5 Fluid Mechanics

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“ We are extremely satisfied with the TecQuipment Fluids and Thermodynamics equipment: it is well presented, works well and the students are able to operate it easily. The best feature is that the user guides are of a very high quality, with excellent theory sections and experiment guides. The support from TecQuipment introducing the equipment and installing it has been excellent too. ”

Richard Albany-Ward, School of Science and Technology, University of Northampton

Fluid Mechanics

Over 50 years of experience

The Fluid Mechanics range includes modern versions of the first products developed by TecQuipment over 50 years ago. These products established our reputation for quality, safety, reliability and service. Recent customer service enquiries have shown that some universities and colleges still use products that we made decades ago, proving that they are still as popular as ever. TecQuipment has added to and improved on the original range, in line with customer demands and the latest teaching techniques. It now offers a large choice of experiments, enough to suit a complete course in fluid mechanics.

Modular and free-standing

To save space, water and costs, the Fluid Mechanics range includes experiment modules that work with our mobile hydraulic benches (H1 and H1D). The range also includes some free-standing products to show more specialized fluid experiments, such as hydrostatics and hydrology.

Hydraulic Bench			Page
H1D	H1	Product	
●		**Set of Weirs** (H1D/a and b)	97–98
●	●	**Flow Through an Orifice** (H4)	112
●	●	**Venturi Meter** (H5)	100
	●	**Discharge over a Notch** (H6)	101
●	●	**Friction Loss in a Pipe** (H7)	107
●	●	**Impact of a Jet** (H8)	113
●	●	**Flow Measurement** (H10)	102
●	●	**Vortex Apparatus** (H13)	114
●	●	**Losses in Piping Systems** (H16)	108
●		**Francis Turbine** (H18)	129
●		**Pelton Turbine** (H19)	130
●		**2.5-Metre Flow Channel** (H23)	120
●		**Hydraulic Ram Pump** (H31)	131
●	●	**Series and Parallel Pump** (H32)	132
●	●	**Jet Trajectory and Orifice Flow** (H33)	115
●	●	**Pipework Energy Losses** (H34)	109
●	●	**Flow Meter Calibration** (H40)	104
●		**Pipe Surge and Water Hammer** (H405)	118
●	●	**Fluid Friction Apparatus** (H408)	110

KEY FEATURES AND BENEFITS:

- **Longevity: long-lasting equipment to teach principles that do not go out of date.**
- **Water and space-saving: many experiments work with the self-contained, mobile hydraulic benches to save water and laboratory space.**
- **Large choice of experiments: a huge range of experiments for a complete course in fluid mechanics, from simple flow and pressure measurements to advanced studies of vortices and open-channel flow.**

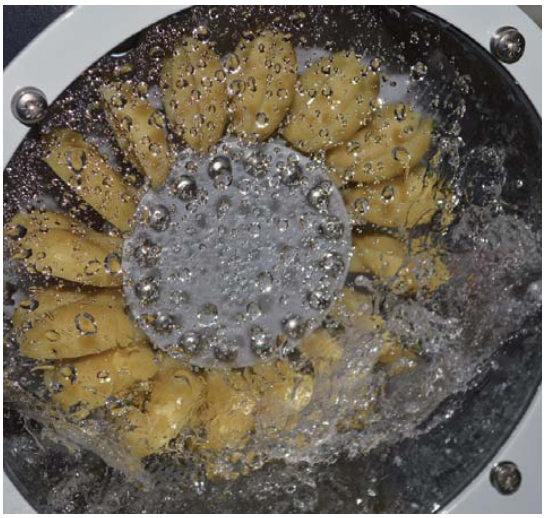
Modular Fluid Power range

The Fluid Mechanics range includes a sub-section of Modular Fluid Power products (pages 137–152) to demonstrate real-world applications of fluid mechanics. They include pumps and turbines, which also provide a link to renewable energy.

Automatic Data Acquisition VDAS®

Each product in this range works with TecQuipment's unique Versatile Data Acquisition System (VDAS®).

See **Section 2** on for more details.



Gravimetric Hydraulic Bench (H1)

MODULAR SYSTEM

Essential Base Unit (H1)

Experiment Modules

Provides a controlled recirculating water supply and accurate gravimetric measuring system for hydraulic and fluid mechanics experiments

The Gravimetric Hydraulic Bench shown with the Discharge Over a Notch (H6) experiment module

FEATURES:		BENEFITS:
Self-contained and fully mobile unit	→	**Flexibility of laboratory layout**
Has flat bench top for experiments	→	Stable surface enables groups of students to do experiments safely
Has recirculating water supply to save mains water	→	**Kinder to the environment and reduces cost of operation**
Separate sump tank outlet facility	→	Provides water supply to floor standing units

The TecQuipment Gravimetric Hydraulic Bench supplies a controlled flow of water to a wide variety of laboratory experiments (experiments available separately). The bench is a sump tank with a submersible pump, gravimetric weighing system and working surface. All parts are made of corrosion-resistant material. The sump outlets allow the bench to be used on almost any hydraulic circuit. Once filled, the bench needs no external water supply.

The top of the sump tank provides the working surface, on which many of the experiments in TecQuipment's Fluid Mechanics range conveniently mount. A rim around the working surface contains any spilled or excess water. Larger experiments usually stand next to the hydraulic bench. A control valve adjusts flow rate.

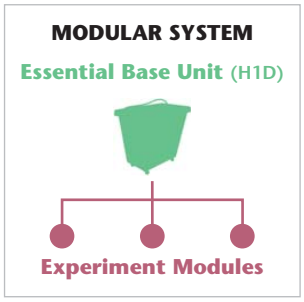
The gravimetric weighing system is a small inner tank on a pivot arm, counter-balanced by weights (included). To measure flow rate, the user directs the water flow into the small inner tank. When the pivot arm becomes horizontal, students start timing using a stopwatch (included). At the same time, they add weights to a hanger at the end of the pivot arm which moves the arm downwards. When the mass of water collected balances the mass of the weights and hanger, the beam returns to the horizontal position and students stop timing. Because the mass of water collected is several times greater than the mass on the hanger, students find an accurate mass flow rate.

The power supply in the Gravimetric Hydraulic Bench includes overload and under-voltage protection.

Available Experiment Modules:	Page
• Flow Through an Orifice (H4)	112
• Venturi Meter (H5)	100
• Discharge Over a Notch (H6)	101
• Friction Loss in a Pipe (H7)	107
• Impact of a Jet (H8)	113
• Flow Measurement (H10)	102
• Vortex Apparatus (H13)	114
• Losses in Piping Systems (H16)	108
• Series and Parallel Pump Test Set (H32)	132
• Jet Trajectory and Orifice Flow (H33)	115
• Pipework Energy Losses (H34)	109
• Flow Meter Calibration (H40)	104
• Fluid Friction Apparatus (H408)	110

Volumetric Hydraulic Bench (H1D)

Provides a controlled recirculating water supply and accurate volumetric measuring system for hydraulic and fluid mechanics experiments



FEATURES:		BENEFITS:
Self-contained and fully mobile unit	→	**Flexibility of laboratory layout**
Bench top providing ample working area	→	Enables groups of students to do experiments
Only service required is a single-phase electricity supply	→	**No need for expensive supply and drains**
Separate sump tank outlet facility	→	Provides water supply to floor standing units

The TecQuipment Volumetric Hydraulic Bench supplies a controlled flow of water to a wide variety of laboratory experiments (experiments available separately).

The bench consists of a sump tank with a submersible pump, volumetric weighing system and working surface. All parts are manufactured in corrosion-resistant material. The sump outlets allow the bench to be used on almost any hydraulic circuit. Once filled, the bench needs no external water supply.

The Volumetric Hydraulic Bench shown with the Vortex Apparatus (H13) experiment module

The top of the sump tank provides the working surface, on which many of the experiments in TecQuipment's Fluid Mechanics range conveniently mount. A rim around the working surface contains any spilled or excess water. The bench top also incorporates an open channel for experiments investigating flow measurement with weirs (sets of different weirs are available separately – see H1D/a and H1D/b). Larger experiments usually stand next to the hydraulic bench.

Students use a control valve to regulate the pump and so adjust flow rate. The volumetric measuring system simply consists of a small inner tank with a level indicator. The level indicator is accurately calibrated in litres. TecQuipment individually calibrates the level indicator for each bench to ensure linearity.

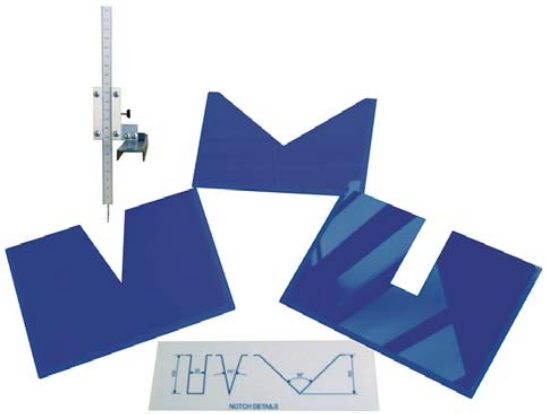
To measure flow rate, students direct the water flow into the small inner tank and start timing using a stopwatch (included). The measurement technique is simply to record the time taken to collect a given amount of water, read off the level indicator. Students divide the volume collected by the time taken to obtain the flow rate in litres per second. From this they can, if necessary, derive the mass flow rate. The power supply in the hydraulic bench includes overload and under-voltage protection.

Available Experiment Modules:	Page
• Set of Weirs (H1D/a)	97
• Advanced Set of Weirs (H1D/b)	98
• Flow Through an Orifice (H4)	112
• Venturi Meter (H5)	100
• Friction Loss in a Pipe (H7)	107
• Impact of a Jet (H8)	113
• Flow Measurement (H10)	102
• Vortex Apparatus (H13)	114
• Losses in Piping Systems (H16)	108
• Francis Turbine (H18)	129
• Pelton Turbine (H19)	130
• 2.5 Metre Flow Channel (H23)	120
• Hydraulic Ram Pump (H31)	131
• Series and Parallel Pump Test Set (H32)	132
• Jet Trajectory and Orifice Flow (H33)	115
• Pipework Energy Losses (H34)	109
• Flow Meter Calibration (H40)	104
• Pipe Surge And Water Hammer (H405)	118
• Fluid Friction Apparatus (H408)	110

Set of Weirs (H1D/a)

For use with TecQuipment's Volumetric Hydraulic Bench (H1D) to study weirs as flow regulation and measurement devices

- One rectangular and two V-shaped notches
- Precise measurement of water level
- Requires minimal installation
- Easy operation



EXPERIMENTS:

Comprehensive study of flow over weirs, including:

- **Investigation of head against discharge**
- **Coefficient of discharge for notches**
- **Rectangular and different angled V-notches**

Specially designed for use with TecQuipment's Volumetric Hydraulic Bench (H1D, available separately), this set of weirs clearly demonstrates the use of weirs as simple flow regulators. They allow students to derive, and then experimentally verify, relationships between upstream water level and weir discharge for a variety of different shaped notches.

Each weir fits in a sealed groove in the channel section of the hydraulic bench. This enables convenient and quick changing of weirs. Plastic materials and corrosion-resistant finishes throughout the equipment give the fullest possible protection against corrosion.

Water from the hydraulic bench supply flows through the channel and over the weir, allowing students to clearly observe the discharge. Students measure the free water surface using an adjustable depth gauge attached to a beam across the channel. The weir discharge flows into the volumetric tank of the hydraulic bench.

The equipment includes two different V-notch weirs and a rectangular notch weir and depth gauge. Other types of weir are available separately – see Advanced Set of Weirs (H1D/b) on the next page.

To perform experiments, students regulate the flow using the hydraulic bench, initially to maximum discharge. They note values of discharge and head, and reduce the flow. They repeat the readings for approximate equal decrements in head, until the stream no longer springs clear of the notch. From their results they plot graphs of discharge rate against head, and also the logs of each.

Note: These weirs are identical to those supplied with TecQuipment's Discharge over a Notch apparatus (H6) on page 101.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Available Experiment Module:	Page
• Advanced Set of Weirs (H1D/b)	98

Alternative Product:	Page
• Discharge over a Notch (H6)	101

Advanced Set of Weirs (H1D/b)

For use with the TecQuipment Volumetric Hydraulic Bench (H1D) or Discharge over a Notch apparatus (H6), to study specialist weirs as flow regulation and measurement devices

- Investigations into Cipoletti (trapezoidal), linear head/flow (proportional) and broad-crested weirs
- Precise measurement of water level
- Requires minimal installation
- Easy operation

EXPERIMENTS:

Comprehensive study of flow over Cipoletti, linear head/flow and broad-crested weirs, including:

- **Investigation of head against discharge**
- **Coefficient of discharge for notches**

Specially designed for use with either TecQuipment's Volumetric Hydraulic Bench or TecQuipment's Discharge over a Notch apparatus (H1D and H6, available separately), the Advanced Set of Weirs clearly demonstrates the use and characteristics of three types of specialist weir. The weirs allow students to derive, and then experimentally verify, relationships between upstream water level and weir discharge for each weir.

The weirs include a Cipoletti (trapezoidal) notch, linear head/flow (proportional) notch, and a broad-crested weir. Each weir fits in a sealed groove in the channel section of the host apparatus, enabling convenient and quick changing. Plastic materials and corrosion-resistant finishes throughout the equipment give the fullest possible protection against corrosion.

Water from the hydraulic bench supply flows through the channel and over the weir, allowing students to clearly observe the discharge. Students measure the free water surface using an adjustable depth gauge attached to a beam across the channel. The weir discharge flows into the collection tank of the hydraulic bench.

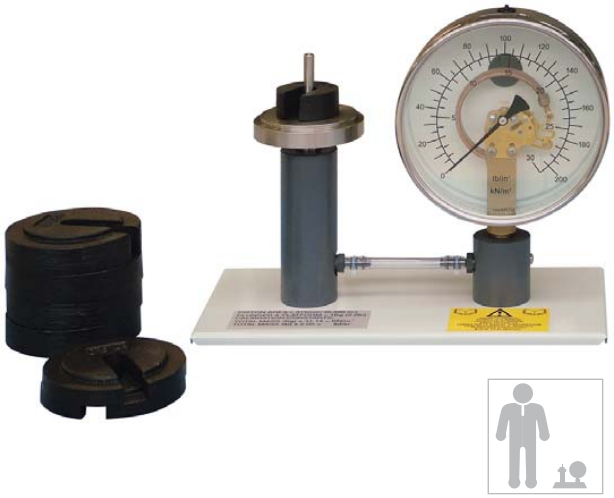
To perform experiments, students regulate the flow using the hydraulic bench, initially to maximum discharge. They note the value of discharge and head, and reduce the flow. They repeat the readings for approximately equal decrements in head, until the stream no longer springs clear of the notch. From their results they plot graphs of discharge rate against head, and also the logs of each.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D) – **with** Set of Weirs (H1D/a)	96 97

Ancillary for:	Page
• Discharge over a Notch (H6)	101

Calibration of a Pressure Gauge (H3a)

Shows students how a Bourdon tube pressure gauge works and how to calibrate it



- Shows 'dead weight' calibration of a Bourdon gauge
- Bourdon gauge has transparent dial so students can see how it works
- Suitable for group demonstrations and student experiments
- Self-contained – needs no extra services

EXPERIMENTS:

Function, operation and calibration of a Bourdon tube pressure gauge.

Many engineering applications use the Bourdon gauge. TecQuipment's Calibration of a Pressure Gauge experiment allows students to study Bourdon tube theory. They see the working mechanism, calibrate the gauge and compare theoretical results to experimental results.

The apparatus is a Bourdon gauge connected to a dead-weight tester. The Bourdon gauge has a transparent dial which allows students to see the working mechanism. The mechanism is a thin-walled tube with an oval cross-section, bent into an arc. One end of the tube is held rigidly. This end admits pressure. The other end of the tube, connected to a dial and pointer mechanism, is free to move. When the pressure in the tube increases, it tries to straighten and so moves the pointer by an amount proportional to the pressure increase.

To calibrate the gauge, students add weights to the platform on the dead-weight tester. The weights put a known force onto a piston. The piston has a known area, so students can calculate the pressure. A flexible tube containing water transfers the pressure on the piston to the Bourdon tube. Students add the weights in increments, recording pressure readings from the gauge at each increment. They then remove the weights and record gauge readings. By working out theoretical results they can work out gauge error and discuss possible causes.

Alternative Products:	Page
• Pressure Measurement Bench (H30)	103
• Hydrostatics and Properties of Fluids (H314)	124

Standard features for all our products:

Supplied with comprehensive user guide

5-YEAR WARRANTY TecQuipment

Five-year warranty

Intertek UKAS MANAGEMENT SYSTEMS

Manufactured in accordance with the latest European Union directives

Venturi Meter (H5)

Allows students to see and measure the complete static head distribution along a horizontal Venturi tube

- Eleven pressure tappings along the tube
- Direct measurement of static heads
- Complete pressure distribution clearly visible
- Compact and simple to operate
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation

EXPERIMENTS:

Comprehensive study of a Venturi meter and Bernoulli's theorem, including:

- **Direct measurement of the static head distribution along a Venturi tube**
- **Comparison of experimental results with theoretical predictions**
- **Measurement of the meter coefficient of discharge at various flow rates**

TecQuipment's Venturi Meter is typical of meters used throughout industry. However, it has many more pressure tappings, connecting to water manometers, which allow full study of the pressure distribution along the convergent-divergent passage.

The apparatus is for use with the Gravimetric or Volumetric Hydraulic Bench (H1 or H1D, available separately). Because these benches measure absolute flow rate, students can find the Venturi meter coefficients over a range of flow conditions.

The apparatus includes a horizontal Venturi tube, a downstream flow-control valve and manometer tubes. A manometer panel holds the manometer tubes vertically. A common manifold above the tubes has an air pressure-control valve. The base has adjustable feet. The manometer panel has a scale behind the manometer tubes for direct reading of the water levels in the tubes. Plastic materials and corrosion-resistant finishes throughout the equipment protect against corrosion.

Water enters the Venturi meter and its flow-control valve sets the flow rate. This valve is downstream, so it does not cause any upstream turbulence.

To adjust the datum water level in the manometer tubes, students connect a hand-pump (included) to the air pressure-control valve above the manometer tubes.

To perform experiments, students set and measure the flow rate through the Venturi. They measure the head at the cross-sectional area at the upstream section, and the head at the throat section. They also note the pressure distribution along the rest of the meter. They then repeat the procedure, reducing the flow rate in increments and taking similar readings each time. Students can compare ideal pressure distribution to measured pressure distribution and calculate the coefficients of discharge for the meter.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Bernoulli's Equation (AF11)	38
• Flow Measurement (H10)	102
• Flow Meter Calibration (H40)	104
• Fluid Friction Apparatus (H408)	110
• Cavitation Demonstration Unit (H400)	116

Discharge over a Notch (H6)

For study of weirs as flow regulation and measurement devices

- Includes one rectangular and two V-shaped notches
- Extra (optional) weirs available for more experiments
- Precise measurement of water level
- Works with TecQuipment's Gravimetric Hydraulic Bench (H1) for easy installation

EXPERIMENTS:

Comprehensive study of flow over weirs, including:

- **Investigation of head against discharge**
- **Coefficient of discharge for notches**
- **Rectangular and different angled V-notches**

The Discharge over a Notch apparatus shows clearly the use of weirs as simple flow regulators. It works with and fits on the top of TecQuipment's Gravimetric Hydraulic Bench (H1, available separately).

