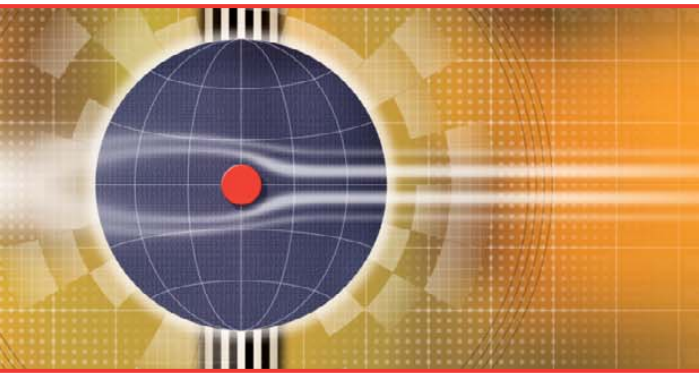
www.tecquipment.com

TecQuipment



Product Catalogue 2014–15

Technical teaching equipment for engineering

To go to the sections please click on the headings below

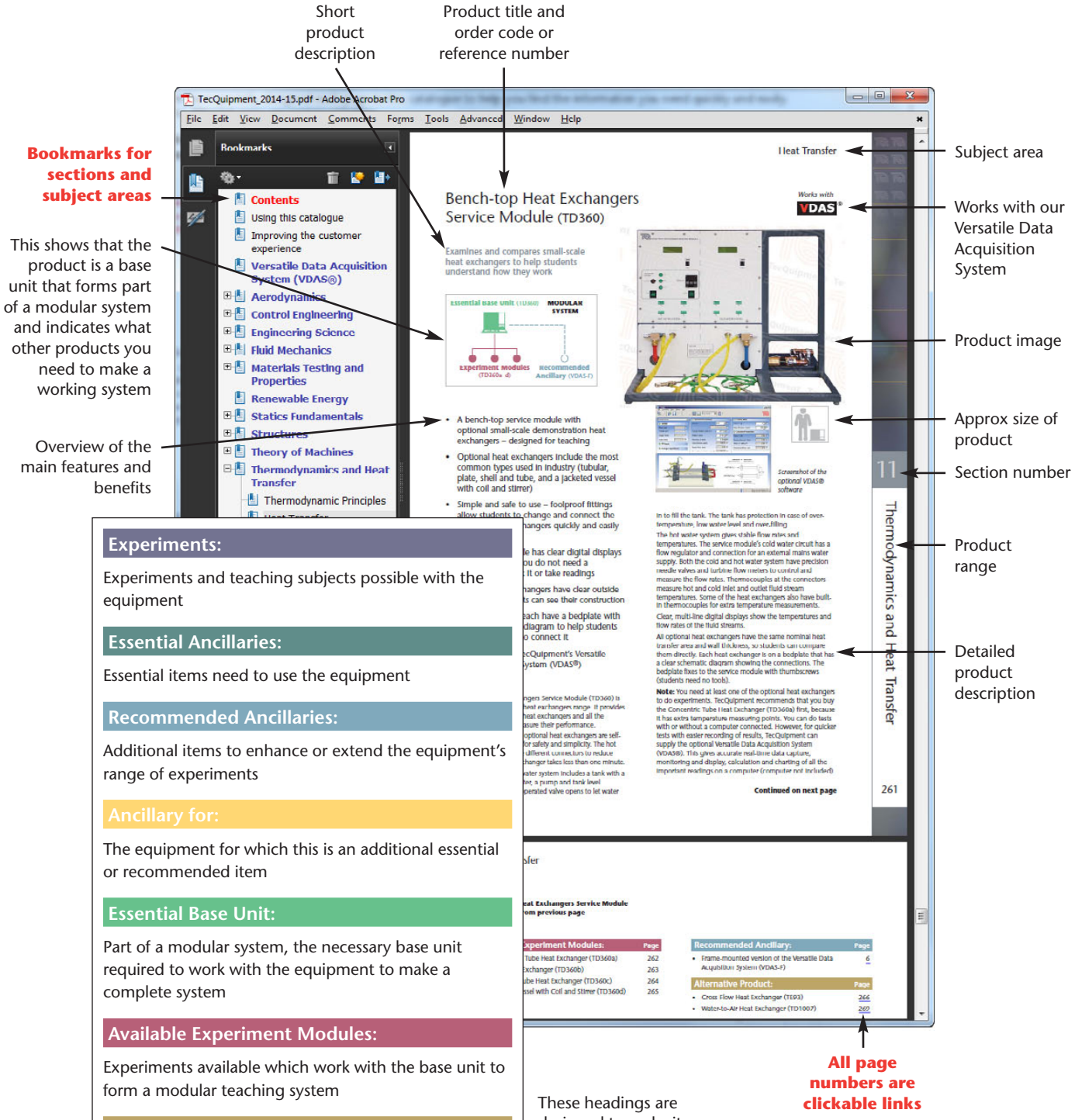
For easy navigation, the referenced page numbers throughout this catalogue are clickable links. You can also use the bookmarks to find the section you are looking for.

If you experience problems using the links, open the PDF files from Windows Explorer.
Can't find a product easily or don't know what section it is in? Go to the Product List to find the right page.

Using this catalogue

We have specially designed each page in this catalogue to help you find the information you need quickly and easily. The different areas are explained below.

We have added bookmarks to navigate to the different sections and subject areas and also made all referenced page numbers into clickable links for easy navigation.



Improving the customer experience

Thank you for your interest in TecQuipment and taking the time to look at our 2014–15 product catalogue.

This year, our theme is focused on enhancing the experience our agents and our customers have with us every time they deal with TecQuipment. It is important that we support our high quality products with an equally high quality of service. Over the last 12 months we have invested in staff and training to ensure that we support our agents and customers around the world. I am always interested in hearing from you if you have any comments or suggestions on how we can further improve this level of service to you.

We have listened to our customers regarding further products which could be added to our range. To accelerate this activity we have invested in a new Product Development department which focuses purely on new product design. The resource within the team includes mechanical, electrical, electronic and software engineers and they have a busy programme of work which will add to or improve products in our portfolio over the months ahead.

Investment in the factory continues with a focus on work flow and quality. Only by manufacturing on site do we truly have control over quality and delivery. Many of our competitors do not manufacture themselves and rely on importing products from other companies. We believe that this approach does not provide the solid foundation to support the products once they are in service. To ensure we do this, we have a dedicated team of qualified engineers to answer all technical enquiries and after-sales questions. This facility, in conjunction with our Sales team, ensures we are supporting you, year on year.

Listening to our agents and customers, we appreciate that delivery times are critical to you and we realise that gives us a real competitive advantage. We have therefore invested more into our manufacturing activity and will

be reducing our lead-times considerably over the weeks ahead as a result of this investment. Already many of our Hydraulics, Engineering Science and Structures products have a turnaround of four weeks and we will be extending this to more products over the weeks ahead.

Our Sales team is busy putting together a schedule for visits to meet agents, customers and end users. Only through these face-to-face meetings will we build strong and lasting relationships in order for us to improve the customer experience. I would like to thank the customers and agents that have extended hospitality to us over the last 12 months during our visits.

I would also like to thank the customers and agents that have visited us over the last 18 months. Our demonstration laboratory has been used on many occasions for visits, training and the demonstration of products. Our Sales team, Customer Support and engineers are always available to welcome you to TecQuipment.

Finally, I hope you find the new TecQuipment product catalogue easy to use. We have changed the style slightly this year in order to make product selection easier. Further details of the product specifications can be found on the datasheets available on our web site.

Once again, thank you on behalf of all of the staff for choosing TecQuipment as your preferred supplier of *Technical Teaching Equipment for Engineering*.

Simon Woods
Managing Director

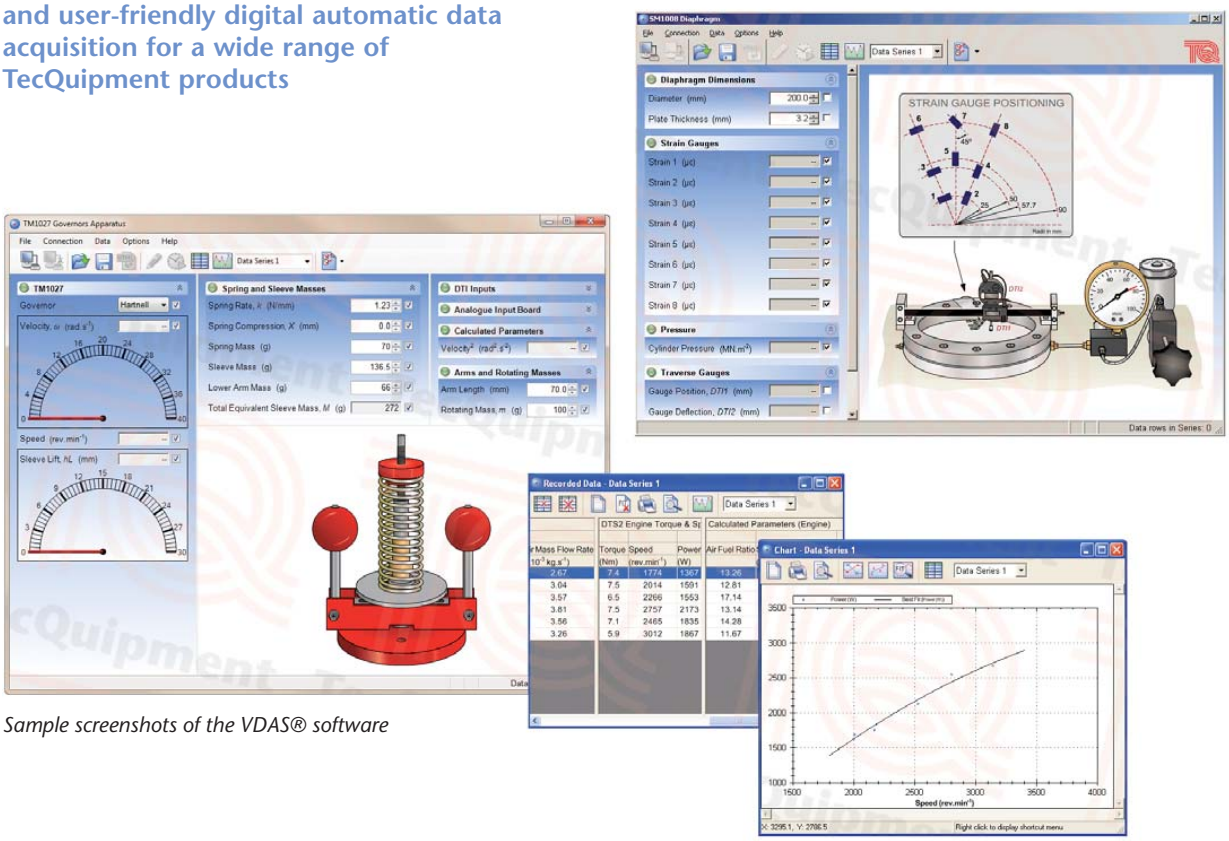
Balance arm of the Flight Demonstration Wind Tunnel (AF41)

Versatile Data Acquisition System

VDAS®

Versatile Data Acquisition System (VDAS®)

Enables high-capacity, accurate, efficient and user-friendly digital automatic data acquisition for a wide range of TecQuipment products



Sample screenshots of the VDAS® software

- Modern, cost-effective digital automatic data acquisition hardware, software and accessories to enhance teaching and laboratory sessions
- Highly versatile system for use with equipment from many TecQuipment product ranges
- Enables real-time data capture, monitoring and display of all relevant parameters on a computer (PC)
- Software is intuitive and easy to use, with clear and convenient data display options
- Highly accurate and noise-resistant
- Fast and convenient automatic calculation, recording, charting and export of relevant data and parameters makes efficient use of students' and lecturers' time
- Compact interface units available in both frame-mounting and bench-top options
- User-friendly software is similar for all VDAS®-compliant products – students do not have to learn to use new software when changing experiments

Frame-mounting Versatile Data Acquisition System (VDAS-F) interface unit

Bench-top Versatile Data Acquisition System (VDAS-B) interface unit

TecQuipment's Versatile Data Acquisition System (VDAS®) is a modern, cost-effective and accurate method of enhancing laboratory teaching. For use with a comprehensive range of TecQuipment products, it enables real-time data capture, monitoring and display of a large number and wide variety of experiment parameters. In addition, because it is digital, it is far more resistant to electrical noise than analogue systems.

Equally suited for individual student use or for lecturers demonstrating experiments to a whole class, VDAS® provides fast and convenient automatic calculation, recording, charting and export of data. This makes efficient, productive and effective use of students' and lecturers' time.

The system, specially designed for use with teaching equipment, has a variety of extremely useful functions. These include continuous data recording, sampling at discrete intervals, obtaining a set number of samples, and running for a pre-defined time.

The system consists of software and a choice of either a frame-mounting (VDAS-F) or a bench-top (VDAS-B) interface unit. The functionality of both types of interface unit is identical: the two presentation formats are available to provide choice and convenience to the user. For example, some TecQuipment VDAS®-compliant products have an integral instrumentation frame so are more suited to the frame-mounting interface unit.

Digital inputs on each interface connect directly to sensors and instrumentation on VDAS®-compatible products. These inputs are non-specific, which makes setting up experiments easy and reduces connection errors. The interface units also have inputs for additional transducers and industrial-standard sensors (for example: digital displacement measuring devices, pressure sensors, flow meters and so on).

The output from the interface unit connects to a suitable computer (computer available separately) running the VDAS® software. One interface unit can service many pieces of VDAS®-compliant equipment in a laboratory.

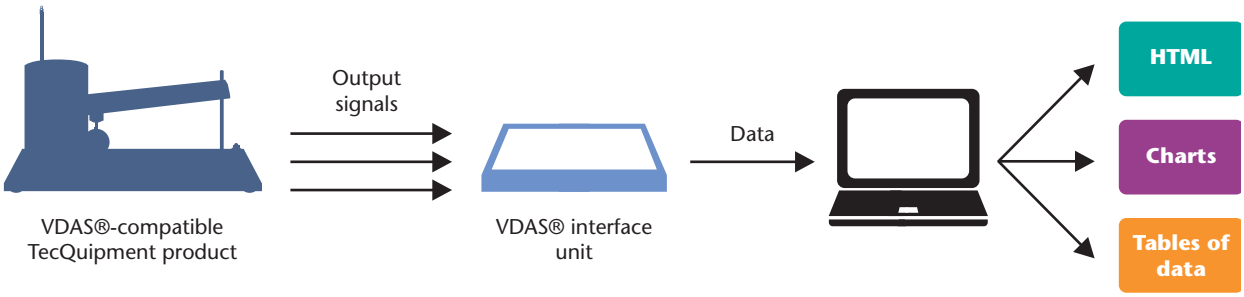
The software is intuitive and easy to use, with clear and convenient data display options. All VDAS®-compatible products use similar user-friendly software. This saves time as students do not have to learn to use new software when changing experiments. The software has a comprehensive range of functions, including:

- Recording data automatically or with some manual input
- Display of real-time data, either in digital form or as an analogue meter
- Logging data for printing and later analysis
- Exporting data for use by other software
- Performing real-time calculations to generate user-defined data
- Creating and printing charts and data tables

In addition, the high flexibility of the software enables students or lecturers to create, save and re-use their own custom layouts if required.

Essential Ancillary:

- Suitable computer



Why choose VDAS®?

TecQuipment's VDAS® is the most up-to-date and effective data acquisition system currently available for education. There are other solutions on the market, but none which offer the same convenience, functionality or wide range of features and benefits.

	VDAS® Solution	Other Solutions (using interface card)
CONVENIENCE	VDAS® software can be installed on multiple computers allowing the user to choose which PC to connect.	If an interface card is used, it can only be used on one computer and the customer has to open their PC to install it!
CONFIGURATION	VDAS® has 'plug and play' operation, meaning no configuration is required for communicating with VDAS®.	Lots of time and inconvenience – users must insert cards into their computers and spend time configuring the software before it will work.
CALIBRATION	Generally, no calibration required. Each VDAS® device is designed for a specific purpose.	More inconvenience and fuss – people using generic data acquisition cards have to calibrate inputs to match the various signals.
CONNECTIVITY	USB connectivity so can be used with laptops and modern computers.	Many other solutions can't be used on laptops, notebooks or modern computers because they need an expansion slot for the interface card. Legacy ISA cards will not plug into modern computers at all!

Look at the benefits:

VERSATILE – can be used across a wide range of TecQuipment products

DATA – transforms raw data instantly which easily exports or creates graphs and tables

ACQUISITION – USB connectivity, multiple-source real-time data capture

SYSTEM – an expandable modular approach providing easy-to-use digital plug-and-play technology

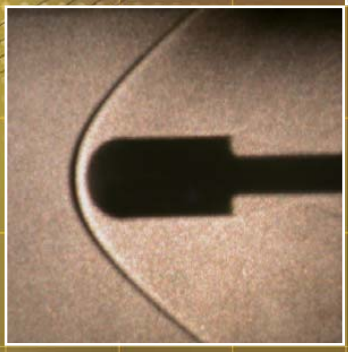
Ancillary for: Page

We are constantly adapting other products throughout many of the TecQuipment ranges, so please keep visiting our website to see the latest list of VDAS®-compatible products.

www.tecquipment.com

2

Aerodynamics



“ We believe that your visit to make our wind tunnel ready to train our students and staff was a great success and we thank you for the great effort you did for us. It was very effective and useful work that raised the spirits of all the Aeronautical Engineering Department staff as well as the College Administration. ”

Dr Ahmed Ibrahim Ahmed, Dean, College of Engineering, Sudan University of Science and Technology

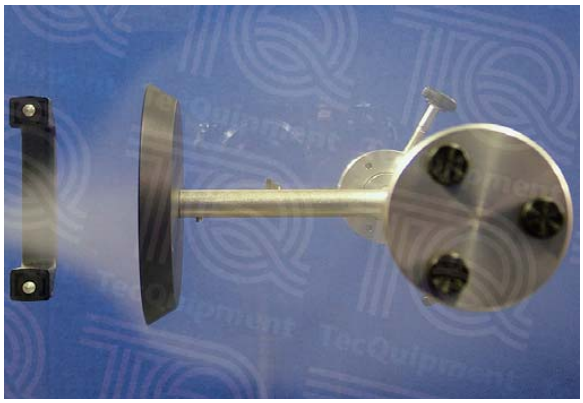
Aerodynamics

Made for education and training

As with all our products, we make the Aerodynamics range for use in teaching and training environments. It may be used for research projects or teaching from first principles to advanced ideas. The equipment is small enough to fit in most laboratories, while still producing results that you can scale to match those of full size wind tunnels. The subsonic and special-purpose wind tunnels are mobile to help with laboratory layouts.

Flexible and comprehensive

Our wind tunnels offer a comprehensive choice of equipment and models, from subsonic flow to supersonic. They allow you to choose only what you need, reducing costs and adding flexibility.



KEY FEATURES AND BENEFITS:

- **Made for teaching: realistic results yet small enough for laboratories.**
- **Flexibility: you can choose a package of equipment to suit your budget and needs.**
- **Easy set-up: it takes only minutes to change and set up an experiment.**
- **Hands-on: laboratory-scale parts allow easy fitting and adjustments, for a more practical understanding.**

Have you also seen our Modular Fluid Power range?

Our Modular Fluid Power range includes products that allow demonstrations and studies of the performance of different types of 'real world' air machines (fans and compressors).

See page 141 for more details.

Centrifugal Fan Module (MFP106)

Automatic data acquisition

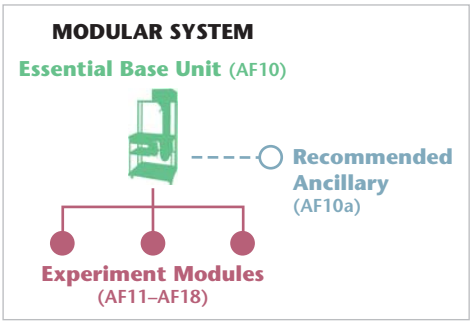
Some of the products in this range work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 1** for more details.

Look out for the VDAS® logo: VDAS®

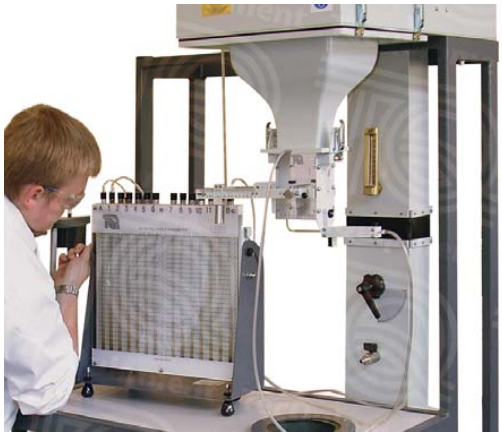
VDAS®	Product	
●	**Subsonic Wind Tunnel** (AF100) **Instruments**	Page 20
●	**Nozzle Flow Apparatus** (AF27)	Page 34
●	**Intermittent Supersonic Wind Tunnel** (AF300)	Page 36
●	**Continuous Supersonic Wind Tunnel** (AF02)	Page 39

Modular Air Flow Bench (AF10)

A mobile bench providing the base unit for a wide range of air flow experiment modules



- The base unit for a comprehensive system for teaching aerodynamic principles
- Works with eight different interchangeable experiment modules each designed to convincingly demonstrate a particular air flow principle or phenomena
- Easy set-up, all the experiment modules can be fitted and removed in minutes
- Simple and safe to use allowing students to gain hands-on practical experience with minimal supervision
- Compact, mobile and simple to install



Shown fitted with one of the available experiment modules (AF12) and Multi-tube Manometer (AF10a)

The AF10 is a small-scale wind tunnel with an electric fan and adjustable air flow control. It is the essential base unit for eight different experiment modules that demonstrate key principles and phenomena of air flow.

The unit consists of a sturdy steel framework on which is mounted a fan which supplies air via a flow-control valve to a specially designed plenum chamber and aerodynamically shaped contraction.

Each of the experiment modules fits either to the plenum chamber or to the contraction. The air then exits the experiment module through the bench top and emerges at an exhaust at the rear of the unit. When smoke is used in experiments for visualisation purposes users can fit flexible ducting to the exhaust to direct waste smoke safely away.

Toggle clamps hold the experiment modules, reducing the need for tools. Pressure measurement connections use reliable quick-release couplings. Both of these features make the changeover from one experiment to another simple and quick.

The bench format of the equipment makes it compact, easy to move and store. The unit also has handy shelves and storage space, which is ideal to store experiment modules when they are not in use.

The minimum requirement is the AF10 and one of the experiment modules, plus the AF10a manometer as required. Other experiments can be purchased at a later date allowing a complete system to be built up as time and budgets allow.

Continued on next page

Modular Air Flow Bench (AF10)
Continued from previous page

Experiments:

Supports a wide variety of subsonic aerodynamics experiments – see separate experiment modules for details.

Available Experiment Modules:	Page
• Bernoulli's Equation (AF11)	12
• Drag Force (AF12)	13
• Round Turbulent Jet (AF13)	14
• Boundary Layer (AF14)	15
• Flow Around a Bend (AF15)	16
• Jet Attachment (AF16)	16
• Flow Visualisation (AF17)	17
• Tapped Aerofoil (AF18)	18

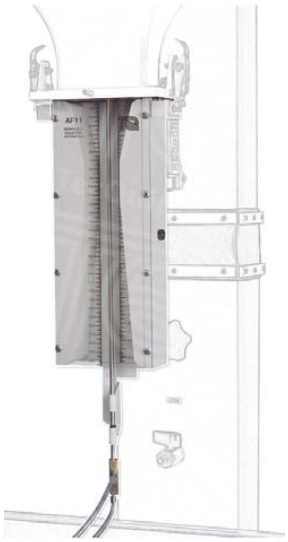
Recommended Ancillary:	Page
• Multi-tube Manometer (AF10a)	19

Alternative Products:	Page
• Subsonic Wind Tunnel (AF100)	20
• Flight Demonstration Wind Tunnel (AF41)	31
• Flow Visualisation Wind Tunnel (AF80)	33

Bernoulli's Equation (AF11)

Allows students to measure the pressure distribution in a convergent-divergent duct

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Quickly and simply illustrates Bernoulli's equation for air, and its limitations due to boundary layer effects
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Quick-release couplings for rapid and reliable pressure connections to the AF10a Manometer
- Transparent front to the duct so that the profile of the test nozzle and the position of the Pitot static tube can be seen clearly



This experiment module illustrates Bernoulli's equation as applied to a convergent-divergent duct. A Pitot static tube measures both the total pressure and the static pressure independently. The tube traverses along the axis of the duct and connects to the AF10a manometer (ancillary) via flexible tubes fitted with quick-release couplings.

A clear scale printed on the duct helps to show the probe position. Students confirm the constant total pressure while observing the rise and fall of the static pressure. They compare the velocity-area ratio as calculated from Bernoulli's equation to the experimental results.

Experiments:

- Confirmation of Bernoulli's equation
- The use of a Pitot static tube and water manometer

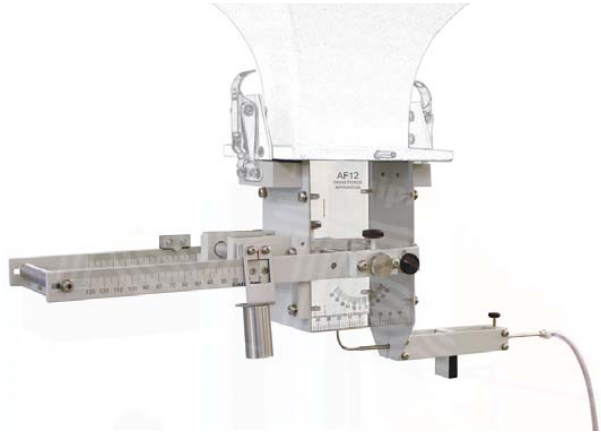
Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	11

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	19

Alternative Product:	Page
• Venture Meter (H5)	102

Drag Force (AF12)

Allows students to investigate the direct and indirect measurement of drag on various shapes



- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Compares drag for a cylinder calculated from a measured pressure distribution, and a wake traverse against that measured directly for a cylinder
- Allows comparisons of drag force between a cylinder, flat plate and aerofoil
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Quick-release couplings for rapid and reliable pressure measurement connections to the AF10a Manometer
- Test duct has transparent sides with clearly printed scales – allows students to see the experiment and accurately position the models and the Pitot tube

This simple yet comprehensive experiment module consists of a duct with transparent front and rear. The front has scales printed on it to position the various parts during the experiments. A Pitot tube and simple mass balance are attached to the outside of the duct for wake traverse and direct drag measurements respectively.

It comes with three models all of the same frontal area:

- A cylinder with a protractor, and a pressure tapping in its outer wall
- A flat plate
- A symmetrical aerofoil shape with a NACA profile

All the models fit in the arms of the mass balance for the wake traverse and direct measurement experiments. For cylinder pressure distribution experiments, the arms of the mass balance can be rotated clear of the duct and the cylinder model fitted between the duct walls directly.

Both the Pitot tube and the cylinder tapping connect to the AF10a manometer (ancillary) via flexible tubes fitted with quick-release couplings.

Experiments:

- Determination of the drag coefficient by measurement of the pressure distribution around the cylinder.
- Determination of the drag coefficient by wake traverse.
- Determination of the drag coefficient around the cylinder by direct measurement and comparison to results obtained by pressure distribution and wake traverse.
- Direct measurement and comparison of drag coefficient between a cylinder, flat plate and aerofoil.

Essential Base Unit:

Essential Ancillary:

Alternative Products:

Round Turbulent Jet (AF13)

Allows students to investigate a jet of air as it emerges from the end of a tube

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Allows a number of tests on the velocity of a submerged jet emerging from the end of a tube
- The tube has a carefully designed inlet for best results
- Toggle clamp connections to the Modular Air Flow Bench plenum chamber for quick and easy fitment
- Quick-release coupling fitted to the Pitot tube to allow rapid and reliable connection to the AF10a Manometer

This module consists of a tube with a specially designed rounded entry. The tube is mounted in a stiff plate with the rounded entry on one side and the exit on the other.

To set the experiment up the contraction is unclipped from the Air Flow Bench (AF10) and set aside. The whole plate is then mounted onto the plenum chamber directly so that air enters the rounded entry of the tube and leaves the end in a jet. The total pressure in the jet is measured by a Pitot tube held by a traversing mechanism. The mechanism allows the Pitot tube to move radially across the jet and axially along it. The Pitot tube is connected to the AF10a manometer (ancillary) via a flexible tube fitted with a quick-release coupling.

Experiments:

- Decay of the centre-line velocity.
- Velocity profile at various distances along the jet and the development of the spread of the jet.
- Analysis of the velocity profiles to show how the mass flux in the jet increases, the kinetic energy flux decreases and the momentum flux remains constant along the jet length.

Essential Base Unit:

	Page
• Modular Air Flow Bench (AF10)	11

Essential Ancillary:

	Page
• Multi-tube Manometer (AF10a)	19

Boundary Layer (AF14)

Allows students to investigate the phenomena of the boundary layer on a flat plate

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Allows a number of tests on laminar and turbulent boundary layers, with rough and smooth surfaces with different pressure gradients
- Boundary layer velocity profile is measured with a Pitot tube with a fine micrometer adjustment for best results
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Quick-release coupling fitted to the Pitot tube to allow rapid and reliable connection to the AF10a Manometer
- Test section has a transparent front – students can see the experiment and the position of the Pitot tube clearly

This module consists of a duct in which there is situated a flat plate. The flat plate is rough on one side and smooth on the other, providing different surface conditions for the formation of a boundary layer. To extend the experiments, removable duct liners can be added or removed to change the pressure gradient in the direction of flow.

The total pressure (and thus velocity) at various distances from the plate surface is measured by a flattened Pitot tube which is positioned by a micrometer. The pitot tube connects to the AF10a manometer (ancillary) via a flexible tube fitted with a quick-release coupling.

Experiments:

- Measurement of the velocity profile in laminar and turbulent boundary layers.
- Measurement of the velocity profile in the boundary layer formed over both rough and smooth plates.
- Measurement of the velocity profile in the boundary layer at various distances from the leading edge of the plate.
- Effect of the pressure gradient on the boundary layer velocity profile.

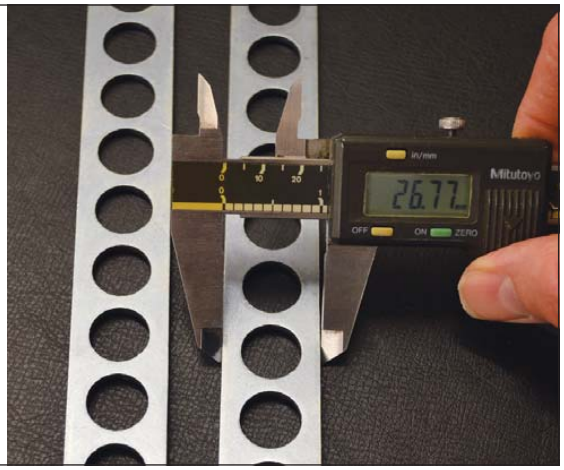
Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	11

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	19

Alternative Product:	Page
• Flat Plate Boundary Layer Model (AF106)	24

Checked and rechecked for quality

100% of all the products we manufacture and processes we use are checked, tested and audited to ensure they are of the highest quality.



Flow Around a Bend (AF15)

Allows students to measure the pressure distribution in a smooth rectangular bend

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Shows the pressure distribution in a smooth rectangular bend as an example of internal flow problems
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Quick-release couplings for rapid and reliable pressure measurement connections to the AF10a Manometer
- Highly visual plot of the pressure profile on the manometer

This module consists of a smooth rectangular bend with ten static tapping points on both the inner and outer curved walls, plus a further nine along the radius. Each one of the tapping points has a flexible tube with quick-release connector for connection to the AF10a Multi-tube Manometer (ancillary).

When air passes through the bend it creates areas of high and low pressure. The resulting pressure plots on the multi-tube manometer are highly visual which enhances students' understanding. The readings allow the students to plot the pressure profile and calculate a value for the loss coefficient K.

Experiments:

- Pressure distribution along the curved inner and outer walls.
- Radial pressure distribution and comparison with that predicted assuming free vortex velocity distribution.
- Calculation of loss coefficient (K).

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	11

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	19

Jet Attachment (AF16)

Allows students to investigate the Coanda effect and a fluidic flip-flop

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Shows an example of how the phenomena of fluid mechanics can be exploited to perform a useful task – a fluidic flip-flop
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Transparent fronted test duct with clearly printed scales allows the experiment to be clearly seen and components accurately positioned
- Effectively demonstrates the Coanda effect

This module consists of an aerodynamically shaped nozzle from which a jet of air emerges. This flows against a wall to which it attaches. The wall may be rotated to show the deflection of the jet through large angles due to the Coanda effect. A second wall may be introduced at the other side of the jet, which may be switched from one side to the other, as is done in a fluidic flip-flop type switch. The effect of sealing the walls and adding a central splitter to the device are also investigated.

Experiments:

- Demonstration of the Coanda effect
- Demonstration of the fluidic flip-flop

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	11

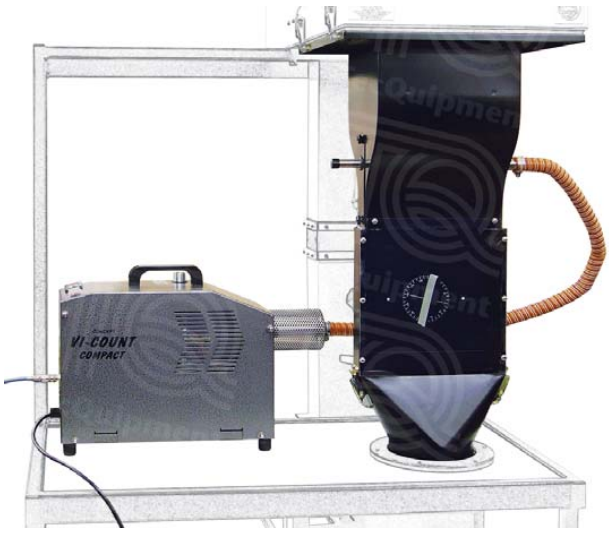
Flow Visualisation (AF17)

Allows students to "see" the air flows around various shapes by using smoke filaments

- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Highly visual and motivating for students – brings fluid mechanics to life
- Toggle clamp connections to the Modular Air Flow Bench plenum chamber for quick and easy fitment
- Includes a set of different shaped two-dimensional models
- Transparent fronted test duct, with clearly printed angular scale, allows the models to be clearly seen and accurately positioned
- Comes complete with ducting to allow the smoke to be easily and safely drawn away by the Modular Air Flow Bench

This module consists of a specially shaped duct which has a large working section with transparent window. The inlet of the duct is attached to the Air Flow Bench plenum chamber using quick-release clamps; the outlet is located into the bench exhaust. The duct has a rake of tubes from which filaments of smoke emerge and flow around two-dimensional models held in the working section. The smoke filaments can be made to visually show areas of steady and unsteady flow, thickening boundary layers, and separation. The rake is adjustable so that filaments can be made to contact the model surface at specific points of interest, if desired.

