Hydraulics Bench

Instruction Manual

F1-10

ISSUE 11

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United Kingdom	International
(0) 1425 478781 (calls charged at local rate)	+44 (0) 1425 478781 (international rates apply)
Email: support@armfield.co.uk	
Fax: +44 (0) 1425 470916	

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General Overview

The Armfield F1-10 Hydraulics Bench and its comprehensive range of optional accessories have been developed to instruct students in the many different aspects of hydraulic theory.

Each accessory to the F1-10 is supplied as a complete piece of equipment needing no additional service items other than the Hydraulics Bench. When coupled to the bench they are immediately ready for use.

The F1-10 Hydraulics Bench

Equipment Diagrams

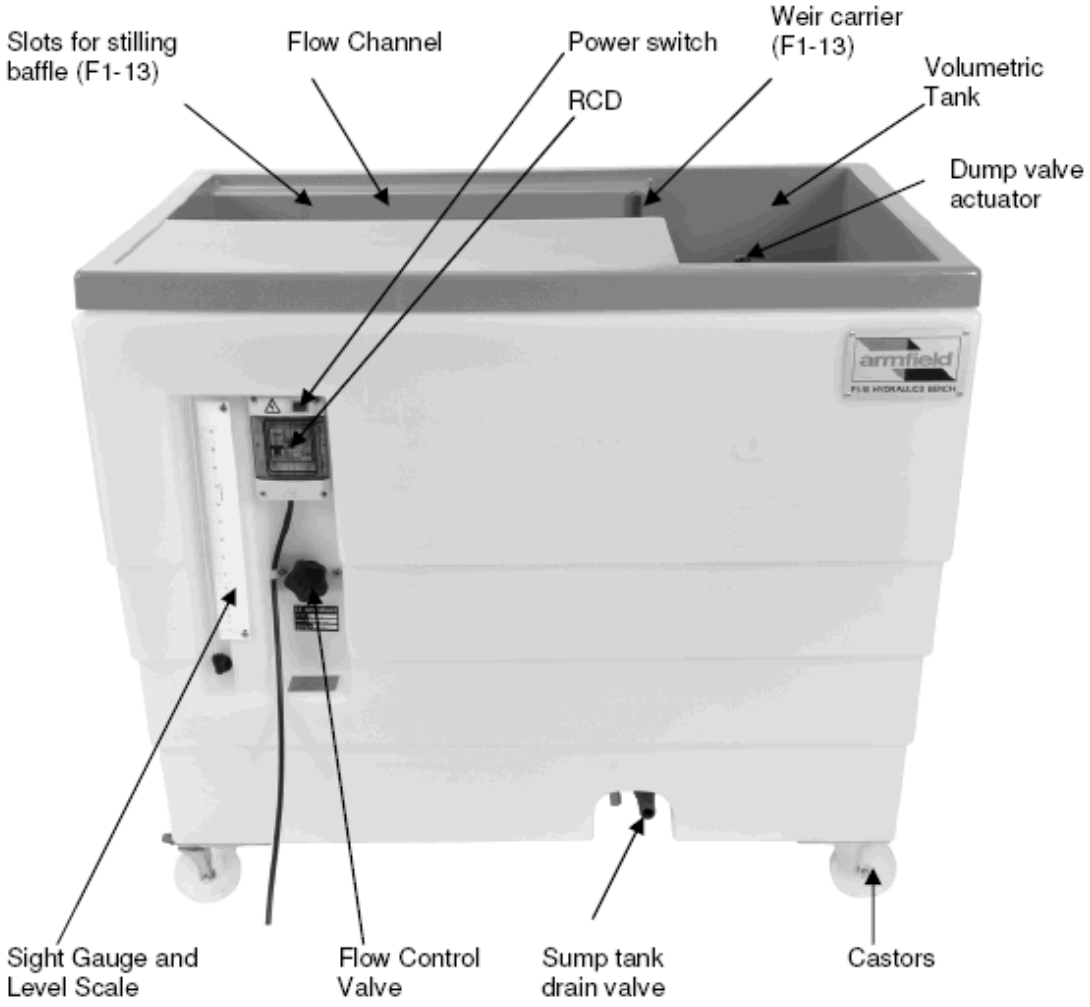


Figure 1: F1-10 Hydraulics Bench

Important Safety Information

Introduction

All practical work areas and laboratories should be covered by local safety regulations which must be followed at all times. If required Armfield can supply a typical set of standard laboratory safety rules.

Your **F1-10 Hydraulics Bench** has been designed to be safe in use, when installed, operated and maintained in accordance with the instructions in this manual. As with any piece of sophisticated equipment, dangers may exist if the equipment is misused, mishandled or badly maintained. If the equipment is used in a manner not specified by Armfield then the protection provided by the equipment may be impaired.

The F1-10 is a heavy piece of equipment, and should be lifted fork lift if possible. Ensure that the arms of the fork lift do not foul the sump moulding in the base of the unit. Do not attempt to lift the unit when it is full of water.

Electrical Safety

The equipment described in this Instruction Manual operates from a mains voltage electrical supply. It must be connected to a supply of the same frequency and voltage as marked on the equipment or the mains lead. If in doubt, consult a qualified electrician or contact Armfield.

The equipment must only be connected to a mains supply with a reliable earth connection so that the equipment is adequately earthed.

The equipment must only be operated using a fused electricity supply. Details of required fuse ratings can be found in Electrical Supply.

The equipment must not be operated with any of the panels removed.

To give increased operator protection, the unit incorporates a Residual Current Device (RCD), alternatively called an Earth Leakage Circuit Breaker, as an integral part of this equipment. If through misuse or accident the equipment becomes electrically dangerous, the RCD will switch off the electrical supply and reduce the severity of any electric shock received by an operator to a level which, under normal circumstances, will not cause injury to that person.

At least once each month, check that the RCD is operating correctly by pressing the TEST button. The circuit breaker **MUST** trip when the button is pressed. Failure to trip means that the operator is not protected and the equipment must be checked and repaired by a competent electrician before it is used.