It allows students to do tests on relationships between upstream water level and weir discharge for various different shaped notches. They can then compare their results with theory.

The equipment is a moulded tank, the middle section of which forms a channel. One end of the tank is wide; the other end is deeper than the rest of the tank. Each weir fits in a sealed groove in the channel section. Plastic materials and corrosion-resistant finishes protect against corrosion.

The hydraulic bench supplies water to the wide end of the tank. Water flows through the channel and over the weir, where the deep tank exit allows students to see the discharge. Students measure the free water surface using an adjustable depth gauge attached to a beam across the channel. The tank outlet fits over the weighing tank of the hydraulic bench (available separately).

The equipment includes two different V-notch weirs and a rectangular notch weir. Other types of weir are available separately (Advanced Set of Weirs, H1D/b).

To do experiments, students regulate the flow using the hydraulic bench. They note the value of discharge and head, and reduce the flow. They repeat the readings for equal decrements in head, until the stream no longer springs clear of the notch. From their results they plot graphs of discharge rate against head, and also the logs of each.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95

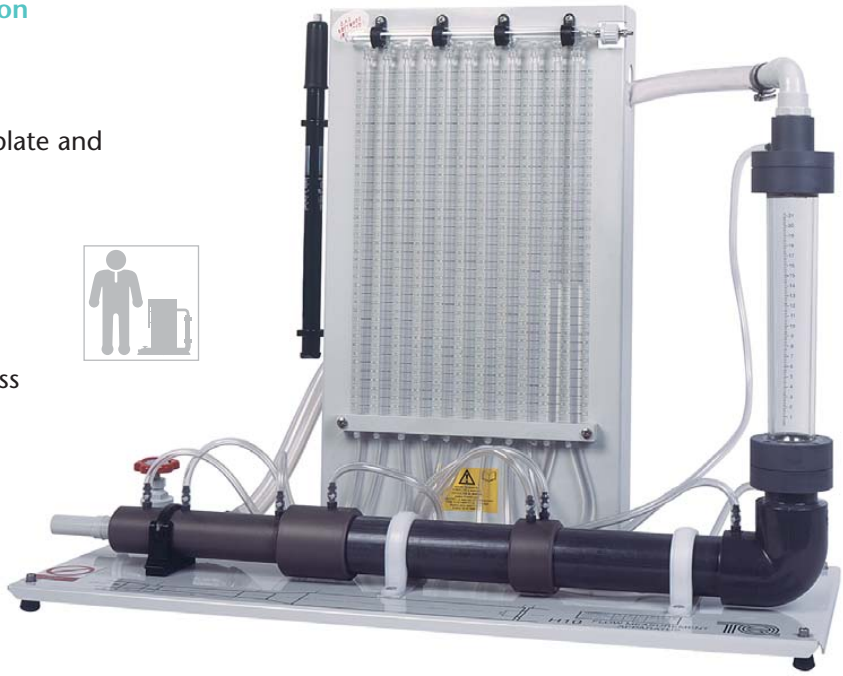
Recommended Ancillary:	Page
• Advanced Set of Weirs (H1D/b)	98

Alternative Products:	Page
• Set of Weirs (H1D/a)	97
• 5-Metre Flow Channel (H12)	121
• 2.5-Metre Flow Channel (H23)	120

Flow Measurement (H10)

Shows typical methods of measuring the flow of an incompressible fluid and demonstrates applications of Bernoulli's equation

- Includes Venturi meter, orifice plate and rotameter
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation
- Direct measurement of head loss
- Three different flow meters which work with Bernoulli's equation
- Multi-tube manometer shows pressure at various points



EXPERIMENTS:

Study of Bernoulli's equation, flow measurement and losses, including:

- **Application of the Bernoulli equation for incompressible fluids**
- **Direct comparison of flow measurement using a Venturi meter, orifice plate and rotameter**
- **Comparison of pressure drops across each flow-measurement device**
- **Comparison of pressure drops across a sudden enlargement and a 90-degree elbow**

TecQuipment's Flow Measurement apparatus shows the typical methods of measuring the flow of an essentially incompressible fluid (water). It also shows applications of Bernoulli's equation.

Students measure flow using a Venturi meter, an orifice plate meter and a rotameter. Bernoulli's equation works for each meter. Students find and compare the head losses associated with each meter, as well as those arising in a rapid enlargement and a 90-degree elbow.

The apparatus is for use with TecQuipment's Gravimetric or Volumetric Hydraulic Bench (H1 or H1D, available separately).

The equipment consists of a horizontal pipe including a gate valve, Venturi meter, orifice plate and pressure tappings. An elbow connects the pipe to a rotameter (gap-type flow meter) with further pressure tappings. All pressure tappings connect to manometers held on a vertical panel behind the pipe work. The manometers measure and clearly show pressure distribution against a calibrated scale.

To perform experiments, students connect the apparatus to the hydraulic bench supply, and set it to a low, steady flow through the apparatus. Water from the hydraulic bench then flows through the Venturi meter, through a rapidly diverging section, a settling length and the orifice plate. It then flows around the elbow, through the rotameter and finally returns to the hydraulic bench measuring tank.

Students measure the flow using the hydraulic bench, noting the manometer levels and rotameter reading. They then increase the flow in set increments, taking readings each time, until reaching maximum flow rate. They then use Bernoulli's equation to find mass flow rate through each of the meters, comparing to flow rates measured using the hydraulic bench. Students can compare advantages, disadvantages and potential applications of each meter.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Venturi Meter (H5)	100
• Flow Meter Calibration (H40)	104
• Fluid Friction Apparatus (H408)	110

Pressure Measurement Bench (H30)

Enables a range of practical investigations into manometer and Bourdon gauge pressure measurement techniques

- Enables practical investigations into pressure measurement using inclined and U-tube manometers, and Bourdon-type vacuum and pressure gauges
- Enables instant comparison of measurement methods
- Also includes separate Bourdon gauge with dead-weight calibration apparatus, and Bourdon tube mechanism clearly visible
- Fully self-contained, bench-top apparatus
- Suitable for group demonstrations and individual student experiments

EXPERIMENTS:

A range of investigations into common pressure-measurement techniques, including:

- **Comparison of pressure measurement by manometer and Bourdon gauge**
- **Calibration of a pressure gauge**
- **Determination of gauge errors as a function of true pressure**

Manometers and Bourdon gauges are fundamental pressure-measuring devices. They are intrinsic parts of more complex measuring instruments, such as pneumatic comparators and flow indicators. It is important therefore that students fully understand their operation, characteristics and principles of calibration.

TecQuipment's Pressure Measurement Bench enables students to fully investigate and compare the operation and characteristics of inclined and U-tube manometers, and Bourdon-type vacuum and pressure gauges. It also includes a separate Bourdon gauge with dead-weight calibration apparatus, enabling clear observation of the Bourdon tube mechanism.

The apparatus consists of two units:

- A manometers and gauges unit
- A Bourdon pressure gauge calibration unit

The manometers and gauges unit is a framed structure with a backboard, holding a:

- vertical U-tube manometer,
- U-tube manometer with an inclined limb,
- Bourdon gauge for measuring vacuums,
- Bourdon gauge for measuring positive pressure, and
- syringe assembly for pressurising and reducing pressure in the measurement devices.

Each gauge and manometer has a delivery point to connect to the syringe using plastic tubing (included). All connections are push-fit, and T-pieces are provided to enable two instruments to be connected to one point.

The Bourdon pressure gauge calibration unit consists of a piston, which is free to move vertically, in a close-fitting cylinder. A transparent, flexible hose connects the cylinder to the Bourdon pressure gauge. The gauge and cylinder are mounted on a common flat base.

The internal mechanism of the gauge is clearly visible through the transparent dial. During test, calibration weights are placed onto the loading platform, which is an integral part of the piston assembly. All air is expelled from the system through a purge hole in the upper part of the cylinder.

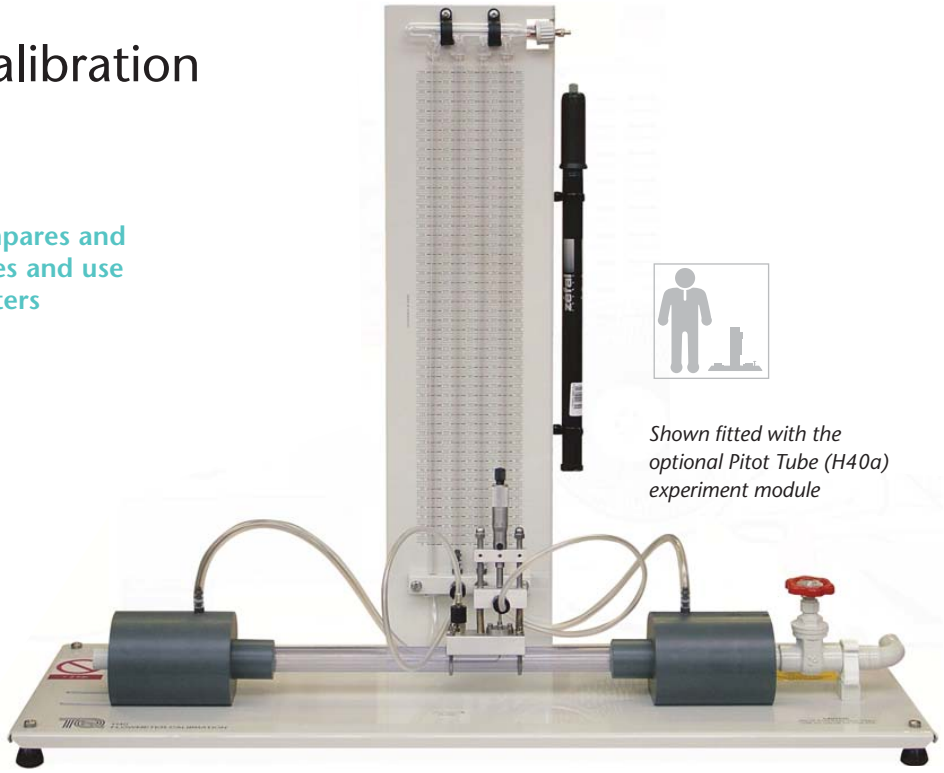
The apparatus is manufactured using materials and finishes carefully chosen to give the fullest protection against corrosion.

Alternative Products:

	Page
• Calibration of a Pressure Gauge (H3a)	99
• Hydrostatics and Properties of Fluids (H314)	124

Flow Meter Calibration
(H40)

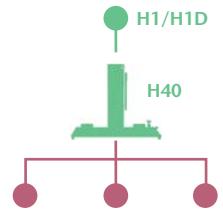
A compact unit that compares and shows the accuracy, losses and use of fundamental flow meters



Shown fitted with the optional Pitot Tube (H40a) experiment module

MODULAR SYSTEM

Essential Base Units



FEATURES:		BENEFITS:
Unique 'quick-change' flow meter adaptors and pressure connections	→	**Safety – self-sealing connectors prevents spillage of water**
Multi-tube manometer to show flow meter and overall pressure changes	→	Visual comparison of pressures – improves student appreciation and understanding of the experiment and measurement reliability
Nozzle flow meter included Optional flow meters available for comparison include: Venturi, orifice and Pitot tube	→	**Complete experiment 'out of the box' with further experiments available**
Shows the boundary layer effect and the fluid velocity profile – needs Pitot tube (H40a)	→	Enables detailed study of flow profile
Works with TecQuipment's Gravimetric or Volumetric Hydraulic Bench for easy installation	→	**Fits into existing laboratory set-up at minimal cost**

EXPERIMENTS:

- Accuracy of nozzle flow meters
- Losses and k value
- Calculation of the coefficient of discharge

For use by all kinds of engineering students, the Flow Meter Calibration apparatus compares and shows the accuracy and use of fundamental flow meters.

The nozzle flow meter (included), or any of the optional flow meters, quickly and easily fit into place between the adaptors in the base unit of the apparatus. Four water-filled manometers show the pressure differences at the flow meter and across the overall flow meter assembly. The manometers have a common manifold fitted with an air valve. Students use the hand-pump (included) to increase the air pressure in the manifold. This 'offsets' the manometer measurement (adjusts the datum).

The straight pipe (included) gives a comparison of the true pressure losses caused by the flow meters.

The optional Pitot Tube Flow Meter (H40a) will also show the velocity profile in a pipe. This helps to explain the 'boundary layer' and surface friction in pipes and flow channels.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Available Experiment Modules:	Page
• Pitot Tube (H40a)	105
• Venturi Flow Meter (H40b)	105
• Orifice Flow Meter (H40c)	106

Alternative Products:	Page
• Venturi Meter (H5)	100
• Flow Measurement (H10)	102
• Fluid Friction Apparatus (H408)	110

Pitot Tube (H40a)

Pitot tube flow meter for use with the Flow Meter Calibration unit (H40)

- Unique 'quick-change' adaptors and pressure connections
- Shows the accuracy and use of a pitot tube flow meter
- Shows the boundary layer effect and the fluid velocity profile
- Micrometer head for precise adjustment

EXPERIMENTS:

- **Accuracy of pitot tube flow meters**
- **Losses and *k* value**
- **Calculation of the coefficient of discharge**
- **Velocity profile**

A popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40). It shows the accuracy and use of a Pitot tube flow meter.

This flow meter quickly and easily fits into place between the adaptors in the base unit of the Flow Meter Calibration unit. The manometers of the calibration unit show the pressure differences at the flow meter and across the overall flow meter assembly.

A precision micrometer head allows the user to accurately adjust the position of the Pitot tip that traverses across the inside of the pipe. The tip measures the change in pressure across the pipe for a given flow rate. A second tapping in the pipe wall measures the 'static' pressure. Plots of these pressures shows the velocity profile in a pipe and explains the 'boundary layer' and surface friction in pipes and flow channels.

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	104

Venturi Flow Meter (H40b)

Venturi flow meter for use with the Flow Meter Calibration unit (H40)

- Unique 'quick-change' adaptors and pressure connections
- Shows the accuracy and use of a Venturi flow meter
- Shows how a flow constriction affects pressure
- ISO standard dimensions for more predictable results

EXPERIMENTS:

- **Accuracy of Venturi flow meters**
- **Losses and *k* value**
- **Calculation of the coefficient of discharge**

A popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40). It shows the accuracy and use of a Venturi flow meter.

This flow meter quickly and easily fits into place between the adaptors in the base unit of the Flow Meter Calibration unit. The manometers of the calibration unit show the pressure differences at the flow meter and across the overall flow meter assembly.

A Venturi made to ISO (International Standards Organisation) standards allows the user to measure pressures before and after a constriction for a given rate of flow. The Venturi shows how standard textbook equations allow you to accurately calculate flow from these pressures, due to the specific design of the Venturi.

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	104

Orifice Flow Meter (H40c)

Sharp-edged orifice flow meter for use with the Flow Meter Calibration unit (H40)

- Unique 'quick-change' adaptors and pressure connections
- Shows the accuracy and use of a sharp-edged orifice flow meter
- Shows how an orifice affects pressure
- ISO standard dimensions for more predictable results

EXPERIMENTS:

- **Accuracy of orifice flow meters**
- **Losses and *k* value**
- **Calculation of the coefficient of discharge**

A popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40). It shows the accuracy and use of a sharp-edged orifice flow meter.

This flow meter quickly and easily fits into place between the adaptors in the base unit of the Flow Meter Calibration unit. The manometers of the calibration unit show the pressure differences at the flow meter and across the overall flow meter assembly.

A sharp-edged orifice made to ISO (International Standards Organisation) standards allows the user to measure pressures before and after an orifice for a given rate of flow. The orifice shows how standard textbook equations allow you to accurately calculate flow from these pressures, due to the specific design of the orifice.

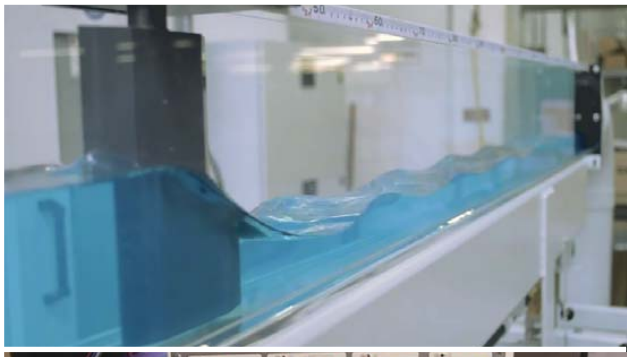
Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	104

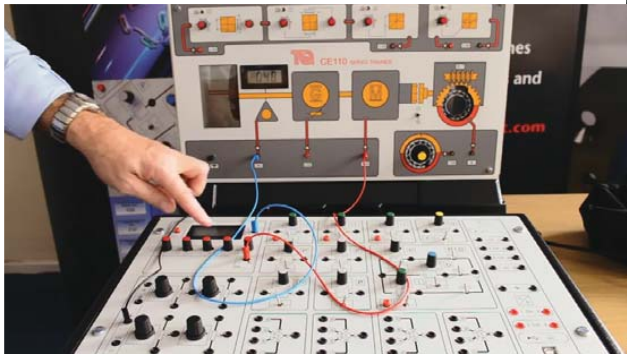
Now you can see our products in action...

YouTube

Visit our YouTube channel to see demonstrations and promotional videos of some of our products:

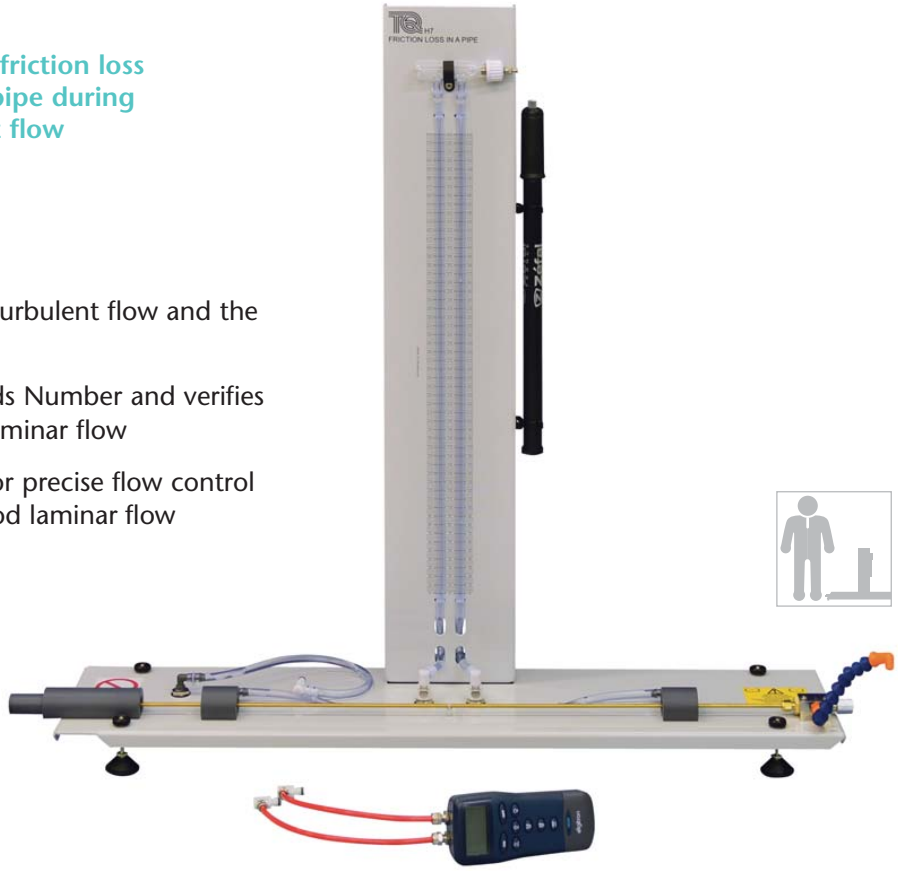
www.youtube.com/c/tecquipment





Friction Loss in a Pipe (H7)

For direct measurement of friction loss in a small-bore horizontal pipe during both laminar and turbulent flow



- Investigates laminar and turbulent flow and the transition point
- Shows the critical Reynolds Number and verifies Poiseuille's Equation for laminar flow
- Includes precision valve for precise flow control and a header tank for good laminar flow
- Works with TecQuipment's Volumetric or Gravimetric Hydraulic Benches (H1 or H1D) for easy installation

EXPERIMENTS:

Study of friction loss in a pipe, including:

- **Investigations of laminar and turbulent flows**
- **Demonstration and measurement in the change of the laws of resistance (friction factor) from laminar to turbulent flow**
- **Finding the critical Reynolds number**
- **Verifying Poiseuille's Equation and the coefficient of viscosity for water in the laminar flow region**

The Friction Loss in a Pipe apparatus allows students to study the change in the laws of resistance for laminar to turbulent flow and find the critical Reynolds number. The apparatus shows the flow transition point from laminar to turbulent, and is ideal for demonstrations as well as student experiments.