The models are quickly and simply mounted, allowing the unit to be used for student project work.



The unit produces considerable amounts of smoke which is safe and non-toxic, but to avoid the air in the laboratory becoming saturated, the unit includes a length of flexible tubing that connects the Air Flow Bench exhaust to either a suitable opening to atmosphere, or to an existing fan extraction system.

Note: The smoke generator uses compressed carbon dioxide. Due to transport regulations the unit is shipped with an empty gas bottle that requires filling before use.

Experiments:

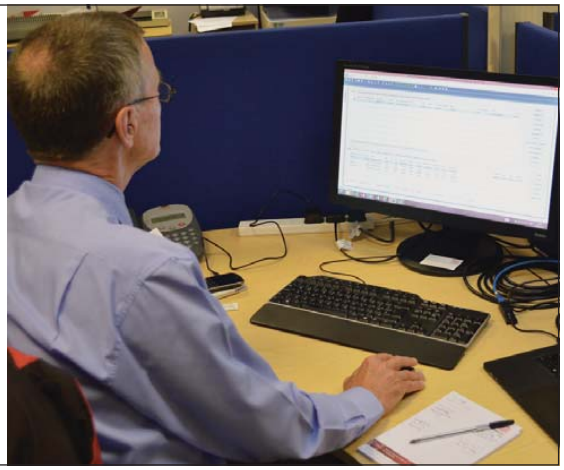
Demonstration of the flow patterns round a cylinder, flat plate, aerofoil and a sharp-edged orifice/slit.

Essential Base Unit: Page

- Modular Air Flow Bench (AF10) 11

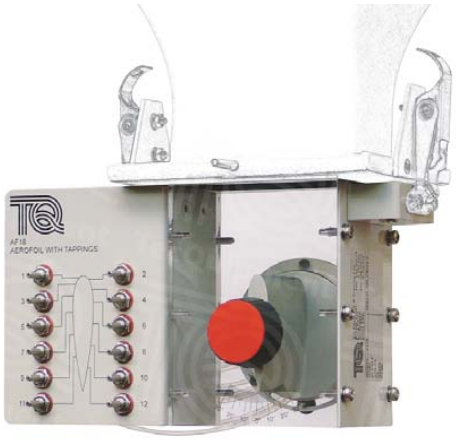
Alternative Product: Page

- Flow Visualisation Wind Tunnel (AF80) 33



Tapped Aerofoil (AF18)

Allows students to investigate the pressure distribution around a two-dimensional aerofoil



- One of a series of eight experiment modules that fits to the Modular Air Flow Bench (AF10)
- Provides both a visual and analytical experience for students as the manometer readings clearly show both the pattern and magnitude of the pressure distribution
- Serves as a useful companion experiment to the Drag Force Apparatus (AF12)
- Toggle clamp connections to the Modular Air Flow Bench contraction for quick and easy fitment
- Quick-release couplings and clear printed schematic for rapid and reliable pressure measurement connections to the AF10a Manometer
- Transparent front and rear to the test duct with a printed scale allows the experiment to be clearly seen and allows the aerofoil angle to be accurately set

This module consists of a duct with transparent front and rear, between which is mounted a symmetrical aerofoil with a NACA profile. The aerofoil has 12 tapping points at various chordwise positions on its surface, allowing the pressure to be measured at that point. The tapping points are permanently connected to a manifold mounted on the duct showing the tapping position and number for easy reference.

The experiment mounts on the Air Flow Bench contraction using toggle clamps. Each one of the tappings connects to the AF10a manometer (ancillary) via flexible tubes fitted with quick-release couplings. The aerofoil may be accurately rotated to various angles of incidence (attack) to the air using the control and printed scale on the front of the duct.

Experiments:

- The visualisation and measurement of the pressure distribution around an aerofoil section.
- Lift characteristics and stall angle of an aerofoil.

Essential Base Unit:	Page
Modular Air Flow Bench (AF10)	11

Essential Ancillary:	Page
Multi-tube Manometer (AF10a)	19

Alternative Product:	Page
150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	23

Standard features for all our products are:

- Supplied with comprehensive user guide
- Two-year warranty
- Manufactured in accordance with the latest European Union directives

Multi-tube Manometer (AF10a)

A multi-tube inclinable manometer for use with the Modular Air Flow Bench

- For measuring multiple air pressures on the optional modules of the Modular Air Flow Bench
- Uses water for safety and simplicity
- Inclinable for increased sensitivity
- Adjustable height datum and levelling feet
- Quick-release couplings for ease of use
- Includes non-toxic coloured dye to see water levels clearly

The multi-tube manometer is an ancillary to the AF10 base module and its experiment modules. It fits on or near to the AF10 and connects to pressure tappings on the optional experiment modules. Some experiment modules may only have two or three pressure tappings but others use up to 12 tappings. This makes the multi-tube manometer essential to see all the pressures at the same time.

The manometer uses clean water as a working fluid for safety and convenience. TecQuipment supplies coloured non-toxic dye to add to the water so students can see the water levels more clearly.

A small reservoir to the side of the manometer tubes holds the water. Students can adjust the reservoir height to change the datum of the water levels in the manometers. Adjustable feet allow students to accurately level the manometer before use.

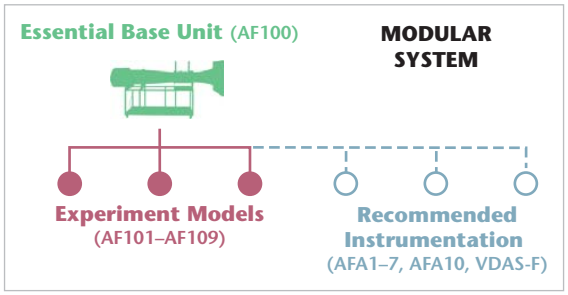
Thumbscrew fixings allow the user to incline the manometer tubes from fully vertical to 80 degrees. This changes the magnification (sensitivity) of the manometer for reading very small changes in pressure. The user guide gives details of the magnification factors for different angles. A set of markings to the side of the manometer shows angles in five and ten-degree divisions.

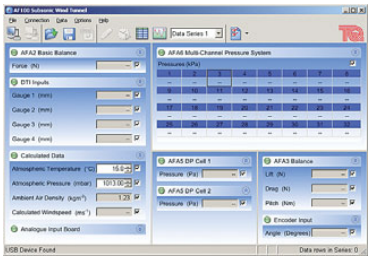
Ancillary for:	Page
• Modular Air Flow Bench (AF10)	11
• Bernoulli's Equation (AF11)	12
• Drag Force (AF12)	13
• Round Turbulent Jet (AF13)	14
• Boundary Layer (AF14)	15
• Flow Around a Bend (AF15)	16
• Tapped Aerofoil (AF18)	18

Subsonic Wind Tunnel (AF100)

Works with VDAS®

Open-circuit subsonic wind tunnel for a wide range of investigations into aerodynamics





Screenshot of the optional VDAS® software

- Saves time and money compared to full-scale wind tunnels or airborne laboratories
- Operates at meaningful Reynolds numbers
- Compact, open-circuit suction design
- Wide variety of experiments in aerodynamics
- Comprehensive selection of optional instrumentation, models and ancillaries
- High levels of safety
- Controls and instrumentation conveniently mount on a separate, free-standing frame
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) to allow accurate real-time data capture, monitoring and display on a computer

A compact, practical open-circuit suction wind tunnel for studying aerodynamics. The wind tunnel saves time and money compared with full-scale wind tunnels or airborne laboratories, and it offers a wide variety of experiments.

The wind tunnel gives accurate results and is suitable for undergraduate study and research projects. TecQuipment offers a comprehensive range of optional models and instrumentation, including a computer-based data acquisition system.

Air enters the tunnel through an aerodynamically designed effuser (cone) that accelerates the air linearly. It then enters the working section and passes through a grill before moving through a diffuser and then to a variable-speed axial fan. The grill protects the fan from damage by loose objects. The air leaves the fan, passes through a silencer unit and then back out to atmosphere.

A separate control and instrumentation unit controls the speed of the axial fan (and the air velocity in the working section). The control and instrumentation unit also includes manometers and electrical outlets to supply electrical power to other optional instruments.

The working section of the tunnel is a square section with a clear roof, sides and floor. The sides are removable. The floor and each side panel has a special position to support the optional wind tunnel models. Supplied with the wind tunnel are a protractor and a model holder to support and accurately adjust the angle of any models fitted.

A Pitot-static tube and a traversing Pitot tube fit on the working section, upstream and downstream of any models. They connect to the manometers of the instrumentation unit (or other optional instruments) to show pressure.

A metal frame supports the wind tunnel. The frame includes lockable castors for convenient mobility.

Electronic sensors on the optional wind tunnel instrumentation can connect to TecQuipment's Versatile Data Acquisition System (VDAS®, not included). VDAS® allows accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

Experiments:

A wide variety of subsonic aerodynamics experiments (some need ancillaries), including:

- Flow past bluff and streamlined bodies with pressure and velocity observations in the wake
- Investigations into boundary layer development
- Influence of aspect ratio on aerofoil performance
- Performance of an aerofoil with flap, influence of flap angle on lift, drag and stall
- Pressure distribution around a cylinder under sub and super-critical flow conditions
- Study of characteristics of models involving basic measurement of lift and drag forces
- Study of the characteristics of three-dimensional aerofoils involving measurement of lift, drag and pitching moment
- Study of the pressure distribution around an aerofoil model to derive the lift and comparison with direct measurements of lift
- Drag force on a bluff body normal to an air flow
- Flow visualisation

Available Experiment Models:

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Cylinder Model with Pressure Tapping (AF101)	23
150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	23
150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	23
150 mm Chord NACA0012 Aerofoils (AF104)	24
100 mm Diameter Flat Plate (AF105)	24
Flat Boundary Layer Model (AF106)	24
Aircraft Model – Low Wing (AF107)	24
Aircraft Model – High Wing (AF108)	24
Three-Dimensional Drag Models (AF109)	24

Smoke trail around the Low Wing Aircraft Model (AF107)

Recommended Instrumentation:

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Multi-Tube Manometer (AFA1)	25
Basic Lift and Drag Balance (AFA2)	26
Three-Component Balance (AFA3)	27
Balance Angle Feedback Unit (AFA4)	28
Differential Pressure Transducer (AFA5)	28
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Pitot-Static Traverse (300 mm) (AFA7)	30
Smoke Generator (AFA10)	25
Versatile Data Acquisition System (VDAS-F)	6

Alternative Products:

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Flight Demonstration Wind Tunnel (AF41)	31
Flow Visualisation Wind Tunnel (AF80)	33
Supersonic Wind Tunnel – Intermittent (AF300)	36
Supersonic Wind Tunnel – Continuous (AF302)	39

TecQuipment makes many ancillaries for the wind tunnel. These include optional models, instruments and extra or different instruments that you need to work with VDAS® for data acquisition.

Refer to the tables below for full details of which instruments you need to do tests with the models.

Continued on next page

Subsonic Wind Tunnel (AF100)
Continued from previous page

Minimum instruments needed for experiments with the available models (without automatic data acquisition)**:**

Experiment Models	Minimum Instrumentation
• Cylinder Model with Pressure Tapping (AF101) • 150 mm Chord NACA0012 Aerofoils (AF104) • 100 mm Diameter Flat Plate (AF105) • Three-Dimensional Drag Models (AF109)	• Basic Lift and Drag Balance (AFA2) **or** • Three-Component Balance (AFA3)
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102) • Flat Plate Boundary Layer Model (AF106)	• Multi-Tube Manometer (AFA1)
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103) • Aircraft Model – Low Wing (AF107) • Aircraft Model – High Wing (AF108)	• Three-Component Balance (AFA3)

Instruments needed which work with VDAS® for data acquisition:
Note: You also need the frame-mounting VDAS-F interface unit (which includes the VDAS® software).

Experiment Models	Minimum Instrumentation for data acquisition
• Cylinder Model with Pressure Tapping (AF101) • 150 mm Chord NACA0012 Aerofoils (AF104) • 100 mm Diameter Flat Plate (AF105) • Three-Dimensional Drag Models (AF109)	• Differential Pressure Transducer (AFA5) x 2 • Pitot-Static Traverse (300 mm) (AFA7) **and either** • Basic Lift and Drag Balance (AFA2) **or** • Three-Component Balance (AFA3) with Angle Feedback Unit (AFA4)
• 150 mm Chord NAC0012 Aerofoil with Tappings (AF102)	• Differential Pressure Transducer (AFA5) x 2 • Pitot-Static Traverse (300 mm) (AFA7) • 32-Way Pressure Display Unit (AFA6)
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103) • Aircraft Model – Low Wing (AF107) • Aircraft Model – High Wing (AF108)	• Pitot-Static Traverse (300 mm) (AFA7) • Differential Pressure Transducer (AFA5) • Three-Component Balance (AFA3) with Angle Feedback Unit (AFA4)
• Flat Plate Boundary Layer Model (AF106)	• Differential Pressure Transducer (AFA5) • 32-Way Pressure Display Unit (AFA6)

A fully operational AF100 Subsonic Wind Tunnel system – computer, chair and work table shown for photographic purposes only (not included)

Subsonic Wind Tunnel Models (AF101–AF109)

A selection of optional models for use with TecQuipment's Subsonic Wind Tunnel (AF100)

- Cylinder, aerofoils, aircraft models, drag models, flat plate and flat plate boundary layer models for use with TecQuipment's Subsonic Wind Tunnel (AF100)
- Allow realistic and accurate experiments and demonstrations
- Simple and quick set-up and use
- Some models include pressure tappings for pressure distribution experiments
- All models work with the other optional instruments for the Subsonic Wind Tunnel
- High-quality surface-finish on all models for accurate results

Cylinder Model with Pressure Tapping (AF101)

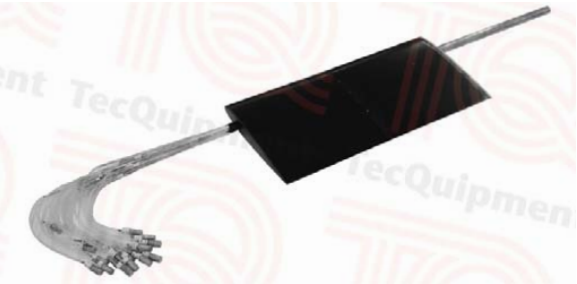
A cylinder model that spans the full width of the working section of the Subsonic Wind Tunnel (AF100). A holder (included with the wind tunnel) supports the model in the tunnel. Also, the optional Three-Component Balance (AFA3, available separately) or the Single-Component Lift and Drag Balance (AFA2, available separately) will support the model.

The model includes a single pressure tapping so, by rotating the model, students can find the pressure distribution around the cylinder. TecQuipment offers several suitable pressure-measuring instruments (available separately).

Using a Pitot tube, students can traverse the model wake to find the downstream pressure distribution and find the drag on the model. They can compare this to direct measurements, obtained using a balance.

TecQuipment's Smoke Generator (AFA10, not included) increases the educational value of the experiments by showing the flow of air around the model.

150 mm Chord NACA0012 Aerofoil with Tappings (AF102)



The aerofoil has 20 static pressure tappings along its chord on the upper and lower surfaces. They each connect to tubes that pass through the aerofoil and then out to clear, numbered, flexible tubes. Students can connect the tubes to other optional pressure-measurement instruments. They can then measure the pressure distribution around the aerofoil, from which they can find the lift.

Using a Pitot tube, students can traverse the aerofoil wake to find the downstream pressure distribution and find the drag on the aerofoil.

Students can compare these values of lift and drag with direct measurements found from a balance. They can also compare them with the results from another aerofoil with the same profile, such as the AF104 (see opposite page). Varying the angle of attack of the aerofoil with respect to the air stream allows students to find the changes to the pressure distribution. It also allows investigations into the critical conditions at stall.

TecQuipment's Smoke Generator (AFA10, not included) increases the educational value of the experiments by showing the flow of air around the model.

150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)

An unsymmetrical sectio (cambered) aerofoil wit adjustable flap. The adjustable flap allows students to study the effects of control surfaces such as flaps, ailerons, elevator or rudder. Students can also examine the difference between unsymmetrical and symmetrical aerofoils, by comparing the results to the AF104 symmetrical aerofoils. The Three-Component Balance (AFA3, available separately) can hold the aerofoil to measure lift, drag and pitching moment.

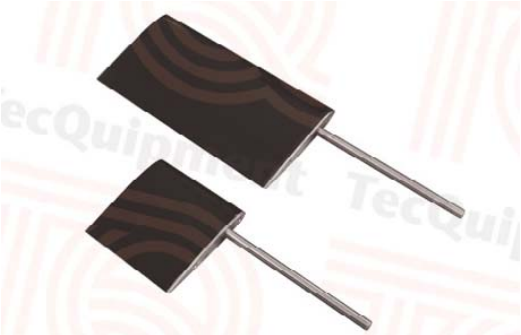
Continued on next page

Subsonic Wind Tunnel Models (AF101–AF109)
Continued from previous page

Using a Pitot tube, students can traverse the aerofoil wake to find the downstream pressure distribution and find the drag on the aerofoil. They can compare these results with the direct measurements from a balance.

TecQuipment's Smoke Generator (AFA10, not included) increases the educational value of the experiments by showing the flow of air around the model.

150 mm Chord NACA0012 Aerofoils (AF104)



A set of two aerofoils. One aerofoil has a span that extends the full width of the working section of the Subsonic Wind Tunnel (AF100). This model has the characteristics of a two-dimensional aerofoil. The other aerofoil has a span that extends for half of the working section of the wind tunnel. This model has the characteristics of a three-dimensional aerofoil. Comparing the measured lift and drag of the two aerofoils shows the differences between two-dimensional and three-dimensional aerofoils.

Using a Pitot tube, students can traverse the aerofoil wake of the full-width aerofoil. This gives them the downstream pressure distribution to find the drag on the aerofoil. They can compare their results to direct measurements from a balance (available separately).

Students can compare the results from the full-width aerofoil with the tapped aerofoil model (AF102, available separately) as it has the same (NACA0012) section.

TecQuipment's Smoke Generator (AFA10, not included) increases the educational value of the experiments by showing the flow of air around the model.

100 mm Diameter Flat Plate (AF105)

This model shows the flow around a bluff body mounted normal to the air flow direction, and the drag force exerted on it.

A holder (included with the AF100 wind tunnel) supports the model in the tunnel. Alternatively, either the optional Three-Component Balance (AFA3, available separately) or the Single-Component Lift and Drag Balance (AFA2, available separately) can hold the model and measure the drag.

TecQuipment's Smoke Generator (AFA10, not included) increases the educational value of the experiments by showing the flow of air around the model.

Flat Plate Boundary Layer Model (AF106)

Shows boundary layer development and separation.

The model is a flat plate that spans the full width of the AF100 wind tunnel working section. It has aerodynamically shaped blocks mounted across the plate at different distances from the leading edge. Each block has five tapping points at different heights along its leading edge. Each tapping connects to flexible, numbered tubing that routes outside the wind tunnel. Students can connect the tubes to other optional pressure-measurement instruments.

The tapping points allow students to measure the stagnation pressure. They use this to find the velocity at different heights from the surface and at different distances from the leading edge. This allows students to find the growth of the boundary layer along the plate.

On the trailing edge of the plate is a hinged flap. Students can adjust the angles of both the plate and the flap independently. This lets them create different arrangements to control pressure distribution and the boundary layer.

The surface of the plate has small 'tufts' to help students see the air flow around the surface of the plate.

Aircraft Model – Low Wing (AF107)
Aircraft Model – High Wing (AF108)

Model aircraft with NACA profile wings. One has a low wing position (bottom of the fuselage), the other has a high wing position (above the fuselage). These models are good for experiments with lift, drag and pitching moment of fixed wing aircraft.

Three-dimensional Drag Models (AF109)

A set of different shaped models with identical frontal area to allow students to compare the different coefficient of drag for each shape. Includes a dummy stem for tests to cancel out the drag due to each model's support arm.

Note: You also need the optional two or three component balance (AFA2 or AFA3) for direct readings of drag.

Multi-Tube Manometer (AFA1)

A 36-tube tilting manometer for measuring pressure

- Thirty-six tube tilting manometer for measuring pressure taken from monitoring points on models in subsonic wind tunnels
- Uses water as manometer fluid with colouring for ease of visibility
- Easy-to-read scale common to each manometer tube
- Preset incline levels for consistency and accuracy – up to five times magnification
- Pressure reading level preset by adjustable fluid reservoir – includes fine-adjustment hand-wheel
- Adjustable feet for precise set up

A 36-tube tilting manometer for measuring pressure on models in subsonic wind tunnels and fan test sets, including TecQuipment's AF100 series. A backboard with graduated scale holds each manometer tube. For safety and convenience, the manometer uses water as the manometer fluid. This is via an adjustable reservoir with fine-adjust hand-wheel held at the side of the equipment. Water colouring is included to aid visibility.

The top of each manometer tube has a connection piece for tubing to connect to pressure tappings on the equipment being monitored. The whole manometer tube assembly is mounted on a swivel. This allows it to be tilted in preset increments to increase the sensitivity of measurement. Adjustable feet enable the whole apparatus to be precisely levelled before use. The manometer is supplied with operating instructions, a filling funnel and a spirit level.

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Alternative Products:	Page
• Differential Pressure Transducer (AFA5)	28
• 32-Way Pressure Display Unit (AFA6)	29

Smoke Generator (AFA10)

Produces a fine trace of smoke to allow students to see air flow in subsonic wind tunnels and other air flow products

- Produces a smooth, fine trace of smoke
- Probe shaped to minimise wake generation
- Low oil consumption
- Fully adjustable smoke strength
- Supplied with smoke oil and spare heater tip

A smoke generator and probe that allows students to see air flow in subsonic wind tunnels and other low flow rate air flow products.

It is a control unit that pumps oil to the tip of a probe. A low-voltage electrical coil at the probe tip heats the oil to produce a fine smoke trail. The smoke moves into the air stream smoothly and steadily. Students can adjust the controls of the control unit to change the smoke strength to suit the air flow conditions.

The apparatus includes an integral reservoir bottle. Low oil consumption allows approximately six hours of use on one filling of the bottle.

Supplied with instructions, smoke probe, spare heater tip and oil.

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Alternative Products:	Page
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• Flow Visualisation Wind Tunnel (AF80)	33

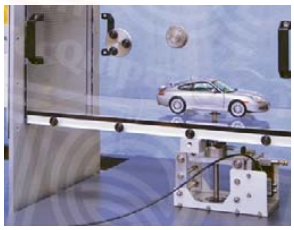
Basic Lift and Drag Balance (AFA2)

Works with VDAS®

Measures lift and drag forces on models mounted in TecQuipment's Subsonic Wind Tunnel (AF100)

- Optional ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100)
- Single-component balance to measure lift and drag forces on models mounted in the tunnel
- Transmits the force on the model directly to a strain gauged load cell with digital display
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) to enable accurate real-time data capture, monitoring and display on a computer
- Includes power supply

Shown fitted with the protractor from the AF100 Wind Tunnel



Base mounted with model car to measure drag

A single-component balance which measures the lift and drag forces on models mounted in TecQuipment's Subsonic Wind Tunnel (AF100).

The balance mechanism enables test models with a rigid support arm to be mounted and held securely in position in the working section of the wind tunnel. The arm transmits the force on the test model directly to a strain gauged load cell. The load cell connects to a readout unit with a digital display, which is powered by a desktop power supply (included).

In addition, the equipment is fully compatible with TecQuipment's optional Versatile Data Acquisition System (VDAS®) and can quickly and conveniently connect to a frame-mounting interface unit (VDAS-F, available separately). Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

To measure the lift and drag forces on models (aerofoils for example, available separately), the balance mounts on the side of the working section of the wind tunnel. The drag force is measured first, then students rotate the balance mechanism through 90 degrees and repeat the test to measure the lift force. When mounted in the base of the wind tunnel working section, the balance measures the drag force only. This is useful for a variety of investigations such as wind loadings on tall buildings. It can also be used to measure drag forces on model vehicles enabling students to determine and compare coefficients of drag.

Note: For experiments requiring measurement of pitching moment as well as drag and lift forces, a three-component balance, such as TecQuipment's AFA3, is required.

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Alternative Products:	Page
• Three-Component Balance (AFA3)	27

Three-Component Balance (AFA3)

Works with VDAS®

Measures lift, drag and pitching moment of models in TecQuipment's Subsonic Wind Tunnel (AF100)

- Optional ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100)
- Provides a convenient support system for models to measure the lift, drag and pitching moment
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) to enable accurate real-time data capture, monitoring and display on a computer
- Digital display shows lift, drag and pitching moment directly
- Allows full adjustment of angle of incidence of the model to direction of air flow

Three-Component Balance shown with the Angle Feedback Unit (AFA4)

The Three-Component Balance fits onto the working section of TecQuipment's Subsonic Wind Tunnel (AF100). It may also be used with other subsonic wind tunnels of similar design.

The Three-Component Balance provides an easy-to-use support system for wind tunnel models. It measures lift, drag and pitching moment exerted on the model.

The balance attaches to the vertical wall of the wind tunnel working section. It is designed for air flows from right to left when the balance is viewed from the front.

The balance comprises a mounting plate secured to the wind tunnel working section. A triangular force plate is held on the mounting plate by a mechanism that constrains it to move in a plane parallel to the mounting plate only, while leaving it free to rotate about a horizontal axis. This arrangement provides the necessary three degrees of freedom.

Models for use with the balance are available from TecQuipment. Other models used with the equipment will need a mounting stem. The forces acting on the model are transmitted by cables to three strain gauged load cells. The output from each load cell is taken via an amplifier to a microprocessor-controlled display module. The display module mounts onto the wind tunnel control and instrumentation frame and includes a digital display to show the lift, drag and pitching moment directly.

The equipment is fully compatible with TecQuipment's optional Versatile Data Acquisition System (VDAS®) and can quickly and conveniently connect to a frame-mounting interface unit (VDAS-F, available separately). Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

The model support of the balance can be rotated by 360 degrees. This allows adjustment of the angle of incidence of the model to the direction of air flow. The model support is locked in the required position by a simple clamp after adjustment.

The Angle Feedback Unit (AFA4, available separately) fits onto the Three-Component Balance and transmits the rotational angle of the test model back to the automatic data acquisition unit.

Recommended Ancillary:	Page
• Balance Angle Feedback Unit (AFA4)	28

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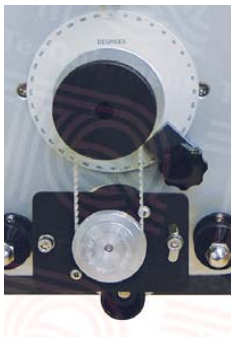
Alternative Products:	Page
• Basic Lift and Drag Balance (AFA2)	26

Balance Angle Feedback Unit (AFA4)



Works with VDAS®

Measures angular positions of models mounted on TecQuipment's Three-Component Balance (AFA3) with the Versatile Data Acquisition System (VDAS®)

The Balance Angle Feedback Unit is an optional ancillary for use with TecQuipment's Three-Component Balance (AFA3) to measure the angular position of models mounted on the balance in TecQuipment's Subsonic Wind Tunnel (AF100). The Balance Angle Feedback Unit mounts on the Three-Component Balance attached to the wind tunnel. It then transmits the rotational angle of the model to TecQuipment's Versatile Data Acquisition System (VDAS-F, not included). The angle of the model can then be logged on a suitable computer (computer not included) along with other captured experimental data.

Note: The Balance Angle Feedback Unit can only be used with the Three-Component Balance (AFA3) and the Versatile Data Acquisition System (VDAS®). The unit is supplied with an input board for VDAS®.

Ancillary for:	Page
• Three-Component Balance (AFA3)	27

Differential Pressure Transducer (AFA5)

Works with VDAS®

Microprocessor-controlled pressure measurement and display unit for use with TecQuipment's Subsonic Wind Tunnel (AF100)

- Optional ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100)
- Measures and displays differential pressures from models, Pitot-static tubes and other devices
- Quicker, easier and more versatile than using liquid manometers
- Integral LCD allows direct pressure measurement
- Measures differential pressures or pressure with respect to atmosphere
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) to enable accurate real-time data capture, monitoring and display on a computer

The Differential Pressure Transducer and readout is an optional ancillary to TecQuipment's Subsonic Wind Tunnel (AF100). It measures and displays pressures in Pitot-static tubes and other pressure-sensing devices fitted to a wind tunnel, with respect to the atmosphere or differential pressures.

The control and instrumentation panel of the AF100 wind tunnel includes a location for mounting up to two Differential Pressure Transducer modules. It is microprocessor-controlled and contains a calibrated pressure transducer. The unit has an integral liquid crystal display that allows the user to read pressure directly.

The signals of the pressure sensors may be output to TecQuipment's optional Versatile Data Acquisition System (VDAS®). Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

When the Differential Pressure Transducer is used with the automatic data acquisition unit it provides a significant advantage over conventional instruments such as manometers. Many readings can be taken and the user may use a suitable spreadsheet software package to obtain a more accurate overview of pressure distributions.

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• Aircraft Model – Low Wing (AF107)	24
• Aircraft Model – High Wing (AF108)	24
• Three-Dimensional Drag Models (AF109)	24

Alternative Products:	Page
• Multi-Tube Manometer (AFA1)	25
• 32-Way Pressure Display Unit (AFA6)	29

32-Way Pressure Display Unit (AFA6)

Works with VDAS®

Microprocessor-controlled 32-way pressure measurement and display unit for use with TecQuipment's Subsonic Wind Tunnel (AF100)

- Optional ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100)
- Measures and displays up to 32 differential pressures from models, Pitot-static tubes and other devices
- Quicker, easier and more versatile than using liquid manometers
- Integral LCD allows direct pressure measurement
- Measures pressures with respect to atmosphere
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) to enable accurate real-time data capture, monitoring and display on a computer

The 32-Way Pressure Display Unit is an optional ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100). It measures and displays up to 32 different pressures from models, Pitot-static tubes and other measuring instruments fitted to a wind tunnel. It is ideally suited in applications where multiple pressure measurements are required, for example in boundary layer and tapped aerofoil model investigations.

The unit mounts onto the control and instrumentation frame of the AF100 wind tunnel. The microprocessor-controlled unit contains 32 calibrated pressure transducers. Input connection to each of the pressure transducers is via quick-release pressure inputs mounted on the front panel of the unit. This allows easy and quick connection between the unit and an experiment mounted in a wind tunnel. All pressures are measured with respect to atmosphere.

The unit has an integral liquid crystal display with a scroll switch that allows all 32 channels to be viewed in groups of four at any time.

The conditioned outputs of the pressure sensors, and any other connected compatible electronic instruments, may be output to TecQuipment's optional Versatile Data Acquisition System (VDAS®) to allow computer-based data acquisition and display. Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

When the 32-Way Pressure Display Unit is used with VDAS® it allows laboratory time to be used more efficiently because data can be captured and processed much more quickly than when using manual techniques. The facility in the software to average data to remove the fluctuations inherent in wind tunnel measurements, enhances the quality of the results by making their interpretation much easier. This option provides significant experimental advantages over conventional instruments such as manometers.

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	20
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	23
• Boundary Layer Model (AF106)	24

Alternative Products:	Page
• Multi-Tube Manometer (AFA1)	25
• Differential Pressure Transducer (AFA5)	28

Pitot-Static Traverse (300 mm)
(AFA7)

Works with VDAS®

A traversing Pitot-static tube with electronic position measurement for use with TecQuipment's Subsonic Wind Tunnel (AF100)

- Optional ancillary to TecQuipment's Subsonic Wind Tunnel (AF100)
- Mounts either upstream or downstream of a test model to measure pressures across the 'wake' of a model
- Accurate digital display of position
- Zero facility allows the starting point of an experiment to be set in any position
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) to give accurate real-time data capture, monitoring and display on a computer

The Pitot-Static Traverse is an ancillary to TecQuipment's modular Subsonic Wind Tunnel (AF100).

It is a Pitot-static tube which mounts in the working section of the wind tunnel, either upstream or downstream of the position of the test model. This allows students to do 'wake' traverses, downstream of a model. The vertical position of the tube, which is adjustable, is displayed on a digital indicator.

The digital indicator position can be set to zero in any position. This allows the datum or starting point of an experiment to be defined by the user.

To display differential pressure, the Pitot-static tube connects to a manometer supplied with the wind tunnel. Alternatively, pressures can be measured using one or more of the following optional instruments:

- Multi-Tube Manometer (AFA1)
- Differential Pressure Unit (AFA5)
- 32-Way Pressure Display Unit (AFA6)

The pressure signals from the Pitot-Static Traverse may be output to TecQuipment's optional Versatile Data Acquisition System (VDAS®) to allow computer-based data acquisition and display. Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included). For pressure measurement this will require the optional Differential Pressure Unit (AFA5) or 32-Way Pressure Display Unit (AFA6).

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	20
• Cylinder Model with Pressure Tapping (AF101)	23
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	23
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	23
• 150 mm Chord NACA0012 Aerofoils (AF104)	24
• 100 mm Diameter Flat Plate (AF105)	24
• Aircraft Model – Low Wing (AF107)	24
• Aircraft Model – High Wing (AF108)	24
• Three-Dimensional Drag Models (AF109)	24

Flight Demonstration Wind Tunnel (AF41)

A model aircraft suspended in an open-circuit wind tunnel. Includes realistic flight controls to teach a variety of principles of aircraft flight.

- Gives students a safe, realistic introduction to the controls of a light aircraft
- Aircraft able to move vertically and pitch about the quarter chord point independently
- Simulates take-off, level flight, cruise and landing
- Demonstrations include aerofoil lift, stall, longitudinal stability and transient motion
- Includes electronic display of air speed, attitude, altitude, pressure and lift
- Tufts on the wing clearly demonstrate the phenomenon of separation and stall
- Brightly illuminated working section
- Adjustable centre of gravity of the model
- Optional smoke generator and chart recorder (available separately)

For classroom demonstrations and student investigations into the behaviour of fixed-wing aircraft and wing performance during take-off, flight and landing.

