



# HM-4140, HM-4150, HM-4160



HM-4150

HM-4160A

## Humboldt FlexPanels



## **Introduction:**

This manual covers the installation and operation of Humboldt FlexPanels for Triaxial and Permeability testing. This equipment comes in different configurations but is essentially built from two basic units. The equipment is packaged for easy installation, which allows you to be up and running as quickly as possible.

The primary intention of this manual is to guide the first-time user of FlexPanels through the familiarization and installation of the equipment. After the initial installation is accomplished the manual can serve as an ongoing reference for installation changes or future reference on the equipment. While this manual is intended to include as much available information as possible, it is designed for those who will not be reading the entire manual or who only want to refer to specific sections. Users should classify themselves and proceed accordingly:

**First-Time User:** We recommend that all first time users and those basically unfamiliar with FlexPanel operation read the entire manual before proceeding with installation.

**Experienced User:** Refer to Precautions and Maintenance.

## **Unpacking and Inspection**

Carefully remove the contents of the carton in which the panel was shipped. Inspect the carton and the panel and make note of any apparent physical damage. If severe damage is present then you should consider rejecting the shipment and contacting the shipping company concerning in-transit damage claims. We have made every effort at the factory before shipping to fully inspect, test, and properly package this product so that it reaches you defect-free and without damage.

All packaging materials should be saved and set aside in case a return shipment needs to be made.

## **Precautions and Warnings**

This equipment was designed to work with a maximum of 150 PSI (1000 kpa) of air pressure. If pressures greater than 150 PSI (1000 kpa) are used it could be dangerous for the operator, as well as cause damage to the equipment.

Leaks in the lines which contain water will influence the test results. Leaks can occur at tube connections especially those which are taken apart and reconnected. The quick-connects will leak if the o-ring has been cut, which will happen when the o-ring is not lubricated. Parker makes an o-ring lubricate called Super-O-Lube designed to be used with O-ring seals.

## Functional Overview

### Purpose of Equipment

The panels are used to control pressure and monitor flow of liquids in and out of various testing apparatus. The device can be used with other equipment to perform these ASTM procedures: D4767, D2850, D5084 and other international standards.

How equipment can be used:

- To back-pressure saturate a specimen.
- Monitor consolidation or swell (volume change)
- Control pressure and monitor volume change during a shear test.
- Monitor flow in and out of a sample and control pressure for permeability testing.

### Description

Humboldt FlexPanels are available in 5 separate panel configurations, which can be grouped together to accommodate from 1 to 5 cell setups. The five different types of Panels include:

**HM-4140.3F**— A Master Controller. The Master Control panel can be used to control the functions of up to 5 cells utilizing combinations of HM-4150A and HM-4160A FlexPanels. Each cell requires a group of dedicated control burettes. HM-4150A panels provide 1 group of controls and the HM-4160A panels provide 2 groups of controls.

**HM-4150.3F**— 1 group of control burettes and an integral master controller

**HM-4160.3F**— 2 groups of control burettes and an integral master controller

**HM-4140M.3F**— Same as HM-4140.3F, except it reads in kPa

**HM-4150M.3F**— Same as HM-4150.3F, except it reads in kPa

**HM-4160M.3F**— Same as HM-4160.3F, except it reads in kPa

**HM-4150A**— Add-on panel with 1 group of control burettes

**HM-4160A**— Add-on panel with 2 groups of control burettes

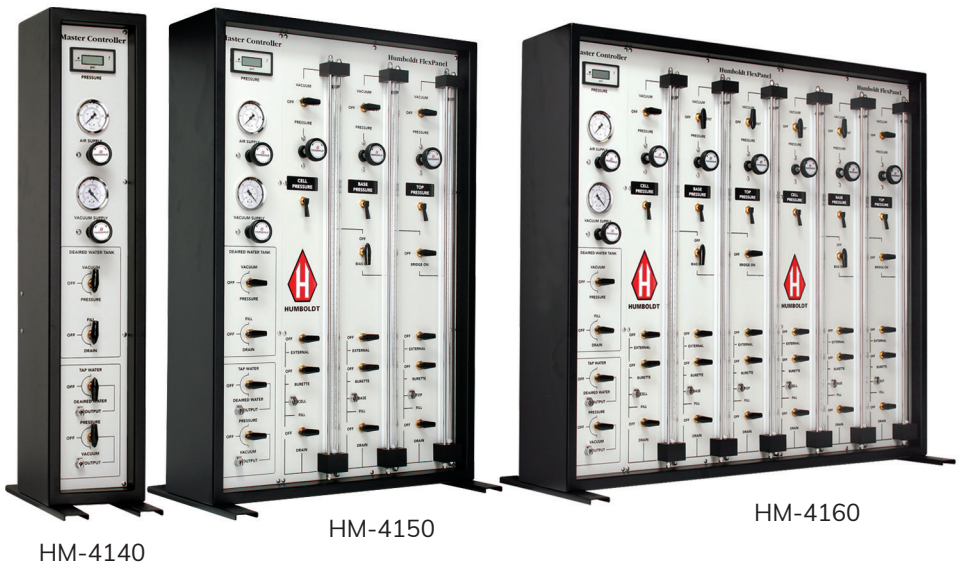


fig. 1

The HM-4140, HM-4150 and HM-4160 Distribution Panels all use the same control section, which is essentially a HM-4140 Master Controller. No matter which panel you are using, the controls will work the same. See the following pages for explanations of the different panels and controls.



fig. 2

The HM-4150A and HM-4160A Distribution Panels are add-on panels, which can be used with any of the Controller Panels in fig. 1

## The Master Controller

The Master Controller (Fig. 3) can be used as a stand-alone controller (HM-4140) for controlling functions when used in conjunction with HM-4150A and HM-4160A Distribution Panels.

