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Dual-Cell Ultrasonic Cement Analyzer

Part No. 120-52

Instruction Manual

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Ver. 1.08

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Table of Contents

Intro **2**

Description **2**

Features **2**

Specifications **3**

Components **3**

Setup **4**

UCA *4*

Software *4*

Operation **6**

Temperature Controller *6*

Alarms *9*

Preparing the Test Cell *9*

Performing the Test *12*

Removing the Test Cell *15*

Maintenance **18**

Calibration *19*

Appendix **20**

Diagram *20*

Intro

By measuring the change in velocity of an acoustic signal, the Ultrasonic Cement Analyzer provides a continuous non-destructive method of determining compressive strength as a function of time.

Description

The cement slurry to be tested is placed in an autoclave unit with temperature and pressure adjusted to simulate downhole conditions. An acoustic signal is then transmitted through the cement sample. As the strength of the cement increases over time, the acoustic signal travels faster through the sample.

A computer running customized Windows® software measures the transit times of the signal over time and interpolates the compressive strength values. This data is available in real time onscreen and is also stored in an Excel® spreadsheet for easy graphical viewing and printing.

The dual-cell UCA consists of two single-cell UCA units in a single enclosure. Both units share electrical power; air, water, and drain plumbing; and PC to UCA connectivity. All other systems (heating, pressurization, etc.) are completely separate.

Features

- Cement samples are not destroyed
- Additional autoclaves are available
- Programmable temperature control (up to 400°F or 204.4°C)
- Regulator and back pressure regulator provide extensive pressure control (up to 16,000 PSI or 110,400 kPa)
- Data is available instantly onscreen and is automatically converted to Excel® spreadsheet format

Specifications

- Size: 15" × 40" × 18" (38 × 122 × 45.8 cm)
- Weight: 170 lbs (78 kg)
- Air Supply - 100 PSI (690 kPa) Recommended; 150 PSI (1,035 kPa) Maximum; ¼" NPT Connector
- Water Supply - standard tap water; ¼" NPT Connector
- 120V/220 V, 50/60 Hz Power
- Computer: Windows XP or higher, RS-232 Serial Port (or Serial to USB Adapter), Minimum Screen Resolution: 1280 × 720

Components

Packing List:

#120-00-001	Sonalert; Qty: 2
#120-25-059	Contactor; Qty: 2
#120-50-TR	Transducer; Set of 2; Qty: 2
#120-50-001	Circuit Board
#120-51-001	Temperature Controller, Eurotherm Model 2408 P4; Qty: 2
#120-104	Rupture Disk; 17,500 PSI (121 MPa); Qty: 2
#120-910-061	Union Elbow; ¼" Tube; Qty: 4
#123-011	O-ring for Test Cell; Qty: 4
#123-023	Low-Temperature Acoustic Couplant; 250°F (121.1°C)
#123-024	High-Temperature Acoustic Couplant; 600°F (315.5°C)
#130-75-71	17" Monitor
#130-75-74	Desktop Computer
#130-76-11	Terminal; Qty: 14
#130-77-025	Leveling Leg; Qty: 4
#130-77-054	⅛" Male Elbow; Qty: 6
#130-78-045	Male Connector; ¼" Tube OD × ¼"; Qty: 7
#130-78-046	Stainless Steel Swagelok Tube Fitting; Male Connector; ¼" Tube OD × ⅜" Male NPT; Qty: 2
#130-79-14	Printer
#130-79-14-1	USB 2.0 Cable; A/B; 10'
#130-79-15	Serial Cable; OB9; M/F
#130-79-26	3-Pin Female Connector; Qty: 4
#130-79-27	3-Pin Male Connector; Qty: 4
#150-80-074	Quick-Connect Stem
#152-38	AC Power Cord; 3-Conductor; International (Continental European); Qty: 3
#171-48-3	Plug Receptacle; Qty: 2
#172-24	Solid State Relay; 240V-25A

Optional:

#120-52-SP	**Spare Parts for #120-52:**
#122-004	Thermocouple Assembly; Qty: 2
#122-010	Heater Assembly; Qty: 2
#122-053	Rupture Disk 22,500 PSI (155 MPa); Qty: 4
#122-073	2-Amp Fuse; 5 mm × 20 mm; Qty: 8
#122-077	10-Amp Fuse; 5 mm × 20 mm; Qty: 8
#123-011	Test Cell O-ring; Qty: 160
#123-023	Low-Temperature Acoustic Couplant; 250°F (121.1°C); Qty: 6
#123-024	High-Temperature Acoustic Couplant; 600°F (315.5°C); Qty: 4

Setup
UCA

1. Begin by making sure all switches are off and all pressure knobs are turned completely counter-clockwise.

2. Connect the **AIR**, **WATER**, and **DRAIN** connectors on the back of the unit to their appropriate source and plug in the power cord to a grounded, 230-volt power source.