The apparatus is an open-circuit wind tunnel with a model aircraft suspended in the working section. The model is supported by linkages that allow it to move vertically and to pitch about the quarter chord point independently.

The working section is brightly illuminated and the aircraft model is clearly visible through a large transparent window. The operator flies the aircraft manually using a control column and throttle. These are positioned directly in front of the window and are arranged typically as found in a light aircraft, providing realistic simulation of flight and the effect of the control surfaces.

To fly the aircraft, the operator pushes the throttle lever forward to increase the tunnel air speed. When the air speed reaches a certain level the aircraft may be made to 'take-off' by drawing the control column slowly back. A digital display shows air velocity (pressure) in the working section, attitude, altitude or lift force on the aircraft.

Continued on next page

Flight Demonstration Wind Tunnel (AF41)
Continued from previous page

Air enters the working section through a flow straightener. The throttle controls the air speed in the tunnel by regulating an axial flow fan downstream of the working section. The change in air speed in the wind tunnel simulates the effect of increasing the change in air speed of a real aircraft due to a change in thrust from the propeller.

The control column is linked to the 'all-flying' tail plane of the aircraft. Pushing the column forward or pulling it back changes the angle of the whole tail plane. A scale on the control column indicates the tail plane angle. The control column differs from that of a normal aircraft in that it has no lateral control of the aircraft: it has no rudder on the tailplane and may only move up or down.

A locking control under the control column can lock the angle of the tail plane to any setting.

Small tufts cover the port wing of the aircraft. These show the direction and quality of air flow over the wing surface, to show separation and stall. Using the optional Smoke Generator (AFA10, available separately) enhances flow visualisation.

An adjustable weight allows the student to set the centre of gravity of the model to different positions from fore to aft of the quarter chord point. A scale below the weight indicates the position. This enables students to derive the trim curves and identify the neutral point.

To find the lift characteristic of the aerofoil, students link the aircraft to a load cell and vary the angle of attack.

Experiments:

A variety of practical demonstrations, 'hands-on' flight simulations, and student investigations into the behaviour of fixed-wing aircraft and wing performance, including:

- Practical investigation of longitudinal stability and control of the aircraft to demonstrate behaviour during take-off, level flight and landing.
- Determination of the effect of speed on attitude for level flight and stall.
- Measurement of the lift curve for the wing up to and beyond stall.
- Students can adjust the centre of gravity of the model to alter its trim. They can then plot trim curves and determine the neutral point.

With Two-Pen Chart Recorder (AF41a, available separately):

- Demonstration of phugoid motion in terms of altitude.
- Short period oscillation due to sudden disturbance can be shown by the change of incidence.

With Smoke Generator (AFA10, available separately):

- Visualisation of flow patterns past the aircraft's aerofoil and tail plane.

Recommended Ancillaries:

	Page
• Two-Pen Chart Recorder (AF41a)	
• Smoke Generator (AFA10)	25

Alternative Products:

	Page
• Modular Air Flow Bench (AF10)	11
• Subsonic Wind Tunnel (AF100)	20
• Flow Visualisation Wind Tunnel (AF80)	33

Flow Visualisation Wind Tunnel (AF80)

Uses smoke trails to show air flow around different shaped models

Photograph of the smoke trails around a hemisphere

- High-quality, vertical wind tunnel that helps students understand air flow around different shaped objects
- Ideal for small group experiments or classroom demonstrations
- Includes smoke generator and lighting to show flow clearly
- Variable air speed
- Optional model sets with wide selection of models available separately

A vertical, suction-type wind tunnel with smoke visualisation. Allows demonstrations and student investigations into the flow of air around a wide variety of different shaped models.

Ideal for small group experiments or classroom demonstrations, the apparatus is floor standing. A variable-speed fan mounted on top of the wind tunnel produces the air flow through the working section. Air flow is vertically upwards.

A smoke generator connects to a comb mounted in the wind tunnel below the working section. Students can move the comb from side to side to aid investigations into the aerodynamic properties of a test model. Smoke is produced by the vapourisation of a high-quality food-grade oil. A filter helps provide uniform air flow. The smoke is non toxic.

The front wall of the working section of the wind tunnel is transparent and removable. This enables users to easily and quickly attach the optional models to the back of the working section. It also allows a clear view of the smoke trails. Test model sets for the wind tunnel are available separately (AF80a and AF80b). Lamps illuminate the working section from both sides to improve the visibility of the smoke.

The wind tunnel is held on a metal frame fitted with castors for mobility. A control unit on the frame contains the controls for the fan speed.

Experiments:

When used with the optional models, the visualisation and demonstration of:

- Boundary layers
- Separation
- Rotational flow

Essential Ancillary:

- Model Set (AF80a), including:
  - Aerofoil
  - Circular cylinder
  - Sphere
  - Slotted orifice
  - Disc
  - Circular orifice
  - Hemisphere
  - Wing tip
  - ISA nozzle
  - Model car and truck

Recommended Ancillary:

- Additional Model Set (AF80b), including:
  - Bend
  - Cascade corner
  - Plain corner
  - Heat exchanger tube bank

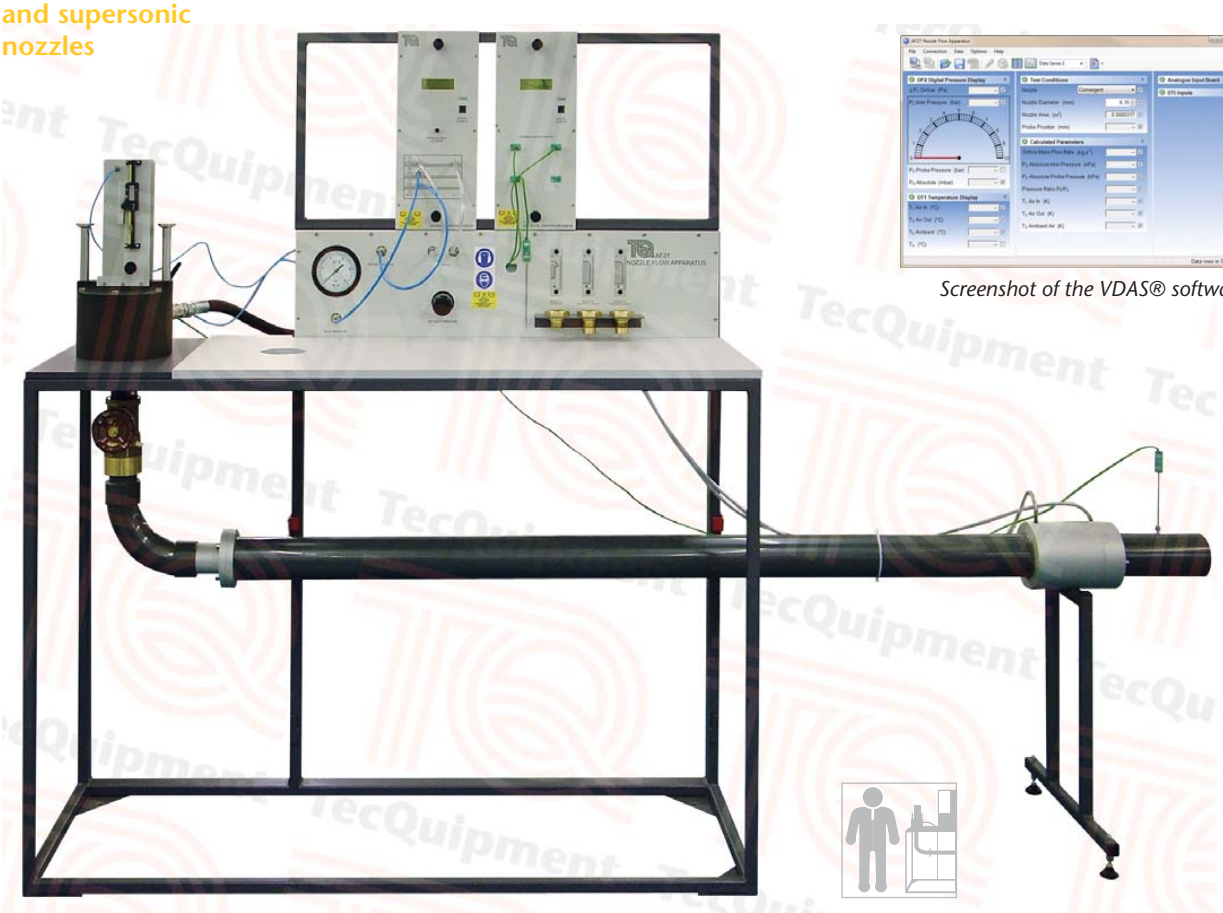
Alternative Products:

	Page
Flow Visualisation (AF17)	17
Subsonic Wind Tunnel (AF100)	20
Flight Demonstration Wind Tunnel (AF41)	31

Nozzle Flow Apparatus (AF27)

Works with VDAS®

Demonstrates the thermodynamics and fluid mechanics of the adiabatic expansion of air through subsonic and supersonic nozzles



Screenshot of the VDAS® software

- Floor-standing apparatus that demonstrates the thermodynamics and fluid mechanics of the adiabatic expansion of air through subsonic and supersonic nozzles
- Connects to suitable laboratory compressed air supply or TecQuipment's optional Compressor (AF27a)
- Includes three interchangeable, profiled and polished brass nozzles - convergent, convergent-divergent and convergent-parallel
- Built-in instrument frame and worktop
- Electronic instruments measure and display multiple pressures and temperatures at the same time, for ease of use and for connection to TecQuipment's VDAS®
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) for instant recording of multiple readings and automatic calculations

The apparatus connects to TecQuipment's optional Compressor (AF27a) or a suitable laboratory supply of dry, clean compressed air.

It demonstrates the thermodynamic and fluid properties of the adiabatic expansion of subsonic and supersonic air flow through nozzles.

Its floor-standing frame holds:

- a pressure chest with a removable lid and nozzle traverse mechanism;
- a useful worktop;
- a pressure regulator to maintain the inlet/upstream pressure, with an analogue reference pressure gauge;
- three interchangeable, profiled and polished brass nozzles with mimics that fit on the traverse mechanism;
- an instrument frame with digital pressure and temperature displays

Students fit a nozzle into the chest (you test one nozzle at a time). Compressed air passes through the pressure regulator and an isolating valve. It then enters the pressure chest and passes vertically down through the nozzle, then through a precision downstream valve. The airflow then settles as it passes along a horizontal pipe, through an orifice and out to atmosphere.

The temperature and pressure displays accurately measure temperatures and pressures at key points around the apparatus, including the pressures around the orifice which students use to determine overall mass flow.

For ease of visibility and for good engineering practice, the analogue gauge also shows pressure in the chest.

A stainless-steel probe on a manually adjustable, vertical traverse measures the pressure distribution along the axis of the nozzle. A digital indicator measures the probe position in the nozzle. The traverse mechanism includes a pointer and a mounting for a 'mimic' of each nozzle. The pointer moves along the mimic to help students visualize the position of the probe.

The instrument frame has extra space for the optional VDAS® interface unit.

VDAS® allows accurate real-time data capture, monitoring, display, calculation and charting of all the important readings on a suitable computer (computer not included).

Experiments:

- The relationship between pressure ratio and flow for convergent and convergent/divergent Laval nozzles
- The pressure profile in convergent/divergent nozzles at various pressure ratios
- Investigation of expansion with friction in a parallel passage at high subsonic velocities
- Boundary layer growth under subsonic and supersonic conditions
- The phenomenon of choked flow corresponding to sonic velocity at a nozzle throat

Essential Ancillary:

- Compressor (AF27a)

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

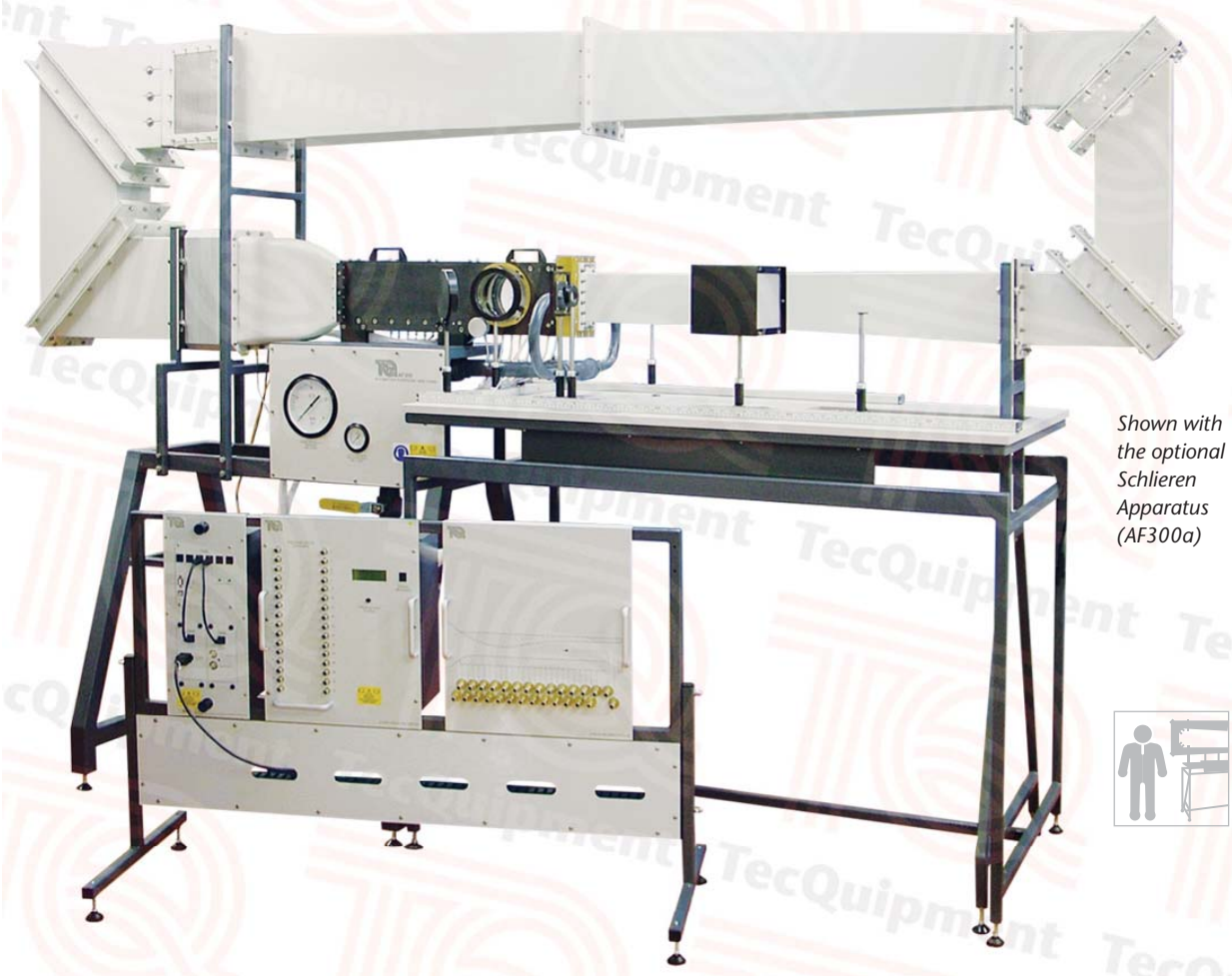
Alternative Products:

	Page
• Supersonic Wind Tunnel – Intermittent (AF300)	36
• Supersonic Wind Tunnel – Continuous (AF302)	39

Intermittent Supersonic Wind Tunnel (AF300)

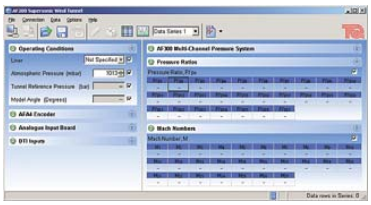
Works with VDAS®

Investigates subsonic and supersonic air flow, including flow around two-dimensional models



Shown with the optional Schlieren Apparatus (AF300a)

- Laboratory-scale wind tunnel for subsonic and supersonic tests, up to Mach 1.8
- Compact design – does not need large laboratory space
- Supplied with aerodynamic models for supersonic tests – includes model angle-feedback encoder
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) for instant recording of multiple readings and automatic calculations
- Electronic instruments measure and display multiple pressures at the same time, for ease of use and for connection to VDAS®
- Supplied with set of different liners for controlled subsonic and supersonic air flow
- Induction flow for better air flow and accurate results



Screenshot of the optional VDAS® software

An intermittent operation, induction-type supersonic wind tunnel for investigations into subsonic and supersonic flow. This includes tests on the flow around two-dimensional models at subsonic and supersonic air speeds.

A compressed air supply (AF300b, available separately) induces a flow in the working section of the wind tunnel. This gives a less turbulent and more stable flow for accurate results and comparison with theory. The optional compressed air supply includes filters and air dryers to give a dust-free and dry air source needed for good results.

Students use a delivery valve to allow compressed air to enter the wind tunnel. The wind tunnel includes two

analogue pressure gauges. One measures the compressed air pressure available from the supply (for reference); the other measures the pressure delivered to the wind tunnel and includes an electronic transducer that connects to TecQuipment's Versatile Data Acquisition System (VDAS®) to record the pressure.

The working section of the wind tunnel is a convergent-divergent nozzle with a removable top part ('liner'). The shape of the liner controls the maximum air velocity at the divergent part of the working section. Included are three different liners.

High optical-quality glass windows ('portals') are at each side of the divergent part of the working section. The portals allow students to use the optional Schlieren Apparatus (AF300a, available separately). This allows display and recording of images of pressure waves around two-dimensional models.

Included is a set of two-dimensional models. These mount between the portals inside the working section. Students can adjust the angle of the models. An encoder electronically measures the model angle.

Spaced at precise intervals along the working section of the wind tunnel are pressure tappings. Two extra tappings connect to one of the models when in use. A 32-way pressure display (included) connects to all the pressure tappings. It displays the pressures and transmits them to VDAS® for instant recording and calculations of pressure ratios and Mach numbers.

Included is a bench-mounting instrument frame that holds and provides power for the electronic instruments and the VDAS® interface unit. The instrument frame connects to a suitable electrical supply.

VDAS® allows accurate real-time data capture, monitoring, display, calculation and charting of all the important readings on a suitable computer (computer not included).

Experiments:

- Pressure distribution along a convergent/divergent (Laval) nozzle with subsonic and supersonic air flow
- Comparison of theoretical and actual pressure distribution
- Comparison of actual and theoretical area ratio of a nozzle at supersonic air velocities (Mach numbers)
- Pressures around a two-dimensional model in subsonic and supersonic flow conditions, at different angles of incidence
- Lift coefficient for aerodynamic models in supersonic flow
- Shock waves and expansion patterns around a two-dimensional model in supersonic flow conditions (when used with the optional Schlieren Apparatus).

Essential Ancillaries: Page

- Air Compressor Receiver and Dryer (AF300b)
- Versatile Data Acquisition System – Frame-mounted version (VDAS-F) 6

Recommended Ancillary: Page

- Schlieren Apparatus (AF300a) 38

Alternative Products: Page

- Subsonic Wind Tunnel (AF100) 20
- Nozzle Flow Apparatus (AF27) 34
- Continuous Supersonic Wind Tunnel (AF302) 39

Schlieren Apparatus (AF300a)

Schlieren apparatus for use with TecQuipment's Intermittent Supersonic Wind Tunnel (AF300)

- Monochrome Schlieren apparatus with a high-power light source and imaging screen
- High-quality, laboratory-standard mirrors and lenses for clear images without distortion
- Shows supersonic air flow patterns around models
- Shows shockwaves and expansions
- Includes digital imaging equipment and TV monitor

A monochrome Schlieren apparatus for use with the Intermittent Supersonic Wind Tunnel (AF300).

The Schlieren apparatus allows students to see density gradients as variations in intensity of illumination. This allows them to see supersonic air flow patterns around models. It also clearly shows shockwaves and expansions, and students can compare their position and angle with values predicted by theory.

The mirrors and lenses are of high optic standards to reduce any possibility of optic distortions of the images.

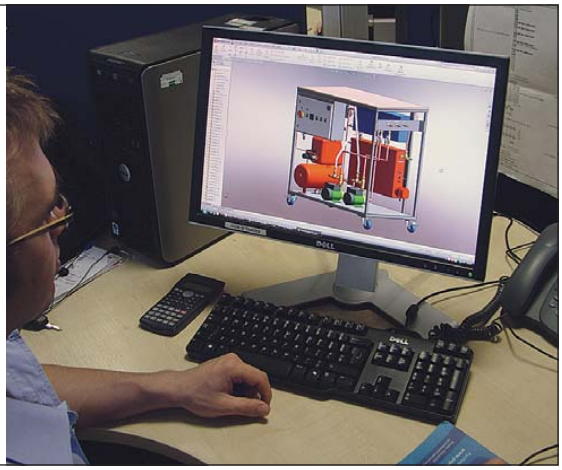
The apparatus includes digital imaging equipment to record the images; this is useful when using an intermittent supersonic wind tunnel.

The TV monitor is particularly useful to display the images to groups of students. The imaging equipment can capture still images and any real-time changes in the image.

Ancillary for:	Page
• Intermittent Supersonic Wind Tunnel (AF300)	36

Using the very latest design technology

Our in-house 3D CAD system allows our engineers to turn concepts into high-quality designs quickly and accurately.

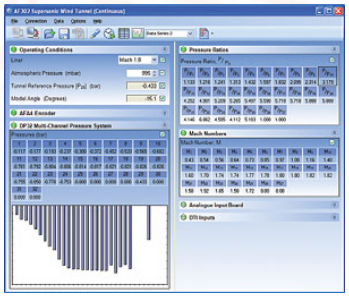


Continuous Supersonic Wind Tunnel (AF302)

Works with VDAS®

For investigations into flow around two-dimensional models at supersonic and subsonic air speeds

Vacuum pump (supplied) not shown on image



Screenshot of the VDAS® software

- A suction-type continuous-operation supersonic wind tunnel for investigations into two-dimensional air flow around models for airspeeds up to Mach 1.8
- Includes high-quality optical glass windows in the working section, suitable for use with an optional Schlieren system
- Includes a selection of models for two-dimensional flow experiments and an encoder for feedback of model angle
- Supplied with a multi-pressure display unit and calibrated pressure sensors to show pressures relative to atmosphere.
- Includes a vacuum pump with remote control for ease of use
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) for automatic data acquisition

A suction-type continuous-operation supersonic wind tunnel for investigations into subsonic and supersonic air flow. It also allows students to study air flow in two dimensions around aerodynamic models.

An instrument frame (supplied) holds a remote control unit that controls a high-capacity vacuum pump (supplied). The pump creates a low pressure downstream of the working section to draw air into the wind tunnel. A bypass duct with a hand-operated valve allows the operator to reduce the airflow through the Working Section without disturbing the quality of the main airflow. This is useful for startup and shutdown and for subsonic tests.

Continued on next page

Continuous Supersonic Wind Tunnel (AF302)
Continued from previous page

The working section of the wind tunnel is a convergent-divergent nozzle with a removable top part ('liner'). The shape of the liner controls the maximum air velocity at the divergent part of the working section. Included are three different liners.

A selection of models are included with the equipment (one has pressure tappings) for experiments in two-dimensional flow. These fit in the 'portal' of the working section, flush to both windows. A geared mechanism allows students to adjust the incidence angle of the models. An encoder works with the optional VDAS to measure the model angle.

Pressure tappings along the working section connect to a 'mimic' panel and multi-pressure display unit in the instrument frame. The display unit shows the pressures at the tappings. The display includes calibrated pressure sensors to measure pressures relative to atmosphere. It also shows the pressures on one of the models.

An analogue pressure gauge measures and displays the suction of the pump (tunnel reference pressure). This pressure line also connects to the multi-pressure display for data acquisition.

The equipment works with TecQuipment's optional Versatile Data Acquisition System (VDAS®) and can quickly and conveniently connect to a frame-mounting interface unit (VDAS-F, not included). Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a suitable computer (computer not included).

The wind tunnel includes transparent windows in the working section. These are high-quality optical glass suitable for use with the optional Schlieren Apparatus (AF302a, available separately) enabling display and recording of images of high-speed flow.

Experiments:

- Pressure distribution along a convergent/divergent (Laval) nozzle with subsonic and supersonic air flow
- Comparison of theoretical and actual pressure distribution
- Comparison of actual and theoretical area ratio of a nozzle at supersonic air velocities (Mach numbers)
- Pressures around a two-dimensional model in subsonic and supersonic flow conditions, at different angles of incidence
- Lift coefficient for aerodynamic models in supersonic flow
- Shock waves and expansion patterns around a two-dimensional model in supersonic flow conditions (when used with the optional Schlieren Apparatus)

Essential Ancillary:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

Recommended Ancillary:

	Page
• Schlieren Apparatus AF302a	40

Alternative Products:

	Page
• Subsonic Wind Tunnel (AF100)	20
• Nozzle Flow Apparatus (AF27)	34
• Intermittent Supersonic Wind Tunnel (AF300)	36

Schlieren Apparatus (AF302a)

Schlieren apparatus for use with TecQuipment's Continuous Supersonic Wind Tunnel (AF302)

- Monochrome Schlieren apparatus with high-power light source and imaging screen
- High-quality, laboratory-standard mirrors and lenses for clear images without distortion
- Shows supersonic air flow patterns around models
- Shows shockwaves and expansions
- Includes digital imaging equipment and TV monitor

A monochrome Schlieren apparatus for use with the Continuous Supersonic Wind Tunnel (AF302).

The Schlieren apparatus allows students to see density gradients as variations in intensity of illumination. This allows them to see supersonic air flow patterns around models. It also clearly shows shockwaves and expansions, and students can compare their position and angle with values predicted by theory.

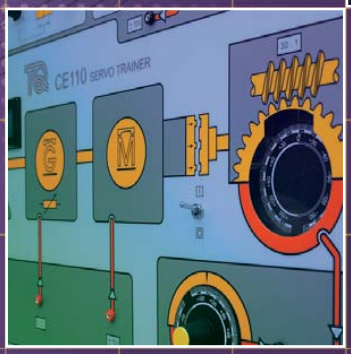
The mirrors and lenses are of high optic standards to reduce any possibility of optic distortions of the images.

The apparatus includes digital imaging equipment to record the images. The TV monitor is useful to display the images to groups of students. The imaging equipment can capture still images and any real-time changes in the image.

Ancillary for:

	Page
• Continuous Supersonic Wind Tunnel (AF302)	39

Control Engineering



“ Our students are comfortable while using products from TecQuipment in labs. Highly innovative products by TecQuipment Ltd for engineering education are ideal for engineering and technical education at all levels. Our students are regularly using this equipment for masters and doctoral research. The products are user-friendly and need minimum after-sales service. ”

Prof R D Misal, Defence Institute of Advanced Technology, Girinagar, Pune, India

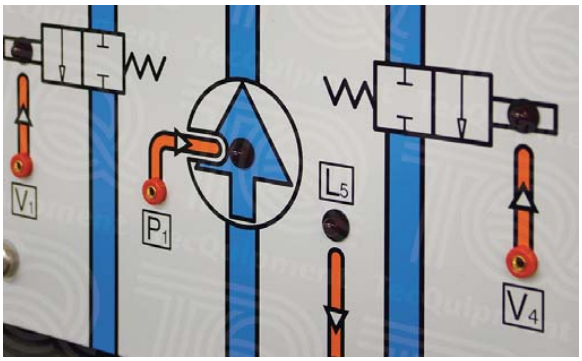
Control Engineering

Made for academic and industrial training

The control range extends from bench-top products made for teaching control principles, to products using industrial parts for vocational training.

Different choices

Both the academic and industrial control ranges allow you to choose a single control scenario, such as flow control, with the option of additional systems later. Alternatively, each range includes a complete product that demonstrates a full set of control scenarios from flow to pressure to temperature and level control.



Academic and industrial software

All our Control Engineering products work with software. Most of the academic products work with TecQuipment's own CE2000 control software. Selected products work with MATLAB®/Simulink® software. The more industrial products work with industrial process or PLC control software.

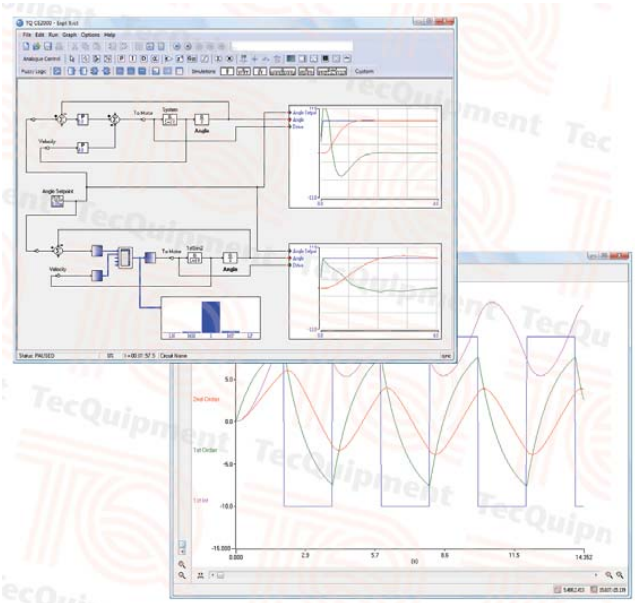
KEY FEATURES AND BENEFITS:

- **Academic and industrial: bench-top products for academic teaching and industrial products for vocational training.**
- **Choice: you can start with a single control scenario and build up, or choose a more complete product to suit your budget and needs.**
- **Safe and easy set-up: simple, low-voltage connections allow you to set up an experiment safely and quickly.**
- **Hands-on: both the academic and industrial products allow easy connection and adjustments, for a more practical understanding.**

CE2000	MATLAB®/ Simulink®	Industrial Process Control/ PLC software	Product	
●			**Controller** (CE120) + **selected experiment modules**	Page 44
●			**Digital Interface** (CE122) + **selected experiment modules**	Page 45
●			**Process Trainer** (CE117)	Page 59
	●		**Helicopter Model** (CE150)	Page 54
	●		**Ball and Plate Apparatus** (CE151)	Page 55
	●		**Magnetic Levitation Apparatus** (CE152)	Page 56
		●	**PLC Process** (CE111) **and PLC Trainer** (CE123)	Pages 57–58
		●	**Pressure, Flow, Level and Temperature Process Training Systems** (TE3300/02 to TE33300/05)	Pages 60–63
		●	**Control and Instrumentation Study Station** (TE37)	Page 65

Control Software (CE2000)

Icon-based software that simulates control systems and works with TecQuipment's Controller (CE120) or Digital Interface (CE122) to control and acquire data from TecQuipment's Control Engineering range



- Powerful simulation, control and data acquisition software
- Software only – needs no extra circuit boards in your computer
- Includes a range of ready-made fuzzy logic and control blocks, such as proportional, integral and derivative blocks
- Collected data can be shown and printed as charts or exported for use in other programs
- Real-time display of variables by virtual meters, virtual chart recorders or virtual oscilloscopes
- Easy-to-create control circuits made by linking together drag-and-drop icons
- Users can create their own circuits and save them, or use the ready-made circuits supplied
- Includes ready-made blocks that simulate first and second-order systems
- Includes blocks that work as function generators, with a full range of output signals

The CE2000 is a powerful control software package with many features. It is supplied as standard with the Controller (CE120), Digital Interface (CE122) and Process Trainer (CE117).

The software allows students and experienced control engineers to develop and test a wide selection of controllers and filters. The Control Software combines controller design and implementation into one logical process. This reduces a student's learning difficulties and helps them to quickly understand and create a working control system.

Students use the software icons and wire them together on screen, just as they would draw a control system on a piece of paper. The icons include the important parts of controllers, signal generators, manually controlled signals and voltages, and virtual instruments. The students set the software to record important variables. They can then plot the results in a chart and export the data for use in other programs.

With the CE2000 software students can create one or more types of controller and simulate the theoretical responses. They can then find the response with real systems, such as selected products in TecQuipment's Control Engineering range. These products give a wide selection of system responses, including linear and non-linear, stable and unstable, oscillatory and multivariable.

Included with the CE2000 software are files that match the experiments supplied with the selected TecQuipment products. Because of its open and flexible structure, the CE2000 and TecQuipment's interface or controller may also model, simulate and run any other compatible system.

For real-time control and data acquisition you must use the software with TecQuipment's Controller (CE120) or Digital Interface (CE122). TecQuipment's Process Trainer (CE117) already contains a built-in interface.

Experiments:

Software only:

The user guide shows students how to use the software and how to build and test common control systems, such as:

- Design and implementation of three-term controllers
- Design of controllers and filters

Software and hardware:

When used with other products from our CE range:

- Thermal control (CE103)
- Level control (CE105/CE105MV)
- Ball and beam control (CE106)
- Engine speed control (CE107)
- Coupled drives control (CE108)
- Ball and hoop control (CE109)
- Servo control (CE110)
- Flow, level, pressure and temperature control (CE117)

Essential Ancillary:

- Suitable computer with two spare USB connections (not supplied by TecQuipment)

Controller (CE120)

Electronic controller with fully adjustable control blocks for control of TecQuipment's Control Engineering (CE) range

- Compact, bench-mounting unit that includes easy-to-connect blocks of all the important parts of a process controller
- All inputs and outputs are low voltage and buffered for educational use
- Includes proportional, integral and PID blocks and summing junctions
- Includes an interface for computer control (with data acquisition) of TecQuipment's Control Engineering range
- Front panel has clear diagrams that mimic parts of the controller, so students can see and understand what they connect
- Supplied with TecQuipment's Control Software (CE2000) for control and data acquisition
- Includes digital meter to measure voltages and show the frequencies from the on-board function generator

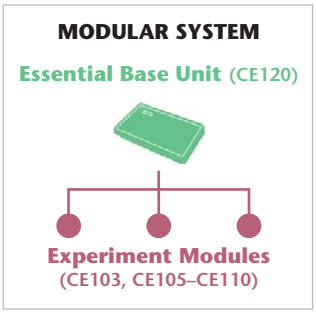
The Controller is for use with most products in TecQuipment's Control Engineering (CE) range, but it will work with any other compatible laboratory equipment.

It is a mains-powered, compact unit with electronic circuits connected in blocks. These blocks mimic the important parts of industrial controllers. Clear diagrams on the front panel of the controller show the blocks and each block has its own set of connection sockets. The user connects the blocks in any way they need and then connects them to their chosen products in the CE range.

