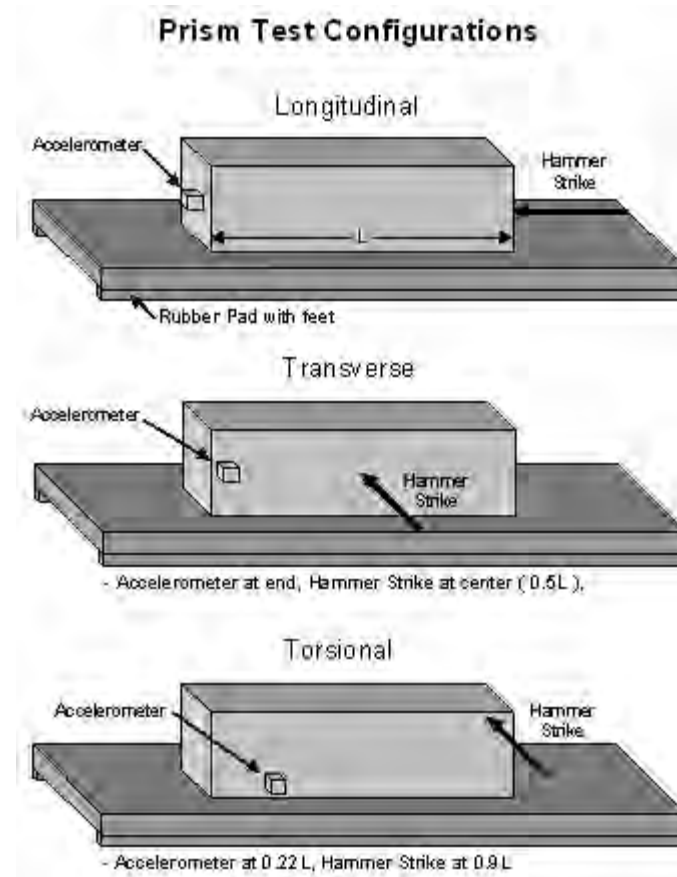
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between 2 - 4 inches in diameter a 0.1 lb (2 oz) hammer may be preferred. See the “Hints” listed in OPERATION NOTES AND HINTS for discussion on Torsional testing on small samples. The testing described in this paragraph is outside the realm of ASTM - C215, is intended for special applications and should be performed only at the end users discretion.

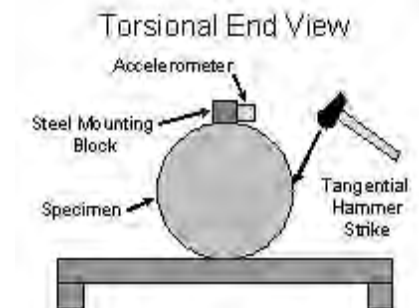
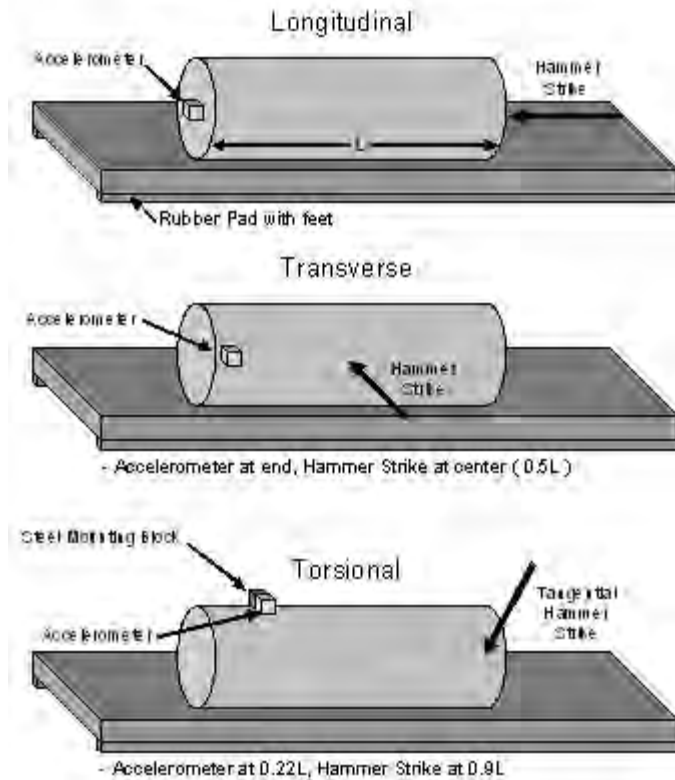


