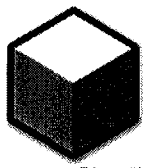


armfield

Hydraulics Bench

Instruction Manual

F1-10

ISSUE 13

November 2015

PC-0055555

1 Introduction

This manual contains instructions for the correct use and maintenance of the F1-10 manufactured by Armfield Limited.

The information contained in this manual is intended for the user who is required to read it carefully and to ensure that he has fully understood it before operating the machine.

The user manual must be available for ready consultation at all times.

If the manual is lost or damaged contact the manufacturer for a replacement copy.

WARNING - The manufacturer is not liable for consequences resulting from an improper use of the machine due to the user's failure to read this manual or incomplete reading of it.

The manual is an integral part of each piece of equipment and consequently must be kept throughout the entire service life of the machine and accompany it at all times, even if transferred to another user.

This manual contains instructions required for the safety, receiving, installation, storage, correct operation and maintenance of the F1-10.

WARNING - Armfield Limited reserves the right to modify the specifications referred to in this manual or the characteristics of each machine. Some of the illustrations in this manual may include parts that are slightly different to those mounted on your machine.

WARNING - All practical work areas and laboratories should be covered by local regulations which must be followed at all times.

2 EC Conformity

Each machine is accompanied by an EC Declaration of Conformity signed by the representative of Armfield Limited.

The declaration of conformity states the model and serial number.

The equipment has been constructed in compliance with the essential health and safety requirements laid down in the following applicable directives:

2006/95/EC The Low Voltage Directive

2004/108/EC The Electromagnetic Compatibility Directive

2006/42/EC The Machinery Directive

The following harmonised standards were also consulted for the design and construction of the equipment:

BS EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control, and laboratory use
BS EN 61000-6-1:2007	Electromagnetic compatibility (EMC). Generic standards. Immunity for residential, commercial and light-industrial environments
BS EN 61000-6-3:2001	Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments

WARNING - This declaration is only valid if the Equipment is installed, used and maintained in compliance with the above mentioned directives and instructions and with the instructions and equipment described in this manual.

Table of Contents

3 Disclaimer

This document and all the information contained within it are proprietary to Armfield Limited. This document must not be used for any purpose other than that for which it is supplied and its contents must not be reproduced, modified, adapted, published, translated or disclosed to any third party, in whole or in part, without the prior written permission of Armfield Limited.

Should you have any queries or comments, please contact the Armfield Customer Support helpdesk (Monday to Thursday: 0830 - 1730 and Friday: 0830 - 1300 UK time). Contact details are as follows:

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	

4 Copyright and trademarks

Any technical documentation made available by Armfield Limited is the copyright work of Armfield Limited and wholly owned by Armfield Limited.

Brands and product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

5 Symbols

 General warning indicating the potential risk of personal injury

 Danger warning

 Caution: Explosion Risk

 Electrical hazard

 Cold Burn hazard

 High Voltage hazard

 Caution: Flammable

 Rotating parts hazard

 Caution: Biohazard

 Caution: corrosive material

 Do not remove safety guards from rotating parts

 Do not repair or oil machine whilst in motion

 This symbol draws your attention to the information

 Wear protective gloves

 Wear eye protection

 Wear ear protection

 Wear safety shoes

 Wear breathing protection

6 Safety

6.1 Failure to comply with safety standards

 Failure to comply with the safety standards described in this manual and those relating to common sense can cause danger to people and the environment and damage the Equipment.

Specifically, such non-observance can cause:

- inability of machine and/or plant to perform key functions;
- damage to the machine and /or plant ;
- electrical, mechanical and/or chemical danger to persons;
- environmental danger due to leakage of hazardous substances.

Failure to observe and comply with these safety standards will invalidate the warranty.

Keep these instructions and all related documents together, ensure that they are legible and easily accessible to all employees.

 Do not remove any safety equipment before operating the Equipment or during its operation. Make sure that there is no evident danger before powering up the Equipment. The system must be inspected regularly to check for damage and to ensure that all safety devices are in good working order.

 The Equipment contains moving parts. Do not insert limbs or materials other than the processing material while the Equipment is functioning. In the event of malfunction, danger or lack of appropriate safety systems, shut down the Equipment immediately and inform the qualified personnel.