The blocks include:

- Proportional and integral blocks
- A complete three-term PID (proportional, integral, derivative) block
- Fully adjustable potentiometers that can work as set-points or attenuators
- A function generator and digital voltmeter
- Summing junctions
- Phase lead

The controller also includes an interface with D/A (digital to analogue) and A/D (analogue to digital) connections. This allows the user to connect their product from the CE range



to a suitable computer (not included) for computer control and data acquisition. Supplied with the CE120 is TecQuipment's CE2000 Control Software (see page 43).

The Controller is an alternative to the CE122 Interface (see page 45), but with the additional hardware controller features.

Experiments:

When used with other products in the CE range:

- Temperature (thermal) control
- Level control
- Engine speed control
- Servo control
- Coupled drive control
- Ball and beam control
- Ball and hoop control

Available Experiment Modules:

	Page
Thermal Control Process Apparatus (CE103)	46
Coupled Tanks Apparatus (CE105/CE105MV)	47
Ball and Beam Apparatus (CE106)	48
Engine Speed Control Apparatus (CE107)	49
Coupled Drives Apparatus (CE108)	50
Ball and Hoop Apparatus (CE109)	51
Servo Trainer (CE110)	53

Recommended Ancillary:

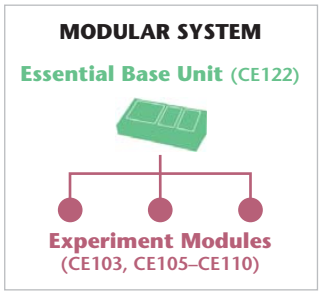
- Suitable computer with two spare USB connections (not supplied by TecQuipment)

Ancillary for:

	Page
Process Trainer (CE117)	59

Digital Interface (CE122)

Electronic interface that connects TecQuipment's Control Engineering (CE) range to a suitable computer for computer control and data acquisition



- Compact, bench-mounting unit
- All inputs and outputs are low voltage and buffered for educational use
- Supplied with TecQuipment's Control Software (CE2000) for control and data acquisition
- Fully digital – needs no user adjustments
- Simple-to-use input and output connections
- Connects to products in TecQuipment's Control Engineering range
- Can work as an interface to other compatible laboratory equipment for computer control and data acquisition
- Connects to most modern computers

The Digital Interface is for use with most products in TecQuipment's Control Engineering range, but it will work with any other compatible laboratory equipment.

It is an alternative to the CE120 Controller (see page 44), when the user only needs the interface part of the CE120.

It converts analogue inputs from other equipment into digital signals for a computer. It also converts the digital signals from a computer into analogue signals to control other equipment.

It will allow the user to monitor up to eight input signals and control up to four output signals.

Supplied with the CE122 is TecQuipment's CE2000 Control Software (see page 43).

Available Experiment Modules:

	Page
• Thermal Control Process Apparatus (CE103)	46
• Coupled Tanks Apparatus (CE105/CE105MV)	47
• Ball and Beam Apparatus (CE106)	48
• Engine Speed Control Apparatus (CE107)	49
• Coupled Drives Apparatus (CE108)	50
• Ball and Hoop Apparatus (CE109)	51
• Servo Trainer (CE110)	53

Essential Ancillary:

- Suitable computer with two spare USB connections (not supplied by TecQuipment)

Thermal Control Process Apparatus
(CE103)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of thermal control

- Electrically-heated and air-cooled model process that mimics a real industrial process
- Includes variable hysteresis for advanced process control experiments
- Temperature sensors with different thermal contact to the process give variations in thermal inertia and time constant
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controllers

The Thermal Control Process Apparatus mimics a common industrial process, including an air-conditioning plant, where a combination of adjustments can control temperature. These can be:

- Varying the heat energy input to the system
- Varying the speed of a circulating fan
- Using a variable vane to restrict the flow

The apparatus has a variable-speed fan that forces air through a duct. In the duct is an electrically-heated process block. A balance of the heat gained from electrical heating and heat lost by convection and conduction gives a steady temperature at the block.

Two temperature sensors measure the temperature of the block. One sensor is in direct thermal contact with the block. The other sensor mounts on an insulating spacer to introduce thermal inertia and variable-time constants into the control loop. A servo-driven vane, mounted after the fan and the process block, creates a variable restriction downstream for more advanced experiments.

The control problem is to keep the process temperature within acceptable limits while it works under various conditions. A combination of regulating the electrical energy to the heater coil, varying the air flow rate and rotating the vane gives the heat control.

A relay amplifier with variable hysteresis allows more advanced experiments.

The Thermal Control Process Apparatus contains the drive power supplies for the fan, vane servo and heater circuits, and the signal conditioning circuits for the sensors.

The user guide supplied contains a detailed description of the apparatus, theory and a set of experiments. The experiments show practical application and setting up of process controllers. The experiments also compare transient response to frequency response. The apparatus has scaled-down time constants for shorter laboratory time.

The CE103 includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- Heat transfer
- ON/OFF control – experiment includes investigation of overshoot and undershoot, ON and OFF time ratio, rates of heating and cooling, offset and hysteresis
- Proportional, proportional + integral, or proportional + integral + differential control
- Frequency response of model process
- Thermal inertia and variable-time constants
- Multi-variable control – up to three variables can be monitored and individually controlled

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** — 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** — 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE103.

Alternative Products: Page

- Process Trainer (CE117) — 59
- Temperature Process Training System (TE3300/05) — 63
- Control and Instrumentation Study Station (TE37) — 65

Coupled Tanks Apparatus
(CE105/CE105MV)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of control of single and coupled tanks

- Established, successful design that mimics a real industrial process
- Option for second pump with second flow meter to allow multivariable (MV) operation (CE105MV)
- Level control of one and two tanks
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controllers
- Includes rotameter-type flow meter so students can see the flow rate

The Coupled Tanks Apparatus investigates basic and advanced control engineering principles. This includes the study of static and dynamic systems. It is also an ideal system to use with other control strategies such as fuzzy logic.

The CE105 shows fluid transport and liquid level control problems in process control.

The basic control problem is to regulate the liquid level in one of the tanks by varying the speed of the circulating pump. The user guide includes experiments that cover system modelling using static and transient measurements, steady-state error analysis, transient response studies and Ziegler/Nichols tuning methods.

Each tank has a level sensor that gives output signals proportional to the water level in each tank. A scale on each tank allows students to check the level-sensor calibration.

A variable-speed pump forces water into the left-hand tank. A valve connects this tank to a second tank, if needed, for two-tank experiments. A rotameter-type flow meter shows the flow rate. An electronic flow meter measures the flow rate.

The CE105MV Multivariable Coupled Tanks Apparatus gives extra experiments. It is similar to the CE105 but with a second pump and flow meter. This pump forces water into the right-hand tank and works independently of the other pump. This gives more advanced experiments into the principles of multivariable control (both pumps work together to give the correct levels in the two tanks simultaneously).

The CE105 and CE105MV include a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- Calibration of transducer and actuator circuits
- System dynamics in process systems
- Design and operation of analogue proportional, proportional + integral, or proportional + integral + differential control controllers
- Steady-state errors and closed-loop transient responses
- Ziegler/Nichols controllers tuning rules
- Multivariable control
- Step-change tuning
- State feedback
- Flow control

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

Essential Base Unit: Page

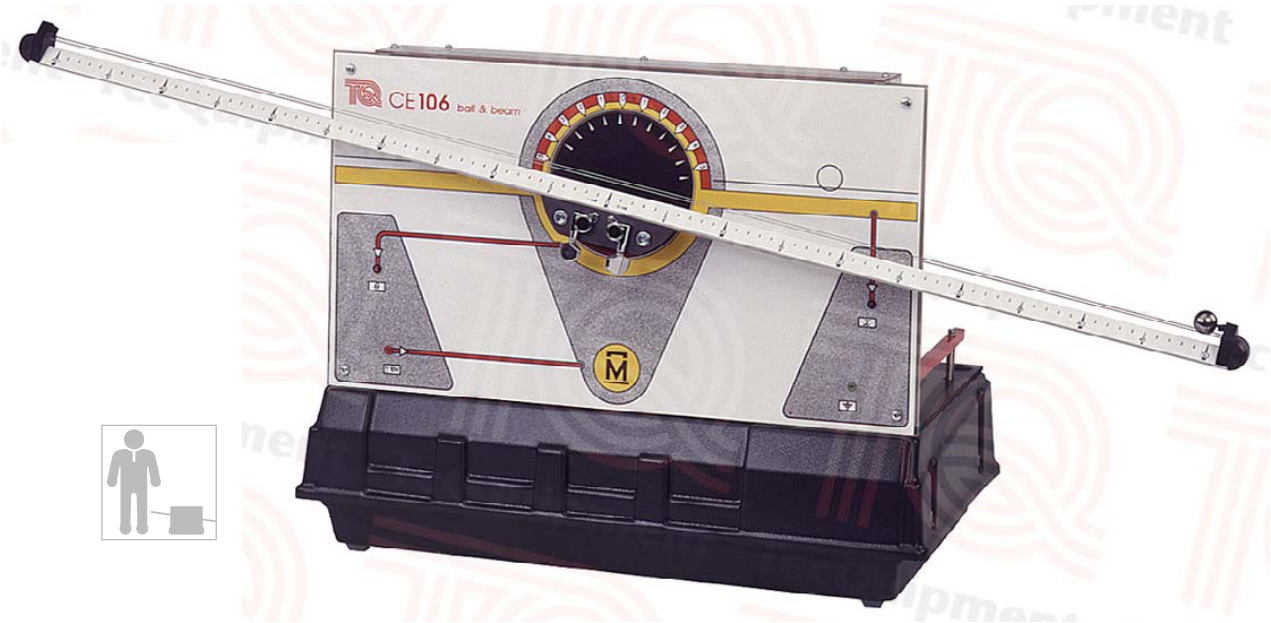
- Controller (CE120) – A controller with analogue and digital controls and instruments **or** 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE105/CE105MV.

Alternative Products Page

- Process Trainer (CE117) 59
- Level Process Training System (TE3300/04) 62
- Control and Instrumentation Study Station (TE37) 65

Ball and Beam Apparatus (CE106)



Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of control, including control of naturally unstable systems

- Naturally unstable mechanical control system
- Self-contained, compact and bench-mounting unit
- Ideal for classroom demonstrations and student project work
- Highly visual apparatus, with moving ball and front panel mimic diagram of the process – students can clearly see what they are controlling
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controllers
- For basic and advanced experiments with angle, velocity and position control
- Mimics real control problems in unstable systems, such as missile or rocket take-off

The Ball and Beam Apparatus shows the control problems of unstable systems, for example a rocket or missile during launch, which needs active control to prevent the missile going unstable and toppling over.

The apparatus has a steel ball which is free to roll on two parallel tensioned wires. The wires are on a beam that pivots at its centre. A servo motor controls the beam angle and sensors measure the beam angle and ball position. The basic control problem is to vary the beam angle to control the ball position. The system is a double integrator, so it is naturally unstable. It needs active feedback control using phase-advance methods.

The CE106 comes with a user guide which includes full details of how to use the equipment and typical experiments.

It also includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- Measurement of system dynamics by transient and closed-loop methods
- Design of analogue phase-advance compensators
- Design of state reconstructors to obtain estimates of ball velocity and position

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

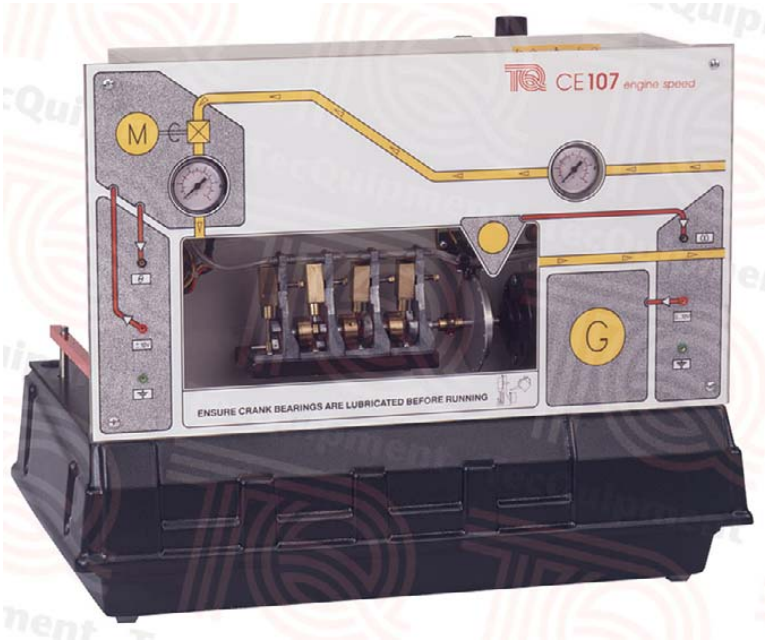
Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE106.

Engine Speed Control Apparatus (CE107)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of engine speed control



- Small-scale, compressed air-powered piston engine to mimic a full-size engine with realistic results
- Shows problems of speed control in non-linear systems
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling
- For basic and advanced experiments with speed control and non-linearity compensation
- Ideal for classroom demonstrations and student project work
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controller

The Engine Speed Control Apparatus shows the problems of regulating the speed of rotating machines, especially problems with non-linear control systems.

It is a scale-model engine, driven by compressed air (not supplied) for safety. The basic purpose is to adjust a motorised valve to regulate the engine speed under load. A d.c. generator connects to the engine output and loads the engine.

More advanced experiments show:

- Non-linearity compensation using dither signals
- Multiple loop and minor loop feedback
- System modelling from step response information
- P+I control and root locus methods

The engine dynamics are similar to those of a typical ignition compression engine coupled to a dynamometer-controlled test bed. It is an ideal physical model to help engineering students at all academic levels gain invaluable practical experience.

The CE107 includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- The use of dither signals in the compensation of system non-linearities
- The measurement of system dynamics from step response information
- Inner loop feedback compensation
- P+I controller design

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** — 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** — 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE107.

Essential Ancillary: Page

- Compressor (CE1B) — 295

Recommended Ancillaries: Page

- Optical Tachometer (OT1) — 295
- Stroboscope (ST1) — 295

Coupled Drives Apparatus (CE108)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of control of coupled drives

- Shows the problems of speed and tension control with coupled drives
- Mimics many industrial and household applications with realistic results
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controller
- Ideal for classroom demonstrations and student project work
- Shows basic speed control and advanced multivariable control
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling

The Coupled Drives Apparatus shows the problems of controlling speed and tension in coupled drives. Many applications use coupled drives, for example magnetic tape drives, textile machines and paper mills.

The apparatus has two electric motors, coupled by a continuous flexible belt. The belt also passes over a swinging arm with a 'jockey wheel' which measures the belt speed and tension. A manual control allows the user to adjust the spring tension at the swinging arm.

The basic control problem is to vary the torque in the motors to regulate the belt speed and tension. The user guide also shows techniques for speed and tension control, simultaneous control of velocity and tension, and analysis of multivariable control systems.

The CE108 includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- Independent control of speed and tension
- Simultaneous control of speed and tension
- Practical methods of controlling multi-variable electro-mechanical systems

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE108.

Recommended Ancillary: Page

- Optical Tachometer (OT1) 295

Ball and Hoop Apparatus (CE109)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of control of a ball in a hoop

- Ideal for classroom demonstrations and student project work
- Shows the problems of speed and position control of a mobile body or liquid in a container
- Mimics industrial, aeronautical, fluid transport and pumping system problems with realistic results
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controllers
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling
- Shows basic control of position or speed, and advanced studies of liquid slop

The Ball and Hoop Apparatus shows the use of electromechanical servo systems for position and velocity control. It also works as a model to show liquid slop problems, for example: aircraft missile fuel storage, fuel tankers and industrial pumping systems.

The apparatus has a steel ball that rolls inside a hoop. The hoop is free to rotate, but controlled by a servomotor. Transducers give outputs of the hoop and ball positions.

When the hoop is under angular position control, the ball moves like a cylindrical pendulum. This allows students to use it as a model for the study of liquid slop dynamics.

Advanced studies cover:

- The influence of liquid slop behaviour on vehicle control system design
- The use of 'pole zero' in the analysis of control systems

The CE109 includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- The design and analysis of servo control systems for position and velocity control
- The analysis and modelling of liquid slop dynamics
- The use of 'pole zero' in the analysis of control systems

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work

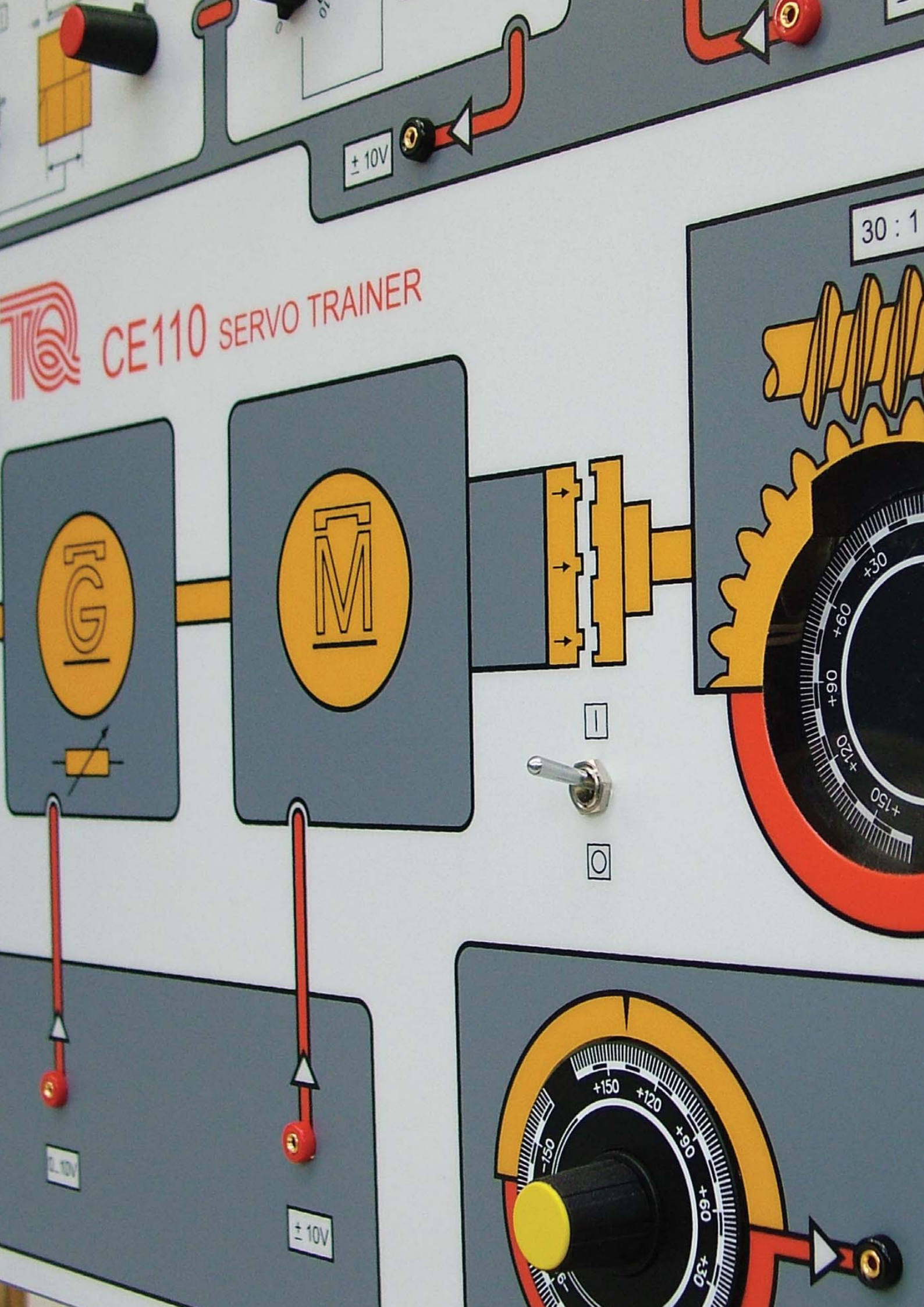
Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** — 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** — 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE109.

Recommended Ancillary: Page

- Optical Tachometer (OT1) — 295
- Oscilloscope (OS1) — 295


CE110 SERVO TRAINER
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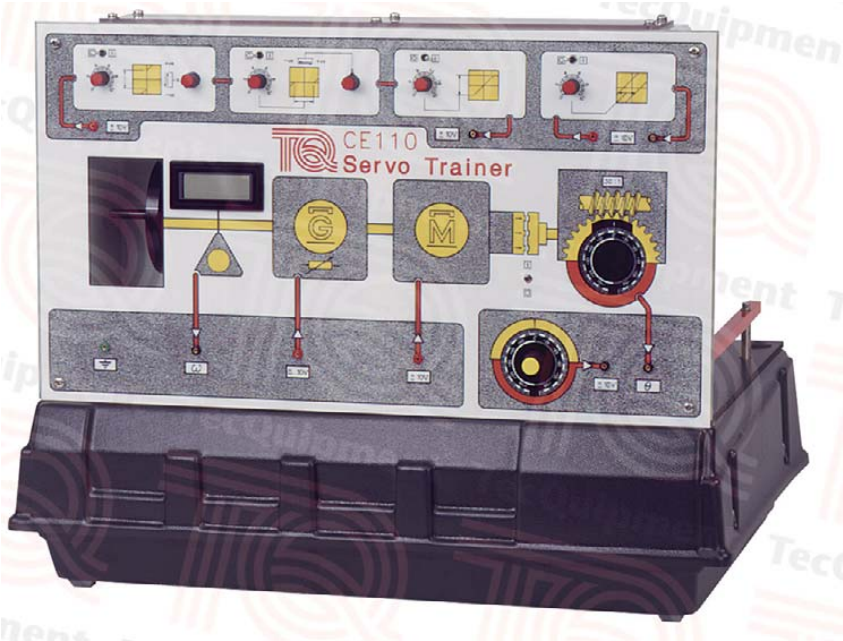
Servo Trainer (CE110)

Compact, self-contained, bench-mounting apparatus to study basic and advanced principles of servomotor control



- Ideal for classroom demonstrations and student project work
- Shows problems of speed and position control of a servomotor under different loads
- Mimics industrial, transport and aeronautical problems with realistic results
- All inputs and outputs buffered for connection to TecQuipment's optional controllers or other suitable controllers
- Front panel includes mimic of the process so students can clearly see what they are controlling
- Shows basic control of speed with advanced studies of non-linear effects of hysteresis, deadzone and saturation

The Servo Trainer shows d.c. servo position and speed control systems using typical industrial techniques. It has a d.c. servomotor, a d.c. generator and a flywheel mounted on a common shaft.

Analogue 0 to ±10 V control signals vary the servomotor shaft speed in either direction. An optical sensor measures the speed and shows it on a panel-mounted digital meter.

The d.c. generator statically or dynamically loads the servomotor.

An electric clutch connects or disconnects the shaft to a 30:1 reduction gearbox for position control studies. A manual control allows the user to set a position control setpoint.

To adjust the shaft inertia, the CE110 comes with two extra interchangeable inertia discs (flywheels).

For advanced experiments, the Servo Trainer includes extra 'block'-type circuits that can add non-linear and fully adjustable effects of:

- Deadzone or 'deadband'
- Anti-deadzone
- Hysteresis
- Saturation

These blocks are important in studies of servo systems because they mimic problems which happen in real applications.

The CE110 includes a set of cables and connectors for connection to other equipment. All control connections work with 0 to 10 VDC signals.

Experiments:

- Basic tests and transducer calibration
- Response calculation and measurement
- Proportional and proportional plus integral control of servo-system speed
- Disturbance cancelling and feedforward control
- Angular position control: proportional control and velocity feedback
- Angular position control and the influence of non-linearities
- Non-linear system characteristics

The flexible design of the equipment allows the user to develop many other analysis and control exercises to suit their needs. It is good for extended or advanced control experiments, and is ideal for student project work.

Essential Base Unit: Page

- Controller (CE120) – A controller with analogue and digital controls and instruments **or** 44
- Digital Interface (CE122) – An interface which connects between most products in the Control Engineering range and a suitable computer (not included) **or** 45
- Other suitable controller with 10 V inputs and outputs

Both the CE120 and the CE122 include TecQuipment's CE2000 Control Software (see page 43) with editable, pre-made control experiments for use with the CE110.

Helicopter Model (CE150)

Shows students how to create a controller to control a dynamic, naturally unstable system (a helicopter)

- Compact, bench-top unit for connection to a suitable computer
- Real-time control of a multi-dimensional, naturally unstable system
- Two-input, two-output system with cross-coupling
- Scale model of a helicopter with main (horizontal) rotor and tail rotor for realistic experience of yaw and pitch control
- Model has adjustable centre of gravity to mimic changes in weight distribution and to test the control system
- System accessible directly from MATLAB®/ Simulink® environment in real time
- Ideal for classroom demonstrations and student project work
- Includes comprehensive educational manual

The model simulates a helicopter with horizontal and tail rotors to give pitch and yaw control. Sensors measure the yaw and pitch angles. This gives a two-input and two-output system, with cross-coupling. Students use the educational manual (supplied) to help identify plant dynamics and create a control system. The control system must keep the helicopter stable and allow for a change in the centre of gravity. When operating near the steady state, the electromechanical system can be linearized to a six-order model.

The equipment includes:

- The model helicopter on a stand
- An interface unit
- A data acquisition board for your computer
- A protective steel cage to put around the helicopter for safety

The data acquisition board fits into a suitable computer (not supplied) to link with the interface and control the motors of the helicopter, and accept inputs from the sensors.

The software (supplied) includes:

- Demonstration program with PID controllers
- Interface library for programming at the system level
- Example Simulink® models for real-time control experiments.

Experiments:

- Direct derivation of a general mathematical model of a helicopter using Lagrange equations, linearisation and simplification.
- On-line identification of parameters of a linear model. Direct and indirect (closed-loop response analysis) methods should be used.
- System decoupling techniques, diagonalisation of system transfer matrix and state space methods.
- Stabilisation and tracking tasks formulation
- State feedback design, observer design
- Robust and adaptive controller design for changing parameters system due to moving centre of gravity, LQ/LQG and H∞ controller design.
- Comparison of an analogue and digital controller design. Selection of a correct sampling frequency.

Essential Ancillaries:

(Not supplied by TecQuipment)

- Suitable computer with a spare PCIe (PCI Express) slot and Microsoft® Windows® XP, Vista, 7 or 8 operating system. 32-bit and 64-bit.

Note: If you have an older computer with only PCI slots, please contact our sales department.

- Software:
  - MATLAB®
  - Simulink
  - Real-Time Windows® Target
  - Simulink Coder® (recommended)
  - Simulink 3D Animation (recommended)

Ball and Plate Apparatus (CE151)

Demonstrates advanced two-dimensional control with visual feedback

- Two-dimensional system with second-order astatism designed for studying system dynamics based on classical and modern control theory
- Compact, bench-top configuration designed for on-line digital control by computer
- High levels of in-built safety combined with ease of operation
- Intelligent ball-position sensor represented by vision system based on digital camera and real-time image processing software
- Control tasks simulate various problems from robotics (path planning and tracking) taking advantage of visual feedback
- Interface library and interactive software package including PID controller – polynomial and fuzzy logic controllers can be developed
- System accessible directly from MATLAB®/ Simulink® environment in real time
- Includes comprehensive educational manual

The Ball and Plate Apparatus shows the problems of the control of an unstable system. The apparatus consists of a plate pivoted at its centre so the plate can tilt in two directions.

Stepper motors tilt the plate. A servo system with a stepper motor control card controls the motors. A camera with an intelligent vision system measures the ball position. The basic control task is to control the ball position. The ball is free to roll on the plate.

The equipment includes:

- Ball and plate model
- Power supply
- A data acquisition board for your computer
- Camera with USB connection

The data acquisition board fits into a suitable computer (not included) to link with the Ball and Plate Apparatus and control its motors.

Software (included):

- Demonstration program with PID controllers
- Interface library for programming at the system level
- Example Simulink® models for real-time control experiments

Experiments:

- Real-time digital image processing
- Digital PID controller design for ball position stabilisation and trajectory following
- LQ/LQG controller design based on state and I/O model
- Fuzzy controller design
- Adaptive controller design
- Path planning for moving the ball between obstacles

Essential Ancillaries:

(Not supplied by TecQuipment)

- Suitable computer with a spare PCIe (PCI Express) slot and Microsoft® Windows® XP, Vista, 7 or 8 operating system. 32-bit and 64-bit.

Note: If you have an older computer with only PCI slots, please contact our sales department.

- Software:
  - MATLAB®
  - Simulink®
  - Real-Time Windows® Target
  - Image Processing Toolbox
  - Image Acquisition Toolbox (recommended)
  - Computer Vision System Toolbox (recommended)

Magnetic Levitation Apparatus (CE152)

Shows students how to control a non-linear, unstable system (a steel ball in a magnetic field)

- Compact, bench-top apparatus, ideal for classroom demonstrations and student projects
- Uses a magnetic field to control the vertical position of a steel ball
- Shows the dynamics of a one-dimensional, non-linear, unstable system
- Supports investigations into a number of different control algorithms based on classical and modern control theory – includes PID, LQ/LQC, adaptive, fuzzy and non-linear controller design and operation
- Hardware module is supplied fully assembled and includes integral power supplies
- System accessible directly from MATLAB®/ Simulink® environment in real time
- Includes comprehensive educational manual

The Magnetic Levitation Apparatus shows control problems with non-linear, unstable systems.

The apparatus consists of a steel ball held in a magnetic field produced by a current-carrying coil.

At equilibrium, the downward force on the ball due to gravity (its weight) is balanced by the upward magnetic force of attraction of the ball towards the coil. Any imbalance and the ball will move away from the set-point position.

The basic control task is to control the vertical position of the freely levitating ball in the magnetic field of the coil.

The Magnetic Levitation Apparatus is a non-linear, dynamic system with one input (coil current) and one output (ball position).

A sensor measures the position of the ball. A power amplifier with overheat protection drives the coil.

The equipment includes:

- The ball and coil
- A power supply/interface
- A data acquisition board for your computer

The data acquisition board fits into a suitable computer (not included) to link with the interface and control the coil, and accept the signal input from the sensor.

Software (included):

- Demonstration program with PID controllers
- Interface library for programming at the system level
- Example Simulink® models for real-time control experiments

Experiments:

The educational manual contains a structured series of experiments that guide the user from system modelling and identification to full non-linear control.

Experiments include:

- Real time digital signal processing
- Digital PID controller design for ball position stabilisation and trajectory tracking
- LQ/LQG controller design based on state and I/O model
- Fuzzy controller design
- Adaptive controller design
- Non-linear controller design

Essential Ancillaries:

(Not supplied by TecQuipment)

- Suitable computer with a spare PCIe (PCI Express) slot and Microsoft® Windows® XP, Vista, 7 or 8 operating system. 32-bit and 64-bit.

If you have an older computer with only PCI slots, please contact our sales department.

- Software:
  - MATLAB®
  - Simulink®
  - Real Time Windows® Target
  - Simulink Coder® (recommended)
  - Simulink 3D Animation (recommended)

PLC Process (CE111)

Compact, self-contained, bench-mounting liquid flow and level process, for use with TecQuipment's PLC Trainer (CE123)

- Connects to TecQuipment's PLC Trainer (CE123) to mimic a realistic industrial process
- Allows basic and advanced studies of programmable logic controllers (PLCs) in industrial applications
- Shows control of liquid flow, volume and level in two tanks
- Includes a selection of fully controllable valves to give many different liquid level and flow control experiments, including batch processing
- Front panel includes mimic diagram of the process so students can clearly see what they are controlling

TecQuipment's PLC Process gives students and engineers practical experience of the principles and application of programmable logic controllers (PLCs). The object is to connect and program an external, programmable logic controller to monitor and control the level and flow rate of water in a two-tank system.

The apparatus has two transparent tanks, mounted one above the other. A variable-speed pump transfers water from the reservoir (in the base of the unit) into the upper tank. The water can drain down to the lower tank and then back into the reservoir. Solenoid valves may be individually opened or closed to control and redirect the movement of the water. The pump control is on or off, but a manual control allows the user to set the speed. A float switch in the reservoir monitors the level of water.

Each tank includes two level sensors which measure maximum and minimum water levels. An in-line flow sensor provides a pulsed output. Its frequency is proportional to the flow rate and the number of pulses proportional to volume.

Indicators next to each input and output socket show the on/off status of the pump, the valves, the maximum and minimum level in each tank, and the flow rate.

An overflow in each tank prevents accidental overfilling.

Note: You must use the PLC Process with TecQuipment's PLC Trainer (CE123). A multi-way lead connects the unit to the trainer. This lead carries the power for the pump and valve solenoids, and completes the return path for the input and output sockets.

Experiments:

When used with the PLC Trainer (CE123):

- Basic programming of a PLC
- Basic level control
- Tank filling sequence
- Simulated batch processing (sequencing)
- Ladder logic programming
- Editing and adding comments in a PLC program

The open structure of the CE111 and CE123 allows the user to create additional experiments to suit their needs.

Essential Ancillary:

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• PLC Trainer (CE123)	58

PLC Trainer (CE123)

Shows students how programmable logic controllers (PLCs) work. For use with TecQuipment's PLC Process (CE111) to show students how to control a common industrial process.

- Self-contained, bench-mounting unit
- An industry-standard programmable logic controller (PLC) upgraded for educational use
- Includes PLC software to program the controller, and ready-made programs to match experiments given in the user guide
- Introduces ladder logic programming
- Works with TecQuipment's PLC Process (CE111) to show students how to control a common industrial process, but in safe conditions
- Uses industry-standard controller to give students realistic industrial experience
- Includes manual override switches to introduce faults for fault-finding training

The PLC Trainer shows students how to use a programmable logic controller. It also works with TecQuipment's PLC Process (CE111) to help students study how to use programmable logic controllers to control a process.

The clearly labelled front panel has all the input and output connections. Each input and output includes a socket and three push-button switches. One switch connects or disconnects the connection. The other two set the connection as permanently high or low to override the controller. This allows students to do some manual control, or add faults to see what effect it has on the process. Indicators show the status of the controller inputs and outputs.

A socket on the front panel connects to a suitable computer (not included). The user must install the software (included) onto their computer so they can program the controller to suit their needs. TecQuipment supplies programs to match the experiments in the user guide (included).

The software introduces students to the features of a controller program. These features include:

- Normally open and closed contacts
- Timers
- Counters
- Shift registers
- Ladder logic

Note: The user guide includes experiments that show the student how to use a programmable logic controller. You must use the PLC Trainer with the PLC Process (CE111) for experiments in process control.