Accidents can be avoided provided that equipment is **regularly maintained** and **staff** and **students** are made aware of potential hazards. A list of general safety rules is included in this manual, to assist staff and students in this regard. The list is not intended to be fully comprehensive but for guidance only.

Please refer to the following notes regarding the Control of Substances Hazardous to Health Regulations.

Water Borne Hazards

The equipment described in this instruction manual involves the use of water, which under certain conditions can create a health hazard due to infection by harmful micro-organisms.

For example, the microscopic bacterium called Legionella pneumophila will feed on any scale, rust, algae or sludge in water and will breed rapidly if the temperature of water is between 20 and 45°C. Any water containing this bacterium which is sprayed or splashed creating air-borne droplets can produce a form of pneumonia called Legionnaires Disease which is potentially fatal.

Legionella is not the only harmful micro-organism which can infect water, but it serves as a useful example of the need for cleanliness.

Under the COSHH regulations, the following precautions must be observed:

- Any water contained within the product must not be allowed to stagnate, ie. the water must be changed regularly.
- Any rust, sludge, scale or algae on which micro-organisms can feed must be removed regularly, i.e. the equipment must be cleaned regularly.
- Where practicable the water should be maintained at a temperature below 20°C. If this is not practicable then the water should be disinfected if it is safe and appropriate to do so. Note that other hazards may exist in the handling of biocides used to disinfect the water.
- A scheme should be prepared for preventing or controlling the risk incorporating all of the actions listed above.

Further details on preventing infection are contained in the publication “The Control of Legionellosis including Legionnaires Disease” - Health and Safety Series booklet HS (G) 70.

Description

Where necessary, refer to the drawings in the Equipment Diagrams section.

Overview

The F1-10 Hydraulics Bench is designed as a portable and self-contained service module for the range of accessories that are listed later.

The bench is constructed from lightweight corrosion resistant plastic and is mounted on wheels for mobility. The GRP bench top incorporates an open flow channel with ledges along both sides to support the accessory on test. The open end of the channel incorporates a weir carrier and the walls of the channel incorporate a pair of slots for use with accessory F1-13 (Flow over weirs). The weir carrier is also used on accessories F1-26 and F1-27 to mount the discharge manifold.

Volumetric measurement is integral and has been chosen in preference to other methods of flow measurement for its ease of use, accuracy and safety in use (no heavy weights for students to drop). The volumetric measuring tank is stepped to accommodate low or high flow rates. A stilling baffle reduces turbulence and a remote sight tube with scale gives an instantaneous indication of water level inside the volumetric tank. When used in conjunction with a stopwatch/stopclock (not supplied), measurement of the change in level with time allows the volume flowrate to be calculated. A measuring cylinder is provided for measurement of very small flow rates.

A dump valve in the base of the volumetric tank is operated by a remote actuator at the top. Lifting the actuator opens the dump valve allowing the measured volume of water to return to the sump in the base of the bench for recycling. When lifted, a twist of 90° at the actuator will retain the dump valve in the open position. An overflow in the side of the volumetric tank allows water to return directly to the sump preventing the volumetric tank from overfilling if the dump valve remains closed.

Water is drawn from the sump tank by a self-priming centrifugal pump that is mounted in a recess below the sump tank. A panel mounted control valve regulates the flow from the pump to an easy-to-use quick release pipe connector situated in the floor of the moulded channel in the bench top. The flexible supply pipe on most accessories simply attaches to the quick release connector. Where higher flowrates are necessary, as in the case of accessories C4-MKII or C6-MKII, the quick release connector is unscrewed and a full bore coupling is fitted in its place. No hand tools are required for either of these operations allowing rapid interchange of accessories.

A drain valve, incorporated in a recess at the front of the sump tank, facilitates emptying of the sump tank. This valve is used for connecting accessories F1-26 and F1-27 where the auxiliary pump can be used in parallel with the pump fitted to the F1-10.

The electrical supply to the pump motor is via a switch and a residual current device (RCD) mounted in a recess on the front of the bench. The latter gives increased protection to the operator against electrical shock in the event that the equipment becomes electrically dangerous.

Accessories to the Hydraulics Bench

The following accessories are available for use with the F1-10 Hydraulics Bench:

F1-11 Dead Weight Calibrator

F1-12 Hydrostatic Pressure

F1-13 Flow Over Weirs

F1-14 Metacentric Height

F1-15 Bernoulli's Theorem Demonstration

F1-16 Impact Of A Jet

F1-17 Orifice And Free Jet Flow

F1-17a Orifice Discharge

F1-18 Energy Loss In Pipes (Pipe Friction)

F1-19 Flow Channel

F1-20 Osborne Reynolds' Demonstration

F1-21 Flow Meter Demonstration

F1-22 Energy Losses In Bends

F1-23 Free And Forced Vortices

F1-24 Hydraulic Ram

F1-25 Demonstration Pelton Turbine

F1-26 Series/Parallel Pumps

F1-27 Centrifugal Pump Characteristics

F1-28 Cavitation Demonstration

C4-MkII-2.5m Multi-Purpose Teaching Flume (2.5m working section)

C4-MkII-5.0m Multi-Purpose Teaching Flume (5.0m working section)

C6-MkII-10 Fluid Friction Apparatus

Each accessory is available with educational software which provides automatic calculation of required results using manually input measurements, along with help texts detailing experimental procedures.

Installation

Electromagnetic Compatibility

This apparatus is classified as Education and Training Equipment under the Electromagnetic Compatibility (Amendment) Regulations 1994. Use of the apparatus outside the classroom, laboratory or similar such place invalidates conformity with the protection requirements of the Electromagnetic Compatibility Directive (89/336/EEC) and could lead to prosecution.

Electrical Supply

	F1-10-A	F1-10-B	F1-10-G
Green/yellow or Green lead	Earth (Ground)	Earth (Ground)	Earth (Ground)
Brown or Black lead	Live (Hot)	Live (Hot)	Live (Hot)
Blue or White lead	Neutral	Neutral	Neutral
Fuse Rating	10 A	20 A	10 A
Voltage	220-230V	110-120V	220V
Frequency	50Hz	60Hz	60Hz

The mains cable supplied with the equipment is terminated with a plug to suit the local electrical supply. Three versions of the F1-10 are available:

F1-10-A 230V/1ph/50Hz – mains lead fitted with a 2 pin Shuko European style plug with adaptor to 3 pin UK style plug.

