

Triaxial Test Systems  
for  
UU-CU-CD Tests



**SOIL**

## Triaxial Test Systems for UU-CU-CD Tests



### PRODUCT MODEL

S4700	Triaxial Test System for UU Test, 220-240 V 50/60 Hz
S4705	Triaxial Test System for UU, CU, CD Test, 220-240 V 50/60 Hz
S4630/01	Multi Speed Electromechanic Load Frame, 220-240 V 50/60 Hz
G345/S5	Load Cell, 5 kN
S4710	Triaxial Cell for 38 and 50 mm Samples
S4712	Triaxial Cell for 70 and 100 mm Samples
S4714	Oil and Water Constant Pressure System
S4715	Block for Pressure Measurement and De-Airing
G360	Pressure Transducer - 2000 kPa
S4716	Automatic Volume Change Unit
S4717	De-Airing Water Tank, 7 L. and Hose
G285/4	Data Logger, 4 Channel Data Acquisition Unit
S4708	TCM Readout Unit Featuring Software to Perform UU Triaxial Tests
S4709	TCM Readout Unit Featuring Software to Perform CU, CD Triaxial Tests

### PRODUCT STANDARDS

Standards	ASTM D2850, D4767, D7181   AASHTO T-297   BS 1377-7, BS 1377-8
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## Triaxial Test Systems for UU-CU-CD Tests

### DESCRIPTION

#### UNCONSOLIDATED UNDRAINED (UU) TEST

The soil is set to be in unconsolidated state, only when the volume of soil remains the same without the air replacement. This soil is loose in the natural state. In case of undrained conditions, the pore water is not allowed to drain out of soil. The undrained and unconsolidated conditions is maintained during the triaxial test. Triaxial test is usually done in a small cell, where the sample is placed in the cylinder whose length to the diameter ratio is 2. In total, three number of principal stresses are applied to soil sample. One is axial stress plus the confining stress. Other two principal stresses are equal, as it is the pressure applied to the soil through water confining all over the sides.

There is a rubber sheath which is completely sealed at top and bottom, acting as an impermeable membrane. Pressure transducers are made to measure the pore pressure of the specimen.

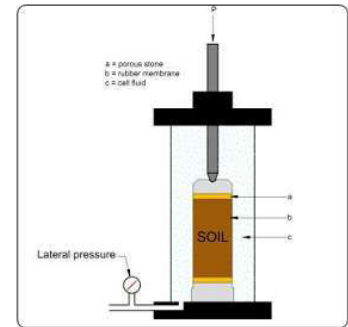
This test is performed in two stages as below.

**Stage 1:** The vertical stress which is applied, forms the major principal stress. The perpendicular confining pressure forms the minor principal stress.

**Stage 2:** The axial deviator stress is applied to the sample, which brings shear stresses. This deviator stress is applied along axial direction till the failure happens in soil. Limiting shear stress value in which the soil fails along a plane is called as shear strength of soil.

#### **S4700 Triaxial Test System for UU Test supplied complete with:**

- Multi Speed Electromechanic Load Frame (S4630/01)
- Load Cell, 5 kN (G345/S5)
- Triaxial Cell for 38 and 50 mm Samples (S4710)
- Triaxial Cell for 70 and 100 mm Samples (S4712)
- Block for Pressure Measurement and De-Airing (S4715)
- Pressure Transducer - 2000 kPa (G360)
- Oil and Water Constant Pressure System (S4714)
- De-Airing Water Tank, 7 L. and Hose (S4717)
- TCM Readout Unit Featuring Software to Perform UU Triaxial Tests (S4708)



## Triaxial Test Systems for UU-CU-CD Tests



### CONSOLIDATED UNDRAINED (CU) TEST

Peak effective strength parameters ( $c'$  and  $\phi'$ ) may be determined either from the results of consolidated undrained (CU) triaxial compression tests with pore pressure measurement, or from consolidated drained (CD) triaxial compression tests. The consolidated undrained/ drained triaxial compression tests are normally performed in several stages, involving the successive saturation, consolidation and shearing of each of three specimens.