6.2 Start up, operation and maintenance

The customer is required to verify the suitability of the Equipment for his specific needs, to provide the necessary processing data for a correct selection of the Equipment type and the accessories needed to guarantee the safety of the Equipment. If the user notices that any accessories he considers useful or essential are missing in the order confirmation, it is the customer's responsibility to contact the manufacturer and request that the accessory or accessories be applied to the Equipment.

 While the Equipment is being used the safety devices provided must be present and correctly installed. Do not carry out any operation on the safety devices while the Equipment is operating.

6.3 Intended conditions of use

The F1-10 Hydraulics Bench is a service unit, with integral circulating pump, designed to supply water to a range of optional accessories designed to introduce students to the fundamental principles of fluid statics and fluid mechanics. The Bench incorporates a stepped volumetric tank that allows low and high flowrates to be measured using a stopwatch. Clean water, stored in the base of the Bench is used as the operating fluid to provide safe demonstrations.

 The Equipment must always observe the operating limitations for which it was constructed and those stated in the order confirmation: observe the temperature, pressure, capacity, viscosity and speed limits. Unless otherwise stated in the order, the Equipment must not be used in environments subject to the formation of potentially explosive atmospheres.

6.4 Safety guidelines relating to maintenance, inspection and assembly work

 The user must ensure that all maintenance, inspection and assembly operations related to the Equipment are carried out by qualified technicians.

Technicians must carefully read this instruction manual before acting on the Equipment. Only authorised and trained personnel are permitted to work on the Equipment.

6.5 Arbitrary production and transformation of spare parts

 Changes or modifications to the machine, within the limits that do not go beyond extraordinary maintenance, are only permitted if agreed on beforehand with the manufacturer.

Only original spare parts or parts specifically declared as compatible by Armfield Limited must be used for regular maintenance operations.

These parts have been designed specifically for the system. There is no guarantee that non-original parts can withstand the loads, and function correctly and safely.

The use of non-original parts voids the warranty.

6.6 Noise

The A-weighted sound power level emitted by the machine does not exceed 70 dB(A).

This value is guaranteed if the Equipment is installed correctly, that is, in stable conditions with appropriate fastenings and measured at a distance of 1 metre from the Equipment.

6.7 Chemical Safety

Clean water, used as the operating fluid, is stored in the base of the unit so precautions must be taken to avoid stagnation of the water. Cleaning should be carried out regularly as described in the maintenance section of this manual which may involve the use of detergents/chemicals. In addition, under certain conditions causing algal growth, it may be necessary to use disinfectants or biocides to avoid the possibility of water-borne infections. However, care must be taken when using chemicals as described below.

6.8 Control of Hazardous Substances

The Control of Substances Hazardous to Health Regulations

The COSHH regulations impose a duty on employers to protect employees and others from substances used at work which may be hazardous to health.

COSHH covers substances that are hazardous to health. Substances can take many forms and include:

- chemicals
- products containing chemicals
- fumes
- dusts
- vapours
- mists
- nanotechnology
- gases and asphyxiating gases and
- biological agents (germs). If the packaging has any of the hazard symbols, then it is classed as a hazardous substance.

- germs that cause diseases such as leptospirosis or legionnaires disease and germs used in laboratories.

The regulations require you to make an assessment of all operations which are liable to expose any person to these hazards. You are also required to introduce suitable procedures for handling these substances and keep appropriate records.

Since the equipment supplied by Armfield Limited may involve the use of substances which can be hazardous (for example, cleaning fluids used for maintenance or chemicals used for particular demonstrations) it is essential that the responsible person in authority implements the COSHH regulations or local equivalent.

Safety data sheets

The regulations also ensure that the relevant Health and Safety Data Sheets must be available for all hazardous substances used in the laboratory.

Products you use may be 'dangerous for supply'. If so, they will have a label that has one or more hazard symbols. These products include common substances in everyday use such as paint, bleach, solvent or fillers. When a product is 'dangerous for supply', by law, the supplier must provide you with a safety data sheet.

Note: medicines, pesticides and cosmetic products have different legislation and don't have a safety data sheet. Ask the supplier how the product can be used safely.

Any person using a hazardous substance must be informed of the following:

- Physical data about the substance.
- Any hazard from fire or explosion.
- Any hazard to health.
- Appropriate First Aid treatment.
- Any hazard from reaction with other substances.
- How to clean/dispose of spillage.
- Appropriate protective measures.
- Appropriate storage and handling.

Although these regulations may not be applicable in your country, it is strongly recommended that a similar approach is adopted for the protection of the users operating the equipment. Local regulations must also be considered.