You must not connect the inputs and outputs of the PLC Trainer to equipment other than the PLC Process.

Experiments:

- Simple programming
- Ladder logic operations
- Timers, counters and monitoring
- Editing and adding comments in a PLC program
- Special ladder logic instructions

Essential Ancillary:

- Suitable computer (not supplied by TecQuipment)

Ancillary for:	Page
• PLC Process (CE111)	57

Process Trainer (CE117)

Self-contained, fully integrated, bench-mounting teaching apparatus that allows process control experiments in flow, level, pressure and temperature

- Includes four basic process control methods in one compact unit
- Supplied with TecQuipment's CE2000 software for supervisory control of the process with data acquisition
- Mimics common industrial parts and processes with realistic results
- Ideal for classroom demonstrations and student experiments
- Shows flow control, level control, pressure control and temperature control by feedback
- Includes experiments from basic control to advanced control methods, including ratio control, cascade control, interactive control and feedforward control

TecQuipment's Process Trainer is an educational package that mimics industrial process engineering. The fully integrated, self-contained teaching apparatus gives a comprehensive range of process control experiments, from basic to advanced.

Using water as the working fluid, the equipment allows safe, practical experiments on control of flow, liquid level, temperature and pressure. Students can study each of these separately or in combinations.

The equipment consists of an experiment module, a control module and TecQuipment's CE2000 software.

The experiment module includes all the essential parts to allow students to create process control systems. The main part is the process vessel, with a stirrer, a temperature sensor, level and pressure sensors, a heat exchanger and vent valve. It also includes two loops, linked by the heat exchanger in the process vessel. One loop is the heating loop with pump, heater tank and heater. The other loop is a process and cooling loop with pump, cooler, fan, valves and reservoir.

The control module links to the experiment module to provide access to the connections of each part on the experiment module. It includes a clear mimic diagram with switches and controls to allow manual control of pump speed, cooler-fan speed, heater power and stirrer. It also includes sockets and a built-in computer interface. This allows the user to link each part of the experiment module to a suitable computer (not included) for remote control and data acquisition.

Alternatively, the user can connect a suitable external controller, such as TecQuipment's CE120.

Supplied with the equipment is TecQuipment's Control Software (CE2000, see page 43) for supervisory control of the CE117 and data acquisition. You need a suitable computer to use the CE2000 software.

You may also connect the Process Trainer to TecQuipment's Controller (CE120) or other suitable controller, for direct control (without a computer).

Experiments:

- Proportional, Integral and Derivative (PID) control
- Control of flow
- Control of level
- Control of pressure
- Control of temperature
- Ratio control
- Cascade control
- Multi-loop control
- Interacting control loops

Essential Ancillary:

- Suitable computer (not supplied by TecQuipment) for the CE2000 software

Recommended Ancillary:

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Controller (CE120) or other similar controller	44

Alternative Products:

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Thermal Control Process Apparatus (CE103)	46
Coupled Tanks Apparatus (CE105/CE105MV)	47
Pressure Process Training System (TE3300/02)	60
Flow Process Training System (TE3300/03)	61
Level Process Training System (TE3300/04)	62
Temperature Process Training System (TE3300/05)	63
Control and Instrumentation Study Station (TE37)	65

Pressure Process Training System (TE3300/02)

For a wide range of practical experiments in pressure control

- Shows automatic control of pressure in an accumulator using proportional, proportional plus integral, and proportional, integral plus derivative (PID) control
- Uses industry-standard parts to make it ideal for industrial, vocational and academic training
- Shows operation, calibration and tuning of controllers, transmitters, converters and valves
- Connects to the Flow Process Training System (TE3300/03) for cascade control
- Connects to the Computer Control System (TE3300/06) for distributed control

The Pressure Process Training System is a compact and mobile unit for a wide range of experiments in pressure control. It gives students a greater understanding of the stability of simple control systems.

The self-contained unit can do many experiments, but it can also connect to other products in the TE3300 range for extra experiments. For cascade control of flow and pressure, it can link to the optional Flow Process Training System (TE3300/03). For distributed control, it can connect to the optional Computer Control System (TE3300/06).

The main parts of the Pressure Process Training system are:

- Industrial controller with auto-tune feature
- Two-channel chart recorder
- Current-to-pressure (IP) converter
- Gauge pressure transmitter
- Pneumatic control valve
- Pressure accumulator
- Three-speed pump
- Reservoir

To perform experiments, students fill the reservoir with clean water and prime the system. They then set the controller to regulate the flow of water using a pneumatic valve. This alters the pressure in the accumulator. A pressure transmitter measures the accumulator pressure and gives feedback to the controller.

For a realistic experience, the equipment has industry-standard instrumentation and parts.

The apparatus includes two gate valves. One valve controls the flow at the output (drain) of the accumulator, and the other acts as a flow-bypass valve. A chart recorder shows and logs the changes of the process variable (pressure) and the controller output.

Note: The chart recorder is paperless, so you need a suitable computer and colour printer if you need to print out hard copies of the chart recorder traces.

A socket on the side of the apparatus links to the Computer Control System (TE3300/06, available separately).

Experiments:

- Proportional, integral and derivative control
- Setting up and demonstrating automatic control
- The principles of loop control and the calibration and tuning of controllers, transmitters, converters and valves
- Cascade control of flow and pressure (when used with the TE3300/03 Flow Process Training System)
- Distributed control (when used with the TE3300/06 Computer Control System)

Essential Ancillary:

- Service Module (SM3300) **or**
- Stable supply of 0.5 litres/s of clean, dry, oil-free air at 2–10 bar

Recommended Ancillaries:

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Flow Process Training System (TE3300/03)	61
Computer Control System (TE3300/06)	64

Ancillary for:

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Flow Process Training System (TE3300/03)	61

Alternative Products:

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Process Trainer (CE117)	59
Control and Instrumentation Study Station (TE37)	65

Flow Process Training System (TE3300/03)

For a wide range of practical experiments in flow control

- Shows automatic control of flow using proportional, proportional plus integral, and proportional, integral plus derivative (PID) control
- Uses industry-standard parts to make it ideal for industrial, vocational and academic training
- Shows operation, calibration and tuning of controllers, transmitters, converters and valves
- Connects to the Pressure Process (TE3300/02) and Level Process (TE3300/04) Training Systems for cascade control
- Connects to the Computer Control System (TE3300/06) for distributed control

The Flow Process Training System is a compact and mobile unit for a wide range of experiments in flow control. It gives students a greater understanding of the stability of simple control systems.

The self-contained unit can do many experiments, but it can also connect to other products in the TE3300 range for extra experiments. For cascade control of flow and pressure, it can link to the optional Pressure Process Training System (TE3300/02). For cascade control of flow and level, it can link to the optional Level Process Training System (TE3300/04). For distributed control, it can connect to the optional Computer Control System (TE3300/06).

The main parts of the Flow Process Training System are:

- Industrial controller with auto-tune feature
- Two-channel chart recorder
- A gap-type (rotameter) flow meter
- Fixed orifice and pressure transmitter
- Pneumatic control valve
- Three-speed pump
- Reservoir

To perform experiments, students fill the reservoir with clean water and prime the system. They then set the controller to regulate the flow of the water using a pneumatic valve. The gap-type flow meter gives a visual indication of flow. The fixed orifice and pressure transmitter give feedback to the controller.

For a realistic experience, the equipment has industry-standard instrumentation and parts.

The apparatus includes two gate valves. One valve controls the flow at the output (drain) and the other acts as a flow-bypass valve. A chart recorder shows and logs the changes of the process variable (flow) and the controller output.

Note: The chart recorder is paperless, so you need a suitable computer and colour printer if you need to print out hard copies of the chart recorder traces.

A socket on the side of the apparatus links to the Computer Control System (TE3300/06, available separately).

Experiments:

- Proportional, integral and derivative control
- Setting up and demonstrating automatic control
- The principles of loop control and the calibration and tuning of controllers, transmitters, converters and valves
- Calibration of an orifice flow meter with a differential pressure transmitter
- Quadratic flow laws and square root extraction
- Cascade control of pressure and flow, and level and flow (when used with the TE3300/02 and TE3300/04)
- Distributed control (when used with the TE3300/06 Computer Control System)

Essential Ancillary:

- Service Module (SM3300) **or**
- Stable supply of 0.5 litres/s of clean, dry, oil-free air at 2–10 bar

Recommended Ancillaries:

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Pressure Process Training System (TE3300/02)	60
Level Process Training System (TE3300/04)	62
Computer Control System (TE3300/06)	64

Ancillary for:

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Pressure Process Training System (TE3300/02)	60
Level Process Training System (TE3300/04)	62

Alternative Products:

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Process Trainer (CE117)	59
Control and Instrumentation Study Station (TE37)	65

Level Process Training System (TE3300/04)

For a wide range of practical experiments in level control

- Shows automatic control of level using proportional, proportional plus integral, and proportional, integral plus derivative (PID) control
- Uses industry-standard parts to make it ideal for industrial, vocational and academic training
- Shows operation, calibration and tuning of controllers, transmitters, converters and valves
- Connects to the Flow Process Training System (TE3300/03) for cascade control
- Connects to the Computer Control System (TE3300/06) for distributed control

The Level Process Training System is a compact and mobile unit for a wide range of experiments in flow control. It gives students a greater understanding of the stability of simple control systems.

The self-contained unit can do many experiments, but it can also connect to other products in the TE3300 range for extra experiments. For cascade control of flow and level, it can link to the optional Flow Process Training System (TE3300/03). For distributed control, it can connect to the optional Computer Control System (TE3300/06).

The main parts of the Level Process Training system are:

- Industrial controller with auto-tune feature
- Two-channel chart recorder
- Current-to-pressure converter
- Differential pressure transmitter
- Transparent vessel
- Pneumatic control valve
- Three-speed pump
- Reservoir

To perform experiments, students fill the reservoir with clean water and prime the system. They then set the controller to regulate the flow of water using a pneumatic valve. This alters the water level in the transparent vessel. The differential pressure transmitter connected to the vessel gives feedback to the controller.

For a realistic experience, the equipment has industry-standard instrumentation and parts.

The apparatus includes two gate valves. One valve controls the flow at the output (drain) and the other acts as a flow-bypass valve. A chart recorder shows and logs the changes of the process variable (level) and the controller output.

Note: The chart recorder is paperless, so you need a suitable computer and colour printer if you need to print out hard copies of the chart recorder traces.

A socket on the side of the apparatus links to the Computer Control System (TE3300/06, available separately).

Experiments:

- Proportional, integral and derivative control
- Setting up and demonstrating automatic control
- The principles of loop control and the calibration and tuning of controllers, transmitters, converters and valves
- Wet and dry leg operation of a differential pressure transmitter
- Operation of a level-control system
- Cascade control of level and flow (when used with the TE3300/03 Flow Process Training System)
- Distributed control (when used with the TE3300/06 Computer Control System)

Essential Ancillary:

- Service Module (SM3300) **or**
- A stable supply of 0.5 litres/s of clean, dry oil-free air at 2–10 bar

Recommended Ancillaries:

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Flow Process Training System (TE3300/03)	61
Computer Control System (TE3300/06)	64

Ancillary for:

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Flow Process Training System (TE3300/03)	61

Alternative Products:

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Coupled Tanks Apparatus (CE105/CE105MV)	47
Process Trainer (CE117)	59
Control and Instrumentation Study Station (TE37)	65

Temperature Process Training System (TE3300/05)

For a wide range of practical experiments in temperature control

- Shows automatic control of temperature using proportional, proportional plus integral, and proportional, integral plus derivative (PID) control
- Uses industry-standard parts to make it ideal for industrial, vocational and academic training
- Shows operation, calibration and tuning of temperature transmitters and thermocouples
- Includes delay coil to mimic realistic time lag due to a process
- Connects to the Computer Control System (TE3300/06) for distributed control

The Temperature Process Training System is a compact and mobile unit for a wide range of experiments in temperature control. It gives students a greater understanding of the stability of simple control systems.

The self-contained unit can do many experiments, but it can also connect to the optional Computer Control System (TE3300/06) for distributed control.

The main parts of the Temperature Process Training System are:

- Industrial controller with auto-tune feature
- Two-channel chart recorder
- Heat-exchanger and fan
- Temperature transmitter
- Thermocouples
- Delay coil
- In-line heater
- Three-speed pump
- Reservoir

To perform experiments, students fill the reservoir with clean water and prime the system. They then set the controller to regulate the power to the in-line heater and control the temperature of the water at any of three places. The heat exchanger removes the heat from the water to give quicker experiments. The thermocouples (selected by a three-way switch) give feedback to the controller.

For a realistic experience, the equipment has industry-standard instrumentation and parts.

The apparatus includes one gate valve that works as a flow-bypass. A chart recorder shows and logs the changes of the process variable (temperature) and the controller output.

Note: The chart recorder is paperless, so you need a suitable computer and colour printer if you need to print out hard copies of the chart recorder traces.

A socket on the side of the apparatus links to the Computer Control System (TE3300/06, available separately).

Experiments:

- Proportional, integral and derivative control
- Setting up and demonstrating automatic control
- The principles of loop control and the calibration and tuning of temperature transmitters and thermocouples
- Operation of a temperature control system
- Distributed control (when used with the TE3300/06 Computer Control System)

Recommended Ancillaries:

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Computer Control System (TE3300/06)	64
Thermocouple calibrator (not supplied by TecQuipment)	
One-litre container with accurate scale and accurate weighing machine to measure water flow rate (not supplied by TecQuipment)	

Alternative Products:

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Thermal Control Process Apparatus (CE103)	46
Process Trainer (CE117)	59
Control and Instrumentation Study Station (TE37)	65

Computer Control System (TE3300/06)

Connects to the TE3300 Process Control modules for remote control and monitoring of processes (distributed control)

- Industry-standard software
- Colourful, easy-to-use on-screen mimics of the processes
- Includes high-specification computer, large monitor, keyboard and mouse
- Controls, monitors and logs all important process controller parameters
- Real-time displays of variables
- Live monitoring of process trends and alarms
- Ready-made applications – includes applications for use with TecQuipment's products

The Computer Control System (TE3300/06) is a computer control package for use with modules from TecQuipment's TE3300 Process Control range. It allows remote control and data acquisition from the controller of each process. This system will also control and collect data from the controllers of TE3300 modules when connected in cascade.

When used with the TE3300 Process Control range, computer control increases the student's experience of industry-standard process control.

The package includes a high-specification computer, with large screen monitor, keyboard and mouse. The package includes connections and cables for connection to the TE3300 modules. Supplied as standard on the computer is a suitable Microsoft® Windows® operating system.

The industry-standard control software includes applications specially written by TecQuipment for use with the TE3300 range. Just as in an industrial environment, the software applications mimic the variables measured by the controllers of each process control module. The user (operator) can easily see what happens at the remotely controlled process, as they adjust its performance.

The fully configurable software logs all data and any alarm conditions. The operator can also see the changing data in real time (as a trend) and log it for later examination. For ease of use, the software mimic (or graphical display window) and all data is in full colour.

Experiments:

When used with the TE3300 Process Control modules, computer control and monitoring of:

- Pressure process (TE3300/02)
- Flow process (TE3300/03)
- Level control process (TE3300/04)
- Temperature process (TE3300/05)
- Cascaded flow and pressure (TE3300/02 and TE3300/03)
- Cascaded flow and level (TE3300/03 and TE3300/04)

Ancillary for: Page

One or more modules from the TE3300 Process Control range:

Control and Instrumentation Study Station (TE37)

Uses industry-standard parts to show process control of pressure, flow, level and temperature

- Patch panel with leads for quick and simple connection between instruments, valves and controls
- Optional distributed computer control
- Gives academic and vocational study for process control engineers and plant technicians
- Includes hidden switches to create faults for fault-finding training
- Fully programmable controllers with local and remote set points, and fully programmable proportional, integral and derivative control

The Control and Instrumentation Study Station uses industry-standard parts to teach industrial process control. It is an excellent tool to help train plant technicians and process control engineers.

Hot and cold water supplies connect to the study station. Two valves (worked by compressed air) control the flow of the water supplies into a process vessel. The process vessel has three jobs:

- A pressure vessel with a pressure-relief valve for safety
- A temperature-mixing chamber for the hot and cold water flows
- A liquid-level reservoir with a sight gauge

Transmitters on the pipework and process vessel send flow, level temperature and pressure signals to a patch panel. Other sockets on the patch panel connect to the valves and other instruments. The students use leads (included) with the patch panel to connect the instruments and valves for any particular experiment.

The two flow transmitters are differential pressure transmitters, connected across orifice meters. The hot flow transmitter normally connects to an orifice meter in the hot water inlet. A set of hand-operated two-way valves also allow it to connect to a third orifice meter in the drain pipe from the process vessel.

The study station includes two fully configurable controllers, each with remote or local set point inputs. The controllers are industry-standard, with a choice of different control methods, and fully adjustable proportional, integral and derivative (PID) circuits. Sockets on the patch panel connect to an electronic multi-channel recorder to log changes in process variables.

Note: The chart recorder is paperless, so you need a suitable computer and colour printer if you need to print out hard copies of the chart recorder traces.

For fault-finding practice, there is a set of hidden switches on the side of the study station. These switches break the electrical circuits from the transmitters, instruments and control valves.

Experiments:

- Setting up process transmitters
- Level, pressure, flow and temperature control
- Cascade control
- Coupled and decoupled interactive control
- Ratio control
- Feedforward control
- Feedforward-feedback control
- Split range control
- Fault-finding

Essential Ancillary:

- Service Module (SM37) – This module connects to a suitable cold-water supply and outputs hot and cold water at the correct flow and pressure for the Study Station. It includes an air compressor and storage vessel to supply compressed air to the Study Station valves.

Recommended Ancillary: Page

- Distributed Control System (TE37DCS) 66

Alternative Products: Page

- Thermal Control Process Apparatus (CE103) 46
- Coupled Tanks Apparatus (CE105/CE105MV) 47
- Process Trainer (CE117) 59
- Pressure Process Training System (TE3300/02) 60
- Flow Process Training System (TE3300/03) 61
- Level Process Training System (TE3300/04) 62
- Temperature Process Training System (TE3300/05) 63

Distributed Control System (TE37DCS)

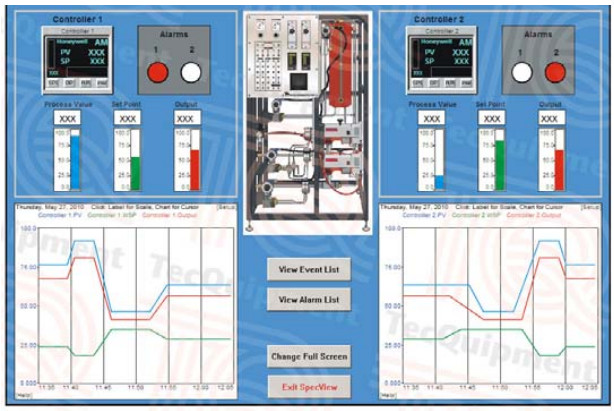
Connects to the TE37 Control and Instrumentation Study Station for remote control and monitoring of processes

- Industry-standard supervisory control and data acquisition (SCADA) software, with colourful, easy-to-use on-screen mimics of the processes
- Improves students' understanding of industrial process control
- Mimics and controls both controllers of the TE37
- Includes high-specification computer, large monitor, keyboard and mouse
- Controls, monitors and logs all important process controller parameters
- Real-time displays of process trends and alarms
- Fully user-editable to allow students to change the way the mimic works

A computer-control package for use with TecQuipment's Control and Instrumentation Study Station (TE37), this product allows remote control and data acquisition. This package remotely controls and collects data from both controllers.

When used with TecQuipment's study station (TE37), computer control improves the student's experience of industry-standard process control.

The package includes a high-specification computer, with large-screen monitor, keyboard and mouse. The computer includes connections for direct communication with the controllers on the study station. A suitable Microsoft® Windows® operating system is already installed on the computer as supplied.



The industry-standard control software includes a graphical display configuration specially made by TecQuipment for use with the TE37 study station. Just as in an industrial environment, the software configuration mimics the real process. The user (operator) can easily see what happens at the remotely controlled process as they adjust its performance at the computer.

The software logs all events and any controller alarm conditions. The data is shown in real-time (as a trend) or logged for later examination. The software mimic (operator interface) and all data is in full colour for ease of use.

The easy-to-use software is fully editable, so the students may change the mimic or how the software works. They may even create their own configurations.

Experiments:

When used with the Control and Instrumentation Study Station (TE37), the remote control and monitoring of control processes including:

- Level
- Pressure
- Temperature
- Cascade control
- Coupled interactive control
- Decoupled interactive control
- Ratio control
- Feedforward control
- Feedforward-feedback control
- Split range control

Ancillary for: Page

- Control and Instrumentation Study Station (TE37) 65

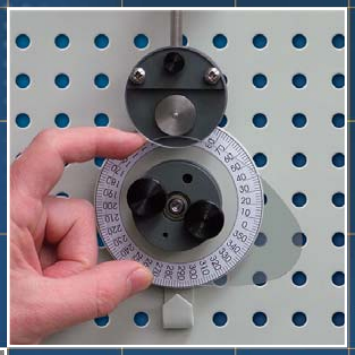
Product development

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

Engineering Science



“ I am very pleased to find the highly innovative and professional approach of TecQuipment Ltd in designing and manufacturing a variety of equipment for engineering and technical education at all levels. Such equipment is very useful to develop conceptual skills in students. ”

Dr Ing V P Singh, Principal, Shri Vaishanv Institute of Technology and Science, Indore, India

Engineering Science

The Engineering Science (ES) range of products is a system of experiment kits that covers many of the underlying mechanical engineering topics that students need to be familiar with, including:

- **Materials testing**
- **Vibration**
- **Mechanisms**
- **Forces and moments**
- **Simple machines**
- **Friction**

The system is suitable for use on courses from foundation level up to hands-on technology familiarisation programmes at post-graduate level.

The kits are high quality, robust, very visual and meant for hands-on learning. They can be used to make the vital link between theory and real systems and practical applications.

This is a modular system based around a robust, re-usable work panel onto which students set up and perform their experiments. This means you can order as much or as little as you like, and a comprehensive system can be built up over a period of time.

Key features of the ES range:

- Each kit can perform a number of different experiments making them great value.
- **The kits are housed in tough trays with a purpose-made moulded insert and a lid to keep everything safe and tidy.**
- The kits and the work panels can be easily stored, making best use of valuable laboratory space.
- **Full worksheets, background notes and lecturer resources are included. The worksheets and notes can be freely printed and distributed to students, saving time and money.**
- The kits are safe and simple to set up and use which, together with the pre-prepared worksheets, allows students to work alone or with minimal supervision, making the kits ideal for open-learning labs.
- **Everything required to do the experiments, other than the work panel, is included in the kit. All the students need is a basic maths set, calculator and the printed worksheets.**

The Engineering Science Work Panel (ES1)

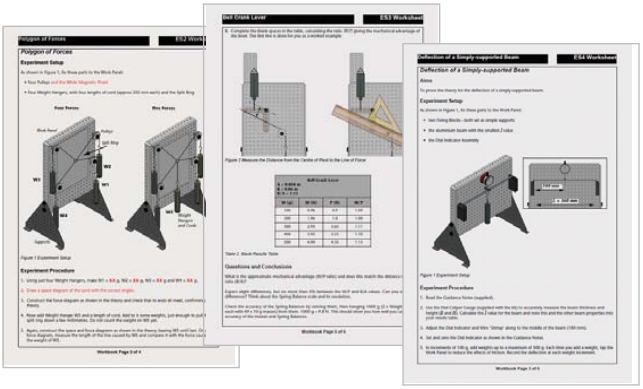
The work panel includes a CD containing all the worksheets, notes and lecturer material for all 18 kits in PDF format.

The work panel has been designed to be rugged, compact and easy to set up and use. It can be set up in a number of different ways to suit a particular experiment.

Sturdy legs can be moved to orientate the work panel to portrait, landscape, flat or angled

Heavy-duty steel panel

Tough paint finish



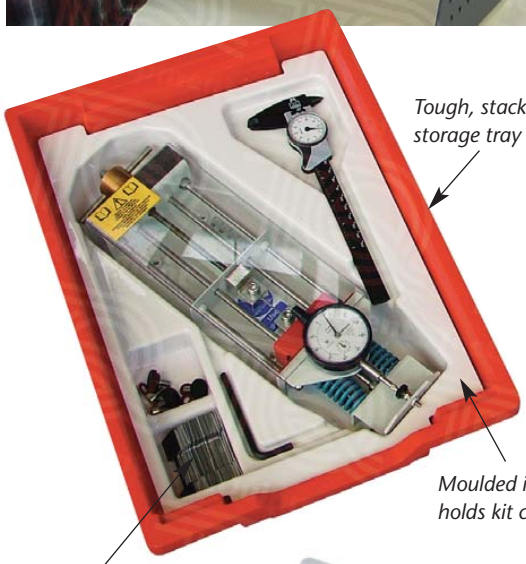
Teaching material for all the experiments in the range is on a CD-ROM

The Experiment Kits (ES2–ES19)

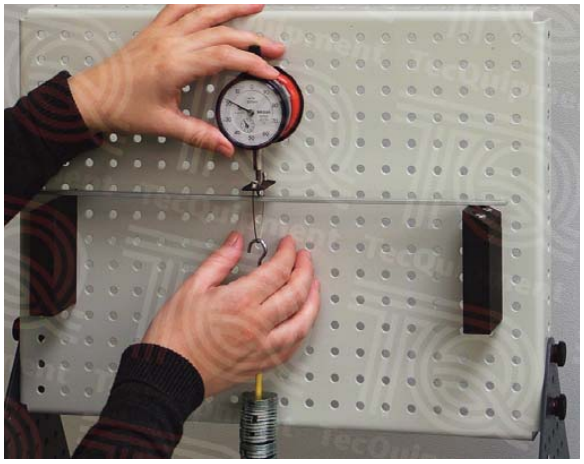
The experiment kits are all housed in a tough tray with a moulded insert and lid to keep the contents safe and tidy. A laminated graphical parts list provides a quick and easy means to check the contents and allows the contents to be audited.

From the 18 kits over 60 experiments can be performed, details of which can be found in our datasheets.

Bar Linkages Kit (ES15)



Code	Experiment Kit
ES2	Forces Kit
ES3	Moments Kit
ES4	Deflection of Beams Kit
ES5	Torsion of Circular Sections Kit
ES6	Tensile Tester Kit
ES7	Simple Harmonic Motion Kit
ES8	Friction and Inclined Plane Kit
ES9	Potential and Kinetic Energy Kit
ES10	Pulley Kit
ES11	Drive Systems Kit
ES12	Cam, Crank and Toggle Kit
ES13	Gear Trains Kit
ES14	Simple Mechanisms Kit
ES15	Bar Linkages Kit
ES16	Centrifugal Force Kit
ES17	Rotational Friction Kit
ES18	Additional Mechanisms Kit
ES19	Spring Tester Kit



Deflection of Beams Kit (ES4)

Cam, Crank and Toggle Kit (ES12)

Storage Options

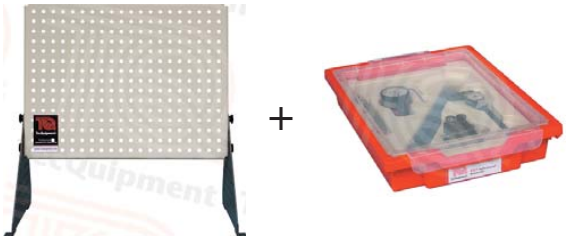
Each kit comes in a stackable tray, a simple solution when there is a small number of kits in a fixed location.

However, TecQuipment offers a purpose-built wheeled storage unit (EST) which will house all of the kits with room for duplication and expansion. This allows the kits to be easily stored beneath a worktop or counter in the lab, or moved in and out of the lab to a separate storage area if desired.

Engineering Science Storage Unit (EST)

Ordering

For new users the minimum requirement is one work panel (ES1) and one experiment kit.



Dependent on the range of experiments you require, and your budget, additional kits and work panels can be ordered at any time and added to your lab.

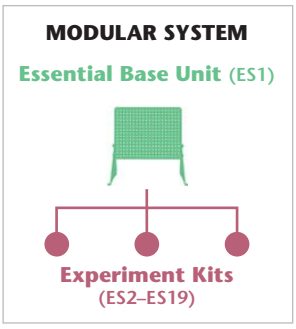
Engineering Science Full Set (ESF)

A complete class set of kits in the storage unit is available consisting of:

- All 18 experiment kits (ES2–ES19)
- Three work panels (ES1)
- A common spare parts kit (ESX)
- Five additional empty storage trays and lids

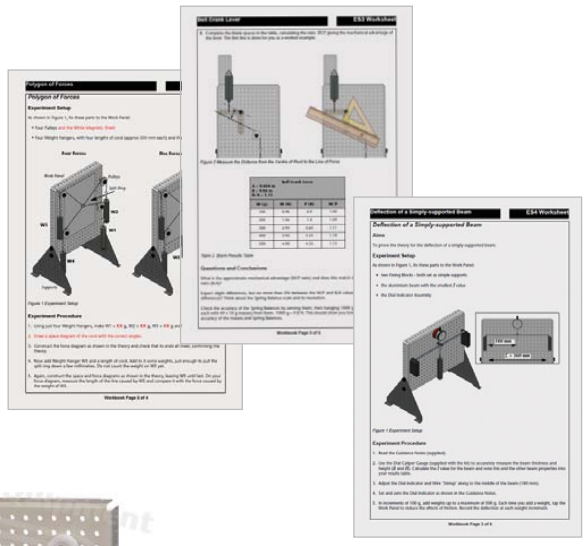
Work Panel (ES1)

Multiposition work panel for use with TecQuipment's Engineering Science kits



- Perfect size for both experiments and simple classroom demonstrations
- Supplied with CD-ROM of all teaching material needed for the full Engineering Science range
- Stable and multipositional – can be used in many different ways to suit the experiments or demonstrations
- Solid, thick perforated metal plate for long life and choice of fixing positions for the experiments
- Simple thumbscrews for safe, quick and easy assembly

Teaching material for all the experiments in the range is on a CD-ROM



For use with TecQuipment's Engineering Science kits, the work panel fits on any standard desk or bench top. Students, teachers or lecturers fit the parts of their kit to the Work Panel (ES1) to study or demonstrate an engineering science topic.

The work panel has its main panel and two supports. All are made from thick perforated metal to allow students, teachers or lecturers to fit the parts of the kits and the work panel in any position suitable for the experiments.

TecQuipment supplies a CD-ROM with the work panel. This valuable resource includes reproducible worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Typical experiment kit shown fitted to the work panel

Continued on next page

Available Experiment Kits:	Page

Sturdy legs can be moved to orientate the work panel to portrait, landscape, flat or angled

Forces Kit (ES2)

Shows how to find the centre of gravity of shapes and the relationship between angles and coplanar forces

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments with centres of gravity and angles and coplanar forces

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a set of different plastic shapes for experiments in centres of gravity of two-dimensional objects. It also includes pulleys, weights and a magnetic protractor for experiments in concurrent and non-concurrent coplanar forces and angles.

The selection of pulleys and weights allows you to create force triangles, polygons and linked polygons. The guidance notes show how to analyse and predict forces using Bow's Notation and the parallelogram of forces.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

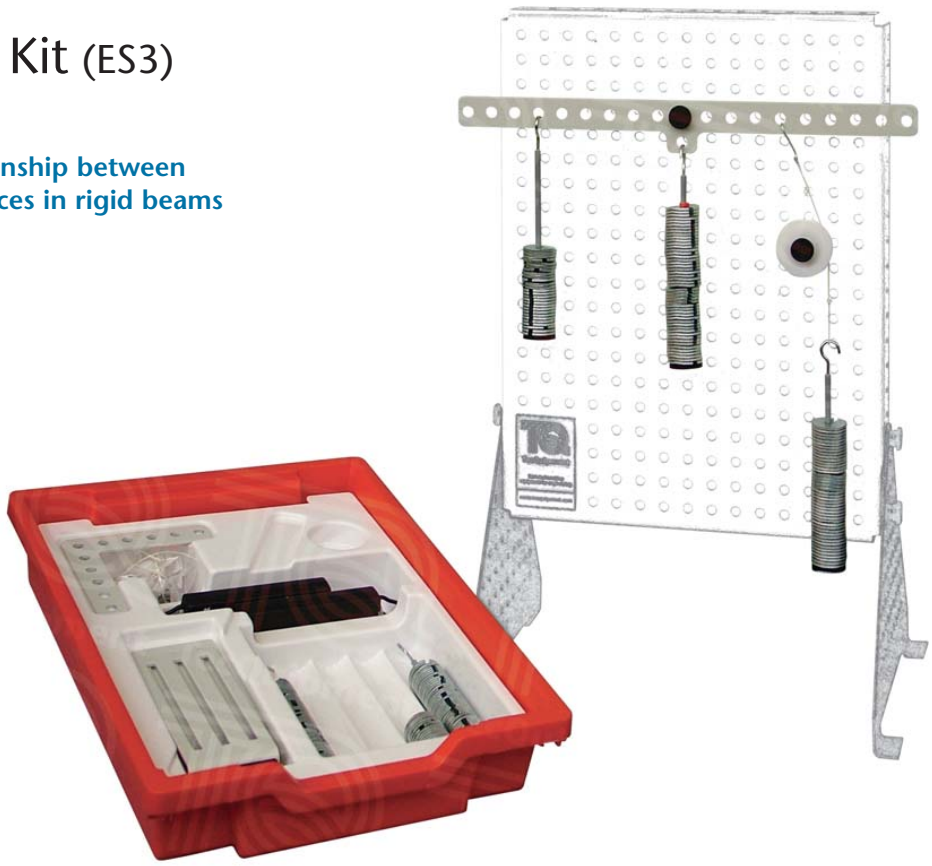
- Centres of gravity
- Force triangles
- Force polygons and Bow's Notation
- Linked polygons (non-concurrent forces)

Essential Base Unit:	Page
• Work Panel (ES1)	71

Alternative Product:	Page
• Equilibrium of Forces (STF4)	199

Moments Kit (ES3)

Shows the relationship between distances and forces in rigid beams and levers



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments showing the principle of moments, beam reactions, beam balances and levers

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a rigid beam for experiments in the principle of moments, extending to levers and beams. It shows the three main lever types (1st, 2nd and 3rd order) and includes an 'L' shape plate for experiments in bell crank levers. A pulley allows extra experiments with moments caused by oblique forces.