3. Turn the “Main” switch on.

Setup
Software

Before you begin your test, you must prepare the PC to record the data.

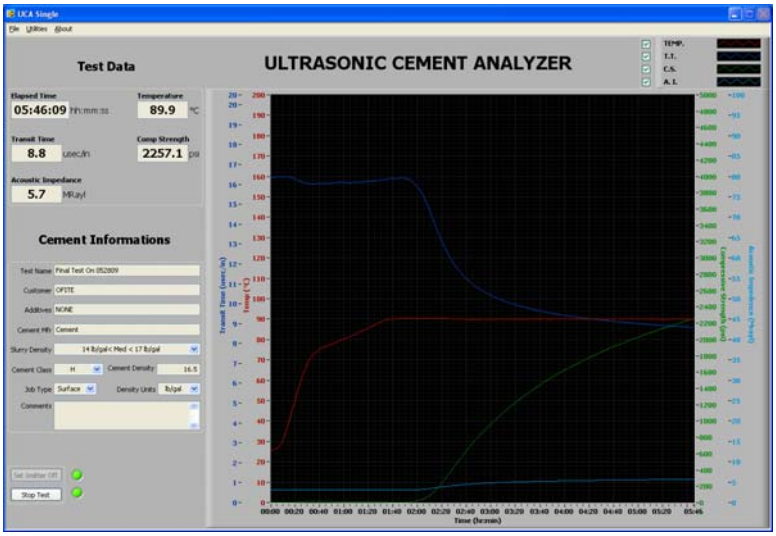
1. Connect the PC to the unit with the serial cable (supplied) and turn the PC on.

2. Open the “OFITE UCA” software by double-clicking the icon on the desktop.

3. The main screen of the software shows a graph of the temperature, transit time, compressive strength, and acoustic impedance with respect to time. To the left of the graph, the current value for each of these variables is displayed. Underneath the current test data is the user-defined information about the test.

   Before a test is started, some of the fields in the Test Data area will read “NaN”. This means that there is no data available yet. Once a test is started, if the field still reads “NaN”, check the connections to the transducers, thermocouple, and PC. If the problem remains, contact OFITE for further help.

   The checkboxes in the Legend in the upper right-hand corner of the screen control which lines display on the graph. To remove a line from the graph, uncheck the box next to it.



4. From the “Utilities” menu, click “Setup”:

   “UCA COM Port” - The PC supplied with the unit has been pre-configured to use COM1.

   “Temp Unit” - Select °F or °C

   “CS Unit” - Compressive Strength Units: Select PSI or kPa

   “Archive Path” - Choose a location to save the data files. After a test is complete, a graph of the test and the raw data files will be stored in this folder.

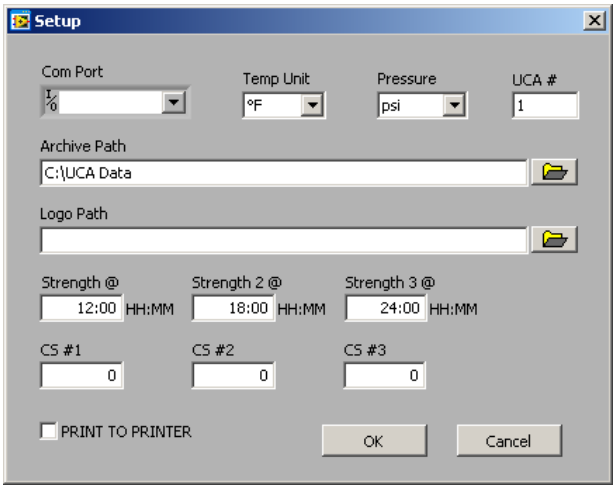
   “CS #1”, “CS #2”, “CS #3” - Enter a compressive strength value in each of these fields. When the cement reaches that compressive strength, the software will record the elapsed time and print it on the graph.