Saturation is carried out in order to ensure that the pore fluid in the specimen does not contain free air. Saturation is normally carried out by leaving the specimens to swell against an elevated back pressure. Back pressure (which is simply an imposed pore pressure) is applied through a volume change gauge to the top of the specimen, while a cell pressure of slightly higher value is also applied. Both cell pressure and back pressure are normally increased in increments, allowing time for equalization at each stage. The degree of saturation can be expressed in terms of Skempton's pore pressure parameter.

$$B = \frac{\Delta u}{\Delta \sigma_3}$$

where  $\Delta u$  is equal to change in pore pressure for an applied cell pressure change of  $\Delta \sigma_3$ . For an ideally saturated soil  $B$  is equal to unity. It is recommended by several standard test methods that a value of  $B$  greater than, or equal to, 0.95 must be achieved before the specimen may be considered as fully saturated and the consolidation stage started. The consolidation stage of an effective stress triaxial test is carried out for two reasons. First, three specimens are tested and consolidated at three different effective pressures, in order to give specimens of different strengths which will produce widely spaced effective stress Mohr circles. Secondly, the results of consolidation are used to determine the minimum time to failure in the shear stage.

The effective consolidation pressures (i.e. cell pressure minus back pressure) will normally be increased by a factor

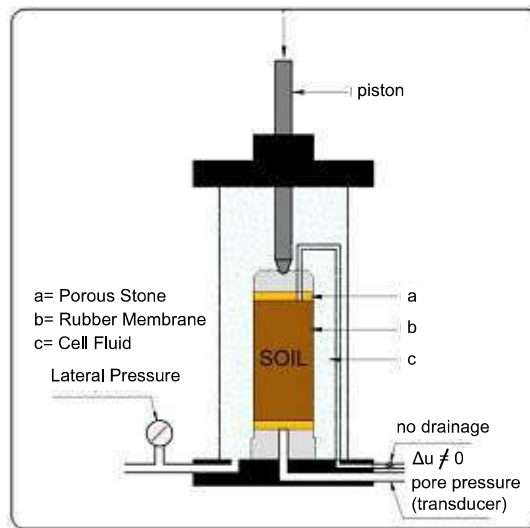
## Triaxial Test Systems for UU-CU-CD Tests

of two between each specimen, with the middle pressure approximating to the vertical effective stress in the ground. When the consolidation cell pressure and back pressure are applied to the specimen, readings of volume change are made using a volume change device in the back pressure line. Pore pressure is measured at the specimen base, with drainage to the back pressure line taking place through a porous stone covering the top of the specimen. The coefficient of consolidation of the clay can be determined by plotting volume change as a function of the square root of time. Theoretical considerations indicate that the first 50% of volume loss during consolidation should show as a straight line on this plot. This straight line is extended down to cut the horizontal line representing 100% consolidation, and the time intercept at this point can be used to obtain the coefficient of consolidation.

### TRIAXIAL TEST SYSTEM (UU-CU-CD TESTS)

#### Consolidated Undrained Test (CU Test) :

Once consolidation is complete, the specimen is to be isolated from the back pressure and the rate of vertical movement of the compression machine platen set according to result of consolidation.. During the shear stage the vertical stress is increased by the loading ram, and measurements are made at regular intervals of deformation, ram load and pore pressure. These are converted to graphs of principal stress difference ( $\sigma_1 - \sigma_3$ ) and pore pressure as a function of strain, and failure is normally taken as the point of maximum principal stress difference. The effective stress Mohr circles are plotted for the failure conditions of the three specimens which has been subjected to different consolidation level, and the gradient and intercept of a straight line drawn tangential to these circles defines the effective strength parameters ( $c'$  and  $\phi'$ ).



#### Consolidated Drained Test (CD Test):

The consolidated drained triaxial compression test, with volume change measurement during shear is carried out in a similar sequence to the consolidated undrained test, but during shear the back pressure remains connected to the specimen which is loaded sufficiently slowly to avoid the development of excess pore pressures. The shear stage of

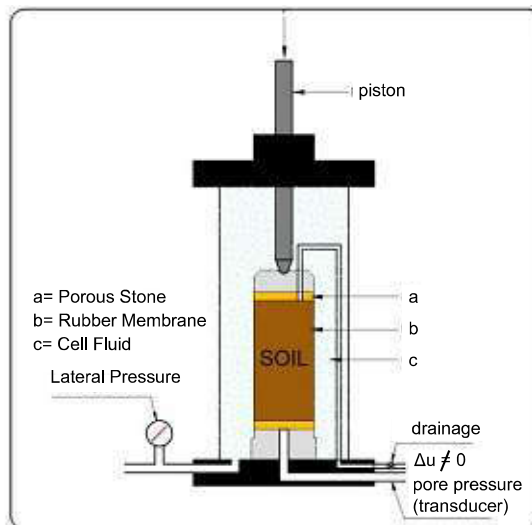
## Triaxial Test Systems for UU-CU-CD Tests

a drained triaxial test can be expected to take between 7 and 15 times longer than that of an undrained test with pore pressure measurement. Once shearing is complete, the results are presented as graphs of principal stress difference and volume change as a function of strain, and the failure Mohr circles are plotted to give the drained failure envelope defined by the parameters  $c_d'$  and  $\phi_d'$ .