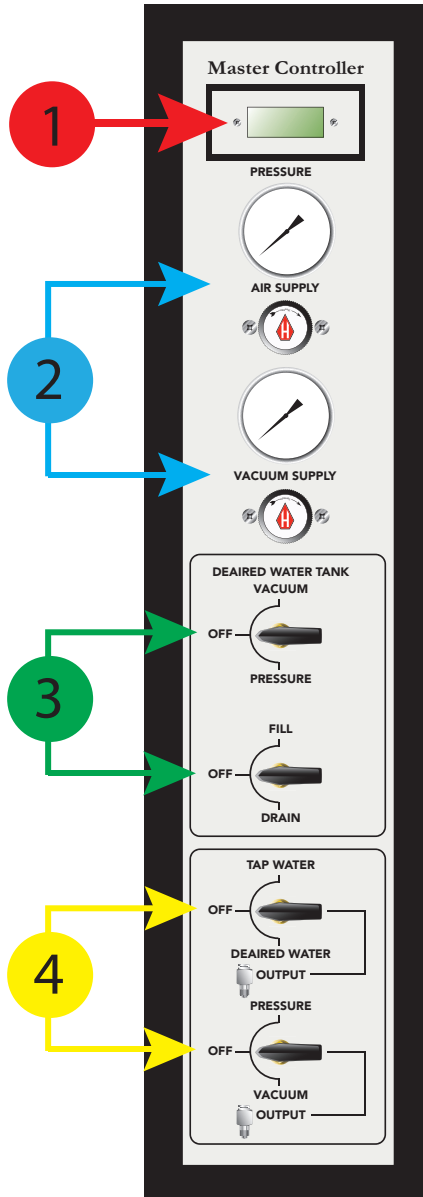


fig. 3

The Master Controller can also be used as an integral part of the HM-4150 and HM-4160 Distribution Panels (Fig. 4). In all cases, the Master Controller functions in the same way.

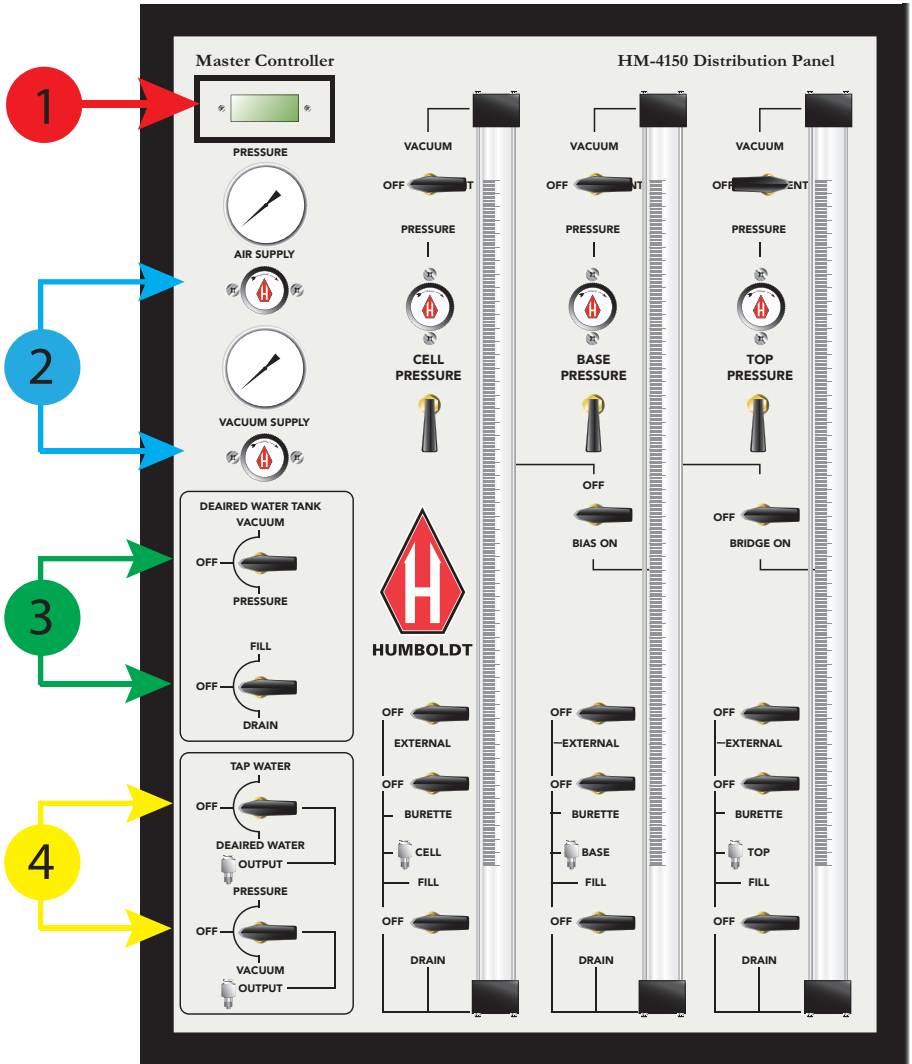


fig. 4

## Master Controller Functions

The Master Controller is shown in **fig. 3 and fig. 4**. The different sections of the Controller are numbered to reference the drawings and the operation of each is explained below.

1

This is the digital display, which allows you to read the current cell, base or top pressures from up to 5 different cells, depending upon your particular configuration.

To read a pressure, raise the toggle valve, located under the regulator for which you wish to check the pressure (indicated by the second red arrow) and the pressure will be displayed in the digital display. Only one line can be read at a time.

2

These are the regulators and dial gauges for setting the air and vacuum supply pressures to the FlexPanel. The Air Supply pressure regulator is used to set incoming air pressures from an air compressor. It can be set from 2-150 psi (14 - 1000 kpa), and the resulting air pressure is displayed on the pressure gauge above the regulator. The regulator setting should be set at least 5 psi (35 kpa) lower than the lowest pressure coming from the air compressor.

The lower regulator controls the vacuum pressure supplied to the FlexPanel, as well as to Section 4 of the control panel. An external vacuum pump is required to supply vacuum to the control panel. The gauge above the regulator displays the regulated vacuum.

3

This section controls the De-aired water tank. The top valve has two input lines. One is connected to a vacuum pump and the other to a low pressure regulator, (less than 5 psi), which has been preset at the factory. The output goes to the top of the de-aired water tank. The lower valve also has two input lines. One going to a drain or a container to collect waste liquid and the other is connected to a water supply (tap water or special permeate). The output is connected to the bottom side of the De-aired water tank.