   “Print to Printer” - When this option is selected, a graph of the test results will automatically print to the default printer when a test is complete.

5. Before starting a test, select “Load Cell Infos” from the “Utilities” menu. Enter the necessary information and click “OK”.

Note

This information is for reference only. It will print on the graph at the end of the test. It will not affect the test itself.



Operation

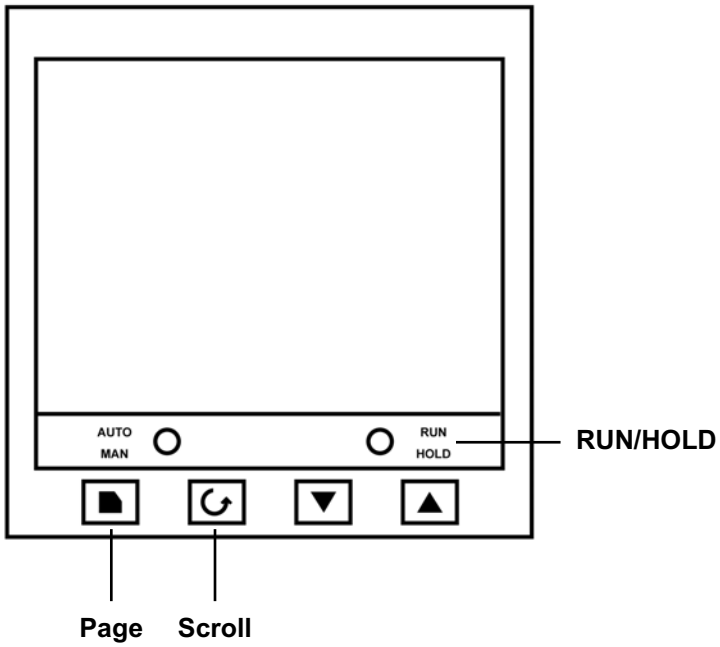
Temperature Controller

The Eurotherm temperature controller allows you to program a temperature profile for your test. This profile will be divided into at least two segments. Each segment represents either a change in temperature or a period of time to hold the current temperature.

The four buttons along the bottom of the display provide access to the temperature controller settings. Begin by pressing the “PAGE” button three times. The display will read "Prog List". Now, press the “SCROLL” key repeatedly until the setting you wish to change is shown on the display. Then press either arrow key until the appropriate value is displayed. Once you've chosen a value, press the “SCROLL” key again to select a new setting.

For more information, refer to the Eurotherm instruction manual.

Temperature Controller



The first group of settings should read as follows:

Setting	Value
Prg1	1
Hb	OFF
Hb.u	0.0
Rmp.u	min
Dwl.u	min
Cyc.n	1

Important

These settings will be the same for every test. Do not change them.

1. Begin by defining the first segment of the test.

    a. Press the “SCROLL” key repeatedly until “Seg” appears on the display.

    b. Press either arrow key repeatedly until “1” appears on the display. You are now editing segment 1.

2. The first setting is “Type”.

    a. Press the “SCROLL” key until the word “Type” appears on the display.

    b. The available options are “rmp.r”, “rmp.t”, or “dwell”. Press either arrow key until the appropriate value appears on the display.

    Rmp.r programs the controller to steadily increase the temperature by a specified rate (degrees per minute). If you choose this value, your next option will be “Tgt”, which is your target temperature and then “Rate” which is the rate you want the temperature to increase.

    Rmp.t increases the temperature over a specified time interval (minutes). If you choose this value, your next option will be “Tgt” (target temperature) and then “Dur” (duration in minutes).

    Dwell holds the temperature at its current setting for a specified length of time. If you choose this value, your next option will be “Dur” (duration in minutes).

3. Now define the second segment.

    a. Press the “SCROLL” key until “Seg” appears on the display.

    b. Press either arrow key until “2” appears on the display. You are now editing segment 2.

4. Continue this process with each segment in the test.

5. When you reach the last segment, set the “Type” to “end”. The next setting will be “End.t”.

    If you choose “**sop**”, the heat will be turned off and the test ended.