More information can be found on http://www.hse.gov.uk/coshh/index.htm

 Any such chemicals used must be stored, handled, prepared and used in accordance with the manufacturer's instructions and with all applicable local regulations. Protective clothing (e.g. gloves, eye protection) should be worn when appropriate, and users should be supplied with any relevant safety information (e.g. the correct procedure in the event of contact with skin or eyes, the correct procedure in the event of a spill, etc.).

6.9 Water Borne Hazards

 The equipment described in this instruction manual involves the use of water/fluid, 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/fluid contained within the product must not be allowed to stagnate, i.e. 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/fluid should be maintained at a temperature below 20°C or the water should be disinfected. In the F1-10 this may not be practicable so the equipment should be drained after use and filled with fresh water for each run. Note that other hazards may exist in the handling of biocides if these are used to disinfect the water.
- After use the water system should be filled and run with water containing a mild disinfectant such as 'Milton' to kill any micro-organisms or algal growth then flushed with clean water and left empty.
- 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.

6.10 Hot/Cold Surfaces

 This unit is designed to operate with water at ambient temperature but the surface of some accessories with an external electrical supply may become hot during operation.

6.11 Hot/Cold Liquids

 This unit is designed to operate with water at ambient temperature. The water pump should not be left running against closed valve for long periods of time to avoid heating the water and possible damage to the circulating pump.

Observe any hot surface warning labels to attached to accessories.

6.12 Leakage of hazardous fluids

 If the Equipment is used to pump/operate with hazardous liquids (toxic, corrosive, flammable, etc.), the volumes of fluid that leak through the seals must be collected and disposed of without endangering human health or the environment and in accordance to local legislation.

6.13 Protective clothing

Wear appropriate protective clothing to protect body parts.

 Safety gloves

Wear suitable gloves to protect your hands from various types of possible hazards: mechanical, electrical, chemical and high/low temperatures.

 Clothing

Wear appropriate clothing to protect your body from chemical hazards.

 Footware

Wear safety footwear to protect your feet from falling objects.

 Eye Protection

Wear suitable eye protection to protect your eyes from various types of possible hazards: mechanical debris, chemicals and hot water/steam.

 Ear Protection

Wear suitable ear protection to protect your ears from excessive noise.


Breathing Protection

Wear suitable breathing protection to protect your respiratory system from fumes.

6.14 Machine maintenance


Do not disassemble the Equipment before emptying the contents/fluids (if applicable). Even if the tubes are all empty, some liquid could remain in the unit. The fluid(s) can be hazardous to human health and the environment, and can be very hot/cold.


All maintenance work must be carried out with the machine isolated from the power supply.


Before beginning maintenance on the Equipment remember to isolate the power supply. All the devices must be secured against automatic or accidental restart. (Where possible turn the main switch to OFF and disconnect the electrical supply. In particular situations where you need to run the Equipment while servicing at least 2 persons must be present so that in the event of danger one person will be able to disconnect the power supply or raise the alarm. Once maintenance has been completed remember to restore the safety devices and check that they are in good working order.