4

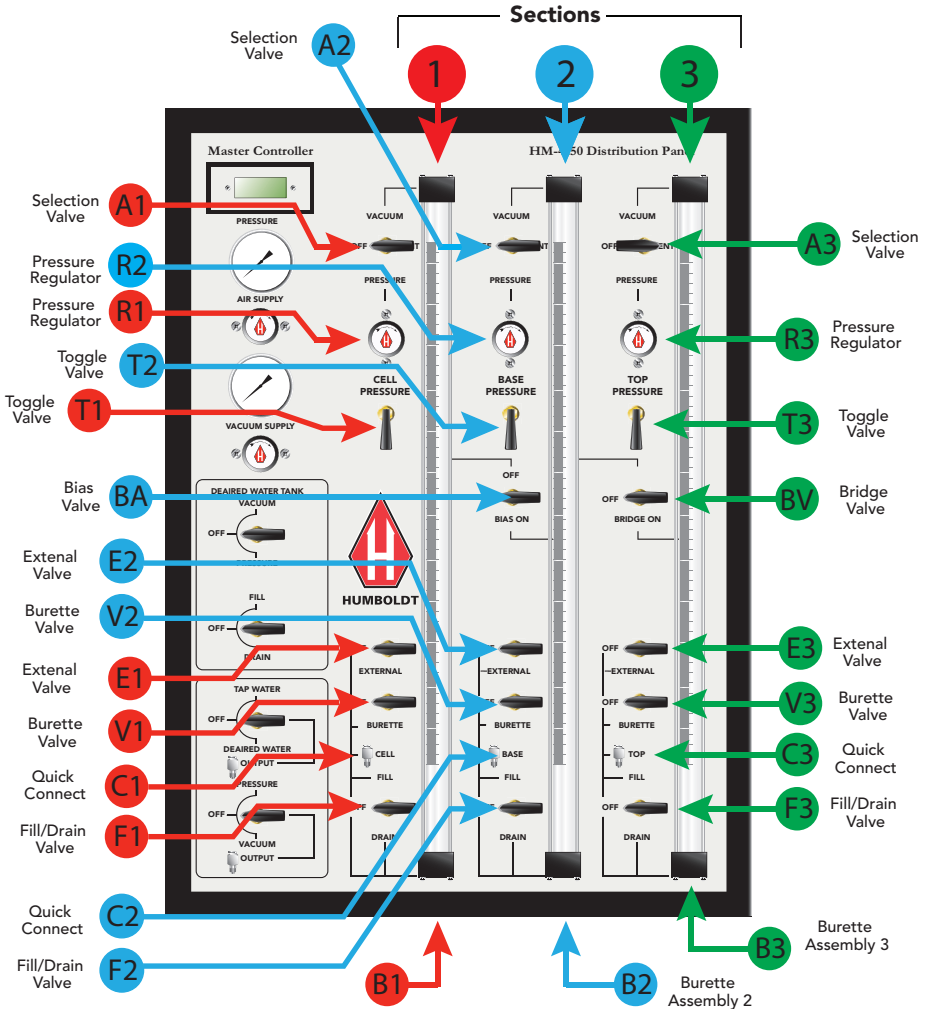
This section controls sources of water, compressed air and vacuum. The top valve can be set to supply tap water or de-aired water to the quick connect located below it. The bottom valve supplies a regulated air pressure or regulated vacuum to the quick connect below it. The air pressure is supplied by the same regulator that supplies air to the de-aired water tank and the vacuum is regulated by the vacuum regulator.



# FlexPanel Control Burette Groups

Humboldt FlexPanel Controls are organized into groups consisting of three, control burettes, each of which can be used to regulate pressure or volume changes.

Models HM-4150 and HM-4150A provide one group of control burettes and Models HM-4160 and HM-4160A provide two groups of control burettes.



HM-4150 with its one group of control burettes labeled for reference.

fig. 5

## Group Controls— Section 1

- A1** The Selection Valve (A1) at the top of the section selects the type of pressure input for the top of the burette assembly. It can select VACUUM (Regulated), VENT (to atmosphere), OFF (closed) or PRESSURE (controlled by the Regulator below it).
- The Pressure Regulator (R1) supplies a regulated pressure for the burette assembly in this section. The regulator in section 1 is different than the regulators in sections 2 and 3. It has a bias feature, which when turned to the Bias On (BA) setting, adds the pressure set in Section 2 to Section 1. When the Bias is on, adjusting pressures with the Section 2 Regulator (R2), will maintain the differences in pressure between Section 1 and 2 in direct proportion to the original Section settings. When using the knob to adjust the pressure it will not turn as easy as the standard type regulator.
- R1**  
**R2**  
**BA**
- T1** To monitor the pressure being set on the regulator there is a Toggle Valve (T1) directly below the regulator, which is used to connect the regulator to a pressure read out. To check the pressure while adjusting the regulator lift the toggle and read the pressure on the digital display located at the top of the Master Controller. Only one pressure can be monitored at a time. The Toggle Valve (T1) should be closed after checking the pressure.
- B1** The Burette Assembly (B1) has one port at the top, which is connected to both the external and internal side of the burette. The bottom of the Burette Assembly has two outlets, one connected to the external side and one connected to the internal side of the burette. The Burette Assembly in Section 1 comes with a 50cc burette readable to 0.1cc.
- C1** The External Valve (E1) is connected to the External Port and to the Cell (C1) Quick-Connect. When the valve is turned to External, water can flow from the external side of the Burette to the Cell (C1) Quick-Connect.
- V1** The Burette Valve (V1) is connected to the burette and to the Cell (C1) Quick-Connect. When the Valve is turned to Burette, water can flow from the burette to the Cell (C1) Quick-Connect. The External and Burette Valves can be opened at the same time and the water levels on both sides of the burette should be about the same level.

The Fill/Drain Valve (F1) is used to fill and drain the Burette Assembly (B1). To fill either the External or the Burette chambers, the External Valve (C1) or the burette valve (V1) are opened. If a line is connected to the Quick-Connect (C1) when filling or draining, the Valve on the cell end should be closed. Turn the valve to Drain very slowly and the Burette or External Burette Chamber will drain to a waste container or a drain line. To use the Fill setting, the burette assembly must be vented. This is done by turning the Selection Valve (A1) to vent. Then the Fill and Drain Valve (F1) can be turned to the Fill setting, and water will flow into the Burette and/or the External chamber. This should be done slowly as not to over-fill the unit.

**F1**

## Group Controls— Section 2

**R2**

The Controls in Section 2 of a control group are primarily the same as Section 1. See Section 1 descriptions for an explanation. However, there are a few differences, which are outlined below:

The Regulator (R2) in Section 2 is not a bias-type regulator.

**BA**

The Pressure Regulator (R2) supplies a regulated pressure for the burette assembly in this section. In addition it can be used in conjunction with Section 1 in Bias mode. With the Bias Valve (BA) set to the Bias On position pressure settings are added to the settings in Section 1. When the Bias is on, adjusting pressures with the Section 2 Regulator (R2), will maintain the differences in pressure between Section 1 and 2 in direct proportion to the original Section settings.

**B2**

The Burette Assembly in Section 2 comes with a 10cc Burette readable to .02cc, and the area of the burette is 0.263cm<sup>2</sup>.

## Group Controls— Section 3

**R3**

The Pressure Regulator (R3) supplies a regulated pressure for the burette assembly in this section.