    If you choose “**dwell**”, the heat will be held at the current temperature indefinitely.

Example 1:
Heat the sample at 2.5° per minute and stop at 150°. Hold at 150° for 180 minutes and then stop the heat.

Setting	Value	Description
Prg	1	
Hb	OFF	
Hb.u	0.0	
Rmp.u	min	
Dwl.u	min	
Cyc.n	1	
Seg	1	Segment 1
Type	rmp.r	Increase temperature at a specified rate
Tgt	150	Heat to 150°
Rate	2.5	Increase temperature at 2.5° per minute
Seg	2	Segment 2
Type	dwell	Hold on the current temperature
Dur	180	Hold for 180 minutes
Seg	3	Segment 3
Type	end	This is the last segment
End.t	sop	Stop the heat

Example 2:
Heat the sample to 200° over a period of 90 minutes. Then increase the temperature to 300° at a rate of 3° per minute. Hold that temperature until the unit is turned off.

Prg	1	
Hb	OFF	
Hb.u	0.0	
Rmp.u	min	
Dwl.u	min	
Cyc.n	1	
Seg	1	Segment 1
Type	rmp.t	Increase temperature for a specified time
Tgt	200	Heat to 200°
Dur	90	Increase temperature for 90 minutes
Seg	2	Segment 2
Type	rmp.r	Increase temperature at a specified rate
Tgt	300	Heat to 300°
Rate	3	Increase temperature at 3° per minute
Seg	3	Segment 3
Type	end	This is the last segment
End.t	dwell	Hold at the current temperature indefinitely

Operation

Alarms

The Ultrasonic Cement Analyzer is designed to protect itself from a heating malfunction. If the temperature of the unit reaches a critical level, the internal alarm automatically turns off the heat and the pump. Two switches on the front control panel determine how the operator is notified of an alarm.

If the **"Sonalert"** switch is turned on, an audible alarm will sound. If the red **"Alarm"** switch is turned on, a light behind the switch will blink. These two alarms can be activated independent of each other.

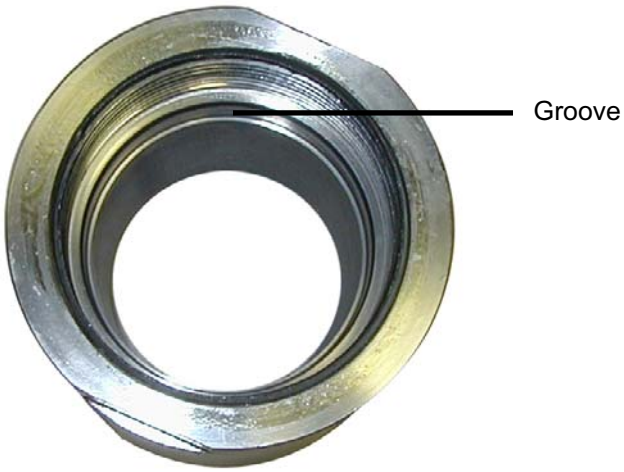
If both alarm switches are off, an alarm condition can still be triggered. However, there will be no warning to indicate the alarm. It is highly recommended that at least one alarm notification is turned on at all times.

Operation

Preparing the Test Cell

For a complete diagram of the test cell, refer to page 20.

1. With both cell caps removed, examine the inside of the test cell from both ends. Below each set of threads is a small groove. The end with the smaller groove is the bottom of the test cell. Some cells have a label on the outside that indicates which end is the top.