F1-10-B 120V/1ph/60Hz – mains lead fitted with a 3 pin NEMA 5-15P plug.

F1-10-G 220V/1ph/60Hz – mains lead fitted with 3 pin NEMA 6-15P plug.

This apparatus is classified as Education and Training Equipment under the Electromagnetic Compatibility (Amendment) Regulations 1994. Use of the apparatus outside the classroom, laboratory or similar such place invalidates conformity with the protection requirements of the Electromagnetic Compatibility Directive (89/336/EEC) and could lead to prosecution.

Water Supply

A temporary supply of water is required for filling the sump tank (capacity 250 litres). Connection to a water supply is not necessary when the bench is in use.

Drain

Temporary connection to a drain is required when emptying the sump tank after use. A suitable flexible hose (not supplied) should be attached to the drain valve in the front wall of the sump tank.

Ensure that the drain is suitable if the water is coloured with dye following flow visualisation demonstrations.

Installation Guide

The Hydraulics Bench is supplied fully assembled and only requires filling with water and connection to an electrical supply for it to be operational.

When the bench has been encased in a wooden crate, for protection during shipping, remove the wooden crate taking care not to damage the bench inside.

Carefully remove the protective cardboard cover from the bench by raising it vertically upwards.

Remove any additional packaging materials from the measuring cylinder, stilling baffle and flexible feed pipe. Ensure that the stilling baffle is located inside the volumetric tank adjacent to the rectangular cut-out at the end of the moulded channel in the bench top. Place the measuring cylinder and flexible feed pipe in a secure location.

Position the Hydraulics Bench in the desired location on a firm level surface following the recommendations in the section ‘Installation Requirements’.

The F1-10 Hydraulics Bench is designed for static location on a firm level floor. For ease of mobility, the bench is mounted on four castors, two of which have brakes.

A temporary supply of clean, cold water is required for the initial filling of the sump tank. A drain is required when emptying the sump tank after use. The water may be coloured with dye provided that this is non-staining and safe for student use.

For ease of mobility, the bench is mounted on four castors, two of which have brakes. Release the brakes and position the bench adjacent to the water supply.

Check that all packaging has been removed from the bench, close the drain valve in the front wall of the sump tank and apply the brakes before filling the sump tank with water.

Before filling with water for the first time it is suggested that the bench is cleaned using a cloth soaked in warm soapy water to remove any grease or dirt that has accumulated during shipping.

Place a filling hose into the overflow slot in the side wall of the volumetric tank so that water will flow directly into the sump tank. Lift the dump valve (sealing ball and weight) out of the aperture in the base of the volumetric tank so that the level inside the sump tank can be observed.

Add a few drops of wetting agent to the sump tank, via the aperture in the base of the volumetric tank, to minimise the effects of surface tension.

Note: If too much wetting agent is added foaming will occur and it will be necessary to replace the water.

Turn on the water supply and allow the sump tank to fill until the water level is just below the outlet in the bottom of the volumetric tank.

When the sump tank is full, turn off the water supply and remove the filling hose. Replace the dump valve in the base of the volumetric tank and locate the actuator in

the raised position so that water can return to the sump tank from the volumetric tank (A twist of 90° at the actuator will retain the dump valve in the open position).

Release the castor brakes and move the bench to the required operating position within reach of the electricity supply.

Attach the flexible feed pipe to the quick release connector on the water inlet in the bed of channel. The free end of the feed pipe should be positioned in the stilling baffle of the volumetric tank. Close the flow control valve.

The equipment requires connection to a single phase fused electrical supply. A 4m length of cable is supplied with the equipment. The electrical requirements of the different versions are described in Electrical Supply.

Connect the equipment to the electrical supply, ensuring that the label fitted to the mains lead on the equipment matches the electrical supply. Switch on the RCD then press the TEST button to check that the RCD is operating correctly. The RCD must trip.

Switch on the RCD again.

Operate the pump ON/OFF switch then slowly open the flow control valve and check that water is delivered to the volumetric tank via the flexible feed pipe.

When the pipework has fully primed and water is flowing steadily into the volumetric tank, release the actuator of the dump valve to seal the aperture in the bottom of the volumetric tank. Allow the volumetric tank to fill until water returns to the sump tank through the overflow. Now check that the sight tube is full and no air bubbles are present. Repeat this filling operation a number of times, ensuring that the sight tube is free from air bubbles.

Adjust the water level in the volumetric tank until the surface is level with the step in the bottom of the tank. A few drops of wetting agent smeared onto the step will enable an accurate level to be achieved.

If necessary, slacken the securing screws at the top and bottom of the sight tube scale and position the scale so that the meniscus of the fluid in the tube is level with the black datum line engraved between the lower and upper scales. This will ensure that the scale is positioned correctly for volumetric measurements using the low or high ranges.

The hydraulics bench is now ready for use.

Installing the Software

Software is available for all accessories designed for use with the F1-10 Hydraulics Bench. Once the experimental data is entered, the software will perform the calculations required by the experiments presented in the accessory teaching manual, reducing the time required to complete the experiments and freeing student study time that would otherwise have been spent performing repetitive calculations.

The software for each accessory includes a *Questions* section, designed to test a student's knowledge of the theory being demonstrated with that accessory. Some calculations may be hidden until the student has answered the questions (in order to prove that they can correctly perform the calculations themselves). A *Lecturer Mode* has been provided which avoids the requirement to complete the questions section. Should the lecturer wish to demonstrate the equipment, or to test the students in an

alternative manner, Lecturer Mode can be selected from the Options menu or by selecting the mortar board (teacher's hat) symbol from the toolbar.

The password required for all Armfield educational software is '*armfield*'.

Setting Up the Software

In order to install the software:

- Insert the CD into CD or DVD/CD drive:
- Choose 'Run' from the 'Start' menu.
- Type **d:setup** (where d: is the drive letter) into the 'Open' box, then choose 'OK'.