High Frequency Hammer

For test set up, connect the accelerometer to the acquisition and display unit’s BNC connection via one of the white BNC cables. Next, attach the accelerometer to the concrete test specimen in *one* of three ways: (1) a mounting washer and grease, (2) the steel mounting block and grease, (3) or hot glue. Next, place the specimen appropriately on the rubber pad. Note that the appropriate location for accelerometer attachment and hammer excitation depends upon the test specimen geometry (prism or cylinder) as well as the desired mode of vibration to be tested (transverse, longitudinal, or torsional), below is a schematic showing typical recommended testing configurations, consult ASTM C215 for further details.



Cylinder Test Configurations



NOTE: Do not allow dirt or moisture to enter the ends of the cable connectors, as this may interfere with the connection and/or operation of the unit.

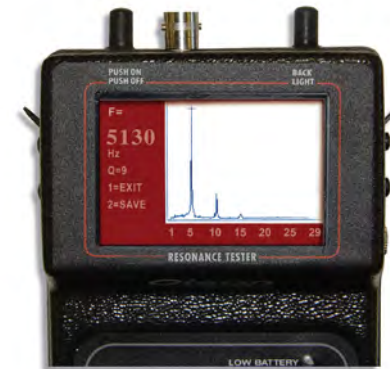
RT-1 Operation

Once setup is complete the RT-1 acquisition and display unit may be turned on by pushing the push-on/push-off power switch. The model and the version number of the software will display momentarily, followed by a display of the number of records currently saved in memory. At this point the main menu will appear, the user may select either to perform a test by pressing any red "fire" key on the keypad (0, 1, or 3), set the frequency range (key 4 or 6 on the keypad, depending on the current range selected), or to go to the Data Transfer/Setup menu by entering 2 on the keypad.



When performing a test, after pressing any red key on the keypad, strike the surface of the specimen as dictated by ASTM C215. Please note that the “normal” frequency range is intended for testing of all normal concrete specimens. The “high frequency” range is only intended for small rock core testing. If the test is successful, in 5 to 10 seconds the frequency spectrum of the measured response will be displayed, with the resonant frequency (Hz) displayed numerically on the left side of the screen. Just below the resonant frequency on the left side of the screen a quality number (Q=) will be displayed. The quality number is a measure of the quality of the data, 9 being the best. Tests with quality numbers below 4 should be repeated. If the quality number is repeatedly low, cable connections and contact between the sensor and specimen should be inspected. At the lower left side of the screen, the option to EXIT or SAVE is presented. Pressing ‘1’ (EXIT) will clear the last reading and display the main menu again. Pressing ‘2’ (SAVE) will save the data in memory,

including the displayed spectrum, and display to the user the current record number the data was saved under; press 1 to return to the main menu. If a time period of more than 3 seconds occurs between pressing a “fire” key and striking the specimen, the unit will not acquire the signal and display the message “No Signal, Retest.” If the specimen is struck too hard the specimen vibration will exceed the accelerometer’s range and the unit will display the message “High Signal, Retest.”



The unit is capable of storing up to 100 records, after which a ‘Memory Full’ message will appear and no more data will be saved. To save more records, the memory must be first cleared (see section on Data/Recall menu). The unit is now ready for the next test.