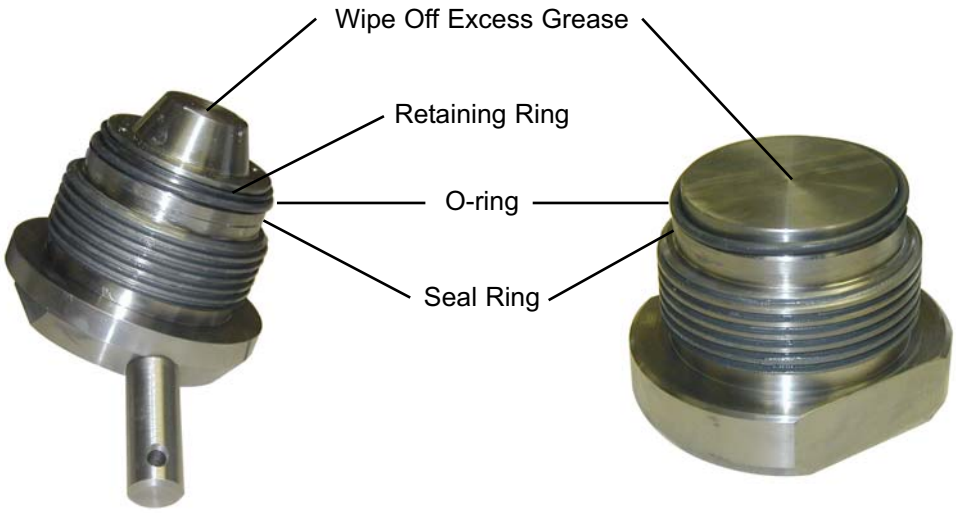
2. Place a metal seal ring onto the bottom cell cap with an o-ring on top of it. The narrow side of the metal seal ring (see diagram of cross-section) should point away from the o-ring.

Metal Seal Ring
(Cross Section)

3. Place an o-ring on the top cell cap between the metal seal ring and the retaining ring.

Note

You should not need to remove the retaining ring and metal seal ring from the top cell cap. However, if you do, be sure to place the metal seal ring back in the same orientation. The narrow end (see cross-section) should point toward the handles at the top of the test cell.



Top Cell Cap

Bottom Cell Cap

4. Apply high-temperature grease to all internal surfaces of the test cell, including the threads. This will lubricate the threads and help prevent the cement from sticking to the sides of the cell.

Tip

Leave only a thin layer of grease on the inside surfaces of the two cell caps. Excess grease will interfere with the transducer signal.

5. Carefully screw the bottom cell cap onto the test cell and tighten it hand tight. The cell cap should turn smoothly in the test cell threads. If you encounter resistance, stop turning and unscrew the cap slightly. Then continue turning until the cap is completely tightened.

6. Turn the test cell over and begin filling it with the cement slurry. Place the fill gauge against the inside of the test cell. Fill the cell until the cement barely touches the bottom of the measuring tool.

Important

It is important that you begin the test no more than 20 minutes after adding the cement slurry to the test cell.

7. Carefully screw the top cell cap into the test cell, just as you did with the bottom cell cap.

8. Make sure the transducers and the transducer holes in the cell caps are clean and free of debris. If they are not, they can be cleaned with a rag or paper towel. You can also use alcohol if further cleaning is necessary.

Transducer

Transducer Hole

9. Apply a thin coat of an acoustic couplant to the two transducers.

Note

Two types of acoustic couplant are provided to you. The low-temperature gel should be used for temperatures up to 260°F (126.7°C). The high-temperature gel is suitable for higher temperatures. Carefully read the label before using either of these gels.