The equipment is a small-bore, straight test pipe on a base plate. It works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches (H1 or H1D, available separately).

Static pressure tappings upstream and downstream of the test pipe connect to a water manometer or a hand-held digital pressure meter (supplied). The back panel holds the manometer with calibrated scales. The water manometer measures lower differential pressures in the laminar and lower turbulent flow regions (just above the critical Reynolds Number). The pressure meter measures higher pressures in the turbulent flow region. The water manometer includes an air valve and hand-pump. The hand-pump adjusts the datum of the water manometer where necessary. A precision needle valve downstream of the test pipe accurately controls flow rate.

To perform experiments, students stand the apparatus on the hydraulic bench and fit the header tank (supplied). For low flow rate experiments, the header tank supplies the test pipe. For higher flow rate experiments, the hydraulic bench supplies the test pipe directly. Students set the flow rate, measuring it by timing the collection of water in a measuring vessel (included).

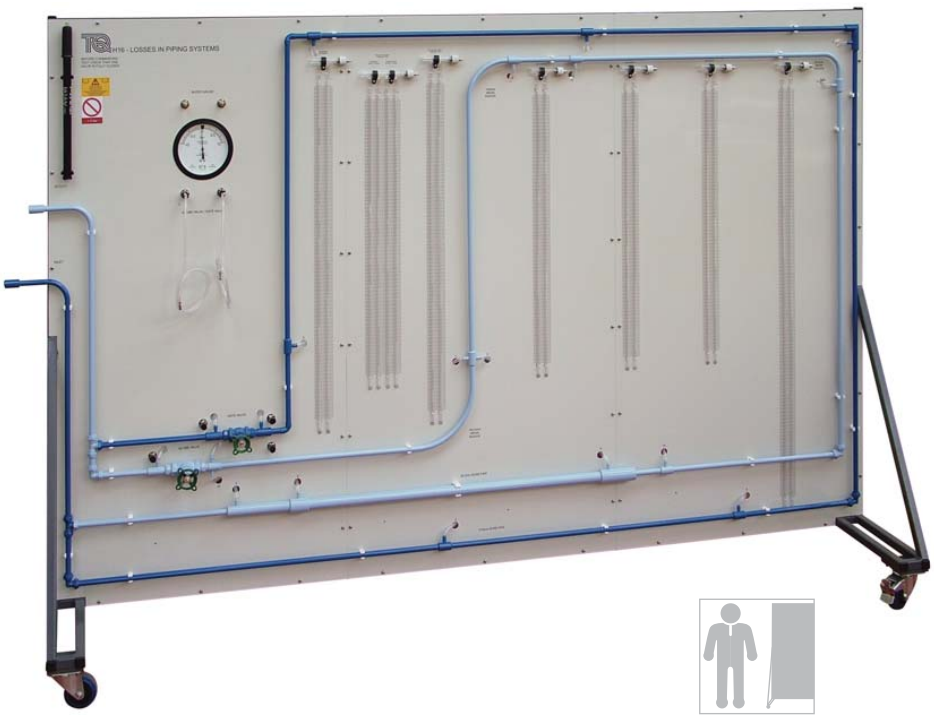
Students take readings of temperature from a thermometer (supplied) and readings of head from the manometer or the pressure meter. They then use the results to produce charts to help compare actual results with theory.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Losses in Piping Systems (H16)	108
• Fluid Friction Apparatus (H408)	110
• Reynolds Number and Transitional Flow (H215)	111
• Pipework Energy Losses (H34)	109

Losses in Piping Systems (H16)

Shows pressure losses in several small-bore pipe circuit components, typical of those found in central heating installations



- Includes two colour-coded water circuits
- Works with TecQuipment's Hydraulic or Gravimetric Hydraulic Benches for easy installation
- Includes different pipe bends and valves for students to compare losses
- Fitted with a range of piezometers and a pressure gauge to give accurate pressure measurement
- Optional 'roughened pipe' ancillary to investigate flow characteristics in a roughened pipe

EXPERIMENTS:

A comprehensive range of investigations into losses in a variety of pipes and pipe system components, including:

- **Straight pipe loss**
- **Sudden expansion**
- **Sudden contraction**
- **Bends with different radius**
- **Valves**
- **Elbows**
- **Flow in a roughened pipe – needs the optional Roughened Pipe (H16p)**

The Losses in Piping Systems apparatus comprises a vertical panel with two separate hydraulic circuits, colour-coded for clarity. Each circuit includes various pipe system components. The unit has wheels for mobility. They also help when storing the apparatus.

TecQuipment's Gravimetric or Volumetric Hydraulic Bench (H1 or H1D, available separately) supplies each circuit with a controlled flow of water. This allows students to study flow through the various pipe forms and components, and study and compare the pipe and component characteristics.

The circuits are made of small-bore copper pipe, commonly used in a wide variety of applications such as domestic central-heating systems. The small bore allows the circuits to include many pipe bends and components, while preserving effective upstream and downstream test lengths.

To measure pressure loss across components, the panel includes piezometer tubes and a pressure gauge. The pressure gauge measures pressure loss across valves; the piezometer tubes measure pressure loss across the other components. Included is a hand-pump to adjust the datum position of the piezometers.

Both circuits have common inlet and outlet pipes, controlled by valves. The valves are at the outlet to minimise flow disruption.

TecQuipment offers the optional "roughened pipe". This can fit to the Losses in Piping Systems apparatus or be used by itself (fitted to a wall and connected to a hydraulic bench). It includes a pipe with a roughened internal bore, and pressure tapping points connected to a manometer. The manometer measures the pressure drop due to the pipe. Students compare their experimental results with Moody and Nickuradse charts.

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1) **or**	95
• Volumetric Hydraulic Bench (H1D)	96

Recommended Ancillary:

- Roughened Pipe (H16p)

Alternative Products:

	Page
• Friction Loss in a Pipe (H7)	107
• Pipework Energy Losses (H34)	109
• Fluid Friction Apparatus (H408)	110

Pipework Energy Losses (H34)

Compares pressure losses and K value of popular fittings in small-bore pipework

- Compact, easy to fit and easy to use
- Includes three different bends: mitre, elbow and large radius
- Compares losses in a sudden enlargement (or expansion) and a contraction
- Includes a multi-tube piezometer for fundamental, accurate pressure measurements
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches

EXPERIMENTS:

Measurement and comparison of losses in:

- **Mitre bend**
- **Elbow bend**
- **Large radius bend**
- **Sudden expansion**
- **Sudden contraction**

This compact bench-top apparatus uses smooth, industry-standard plastic pipe, commonly used in domestic and other small-bore water systems.

It works with TecQuipment's Gravimetric Hydraulic Bench or Volumetric Hydraulic Bench (H1 and H1D, available separately). Either bench supports the apparatus and circulates and measures the water flowing through it.

This apparatus has a single circuit with bends, pressure tappings and an expansion-contraction. A ball valve at the pipe exit controls water flow.

Each pressure tapping point in the pipe connects to a piezometer tube in the vertical panel of the apparatus.

During experiments, these tubes measure and compare pressure differences across the bends, expansion and contraction.

A useful diagram on the apparatus shows the main dimensions of the pipework and fittings. It also shows the positions of the tappings and the tubes that they connect to. The product includes a hand-pump to adjust the datum of the piezometer tubes.

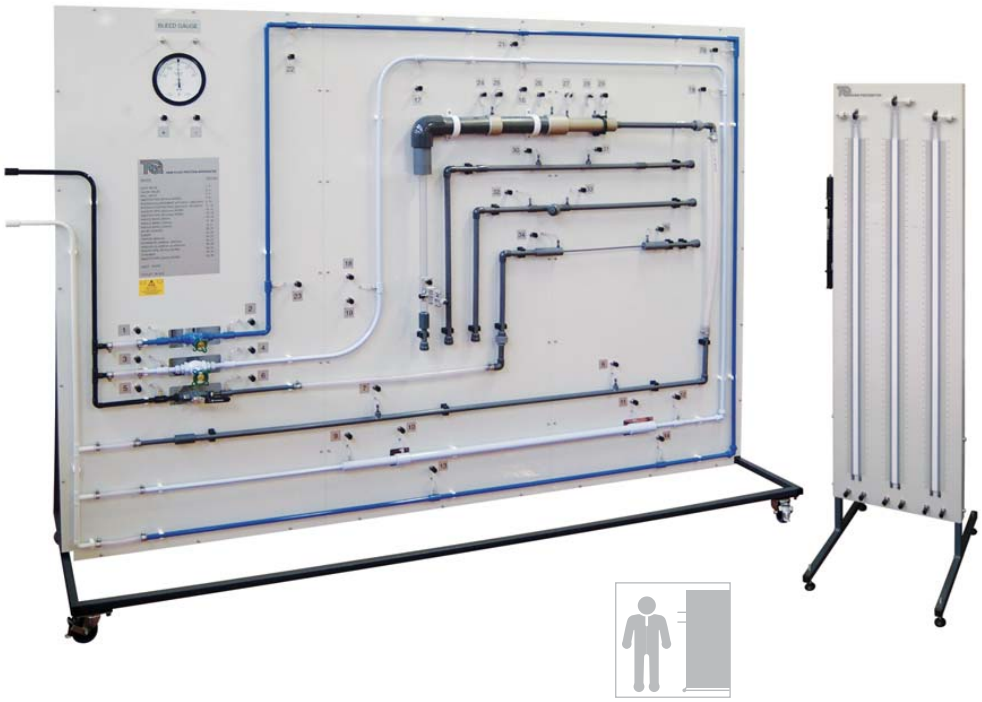
This apparatus is a smaller version of TecQuipment's Losses in Piping Systems (H16), which has two pipe circuits and scope for further project work.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Friction Loss in a Pipe (H7)	107
• Losses in Piping Systems (H16)	108
• Fluid Friction Apparatus (H408)	110

Fluid Friction Apparatus (H408)

Shows flow and losses in different pipes, fittings and valves. Shows popular flow measurement instruments.



- A space-saving vertical panel that works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation
- Includes experiments on roughened pipes
- Uses Bernoulli's equation
- Shows how to use Venturi and orifice meters to measure flow
- Includes a traversing Pitot tube to measure velocity profile

EXPERIMENTS:

- **Use of the Pitot-static tube**
- **Flow measurement using a Venturi meter and an orifice meter**
- **Smooth pipes**
- **Artificially roughened pipe**
- **Straight pipe loss**
- **Sudden expansion and contraction**
- **Bends and elbows**
- **Valves**
- **In-line strainer**

TecQuipment's Fluid Friction Apparatus allows students to study flow, flow measurement techniques and losses in a wide variety of pipes and fittings.

The equipment has three water circuits with instruments, pipes and pipe system components. These allow students to examine and compare the different component characteristics. A hydraulic bench (Gravimetric (H1) or Volumetric (H1D), available separately) supplies the circuit with a controlled flow of water. A space-saving vertical panel holds all the parts for easy use.

To measure pressure loss across components, students use a piezometer set and differential pressure gauge (included).

To perform experiments students record the temperature of water in the hydraulic bench and set the hydraulic bench to pump water through a circuit. They measure pressure losses across instruments or components. The hydraulic bench gives an external flow rate for reference and comparison.

The flow measurement instruments show students the common methods of measuring water flow. They also give applications of the steady flow energy equation (Bernoulli's equation). Students use a Venturi meter and an orifice plate meter and compare the losses of each. They also find the losses in a rapid enlargement.

The equipment also includes a Pitot-static tube. By traversing the Pitot across the pipe diameter, students can find the velocity profile and flow coefficients. They also find the relationship between the flow rate and pressure differential.

An artificially roughened pipe allows students to study friction factor at different Reynolds numbers. They can compare results to those predicted by Nickuradse's results and a Moody chart.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1) **or**	95
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Losses in Piping System (H16)	108
• Pipework Energy Losses (H34)	109
• Flow Meter Calibration (H40)	104
• Flow Measurement (H10)	102
• Venturi Meter (H5)	100
• Friction Loss in a Pipe (H7)	107

Reynolds Number and Transitional Flow (H215)

Free-standing apparatus that gives a visual demonstration of laminar and turbulent flow

Optional Heater Module (H215a)

- Constant head reservoir and flow-smoothing parts for a smooth flow
- Uses dye injector system to show flow patterns
- Investigates Reynolds number at transition
- Optional heater module available for tests at different viscosities

EXPERIMENTS:

- **Demonstration of transition between laminar and turbulent flow.**
- **Determination of transition Reynolds numbers and comparison with accepted values.**
- **Investigation of the effect of varying viscosity, and demonstration that the Reynolds number at transition is independent of viscosity.**

The apparatus consists of a precision-bore glass pipe (test tube) held vertically in a large shroud. The shroud is open at the front and the inside surface is light coloured. This allows the students to see the flow clearly.

Water enters a constant head tank (reservoir) above the test tube and passes through a diffuser and stilling bed. It then passes through a specially shaped bell-mouth into the test tube. This arrangement ensures a steady, uniform flow at entry to the test tube. A thermometer measures the temperature in the constant head reservoir.

A fixed overflow pipe in the reservoir connects to a suitable drain. At the bottom of the test pipe is a valve which controls the flow rate through the pipe, without disturbing the flow.

Students collect a known quantity of water in a measured time to find the flow rate. Included is a measuring cylinder.

To see the pattern of flow in the pipe, students use a dye injector (included). They use it to inject a fine filament of dye into the top of the tube. The dye injector is a dye reservoir connected to a fine hypodermic tube.

The base of the apparatus has adjustable feet for levelling prior to use (included is a levelling device).

The optional Heater Module (H215a) is a separate free-standing unit. It connects to the water supply line to heat the water and thus vary its temperature and viscosity. Controls on the module vary the electrical heat input and the flow rate, to give steady conditions over a range of temperatures.

Essential Ancillary:

Page

- Stopwatch (SW1) – To measure flow rates 30

Recommended Ancillary:

- Heater Module (H215a) – Free-standing unit to vary and control the water temperature and hence its viscosity

Alternative Product:

Page

- Friction Loss in a Pipe (H7) 107
- Particle Drag Coefficient (H410) 125

Flow Through an Orifice (H4)

Shows flow through different orifices for different flow rates

- Direct measurement of total head, head loss and diameter of jet
- Vertical water jet
- Integral Pitot traverse tube
- Sharp-edged orifice included
- Works with TecQuipment's gravimetric or volumetric hydraulic benches for easy installation

Optional Set of Orifices (H4a)

EXPERIMENTS:

Investigations into a variety of orifices over a range of flow rates, including:

- **Determination of contraction and velocity coefficients**
- **Calculation of discharge coefficient**
- **Determination of actual discharge coefficient, and comparison with calculated values**
- **Determination of the various coefficients over a range of flow rates to show the influence of Reynolds number**
- **Study of the characteristics of different orifices (needs ancillary products H4a)**

TecQuipment's Flow Through an Orifice apparatus allows students to measure:

- Decrease in flow
- Contraction of the stream
- Energy loss

They find these measurements as water leaves an orifice. Students can also use the apparatus to study different shapes of orifice (extra orifices are available separately).

The apparatus works with either of TecQuipment's hydraulic benches (H1 or H1D, available separately) and stands on the hydraulic bench worktop. The equipment has a transparent cylindrical tank, with a mounting in the base for different orifices. TecQuipment supplies the apparatus with a sharp-edged orifice already mounted.

Water flows into the tank from the hydraulic bench through an adjustable diffuser. The flow rate and an overflow pipe set the water level. To change the level in the tank (and so the head on the orifice), students adjust the flow to the diffuser. Water leaves the tank through the orifice. The jet that leaves the orifice discharges into the hydraulic bench measuring tank.

Manometers measure the total head on the orifice and under the jet. A traverse assembly holds a Pitot tube which students can position anywhere in the jet. A sharp blade accurately measures the jet diameter. This allows students to find the contraction coefficient.

Essential Base Unit:

Page

- Gravimetric Hydraulic Bench (H1) 95

  or

- Volumetric Hydraulic Bench (H1D) 96

Recommended Ancillary:

- Set of Orifices (H4a) – A set of four circular orifices (nozzles), each with the same minimum throat diameter but with different length. Each has different approach and discharge section. Additional square and triangular orifice.

Alternative Product:

Page

- Jet Trajectory and Orifice Flow (H33) 115

Impact of a Jet (H8)

Investigates the force generated by a jet striking plates (representing turbine vanes)

- Includes flat and hemispherical plates
- Extra (optional) angled and conical plates
- Ideal for demonstrations as well as in-depth experiments
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation

Optional 120-degree Conical Plate and 30-degree Angled Plate (H8a)

EXPERIMENTS:

- **Measurement of the impact force on a flat plate and comparison with momentum change**
- **Measurement of the impact force on a hemispherical plate and comparison with momentum change**
- **Measurement of the impact force on an inclined flat plate (available separately) and comparison with momentum change**
- **Measurement of the impact force on a conical plate (available separately) and comparison with momentum change**

To understand correctly how a turbine (a Pelton wheel for example) works, students need to understand how jet deflection produces a force on turbine vanes. They also need to know how this force affects the rate of momentum flow in the jet.

The Impact of a Jet apparatus shows students the force produced by a jet of water as it strikes a flat plate or hemispherical cup. They can then compare this to the momentum flow rate in the jet. To extend the range of investigations, the 120-Degree Conical Plate and 30-Degree Angled Plate (H8a) are available separately.