Triaxial CD-CU-UU equipment is computer controlled, test values can be transferred to computer and data processing can be made with Triaxial software on Windows operating system. All data can be used on Excel programs. The load data and axial displacement data are transferred and recorded through PROFIX6 Unit to the software. Three pressure data (cell pressure, back pressure and pore pressure) from triaxial cell and volume change data transferred and recorded through the unilogger to the software.

### **S4705 Triaxial Test System for UU, CU, CD Test supplied complete with:**

- Multi Speed Electromechanic Load Frame (S4630/01)
- Load Cell, 5 kN (G345/S5)
- Triaxial Cell for 38 and 50 mm Samples (S4710)
- Triaxial Cell for 70 and 100 mm Samples (S4712)
- Block for Pressure Measurement and De-Airing (S4715) (3 Pcs)
- Pressure Transducer - 2000 kPa (G360) (3 Pcs)
- Oil and Water Constant Pressure System (S4714) (2 Pcs)
- Automatic Volume Change Unit (S4716)
- De-Airing Water Tank, 7 L. and Hose (S4717)
- Data Logger, 4 Channel Data Acquisition Unit (G285/4)
- TCM Readout Unit Featuring Software to Perform UU Triaxial Tests (S4708)
- TCM Readout Unit Featuring Software to Perform CU - CD Triaxial Tests (S4709)





## Triaxial Test Systems for UU-CU-CD Tests

Typical configuration of system for different tests (UU-CU-CD)			
Product Code	Description	UU TEST	UU - CU - CD TEST
S4630	Multi Speed Universal Electromechanic Test Machine	1 Piece	1 Piece
G345/S5	Load Cell 5 kN	1 Piece	1 Piece
S4710	Triaxial Cell**	1 Piece	1 Piece
S4715	Block for Pressure Measurement and De-Airing	1 Piece	3 Piece
G360	Pressure Transducer	1 Piece	3 Piece
TMS-4625	Oil and Water Constant Pressure System	1 Piece	2 Piece
S4716	Automatic Volume Change Unit	-	1 Piece
G285/4	Static Datalogger 4 Channels	-	1 Piece
S4708	Software to Perform UU Triaxial Tests	1 Piece	1 Piece
S4708	Software to Perform CU-CD Triaxial Tests	-	1 Piece
S4717	De-Airing Water Tank, 7 L. and Hose	1 Piece	1 Piece

**NOTE:** S4630 Multi Speed Universal Electromechanic Test Machine supplied complete with G345/S5 50 kN Load Cell and PROFIX6 Data Acquisition and Control Unit.

### Multi Speed Universal Electromechanic Test Machine

The S4630 Multi Speed Universal Electromechanic Test Machine is a Servo Controlled Multi Speed Machine supplied complete with G345/S5 50 kN Load Cell and PROFIX6 Data Acquisition and Control Unit. 5 kN Loadcell should be ordered separately for Triaxial Tests.

The Frame capacity is 50 kN. This versatile digital loading frame features a microprocessor controlled drive system with an advanced servo motor enabling the operator to easily set any test speed via the membrane keyboard. The keyboard comprises adjustment buttons such as “start”, “increase”, “automatic”, “manual”, “down”, “up”. The testing speed can be set between 0,00001 mm/min to 51mm/min. The test automatically stops when load and displacement is reached to 99% value of the set measuring range.

Load and displacement values are collected by PROFIX6 and transferred to PC for further processing with the S4708 UU and S4709 CU-CD Software.

## Triaxial Test Systems for UU-CU-CD Tests

### PROFIX6 PLUS LCD Data Acquisition Control System

PROFIX6 TFT unit is designed to control the machine and processing of data from load-cells, pressure transducers or displacement transducers which are fitted to the machine. All the operations of PROFIX6 are controlled from the front panel consisting of a 800x480 pixel 65535 color resistive touch screen display and function keys 4 analogue channels are provided for load-cells, pressure transducers or displacement transducers.