Operation

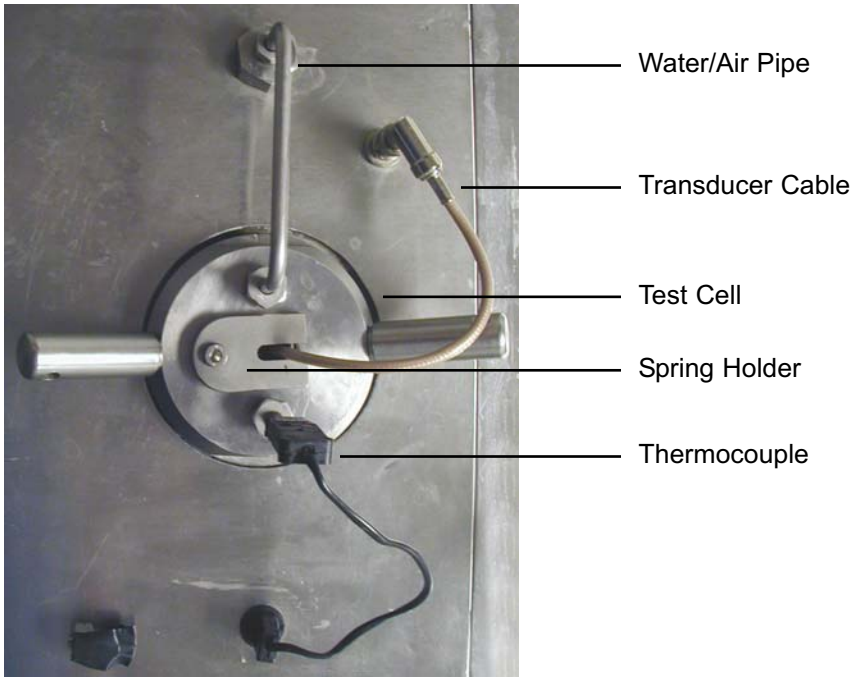
Performing the Test

1. Carefully place the cell into the heating jacket. Make sure the bottom transducer is inside the hole in the cell cap before lowering the cell.

2. Connect the water/air pipe to the test cell.

3. Attach the thermocouple to the test cell and hand tighten.

4. Plug the transducer cable into the receptacle on the unit and place the transducer head into the hole in the cell cap. Place the spring holder over the transducer spring and secure it in place with the supplied screw.



5. Make sure the pressure release valve is closed by turning it completely clockwise. Open both the Regulator and the Back Pressure Regulator by turning them completely counter-clockwise.

6. Have a 5/8" wrench handy and open the water valve. When water starts coming out of the top cell cap, tighten the thermocouple. This will allow any air inside the test cell to escape before the test begins.

   You may hear water circulating through the system. This means the Back Pressure Regulator is open too much and pressure is venting from the cell. Close the Back Pressure Regulator slightly by turning it clockwise. The sound will stop and enough pressure will build in the cell to purge the air.

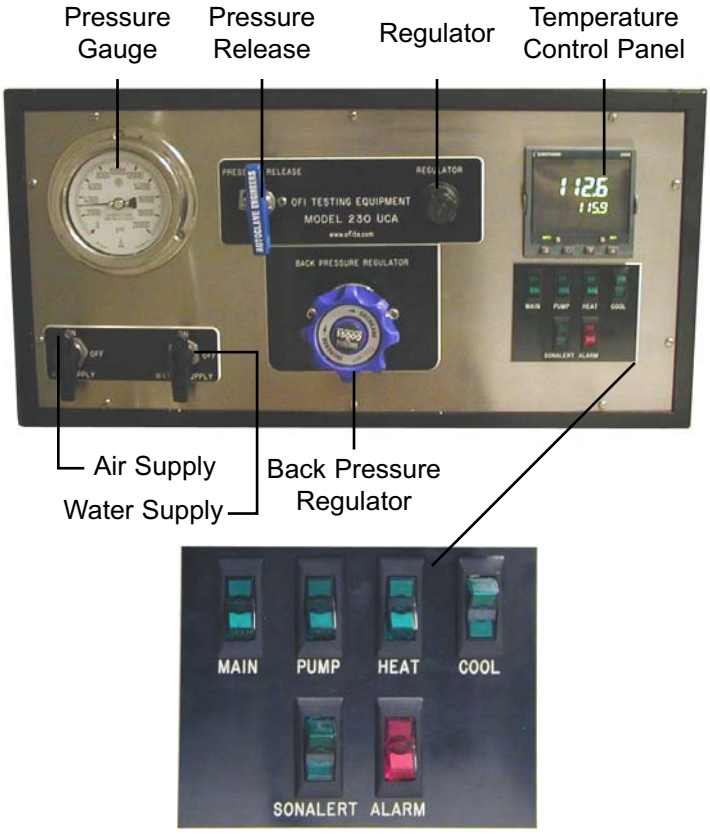
Note

7. Open the air valve and turn on the pump.

8. Turn the regulator clockwise to increase the pressure within the test cell. If the pressure does not build, turn the back pressure regulator clockwise. Allow the pressure to build slightly higher than necessary for your test. Then, turn the back pressure regulator counter-clockwise slowly to lower the pressure.

   The regulator allows pressure to enter the test cell. If the pressure falls too low, the regulator engages to bring it back up. Turning the regulator clockwise increases the amount of pressure allowed into the test cell. The back pressure regulator allows pressure to leave the test cell. If the pressure builds up too much (due to thermal expansion), the back pressure regulator bleeds off the excess. Turning the back pressure regulator counter-clockwise increases the amount of pressure allowed to leave the test cell.