The rigid beam allows experiments that show the use of moments to find unknown weights, creating simple beam balances. It also works with spring balances to show reaction forces on beams with point loads and uniformly distributed loads (UDLs).

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

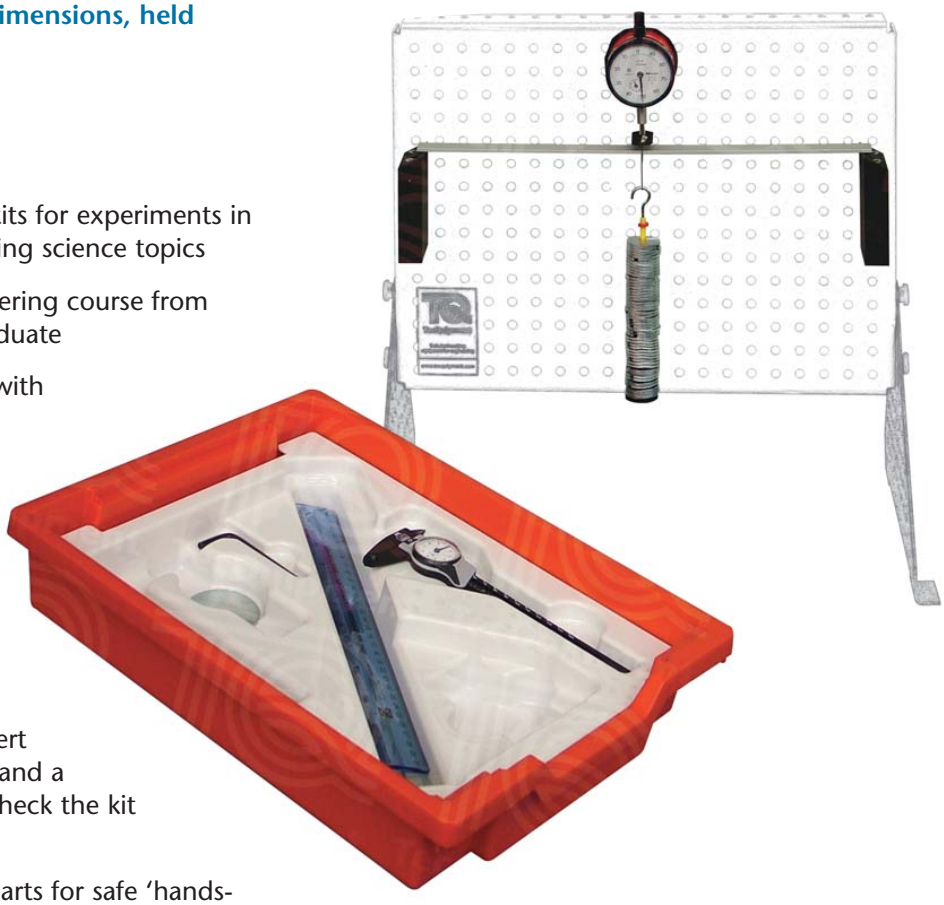
- Principle of moments
- Beam balances
- 1st, 2nd and 3rd order levers
- Bell crank lever
- Beam reactions

Essential Base Unit:	Page
Work Panel (ES1)	71

Alternative Product:	Page
Equilibrium of a Beam (STF5)	200

Deflection of Beams and Cantilevers Kit (ES4)

Shows the deflection of beams of different material and dimensions, held on different supports



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments showing the deflection of beams with different supports, including cantilevers

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes different beams and fixing blocks. The fixing blocks work as clamps or knife-edge supports. They hold the beams in different ways, such as a cantilever, simply supported, fixed (encastre) and a propped cantilever.

Students set up a beam on the supports and add weights to deflect the beams. An accurate dial indicator measures the deflection at the point of loading.

The choice of different beams allow extra experiments, showing the relationships between beam deflection and 'I' (second moment of area) value. They also allow comparisons of different beam material and how it affects deflection, introducing Young's Modulus.

Students also use the cantilever for easy experiments showing the relationship between beam length and deflection.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

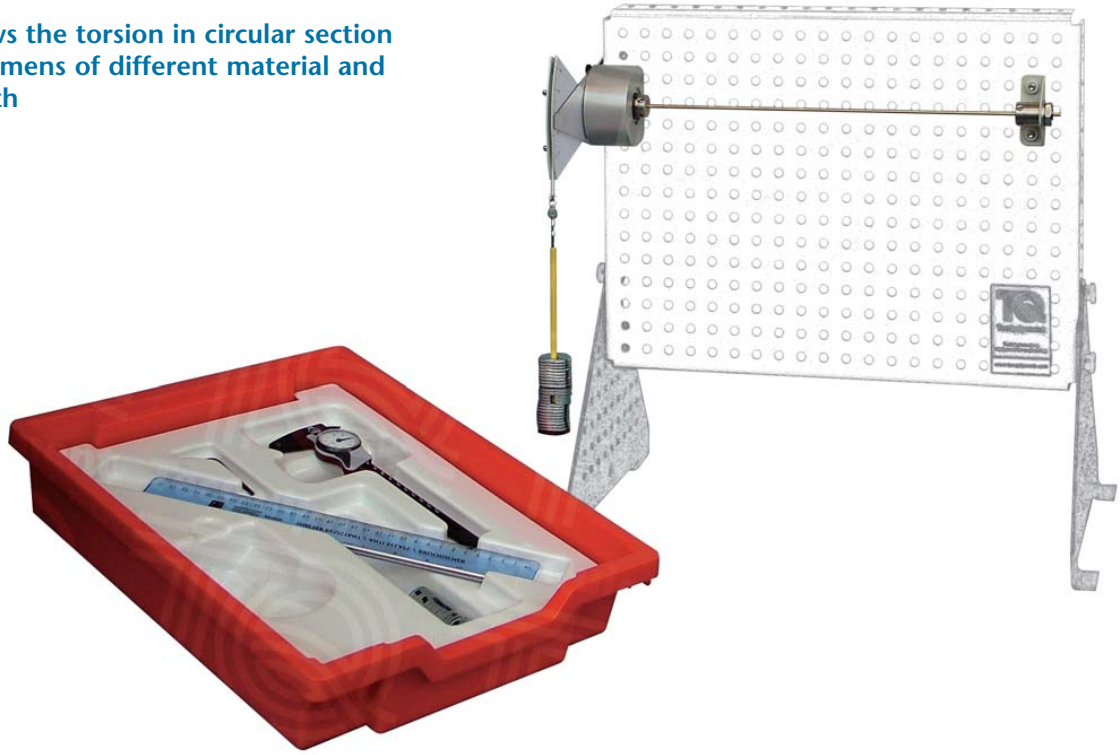
- Beam length and deflection
- Beam material and deflection (Young's Modulus)
- Beam 'I' value and deflection
- Beam supports (cantilever, propped cantilever, fixed beam and simply supported) and deflection

Essential Base Unit:	Page
• Work Panel (ES1)	71

Alternative Products:	Page
• Stiffness of Materials and Structures (TE16)	160
• Beam and Leaf Spring (SM1000g)	176
• Beam Apparatus (SM1004)	182
• Deflection of Beams and Cantilevers (STR4)	209
• Continuous and Indeterminate Beams (STR13)	218

Torsion of Circular Sections Kit (ES5)

Shows the torsion in circular section specimens of different material and length



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments showing the torsion in circular section specimens of different material and length

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes different circular section specimens and adjustable chucks for experiments in torsion.

Students fix the specimens in the chucks and apply weights to a lever arm. The arm applies a moment (torque) to one end of the specimen. A scale on the arm shows the angle of twist.

Standard tests show the relationship between torsion and 'J' (polar second moment of area) value. Students use this to predict the twist angle for any given specimen.

The choice of different specimens allows comparisons of different specimen material and how it affects torsion, introducing the Modulus of Rigidity.

Students also move the chuck positions for easy experiments showing the relationship between specimen length and angle of twist.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Specimen length and angle of twist
- Specimen material and angle of twist (Modulus of Rigidity)
- Specimen 'J' value and angle of twist

Essential Base Unit:

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• Work Panel (ES1)	71

Alternative Products:

	Page
• Torsion Testing Machine – 30 Nm (SM1001)	168
• Torsion of Circular Sections (STR6)	211
• Torsion Testing Components (TE16b)	160

Tensile Tester Kit (ES6)

Shows the principles of tensile tests on specimens of different material

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments in tensile testing of different materials

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes specimens of different materials to show students the principles of tensile tests.

Students use the tensile tester to stretch the specimens to destruction, while measuring the extension and force. The tests introduce students to tensile test terms including:

- Overall stress and strain
- Yield properties
- Tensile strength
- Elongation

The choice of different specimens allows comparisons of different specimen material and how it affects its tensile properties.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Tensile tests (to destruction) of different materials
- Finding the tensile strength of a material
- Material behaviour in the elastic and plastic region
- Creating a force and extension chart

Essential Base Unit:

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Work Panel (ES1)	71

Recommended Ancillary:

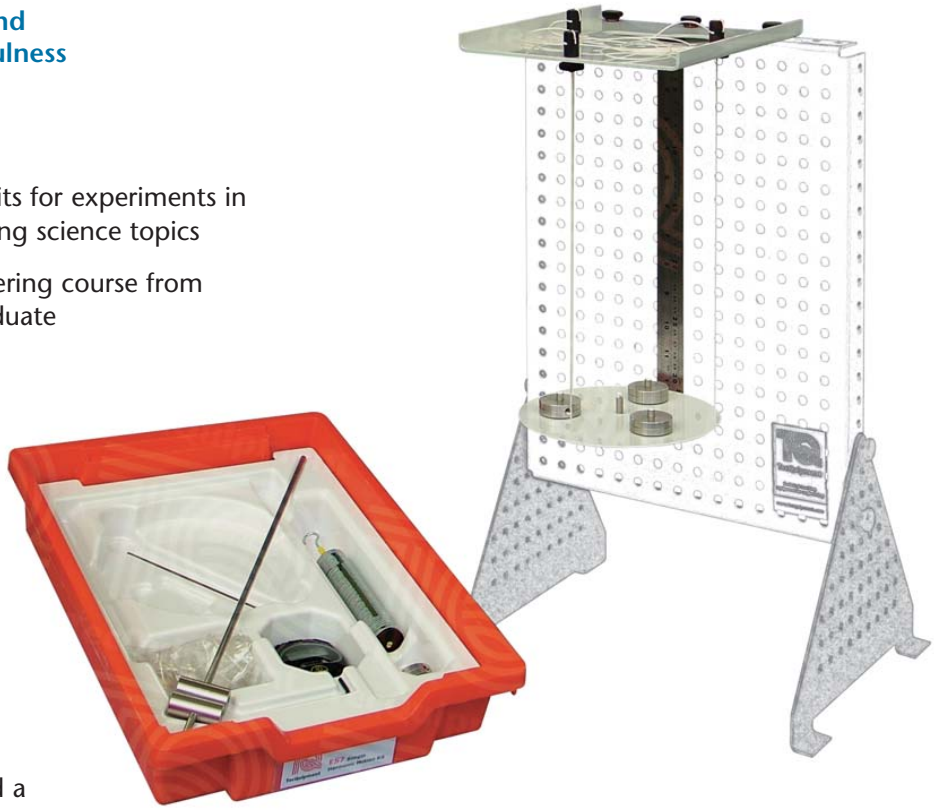
	Page
Tensile Test Specimens	94

Alternative Products:

	Page
Universal Testing Machine (SM1000)	173
Bench-top Tensile Testing Machine (SM1002)	171
Materials Laboratory with Data Capture (MF40)	177

Simple Harmonic Motion Kit (ES7)

Shows simple harmonic motion (oscillation) in springs and pendulums, and its usefulness



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments in simple harmonic motion

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes different pendulums and a spring to show students the principles and use of simple harmonic motion.

Students test different pendulums and a spring to see how different factors, such as mass or pendulum length, affect simple harmonic motion and the period of oscillation. The theory shows how to predict the period of oscillation for a given pendulum or spring for comparison with actual results. The kit includes an experiment with the Kater's pendulum that shows the relationship between simple harmonic motion and gravity, for prediction of gravity to a reasonable accuracy.

The kit also introduces students to a simple 'spring rate' test, and key scientific terms such as:

- Moments of inertia
- Parallel axis theorem

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Simple harmonic motion of simple, bifilar and trifilar pendulums of different length and mass
- Simple harmonic motion of a spring with different masses, and a simple spring rate test
- Simple harmonic motion of a compound pendulum
- Simple harmonic motion and gravity using a Kater's pendulum

Essential Base Unit:	Page
Work Panel (ES1)	71

Alternative Product:	Page
Pendulum Experiments (TM16b)	244

Friction and Inclined Plane Kit (ES8)

Shows the frictional and other forces on bodies and between different surfaces on a flat or inclined plane

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains an inclinable flat metal plate for experiments in frictional forces and the classic 'forces on an inclined plane' experiment

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes parts for experiments in friction and forces on a flat or inclined plane. The plane has an inclinometer and adjustment to allow the student to set the plane to any angle between zero and 90 degrees. The parts include different friction surfaces, a roller set, a rolling car or sled with adjustable mass, and a simple roller.

Students fit the different parts to the plane and apply masses. They learn how different surface finishes and mass affect friction and how surface angles and mass affect forces around a body on a plane.

The experiments introduce students to important engineering and scientific terms, such as the coefficient of friction, sliding friction and kinetic friction.

The inclinable plane allows students to do the classic 'forces on an inclined plane' experiments. It also shows the relationship between frictional forces and angles other than horizontal.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

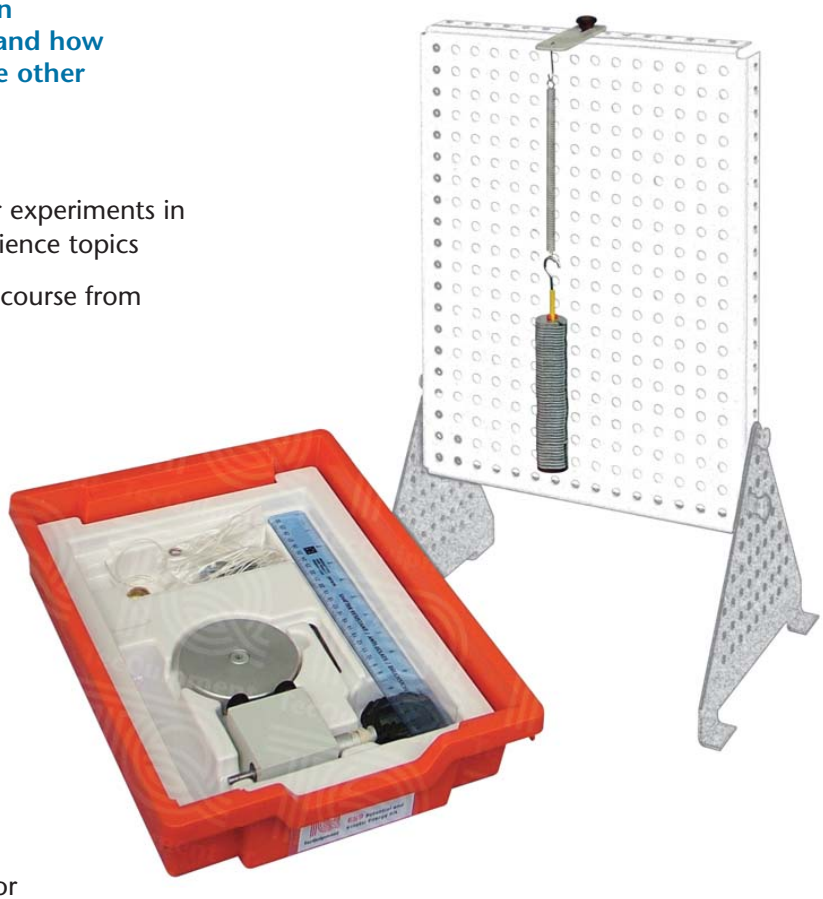
Experiments:

- Forces on an inclined plane
- Rolling and sliding friction on different surfaces
- Kinetic and static sliding friction between different surfaces
- Surface angle and friction between different surfaces

Essential Base Unit:	Page
• Work Panel (ES1)	71

Potential and Kinetic Energy Kit (ES9)

Shows the difference between potential and kinetic energy and how it can change from one to the other



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments in potential and kinetic energy

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a pendulum, a spring and a flywheel for experiments in potential and kinetic energy.

Students test each part to discover the difference between potential and kinetic energy and the transfer of energy from one form to another.

The kit introduces students to key engineering terms such as 'moment of inertia' and 'elastic potential energy'.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Kinetic and potential energy in a pendulum
- Elastic potential energy in a spring
- Kinetic energy in a flywheel

Essential Base Unit:	Page
Work Panel (ES1)	71

Pulley Kit (ES10)

Shows the mechanical advantage of different combinations of pulleys and a simple wheel and axle

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments in pulleys

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a wheel and axle with single, double and triple wheel or 'sheave' pulleys for experiments in mechanical advantage.

Students test fixed, movable and compound pulleys attached to load and effort weights to test their mechanical advantage.

The kit includes a unique pulley – the Weston Differential pulley – to show how two different sized sheaves on one pulley has a dramatic effect on mechanical advantage.

The kit introduces students to key engineering terms such as machine efficiency, velocity ratio and 'work done'.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

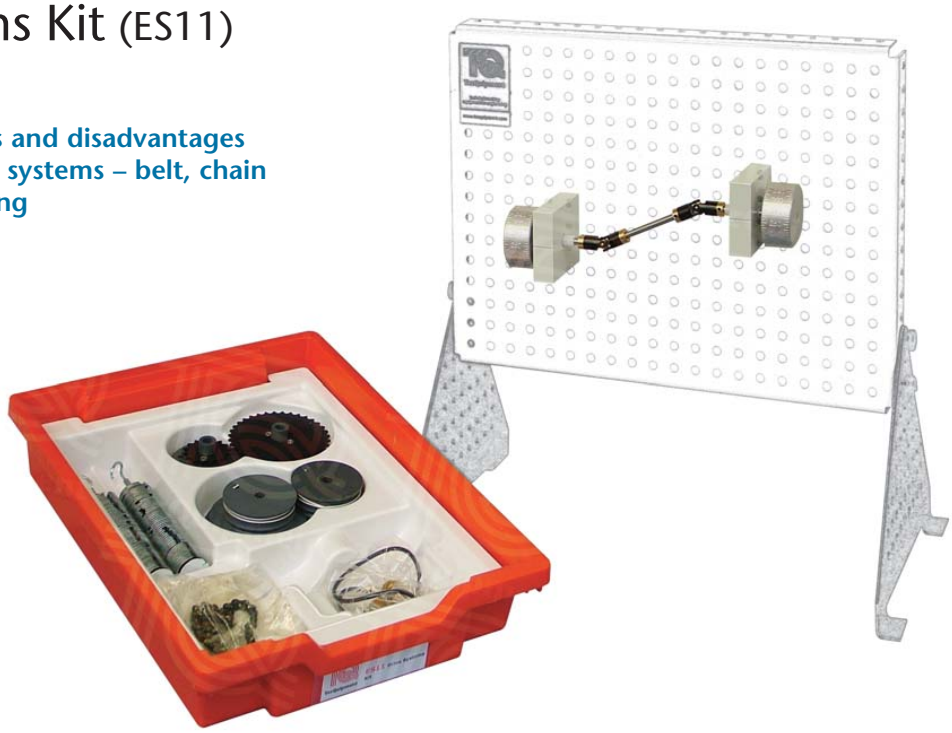
- Simple pulleys – fixed, movable and compound
- The wheel and axle
- The Weston differential pulley

Essential Base Unit: Page

- Work Panel (ES1) 71

Drive Systems Kit (ES11)

Shows the advantages and disadvantages of three popular drive systems – belt, chain and a universal coupling



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments with three popular drive systems

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes three different drive systems to show their relative advantages and disadvantages.

Students test a universal coupling, a belt drive and a chain drive to see how they work and how they differ in the way they transfer motion (power).

The kit includes extra parts to help show the importance of the angle of lap around a pulley and its relationship with friction.

The kit introduces students to key engineering terms such as gear ratio, pulley ratio and efficiency.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

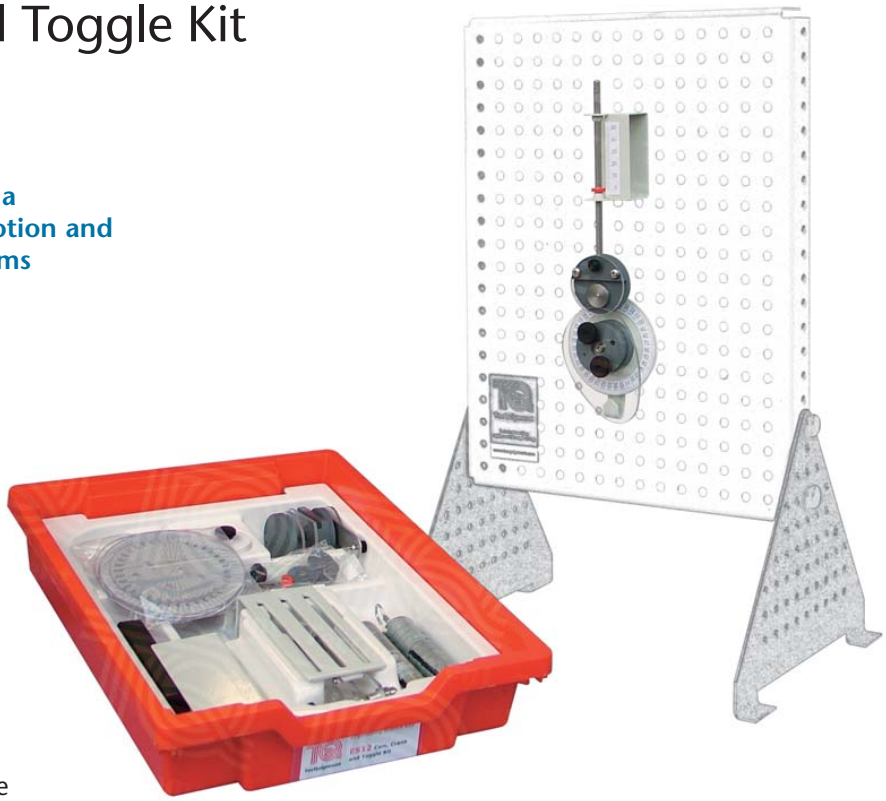
Experiments:

- Power transfer, efficiency and direction in a belt drive
- Power transfer and efficiency in a chain drive
- Input and output relationships of a universal coupling
- Friction and angle of lap on a pulley

Essential Base Unit:	Page
• Work Panel (ES1)	71

Cam, Crank and Toggle Kit
(ES12)

Shows the characteristics of a mechanical toggle, crank motion and the most popular shaped cams



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments with a mechanical toggle, crank motion and four popular shapes of cam

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a crank and slider to show the relative forces during crank motion. It also includes four popular cam shapes to show their different characteristics. Another set of parts in the kit shows the characteristics of a mechanical toggle.

Students fit the crank and slider with weights and a spring balance to see the change in linear and rotational forces (moments) as the crank turns. They also use the slider with different followers on a set of four popular shaped cams: heart, pear, spiral and round. This gives several cam and follower combinations to help students understand the different characteristics of each cam and why engineers choose between them for different applications.

The last set of parts in the kit has a simple linkage that allows students to see the characteristics of a toggle mechanism. It shows the relative forces and angular conditions of the toggle in its initial state and how they affect the point at which it locks or 'snaps' into a horizontal state.

The kit introduces students to key engineering terms such as a 'flat follower', a 'roller follower' and 'toggle action'.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Displacement and angle characteristics of pear, heart, round and spiral cams
- Characteristics of a mechanical toggle
- Turning moments and forces during crank motion

Essential Base Unit:	Page
• Work Panel (ES1)	71

Alternative Product:	Page
• Cam Analysis Machine (TM21)	237

Gear Trains Kit (ES13)

Shows the characteristics of the most popular gear sets

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains a selection of the most popular gears and arrangements to show the efficiencies, advantages and disadvantages of each type of gear

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a selection of different gears for experiments to find their unique characteristics.

The gears include spur gears, a bevel gear and a worm drive. The spur gears have two sets of teeth on the same shaft, allowing extra experiments in compound gear trains.

Students test each set of gears to see how it works and note the differences in characteristics (such as efficiency, gear ratio and mechanical advantage) of each set.

The gear sets are a selection of the most common sets, similar to those used in real applications such as automobile gear boxes, domestic and industrial hand tools and clockwork instruments. Each has advantages and disadvantages that make them suitable for a particular job.

The kit introduces students to key engineering terms such as gear ratio, efficiency, mechanical advantage and velocity ratio.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Characteristics of spur gears, including single and compound gear trains and the 'idler' gear
- Characteristics of a bevel gear
- Characteristics of a worm drive

Essential Base Unit:	Page
• Work Panel (ES1)	71

Alternative Product:	Page
• Geared Systems (TM18)	238

Simple Mechanisms Kit (ES14)

Shows how three popular mechanisms convert motion

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains three popular mechanisms that show how they can usefully convert motion from one form or direction to another

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes three popular mechanisms for experiments in conversion of motion from linear to rotary or rotary to linear. These include the Scotch yoke (sometimes called 'donkey crosshead' or 'slotted link'), the crank and slider, and the quick return mechanisms.

Students test each mechanism to see how it works and note the differences in the way that each mechanism converts the motion.

The three mechanisms are the same as those used in real applications, such as combustion engines, power-assisted valves or fluid pumping systems. Each has a unique way of converting motion, shown by the experiments.

The kit introduces students to key engineering terms such as reciprocating motion, rotary to linear motion and linear to rotary motion.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

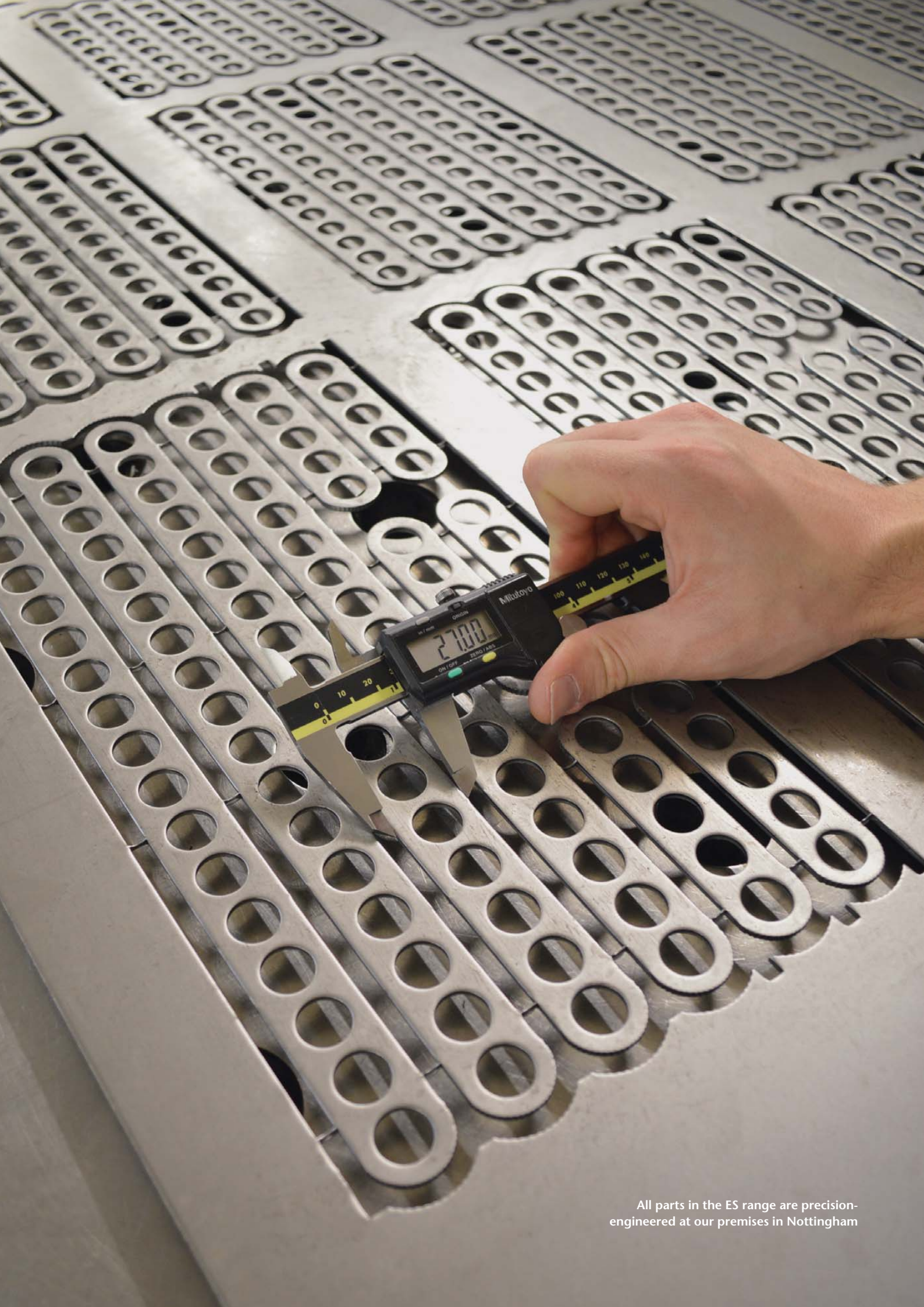
Note: the kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Conversion of motion using the 'Scotch yoke' (or 'slotted link')
- Conversion of motion using the quick return mechanism
- Conversion of motion using the crank and slider

Essential Base Unit:

	Page
• Work Panel (ES1)	71



All parts in the ES range are precision-engineered at our premises in Nottingham

Bar Linkages Kit (ES15)

For students to assemble and understand different bar linkage mechanisms

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains an assortment of different length bar 'links' and joints needed for over 10 suggested experiments in bar linkages

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a selection of over 20 perforated bars of different lengths and pivots or 'joints' to allow students to create an unlimited choice of linkages.

Students assemble the bars and joints in any arrangement and note how the linkage converts movement from one form to another (for example: rotary motion to linear motion). Bar linkages are one of the most basic mechanisms used in mechanical engineering.

The kit includes magnetic 'wipeable' sheets and holders for non-permanent markers so the student can trace the relative movements of the linkages or joints.

The kit introduces students to key engineering terms such as four-bar linkages, rotary and linear movement, and planar linkages.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

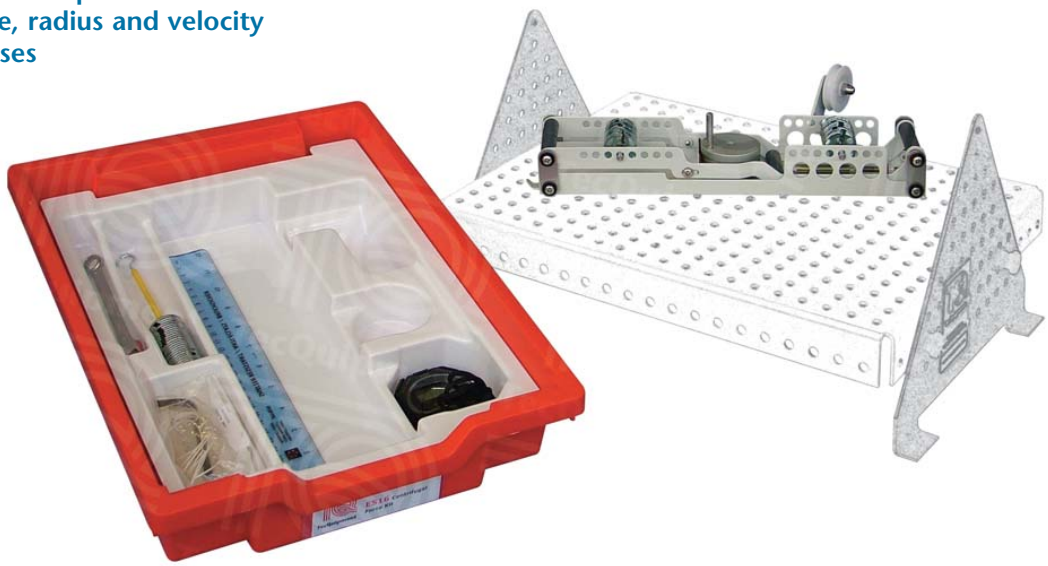
- Four-bar linkages – crank rocker, double rocker, draglink and parallelogram
- Straight line linkages – Watt's straight line, Chebyshev, Peaucellier-Lipkin, Hart's inversor, Robert's and Hoeken's
- Pantograph
- Ackermann steering

Essential Base Unit: Page

- Work Panel (ES1) 71

Centrifugal Force Kit (ES16)

Shows the relationship between centripetal force, radius and velocity of rotating masses



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains a manually-rotated frame that shows the relationship between centripetal force, radius and velocity of different rotating masses

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a manually rotated frame with a low-friction cantilever linkage. The frame has mounting positions for adjustable masses and a spring that applies a fixed frictional force value to a rotating drum. The range of mounting positions and masses allows many variations of the experiment to help students understand the relationships between the variables of speed, mass and radial position.

Students fit the chosen masses to one side of the frame and an equal counterbalance to the opposite side of the frame. They rotate the assembly which will overcome the spring frictional force at a given speed, working as a centrifugal clutch that regulates its own speed. The frame has a durable 'clicking' tab that students use with a stopwatch (supplied) to measure the speed. They use their measurements to calculate the forces due to the rotating masses and compare them with the opposing force from the spring.