PROFIX6 has easy to use menu options. It displays all menu option listings simultaneously, allowing the operator to access the required option in a seamless manner to activate the option or enter a numeric value to set the test parameters. The PROFIX6 digital graphic display is able to draw realtime "Load vs. Time", "Load vs. Displacement" or "Stress vs. Time" graphics.

PROFIX6 unit offers many addition unique features. You can save more than 10000 test results in its internal memory. PROFIX6 unit has support for various off-the-shelf USB printers, supporting both inkjet and laser printers. Thanks to its built-in internet protocol suite, every aspect of PROFIX6 device can be controlled remotely from anywhere around the world.

- Different menu languages can be selected via the device via language support. ( English, Spanish, Russian)
- 4 analog high-precision measuring capacities
- 2 analog output sockets (DAC)
- 5 digital outputs for general purpose (can pull relays and control different electrical units)
- Potentiometer input (reference signal input for calibration and remote control)
- 2 each RS 232 serial communication signal outputs (communicates with computers)
- USB communication signal output (communicates with computers)
- Connects to local networks and the Internet with Ethernet 10/100 network connection output (optional)
- Connects to portable devices via Bluetooth wireless connection (optional)
- 500 test results can be stored in internal memory
- Due to the SD (memory) card connection, a large number of test results can be stored in the device memory (40,000 test results).
- Color TFT display supports 16 lar and 7 800 screen sizes, supports 16M colors and supports 800x480 pixel screen resolution
- Resistive touch screen allows easy operation of device functions by touching the screen
- Access to frequently used functions with 6 membrane keypads
- The industrial standard operates with 24VDC supply voltage. Built-in voltage filter and regulator protects against input signal fluctuations
- Sensor modules are compatible with loadcell (load cell), pressure sensor (4-20 / 0-20 mA), potentiometric distance



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sensors, strain washers, thermocouples and all kinds of mV output sensors.

- Provides precise calibration with multi-point calibration (up to 10 points)
- Setting and calibration menus are password protected and prevent unauthorized use.
- Allows testing with a computer or device
- The device can switch between one-touch load and deformation control modes.
- Firmware updates can be made via USB input. In addition, via the computer allows remote or internet update.

### Data Acquisition & PC Software

The CU-CD triaxial test is a complicated test needs load data, displacement data 3 pressure data from triaxial cell and volume change data. Load data and displacement data are transferred and recorded through PROFIX6 Unit to the software. 3 pressure data from triaxial cell and volume change data transferred and recorded through the unilogger to the software.

The software for CD-CU tests is compatible with TMG-0945 datalogger and PROFIX6 unit. Datalogger can be connected to PC by RS232 port. All channel gains can be set manually and accuracy of the reading can be increased.

Triaxial Software is a modular software that when a new test wanted to do, it directs the user step by step. First the software wants to input initial measurements such as diameter, height, sample weight etc. On this stage the user decides CU or CD test will be done and enters cell pressure increment steps, back pressure differential pressure and effective stress that will be used on consolidation.

After the initialization is completed, the user goes to Saturation Cell Pressure increment stage. Cell pressure must be incremented to the pressure entered at initialization stage. During this stage the software calculates B and pore pressure and submits their graph respect to time. When B value saturates this stage must be ended. Generally value of B would not reach to 0.95, therefore a back pressure increment stage must be implemented. On the saturation back pressure increment stage, prior to the start of this stage software commands what back pressure must be applied respect to initial settings. The software draws volume change and pore pressure data during this stage.

Saturation stages can be done recursively at most of 10 cycles. The relevant data of each stage is written to respective files for further investigation and report facilities. When the saturation is completed the consolidation stage can be implemented. On this stage the software commands to adjust both cell and back pressure to apply effective stress.

On the consolidation stage Volume change, pore pressure and pore pressure dissipation percent is drawn as graphs. When the stage is completed, the next stage will be shear stage of CU or CD. The software suggest the shear speed respect to the results found on consolidation stage. Axial displacement and force must be tared prior to the start of shearing.