**R3**

Below the Pressure Regulator (R3) is a Bridge Valve (BV), which takes the pressure from Pressure Regulator (R2) and bridges it to Burette

**R2**

Assembly (B3) when the valve is turned to Bridge On. When the

**B3**

bridge is used, the valve (BA) should be turned to off so the Regulator

**BV**

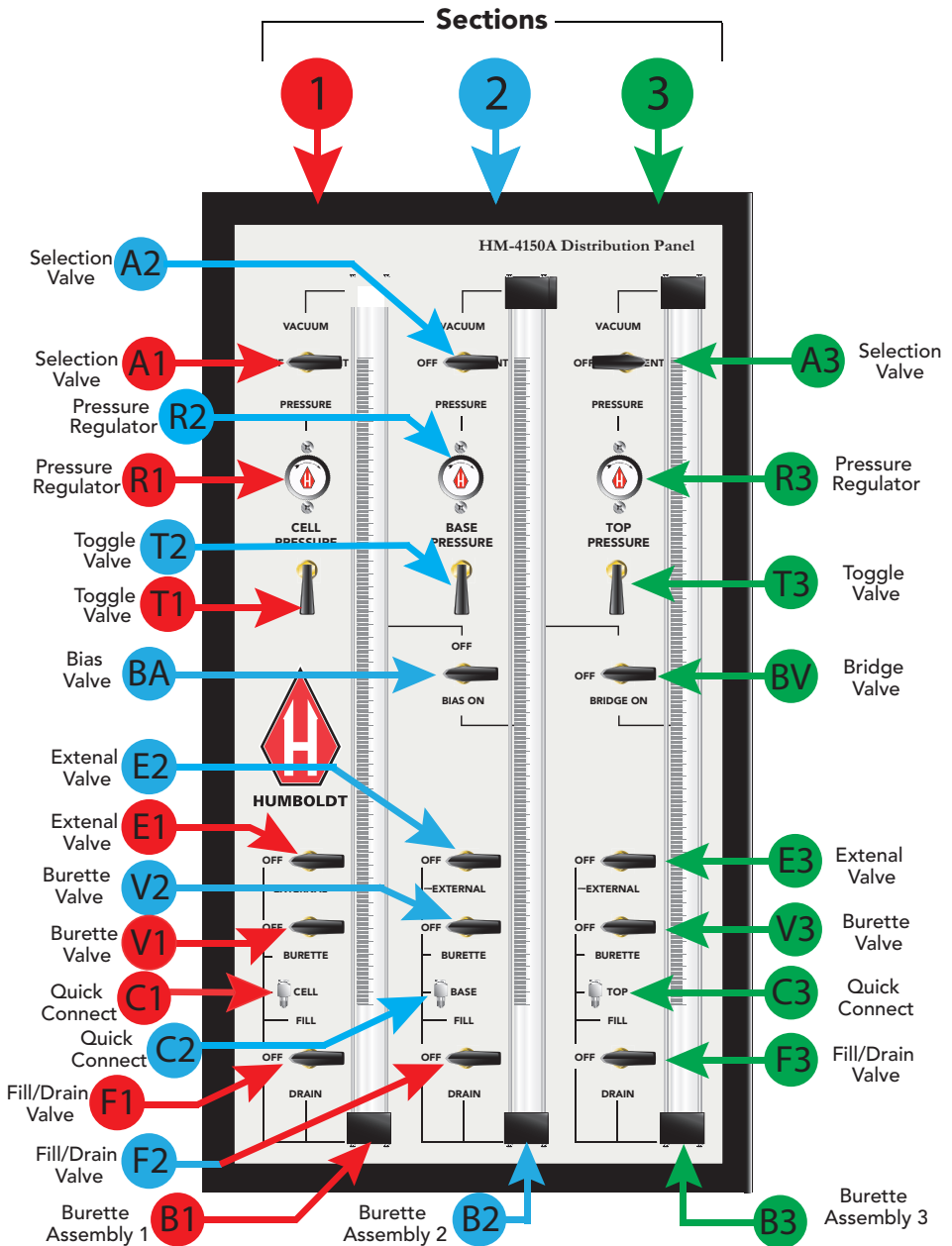
is isolated from the system. When using the Regulator (R3) with the

**B3**

Burette Assembly (B3) the Bridge Valve (BV) should be turned to Off.

The Burette Assembly (B3) comes with a 10cc Burette readable to .02cc, and the area of the burette is 0.263cm<sup>2</sup>.

Models HM-4150A and HM-4160A are Add-on panels, which can be used with any of the Control Panels. The HM-4150A provides the controls for one cell and the HM-4160A provides controls for two.



HM-4150A Add-on Panel with its one group of control burettes labeled for reference.

fig. 6

## **Installation and Configuration**

The contents of this section will guide the user through the proper steps required to safely install and hook up the Panel. This section should be read in its entirety for first-time installers and reviewed during the installation process.

### **Equipment Set-up**

The first thing, after taking the panel out of the carton, is to place the panel(s) on a level work surface capable of supporting the unit(s) and providing sufficient room in which to work and service the panels later. It is advantageous to be able to walk behind the panel(s) to perform maintenance and check for leaks. Service lines will need to be run to the rear of the panel and the work space in front of the panel(s) will need to supply sufficient room for permeability or triaxial cells, as well as the tubing connecting the cells to the panel(s).

### **Required Utilities**

All panels need the following utilities for operation.

#### **Compressed Air Supply**

FlexPanels require a reliable source of clean, dry air of sufficient volume to supply the Panels' bleeding regulators. The minimum requirement is a compressor that can supply 3cfm at 125 or 150psi with a 30-gallon tank. As more units are added the capacity of the compressor should be increased (Some installations may require a 15cfm compressor with a 60-gallon tank). The air coming from the compressor should pass through a filter system to remove dirt and entrained liquid in the air line.

#### **Tap Water Supply**

Tap water is used to fill the de-aired water tank and run Triaxial quick tests. It is connected to one of the control panels (HM-4140, HM-4150 or HM-4160) on the Lower Service Connector Plate. HM-4150A and HM-4160A Add-On Panels do not have a Tap Water Connector.

#### **De-Aired Water Supply**

A source of De-Aired water is required to perform most triaxial permeability tests. This is usually supplied by the use of a De-Airing tank

#### **Vacuum Supply**

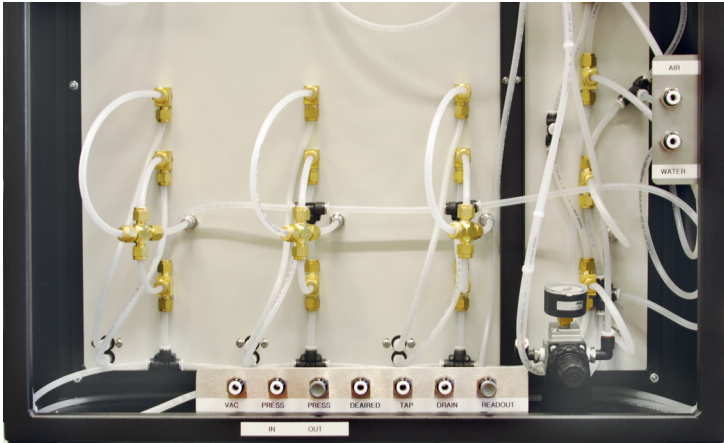
FlexPanels need a source of vacuum. This is usually supplied by a small vacuum pump. Control Panels have a vacuum regulator that regulates vacuum between 0 and -14.7 PSI (29 in hg, 101 kpa, 760 mm hg). Add-on Panels, which do not have a vacuum regulator can be supplied with regulated vacuum from a Control Panel or unregulated vacuum from the vacuum pump.