The Armfield software will be installed onto the hard drive of the computer and a program group will be set up within Programs in the Start menu.

Operation

Where necessary, refer to the drawings in the Equipment Diagrams section.

Operating the Equipment

Measurement of Volume Flow Rate

The moulded bench top incorporates a volumetric measuring tank which is stepped to accommodate low or high flow rates.

A remote level gauge, consisting of a sight tube and calibrated scale is connected to a tapping in the base of the tank, and gives an instantaneous indication of water level inside the volumetric tank. The scale is divided into two zones corresponding to the volume above and below the step in the tank. In operation, the volumetric tank is emptied by lifting the dump valve, allowing water to return to the sump. When flow trough the model on test has stabilised, the dump valve is lowered, retaining the water in the tank.

Timings are taken as the water level rises in the tank. Low flow rates are monitored on the lower portion of the scale corresponding to the small volume beneath the step (6 litres capacity). Larger flow rates are monitored on the upper scale corresponding to the main tank (40 litres capacity).

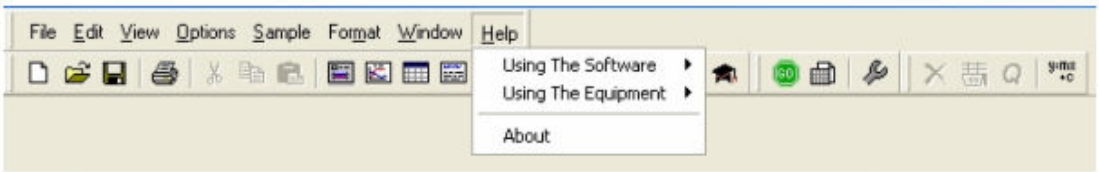
When extremely small volumetric flow rates are to be measured, the measuring cylinder should be used rather than the volumetric tank. When using the measuring cylinder diversion of the flow to and from the cylinder should be synchronised as closely as possible with the starting and stopping of the watch.

All volumetric readings using the volumetric tank should be taken with the stilling baffle installed since calibration has been effected in this condition.

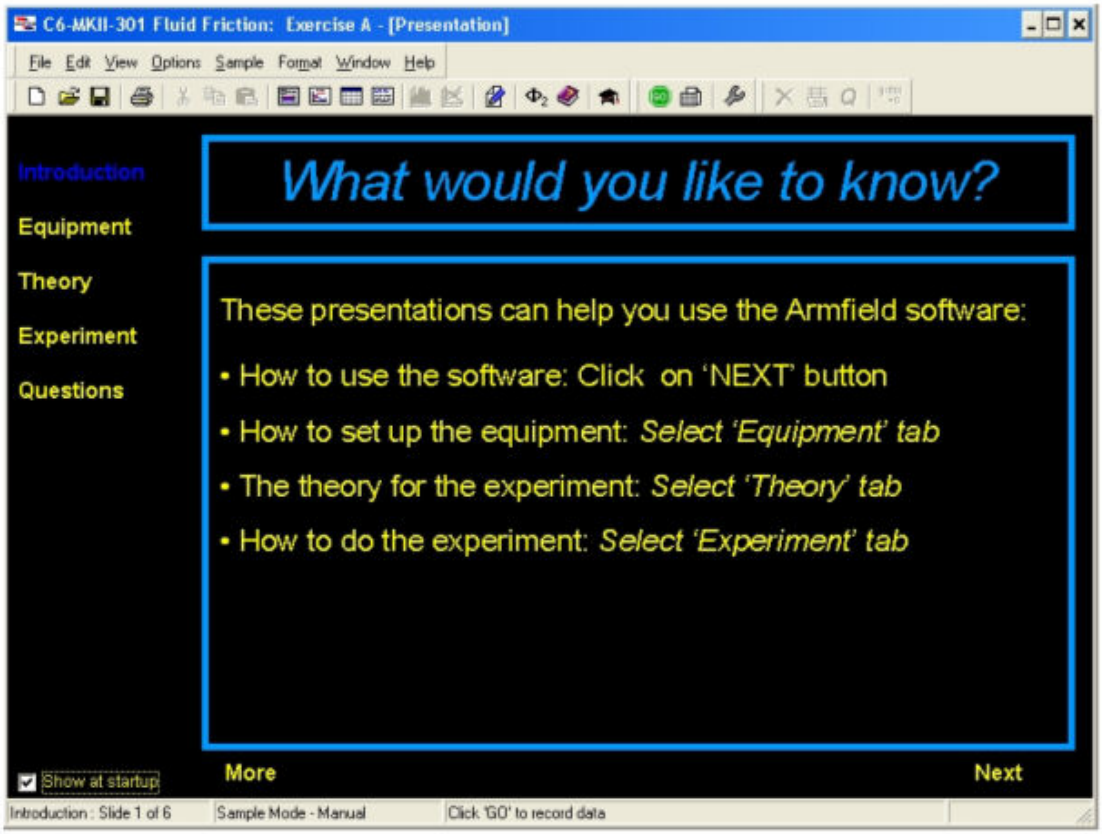
Operating the Software

Note: The diagrams in this section are included as typical examples and may not relate specifically to an individual product.

The Armfield Software is a powerful Educational and Data Logging tool with a wide range of features. Some of the major features are highlighted below, to assist users, but full details on the software and how to use it are provided in the presentations and Help text incorporated in the Software. Help on Using the Software or Using the Equipment is available by clicking the appropriate topic in the **Help** drop-down menu from the upper toolbar when operating the software as shown:



Load the software. If multiple experiments are available then a menu will be displayed listing the options. Wait for the presentation screen to open fully as shown:

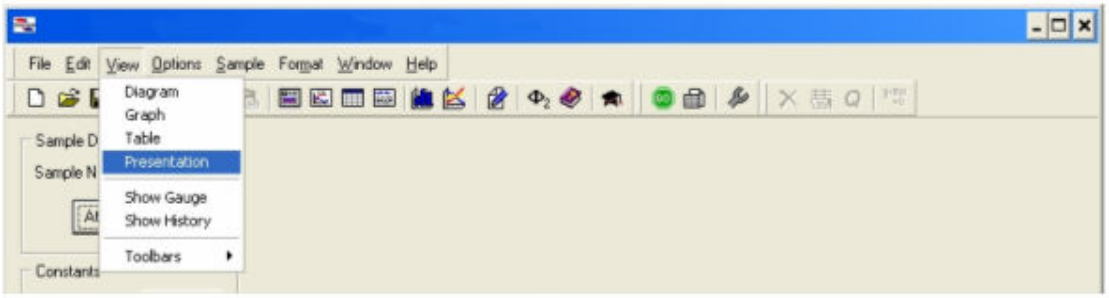


Presentation Screen - Basics and Navigation

As stated above, the software starts with the Presentation Screen displayed. The user is met by a simple presentation which gives them an overview of the capabilities of the equipment and software and explains in simple terms how to navigate around the software and summarizes the major facilities complete with direct links to detailed context sensitive 'help' texts.