Backlight

The RT-1 has a built-in backlight for the display to allow operation in low-light conditions. Simply press in the 'Backlight' switch to activate. Note that the continuous use of the backlight will reduce the battery life by a few hours less than the typical 6-7 hour battery life of the RT-1.

Note: The RT-1 does not require a strong, hard hit to collect good-quality data. A light strike with the hammer allowed to rebound off of the surface is usually the best.

OPERATION NOTES AND HINTS

Display Messages

Several different messages may be displayed instead of the signal spectrum after a test if the test does not yield clear results. If the RT-1 does not receive good data the unit will not give a resonant frequency reading and will instead give a message to the user indicating why a reading was not obtained.

A message of “**No Signal, Retest, Press any Key**” indicates that the signal level seen by the accelerometer was insufficient. This will typically happen if the test is not performed within approximately 3 seconds of pressing a “fire” key. This error message may also occur if the specimen is not struck hard enough, the sensor is not in good contact with the specimen, or there is a poor cable connection between the sensor and acquisition unit.

A message of “**High Signal, Retest, Press any Key**” indicates that the signal level was too high. This is typical if the specimen is struck too hard and the measurement range of the accelerometer is exceeded. Retest by applying a lower level impact.

Hints

Torsional testing of small core or cylinder samples (diameter ≤ 2 inches) can be very difficult. We recommend performing the Longitudinal and Transverse testing first to eliminate possible Torsional frequencies. Then attach the accelerometer as securely as possible, we have had the best luck by removing the magnetic base from the accelerometer and holding the sensor on the sample with your thumb. Then use the high frequency hammer to strike the core/cylinder tangentially. The Torsional frequency should be different than the Transverse and Longitudinal frequencies. Make sure your results are repeatable and check the validity of the measurement by insuring that the dynamic Poisson's ratio calculated in the spreadsheet is of a reasonable value.

BATTERIES

The rechargeable batteries in the RT-1 should last 8 hours typically on one charge if the backlight is not used, or 6 hours if the backlight is used. To charge the batteries, simply plug the charger into a 110 VAC outlet (220 vac if ordered with that option) and plug the other end into the jack on the right side of the RT-1. Allow the unit to charge

10-12 hours (overnight) to fully recharge. Charging is best done at room temperatures to maximize battery life and to allow a full charge. Note that the unit can be used while charging, if desired, but that this will slow down the charge rate. The 'LOW BATTERY' light on the front of the unit will light up (or flash during tests) when there is about 30 minutes of operating time left on the batteries. Operating the unit after the low battery light is on continuously may result in erratic readings or error messages.

Battery Replacement

The batteries in the RT-1 will typically last for 500-1000 recharge cycles before reduced operating time from an overnight recharge is noticed. The battery pack in the RT-1 consists of 10 A-A sized batteries in a holder. If needed, they can be replaced by the user with new rechargeable batteries or with standard alkaline batteries. Battery replacement requires opening up the back of the RT-1 to expose the battery compartment, disconnecting the battery pack connector, and then replacing the batteries in the holder. After battery replacement, reconnect the battery connector and replace the battery pack into the space in the RT-1.

After replacing the top cover, replace the 6 screws removed to access the battery pack. If the new batteries are rechargeable, it will be necessary to charge the unit overnight before use, as rechargeable batteries normally come in a discharged state.

Caution: Do not attempt to recharge non-rechargeable batteries (such as alkaline cells), as damage to the unit or personal injury may result. Also, only replace the batteries with nickel (N.MH) rechargeable batteries or non-rechargeable alkaline cells. Do not use Li-Ion or other similar batteries, the use of those may result in damage to the unit or personal injury, as the charging system has not been designed for these batteries.

CALIBRATION

The RT-1 measures the resonant frequency of concrete specimens by measuring the vibratory response to an impulse load. Because the resonant frequency is related to how the relative amplitude of the response of the specimen changes with time and not the absolute amplitude of the vibration, no calibration is necessary.