#### **Water Drain**

FlexPanel operation requires a drain for water used in operation. The Lower Service Connector Plate has a connector for attaching a drain line to carry away the liquids released.

## Connecting Utilities

Located on the back of each FlexPanel is one or two service connector plates. These connector plates are used to connect utilities to the panels (Figure 7). Twenty feet of 1/4-inch plastic tube has been supplied for service connections.



Rear of Control Panels (HM-4140, HM-4150, HM-4160) showing Lower and Upper Service Connector Plates. Also shows plugs used in exit connector for Pressure and Readout when not using Add-On Panel.



Rear of Add-On Panels (HM-4150A, HM-4160A) showing Lower Service Connector Plate.

Figure 7

### **Control Panel Connections (HM-4140, HM-4150, HM-4160):**

(1/4-inch tubing is used for connections)

- 1) Install a section of tubing from the air supply to the PRESS IN connector on the lower service connector plate.
- 2) Install a section of tubing from the water line to the TAP connector on the lower service connector plate.
- 3) Install a section of tubing from the water side of the de-aired water tank to the DEAIRED connector, marked de-aired on the lower service connector plate.
- 4) Install a section of tubing from the vacuum supply to the VAC connector on the lower service connector plate.
- 5) Install a section of tubing from a drain pipe or tank to the DRAIN connector on the lower service connector plate.
- 6) Install a section of tubing from the top or air side of the de-aired water tank to the AIR connector on the upper service connector plate.
- 7) Install a section of tubing from the water side of the de-aired water tank to the WATER connector on the upper service connector plate.

### **Add-On Panel Connections (HM-4150A, HM-4160A):**

(1/4-inch tubing is used for connections)

1. Install a section of tubing between the two service connectors of the Control Panel PRESS OUT and the Add-On Panel PRESS.
2. Install a section of tubing between the two service connectors of the Control Panel READOUT and the Add-On Panel READOUT.
3. Install a section of tubing with UNION TEE FITTING (HM-4150.25) between the two service connectors of the Control Panel DEAIRED and the Add-On Panel DEAIRED.
4. Install a section of tubing with UNION TEE FITTING (HM-4150.25) between the two service connectors of the Control Panel DRAINAGE and the Add-On Panel DRAINAGE.
5. Install a section of tubing with UNION TEE FITTING (HM-4150.25) between the two service connectors of the Control Panel VAC (vacuum) and the Add-On Panel VAC.

## **Operation**

This section discusses the use of FlexPanels when running a typical test. Refer to Figure 8 on next page)

### **Master Controller**

The individual functions of the Master Controller are reviewed below.

### **Digital Display**

The Digital Display provides a readout of the cell, base or top pressures of an individual test cell. To read a pressure, raise the toggle valve (T1, T2 or T3), located under the regulator for the section you wish to check. (Indicated by the second red arrow) and the pressure will be displayed in the digital display. Only one section pressure can be read at a time.

### **Air Pressure Supply Regulator and Gauge**

The Lower Service Connector Plate has a connector for a compressed air line (PRESS IN). Compressed air is connected to the air regulator, which is adjusted to set the desired pressure. This pressure is displayed on the regulator's pressure gauge. The regulator is turned clockwise to increase pressure and counter-clockwise to decrease it. Regulated pressure is connected to the Lower Service Connector Plate, which feeds pressure to any Add-On Panels. The regulated output should be set at a pressure below the low-end pressure of the air compressor. The Add-On Panel Regulators can not be used at levels near or greater than the pressure setting.

### **Vacuum Regulator and Gauge**

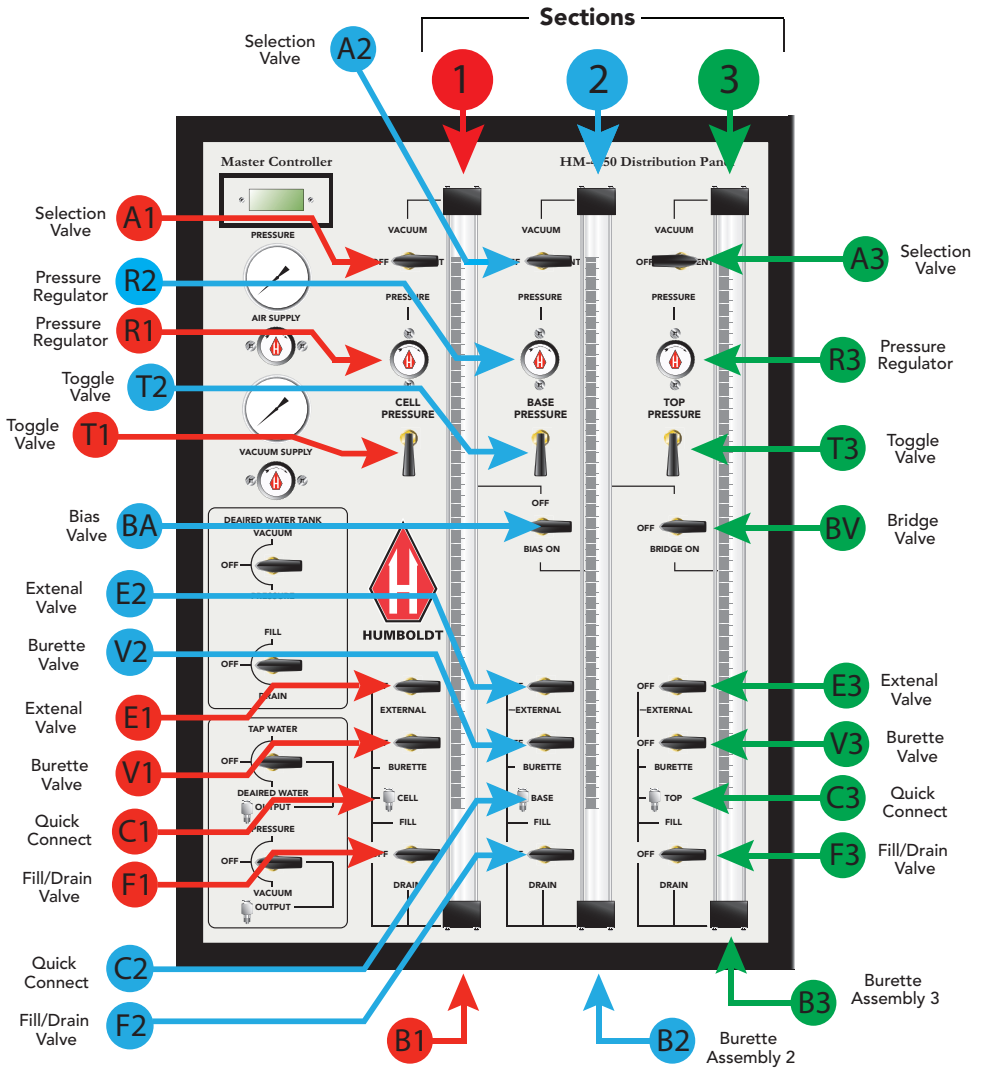
The Lower Service Connector Plate has a connector for a vacuum pump (VAC). The vacuum pump's output is controlled by a vacuum regulator connected to the Lower Service Connector Plate. The vacuum pressure can be read on the Pressure Gauge on the front of the panel above the regulator. There is a connection for regulated vacuum and the Pressure/Vacuum Output Quick Connect at the bottom left corner of a Control Panel.