The kit introduces students to key engineering terms such as centrifugal and centripetal force, while explaining the fictitious term 'centrifugal' force and its accepted use. It also shows the use of 'radians' in rotational velocity measurement.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

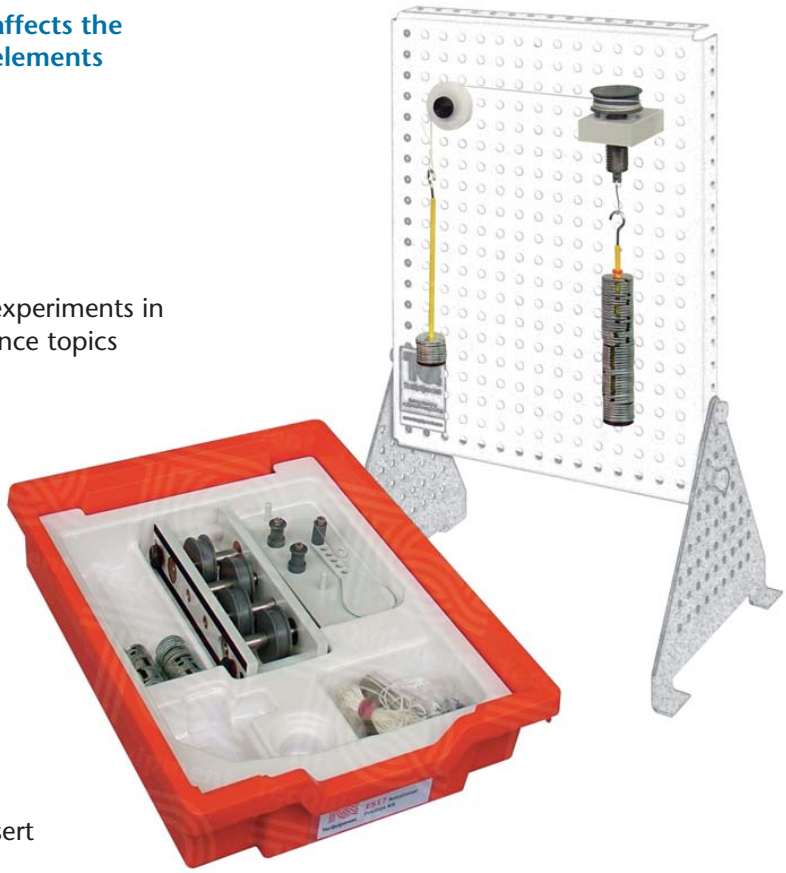
- Relationship between centripetal force, radius and velocity of different rotating masses.

Essential Base Unit:	Page
• Work Panel (ES1)	71

Alternative Product:	Page
• Centrifugal Force (TM1005)	242

Rotational Friction Kit (ES17)

Shows how rotational friction affects the efficiency of popular machine elements



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for experiments in rotational friction

This versatile kit is part of a series that allows many experiments using different arrangements of their parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or show an engineering science topic.

This kit includes a screw jack (or 'jackscrew'), a wedge and different bearings. It helps students understand how rotational friction affects the efficiency of popular machine elements and bearing materials. It shows why engineers choose some materials and devices above others for any given application.

Students fit the parts to the work panel and apply effort and load weights to find their relative mechanical advantage and efficiency.

The kit introduces students to key engineering terms such as:

- Mechanical advantage
- Velocity ratio
- Efficiency
- 'Overhaul'

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the Work Panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Efficiency of a screw jack
- Efficiency of a wedge
- Efficiency of different bearings

Essential Base Unit:	Page
• Work Panel (ES1)	71

Additional Mechanisms Kit (ES18)

Shows how two popular mechanisms convert motion

- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains two popular mechanisms that show how they can usefully convert motion from one form or direction to another

This kit offers additional mechanisms, supplementary to those of the Simple Mechanisms Kit (ES14). Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or demonstrate an engineering science topic.

This kit includes two popular mechanisms for experiments in conversion of motion from one form to another. These include the Geneva mechanism (sometimes called the Maltese Cross mechanism or crank and star), and a ratchet mechanism.

Students test each mechanism to see how it works and note the differences in the way that each mechanism converts the motion.

The two mechanisms are the same as those used in real applications, such CNC machines, hand tools, turnstiles and lifting hoists. Each has a unique way of converting motion, shown by the experiments.

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

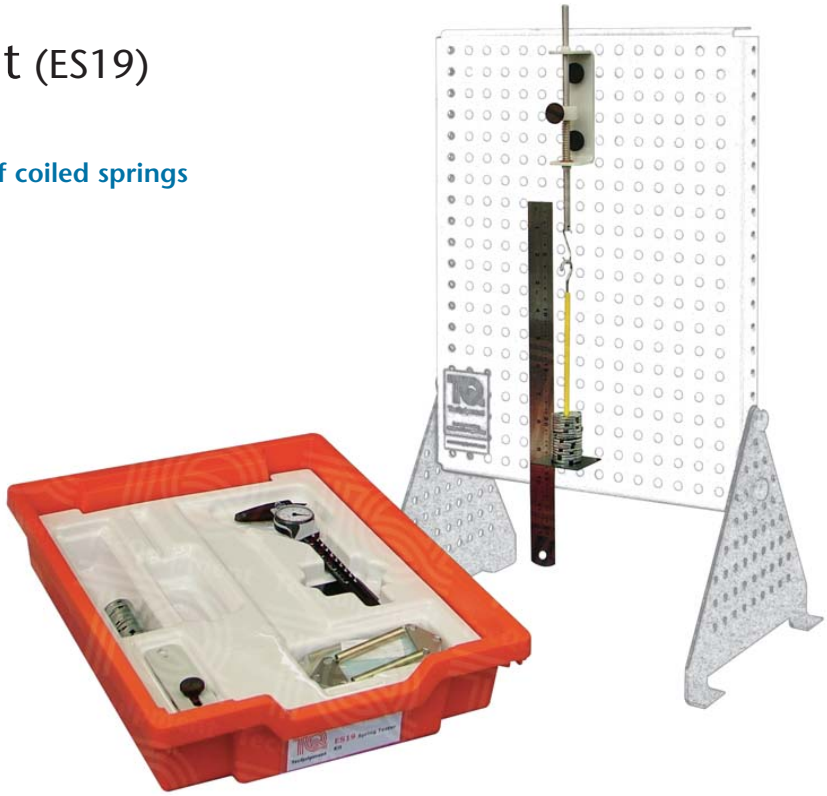
Experiments:

- Conversion of motion using the Geneva mechanism
- Conversion of motion using a ratchet

Essential Base Unit:	Page
• Work Panel (ES1)	71

Spring Tester Kit (ES19)

Shows the characteristics of coiled springs and how to test them



- One of a series of 18 kits for experiments in fundamental engineering science topics
- For use on any engineering course from foundation to postgraduate
- Flexible and modular with sensible size parts – each kit fits onto the Work Panel (ES1) for experiments and simple classroom demonstrations
- Supplied in a hard-wearing storage tray with moulded insert to hold parts securely and a graphical list to help check the kit contents
- Rugged and durable parts for safe 'hands-on' experiments – allowing better understanding
- Contains all parts needed for easy to do tests of coiled extension and compression springs, showing the use of 'Hookes law'

This versatile kit allows many experiments using different arrangements of its parts. Students, teachers or lecturers fit the parts of the kit to the Work Panel (ES1, supplied separately) to study or demonstrate an engineering science topic.

This kit includes different coiled springs for experiments in spring testing. These include extension springs, compression springs, parallel springs and springs that can connect in series.

Students test the springs to prove Hooke's Law and find their spring rate, comparing it with given manufacturers' values. They also test springs in parallel and series to see how this affects the overall spring rate.

The kit helps students to understand the link between spring rate, spring extension and the design and construction of springs. It introduces students to key engineering terms such as:

- Spring rate
- Hooke's Law
- Spring pretension

TecQuipment supplies a CD-ROM with the Work Panel (ES1). It includes all the worksheets, guidance notes and lecturer notes (with answers) needed for typical experiments with each kit. The selection of parts in the kits and the choice of fixing points on the work panel means that teachers or lecturers may extend the experiments to an even greater range.

Note: The kit is for use with the ES1 Work Panel (supplied separately).

Experiments:

- Hooke's Law and compression spring tests
- Hooke's Law and extension spring tests
- Parallel and series spring tests

Essential Base Unit:	Page
Work Panel (ES1)	71

Alternative Products:	Page
Spring Testing Apparatus (SM110)	159
Coil Spring (SM1000f)	175

Engineering Science Full Set (ESF)

A mobile trolley with a complete set of TecQuipment's Engineering Science kits and Work Panels

- A mobile and compact trolley holding a full set of TecQuipment's Engineering Science kits (ES2 to ES19) and three Work Panels (ES1) for over 60 experiments in fundamental engineering science topics
- All the parts needed in one mobile frame – one person can move a full set of kits from one room to another
- Includes a Spares Kit (ESX) to replace common parts that could become lost from experiments during use
- Spare empty trays to store additional material such as coursework, worksheets or guidance notes
- Strong, lockable wheels on the trolley allow easy movement but also hold the trolley stable when needed – making it an ideal demonstration table
- Flat top with fixing positions for storage of the work panels

A complete package in Engineering Science experiments. The full set (ESF) includes the Engineering Science mobile trolley (EST), a full set of TecQuipment's Engineering Science kits (ES2 to ES19), Work Panels (ES1) and a Spares Kit (ESX).

This full set allows at least three sets of students to work with any three of the Engineering Science experiments at the same time, while storing the other kits tidily and efficiently.

Alternatively, lecturers or teachers may set up one experiment as a demonstration on the mobile trolley while two groups of students do experiments at their desks.

TecQuipment supplies a Spares Kit (ESX) with the package to help replace the common smaller parts of the kits that may get lost over time. The trolley also includes some empty trays, useful for storing coursework, worksheets or guidance notes.

Experiment kits

- Forces Kit (ES2)
- Moments Kit (ES3)
- Deflection of Beams and Cantilevers Kit (ES4)
- Torsion of Circular Sections Kit (ES5)
- Tensile Tester Kit (ES6)
- Simple Harmonic Motion Kit (ES7)
- Friction and Inclined Plane Kit (ES8)
- Potential and Kinetic Energy Kit (ES9)
- Pulley Kit (ES10)
- Drive Systems Kit (ES11)
- Cam, Crank and Toggle Kit (ES12)
- Gear Trains Kit (ES13)
- Simple Mechanisms Kit (ES14)
- Bar Linkages Kit (ES15)
- Centrifugal Force Kit (ES16)
- Rotational Friction Kit (ES17)
- Additional Mechanisms Kit (ES18)
- Spring Tester Kit (ES19)

Support Equipment

Support equipment for use with TecQuipment's Engineering Science range

- Supporting products for TecQuipment's Engineering Science kits
- Maths Instrument Class Set (MCS) to help students produce accurate results and drawings from their experiments
- A set of five spare trays and lids (ETL) – useful for safely storing ancillaries or printed material such as lecturer guides or worksheets
- A compact mobile frame (EST) that stores up to 24 trays safely and tidily, while allowing one person to move all 24 trays from one room to another

Storage Unit (EST)

For use with the Engineering Science kits, TecQuipment offers these supporting products as a useful resource for lecturers or teachers.

Storage Unit (EST)

A mobile trolley for use with the Engineering Science kits. This trolley allows teachers or lecturers to safely and tidily store up to 24 trays in one mobile unit.

The trolley allows one person to push all the trays from one room to another. It has extra space on top with fixing points so it may also carry or hold Work Panels (ES1).

Its lockable wheels allow it to be both mobile and stable. It allows teachers or lecturers to fit work panels to the top and use the trolley as a mobile demonstration table.

Trays and Lids (ETL)

A set of five trays and lids. Identical to those used for the kits, so they fit and stack in the same way. These trays and lids are useful to safely store ancillaries, writing materials or A4 size printed material.

Maths Instrument Class Set (MCS)

30 sets of geometrical drawing instruments in one tray (the tray is identical to those used for the kits). This set includes rulers, pencils, set squares and safety compasses.

Spares and Consumables

Spares and consumables for use with TecQuipment's Engineering Science range

- Spares and consumable products for TecQuipment's Engineering Science kits
- Useful to replace any parts that become lost from the experiment kits during use, or to increase the variation of experiments
- Additional Tensile Test Specimens (MTT) for the Tensile Tester Kit (ES6)
- Additional Weight Sets (WT and WTL) and Stopwatch (SW1) – useful spares for both the Engineering Science range and other TecQuipment products
- A tray of spares (ESX) containing the most common parts of the Engineering Science kits

Spare Parts Kit (ESX)

TecQuipment offers these spares and consumables mainly for the Engineering Science range. However, the stopwatch and weight sets also work as spares for other TecQuipment product ranges.

Spare Parts Kit (ESX)

This kit includes spares of the most common parts used in the other Engineering Science kits, including fixings, weights, hooks and cord.

Lecturers or teachers may use the spares to replace lost parts or add additional parts to the existing experiments.

The kit reduces the need to order the small parts that may become misplaced during use. It also reduces the problems created by 'borrowing' items from one kit to replace those lost in another kit.

This kit also allows teachers to add more variation to some of the standard experiments suggested by TecQuipment.

Stopwatch (SW1)

An easy-to-use, accurate, hand-held digital stopwatch. Replaces any lost from the kits or allows more students to share experiments. This general-purpose stopwatch also works well with several other TecQuipment products.

Tensile Test Specimens (MTT)

Specimens made from a choice of four different materials for use with the Engineering Science Tensile Tester (ES6).

MTTA – Aluminium

MTTD – Duralumin

MTTP – PVC

MTTS – Mild Steel

Note: TecQuipment supplies all specimens individually, but a minimum order charge applies.

Weight Sets (WT and WTL)

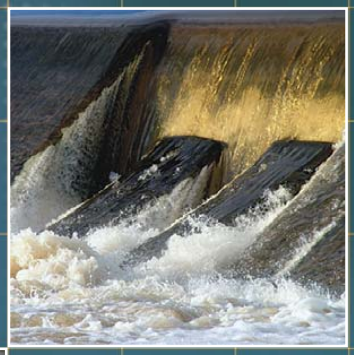
Slotted masses that fit onto TecQuipment's weight hangers. They will work as general-purpose weights and spares for those in several other TecQuipment products, such as the Structures range.

Useful to replace any that become lost from the Engineering Science kits or to extend the experiments suggested in the worksheets.

WT – A set of 10 g masses and weight hangers

WTL – A set of 1 g masses

Fluid Mechanics



“ 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			
H1D	**H1**	**Product**	
●		**Set of Weirs** (H1D/a and b)	Pages 99–100
●	●	**Flow Through an Orifice** (H4)	Page 114
●	●	**Venturi Meter** (H5)	Page 102
	●	**Discharge over a Notch** (H6)	Page 103
●	●	**Friction Loss in a Pipe** (H7)	Page 109
●	●	**Impact of a Jet** (H8)	Page 115
●	●	**Flow Measurement** (H10)	Page 104
●	●	**Vortex Apparatus** (H13)	Page 116
●	●	**Losses in Piping Systems** (H16)	Page 110
●		**Francis Turbine** (H18)	Page 132
●	●	**Pelton Turbine** (H19)	Page 133
●		**2.5-Metre Flow Channel** (H23)	Page 123
●		**Hydraulic Ram Pump** (H31)	Page 134
●	●	**Series and Parallel Pump** (H32)	Page 135
●	●	**Jet Trajectory and Orifice Flow** (H33)	Page 117
●	●	**Pipework Energy Losses** (H34)	Page 111
●	●	**Flow Meter Calibration** (H40)	Page 106
●		**Pipe Surge and Water Hammer** (H405)	Page 120
	●	**Fluid Friction Apparatus** (H408)	Page 112

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 141–156) to demonstrate real-world applications of fluid mechanics. They include pumps and turbines, which also provide a link to renewable energy.

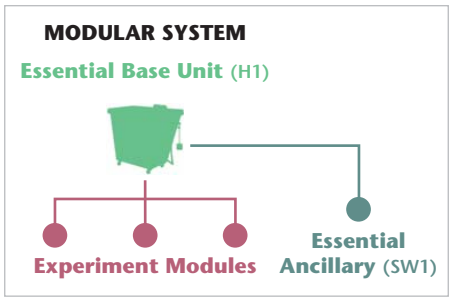
Automatic Data Acquisition VDAS®

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

See **Section 1** on for more details.

Gravimetric Hydraulic Bench (H1)

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



- Self-contained and fully mobile unit
- Made of plastics and corrosion-resistant parts
- Has flat bench top for experiments
- Includes accurate, fundamental gravimetric (weighing) flow measurement system
- Has recirculating water supply to save mains water
- Separate sump tank outlet facility

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

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 (SW1, available separately). 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.

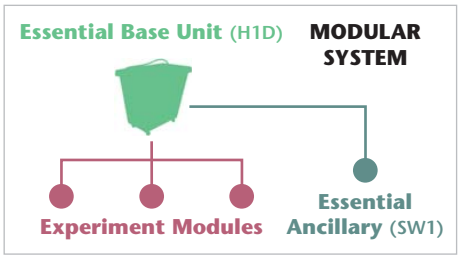
The power supply in the Gravimetric Hydraulic Bench includes overload and under-voltage protection.

Available Experiment Modules:	Page
• Flow Through an Orifice (H4)	114
• Venturi Meter (H5)	102
• Discharge Over a Notch (H6)	103
• Friction Loss in a Pipe (H7)	109
• Impact of a Jet (H8)	115
• Flow Measurement (H10)	104
• Vortex Apparatus (H13)	116
• Losses in Piping Systems (H16)	110
• Pelton Turbine (H19)	133
• Series and Parallel Pump Test Set (H32)	135
• Jet Trajectory and Orifice Flow (H33)	117
• Pipework Energy Losses (H34)	111
• Flow Meter Calibration (H40)	106
• Fluid Friction Apparatus (H408)	112

Essential Ancillary:	Page
• Stopwatch (SW1)	94

Volumetric Hydraulic Bench (H1D)

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



- Self-contained and fully mobile
- Plastic and non-ferrous construction
- Bench top providing ample working area
- Range of experiments available for a complete course
- Only service required is a single-phase electricity supply
- Separate sump tank outlet facility
- Ideal service unit for student projects

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.

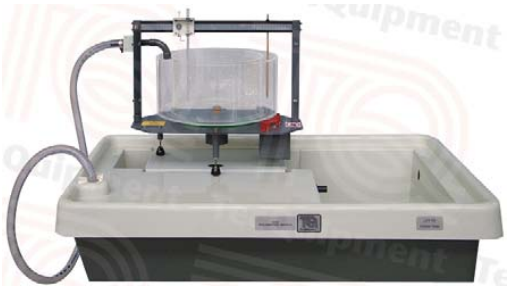
The top of the sump tank provides the working surface, on which many of the experiments in TecQuipment's Fluid Mechanics range conveniently mount. A rim around the working surface contains any spilled or excess water. The bench top also incorporates an open channel for experiments investigating flow 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 (SW1, available separately). 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)	99
Advanced Set of Weirs (H1D/b)	100
Flow Through an Orifice (H4)	114
Venturi Meter (H5)	102
Friction Loss in a Pipe (H7)	109
Impact of a Jet (H8)	115
Flow Measurement (H10)	104
Vortex Apparatus (H13)	116
Losses in Piping Systems (H16)	110
Francis Turbine (H18)	132
Pelton Turbine (H19)	133
2.5 Metre Flow Channel (H23)	123
Hydraulic Ram Pump (H31)	134
Series and Parallel Pump Test Set (H32)	135
Jet Trajectory and Orifice Flow (H33)	117
Pipework Energy Losses (H34)	111
Flow Meter Calibration (H40)	106
Pipe Surge And Water Hammer (H405)	120
Fluid Friction Apparatus (H408)	112

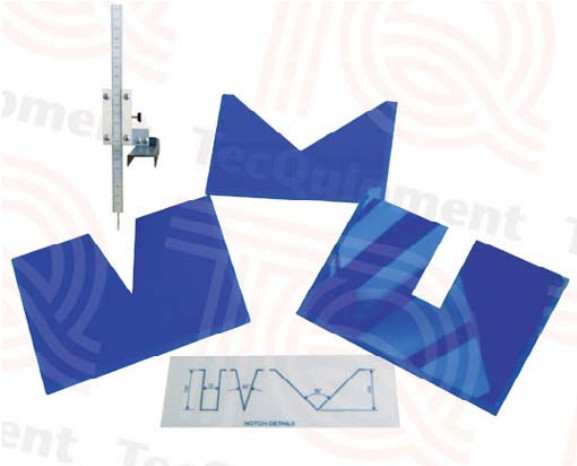
Essential Ancillary:	Page
Stopwatch (SW1)	94



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

Set of Weirs (H1D/a)

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



- Full quantitative analysis possible
- One rectangular and two V-shaped notches
- Precise measurement of water level
- Requires minimal installation
- Easy operation
- Specially designed for use on TecQuipment's Volumetric Hydraulic Bench (H1D)

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 103.

Experiments:

Comprehensive study of flow over weirs, including:

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

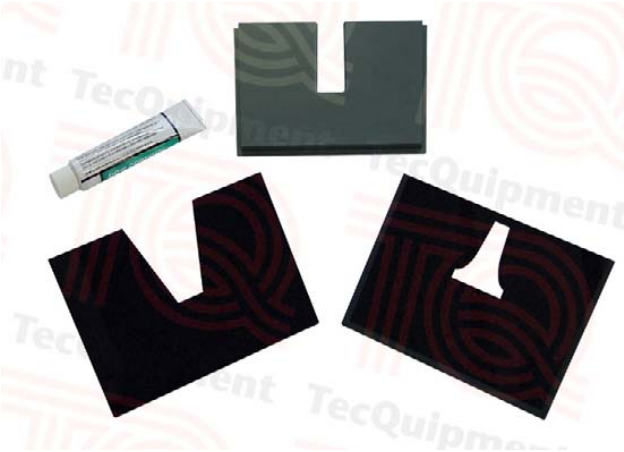
Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	98

Available Experiment Module:	Page
• Advanced Set of Weirs (H1D/b)	100

Alternative Product:	Page
• Discharge over a Notch (H6)	103

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
- Full quantitative analysis possible
- Precise measurement of water level
- Requires minimal installation
- Easy operation
- Specially designed for use on TecQuipment's Volumetric Hydraulic Bench (H1D) or TecQuipment's Discharge over a Notch Apparatus (H6)

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 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.

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

Essential Base Unit:

	Page
• Volumetric Hydraulic Bench (H1D) – **with**	98
Set of Weirs (H1D/a)	99

Ancillary for:

	Page
• Discharge over a Notch (H6)	103

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
- Compact, bench-mounting unit
- Self-contained – needs no extra services

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.

Experiments:

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

Alternative Products:

	Page
• Pressure Measurement Bench (H30)	105
• Hydrostatics and Properties of Fluids (H314)	127

Equipment training

We can 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.

Venturi Meter (H5)

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

- Robust circular-section 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

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.

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

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Alternative Products:

	Page
• Bernoulli's Equation (AF11)	12
• Flow Measurement (H10)	104
• Flow Meter Calibration (H40)	106
• Fluid Friction Apparatus (H408)	112
• Cavitation Demonstration Unit (H400)	118

Discharge over a Notch (H6)

For study of weirs as flow regulation and measurement devices

- Portable, corrosion-resistant glass-fibre channel
- Includes one rectangular and two V-shaped notches
- Extra (optional) weirs available for more experiments
- Precise measurement of water level
- Easy operation
- Works with TecQuipment's Gravimetric Hydraulic Bench (H1) for easy installation

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.

Experiments:

Comprehensive study of flow over weirs, including:

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

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	97

Recommended Ancillary:	Page
• Advanced Set of Weirs (H1D/b)	100

Alternative Products:	Page
• Set of Weirs (H1D/a)	99
• 5-Metre Flow Channel (H12)	124
• 2.5-Metre Flow Channel (H23)	123

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
- Easy to operate
- Direct measurement of head loss
- Three different flow meters which work with Bernoulli's equation
- Multi-tube manometer shows pressure at various points

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.

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

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Alternative Products:

	Page
• Venturi Meter (H5)	102
• Flow Meter Calibration (H40)	106
• Fluid Friction Apparatus (H408)	112

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
- Pressure and vacuum are accurately and conveniently controlled by fine adjustment of a syringe assembly
- 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

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.

Experiments:

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

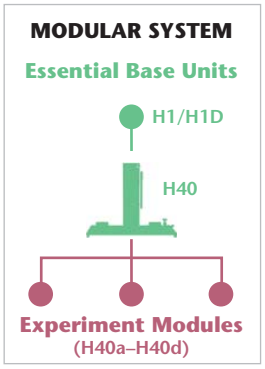
- Comparison of pressure measurement by manometer and Bourdon gauge
- Calibration of a pressure gauge
- Determination of gauge errors as a function of true pressure

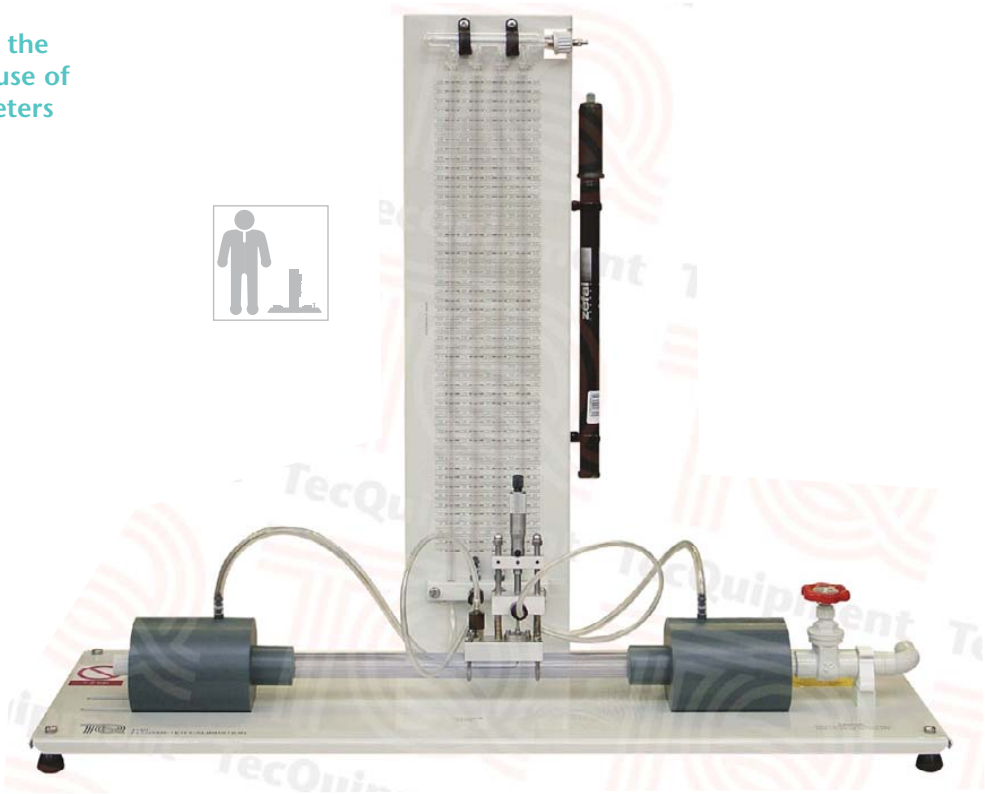
Alternative Products:

Alternative Products:	Page
• Calibration of a Pressure Gauge (H3a)	101
• Hydrostatics and Properties of Fluids (H314)	127

Flow Meter Calibration (H40)

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





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

- Cost-effective and simple to use
- Unique 'quick-change' flow meter adaptors and pressure connections
- Multi-tube manometer to show flow meter and overall pressure changes
- Optional flow meters for comparison: Venturi, orifice, nozzle and Pitot tube
- Shows the boundary layer effect and the fluid velocity profile – needs Pitot tube (H40a)
- Includes hand-pump and manifold with air valve for increased measurement range
- Works with TecQuipment's Gravimetric or Volumetric Hydraulic Benches for easy installation

The Flow Meter Calibration apparatus is for use by all kinds of engineering students. It compares and shows the accuracy and use of the optional fundamental flow meters.

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.

Note: You must order at least one of the optional flow meters to use with the Flow Meter Calibration apparatus.

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Available Experiment Modules:	Page
• Pitot Tube (H40a)	107
• Venturi Flow Meter (H40b)	107
• Orifice Flow Meter (H40c)	108
• Nozzle Flow Meter (H40d)	108

Alternative Products:	Page
• Venturi Meter (H5)	102
• Flow Measurement (H10)	104
• Fluid Friction Apparatus (H408)	112

Pitot Tube (H40a)

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

- Popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40)
- Cost-effective and simple to use
- 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

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.

Experiments:

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

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	106

Venturi Flow Meter (H40b)

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

- Popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40)
- Cost-effective and simple to use
- 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

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.

Experiments:

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

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	106

Orifice Flow Meter (H40c)

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

- Popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40)
- Cost-effective and simple to use
- 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

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.

Experiments:

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

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	106

Nozzle Flow Meter (H40d)

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

- Popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40)
- Cost-effective and simple to use
- Unique 'quick-change' adaptors and pressure connections
- Shows the accuracy and use of a nozzle flow meter
- Shows how a nozzle affects pressure
- ISA standard dimensions for more predictable results

A popular flow meter for use with TecQuipment's Flow Meter Calibration unit (H40). It shows the accuracy and use of a nozzle 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 nozzle made to ISA (Instrument Society of America) standards allows the user to measure pressures at the throat and downstream of the nozzle for a given rate of flow. The nozzle shows how standard textbook equations allow you to accurately calculate flow from these pressures, due to the specific design of the nozzle.

Experiments:

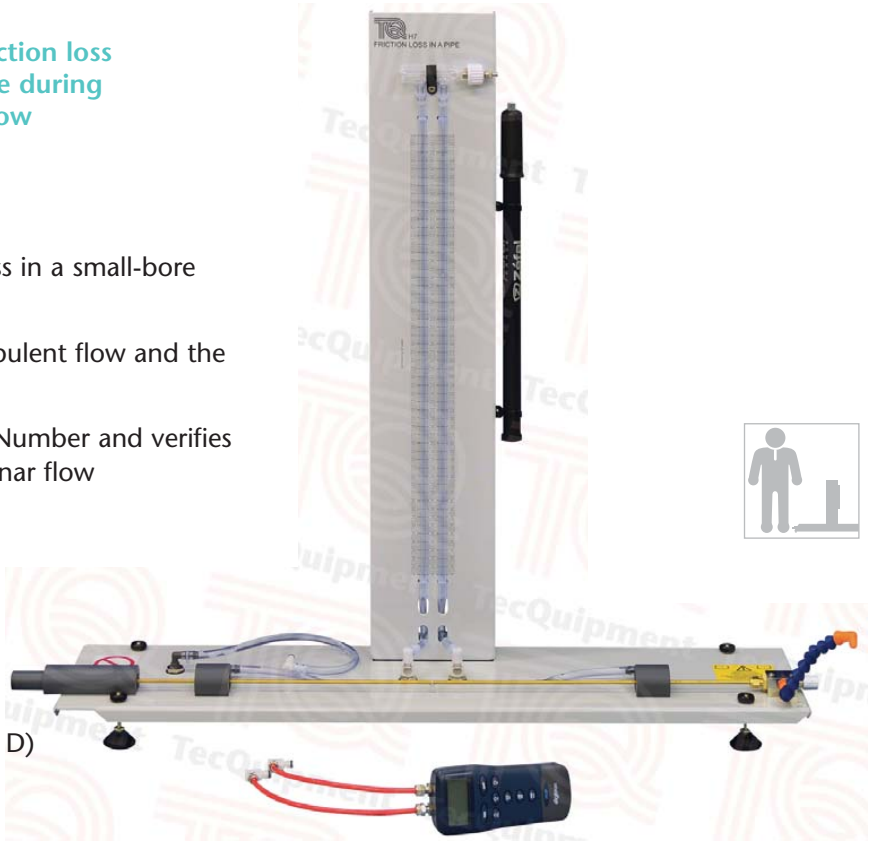
- Accuracy of nozzle flow meters
- Losses and k value
- Calculation of the coefficient of discharge

Essential Base Unit:	Page
• Flow Meter Calibration (H40) – with H1 or H1D	106

Friction Loss in a Pipe (H7)

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

- Directly measures friction loss in a small-bore test pipe
- 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



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.

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

Essential Base Unit: Page

- Gravimetric Hydraulic Bench (H1) 97

  or

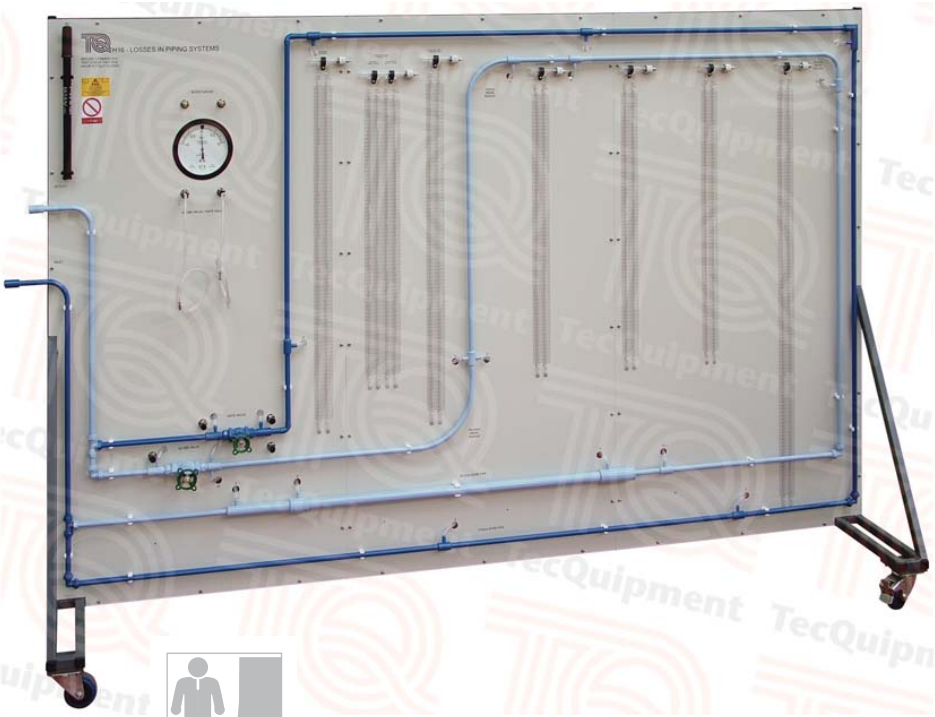
- Volumetric Hydraulic Bench (H1D) 98

Alternative Products: Page

- Losses in Piping Systems (H16) 110
- Fluid Friction Apparatus (H408) 112
- Reynolds Number and Transitional Flow (H215) 113
- Pipework Energy Losses (H34) 111

Losses in Piping Systems (H16)

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



- Mobile, space-saving panel that includes the common pipework parts used in domestic heating systems
- 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

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.

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)

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1) **or**	97
• Volumetric Hydraulic Bench (H1D)	98

Recommended Ancillary:

- Roughened Pipe (H16p)

Alternative Products:

	Page
• Friction Loss in a Pipe (H7)	109
• Pipework Energy Losses (H34)	111
• Fluid Friction Apparatus (H408)	112

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
- Direct comparison of pressure loss across different pipe fittings and their K value
- 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

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.