To view the presentations click **Next** or click the required topic in the left hand pane as appropriate. Click **More** while displaying any of the topics to display a Help index related to that topic.

To return to the Presentation screen at any time click the View Presentation icon  from the main tool bar or click **Presentation** from the dropdown menu as shown:



For more detailed information about the presentations refer to the **Help** available via the upper toolbar when operating the software.

Toolbar

A toolbar is displayed at the top of the screen at all times, so users can jump immediately to the facility they require, as shown:

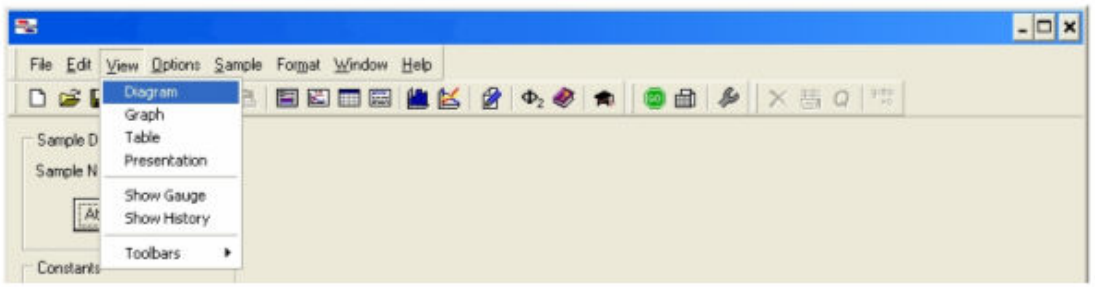
The upper menu expands as a dropdown menu when the cursor is placed over a name.

The lower row of icons (standard for all Armfield Software) allows a particular function to be selected. To aid recognition, pop-up text names appear when the cursor is placed over the icon.

Mimic Diagram

The Mimic Diagram is the most commonly used screen and gives a pictorial representation of the equipment, with boxes to enter measurements from the equipment, display any calculated variables etc. directly in engineering units.

To view the Mimic Diagram click the View Diagram icon  from the main tool bar or click **Diagram** from the **View** drop-down menu as shown:



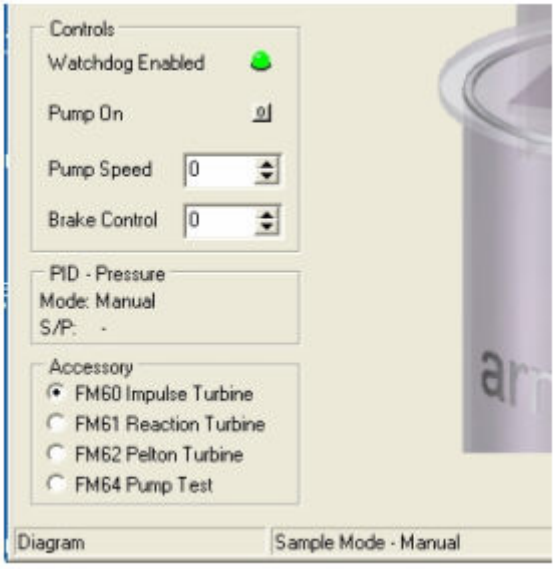
The mimic diagram displayed will depend on the accessory connected to the F1-10. Refer to ‘Operating the Software’ in the instruction manual supplied with the accessory for more details about the mimic diagram displayed.

Manual data input boxes with a coloured background allow measured variables, constants such as Orifice Cd and Atmospheric Pressure, as appropriate, to be changed by over-typing the default value. After typing the value press the Return key or click on a different box to enter the value.

In addition to measured variables such as Volume, Time, Temperature or Pressure, calculated data such as Discharge / Volume flowrate, Headloss etc are continuously displayed in data boxes with a white background. These are automatically updated and cannot be changed by the user.

After entering a complete set of data from measurements on the equipment click on the  icon to save the set of results before entering another set.

The mimic diagram associated with some products includes the facility to select different experiments or different accessories, usually on the left hand side of the screen, as shown:



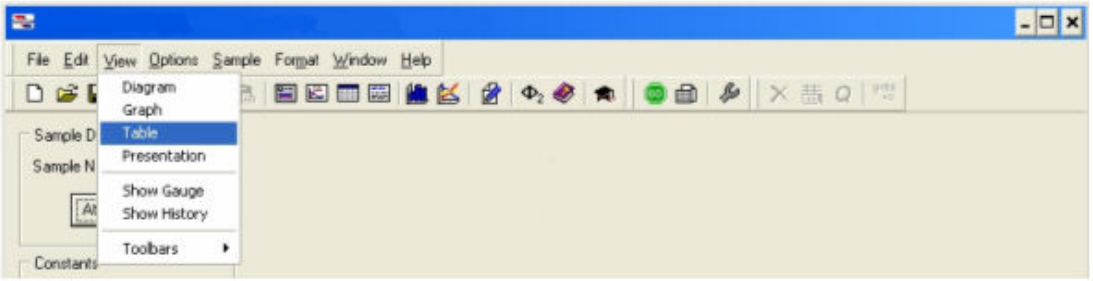
Clicking on the appropriate accessory or exercise will change the associated mimic diagram, table, graphs etc to suit the exercise being performed.