For use with TecQuipment's hydraulic benches (H1 or H1D, available separately), the equipment comprises a transparent cylinder containing a vertically tapered nozzle and a test plate. The cylinder is on legs and mounts on the top of the hydraulic bench. The nozzle, supplied by the hydraulic bench, produces a high-velocity jet of water which hits the test plate. The test plate connects to a weigh beam assembly with jockey weight which measures the jet force. A drain tube in the base of the cylinder directs water back into the hydraulic bench, allowing accurate flow rate measurement.

All test plates are all easily interchangeable, taking only a few seconds and needing no tools.

To perform experiments, students level the apparatus and zero the weigh beam assembly. They set the flow from the hydraulic bench to maximum, and measure the jet force. They reduce the flow from the hydraulic bench in several increments. At each increment they record the force of the jet on the plate and the flow rate. They then repeat the experiments for different test plates. Students compare their experimental results to those calculated from theory, working out graphs of rate of delivery of momentum against force on the plate.

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Recommended Ancillaries:

- 120-degree Conical Plate and 30-degree Angled Plate (H8a)

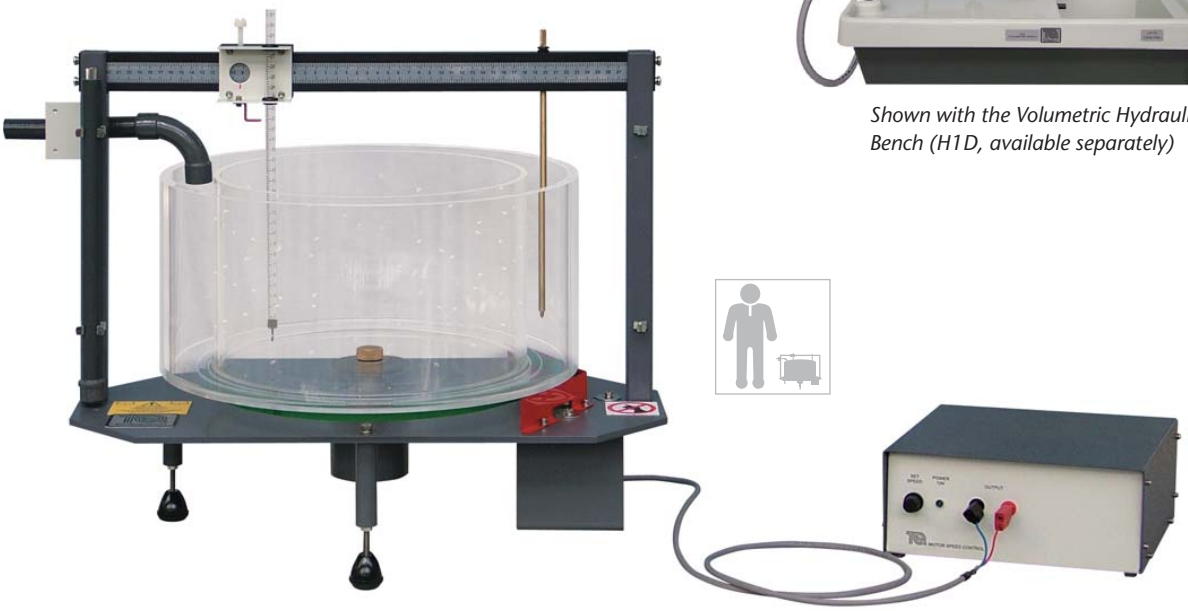
Alternative Products:

	Page
• Pelton Turbine (H19)	130
• Pelton Wheel (Turbine) (MFP101b)	140

Vortex Apparatus (H13)

Studies the phenomena of free and fixed vortices

Shown with the Volumetric Hydraulic Bench (H1D, available separately)



- Transparent vessel – users can see the vortices from all angles
- Includes a traverse probe to measure water surface profile
- Low-voltage variable speed motor for safety
- Ideal for classroom demonstrations as well as laboratory experiments
- Works with either of TecQuipment's Hydraulic Benches (H1 or H1D)

EXPERIMENTS:

- **Determination of the surface profile of a forced vortex**
- **Determination of the surface profile of a free vortex**
- **Determination of the total head variation in a forced vortex**
- **Comparison of results with theoretical predictions**

The TecQuipment Vortex Apparatus enables students to produce both free and forced vortices, and measure the vortex water surface profile.

The equipment consists of a transparent vessel on a support frame, which mounts on a TecQuipment hydraulic bench (Gravimetric or Volumetric Hydraulic Benches, H1 or H1D - available separately). It may also work with another suitable clean water supply and drain.

A low-voltage, variable-speed motor rotates the vessel about its vertical axis. A speed-control unit (included), sited away from the main apparatus, controls the speed of rotation.

To produce a forced vortex, students add water to the rotating vessel until it is about half full. A forced vortex forms. After a few minutes the vortex becomes constant, and students can measure the surface profile using the traverse probe. The traverse probe can move both horizontally and vertically, and both axes have linear scales. Students can also measure distribution of total head by replacing the traverse probe with a Pitot tube.

To produce a free vortex, students place a smaller, perforated transparent cylinder inside the main vessel. This forms an annulus into which a continuous water supply is directed. When the vessel rotates, water passes through the perforations and spirals slowly inwards to a small hole in the centre of the base of the vessel. The surface falls rapidly towards the centre and produces an air core. Students measure the surface profile using the traverse probe.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96
or	
• Suitable water supply and drain	

Jet Trajectory and Orifice Flow (H33)

Shows vertical flow and horizontal jet trajectory through different orifices (nozzles)

- Supplied with four interchangeable nozzles with different throat (or orifice) designs
- Direct measurement of total head, head loss and diameter of jet
- Integral Pitot traverse tube
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation

Shown with the Volumetric Hydraulic Bench (H1D, available separately)

EXPERIMENTS:

- **Determination of the contraction and velocity coefficients; hence the calculation of the discharge coefficient.**
- **Determination of the actual discharge coefficient by measurement of flow rate for comparison against calculated value.**
- **Determination of the above over a range of flow rates to show the influence of Reynolds number.**
- **Determination of discharge characteristics (jet trajectory) for an orifice mounted in the side of a vertical tank and comparison with simple theory.**

TecQuipment's Jet Trajectory and Flow Through an Orifice apparatus allows students to measure:

- Decrease in flow
- Contraction of the stream
- Energy loss

They make these measurements as water discharges from four vertically mounted, interchangeable nozzles with different throat (orifice) designs.

It also allows students to study the trajectory profiles of water jets from the nozzles when mounted horizontally.

The equipment is for use with a hydraulic bench (H1 or H1D, available separately) and stands on the hydraulic bench worktop. The apparatus has a transparent cylindrical tank, with a mounting in the base for the nozzles. The nozzles either fit to the unit to discharge water vertically (down) or horizontally dependent on the experiment taking place. They are easily interchangeable.

Water flows into the tank from the hydraulic bench through an adjustable diffuser. The flow rate and an overflow pipe set the water level. To change the level in the tank (and so the head on the orifice), students adjust the flow to the diffuser. Water leaves the tank through the nozzles. The jet that leaves the orifice discharges into the hydraulic bench measuring tank.

Manometers measure the total head on the orifice and under the jet. A traverse assembly allows students to position a Pitot tube anywhere in the jet. A sharp blade accurately measures the jet diameter. This allows students to find the contraction coefficient.

To measure trajectory of jets, the base of the tank includes a horizontal mounting for the nozzles. Students use a bung to seal the base of the unit. They then use the plotting board and depth gauge pins to plot the jet trajectory onto graph paper.

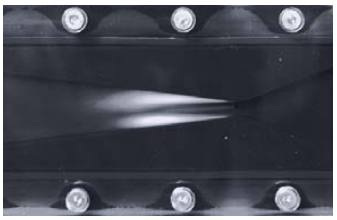
Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Product:	Page
• Flow Through an Orifice (H4)	112

Cavitation Demonstration Unit (H400)

Shows the causes and effects of cavitation, and how the Venturi meter works

- Also allows practical and effective study of flow and pressure in a Venturi meter
- Ideal for classroom demonstrations and student experiments
- Fully self-contained recirculating apparatus – no additional water supply needed
- Includes full instrumentation, including pressure, flow and temperature measurement



Cavitation in the Venturi

EXPERIMENTS:

Investigations into cavitation and the Venturi, including:

- **Flow and pressure in the Venturi**
- **Demonstrations of cavitation**
- **How to predict the onset of cavitation**

The causes and effects of cavitation are one of the most important subjects in any course on fluid mechanics. In severe cases, cavitation will damage machines and hydraulic systems. Designers and engineers must be aware of cavitation when they create a new design or installation.

TecQuipment's Cavitation Demonstration Unit is a purpose-designed teaching unit which enables efficient and effective investigations into the causes and effects of cavitation. It also allows students to understand the Venturi by studying upstream and throat pressures.

The Cavitation Demonstration Unit offers a clear and easy-to-understand display of cavitation. Students create clearly visible cavitation in a Venturi (which has a transparent window) and take measurements of flow and pressure. Students use theory and practical experiments to learn how to predict the onset of cavitation. They gain practical experience of using the continuity equation and Bernoulli's equation. They use these to calculate flow and pressure, different methods of creating cavitation and causes of error.

The apparatus is a self-contained, mobile unit. It consists of a robust frame which holds a water tank (or reservoir), an electric pump, a flow-control valve, a flow meter and a Venturi. The frame includes a handy worktop for student paperwork.

Pressure gauges show the pressure upstream of the Venturi and the pressure at the Venturi throat. A thermometer shows the temperature of the water in the tank.

The pump includes electrical protection and the water tank includes a splash cover to prevent water spillage.

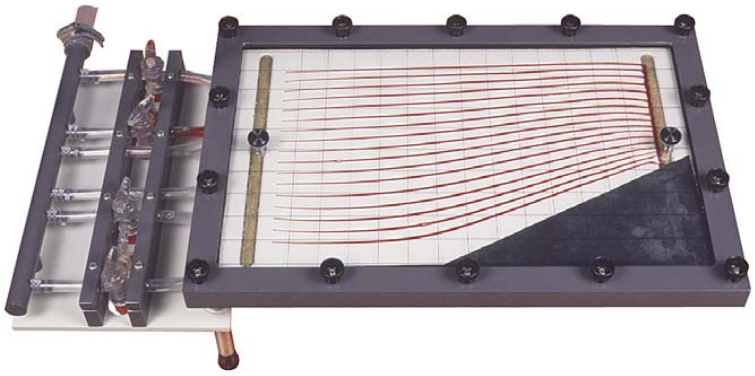
TecQuipment offers an optional stroboscope. This can improve the image of the cavitation.

Recommended Ancillary:	Page
• Stroboscope (ST1)	299

Alternative Product:	Page
• Venturi Meter (H5)	100

Hele-Shaw Apparatus (H9)

A powerful method of demonstrating potential flow in fluid dynamics



- Visually effective demonstration of a wide variety of flow patterns around different shapes
- Models easily cut from sheet (included) – almost any shape possible
- Ideal introduction to incompressible potential flow (aerodynamics)
- Source and sink points provided
- Can show soil seepage problems

EXPERIMENTS:

Various flow visualisation experiments in two dimensions, including sink and source points and flow around models, for example:

- **Sources and sinks in a uniform stream**
- **Doublet in a uniform stream**
- **Flow around a cylinder (disc) and an aerofoil**
- **Flow through an orifice and a diffuser**
- **Flow through a heat exchanger**
- **The momentum equation**
- **Laminar flow relationship for flow between two parallel plates**
- **Mean velocity equations (including seepage in soils)**
- **Potential flow relationships**

TecQuipment's Hele-Shaw apparatus produces streamlines in a laminar, steady flow. It allows students to study various source and sink arrangements, and look at flow around an unlimited variety of different shaped models. The apparatus can represent water seepage through solids, and can simulate any process satisfying the Laplace equation in two dimensions. Thus lecturers can also use it to represent flow in other branches of engineering, such as aerodynamics or electricity and heat flow.

The apparatus works with a steady, air-free water supply and suitable drain. The equipment consists of a channel formed between two plates. Water flows along the channel at a low Reynolds number, so the inertia forces are not important.

A dye flowing through several small holes at the upstream end produces streamlines. The removable top glass plate has gridlines to help analysis of the flow patterns. The apparatus comes with a rubber sheet from which to cut out various shapes of models. When placed between the two plates, students can see the streamline patterns flowing around the models. Also, valves and a vacuum pump allow students to connect two sources and two sinks (or any combination of both).

To perform experiments, students start the water flow and open a dye valve just enough to produce easily visible streamlines. They then use valves to allow water to flow from a source point or drain into a sink point, or various combinations of flow or sink points. The vacuum pump strengthens the sink points.

To incorporate models into the free stream of the apparatus and study the effect on streamlines, students cut the shapes they need from the rubber sheet (supplied). They then sandwich the model between the two plates of the apparatus and start the flow.

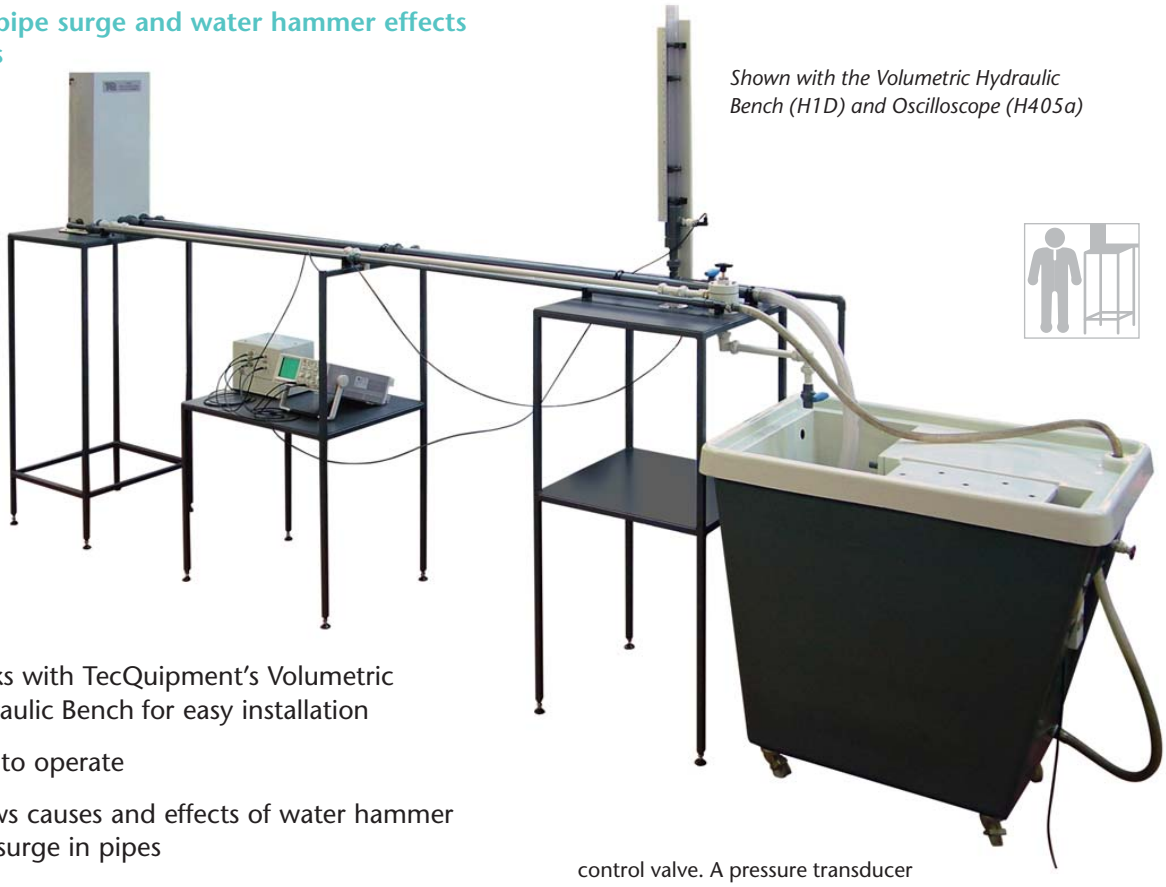
To provide a constant head and smooth, air-free flow from your water supply, TecQuipment offers the optional Header Tank (H9a).

Recommended Ancillary:

- Header Tank (H9a) – A wall-mounting tank with a float valve, overflow and a flow-control valve and pipework

Pipe Surge and Water Hammer (H405)

Shows pipe surge and water hammer effects in pipes



Shown with the Volumetric Hydraulic Bench (H1D) and Oscilloscope (H405a)

- Works with TecQuipment's Volumetric Hydraulic Bench for easy installation
- Easy to operate
- Shows causes and effects of water hammer and surge in pipes
- Helps students find velocity of sound in pipes
- Includes transparent surge tower so students can see what is happening

EXPERIMENTS:

Investigations into the transient effects of pipe surge and water hammer caused by changing flow rates in pipes including:

- **Demonstration and analysis of pipe surge**
- **Demonstration and analysis of water hammer**
- **Determination of frictional head loss between reservoir and surge tower**
- **Determination of pressure profiles**
- **Determination of velocity of sound in the test pipe**

TecQuipment's Pipe Surge and Water Hammer apparatus shows the transient effects of pipe surge and water hammer caused by changing flow rates in pipes.

The apparatus has two separate test pipes: one for water hammer investigations and one for surge investigations. A header tank supplies both test pipes, and includes an internal overflow weir to keep a constant head. A Volumetric Hydraulic Bench (H1D, available separately) supplies the header tank with a controlled flow of water via an inlet valve. The outlets from the test pipes flow into the measuring tank of the hydraulic bench. The outlet from the overflow weir goes to the sump.

The test pipe for surge investigations includes a clear plastic surge tower connected near its downstream end, and a control valve. A pressure transducer in the base of the surge tower connects to an electrical enclosure, with sockets for an oscilloscope with printout (H405a, available separately).

To perform surge experiments, students create a steady flow from the header tank through the pipe, using the inlet valve and surge pipe control valve. They set a known head drop from the header tank to the surge tower. To create the surge, students quickly close the surge pipe control valve. The oscilloscope records the pressure surge. Students also examine the maximum surge height, and use a stopwatch to measure the time from valve closure to maximum surge. They then repeat the experiment with a smaller initial head drop.

The test pipe for water hammer experiments has a manual valve and a special quick-closing valve. Pressure transducers on the water hammer pipe connect to an electrical enclosure, with sockets for an oscilloscope with printout (H405a, available separately).

To perform water hammer experiments, students create a steady flow from the header tank through the pipe, using the inlet valve and manual control valve. To create the water hammer effect, students use the quick-closing valve. The oscilloscope shows the passage of the acoustic wave past each pair of pressure transducers.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Essential Ancillary:	Page
• Dual Beam Storage Oscilloscope (H405a)	299

Alternative Product:	Page
• Water Hammer Apparatus (TE86)	119

Water Hammer Apparatus (TE86)

A compact unit that shows the water hammer effect

- Shows the propagation of shock waves at sonic velocity in water
- Shows how to calibrate an electronic pressure transducer
- Includes electric valve to stop flow instantly
- Contains over 60 m of pipe in one compact unit to save space
- Includes mechanical and electronic pressure measurement
- Includes connectors for extra (optional) equipment for transient measurements

EXPERIMENTS:

- **Water hammer**
- **Propagation of shock waves in water**
- **Velocity of sound in a water filled pipe**
- **Transducer calibration**

The apparatus is made up of a coil of copper pipe 60 m long, supplied with mains water and fitted with a solenoid valve at the discharge end.