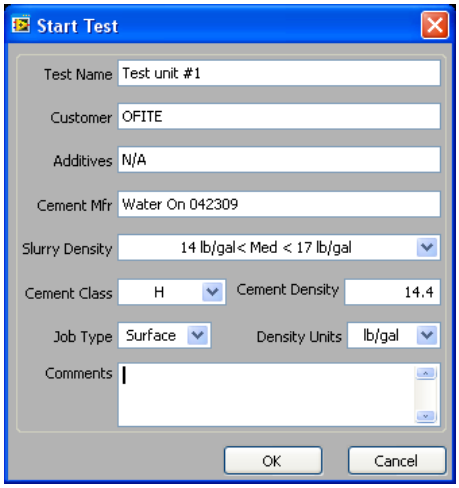
   Correctly setting the regulator and back pressure regulator is a trial and error process. Always start with the back pressure regulator closed (clockwise) and use the regulator to increase the pressure higher than you need. Then, slowly open the back pressure regulator (counterclockwise) until the pressure drops to the desired level.



9. Turn on the heat.

10. Push and hold the “RUN/HOLD” button on the temperature controller until you see the word “RUN” on the display.

11. Once the test cell is in the unit and ready, click “Start Test” button on the main screen in the UCA software. You will have one more opportunity to enter any test information before the test begins. When ready, click “OK”.



After 30 seconds, the graph will start showing data. The “Elapsed Time”, “Temperature”, “Transit Time”, and “Compressive Strength” fields will begin to display readings immediately.

“Elapsed Time” - Time since the test began (HH:MM:SS)

“Temperature” - Temperature within the test cell. (°F or °C, depending on the temperature controller on the UCA unit)

“Transit Time” - Time required for the sound wave to travel through the sample (microseconds/inch)

Important

Solid particles and air bubbles within the cement slurry can adversely affect the results of your test. The first Transit Time reading should be at least 10 µs. If it is less than 10 µs, wait a few minutes to see if the problem corrects itself. When you see a Transit Time greater than 10 µs, restart the test by clicking the “Stop Test” button and then clicking the “Start Test” button again. If the problem does not self-correct, you will need to remix your slurry and start the test again. To avoid this problem, carefully follow the mixing procedure in API Specification 10.

“Compressive Strength” - Calculated compressive strength of the sample (PSI or MPa)

“Acoustic Impedance” - Calculated acoustic impedance of the sample. Mostly used for well logging.

12. Once a test is started, the software cannot be closed. To close the software, click “Stop Test” first to stop any tests that are still running. Then select “Exit” from the “File” menu.

Operation

Removing the Test Cell

1. When the test is complete, click the “Stop Test” button. The data file and graph will be saved automatically in the folder specified on the “Setup” screen.

2. Push the “Run/Hold” button on the controller and hold it until both lights are off.

3. Turn the “Heat” switch off.

4. Turn the “Cool” switch on and allow the test cell to cool completely.

5. When the cell has cooled, turn the “Pump” and the “Cool” switches off.

6. Turn off both the water and air valves.

7. Open the pressure release valve by slowly turning it counter-clockwise.

8. Remove the thermocouple, pipe, and transducer from the test cell. Leave the thermocouple plugged into the receptacle on the UCA unit.

9. Remove the test cell from the heating jacket.

10. Remove both cell caps and pour off any excess water.

☑ **Tip**

The cell caps may be too tight to remove by hand. To remove the top cell cap, place the test cell in a vise. Use the grooves on the test cell cylinder to anchor the vise. To remove the bottom cell cap, place the cell back in the vise. This time use the grooves on the cell cap. Then use a strap wrench to turn the cell and remove it from the cell cap.

To remove top cap

To remove bottom cap

If the test cell will not turn, remove it from the vise and tap on the bottom cell cap with a hammer to loosen the cement inside. Then return the cell to the vise and try again.

11. With the bottom cell cap off, remove the o-ring and seal ring from inside the cell.

12. To remove the cement from the cell, it will be necessary to repressurize the cell with the bottom cap off. This will force the cement out of the cell.

    a. Screw the top cell cap back onto the top of the test cell.

    b. Screw the plug into one of the holes in the cell cap. Screw the test cell adapter into the other hole.