### **De-aired Water Tank Controls**

This section is made up of two valves which control the functions of the de-aired water tank. The top valve connects a regulated, low-level air pressure source or a vacuum from the vacuum pump. The air pressure is used to help force the water from the de-aired water tank into the individual Section Burettes of a Control Burette Group, or it is used when force draining the De-airing tank. It is recommended that the De-airing Tank be positioned above the panel boards and allowing the de-aired water to gravity flow into the burettes rather than applying pressure to force the water into the burettes. This helps maintain the de-aired quality of the water.

The vacuum is used when making de-aired water. The lower valve is used to drain the tank or fill it with water from a supply. The water supplied can be tap water or a specially prepared water.





HM-4150 FlexPanel all components labeled for reference.

fig. 8

To make De-aired water, assuming a Nold De-aired unit or a De-aired water tank has been connected to the panel, following these steps:

1. Set the vacuum regulator to highest vacuum level.
2. Turn the Deaired Water Tank Valve in Section 3 of the Master Controller to vacuum, which applies a vacuum to the De-aired Water Tank.
3. Fill the tank about three quarters full with water by turning the Fill/Drain Valve to Fill. Once the tank is filled, turn valve to Off.
4. If using a Nold De-airing tank, turn the unit's motor on for 10 minutes prior to testing. If using a De-airing tank, apply vacuum for one hour. When water has been De-aired turn valve to off.

## **Control Burette Groups**

This section will discuss how the panel is used with a triaxial or permeability cell. Humboldt FlexPanel Controls are organized into Groups consisting of three, Control Burettes, each of which can be used to regulate pressure or volume changes. There are a few differences in the controls for these burettes, which are discussed below.

### **Pressure Selection Valve**

The Selection Valve (A1) at the top of the section selects the type of pressure input for the top of the burette assembly. It has four settings:

- VACUUM— In this position, the regulated vacuum from the master panel or other vacuum connected to the service panel is connected to the burette section. The vacuum is used to pull air out of the water in the burette assemble or pull a partial vacuum on the sample. The water can boil at high vacuum levels.
- VENT— In this position, the Burette Section is vented to the atmosphere. It is used to apply atmospheric pressure to the Burette Section.
- OFF— In the off position, the top of the Burette Section is sealed off.
- PRESSURE— In this position, the pressure, controlled by the regulator below the valve is applied to the Burette Section,

This valve for all of the sections function the same.

It is used to apply atmospheric pressure to the top of the burette assembly. It is used when filling the burette assembly before opening the valve. To vent close one of the valves on the cell to isolate the cell from the panel. Turn valve (A1) to the pressure position which connects the pressure from the regulator below the valve to the top of the burette assemble.

### **Pressure Regulator**

The Pressure Regulator controls the air pressure provided to the Pressure Selection Valve, located above the Regulator. To set a pressure, lift the Toggle Valve, located below the Pressure Regulator, and then, turn the Regulator while monitoring the pressure on the digital display of the master panel.

The pressure should be checked and adjusted after approximately 15 minutes and then checked periodically when taking readings on from the Burettes.

### **Toggle Valve**

The Toggle Valves are all connected in a series of tees, leading to the Digital Display on the Control Panel. When the Toggle Valve is lifted, the pressure for the adjacent Control Burette is indicated on the Digital Display. Only one Control Burette pressure can be read at one time.

### **Bias Valve**

Burette Section 2 (Base) is the only section with a Bias Valve (BA). This valve is located below the Section 2 Toggle Valve. The Bias Valve (BA) is used to combine the output pressure of Section 2 (Base) with that of Section 1 (Cell).

This is accomplished through the use of an extra port in the Regulator for Section 1, which allows it to connect the output from Section 2 (Base) via the Bias Valve. When the Bias Valve is open, it will connect the output of Section 2 with Section 1. Therefore, when adjustments are made to the Section 2 (Base) Regulator (R2) the Section 1 (Cell) Regulator (R1) will be changed by the same amount. This feature can be used during back pressure saturation, allowing the operator to use the Section 2 regulator (R2) to alter pressures, which maintains the pressure difference between Section 1 (Cell) and Section 2 (Base).

### **Bridge Valve**

Section 3 (Top) is the only Section with a Bridge Valve. This valve is located below the Section 3 Toggle Valve. The Bridge Valve, when open, connects the output of the Section 2 Regulator, to the top of the Section 3 (Top) Control Burette. The Section 3 Pressure Selection Valve (A3) should be in the off position when using the Bridge. If the Bias and Bridge Valves are both open, the Section 2 Regulator can be used to increase the pressure equally to all three Control Burette Sections.

### **Burette and External Valves**

These valves are located at the bottom of the controls in each Control Burette Section. The Burette Valve is connected to the bottom of the Internal Burette of the Burette Assembly, while the External Valve is connected to the Outer Burette. Opening one or both of these valves connects them with the Quick Connect in Section 1 (Cell). When the Burette Valve is open, the Internal Burette is connected to the Section 1 Quick Connect. When the External Valve is open the External Burette is connected to the Section 1 Quick Connect. These Valves can both be open at the same time, which results in the Internal and the External Burette seeking the same water level. When monitoring volume changes, only the Burette Valve should be open.