An electronic pressure transducer near to the valve measures the pressure fluctuations in the pipe when the solenoid valve shuts.

A bypass valve discharges to waste at the inlet end of the pipe. A second adjustable valve is at the discharge from the pipe, downstream of the solenoid valve. This regulates the mean pressure in the pipe before the solenoid valve shuts.

A Bourdon pressure gauge fitted between the solenoid valve and the downstream control valve shows the pressure in the system. It also allows students to calibrate the pressure transducer.

Essential Ancillary:	Page
• Dual Beam Storage Oscilloscope (H405a)	299

Alternative Product:	Page
• Pipe Surge and Water Hammer (H405)	118

Equipment training

We offer a comprehensive equipment training programme that includes start-up, operation, shut-down, safety and maintenance procedures. Training programmes can be delivered at your premises or our manufacturing facility in the UK.

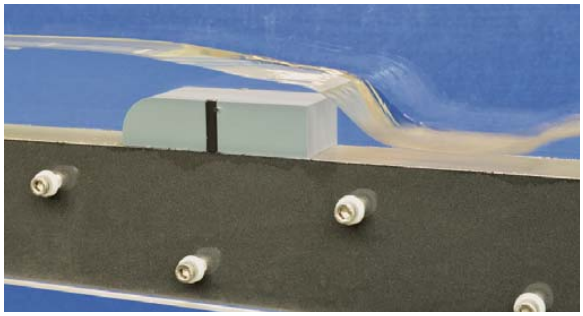
2.5-Metre Flow Channel (H23)

Shows clearly the flow around weirs and other objects in an open channel. Supplied with model weirs, gates, blocks and a Venturi.

- Inclinable acrylic channel providing maximum flow visualisation
- Inlet includes baffle section to provide steady flow conditions
- Works with TecQuipment's Volumetric Hydraulic Bench (H1D) for easy installation
- Includes:
  - Depth gauge
  - Pitot tube
  - Submerged narrow-crested weir
  - Crump weir
  - Calliper gauge
  - Stopwatch
  - Sluice gate
  - Drum gate
  - Venturi
  - Square jump block
  - Radius jump block

EXPERIMENTS:

- **Study of sluice and drum gates including investigation into hydraulic jump, specific energy and the determination of discharge coefficient.**
- **Study of submerged narrow-crested and crump weirs revealing the relationship between head over a weir and discharge.**
- **Study of a broad-crested weir (by combining the square and radius jump blocks) and the effects of changing the profile of the weir.**
- **Study of uniform flow in an inclined channel with investigations into the Chezy factor and coefficient.**
- **Study of a Venturi flume to indicate the discharge and surface profile, thus the derivation of the discharge coefficient.**



The apparatus consists of a floor-standing 2.5-metre flow channel fabricated from transparent acrylic and anodised aluminium, together with various gates, weirs and blocks, enabling the phenomenon of flow channels to be easily demonstrated and studied.

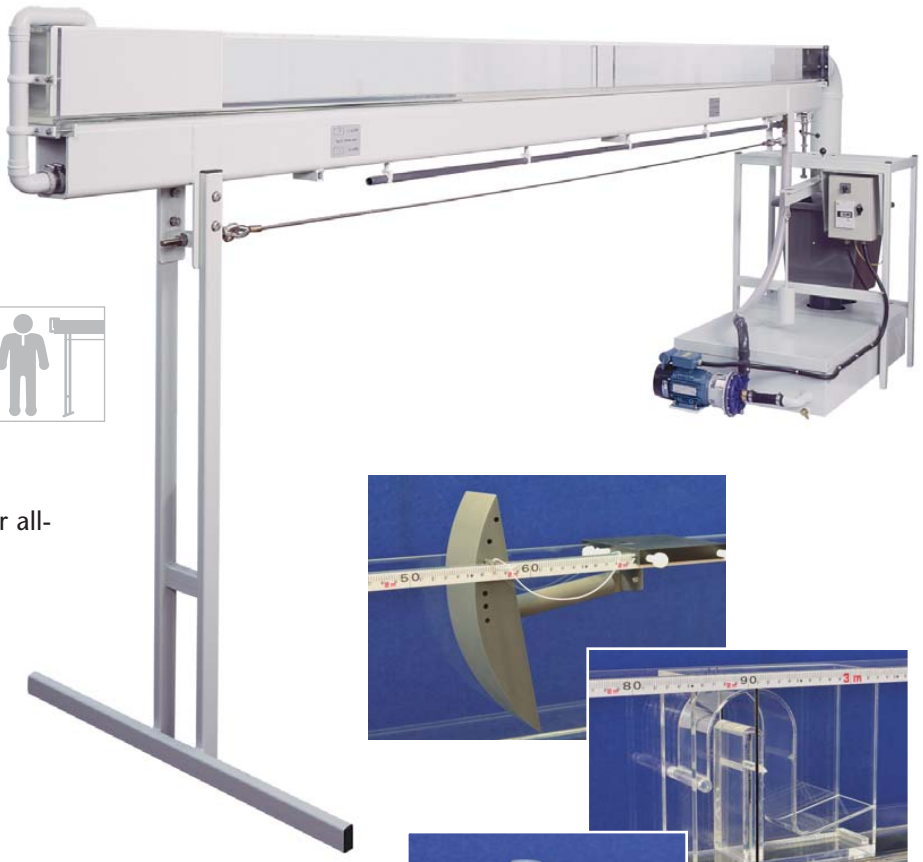
The equipment is designed primarily for use with TecQuipment's Volumetric Hydraulic Bench (H1D, available separately) which provides the necessary water supply, drain and volumetric flow-measurement facilities. Alternatively, the customer may arrange their own water supply and flow-measurement facilities, if desired.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products:	Page
• Discharge Over a Notch (H6)	101
• 5-Metre Flow Channel (H12)	121

5-Metre Flow Channel (H12)

Provides facilities for experiments and demonstrations in water flow, including weirs, gates and flumes



- Clear sides at eye-level for all-round visibility of flow
- Completely self-contained, free-standing unit – only needs an electrical supply
- Ideal for group demonstrations
- Includes models of sluice gate, different weirs and flume
- Extra models available include wave generator, different weirs and flow splitter

From the top: Radial Gate (H12b), Siphon Spillway (H12l) and Bridge Pier Construction (H12j) – all shown fitted to the Flow Channel

EXPERIMENTS:

- **Friction in a uniform channel flow**
- **Flow under a sluice gate**
- **The Venturi flume**
- **Flow over a sharp-crested weir**
- **The broad-crested weir**

Additional experiments with the recommended ancillaries:

- **The drum gate and the radial sector gate (H12a and b)**
- **The Crump weir (H12d)**
- **Flow over a spillway (H12e/f and l)**
- **Flow over a streamlined hump (H12g)**
- **The Parshall flume (H12h)**
- **Flow round a bridge pier (H12j)**
- **Friction in a uniform channel with roughened bed (H12k)**
- **Flow over a siphon spillway (H12l)**
- **Flow-induced vibration of a cylinder (H12m)**
- **Wave generator and beach (H12n)**
- **Flow through a culvert (H12p)**
- **Splitting flow in an open channel (H12v)**

The channel is made of transparent perspex, precision-built to ensure parallel walls and a consistently accurate cross-section along its length. A sturdy tubular-steel section firmly supports the channel throughout its length. It has a floor-standing 'T' frame at the upstream end, and a trunnion screw support at the downstream (weigh tank) end. A calibrated jack raises and lowers the screw support to give an accurate adjustment of the channel angle (inclination).

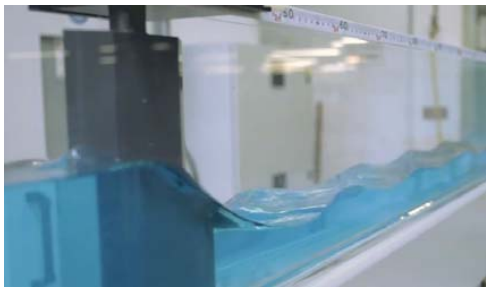
The water supply and measuring system is similar to that of TecQuipment's successful Gravimetric Hydraulic Bench (H1), but larger in overall size. A pump forces water from a sump, up to flow straighteners at the upstream end of the channel. This gives smooth, uniform flow, free from entry effects. The outlet water from the channel falls freely into a weigh tank. On completion of weighing, students open the outlet valve of the weigh tank to discharge the water back to the sump tank for recirculation.

Continued on next page

5-Metre Flow Channel (H12)
Continued from previous page

Supplied with the flow channel is a selection of models that fit into the channel for experiments and demonstrations. The models include weirs, a sluice gate and a flume. Also included is a Pitot tube to accurately measure pressures around the models.

TecQuipment makes a selection of extra (optional) models for use with the flow channel – see Recommended Ancillaries for details.



Recommended Ancillaries:

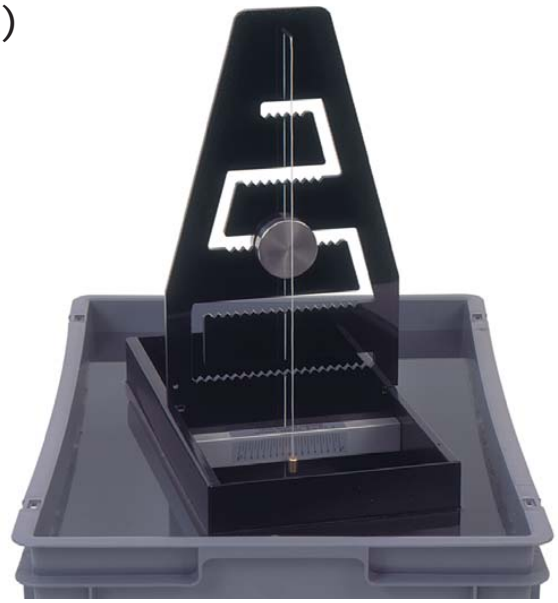
- Cylindrical Gate (H12a)
- Radial Gate (H12b)
- Crump Weir (H12d)
- Spillway (Ogee Weir) with Flat Apron and Ski Jump (H12e/f)
- Streamlined Hump (H12g)
- Parshall Flume (H12h)
- Bridge Pier Construction (H12j)
- Roughened Bed (H12k)
- Siphon Spillway (H12l)
- Vibration of Structural Columns (H12m)
- Wave Generator and Beach (H12n)
- Culvert (H12p)
- Flow Splitter (H12v)

Alternative Products:

	Page
• Discharge over a Notch (H6)	101
• 2.5-Metre Flow Channel (H23)	120

Stability of a Floating Body (H2)

Shows how to find the metacentric height of a floating body. Allows full investigations into theoretical predictions.



- Ideal for classroom demonstrations
- Bench-mounting
- No services required
- Compact and requires minimal storage space

EXPERIMENTS:

Determination of the metacentric height, and thus the metacentre, of a floating pontoon. This is by graphic analysis of the angles of tilt of the pontoon with various centres of gravity.

Determination and analysis of the stability of floating bodies, such as ships, rafts and pontoons, is important throughout many branches of engineering. This experiment allows students to determine the stability of a pontoon with its centre of gravity at various heights. They can then compare this to predictions calculated from theory.

The experiment consists of a rectangular pontoon floating in water. Plastic materials and corrosion-resistant finishes throughout the equipment give the fullest possible protection against corrosion.

The pontoon has a plastic sail with five rows of slots. These rows are at equally spaced heights on the sail. The slots are equally spaced around the centre line.

To change the centre of gravity and the tilt (list) angle of the pontoon, students fit an adjustable weight into one of the slots. A plumb line from the top centre of the sail and a scale below the base indicate the tilt angle. Students obtain fore and aft balance by positioning two small magnetic trim weights on the bottom of the pontoon.

Alternative Product:

	Page
• Hydrostatics and Properties of Fluids (H314)	124

Centre of Pressure (H11)

For finding the centre of pressure of a totally or partially submerged plane surface

- Compact and self-contained – just needs clean water
- Determines theoretical centre of pressure and compares actual and theoretical hydrostatic thrust
- Simple but accurate balance to measure moment due to hydrostatic thrust
- Tests a vertical and inclined plane surface

EXPERIMENTS:

- **Studying the relationship between hydrostatic force and head of water for a fully and partially submerged vertical and inclined plane**
- **Comparison of actual and theoretical hydrostatic force on a fully or partially submerged plane for any given head of water**
- **Theoretical calculation of the position of centre of pressure on a fully or partially submerged plane**

This product allows students to measure the moment due to the fluid (hydrostatic) thrust on a fully or partially submerged plane. The plane works in either a vertical or inclined (angled) position. Students then compare their measurements with theoretical analysis.

The equipment consists of a vertical panel that holds a clear plastic quadrant, to which students add water. The quadrant has engraved lines to help students keep the plane in a vertical or angled position.

The cylindrical sides of the quadrant have their central axis coincidental with the moment measurement axis. The total fluid pressures on these curved surfaces therefore exert no moment about this pivot. Therefore, the moment is only due to the fluid pressure on the plane test surface. Students measure this moment using weights suspended from a level arm. A scale on the panel of the apparatus shows the head of water.

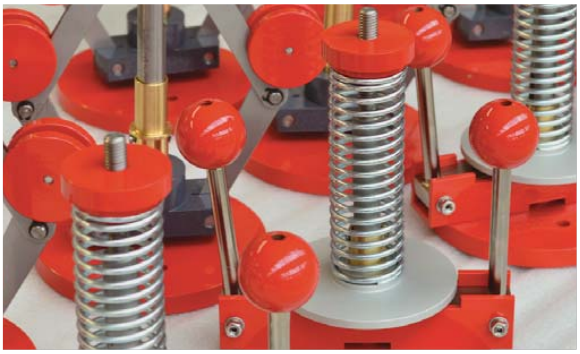
To perform experiments, students level the apparatus using its levelling feet and spirit (bubble) level. They decide whether to test either a vertical or inclined plane. They then initially balance the quadrant tank using one of the weight hangers and the smaller trimming tank. They take results by balancing incremental weights on the hanger with known quantities of water. They then use the results to calculate the equivalent moment of force (M) or hydrostatic thrust. Students note the relationship between the moment and the water height (h).

The equipment includes non-toxic water dye to help students see the water levels more clearly and a syringe for accurate addition or removal of small amounts of water.

Alternative Product:	Page
• Hydrostatics and Properties of Fluids (H314)	124

Manufacturing in quantity to improve delivery and prices

We set manufacturing batch sizes to ensure that we can offer both realistic deliveries and competitive prices.



Hydrostatics and Properties of Fluids (H314)

Self-contained, mobile unit for many experiments in fluid mechanics, from Archimedes' principle to stability of a floating body

- Wide range of experiments
- Determination of fluid properties including density, specific gravity, surface tension and viscosity
- Demonstration of hydrostatic principles including Pascal's law, Archimedes' principle and determination of pressure at a point in a fluid
- Experiments cover study of buoyancy, flotation and stability of floating bodies, forces on a plane surface, centre of pressure, operation and calibration of a Bourdon pressure gauge and liquid column manometers

EXPERIMENTS:

- **Determination of fluid density and specific gravity**
- **Principles and use of a hydrometer**
- **Capillarity in tubes and between plates**
- **Measurement of viscosity by falling sphere method**
- **Demonstration of Pascal's law**
- **Measurement of fluid levels by vernier hook gauge**
- **Fluid flow head relationship**
- **Verification of Archimedes' principle and demonstration of principles of flotation**
- **Stability of a floating body and determination of metacentric height**
- **Measurement of force and centre of pressure on a plane surface**
- **Operation and calibration of a Bourdon pressure gauge**
- **U-tube manometers with fluids of different density**

The apparatus consists of a self-contained bench complete with all necessary equipment for a wide range of demonstrations and experiments in hydrostatics and properties of fluids. Much of the equipment is rigidly mounted on the bench, the remainder being free-standing items suitable for use on the bench top.

The bench has a reservoir that supplies water for the experiments. A tank on the unit can be filled from the reservoir for experiments that need a free-water surface. A drain tray next to the tank is for collecting and returning water to the reservoir.

The bench is readily movable and is therefore ideal for lecture room demonstrations as well as student experiments.

Experimental equipment supplied with the bench includes a fluid-level apparatus for demonstrating Pascal's law, and two U-tube manometers. A toroidal sloped tank is mounted within an integrated balance to determine centre of pressure. Archimedes' principle is proved by using a fixed mass immersed in a header of water mounted on a beam balance. Further items of equipment include a Bourdon pressure gauge with deadweight calibration, and a rectangular pontoon with adjustable weights for studies of a floating body and metacentric height.

Apparatus for determination of fluid properties includes a Eureka can, a specific-gravity bottle, a hydrometer capillarity apparatus, a falling-sphere viscometer and a vernier point gauge for fluid level measurement.

Recommended Ancillaries:

- Surface Tension Balance (H314a)
- Hare's Tube (H314b)

Alternative Products:

	Page
• Stability of a Floating Body (H2)	122
• Calibration of a Pressure Gauge (H3a)	99
• Centre of Pressure (H11)	123
• Pressure Measurement Bench (H30)	103

Particle Drag Coefficient
(H410)

Shows the drag coefficient of different sized particles (spheres) and the viscosity of liquids

- Chemically inert, high-quality clear-glass tube for use with water and other suitable fluids
- Safe, low-voltage backlighting so students can see the falling test spheres through dark fluids (low translucence)
- Includes test spheres of different sizes and densities to help match a range of test fluids
- Includes stopwatch and timing marks for accurate results

EXPERIMENTS:

- **Determination of the viscosity of different fluids**
- **Determination of the drag coefficient of various spheres**

The Particle Drag Coefficient apparatus is a simple falling-sphere viscometer. A wall-mounted back plate holds a glass tube filled with the test fluid. The back plate has a low-voltage backlight so students can easily see the test spheres through the fluid.

Students fill the tube with their chosen test fluid, then select a sphere of the correct density and size for the fluid. They drop the sphere into the test fluid at the top of the glass tube. They then use a stopwatch (included) to measure the time taken for the sphere to fall a set distance down the tube.

When the test sphere reaches the bottom of the tube, it enters a valve that the students turns, dropping the sphere into a collection vial for recovery. The valve system minimises the fluid loss from the tube and helps when draining the tube after the tests are complete.

Students may also make their own shapes to test in the unit. The shapes must fit through the valve at the base (maximum 8 mm in any single dimension).

Suitable test fluids include: water, thin machine oil, castor oil and motor oil. The apparatus can be used with any fluid that can be safely handled and is chemically compatible with the wetted parts of the equipment – glass and PTFE.

Note: TecQuipment does not supply test fluids with the equipment.

Alternative Product: Page

- Reynolds Number and Transitional Flow (H215) 111

Liquid Sedimentation Apparatus (H311)

Shows how different particles settle in liquid

- Finds settling characteristics and particle sizes of suspended solids
- Five identical sedimentation columns for comparison of different sediments
- Translucent rear panel with back lighting for better visibility
- Includes stopwatch, measuring beakers and specific gravity bottle

EXPERIMENTS:

- **Comparison of settling characteristics of different sediments**
- **Determination of the effect of concentration on settling characteristics (hindered settlement)**
- **Determination of velocity distribution curves**
- **Comparison of flocculent and particle suspensions**
- **Determination of particle size distribution (grading curve) by liquid sedimentation**

The bench-mounting apparatus consists of five long, transparent sedimentation columns mounted on a rigid frame.