Note

The holes in the top of the cell cap are interchangeable.

    c. Screw the UCA adapter into the top of the unit casing.

    d. Attach the supplied air hose to the two quick-connect fittings.

    e. Close the pressure release by turning the valve clockwise. Then open the water and air valves.

    f. Place the test cell in bucket or other container.

    g. Turn on the pump.

Tip

The cement block may be propelled out of the test cell with great force, causing serious injury and damage. Be sure to always point the test cell away from people or equipment.

Make sure the thermocouple is plugged into the unit. The pump will not function if the thermocouple is not plugged in.

Important

If the pressure does not begin building, close the Back Pressure Regulator by turning the valve clockwise.

h. When you hear the block of cement pop out of the test cell, turn off the pump and close the water and air valves.

i. Open the pressure release by turning the valve counter-clockwise.

j. Disconnect the air hose and remove all of the fittings.

k. Remove the cell cap and thoroughly clean the test cell.

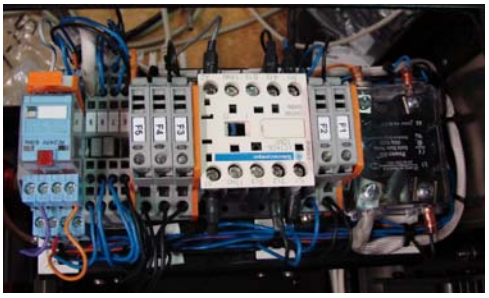
Maintenance

1. After every test, completely disassemble the test cell and thoroughly clean all surfaces, including the metal seal ring and the metal retaining ring, with soap and water. Any cement left on the test cell will harden and could damage the equipment.

2. Before every test, inspect the o-rings, seal rings, and retaining ring for damage or wear. O-rings should not be cracked, split, or brittle. The seal rings and retaining ring should not be bent or dented. Replace any damaged pieces before beginning a new test.

3. Ensure that the transducer holes in both cell caps are clean and free of debris. Also, be sure to clean the bottom surface of the transducers. This will help ensure a strong signal with minimal interference during a test.

4. The UCA has five fuses inside the unit cabinet. To access them, remove the top panel.



To replace a fuse, pull the fuse housing towards the front of the UCA. Then open the door on the side of the housing and remove the blown fuse. Place a new fuse into the housing, close the door, and push the housing back into place.

The fuses are labeled F1 - F5. The amperage and function are listed below:

F1:	10 Amp	Main Power
F2:	10 Amp	Main Power
F3:	2 Amp	Fan
F4:	6 Amp	Heater
F5:	2 Amp	Pump and Cooling Solenoid

Appendix

Calibration

Note

Your UCA unit has been calibrated at the factory, and should not need to be calibrated again. However, if any part of the test cell, transducers, control card, or software are changed, or if you suspect your readings are inaccurate, a calibration will be necessary.

1. Begin by filling the test cell with distilled water and placing it in the unit as described in the “Preparing the Test Cell” section on page 9.

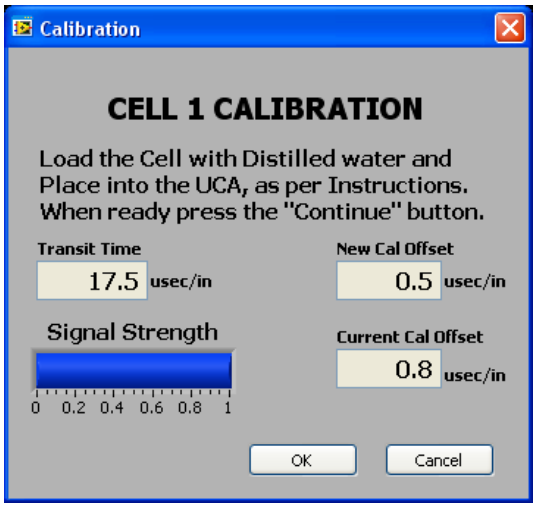
   The water used for calibration must be at 70°F (21.1°C).

2. Click the “Set Xmitter On” button.

3. Select “Calibrate Cell” from the “Utilities” menu.

4. The transit time should be about 18. If it is not, the unit will have to be serviced by an OFITE technician. If the transit time is close to 18, click “OK” to save the calibration and continue.

5. Click the “Set Xmitter Off” button to turn off the transmitter.



Appendix

Diagram