Data Logging Facilities in the Mimic Diagram

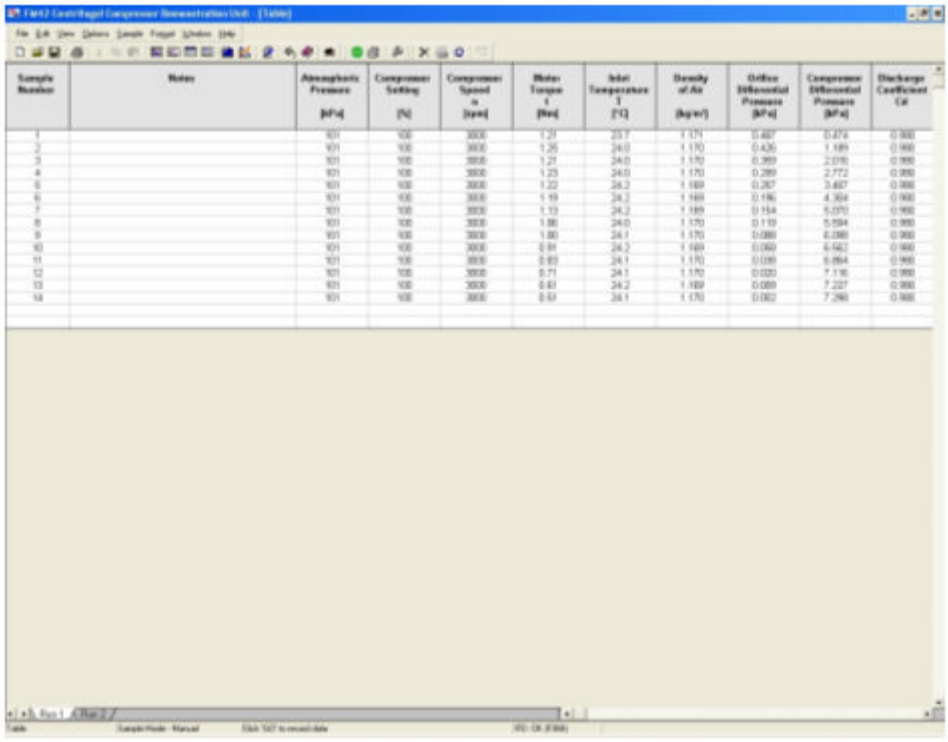
Armfield software designed for manual entry of measured variables does not include automatic data logging facilities and these options are greyed out where not appropriate. When manually entering data the  icon simply saves the set of entered data into a spreadsheet as described above.

Tabular Display

To view the Table screen click the View Table icon  from the main tool bar or click **Table** from the View dropdown menu as shown:



The data is displayed in a tabular format, similar to the screen as shown:



As the data is sampled, it is stored in spreadsheet format, updated each time the data is sampled. The table also contains columns for the calculated values.

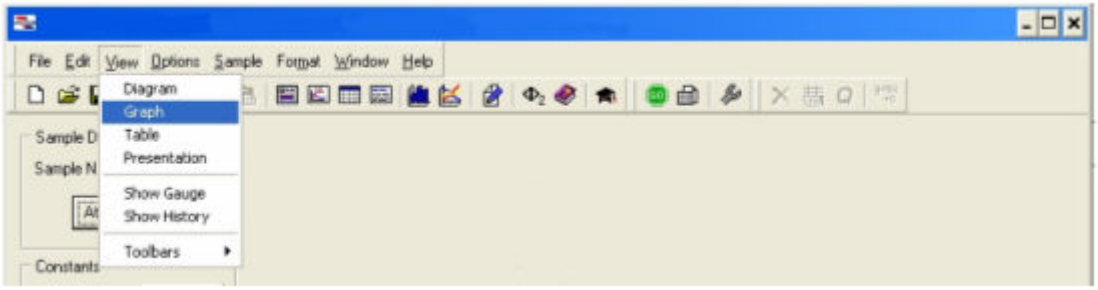
New sheets can be added to the spreadsheet for different data runs by clicking the  icon from the main toolbar. Sheets can be renamed by double clicking on the sheet name at the bottom left corner of the screen (initially Run 1, Run 2 etc) then entering the required name.

For more detailed information about Data Logging and changing the settings within the software refer to the **Help** available via the upper toolbar when operating the software.

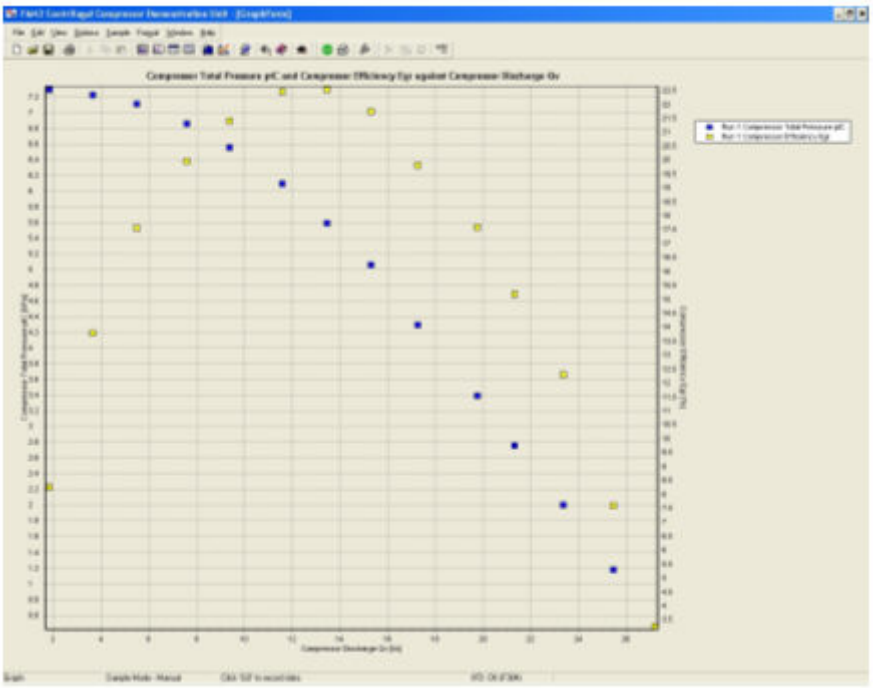
Graphical Display

When several samples have been recorded, they can be viewed in graphical format.