## **Fill and Drain Valves**

This valve located at the bottom of each of the Control Burette Sections and is used to fill and drain the Internal and External Burettes of the Burette Assemblies. To Fill, the Burette or External Valves need to be open to fill that portion of the Burette Assembly. The water to fill the Burette Assembly comes from the Deaired Water Port on the Lower Service Connector Plate. The Burette Assembly can not be filled unless the top is vented by turning the Selection Valve to vent. The top does not have to be vented to drain the Burette Assembly.

## **Triaxial Hydraulic Conductivity Testing Procedure**

This section discusses how the equipment can be used for back pressure saturation and consolidation of a Triaxial/Hydraulic Conductivity test specimen. The steps for setting up a sample in a Triaxial Shear cell or a Hydraulic Conductivity Cell will not be discussed.

## **Triaxial Cell Connection**

FlexPanel Control Burette Groups are comprised of three Control Burettes, which are labeled: Cell, Base and Top. These correspond to the Valve Ports on Triaxial Cells labeled the same.

To connect a Triaxial Cell to the Flexpanel:

Use a length of 1/4-inch tubing to connect the Cell Quick Connect (Section 1 of a Control Burette Group) to the Cell Pressure Valve Port on the Triaxial Cell. For a Hydraulic Conductivity Set-up, the length of the tube can be as short as 2 feet. For a Triaxial Shear Set-up, the tube should be long enough to permit the Triaxial Cell to be placed in a load frame without disconnecting the cell pressure line.

Two lengths of 1/8-inch tubing should be used to connected the Base (Section 2 of a Control Burette Group) and Top (Section 3 of a Control Burette Group) Quick Connects to the corresponding Valve Ports on the Triaxial Cell.

## **Filling The Burette Assemblies**

It is assumed that De-aired Water has been prepared following the procedure in the De-aired Water Tank Controls Section on page 16-18.

Fill the Burette Assemblies with De-aired water by using pressure supplied by selecting "Pressure" from the Valve in section 3 of the Master Control section or by allowing gravity feed from the De-airing tank if it is located above the panel board and by turning the selection valves (A1, A2, A3) to vent. Then, fill the External Burettes for each section by turning the External Valve (E1, E2, E3) to the external position. Turn the Fill/Drain Valve (F1, F2, F3) slowly to allow water to fill the external section of the Burette Assembly. Initially there will be a mixture of air and water. Allow the External Burette to fill about 3/4 full, then turn the Fill/Drain Valves and the External Valves (E1, E2, E3) to off.

Now, turn the Burette Valves (V1, V2, V3) to Burette. Turn the Fill/Drain Valve (F1, F2, F3) slowly to allow water to fill the internal section of the Burette Assembly.

Allow the Internal Burette to fill about 3/4 full, then turn the Fill/Drain Valves (F1, F2, F3) and the Burette Valves (V1, V2, V3) to off. It is now assumed the Burette Assemblies are filled with De-aired Water.

### **Flushing Lines from Panel to Cell**

Before setting up a sample in the Triaxial Cell, allow water to flow through the Top and Base tubes to flush air out of the lines. This can be accomplished by turning the External Valve (E2 and E3) to External and opening the Base and Top Valve on the Triaxial Cell. If the Base Valve is open and the Base External Valve is on, water and bubbles of air will start flowing from the holes in the Base Pedestal of the Triaxial Cell, and If the Top Valve is open and the Top External Valve is on, water and bubbles of air will start flowing from the Top drain line of the Triaxial Cell. The flushing process is complete when no additional bubbles come from the base or the Top Cap tubes, and there are no apparent bubbles in the tubes connecting the Cell to the FlexPanel.

Do not allow all the water to flow out of the External Burette. If it gets close to the bottom it should be refilled to 3/4 full. **Note: The cell has two top and base drain ports and only one is being flushed with water at this time.**

### **Triaxial Sample Set-Up**

Be sure to saturate the Porous Stones and trap as little air as possible inside the Sample Membrane. Once the sample has been set up and the Triaxial Cell cover is in place, the Cell can be filled with water. This can be accomplished in two ways. If the cell is going to be filled with De-aired water and the 1/4-inch tube going to the cell is plugged into the Quick Connect (C1) these are the steps.

- 1) Make sure External Valve (E1) and Burette Valve (V1) are turned off.
- 2) Make sure the Top of the Triaxial Cell is vented to the atmosphere.
- 3) Turn the Fill/Drain valve (F1) to FILL and the Cell should start filling with water.
- 4) When water begins coming out of the top of the Cell, turn the Fill/Drain Valve (F1) to off.
- 5) Close the vent on the top of the Cell.

The Cell can also be filled with Tap Water or De-aired Water from the FlexPanel by following these steps.

- 1) Unplug the Cell Pressure line from Quick Connect (C1) and plug it into the Quick Connect (P1) below the Tap Water/De-Aired Water Valve in the Master Control Section (4) of the panel.
- 2) Make sure the top of the Cell is vented.
- 3) Turn the Water/De-Aired Water Valve to Tap Water or De-aired Water to fill the Cell
- 4) When the water begins coming out of the top of the Cell turn the Water/De-Aired Water Valve off.
- 5) Close the vent on the top of the Cell.

- 6) Unplug the cell line from quick connect (P1) and plug it into quick connect (C1) on the standard panel.

### **Applying Initial Cell Pressure**

The following steps should be followed when applying the initial cell pressure before starting back pressure saturation.

- 1) If the sample length is being monitored take a reference reading before applying pressure to cell.
- 2) Turn the selection valve (A1) to the pressure position.
- 3) Lift the Toggle Valve (T1) and check the pressure setting of the pressure regulator (R1).
- 4) Those systems with a Master Control Panel can read the pressure on the Digital Display.
- 5) Adjust the Pressure Regulator to a pressure between 2 and 5 psi (14 - 35 kpa).
- 6) Turn either the External Valve (E1) or Burette Valve (V1) to the open position.
- 7) Open the Cell Pressure Valve on the Cell and the Cell will now be pressurized.

### **Flushing Triaxial Cell Drain Lines**

The following steps should be followed to flush air out of the Triaxial Cell drainage lines or any air trapped during sample set up.

To flush the Base:

- 1) Turn the Selection Valve (A2) to the Vent position.
- 2) Turn the External Valve (E2) to the External position.
- 3) Open the Triaxial Cell's Base Drain Valve, which is connected to the tube leading to the FlexPanel.
- 4) Open the Triaxial Cell's Base Drain Valve, which is not connected to the Flexpanel so water can flow through the Base Valves and flush air bubbles out of the Base Drainage Lines. If a transducer is connected to the Base Drainage Valve it will need to be vented so water can flow through it
- 5) When it appears that all the air is out of the drainage line close the Valves being used to flush the Base Drain Lines.