On the shear stage deviator stress, pore pressure,  $\sigma'$  versus  $\sigma'_3$  and  $s'$  versus  $t'$  graphs are drawn. 4 different test

## Triaxial Test Systems for UU-CU-CD Tests

specimen can be configured in same file. All the results are used for drawing mohr circles. The data is evaluated with respect to specimen shear end condition. This condition can be selected as constant pore pressure, constant volume change effective prime deviator ratio etc. With the final measurements one set of data is closed. The raw data can be exported to Microsoft Excel. Without using Microsoft Excel environment all reports can be printout which includes summary of each stage with relevant graphs.

### TRIAXIAL CELLS

S4710 Standard Triaxial cell for 38 and 50 mm dia. samples S4712 Standard Triaxial cell for 70 and 100 mm dia. samples.

The cell has been designed and treated to minimize corrosion. Particular attention has been paid to the quality of finish between the piston and the head. Final assembly includes the fitting of an O-ring seal and the use of a special lubricant to reduce friction to a minimum and eliminate water leakage. The piston load capacity is designed to accept high axial loads which may be present during the final stages of a test.

Each cell has five take-off positions drilled in the base for top drainage/back pressure, pore water pressure and bottom drainage. Three no volume change valves and anvil for displacement transducer are supplied complete with the cell. Each cell will accept a range of base adaptors and various accessories for testing a wide range of specimens. The cell capacity is designed to tolerate confining pressures as high as 1700 kPa which is enough for simulating most in-situ conditions. For cell accessories and sample preparation accessories see next page.



S4712

S4710

Product Code	S4710	S4712
Dimensions	160X160X400 mm	210X210X550 mm
Weight (approx.)	5 kg	12 kg

## Triaxial Test Systems for UU-CU-CD Tests

CELL ACCESSORIES						
Sample Diameter	38 mm	50 mm	70 mm	100 mm	UU TEST	CU - CD TEST
Base Adaptor	S4710/38-01	S4710/50-01	S4710/70-01	S4710/100-01	YES	YES
Porous Top Cap	S4710/38-02	S4710/50-02	S4710/70-02	S4710/100-02	YES	YES
Nylon Tubing for Drainage	S4710/38-03	S4710/50-03	S4710/70-03	S4710/100-03	-	YES
Pair of Porous Discs	S4710/38-04	S4710/50-04	S4710/70-04	S4710/100-04	-	YES
Rubber Membrane	S4710/38-05	S4710/50-05	S4710/70-05	S4710/100-05	YES	YES
Membrane Placing Tool (Strecher)	S4710/38-06	S4710/50-06	S4710/70-06	S4710/100-06	YES	YES
O Ring(10 pcs.)	S4710/38-07	S4710/50-07	S4710/70-07	S4710/100-07	YES	YES
O Ring Placing Tool	S4710/38-08	S4710/50-08	S4710/70-08	S4710/100-08	YES	YES
Lateral Filter Paper(50 pcs.)	S4710/38-09	S4710/50-09	S4710/70-09	S4710/100-09	-	YES
Filter Paper Discs(100 pcs.)	S4710/38-10	S4710/50-10	S4710/70-10	S4710/100-10	-	YES
Plastic Discs ( 2pcs )	S4710/38-11	S4710/50-11	S4710/70-11	S4710/100-11	YES	-

Sample Preparation Accessories				
Sample Diameter	38 mm	50 mm	70 mm	100 mm
Split Sand Former	S4710/38-12	S4710/50-12	S4710/70-12	S4710/100-12
Porous Top Cap	S4710/38-13	S4710/50-13	S4710/70-13	S4710/100-13
Split Mould	S4710/38-14	S4710/50-14	S4710/70-14	S4710/100-14
Cutter	S4710/38-15	S4710/50-15	S4710/70-15	S4710/100-15
Aluminium Dolly	S4710/38-16	S4710/50-16	S4710/70-16	S4710/100-16

## Triaxial Test Systems for UU-CU-CD Tests

### OIL AND WATER CONSTANT PRESSURE SYSTEM

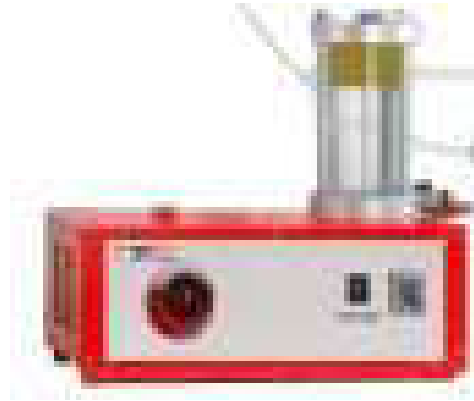
The Oil and Water Constant Pressure Unit is extremely versatile and can be used in conjunction with a wide range of test equipment. The unit provides continuous variable pressure up to 1700 kPa. Pressure is increased or decreased simply by turning a control wheel.