The rear panel is translucent, with back lighting to improve observation of settling sediments in the columns. The columns are removable for filling before tests. A graduated scale on the rear panel allows students to measure settlement depth.

Supplied with the equipment is a stopwatch to find settling times, a specific gravity bottle, measuring beakers and five rubber bungs. The rubber bungs seal the ends of the columns when the students shake the liquid and particles (slurry) before an experiment.

Packed and ready for shipment

First-class products deserve first-class packing and shipping. You can be confident your order will arrive safely and on time.

Permeability Tank (H312)

Shows flow through permeable media with common structures, for example dams or walls

- Dye-injector system to help show flow lines
- Clear plate glass resists abrasion and allows students to see flow patterns
- Includes pressure tappings and piezometer tubes to measure head distribution
- Plates supplied to simulate models of walls, sheet piling and dams
- Self-contained, floor-standing unit – only needs water supply and drain

EXPERIMENTS:

- **Determination of seepage beneath a structure**
- **Construction of flow nets and determination of coefficient of permeability**
- **Flow under a sheet pile and determination of critical seepage force at which 'piping' occurs**
- **Seepage flow under an impermeable dam**
- **Flow through an earth dam with and without a toe drain**
- **Drawdown in horizontal flow (simulation of groundwater flow into a river or well)**
- **Determination of uplift pressures on structures such as building foundations**
- **General studies of seepage and drainage**
- **Flow through a porous medium (Darcy's law)**

The apparatus is a transparent-sided tank, mounted on a steel-framed bench with worktop.

The tank is clear so students can see the flow patterns. The sides are plate glass to resist abrasion from the permeable medium. The rear of the tank contains pressure tappings. Each tapping has filters that stop any unwanted particles. The tappings connect to a bank of piezometer tubes at the side of the apparatus which allow measurement of the head distribution along the tank.

Removable stainless-steel mesh baffles at each end of the tank hold the permeable medium (usually sand) in place. At each side of the baffles are end compartments with adjustable overflow pipes for setting the water levels at each end of the model. The top of the tank is open to allow students to fill the tank and set up model structures. Supplied are clear, self-sealing plates for students to build models of sheet piling, walls and simulated dams.

Included is a dye-injector system to help show flow lines. Around the front edge of the glass tank are scales to help students position and measure flow nets correctly. The self-contained apparatus needs only a mains water supply and drain.

Recommended Ancillary:

- Permeable Medium (H312a) – Washed sand, graded 0.5 mm to 1.5 mm

Hydrology Apparatus (H313)

For students to study hydrology, including rainfall and movement of water over land and rivers

- Permeable catchment area fed with 'rain' from overhead spray nozzles and/or by groundwater flow from ends of tank
- Spray nozzles to supply half or all of catchment area
- Can measure 'drawdown' due to single or two interacting wells
- Self-contained – requires only an electrical supply

EXPERIMENTS:

- **Investigation of rainfall/run-off relationships for dry, saturated and impermeable catchments of various slopes (surface run-off only)**
- **Effect of interflow on outflow hydrograph surface run-off (plus groundwater flow)**
- **Simulation of multiple and moving storms**
- **Measurement of cone of depression for a single well and comparison with theory interaction of cones of depression for two adjacent wells**
- **De-watering of excavation sites by use of wells**
- **Flow from a well in a confined aquifer**
- **Demonstration of watersheds for a simulated island with rainfall and well flows**
- **Sediment transport and meanders in simulated rivers**
- **Studies of scour around simulated bridge piers**

The apparatus is a sturdy metal frame which holds a large rectangular stainless-steel tank (catchment area) and a reservoir tank. Students can fill the catchment area with a granular medium (not included) to form a permeable catchment area.

A jacking mechanism allows adjustment of the angle of the catchment area. Above the catchment area is a frame that holds spray nozzles which simulate rainfall on the catchment. A valve selects all or half the nozzles. Students can use this facility to vary the lag time on a hydrograph or to simulate a moving storm.

At each end of the catchment area are end compartments, separated from the catchment by weir plates with porous 'port holes'. Students can open the port holes to drain water from the catchment area, or to supply water to it from the end compartments.

In the middle of the catchment area are two 'wells' for experiments with water wells. A row of 20 tappings along the centre line of the catchment area allows students to measure the water table profile. Each tapping has special slotted ends to stop the permeable media entering its pipe. The tappings connect to a bank of piezometer tubes at the front of the catchment area.

A pump takes water from the reservoir and feeds it to the overhead nozzles and to the ends of the catchment area. Students can vary the flow to the nozzles and tank. A flow meter measures the overall flow.

Students can use a calibrated rectangular weir under the catchment area to measure flow from the wells or the tank.

The apparatus is completely self-contained and needs only a mains electrical supply. The permeable medium is not included with the apparatus, but TecQuipment offers a suitable grade of sand as an essential ancillary.

Recommended Ancillary:

- Permeable Medium (H313a) – Washed sand, graded 0.5 mm to 1.5 mm

Francis Turbine (H18)

Shows how a Francis turbine works and tests its performance

- Mounts onto TecQuipment's Volumetric Hydraulic Bench (H1D) for flow measurement and easy installation
- Includes band brake to measure turbine torque
- Fully adjustable guide vanes with position indicator
- Includes pressure gauge to measure inlet pressure

EXPERIMENTS:

- **Efficiency of a Francis turbine**
- **Performance of a Francis turbine at different flow rates**
- **The effect of different guide vane settings on turbine performance**

The Francis Turbine is a laboratory-scale reaction turbine for use with TecQuipment's Volumetric Hydraulic Bench (H1D, available separately).

The turbine has a sturdy base which sits on the top of the hydraulic bench. The turbine connects to the pumped supply of the hydraulic bench. The bench measures the flow rate. A mechanical gauge measures the inlet pressure to the turbine. Adjustable guide vanes in the turbine alter the flow rate and direction of flow to the impeller (runner) of the turbine. The end of the turbine outlet tube (draft) is in the open-water channel of the hydraulic bench.

Included with the turbine is a weir plate to create a shallow reservoir in the water channel of the bench. This ensures that water covers the end of the draft during tests.

A band brake with spring balances measures the torque at the turbine shaft. A stroboscope with speed display (ST1, available separately) or an optical tachometer (OT1, available separately) can measure the speed of the turbine.

The stroboscope can also 'freeze' the image of the turbine and water flow to improve students' understanding of the turbine.

Students test the turbine at different flow rates, loads and guide vane settings. They use the flow, torque, pressure and speed measurements to calculate hydraulic power input and mechanical (shaft) power at the turbine. They use these to create performance curves for the turbine.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Essential Ancillary:	Page
• Optical Tachometer (OT1)	299

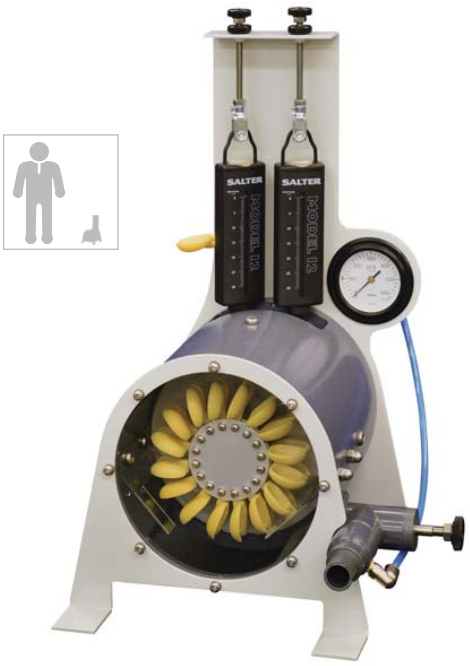
Recommended Ancillary:	Page
• Stroboscope (ST1)	299

Alternative Product:	Page
• Francis Turbine (MFP101d)	141

Pelton Turbine (H19)

A compact unit for demonstrations and performance tests on a Pelton turbine

- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation
- Includes dynamometer to load the turbine and help find the power absorbed (needs an optional tachometer to find speed)
- Includes inlet pressure gauge
- Screw-controlled spear valve for precise inlet flow control



EXPERIMENTS:

- **Performance charts of power, speed, torque and efficiency**
- **The effect of spear valve position**

Shows students how an impulse (Pelton) turbine works and tests its performance. The Pelton wheel is an important and efficient fluid power machine, used in many applications.

The unit consists of a Pelton wheel mounted in a corrosion-resistant enclosure. A transparent front panel allows students to see the turbine working. An optional Stroboscope (ST1, available separately) can 'freeze' the image of the turbine to help students better understand how it works.

An adjustable spear valve directs a jet of water through a nozzle to the buckets of the Pelton wheel to make it turn. Manual adjustment of the spear valve controls the water jet from the nozzle.

The turbine includes all pipes and fittings to connect it to TecQuipment's Volumetric Hydraulic Bench (H1D, available separately). The hydraulic bench also measures flow rate.

The Optical Tachometer (OT1, available separately) can measure the speed of rotation of the turbine. A simple mechanical brake and spring balance assembly attached to the shaft of the Pelton wheel applies a variable mechanical load (torque). Students use this with the speed (from the optional tachometer) to find power absorbed by the turbine. A gauge measures inlet pressure.

Students adjust the spear valve and measure inlet pressure, flow rate and torque (and speed with the optional tachometer). They plot these values to find the turbine performance.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Essential Ancillary:	Page
• Optical Tachometer (OT1)	299

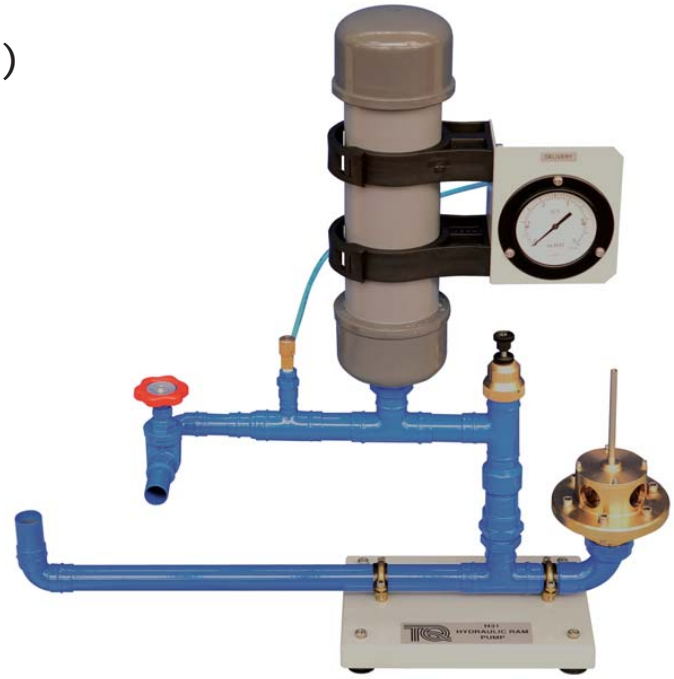
Recommended Ancillary:	Page
• Stroboscope (ST1)	299

Alternative Products:	Page
• Impact of a Jet (H8)	113
• Pelton Wheel (Turbine) (MFP101b)	140

Hydraulic Ram Pump (H31)

Shows the use of water hammer to create a pumping action

- Works with TecQuipment's Volumetric Hydraulic Bench for easy installation
- Includes air vessel to reduce hydraulic shock
- Ideal for demonstrations to small groups of students
- Includes header tank and all necessary pipework



EXPERIMENTS:

- **Demonstration of the water hammer effect to produce a pumping action**

The Hydraulic Ram Pump uses the water hammer effect. The momentum of a long column of moving water in a pipe causes the water hammer.

Shown fitted to the Volumetric Hydraulic Bench (H1D)

The ram pump is not a normal mechanically operated pump. A column of water in the supply (drive) pipe, moving at low velocity, is similar to a plunger. The energy in the plunger forces water from the supply into a delivery pipe.

The Hydraulic Ram Pump fits onto and works with TecQuipment's Volumetric Hydraulic Bench (H1D).

The apparatus has three main parts: the header tank, the pump and the interconnecting pipe work. The header tank fits on a wall, pillar or similar feature. The pump has:

- a supply pipe fitted with an inner and outer valve,
- an air vessel to reduce hydraulic shock, and
- a delivery section.

The outer valve has a weight platform, for loading with the weights provided. This changes the pump's cycle times.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	96

Have you seen our Modular Fluid Power range?

All the modules in this modern and comprehensive range combine pump, turbine, fan and compressor technologies, enabling the study of applied fluid mechanics and aerodynamics with practical applications.

See pages 137–152

Series and Parallel Pump Test Set (H32)

Shows the performance of pumps in series and parallel

- Easy-to-use, mobile unit
- Shows performance of one pump, or two pumps in series or parallel
- Long-life, robust valves with large handles allow students to change water circuit in seconds, ready for the next experiment
- Works with TecQuipment's hydraulic benches for easy installation and flow measurement
- Includes pressure gauge to measure delivery pressure

EXPERIMENTS:

- **Performance of a single centrifugal pump**
- **Parallel operating characteristics of two similar pumps**
- **Series operating characteristics of two similar pumps**
- **Parallel operating characteristics of two pumps operating at different speeds**
- **Series operating characteristics of two pumps operating at different speeds**

This apparatus works with TecQuipment's Gravimetric Hydraulic Bench or Volumetric Hydraulic Bench (H1 and H1D, available separately). It gives a low-cost demonstration of pump performance in series and parallel.

The apparatus is made up of a self-contained modular frame with two similar three-speed centrifugal pumps connected by pipes and valves. Students can set the pipes and valves to test the performance of a single pump, two pumps in series, or two pumps in parallel. A mechanical gauge measures delivery pressure. TecQuipment's hydraulic benches measure flow rate.

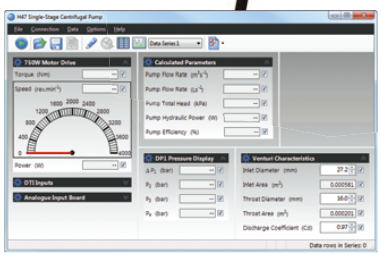
Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	95
or	
• Volumetric Hydraulic Bench (H1D)	96

Alternative Products :	Page
• Centrifugal Pump Test Set (H47)	133
• Two-Stage (Series and Parallel) Pumps (H83)	135
• Centrifugal Pump Module (MFP101)	138

Centrifugal Pump Test Set (H47)

Works with VDAS®

For a comprehensive range of investigations into the performance and characteristics of a centrifugal pump



Screenshot of the optional VDAS® software

Test Set with analogue pressure measurement, digital pressure measurement and Versatile Data Acquisition Unit

- Pump has a transparent 'window' to allow students to see clearly its impeller, the water flow and cavitation
- Shows how to use a Venturi meter and differential pressure measurement to find flow rate
- Optional stroboscope allows students to see clearly the effects of cavitation around the pump impeller
- Optional easy-to-read analogue instrumentation

EXPERIMENTS:

Comprehensive demonstrations and investigations into a centrifugal pump including:

- **Centrifugal pump performance and characteristics, typically head versus flow and efficiency versus flow**
- **Non-dimensional performance characteristics**
- **Flow measurement using a Venturi tube**
- **Demonstration of cavitation**

Continued on next page

Centrifugal Pump Test Set (H47)
Continued from previous page

A compact, mobile and fully self-contained centrifugal pump test set that allows students to find the characteristics of a centrifugal pump. It also allows them to see (and hear) cavitation and understand the use of a Venturi meter and differential pressure measurement to find flow rate.

A motor mounted in bearings drives the pump. The pump draws water from the integral reservoir. The water travels up through a valve and filter, through an inlet valve to the pump body, then out through a delivery valve. It then passes through a Venturi meter and returns to the reservoir for re-use. This self-contained water supply keeps water consumption to a minimum. The pump has a transparent 'window' so students can see the impeller turning and how the water vapour bubbles form in the pump at cavitation. The optional stroboscope makes the effect easier to see.

Instrument and control modules fit into a frame above and behind the pump. An electronic Motor Drive controls the pump speed. A strain gauge load cell measures the driving torque of the pump and a sensor measures pump speed. A display on the Motor Drive shows speed and torque and automatically calculates and displays true 'shaft' power.

Cavitation demonstration

The differential pressure across the Venturi gives flow rate. The adjustable inlet and delivery valves allow students to create different operating conditions.

TecQuipment supplies a Digital Pressure Display (DP1) as standard but offers an optional, additional easy-to-read Analogue Pressure Display (AP1). Both instruments display the inlet pressure, delivery pressure and differential pressure across the Venturi. The analogue display is more visual, but the digital display increases ease of measurement, and allows connection to TecQuipment's frame-mounted Versatile Data Acquisition System (VDAS-F, available separately).

The equipment can use both analogue and digital instrumentation at the same time, enabling students to compare the different pressure measurement methods.

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Frame-mounting version (VDAS-F)	32
• Stroboscope (ST1)	299
• Analogue Pressure Display (AP1)	

Alternative Products:	Page
• Two-Stage (Series and Parallel) Pumps (H83)	135
• Series and Parallel Pump Test Set (H32)	132
• Centrifugal Pump Module (MFP101)	138

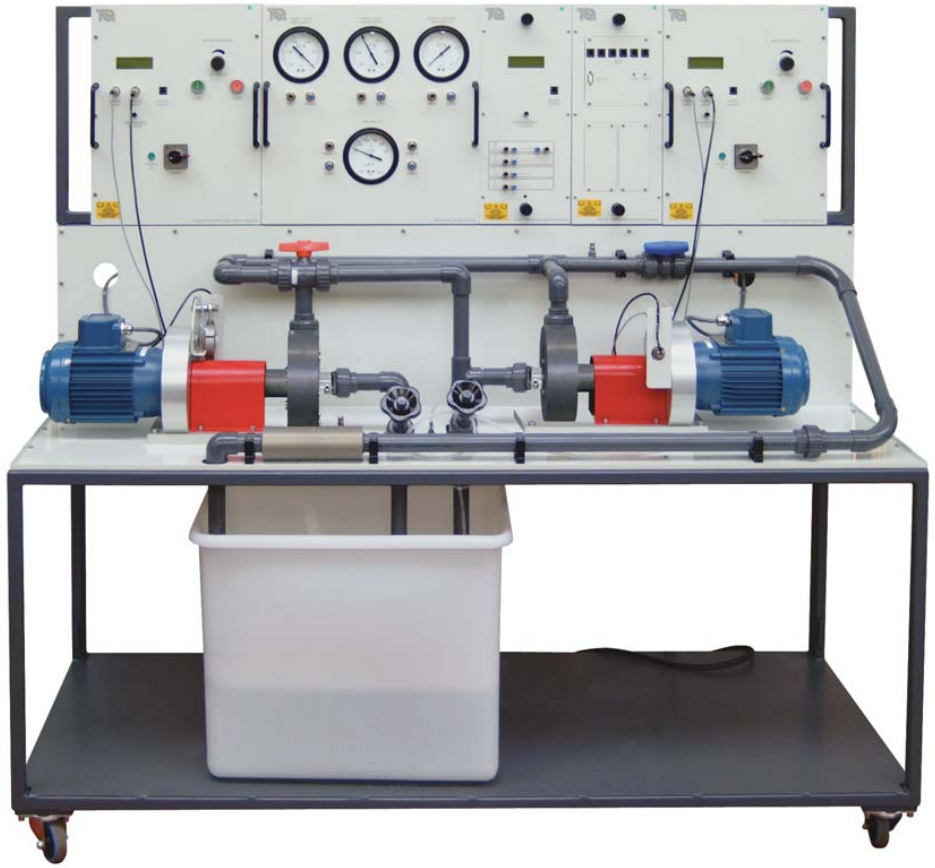
Installation and commissioning

TecQuipment is pleased to offer a world-class installation and commissioning service for all of our equipment. Our skilled engineers can professionally and safely install your new equipment to the highest standard.