GRAPHICAL SPECTRAL DISPLAY

The RT-1 test kit operates on the principles of impulse vibration testing. The resonant test method uses a sensor (accelerometer) to measure and record the waveform resulting from an impact to the surface of the specimen (which is free to vibrate). This time domain data (time versus amplitude) includes energy from the initial impact as well as energy from the free vibration of the specimen. By performing a Fast Fourier Transform (FFT) on the data (converting it to frequency versus amplitude), the

predominant frequency at which the specimen freely vibrates becomes clear and easy to see, appearing as an amplitude peak in the frequency versus amplitude (spectrum) plot. It is important to remember that the fundamental resonant frequency will correspond to the peak with greatest amplitude. It is also important to remember that each specimen will have multiple modes of vibration. See ASTM C215 for guidelines on how to excite and measure the three specified modes (transverse, longitudinal, and torsional).

The RT-1 includes a graphical display which presents the frequency spectrum of the data collected for each test in one of two selectable ranges. The automatically picked resonant frequency peak is noted on the display with a small cross. The fundamental resonant frequency is also numerically displayed on the left side of the screen (i.e. F=6099 Hz). The sharpness of this peak is reflected in the Q value displayed right under the thickness value.

There are several advantages to having the complete spectral display (rather than just the picked resonant frequency value). The most important are that the validity of the picked peak and the quality of data can be checked at the time of the test. In addition, the left/right cursors (arrow keys) can be used to measure the frequency of peaks other than the highest amplitude peak.

CARE AND MAINTENANCE

The RT-1 is a rugged unit designed for both laboratory and field site use, but it is not indestructible. Certain precautions should be taken to ensure the reliable operation of the unit.

1. Do not be expose to direct rain or other moisture.
2. Do not drop the RT-1, as damage may result.
3. Do not pick up the RT-1 or the accelerometer by the cable, as the cable and connector are not designed for this type of stress.
4. The display screen can be damaged by impacts, excessive pressure, or sharp objects.
5. Do not leave the power switch in the ON position once the batteries have been discharged unless the unit is being used with the external power supply/charger attached.
6. All cable connections should be kept clean and free of mud, dirt, dust, and moisture as all can interfere with the operation of the unit

7. While the unit and accelerometer will operate properly on wet concrete or even through a film of water, do not submerge the unit or accelerometer. If either piece of equipment falls into water, disconnect the cable, clean off any mud or dirt, and allow it to dry out as soon as possible.
8. The keypad is designed for finger operation. Do not operate the keypad with a sharp object (such as a pencil end) as this may pierce the keypad cover and damage it.

RECALLING DATA

To access the recall data function select the Data Transfer/Setup menu by pressing 2 at the main menu; then press 1 to select Recall Data. Next enter the data file number to be recalled and press “ENT” on the keypad. The RT-1 will display the spectrum graph, the fundamental resonant frequency and the quality number “Q”.

CLEARING DATA

To access the clear data function select the Data Transfer/Setup menu by pressing 2 at the main menu; then press 2 to select Clear Data. Next press 1 to erase all the data stored in the RT-1, or press any other key to cancel.

CLOCK SET/DISPLAY

The clock functions on the RT-1 are accessed from the “Data Transfer/Setup” selection (2) on the main menu. Next, select “Clock Set/Display” (3).

The currently set date and time will be displayed in the format:

‘Date = MM/DD/YY’
‘Time = HH:MM:SS’

If these settings are correct, simply select “Exit” (2) to return to the main menu. If the date or time needs to be set, press 1 to select the “Set Time/Date” option. After pressing 1, the screen asks for the date in the format MMDDYY, where MM is the current month, DD is the current date, and YY is the current year. After entering the digits requested (June 3, 2007 is entered as 060307), press ENT to enter the date and move to the time set. Enter the time in the format HHMM, where HH is the current hour (in 24 hour format) and MM is the current minute. Then press ENT to enter the time and return to the main menu.