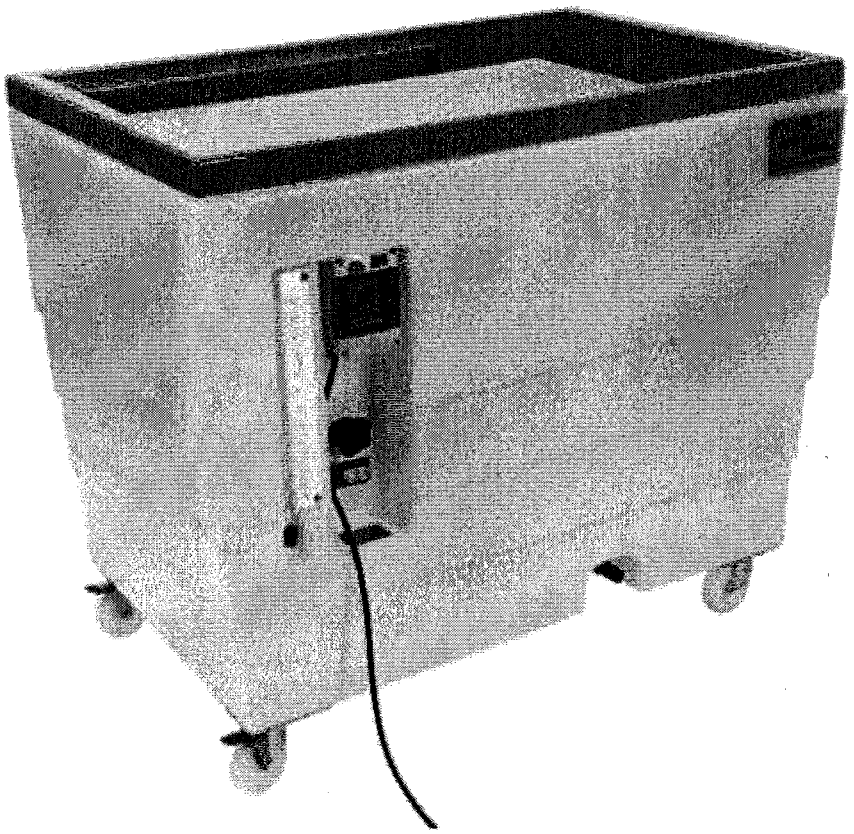

To give increased operator protection, the unit incorporates a Residual Current Device (RCD), alternatively called an Earth Leakage Circuit Breaker, as an integral part of this equipment. If through misuse or accident the equipment becomes electrically compromised, the RCD will switch off the electrical 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.

7 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

8 Equipment Diagrams

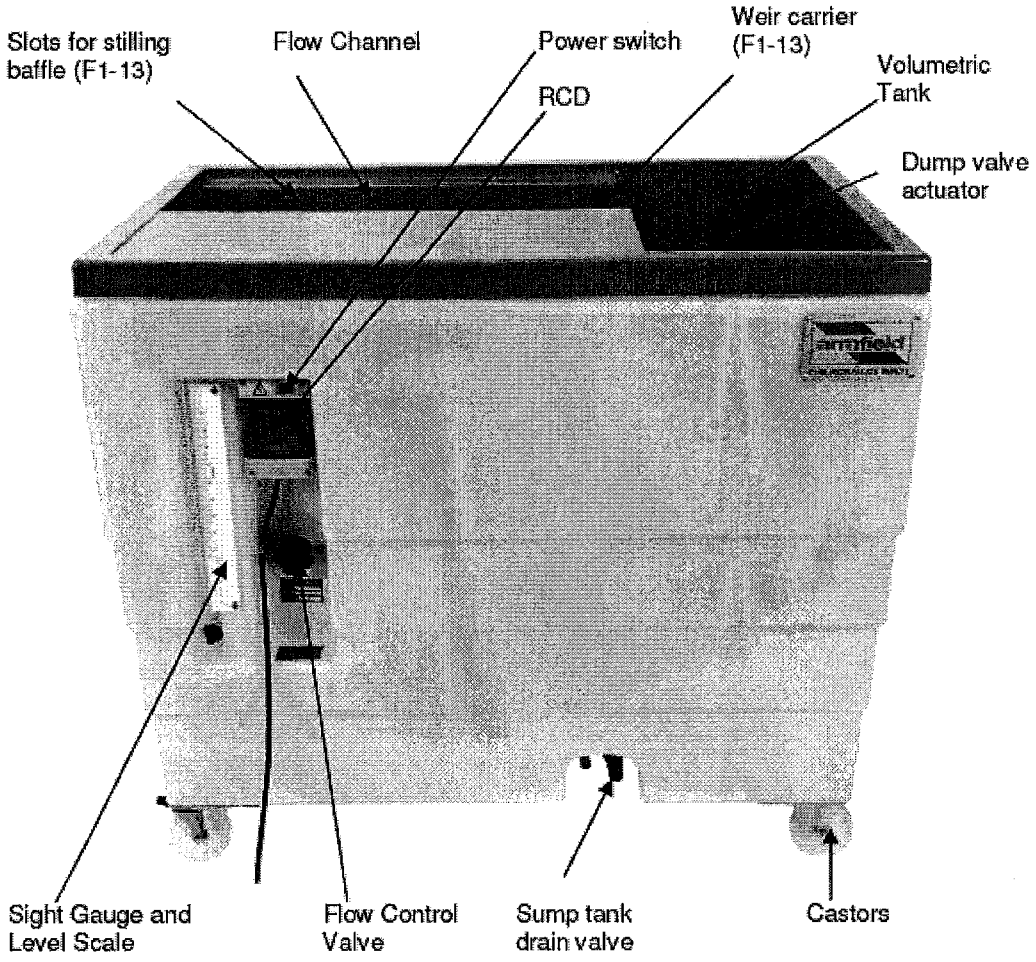


Figure 1: F1-10 Hydraulics Bench

9 Description

Where necessary, refer to the drawings in Equipment Diagrams section 8.