To view the data in Graphical format click the View graph icon  from the main tool bar or click **Graph** from the **View** drop-down menu as shown:



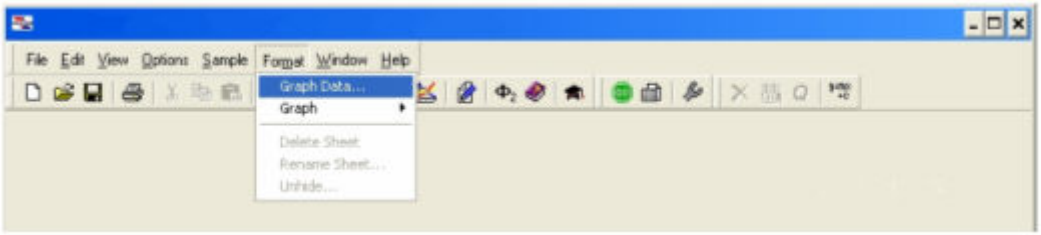
The results are displayed in a graphical format as shown:



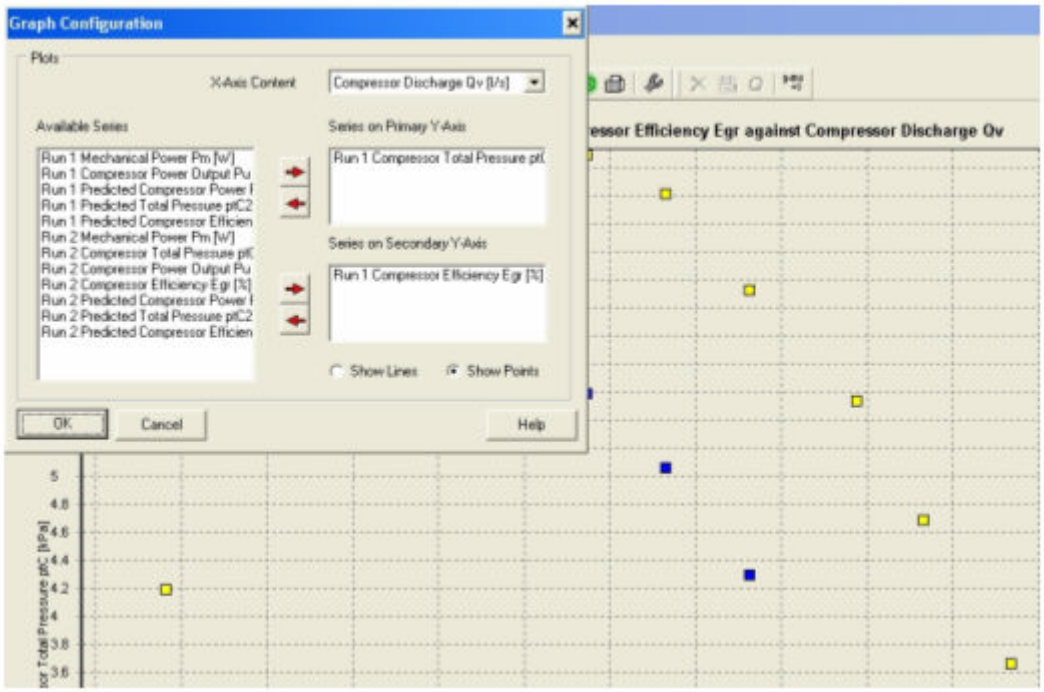
(The actual graph displayed will depend on the product selected and the exercise that is being conducted, the data that has been logged and the parameter(s) that has been selected).

Powerful and flexible graph plotting tools are available in the software, allowing the user full choice over what is displayed, including dual y axes, points or lines, displaying data from different runs, etc. Formatting and scaling is done automatically by default, but can be changed manually if required.

To change the data displayed on the Graph click **Graph Data** from the **Format** dropdown menu as shown:



The available parameters (Series of data) are displayed in the left hand pane as shown:



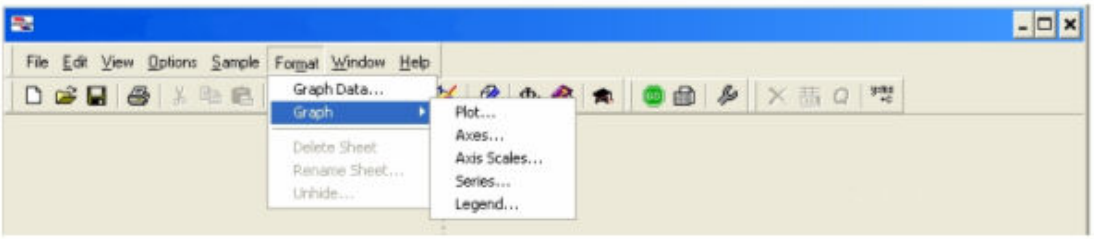
Two axes are available for plotting, allowing series with different scaling to be presented on the same x axis.

To select a series for plotting, click the appropriate series in the left pane so that it is highlighted then click the appropriate right-facing arrow to move the series into one of the windows in the right hand pane. Multiple series with the same scaling can be plotted simultaneously by moving them all into the same window in the right pane.

To remove a series from the graph, click the appropriate series in the right pane so that it is highlighted then click the appropriate left-facing arrow to move the series into the left pane.

The X-Axis Content is chosen by default to suit the exercise. The content can be changed if appropriate by opening the drop down menu at the top of the window.

The format of the graphs, scaling of the axes etc. can be changed if required by clicking **Graph** in the **Format** drop-down menu as shown:



For more detailed information about changing these settings refer to the **Help** available via the upper toolbar when operating the software.

Equipment Specifications

Overall Dimensions

The overall dimensions of the F1-10 Hydraulics Bench are as follows:

Length - 1.13m

Width - 0.73m

Height - 1.00m

Equipment Location

The equipment is designed to stand on level ground capable of carrying the loadings involved. Access is required all round the service unit.