DOWNLOADING DATA

The test results and test time/data from the RT-1 are saved automatically each time the user elects to save a record from the test results display screen. In addition, the time domain waveform data for the current test is also saved.

The test result which are saved by the unit for each test include the test number (displayed upon saving), the measured fundamental resonant frequency, the Q value, the mode (0 is normal, 1 is high frequency mode), and the time and date of the test. These parameters are downloaded in ASCII format into a tabular format file which can be easily read in by Excel or other spreadsheet programs.

To download the data, the user must first install and run the RT-1 download software on a Windows-based PC (WIN 95/98/2000/XP) with a free serial (COM) port. The software is capable of using COM1-COM4 for download.

To install the download software, first insert the software CD in to a CD drive. Using Explorer, or other file display software, open the CD directory and double click (execute) the SETUP file. Follow the instructions on-screen to install the software and select the location for the shortcut on the START menu. If a single computer is to be used often for downloading, it may be useful to create a shortcut on the desktop to the download software as well. Please note for certain computers, there have been reports of errors in registering certain files during loading. If this occurs, simply choose 'Ignore' and continue on. The software in all cases has loaded correctly. After the completion of software loading, the normal location for the shortcut is under the START menu, PROGRAMS, RT-1 DOWNLOAD. Open this menu item to access the download software shortcut. Drag this shortcut out into the desktop to create an easily-accessible icon.

Executing the download software will open up the main download dialog box. The box shows the pre-selected default file names, as well as the various options for use.

DOWNLOAD DIALOG BOX FUNCTIONS

Results File Name Display and Selection

The download software allows the user to select a file name and location for the downloaded ASCII results data ("Select Results File" button) and shows the currently selected results file name and location. This is the only file name options applicable to the RT-1 systems. Please note that if an existing file name and directory is selected as the download target, or if the default file name and directory is used all the time, the download software WILL OVERWRITE any data currently in that file.

Select Port

The Select Port option allows the user to select which COM port to use for the data download. Note that up to 6 COM ports can be displayed, but that only valid ports which are currently NOT IN USE will be displayed for possible selection. If no valid ports are found, a message is printed in a message box at the lower left corner of the screen. If this occurs, then either a serial port needs to be freed up from it's current use (such as running an external modem or mouse), or additional COM ports must be installed or turned on. Note that most motherboards allow the activation or deactivation of the COM ports in the CMOS

setup mode. If one or more serial ports have been turned off, they will not be usable until turned on again.

If more than one valid COM port is shown on the screen, select the port that will be used for the download. Note that one of the most common problems in downloading data is the selection of a different COM port in the software than the one to which the download cable is connected.

Clear RT-1

The Clear RT-1 button is used to ERASE all data currently stored in the RT-1, if it is in DOWNLOAD mode. Pressing this button will bring up a confirmation message, asking the user to click one more time, and then will erase all stored data in the RT-1 connected to the COM port. **Please be careful with this function, as the data cannot be recovered once erased.**

Download RT-1 and Status Window

The Download RT-1 button is used to download the data from the RT-1. Do not click on this button until the desired data file names and directories for the results and the time data (as applicable) have been set. Also, this button should be clicked only AFTER the RT-1 is in the DOWNLOAD mode, as described below. When data is being downloaded, the current file number being sent is displayed in the status window located directly under the Download RT-1 button. The status window then allows the user to monitor the progress of the download operation.

OK and Cancel Buttons

Both of these buttons can be used to exit the program. At this time, there is no difference in function between them.