Two-Stage (Series and Parallel) Pumps (H83)

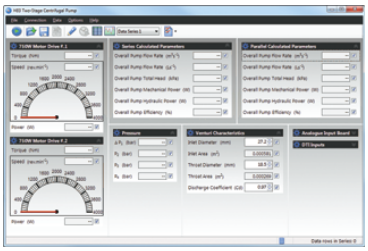
Works with VDAS®

For a comprehensive range of investigations into the operation and characteristics of a single centrifugal pump, and two centrifugal pumps in both series and parallel



Test set shown with all instrumentation options and Versatile Data Acquisition System

- Pumps have a transparent 'window' to allow students to see clearly their impellers, the water flow and cavitation
- Pumps can be tested individually, in series and in parallel, with independent speed control
- Shows how to use a Venturi meter and differential pressure measurement to find flow rate
- Optional stroboscope allows students to see clearly the effects of cavitation around a pump impeller
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) and software



Screenshot of the optional VDAS® software

EXPERIMENTS:

Comprehensive demonstrations and investigations into a centrifugal pump including:

- **Centrifugal pump performance and characteristics, typically head versus flow and efficiency versus flow**
- **Non-dimensional performance characteristics**
- **Flow measurement using a Venturi tube**
- **Demonstration of cavitation**
- **Operation of centrifugal pumps in series**
- **Operation of centrifugal pumps in parallel**

Continued on next page

Two-Stage (Series and Parallel) Pumps (H83)
Continued from previous page

A compact, mobile and fully self-contained centrifugal pump test set, that allows students to find the characteristics of centrifugal pumps working alone or in series or parallel. It also allows students to see (and hear) cavitation and understand the use of a Venturi meter and differential pressure measurement to find flow rate.

Two bearing-mounted motors drive each pump independently. The pumps draw water from the integral reservoir. The water travels through strainers and a series of valves to be delivered to a Venturi meter. The water then returns to the reservoir for re-use, keeping water use to a minimum. The pumps each have a transparent 'window' so students can see the impeller turning and how the water vapour bubbles form in the pump at cavitation. The optional stroboscope makes the effect easier to see.

Instrument and control modules fit into a frame above and behind the pumps. Each pump has an electronic Motor Drive to control its speed, a load cell to measure torque and a sensor to measure pump speed. A display on each Motor Drive shows speed and torque and automatically calculates and displays true 'shaft' power.

The differential pressure across the Venturi gives flow rate. Each pump has its own inlet valve. A two-way valve in the system allows the pumps to work alone, in parallel or in series.

TecQuipment supplies a Digital Pressure Display (DP1) as standard, but offer an optional, additional easy-to-read Analogue Pressure Display (AP2). Both instruments display the inlet pressure, delivery pressure and differential pressure across the Venturi. The analogue display is more visual, but the digital display increases ease of measurement, and allows connection to TecQuipment's frame-mounted Versatile Data Acquisition System (VDAS-F, available separately).

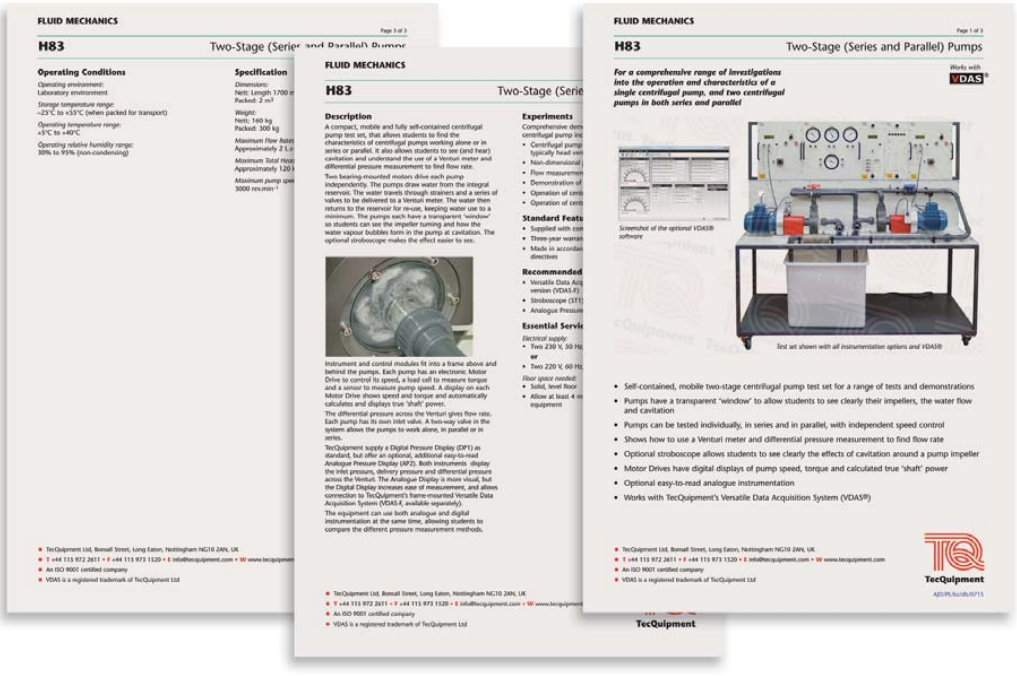
The equipment can use both analogue and digital instrumentation at the same time, allowing students to compare the different pressure measurement methods.

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Frame-mounting version (VDAS-F)	32
• Stroboscope (ST1)	299
• Analogue Pressure Display (AP2)	

Alternative Products:	Page
• Series and Parallel Pump Test Set (H32)	132
• Centrifugal Pump Test Set (H47)	133
• Centrifugal Pump Module (MFP101)	138

For more information download our datasheets

www.tecquipment.com



Universal Dynamometer (MFP100)

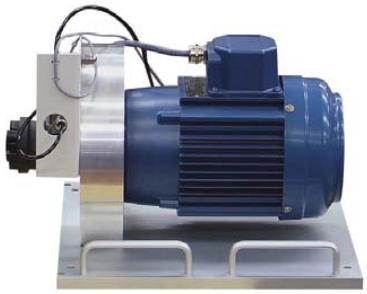
Works with VDAS®

Provides motive power with speed, torque and power measurements for TecQuipment's Modular Fluid Power range

MODULAR SYSTEM

Essential Base Unit (MFP100)

Experiment Modules (MFP101–MFP107)



FEATURES:		BENEFITS:
Only one Universal Dynamometer is needed for use with the Fluid Power experiment modules	→	**No need to purchase duplicate items – saves costs and laboratory space**
Has multiple outlets to provide electrical power for other instruments supplied with the Fluid Power modules	→	No additional power supplies needed – increased safety
Quick and easy disconnection and reconnection from one module to another	→	**Maximises experiment time in laboratory session**
Direct drive – no belts or pulleys to adjust	→	Accuracy of results, repeatability

For use with all of TecQuipment's Modular Fluid Power range, the Universal Dynamometer (MFP100) gives motive power and instrumentation for the machines fitted to each module.

It has two parts: the electric dynamometer, and a motor drive and display unit. The dynamometer is an induction motor, trunnion-mounted to allow it to move freely against a strain gauge load cell. An inductive sensor measures the shaft speed. The load cell measures the shaft torque.

A precision-machined base plate holds the motor and its sensors. The base plate has location points to give accurate and repeatable alignment onto each Fluid Power module. The coupling between the Universal Dynamometer and all Fluid Power machines is a jaw-type coupling with a rubber element. The Universal Dynamometer directly drives the Fluid Power machines. This means that the user has no need to fit or adjust the tension of belts and pulleys.

The motor drive and display unit contains a variable-speed a.c. inverter drive and includes signal conditioning. It digitally displays speed, torque and shaft power. The unit fits on the instrument frame fitted to all the Fluid Power modules. The front of the motor drive and display unit has motor stop, start and speed controls. Outlets on the back of the unit give power for instruments supplied with the Fluid Power modules. This reduces the need for multiple mains connections and gives a neater and safer equipment arrangement.

The control and instrumentation unit includes a socket to link it to TecQuipment's optional Versatile Data Acquisition System (VDAS®). When used with a suitable computer (computer not included), it gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings. VDAS® makes tests quick and reliable.

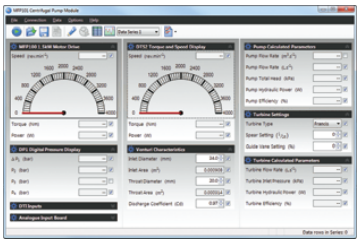
Available Experiment Modules:	Page
• Centrifugal Pump Module (MFP101)	138
• Axial Flow Pump Module (MFP102)	142
• Positive Displacement Pump Module (MFP103)	143
• Reciprocating Compressor Module (MFP104)	147
• Centrifugal Compressor Module (MFP105)	148
• Centrifugal Fan Module (MFP106)	149
• Axial Fan Module (MFP107)	151

Centrifugal Pump Module (MFP101)

Works with VDAS®

Allows students to study and perform tests on a centrifugal pump and optional turbines, to understand how they work and calculate their performance

Shown fitted with the Universal Dynamometer (MFP100), turbine dynamometer and a turbine



Screenshot of the optional VDAS® software

- Centrifugal pump mounted in mobile frame with full instrumentation
- Part of TecQuipment's Modular Fluid Power range which connects with the Universal Dynamometer (MFP100) as a common motive power source for a cost-effective solution
- Inlet and delivery valves for wide range of operating conditions
- Turbine dynamometer and turbines (available separately) – Propeller, Francis and Pelton

EXPERIMENTS:

- **Centrifugal pump performance and characteristics, typically head against flow and efficiency against flow**
- **Variation of pump performance with inlet pressure**
- **Variation of pump performance with speed**
- **Non-dimensional performance characteristics**
- **Flow measurement using a Venturi**

For use with and driven by the Universal Dynamometer (MFP100, available separately), the Centrifugal Pump Module is part of TecQuipment's Modular Fluid Power range. The Centrifugal Pump Module is ideal for student experiments, demonstrations and projects.

Centrifugal pumps are common machines used to move water and other fluids in many applications. These can be domestic water systems, agriculture, sanitation and many industrial applications.

The module includes a centrifugal pump, a Venturi flow meter, valves, a reservoir and instrumentation; all mounted on a robust, mobile trolley for ease of use. The separate Universal Dynamometer (MFP100) measures and displays the speed and torque of the pump to calculate and display mechanical (shaft) power. Electronic pressure transducers measure the pump inlet and delivery pressures and the Venturi differential pressure (flow rate). Speed is fully variable up to the maximum allowable for the pump.

The centrifugal pump is also the power source for the optional turbines: a Pelton wheel, a Francis turbine and propeller turbine (all available separately). The turbines (only one turbine can be used at a time) mount onto the Turbine Dynamometer (MFP101a, available separately).

The turbine dynamometer fits onto the Centrifugal Pump Module. The centrifugal pump delivery pipe then connects to the turbine. The turbine dynamometer includes a display unit, and measures and displays the torque, speed and mechanical power of the turbine.

The Pelton wheel has a variable spear jet to control the flow rate and pressure. The Francis and propeller turbines have variable angle inlet guide vanes for flow control. A pressure transducer on the Centrifugal Pump Module measures the turbine inlet pressure. When used with an optional stroboscope, students can 'freeze' the image of the moving turbines and water flow to improve their understanding of the turbines.

For quick and reliable tests, TecQuipment can supply its optional Versatile Data Acquisition System (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not included).

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Available Experiment Modules:	Page
• Pelton Wheel (Turbine) (MFP101b)	140
• Propeller Turbine (MFP101c)	140
• Francis Turbine (MFP101d)	141

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32
• Stroboscope (ST1)	299

Alternative Products:	Page
• Series and Parallel Pump Test Set (H32)	132
• Centrifugal Pump Test Set (H47)	133
• Two-Stage (Series and Parallel) Pumps (H83)	135

Turbine Dynamometer (MFP101a)

Works with VDAS®

Dynamometer for the turbines of the Centrifugal Pump Module (MFP101)

- Dynamometer that fits on the Centrifugal Pump Module to test the optional turbines
- Electrically powered from outlets on the Universal Dynamometer motor drive
- Measures and displays torque, speed and shaft power
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

You need the Turbine Dynamometer for tests on the optional turbines. It fits on the Centrifugal Pump Module (MFP101), near the outlet end of the centrifugal pump. You fit any of the three optional turbines to the Turbine Dynamometer. Each turbine has a brake drum that fits inside the dynamometer.

You connect the outlet of the centrifugal pump to your turbine. As the pump forces water through the turbine, you use a control on the Turbine Dynamometer to adjust a band brake. This loads the turbine. The Turbine Dynamometer and its instrumentation then measures and displays the speed, torque and shaft power available at the dynamometer. The Turbine Dynamometer instrumentation fits above the dynamometer, in the instrument frame of the Centrifugal Pump Module. It has a socket for connection to TecQuipment's optional VDAS®.

Ancillary for:	Page
• Pelton Wheel (MFP101b)	140
• Propeller Turbine (MFP101c)	140
• Francis Turbine (MFP101d)	141

Note: You need only one Turbine Dynamometer to test all three turbines.

Pelton Wheel (Turbine) (MFP101b)

Turbine for use with the Centrifugal Pump Module (MFP101)

- Optional turbine that fits on the Turbine Dynamometer (MFP101a) of the Centrifugal Pump Module (MFP101)
- Impulse turbine
- Variable spear jet

EXPERIMENTS:

- **Variation of turbine performance with inlet pressure and flow rate**
- **Variation of turbine performance with speed**
- **Non-dimensional performance characteristics**

The Pelton Wheel is an impulse turbine with tangential flow (the water hits its wheel at a tangent). It is good for applications with high pressure (head) and low flow.

It has a large wheel or 'runner' that has 'buckets' (turbine blades) that absorb the energy in the water. The buckets are in pairs to correctly balance the wheel and to work efficiently. The Pelton Wheel has a variable spear jet at its inlet. This allows students to understand the effect of changing the velocity of the water that hits the buckets. A clear viewing window on the side of the turbine allows students to see how the turbine works.

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	138

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	139

Alternative Products:	Page
• Impact of a Jet (H8)	113
• Pelton Turbine (H19)	130

Propeller Turbine (MFP101c)

Turbine for use with the Centrifugal Pump Module (MFP101)

- Optional turbine that fits on the Turbine Dynamometer (MFP101a) of the Centrifugal Pump Module (MFP101)
- Inward flow reaction turbine
- Four-blade propeller
- Fully adjustable guide vanes

EXPERIMENTS:

- **Variation of turbine performance with inlet pressure and flow rate**
- **Variation of turbine performance with speed**
- **Non-dimensional performance characteristics**

The Propeller Turbine is an inward flow reaction turbine, similar to a Kaplan design, but with fixed blades. It is a very common turbine and works best with high flow rates. Its moving part (runner) is a propeller, similar to those that push ships and submarines through water.

The turbine has adjustable guide vanes that control the water flow in the turbine. They also direct the water at an angle to the back of the propeller. Students learn how the guide vane setting affects how the turbine works. The turbine has a clear viewing window around the guide vanes and a clear draft tube so that students can see the turbine working.

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	138

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	139

Francis Turbine (MFP101d)

Turbine for use with the Centrifugal Pump Module (MFP101)

- Optional turbine that fits on the Turbine Dynamometer (MFP101a) of the Centrifugal Pump Module (MFP101)
- Reaction turbine
- Ten-blade runner
- Fully adjustable guide vanes

EXPERIMENTS:

- **Variation of turbine performance with inlet pressure and flow rate**
- **Variation of turbine performance with speed**
- **Non-dimensional performance characteristics**

The Francis Turbine is a reaction turbine. It is the most common turbine in the world, due to its ability to work for a wide range of applications. Its moving part (runner) is a radial impeller.

The turbine has adjustable guide vanes that control the water flow in the turbine. They also direct the water at an angle to the blades of the impeller. Students learn how the guide vane setting affects how the turbine works. The turbine has a clear viewing window and draft tube so that students can see the turbine working.

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	138

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	139

Alternative Product:	Page
• Francis Turbine (H18)	129

Product development

The information contained in this publication has been carefully prepared and is correct at the time of printing. TecQuipment, however, operates a continual product improvement process and therefore reserves the right to modify and update equipment to ensure it continues to meet your needs.

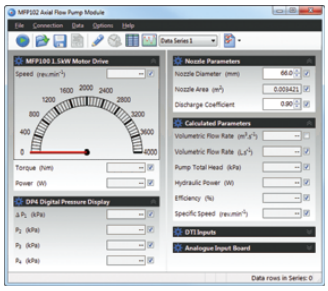
For the latest information on all our products please visit our website at:

www.tecquipment.com

Axial Flow Pump Module (MFP102)

Works with VDAS®

Allows students to study and perform tests on an axial flow pump: to understand how it works and calculate its performance



Screenshot of the optional VDAS® software

Shown fitted with the Universal Dynamometer (MFP100)

- Axial flow pump, mounted in a mobile frame with full instrumentation, including a digital pressure display
- Self-contained – has its own water reservoir and needs no external water supply
- Part of TecQuipment's Modular Fluid Power range which connects with the Universal Dynamometer (MFP100) as a common motive-power source for a cost-effective solution
- Connection plate with schematic diagram shows the water flow circuit and how parts of the module connect to each other

EXPERIMENTS:

- **Variation of pump performance with speed**
- **Variation of pump performance with different outlet pressures and flow rate**
- **Non-dimensional performance curves**
- **Determination of the specific speed of the pump**

For use with the Universal Dynamometer (MFP100), the Axial Flow Pump Module is part of TecQuipment's Modular Fluid Power range. The Axial Flow Pump Module is ideal for student experiments, demonstrations and projects.

Axial flow pumps are common machines, used to pump water and other liquids. They can be as small as a few centimetres in domestic use, or up to a metre when used in large irrigation systems. They give high flow rates at a reasonable pressure. The pump fitted to this module has two sections – one fixed and one moving, each with a set of blades.

The module has an axial flow pump and instrumentation, all mounted on a robust, mobile trolley for ease of use. The module is for use with and driven by TecQuipment's Universal Dynamometer (MFP100, available separately). The Universal Dynamometer measures the speed, torque and power absorbed by the pump. Speed is fully variable up to the maximum allowable for the pump.

Water moves from a water tank through a calibrated nozzle. It then passes through the pump and down to a fully adjustable delivery valve. It then returns to the water tank. The delivery valve allows the user to gradually shut the downstream water flow for a range of pump performance tests.

Electronic transducers measure the pump inlet and outlet pressures, and the pressure difference across the nozzle. A digital display shows all the readings.

For quick and reliable tests, TecQuipment can supply the optional Versatile Data Acquisition System (VDAS®). VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not supplied).