To flush the Top:

- 6) Turn the Selection Valve (A3) to the vent position.
- 7) Turn the External Valve (E3) to the External position.
- 8) Open the Triaxial Cell's Top Drain Valve, which is connected to the tube leading to the FlexPanel.
- 9) Open the Triaxial Cell's Top Drain Valve, which is not connected to the Flexpanel so water can flow through the Top Drain Lines and flush air

bubbles out of the Top Drainage Lines. If a transducer is connected to the Top Drainage Valve it will have to be vented so water can flow through it.

- 10) When it appears all the air is out of the drainage lines close the Valves being used to flush the Top Drain Lines.

### **Back Pressure Saturate Sample**

The following steps should be followed to back pressure saturate the sample.

- 1) Turn the Selection Valve (A2) to Pressure.
- 2) Turn the Bias Valve to Bias On.
- 3) Turn the Burette Valve (V2) to Burette.
- 4) Turn the Selection Valve (A3) to off.
- 5) Turn the Bridge Valve (BV) to Bridge On.
- 6) Turn the Burette Valve (V3) to Burette.
- 7) Make sure the Top and Base Valves on the Triaxial cell, which are connected to the FlexPanel, are open. Check the cell pressure by lifting the Toggle Valve (T1).
- 8) Check the level of the water in the Burettes in Section 2 (Base) and 3 (Top) to make sure they are over half full.
- 9) Apply back pressure to Sample.
  - a) Take Pore Pressure reading and Burette readings for Section 2 (Base) and 3 (Top).
  - b) Lift to open Toggle Valve (T2) in Section 2.
  - c) Adjust the back pressure using Regulator (R2). Raise the pressure to 5 psi (35 kpa). When the pressure is increased, check the sample and burette to make sure the Membrane is not blowing up. If water from the Burettes in Section 2 (Base) and 3 (Top) start filling the membrane, close the Top and Base Valves on the Triaxial Cell and check pressure in Section 1 (Cell) to make sure it has increased. The pressure can be read on the Digital Display on the Control Panel.
  - d) Check cell pressure by lifting Toggle Valve (T1) in section 1 and read the pressure on the Digital Display on the control panel. The cell pressure should have increased by 5 psi (35 kpa). If the pressure did not increase by 5 psi (35 kpa) adjust the Pressure Regulator (R1) to the appropriate reading.

The following steps should be followed to check B valve during back pressure saturation.

- 1) Check the back pressure, lift Toggle Valve (T2) in section 2 (Base). Make adjustments in reading if necessary.
- 2) Check the cell pressure, lift Toggle Valve (T1) in section 1 (Cell) and make adjustment in reading if necessary.

- 3) Close the Top and Base Drainage Valves on the base of the Triaxial Cell.
- 4) Take Pore Pressure Transducer reading. The pore pressure transducer is part of the Triaxial cell when we do the triaxial cell manual will address the pore pressure transducer.
- 5) Adjust the back pressure, lift Toggle Valve (T2) in section 2 (Base). Increase pressure by an increment of 5, 10 or 20 psi (35, 70, or 140 kpa).
- 6) Take Pore Pressure Transducer reading. Monitor for 1 to 2 minutes.
- 7) Open the Top and Base Drainage Valves on base of Triaxial Cell.
- 8) Determine the "B" parameter:

$$B = \frac{\Delta\mu}{\Delta\delta_3}$$

$\Delta\mu$  = Change in pore pressure

$\Delta\delta_3$  = Change in cell pressure

The water being pushed into sample can be monitored on Burettes in Sections 2 (Base) and 3 (Top).

### **Consolidation of Sample**

The following steps should be followed to consolidate the sample after back pressure saturation.

- 1) Check the back pressure by lifting the Toggle Valve (T2) under the Pressure Regulator (R2) in Section 2 (Base) and make any adjustments, if necessary, then close the Toggle Valve.
- 2) Check the water level of the Burettes in section 2 (Base) and 3 (Top). The level should be set near the bottom of the burette so that the volume of water coming from the sample can be measured.
- 3) Close the Drainage Valves for the Top and Base on the Triaxial Cell.
- 4) Raise the effective pressure to the desired consolidation pressure. This is done by adjusting pressure regulator (R1) to a pressure which equals the sum of the effective consolidation pressure and the back pressure. To adjust the pressure lift the Toggle Valve (T1) under the Pressure Regulator (R1) in Section 1 (Cell). Change the pressure using the Pressure Regulator (R1). Then close the toggle valve.
- 5) Take Burette readings for the Base (Section 2) and Top (Section 3). Start timing and open the Drainage Valves on the Triaxial Cell at the same time. Take readings on the burettes to monitor rate of consolidation.



## **Shearing Triaxial**

The Following steps should be taken to shear the sample after consolidation.

- 1) Check the back pressure by lifting the Toggle Valve (T2) under the pressure Regulator (R2) in Section 2 (Base). Take a reading, do not adjust, close the Toggle Valve (T2).
- 2) Check the cell pressure by lifting the Toggle Valve (T1) under the Pressure Regulator (R1) in Section 1 (Cell)
  1. Take reading, do not adjust, then close toggle valve
- 3) Place cell in load frame and take reading on pore pressure transducer.
- 4) Take other appropriate steps outlined in the ASTM Standard D4767 or any international standard.
- 5) For a undrained triaxial shear test, close the Drainage Valves on the bottom of the Triaxial Cell, not those going to the pressure transducer.

## **Hydraulic Conductivity of Triaxial Sample**

The following steps can be taken after back pressure saturation or consolidation to set the panel up for Hydraulic Conductivity. There are additional steps to be taken when running the test but they will depend on the type of test being run and the specific equipment being used with the FlexPanel.

- 1) Lift the Toggle Valve (T3) under Pressure Regulator (R3) in section 3 (Top). Adjust the Pressure Regulator (R3) to read the same pressure as Pressure Regulator (R2) in Section 2 (Base). Close the Toggle Valve (T3).
- 2) Turn the Selection Valve (A3) in Section 3 (Top) to Pressure.
- 3) Turn the Bridge Valve (BV) to off.
- 4) Set the Head Pressure across the sample by adjusting Regulator (R2) in Section 2 (Base).
- 5) Make adjustments to the effective stress on the sample using the Pressure Regulator (R1) in Section 1 (Cell).
- 6) Monitor the flow of water in and out of the sample using the Burettes in Sections 2 (Base) and 3 (Top).
- 7) When adjusting water levels in the Burettes, close the Drainage Valve on the Triaxial Cell first. Turn the Selection Valve (A2) and (A3) to Vent, then use the Fill/Drain to adjust water level in Burette.





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