DOWNLOADING PROCEDURE

The step-by-step procedure is as follows:

1. Connect the RT-1 to a PC serial port via the download cable supplied with the unit.
2. Start the download software.
3. Select the correct COM port
4. Select the desired file name and directory for the ASCII results data file.
5. Set the file download base name and directory for time domain file downloads.
6. Turn on the RT-1 unit.
7. On the RT-1, press '2' to enter the Data Transfer/Setup menu, then press '4' to select Download. The number of saved results will appear on the screen and the RT-1 is now in DOWNLOAD mode.
8. Click on the 'Download RT-1' button on the software. Note: you have about 25 seconds to click

on the 'Download RT-1' button after the selection of Download on the RT-1 Data Transfer/Setup menu (while the RT-1 is displaying the number of saved records). If no action is taken within 25 seconds, the RT-1 will exit DOWNLOAD mode and will go back to the main menu. To download data, simply start again by pressing '2', then '4' when ready.

After clicking the 'Download RT-1' button, the download process will begin. At the end of a successful download, the status window will show the total number of records downloaded. Click on 'OK' to exit.

DOWNLOAD TROUBLESHOOTING

If problems are experienced in downloading, the most likely cause is a problem in the serial connection between the computer and the RT-1 unit. If the download software runs, but no data appears to be downloading (the counter does not increment), check the following:

1. Be sure the RT-1 unit is in DOWNLOAD mode, as described in the download procedure above, prior to clicking on "Download RT-1".
2. Be sure that there are saved records in the RT-1 (Number of saved records is greater than 0).
3. Check the connection between the RT-1 unit and the serial port - is the serial port active, is the connection sound, is the connector plugged into the correct port?

4. Verify the battery condition on the RT-1 unit - is the low battery light on

RT-1 RESULTS FILE

The RT-1 results file is an ASCII file with data arranged in columns. The column format is as follows:

1. Test Number
2. Measured Fundamental Resonant Frequency (Hz)
3. Q Value (1-9)
4. Range Selected (0 = normal, 1 = high frequency)
5. Date of Test (MM/DD/YY)
6. Time of Test (HH:MM:SS)

The columns of information are separated by spaces, so when importing the data into a spreadsheet, be sure to click on the "spaces as delimiters" box, or otherwise tell the spreadsheet program to split up the data based on the location of spaces.

ASTM C215 CALCULATION SPREADSHEET

Along with the download software you will find an Excel calculation spreadsheet on the software CD. The calculations suggested in ASTM C215 for both cylinders and prisms are programmed into the spreadsheet. Two versions of the spreadsheet, one in English units and one in SI units are provided. Because the ASTM standard uses SI

units, in the English unit spreadsheet the user entered parameters are converted to SI units before the calculations are completed and the resulting values are provided in both SI and English units.

The spreadsheet has five tabs. The first two tabs are the calculation worksheets for prisms and cylinders. The following two tabs are laboratory worksheets for prisms and cylinders and are intended to be printed out to aid in data recording during testing. The final tab is a look-up table for the T-correction factor for the calculation tabs and should not be altered. Although the spreadsheet is preprogrammed, **it will allow any user to change any cell**, including the calculations. Therefore, care should be taken not to accidentally change any calculation cell.

As noted in the spreadsheet, columns with yellow headings must be entered by the user, while columns with green headings will be automatically calculated. As of yet, there is no easy way to incorporate the RT-1 results file into the calculation spreadsheet, therefore manual entering of some data will be required.

For more information on ASTM standards C215 and C666, please reference www.astm.com

Resource Material -

Resonant Frequency Test Kit Warranty

Olson Instruments, Inc. Warranties purchased equipment that it manufactures directly against manufacturing defects from one year of the date of purchase. We will provide free loaners if the equipment must be shipped back for repairs, but all shipping, insurance, and duty costs for a loaner system will be the responsibility of the purchaser to and from our office. We will provide loaner system components free of charge while repairs are being made to instruments within the warranty period, but the customer is responsible for freight and insurance for shipping their system to our office to be repaired and return shipping freight. The warranty information and period stated above represent our only obligation to the purchaser and its assigns. The one year warranty by Olson Instruments, Inc. will not cover equipment abuse or improper use. They cover manufacturing defects and equipment failure in the first year of equipment ownership by the purchaser. Other manufacturer's warranties extended to the purchaser are subject to the limitations presented in their warranties.