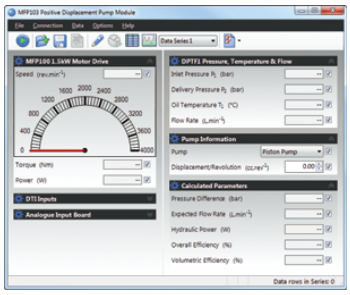
Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Positive Displacement Pump Module (MFP103)

Works with VDAS®

Allows students to study and perform tests on a range of positive displacement pumps, to understand how they work and calculate their performance



Screenshot of the optional VDAS® software

- Mobile pump-support module with full instrumentation
- Part of TecQuipment's Modular Fluid Power range which connects with the Universal Dynamometer (MFP100) as a common motive-power source for a cost-effective solution
- Allows students to study and test a range of popular positive-displacement pumps (available separately)
- Connection plate with schematic diagram clearly shows oil-flow circuit and how parts of the module connect to each other

For use with and driven by the Universal Dynamometer (MFP100, available separately), the Positive Displacement Pump Module is part of TecQuipment's Modular Fluid Power range. When used with one of the optional pumps, the Positive Displacement Pump Support Module is ideal for student experiments, demonstrations and projects.

Positive-displacement pumps are common machines, used to move fluids in many applications, and usually at high pressures. They can be rotary pumps or reciprocating pumps and work by moving a fixed volume of fluid from their inlet to their outlet. These pumps are used in lubrication systems, hydraulic systems, automobiles, agriculture, medical equipment, sanitation and many industrial applications.

The module consists of a mobile frame with an oil reservoir, a flow meter, valves and instruments to measure pump performance. The flow meter is a positive-displacement unit, so that it still works correctly at any oil viscosity. Any of the optional pumps fit to the module. Two flexible, high-pressure pipes with quick-release, self-sealing connections connect the pump to the oil circuit.

The separate Universal Dynamometer (MFP100) also fixes to the module to drive the pump. The Universal Dynamometer measures and displays the speed and torque of the pump to calculate and display mechanical (shaft) power. Electronic pressure transducers measure the pump inlet and delivery pressures and the fluid flow rate. Speed is fully variable up to the maximum allowable for the pump. Included with the module is the oil to fill the oil reservoir. A thermocouple measures the oil temperature to allow calculation of the oil viscosity. The oil system includes a pressure-relief valve to keep the oil pressure at a safe level.

The optional positive-displacement pumps include rotary and reciprocating types, including a piston pump, a gear pump, a vane pump and a swash-plate (axial piston) pump.

Continued on next page

Positive Displacement Pump Module (MFP103)
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The optional pumps fix to the bottom shelf of the pump-support module when not in use.

For quick and reliable tests, TecQuipment can supply the optional Versatile Data Acquisition System (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not included).

Available Experiment Modules:	Page
• Piston Pump (MFP103a)	144
• Gear Pump (MFP103b)	145
• Vane Pump (MFP103c)	146
• Swash Plate Pump (MFP103d)	146

Note: You must choose at least one of the optional pumps to use with the Positive Displacement Pump Module. You cannot do tests or experiments without an optional pump.

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Shown fitted with the Universal Dynamometer (MFP100) and a pump

Piston Pump (MFP103a)

Piston pump for use with the Positive Displacement Pump Support Module (MFP103)

- Popular design pump for use with TecQuipment's Positive Displacement Pump Support Module (MFP103)
- Quick-release, self-sealing connections for simple and safe fitting
- Shows the characteristics of a twin-piston pump

EXPERIMENTS:

- **Performance and characteristics of a piston pump**
- **Volumetric and overall efficiencies**
- **Use of an oval gear flowmeter**

When two or more optional pumps are ordered:

- **Comparison of positive displacement pumps (economy, flow rate and output pressure pulses)**

For use with the Positive Displacement Pump Module (MFP103) this pump is ideal for student experiments, demonstrations and projects.

The piston pump is a positive displacement pump. It has twin vertically-opposed pistons that deliver a given volume of fluid (oil) for each full rotation of the pump shaft.

Built-in one-way valves determine the flow direction, but you only test the pump in one direction, determined by the Universal Dynamometer.

Self-sealing connections reduce oil spillage and simplify installing the pump to the pump module.

Essential Base Unit:	Page
• Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100)	143

Gear Pump (MFP103b)

Gear pump for use with the Positive Displacement Pump Support Module (MFP103)

- Popular design pump for use with TecQuipment's Positive Displacement Pump Support Module (MFP103)
- Quick-release, self-sealing connections for simple and safe fitting
- Shows the characteristics of a double helical gear pump

EXPERIMENTS:

- **Performance and characteristics of a gear pump**
- **Volumetric and overall efficiencies**
- **Use of an oval gear flowmeter**

When two or more optional pumps are ordered:

- **Comparison of positive displacement pumps (economy, flow rate and output pressure pulses)**

For use with the Positive Displacement Pump Module (MFP103) this pump is ideal for student experiments, demonstrations and projects.

The gear pump is a positive displacement pump. It has double helical gears that deliver a given volume of fluid (oil) for each full rotation of the pump shaft.

The gear rotation generally determines the flow direction, but you only test the pump in one direction, determined by the Universal Dynamometer. A built-in pressure bypass valve helps to reduce over-pressuring the pump.

Self-sealing connections reduce oil spillage and simplify installing the pump to the pump module.

Essential Base Unit:	Page
• Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100)	143

Have you seen our other pumps?

TecQuipment's **Centrifugal Pump Test Set** (H47) on page 133 clearly and effectively enables students to assess the characteristics of a centrifugal pump.

Or for a centrifugal pump test set which enables students to assess the characteristics of a centrifugal pump, and two centrifugal pumps operating in series or parallel, see our **Two-Stage (Series and Parallel) Pumps** (H83) on page 135.

Both of these test sets are compact, mobile and fully self-contained and also work with TecQuipment's Versatile Data Acquisition System (VDAS®) VDAS®

Vane Pump (MFP103c)

Vane pump for use with the Positive Displacement Pump Support Module (MFP103)

- Popular design pump for use with TecQuipment's Positive Displacement Pump Support Module (MFP103)
- Quick-release, self-sealing connections for simple and safe fitting
- Shows the characteristics of a vane pump

EXPERIMENTS:

- **Performance and characteristics of a vane pump**
- **Volumetric and overall efficiencies**
- **Use of an oval gear flowmeter**

When two or more optional pumps are ordered:

- **Comparison of positive displacement pumps (economy, flow rate and output pressure pulses)**

For use with the Positive Displacement Pump Module (MFP103) this pump is ideal for student experiments, demonstrations and projects.

The vane pump is a positive displacement pump. It has a fixed displacement balanced vane that delivers a given volume of fluid (oil) for each full rotation of the pump shaft.

The pump rotation determines the flow direction, but you only test the pump in one direction, determined by the Universal Dynamometer.

Self-sealing connections reduce oil spillage and simplify installing the pump to the pump module.

Essential Base Unit:	Page
• Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100)	143

Swash Plate Pump (MFP103d)

Swash Plate pump for use with the Positive Displacement Pump Support Module (MFP103)

- Popular design pump for use with TecQuipment's Positive Displacement Pump Support Module (MFP103)
- Quick-release, self-sealing connections for simple and safe fitting
- Shows the characteristics of a swash plate pump

EXPERIMENTS:

- **Performance and characteristics of a swash plate pump**
- **Volumetric and overall efficiencies**
- **Use of an oval gear flowmeter**

When two or more optional pumps are ordered:

- **Comparison of positive displacement pumps (economy, flow rate and output pressure pulses)**

For use with the Positive Displacement Pump Module (MFP103) this pump is ideal for student experiments, demonstrations and projects.

The Swash Plate Pump is a positive displacement pump. It has a fixed displacement axial piston assembly that delivers a given volume of fluid (oil) for each full rotation of the pump shaft.

The pump shaft rotation determines flow direction, but you only test the pump in one direction, determined by the Universal Dynamometer.

Self-sealing connections reduce oil spillage and simplify installing the pump to the pump module.

Essential Base Unit:	Page
• Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100)	143

Reciprocating Compressor Module (MFP104)

Works with VDAS®

Allows students to study and perform tests on a reciprocating compressor, to understand how it works and calculate its performance

Screenshot of the optional VDAS® software

- Reciprocating compressor and air receiver mounted in a mobile frame with full instrumentation
- Allows students to study and test a popular fluid power machine
- Temperature and pressure measurements at key points in the system
- Connection plate with schematic diagram clearly shows how parts of the module connect together

EXPERIMENTS:

- **Energy balance for a compressor**
- **Variation of compressor performance with pressure**
- **Variation of compressor performance with speed**
- **Mechanical, volumetric and isothermal efficiencies**
- **Thermodynamics of a compressor**

For use with and driven by the Universal Dynamometer (MFP100, available separately), the Reciprocating Compressor Module is part of TecQuipment's Modular Fluid Power range. It is ideal for student experiments, demonstrations and projects.

Reciprocating compressors are common machines that provide compressed air for machines and tools. These can be air tools (saws, sanders and screwdrivers), paint spray equipment, pneumatic actuators and control systems.

The module includes a small compressor with an air receiver and instrumentation, all mounted on a robust, mobile trolley for ease of use.

The separate Universal Dynamometer (MFP100) measures the speed, torque and power absorbed by the compressor. Speed is fully variable up to the maximum allowable for the compressor. Air enters the compressor, which then delivers it under pressure to the receiver. A valve releases pressure from the receiver to atmosphere through an orifice. The valve sets the pressure in the receiver and hence the flow rate; the orifice allows an accurate measurement of the mass flow rate of the outlet air. These values help students to discover how the compressor flow rate relates to the pressure delivered by the compressor.

Thermocouples measure temperatures at the inlet and delivery of the compressor, and upstream of the orifice. Electronic transducers measure the delivery pressure, nozzle differential pressure (flow rate) and the atmospheric (barometric) pressure. Also, for safety and good engineering standards, a Bourdon gauge shows the vessel pressure, even if the mains electricity fails. Digital displays show all the important pressures and temperatures.

For quick and reliable tests, TecQuipment can supply its optional Versatile Data Acquisition System (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not included).

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Alternative Product:	Page
• Two-Stage Compressor Test Set (GT103)	298

Centrifugal Compressor Module (MFP105)

Works with VDAS®

Allows students to study and perform tests on a centrifugal compressor: to understand how it works and calculate its performance

Screenshot of the optional VDAS® software

- Centrifugal compressor, mounted in a mobile frame with full instrumentation
- Part of TecQuipment's Modular Fluid Power range that connects with the Universal Dynamometer (MFP100) as a common motive power source for a cost-effective solution
- Pressure and temperature measurements at key points in the system
- Connection plate with schematic diagram clearly shows the arrangement of the module

EXPERIMENTS:

- **Performance of a compressor**
- **Variation of compressor performance with speed**
- **Investigation of non-dimensional characteristics**
- **Comparison of performance with that of an ideal adiabatic system**

For use with the Universal Dynamometer (MFP100), the Centrifugal Compressor Module is part of TecQuipment's Modular Fluid Power range. This range examines and explains fluid power machines. The Centrifugal Compressor Module is ideal for student experiments, demonstrations and projects.

Centrifugal compressors are common machines, used for forced ventilation in applications that need a good volume of air at a reasonable pressure – for example: forced ventilation and cooling systems.

The module consists of a compressor and instrumentation, all mounted on a robust, mobile trolley for ease of use. The module is for use with and driven by TecQuipment's Universal Dynamometer (MFP100, available separately). The Universal Dynamometer measures the speed, torque and power absorbed by the compressor. Speed is fully variable up to the maximum allowable for the compressor. Air enters the compressor through a shaped nozzle, used to measure the air flow rate. The air then moves past a hand-operated delivery valve and out to atmosphere. The delivery valve controls the air flow rate (and therefore delivery pressure).

Electronic transducers measure the inlet pressure, delivery pressure, nozzle differential pressure (flow rate) and the atmospheric (barometric) pressure. Thermocouples measure inlet, outlet and ambient temperatures. Digital displays show all the readings.

For quick and reliable tests, TecQuipment can supply the optional Versatile Data Acquisition System (VDAS®). VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not supplied).

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Centrifugal Fan Module (MFP106)

Works with VDAS®

Allows students to study and perform tests on a centrifugal fan: to understand how it works and calculate its performance

Screenshot of the optional VDAS® software

Shown fitted with the Universal Dynamometer (MFP100)

- Centrifugal fan, mounted in a mobile frame with full instrumentation
- Part of TecQuipment's Modular Fluid Power range that connects with the Universal Dynamometer (MFP100) as a common motive power source for a cost-effective solution
- Three interchangeable impellers provided as standard
- Optional Pipe Flow and Nozzle Kit (MFP106a) for more experiments

EXPERIMENTS:

- **Performance of a centrifugal fan**
- **Variation of fan performance with speed**
- **Variation of fan performance with type of impeller**
- **Non-dimensional performance curves**
- **Determination of the specific speed of the fan**

For use with the Universal Dynamometer (MFP100), the Centrifugal Fan Module is part of TecQuipment's Modular Fluid Power range. This range examines and explains fluid power machines. The Centrifugal Fan Module is ideal for student experiments, demonstrations and projects.

Centrifugal fans are common machines, used for ventilation or any application that needs a good volume of air at a reasonable pressure.

The module consists of a fan and instrumentation, all mounted on a robust, mobile trolley for ease of use. The module is for use with and driven by TecQuipment's Universal Dynamometer (MFP100, available separately). The Universal Dynamometer measures the speed, torque and power absorbed by the fan. Speed is fully variable up to the maximum allowable for the fan. Air enters the fan through a shaped nozzle, used to measure the air flow rate. The air then moves past a slide valve and out to atmosphere. The slide valve controls the air flow rate (and therefore delivery pressure).

The fan impeller (moving part) is interchangeable. Supplied with the fan are three different impellers for more tests on fan performance.

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Centrifugal Fan Module (MFP106)
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Electronic transducers measure the inlet pressure, delivery pressure, nozzle differential pressure (flow rate) and the atmospheric (barometric) pressure. Digital displays show all the readings.

TecQuipment supplies an optional Pipe Flow and Nozzle Kit (MFP106a) for the fan. This kit allows study into velocity profiles and losses in pipes, bends and other pipe fittings.

For quick and reliable tests, TecQuipment can supply the optional Versatile Data Acquisition System (VDAS®). VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer. The computer is not supplied.

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32
• Pipe Flow and Nozzle Kit (MFP106a)	150

Pipe Flow and Nozzle Kit (MFP106a)

Optional pipe flow and nozzle kit for use with the Centrifugal Fan Module (MFP106)

- Includes a multiway pressure display with additional instrument frame
- Includes different pipe fittings to compare losses in bends and elbows
- Axial probe and additional nozzle to find pressures along a nozzle
- Pitot traverse to find pressure profile and calculate theoretical flow
- Orifice plate to calculate theoretical flow and compare with the Pitot and standard nozzle measurement

EXPERIMENTS:

- **Axial pressure profile along a nozzle**
- **Velocity profile across a pipe**
- **Losses in straight pipes**
- **Losses in bends and elbows (fittings)**
- **Flow through an orifice**

An optional Pipe Flow and Nozzle Kit for the Centrifugal Fan Module (MFP106). This kit includes two long lengths of smooth-walled pipe with multiple pressure tappings and a Pitot traverse. The pipes connect to the inlet of the MFP106 (you move the standard inlet nozzle), so it becomes a suction fan for tests on the pipes. The pipe tappings connect to a multiway pressure display (supplied with the kit).

The multiple pressure tappings along the long pipes allow you to measure the pressure drop and therefore losses along them.

The kit includes three different fittings – two elbows and a bend – that each fit between the long pipes to test the pressure drop and therefore loss caused by the fitting.

A probe mounts in an assembly so that it moves axially through an additional nozzle to measure its axial pressure profile.

A Pitot traverse fits at the end of one long pipe to allow you to measure the velocity profile across a pipe and calculate the theoretical flow. This allows a comparison with the flow found from the standard MFP106 nozzle and the orifice plate included with the kit.

Ancillary for:	Page
• Centrifugal Fan Module (MFP106)	149

Axial Fan Module (MFP107)

Works with VDAS®

Allows students to study and perform tests on an axial fan, to understand how it works and calculate its performance

Screenshot of the optional VDAS® software

Shown fitted with the Universal Dynamometer (MFP100)

- Part of TecQuipment's Modular Fluid Power range which connects with the Universal Dynamometer (MFP100) as a common motive-power source for a cost-effective solution
- Multiple pressure measurement points along fan duct allow students to examine full range of performance characteristics
- Connection plate with schematic diagram clearly shows air flow circuit and how parts of the module connect to each other
- Traversing, calibrated Pitot tube allows investigations of velocity distribution

EXPERIMENTS:

- **Characteristics of an axial fan, including head against flow efficiency**
- **Relationship between power and speed (power law)**
- **Velocity distribution in a round duct**
- **Calibration of an inlet nozzle**
- **Duct resistance and matching to fan to find operating point**

For use with and driven by the Universal Dynamometer (MFP100, available separately), the Axial Fan Module is part of TecQuipment's Modular Fluid Power range. The Axial Fan Module is ideal for student experiments, demonstrations and projects.

Axial fans move air in a wide range of applications from ventilation in domestic and commercial buildings to mines and agriculture. For these reasons it is important for engineers to be able to study and understand the characteristics of axial fans.

The module has an axial fan mounted in a cylindrical steel duct. Air enters the duct through an inlet nozzle. The pressure at a set of tappings just downstream of the nozzle allows calculation of the inlet air flow rate. A slide-valve (downstream of the fan) controls flow rate and delivery pressure. Air exits the duct through a silencer to reduce noise in the laboratory.

TecQuipment's Universal Dynamometer measures the speed, torque and power of the axial fan. Two more sets of pressure tapping points measure the pressure difference across the fan. Each tapping point has three tappings arranged at 120-degree separation around the duct to give a good average value at that location. A traversing Pitot tube with a calibrated scale allows students to find the velocity distribution across the duct. The Pitot tube fits to a choice of two positions, to allow students to move it across the duct in two axes.

For quick and reliable tests, TecQuipment can supply its optional Versatile Data Acquisition System (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not included). VDAS® will also log the position of the optional Pitot-Static Traverse (MFP107a).

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	137

Recommended Ancillaries:	Page
• Pitot-Static Traverse – 450 mm (MFP107a)	152
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Pitot-Static Traverse (450 mm) (MFP107a)

Works with VDAS®

A traversing Pitot-static tube with electronic position measurement for use with TecQuipment's Axial Fan Module (MFP107)

The Pitot-Static Traverse allows students to find the velocity distribution across the duct of the Axial Fan Module (MFP107). This optional ancillary comprises a Pitot-static tube which fits on the duct of the Axial Fan Module and has a digital indicator to show the tube position across the duct.

The digital indicator has a zero button to allow the user to set the datum or starting point to any position during an experiment. To display differential pressure, the Pitot-static tube connects to the instruments on the Axial Fan Module.

For computer-based data acquisition and display of position, the Pitot-Static Traverse connects to TecQuipment's optional Versatile Data Acquisition System (VDAS-F). This allows real-time data acquisition, monitoring, display, calculation and charting of all important readings on a computer (computer not included).

Ancillary for:	Page
• Axial Fan Module (MFP107)	151