The Unit is used for providing cell/back pressure in triaxial tests. The apparatus is supplied without a gauge for those customers who have suitable pressure monitoring equipment.

As optional equipment for monitoring the pressure of the unit;

- The Digital Pressure Gauge
- The pressure transducer which can be used with PROFIX6 Unit on the Multi Speed Universal Electromechanic Test Machine for only UU test or
- The pressure transducer which should be used with the datalogger for CU-CD tests can be used and preferred optional equipment should be ordered separately.

The machine features a clear hydraulic/water interface reservoir and up to 1 liter capacity of water is available under pressure. Supplied complete with 2 liters of No.46 regular hydraulic oil.



S4714

Product Code	S4714
Dimensions	300X250X250 mm
Weight (approx.)	7.5 kg
Power	35W

## Triaxial Test Systems for UU-CU-CD Tests

### AUTOMATIC VOLUME CHANGE UNIT

The Unit consists of a piston connected to a 25 mm travel linear transducer which is sealed against a precision machined calibration chamber so that the linear movement of the piston is exactly proportional to the volume of water in the calibration chamber.

The apparatus creates an electrical signal proportional to the volume of water flowing through the unit.

By connecting it to the data acquisition system the measured volume change will be used by software during the test and in final report.

Capacity	100 cm <sup>3</sup>
Transducer Input	up to 12 V DC
Accuracy	± 0.1 ml
Dimensions	260x260x400 mm
Weight (approx.)	5 kg



S4716

### PRESSURE TRANSDUCER AND BLOCK FOR TRIAXIAL CELLS

The Pressure Transducer is used for the measurement of cell or back or pore pressure of water in triaxial test systems and also should be used with an PROFIX6 Unit or a datalogger. The Block for triaxial test cells is used for connection of the pressure transducers and de-airing in the water hoses.

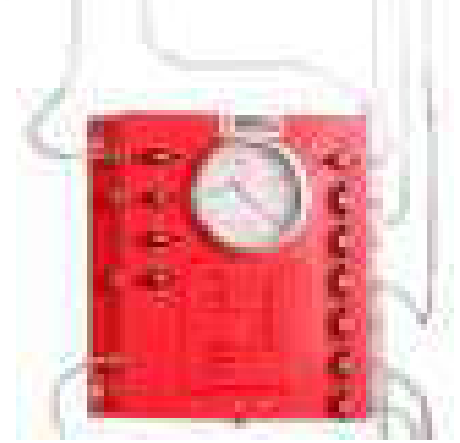
## Triaxial Test Systems for UU-CU-CD Tests



S4715



S4717



S4720

TMS-4715 | De-Airing Water Apparatus, 230V, 50Hz, 1ph

TMS-4716 | De-Airing Water Tank 7 Liters with Plastic Hose, Ø8mm, 6m

TMS-4720 | Vacuum Control and Water Connection Panel with Regulator

The De-Airing Water Apparatus is a compact and self-contained equipment which can de-air water quickly and efficiently down to levels of dissolved oxygen acceptable for geotechnical test methods. The apparatus is used in conjunction with the de-airing tank. Air is removed from the water by a vacuum system. De-airing tank should be ordered separately.

### The first option for de-airing water;

- De-Airing Water Apparatus
- De-Airing Water Tank
- Vacuum Control and Water Connection Panel with Regulator and Vacuum Gage Manometer or Connection Panel for Vacuum and Water with Vacuum Gage (These panels are optional)
- Plastic Hose

### The second option for de-airing water;

- Vacuum Pump,
- Filter Flask or Air Drying Unit / Water Trap
- De-Airing Water Tank
- Vacuum Control and Water Connection Panel with Regulator and Vacuum Gage Manometer or Connection Panel for Vacuum and Water with Vacuum Gage (These panels are optional)
- Plastic Hose

By using Vacuum Control and Water Connection Panel, vacuum pressure degree can be regulated. By using Connection Panel for Vacuum and Water with Vacuum Gage Manometer and Vacuum Control and Water Connection Panel with Regulator, de-airing water equipment can be used without repeated assembling the hoses.





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