9.1 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.

9.2 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

F1-29 Fluid Statics and Manometry

F1-30 Fluid Properties

F1-31 Pascal's Apparatus

F1-32 Francis Turbine

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.

10 Installation

10.1 Advisory

Before operating the equipment, it must be unpacked, assembled and installed as described in the steps that follow. Safe use of the equipment depends on following the correct installation procedure.

10.2 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.

10.3 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.

10.4 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.

10.5 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.

10.6 Optional Software

Optional software is available for most of the accessories to the F1-10 Hydraulics Bench that allows experimental data, recorded manually, to be analysed using a PC. Relevant data is entered manually then the software will perform the calculations required by the experiments presented in the appropriate teaching manual, reducing the time required to complete the experiments and freeing student study time that would otherwise have been spent performing repetitive calculations.

10.7 Installing the Software

Please refer to the software installation instructions supplied on the Armsoft CD ROM or data stick.

10.8 Installing the Equipment

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 section 10.3.

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.

11 Operation

Where necessary, refer to the drawings in Equipment Diagrams section 8.

11.1 Operating the Software

Please refer to the software operating instructions supplied on the Armsoft CD ROM or data stick. No USB connection is required when operating the software.

11.2 Operating the Equipment

11.2.1 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 through 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.

12 Equipment Specifications

12.1 Overall Dimensions

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

Length - 1.13 m

Width - 0.73 m

Height - 1.00 m

12.2 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.

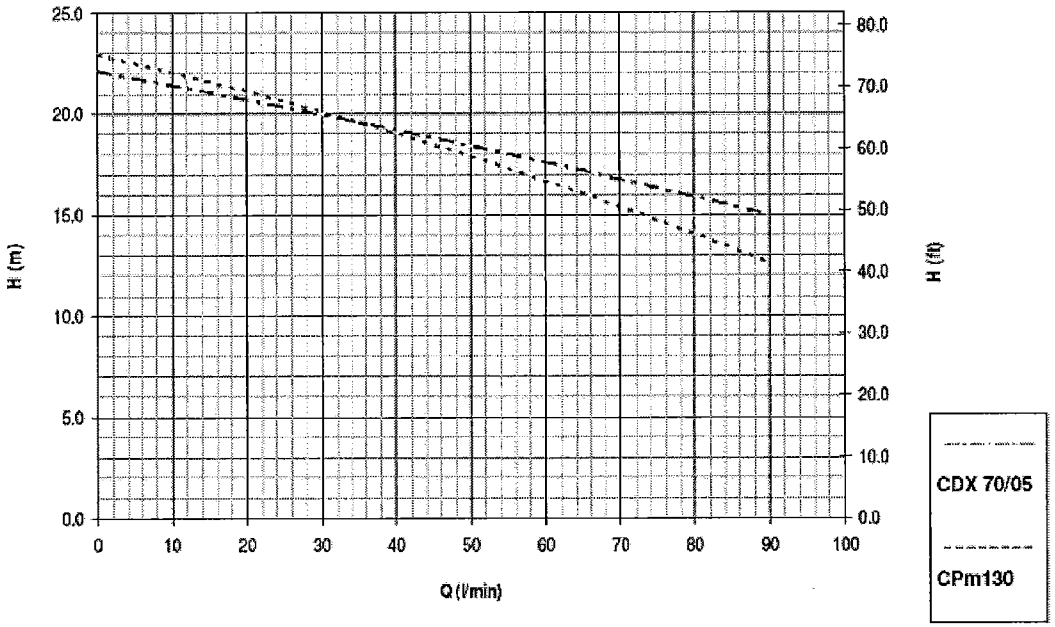
The equipment requires connection to a single phase, fused electrical supply. Five metres of supply cable are included with the equipment.

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.

12.3 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

12.4 Pump Performance Curve



Pump Performance Curve for CDX 70/05 and CPm130

12.5 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.

13 Routine Maintenance

13.1 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.

13.2 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.

14 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
support@armfield.co.uk

Web: http://www.armfield.co.uk

US Office: **Armfield Inc.**
9 Trenton - Lakewood Road
Clarksburg, NJ 085

Tel: (609) 208 2800

Email: info@armfieldinc.com