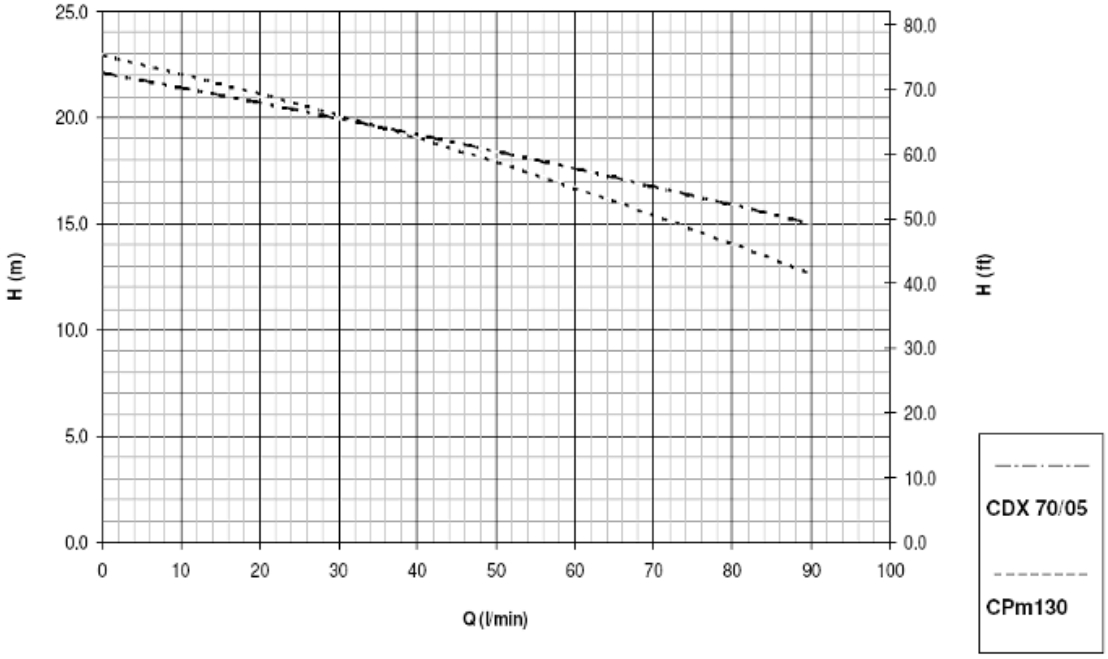
The equipment requires connection to a single phase, fused electrical supply. Five metres of supply cable are included with the equipment.

The equipment is a self-contained unit and needs only a temporary supply of cold water for the initial filling of the sump tank and for cleaning/flushing purposes.

Equipment Details

Circulating Pump:	Type: Centrifugal Max. head: 21m H_2O Max. flow: 80 litres/min (using volumetric tank) Max. flow: 100 litres/min (using appropriate accessory)
Pump motor rating:	0.37kW
Sump tank capacity:	250 litres
High-flow volumetric tank capacity:	40 litres
Low-flow volumetric tank capacity:	6 litres

Pump Performance Curve



Pump Performance Curve for CDX 70/05 and CPm130

Environmental Conditions

This equipment has been designed for operation in the following environmental conditions. Operation outside of these conditions may result reduced performance, damage to the equipment or hazard to the operator.

a. Indoor use;

b. Altitude up to 2000 m;

c. Temperature 5 °C to 40 °C;

d. Maximum relative humidity 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C;

e. Mains supply voltage fluctuations up to ±10 % of the nominal voltage;

f. Transient over-voltages typically present on the MAINS supply;

NOTE: The normal level of transient over-voltages is impulse withstand (over-voltage) category II of IEC 60364-4-443;

g. Pollution degree 2.

Normally only nonconductive pollution occurs.

Temporary conductivity caused by condensation is to be expected.

Typical of an office or laboratory environment

Routine Maintenance

Responsibility

To preserve the life and efficient operation of the equipment it is important that the equipment is properly maintained. Regular maintenance of the equipment is the responsibility of the end user and must be performed by qualified personnel who understand the operation of the equipment.

General

In addition to regular maintenance the following notes should be observed:

1. When not in use the Hydraulics Bench should be disconnected from the electricity supply.

2. The bench should be disconnected from the electricity supply during all maintenance operations.

3. After use, all accessories should be removed from the bench, drained of water and cleaned thoroughly.

4. If the bench is not to be used for any period of time all water should be drained via the drain valve in the front wall of the sump tank. A sponge may be used to remove any remaining water from the bench top flow channel and volumetric tank.

5. The bench mouldings should be cleaned regularly using a mild detergent or cleaning agent suitable for use with plastics.

6. The water in the sump tank should be replaced at regular intervals.

   When dye is used with appropriate accessories the water will require replacing more frequently. It is suggested that the sump tank is flushed through several times with clean water to remove any contamination. Any dye used must be non-staining and safe for student use.

   Note: If necessary the moulded top can be removed to gain access to the sump tank if cleaning is necessary. The top moulding should be lifted partially and retained in this position using suitable supports. The flexible connections between the pump/bench top inlet and sight tube/tapping at the base of the volumetric tank should be disconnected. The top moulding can then be lifted clear of the bottom moulding.

   Reassembly is the reverse of the above procedure.

   The centrifugal pump is located in a recess below the sump tank. The pump should not normally require any maintenance. However, if access to the pump is required then the sump tank should be drained, the top should be removed as described above then the lower moulding should be tipped over onto one side on to a large piece of cardboard or similar to protect the moulding from damage.

Contact Details for Further Information

Main Office: **Armfield Limited**

Bridge House
West Street
Ringwood
Hampshire
England BH24 1DY

Tel: +44 (0)1425 478781
Fax: +44 (0)1425 470916
Email: sales@armfield.co.uk
Web: http://www.armfield.co.uk

US Office: **Armfield Inc.**

436 West Commodore Blvd (#2)
Jackson, NJ 08527

Tel: (732) 928 3332
Fax: (732) 928 3542
Email: info@armfieldinc.com