Experiments:

Measurement and comparison of losses in:

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

Essential Base Unit:

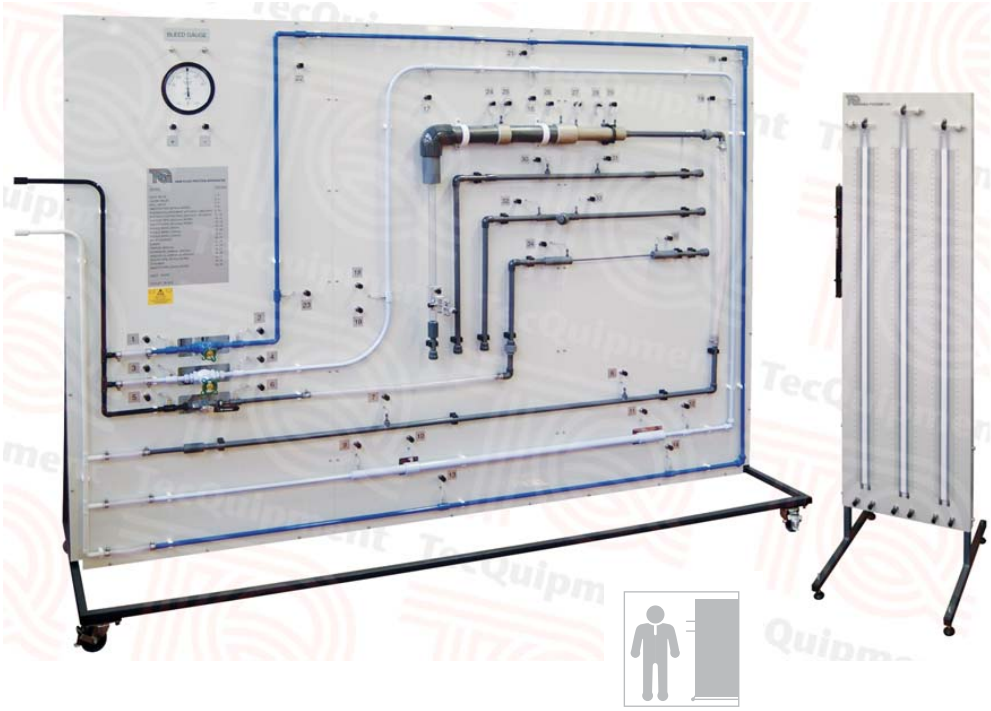
	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Alternative Products:

	Page
• Friction Loss in a Pipe (H7)	109
• Losses in Piping Systems (H16)	110
• Fluid Friction Apparatus (H408)	112

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 different valves, pipes and fittings to show losses
- 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

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.

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

Essential Base Unit:

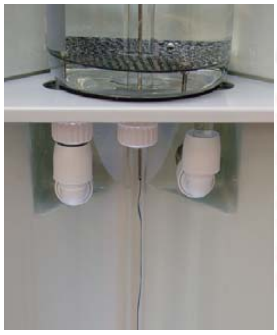
	Page
Gravimetric Hydraulic Bench (H1) **or**	97
Volumetric Hydraulic Bench (H1D)	98

Alternative Products:

	Page
Losses in Piping System (H16)	110
Pipework Energy Losses (H34)	111
Flow Meter Calibration (H40)	106
Flow Measurement (H10)	104
Venturi Meter (H5)	102
Friction Loss in a Pipe (H7)	109

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
- Clear tube and light-coloured shroud to help flow visualisation (see flow more clearly)
- Shows turbulent and laminar flow
- Optional heater module available for tests at different viscosities
- Ideal for classroom demonstrations and student experiments

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.

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

Essential Ancillary:

	Page
• Stopwatch (SW1) – To measure flow rates	94

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)	109
• Particle Drag Coefficient (H410)	128

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
- Sets of additional interchangeable orifices available (H4a)
- Works with TecQuipment's gravimetric or volumetric hydraulic benches for easy installation

Optional Set of Orifices (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.

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)

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Recommended Ancillaries:

- 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)	117

Impact of a Jet (H8)

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

- Includes flat and hemispherical plates
- Clear vessel so students can see what is happening
- Extra (optional) angled and conical plates
- Quick and accurate force measurements
- 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)

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.

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

Essential Base Unit:

	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Recommended Ancillaries:

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

Alternative Products:

	Page
• Pelton Turbine (H19)	133
• Pelton Wheel (Turbine) (MFP101b)	144

Vortex Apparatus (H13)

Studies the phenomena of free and fixed vortices

Shown fitted to the Volumetric Hydraulic Bench (H1D, available separately)

- For studies of both free and forced vortices
- 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
- Compact and easily installed in the laboratory
- Works with either of TecQuipment's Hydraulic Benches (H1 or H1D)

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.

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

Essential Base Unit: Page

- Gravimetric Hydraulic Bench (H1) 97

  or
- Volumetric Hydraulic Bench (H1D) 98

  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
- Nozzles mount vertically and horizontally
- Simple and clear plotting of horizontal jet trajectory
- 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)

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.

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.

Essential Base Unit: Page

- Gravimetric Hydraulic Bench (H1) 97

  or
- Volumetric Hydraulic Bench (H1D) 98

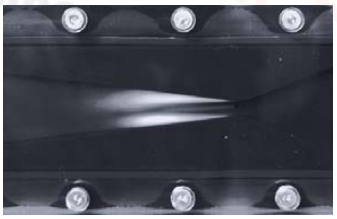
Alternative Product: Page

- Flow Through an Orifice (H4) 114

Cavitation Demonstration Unit (H400)

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

- Mobile unit that shows students the causes and effect of cavitation
- 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
- Supplied fully assembled – minimal installation needed



Cavitation in the Venturi

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.

Experiments:

Investigations into cavitation and the Venturi, including:

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

Recommended Ancillary:

	Page
• Stroboscope (ST1)	295

Alternative Product:

	Page
• Venturi Meter (H5)	102

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
- Ideal for individual as well as group work and classroom demonstrations
- Compact and free-standing
- 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

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).

Experiments:

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

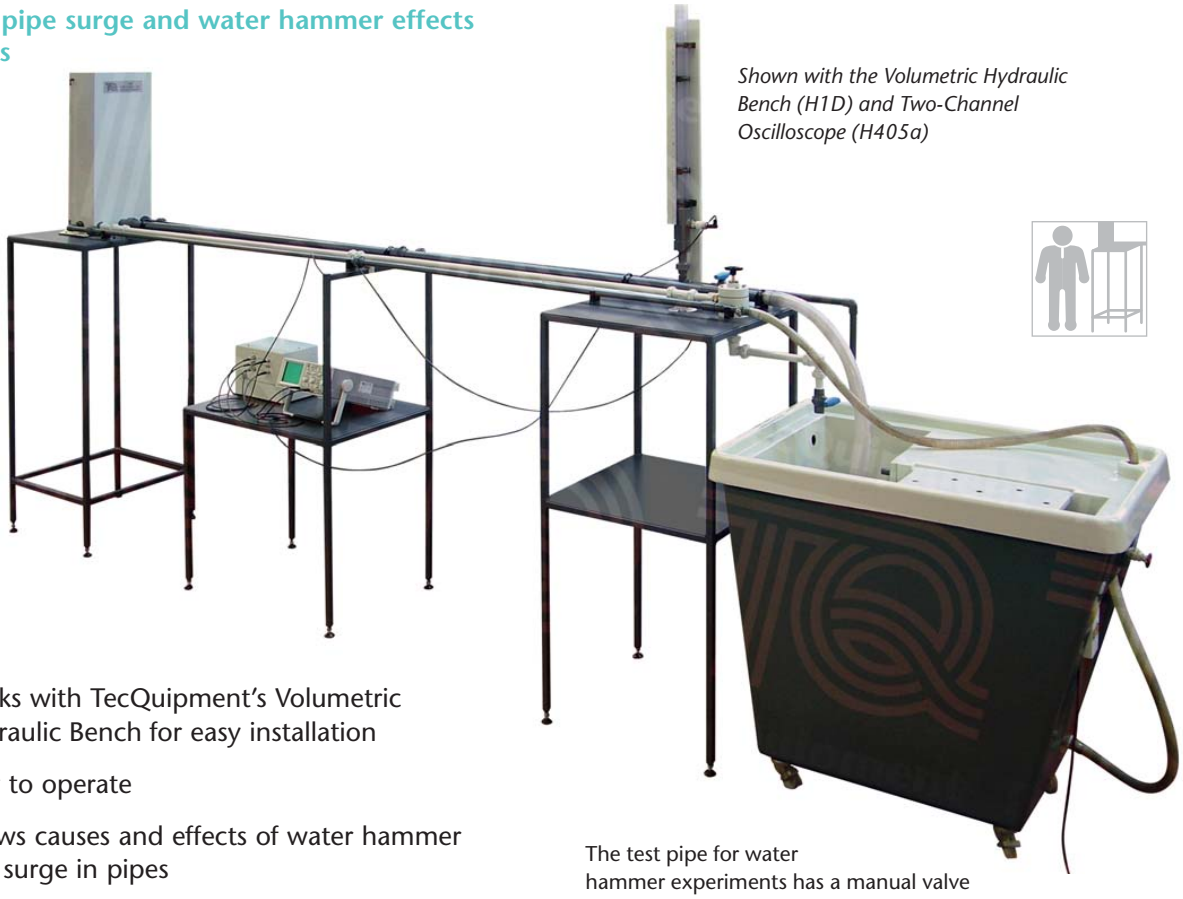
- Sources and sinks in a uniform stream
- Doublet in a uniform stream
- Flow around a cylinder (disc) and an aerofoil
- Flow through an orifice and a diffuser
- Flow through a heat exchanger
- The momentum equation
- Laminar flow relationship for flow between two parallel plates
- Mean velocity equations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

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 Two-Channel 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

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.

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

Essential Base Unit:

	Page
• Volumetric Hydraulic Bench (H1D)	98

Essential Ancillary:

	Page
• Dual Beam Storage Oscilloscope (H405a)	295

Alternative Products:

	Page
• Model Reservoir and Surge Tower Apparatus (TE58)	121
• Water Hammer Apparatus (TE86)	122

Model Reservoir and Surge Tower Apparatus (TE58)

Shows water storage and flood control with reservoirs and pipe distribution

- Shows the use of reservoirs for water storage and flood control
- Also allows investigations of a pipe distribution system
- Includes a sharp-edged weir
- Shows how to calibrate pressure transducers
- Includes two reservoirs and a surge tower
- Supplied with instrumentation
- Ideal for students working in small groups, or for classroom demonstrations

This equipment has two main parts: a main unit and a separate electrical enclosure. The electrical enclosure has connections for transducers, a power supply and an output for an oscilloscope with printer.

The main unit connects direct to a mains-water supply and has two identical reservoirs connected in series, one above the other. The water passes through an inlet valve into a rotameter-type flow meter. The water then passes into the highest reservoir, out through a sharp-edged weir and down a chute to the lowest reservoir. The lowest reservoir includes an overflow that leads to waste.

The main output of the lowest reservoir is to a serpentine (or 'penstock') pipe. The pipe connects to the floor of the lower reservoir via a shaped bell mouth to minimise frictional losses at entry. The water passes through the pipe to a surge tower and then two valves. One valve controls the flow from the pipe, the other is used to create a surge in the water flow.

The surge tower is transparent so students can see the water behaviour. Level transducers measure the water levels in the reservoirs and the surge tower.

Experiments:

Investigations into the use of reservoirs for storage and flood control, and the properties of a pipe distribution system, including:

- Transducer calibration
- Calibration of a weir
- Reservoir filling and inflow relationship
- The hydrograph and flood routing
- Water surge

Essential Ancillary:	Page
• Dual Beam Storage Oscilloscope (H405a)	295

Alternative Product:	Page
• Pipe Surge and Water Hammer (H405)	120

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

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.

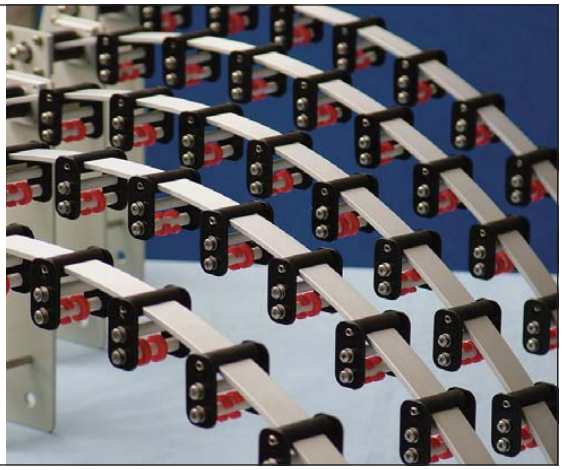
A Bourdon pressure gauge fitted between the solenoid valve and the downstream control valve shows the pressure in the system. It also allows students to calibrate the pressure transducer.

Experiments:

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

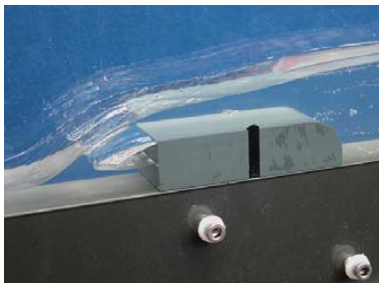
Essential Ancillary:	Page
Dual Beam Storage Oscilloscope (H405a)	295

Alternative Product:	Page
Pipe Surge and Water Hammer (H405)	120



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

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.

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.

Essential Base Unit:

	Page
• Volumetric Hydraulic Bench (H1D)	98

Alternative Products:

	Page
• Discharge Over a Notch (H6)	103
• 5-Metre Flow Channel (H12)	124

5-Metre Flow Channel (H12)

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

- Adjustable channel angle (inclination) and flow rate
- 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 Pitot tube for pressure measurement
- Includes models of sluice gate, different weirs and flume
- Extra models available include wave generator, different weirs and flow splitter

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:

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

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.

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)	103
2.5-Metre Flow Channel (H23)	123

Stability of a Floating Body (H2)

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

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

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 gives 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.

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.

Alternative Product: Page

- Hydrostatics and Properties of Fluids (H314) 127

Centre of Pressure (H11)

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

- Transparent construction – students can see what is happening
- 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
- Suitable for classroom demonstrations
- Includes built-in bubble level and adjustable levelling feet

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.

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

Alternative Product:	Page
• Hydrostatics and Properties of Fluids (H314)	127

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
- Self-contained mobile bench
- 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, mercury barometer and liquid column manometers
- Ideal for lecture room demonstrations as well as student experiments

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 is fitted with a reservoir tank which supplies water for the experiments. A tank is mounted on the unit and can be filled from the reservoir for experiments which require a free-water surface. A drain tray is fitted in the top 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, a single-limb mercury barometer and a set of U-tube manometers. The manometers can be filled with various fluids and their operating range fully demonstrated. 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.

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
- Periodicity of a floating body
- Measurement of force and centre of pressure on a plane surface
- Operation and calibration of a Bourdon pressure gauge
- Principle of a single limb mercury barometer
- U-tube manometers: fluid/air and mercury under water

Essential Ancillary:

- 1 kg of mercury (for barometer)
  Note: Due to transport laws, we cannot supply mercury with this equipment – you must find it locally.

Recommended Ancillaries:

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

Alternative Products:

	Page
Stability of a Floating Body (H2)	125
Calibration of a Pressure Gauge (H3a)	101
Centre of Pressure (H11)	126
Pressure Measurement Bench (H30)	105

Particle Drag Coefficient
(H410)

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

- Falling sphere viscometer for experiments in drag coefficient and fluid viscosity
- 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
- Unique valve exit system allows students to recover test spheres with minimal fluid loss
- Includes stopwatch and timing marks for accurate results

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.

Experiments:

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

Alternative Product: Page

- Reynolds Number and Transitional Flow (H215) 113

Liquid Sedimentation Apparatus (H311)

Shows how different particles settle in liquid

- Compact, bench-mounting apparatus to study how 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
- Ideal for classroom demonstrations and student experiments

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.

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

Standard features for all our products are:

- Supplied with comprehensive user guide
- Two-year warranty
- Manufactured in accordance with the latest European Union directives

Permeability Tank (H312)

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

- Visualisation and measurement of flow through permeable media
- 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
- Includes adjustable overflow pipes to vary the head across the models
- Self-contained, floor-standing unit – only needs water supply and drain

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.

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)

Essential 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
- Piezometer tappings to measure water table profile
- Can measure 'drawdown' due to single or two interacting wells
- Adjustable inclination of catchment area angle
- Includes flow meter to measure flow to the catchment area
- Run-off and well flows measured by calibrated rectangular weir
- Self-contained – requires only an electrical supply

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.

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

Essential 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

- A simple-to-use, laboratory-scale unit which tests the performance and efficiency of a Francis turbine
- Ideal for classroom demonstrations and student experiments
- 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
- Transparent front so students can see what is happening

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 at the inlet connection of the turbine measures the inlet pressure. 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.

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

Essential Base Unit:	Page
Volumetric Hydraulic Bench (H1D)	98

Essential Ancillary:	Page
Optical Tachometer (OT1)	295

Recommended Ancillary:	Page
Stroboscope (ST1)	295

Alternative Product:	Page
Francis Turbine (MFP101d)	145

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
- Transparent window so students can see the Pelton wheel working
- Includes dynamometer to load the turbine and help find the power absorbed (needs an optional tachometer to find speed)
- Low bearing resistance for accurate results
- Includes inlet pressure gauge
- Screw-controlled spear valve for precise inlet flow control
- Range of performance tests

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 Gravimetric or Volumetric Hydraulic Bench (H1 or 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. An integral pressure 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.

Experiments:

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

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

Essential Ancillary:	Page
• Optical Tachometer (OT1)	295

Recommended Ancillary:	Page
• Stroboscope (ST1)	295

Alternative Products:	Page
• Impact of a Jet (H8)	115
• Pelton Wheel (Turbine) (MFP101b)	144

Hydraulic Ram Pump (H31)

Shows the use of water hammer to create a pumping action

- Uses water hammer effect to pump water
- 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

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.

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.

Experiments:

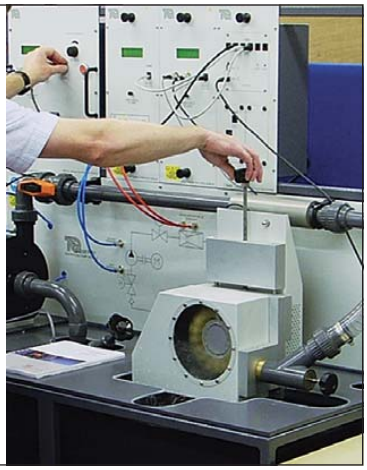
- Demonstration of the water hammer effect to produce a pumping action.

Essential Base Unit:	Page
• Volumetric Hydraulic Bench (H1D)	98

Have you seen our Modular Fluid Power range?

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

See pages 141–156.



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

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.

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

Essential Base Unit:	Page
• Gravimetric Hydraulic Bench (H1)	97
or	
• Volumetric Hydraulic Bench (H1D)	98

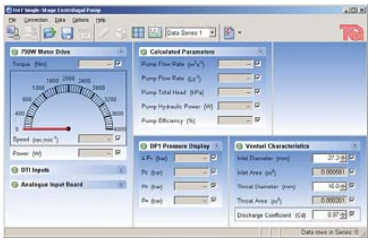
Alternative Products :	Page
• Centrifugal Pump Test Set (H47)	136
• Two-Stage (Series and Parallel) Pumps (H83)	138
• Centrifugal Pump Module (MFP101)	142

Centrifugal Pump Test Set (H47)

Works with VDAS®

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

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



Screenshot of the optional VDAS® software

- Self-contained, mobile centrifugal pump test set for a range of experiments and demonstrations
- 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
- Motor Drive has a digital display of pump speed, torque and calculated true 'shaft' power
- Optional easy-to-read analogue instrumentation
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

Cavitation demonstration

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.

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.

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

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Frame-mounting version (VDAS-F)	6
• Stroboscope (ST1)	295
• Analogue Pressure Display (AP1)	

Alternative Products:

	Page
• Two-Stage (Series and Parallel) Pumps (H83)	138
• Series and Parallel Pump Test Set (H32)	135
• Centrifugal Pump Module (MFP101)	142

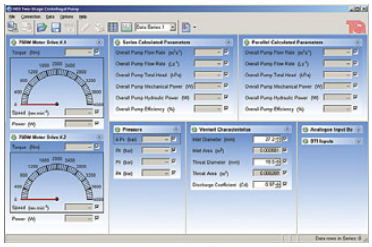
Two-Stage (Series and Parallel) Pumps (H83)

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

- Self-contained, mobile two-stage centrifugal pump test set for a range of tests and demonstrations
- 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
- Motor Drives have digital displays of pump speed, torque and calculated true 'shaft' power
- Optional easy-to-read analogue instrumentation
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®) and software



Screenshot of the optional VDAS® software

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.

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

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Frame-mounting version (VDAS-F)	6
• Stroboscope (ST1)	295
• Analogue Pressure Display (AP2)	

Alternative Products:

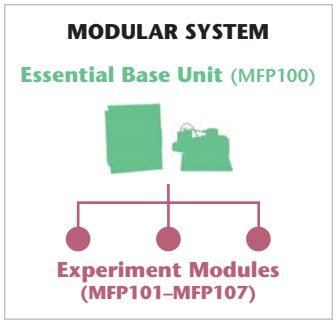
	Page
• Series and Parallel Pump Test Set (H32)	135
• Centrifugal Pump Test Set (H47)	136
• Centrifugal Pump Module (MFP101)	142

One of the impellers from the Centrifugal Fan Module (MFP106)

Universal Dynamometer (MFP100)

Works with VDAS®

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



- Robust electric motor with external speed and torque sensors, mounted onto transportable base plate with handles
- Cost-effective – only one Universal Dynamometer is needed for use with many TecQuipment Fluid Power modules
- Includes motor drive and display unit with digital displays of speed, torque and calculated mechanical (shaft) power
- Has multiple outlets to provide electrical power for other instruments supplied with the Fluid Power modules, for neater and safer arrangement
- Quick and easy disconnection and reconnection from one module to another
- Direct drive – no belts or pulleys to adjust
- Variable-speed electric motor with industry-standard electronic drive control
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®) and software

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.

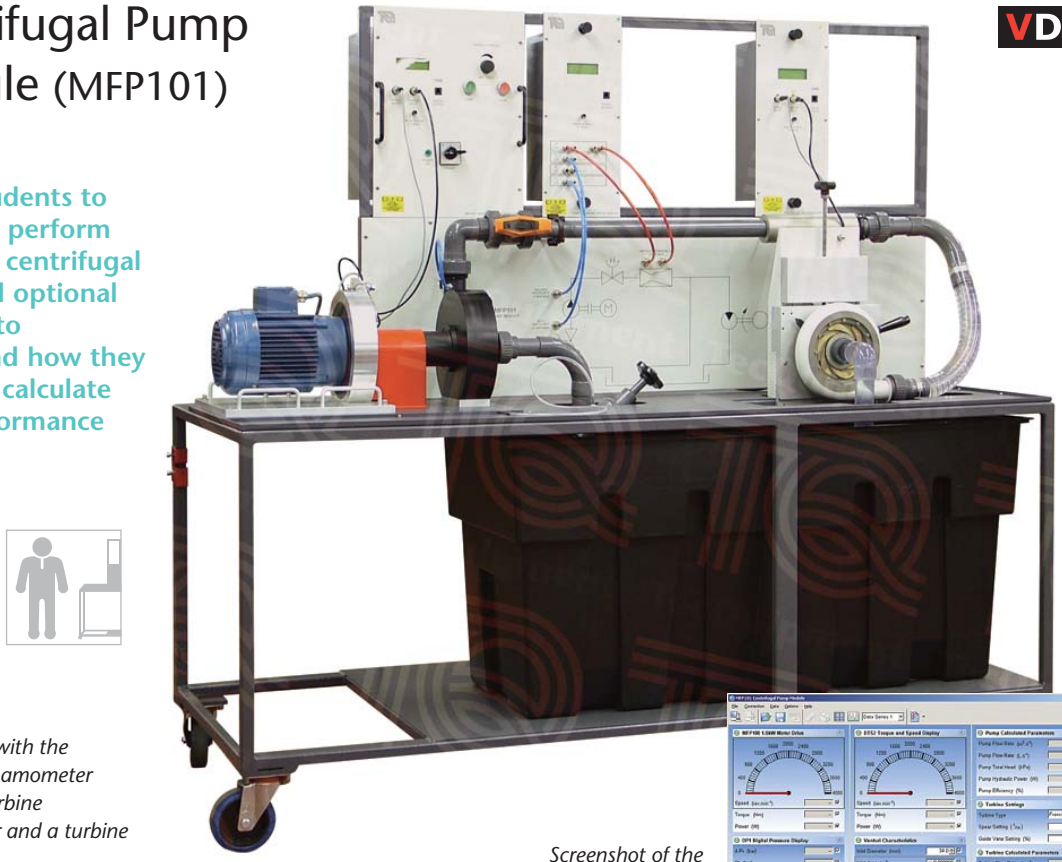
The control and instrumentation unit includes a socket to link it to TecQuipment's optional Versatile Data Acquisition System (VDAS®). When used with a suitable computer (computer not included), it gives accurate real-time data capture, monitoring and display, calculation and charting of all the important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

Available Experiment Modules:	Page
• Centrifugal Pump Module (MFP101)	142
• Axial Flow Pump Module (MFP102)	146
• Positive Displacement Pump Module (MFP103)	147
• Reciprocating Compressor Module (MFP104)	151
• Centrifugal Compressor Module (MFP105)	152
• Centrifugal Fan Module (MFP106)	153
• Axial Fan Module (MFP107)	155

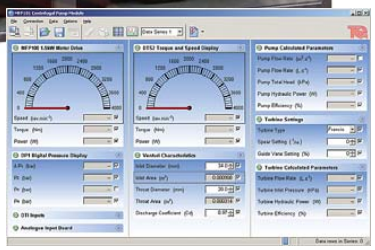
Works with VDAS®

Centrifugal Pump Module (MFP101)

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
- Allows students to study and test a popular fluid power machine
- Inlet and delivery valves for wide range of operating conditions
- Connection plate with schematic diagram clearly shows the water flow circuit and how parts of the module connect to each other
- Fully variable speed, for range of test results
- Turbine dynamometer and turbines (available separately) – Propeller, Francis and Pelton
- Includes digital pressure display
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®) and software

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).

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

Essential Base Unit:

	Page
• Universal Dynamometer (MFP100)	141

Available Experiment Modules:

	Page
• Pelton Wheel (Turbine) (MFP101b)	144
• Propeller Turbine (MFP101c)	144
• Francis Turbine (MFP101d)	145

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6
• Stroboscope (ST1)	295

Alternative Products:

	Page
• Series and Parallel Pump Test Set (H32)	135
• Centrifugal Pump Test Set (H47)	136
• Two-Stage (Series and Parallel) Pumps (H83)	138

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)	144
• Propeller Turbine (MFP101c)	144
• Francis Turbine (MFP101d)	145

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
- Clear viewing window
- Flexible inlet pipe with inlet pressure tapping

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.

Experiments:

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

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	142

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	143

Alternative Products:	Page
• Impact of a Jet (H8)	115
• Pelton Turbine (H19)	133

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
- Clear viewing window around the guide vanes
- Flexible inlet pipe with inlet pressure tapping

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.

Experiments:

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

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	142

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	143

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
- Clear viewing window and draft tube
- Flexible inlet pipe with inlet pressure tapping

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.

Experiments:

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

Essential Base Unit:	Page
• Centrifugal Pump Module (MFP101) (with Universal Dynamometer MFP100)	142

Essential Ancillary:	Page
• Turbine Dynamometer (MFP101a)	143

Alternative Product:	Page
• Francis Turbine (H18)	132

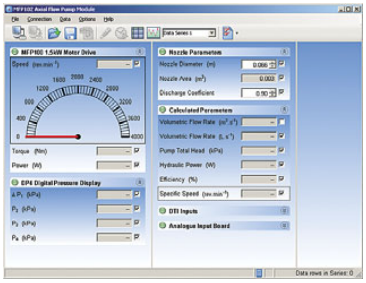
Installation and commissioning

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.

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
- Allows students to study and test a common type of rotodynamic pump, safely and at a realistic scale
- Connection plate with schematic diagram shows the water flow circuit and how parts of the module connect to each other
- Fully variable speed and flow, for range of tests
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

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).

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

Essential Base Unit: Page

- Universal Dynamometer (MFP100) 141

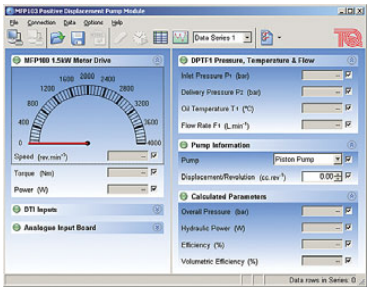
Recommended Ancillary: Page

- Versatile Data Acquisition System – Frame-mounted version (VDAS-F) 6

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
- Fully variable speed, for range of test results
- Includes digital display of pressures, flow and oil temperature
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®) and software

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

Continued on next page

Positive Displacement Pump Module (MFP103)
Continued from previous page

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.

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

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. 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)	148
• Gear Pump (MFP103b)	149
• Vane Pump (MFP103c)	150
• Swash Plate Pump (MFP103d)	150

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)	141

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

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

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.

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)

Essential Base Unit:	Page
• Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100)	147

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

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.

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)

Essential Base Unit: Page

- Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100) 147

Have you seen our other pumps?

TecQuipment's **Centrifugal Pump Test Set** (H47) on page 136 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 138.

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

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.

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)

Essential Base Unit: Page

- Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100) 147

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

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.

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)

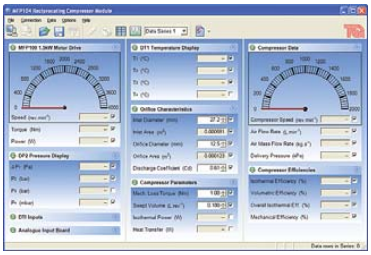
Essential Base Unit: Page

- Positive Displacement Pump Module (MFP103) (with Universal Dynamometer MFP100) 147

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
- 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 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
- Fully variable speed, for range of test results
- Includes digital displays of temperature and pressure
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®) and software

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).

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

Essential Base Unit: Page

- Universal Dynamometer (MFP100) 141

Recommended Ancillary: Page

- Versatile Data Acquisition System – Frame-mounted version (VDAS-F) 6

Alternative Product: Page

- Two-Stage Compressor Test Set (GT103) 294

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
- Allows students to study and test a common type of rotodynamic machine, safely and at a realistic scale
- Pressure and temperature measurements at key points in the system
- Connection plate with schematic diagram clearly shows the arrangement of the module
- Fully variable speed, for a range of test results
- Includes digital displays of pressure and temperature
- Connects to TecQuipment's optional Versatile Data Acquisition System (VDAS®)

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).

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

Essential Base Unit: Page

- Universal Dynamometer (MFP100) 141

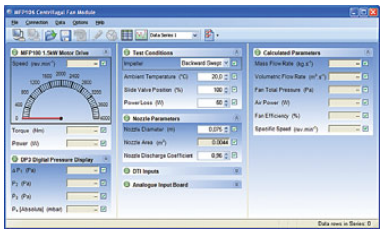
Recommended Ancillary: Page

- Versatile Data Acquisition System – Frame-mounted version (VDAS-F) 6

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
- Allows students to study and test a popular rotodynamic machine, safely and at a realistic scale
- Three interchangeable impellers provided as standard
- Includes digital pressure display and pressure measurements at key points in the system
- Connection plate with clear schematic diagram shows the arrangement of the module
- Fully variable speed, for a range of test results
- Optional Pipe Flow and Nozzle Kit (MFP106a) for more experiments
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

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.

Electronic transducers measure the inlet pressure, delivery pressure, nozzle differential pressure (flow rate) and the

Continued on next page

Centrifugal Fan Module (MFP106)
Continued from previous page

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.

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

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	141

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6
• Pipe Flow and Nozzle Kit (MFP106a)	154

Pipe Flow and Nozzle Kit (MFP106a)

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

- A kit of additional parts to fit to TecQuipment's Centrifugal Fan Module (MFP106)
- Includes a multiway pressure display with additional instrument frame
- Multiple pressure tappings along lengths of straight pipe to find pressure losses
- 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

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.

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

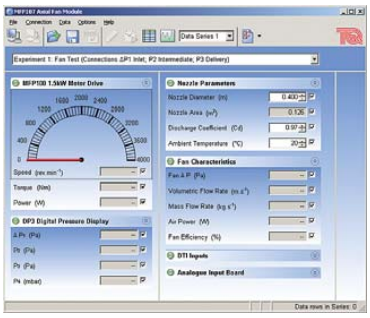
Ancillary for:	Page
• Centrifugal Fan Module (MFP106)	153

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

Shown fitted with the Universal Dynamometer (MFP100)



Screenshot of the optional VDAS® software

- 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 popular type of rotodynamic machine safely and at a realistic scale
- 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
- Includes digital multi-input pressure display
- Can be used with TecQuipment's Versatile Data Acquisition System (VDAS®) and software
- Includes efficient exhaust silencer to reduce noise

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).

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

Essential Base Unit:	Page
• Universal Dynamometer (MFP100)	141

Recommended Ancillaries:	Page
• Pitot-Static Traverse – 450 mm (MFP107a)	156
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

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)

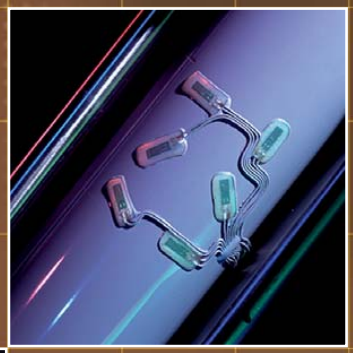
The Pitot-Static Traverse allows students to find the velocity distribution across the duct of the Axial Fan Module (MFP107). This optional ancillary comprises a Pitot-static tube which fits on the duct of the Axial Fan Module and has a digital indicator to show the tube position across the duct.

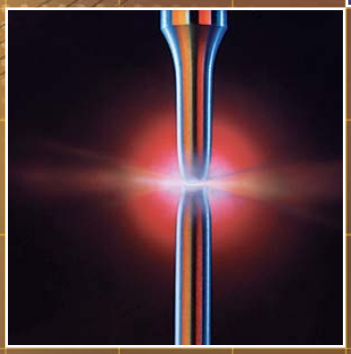
The digital indicator has a zero button to allow the user to set the datum or starting point to any position during an experiment. To display differential pressure, the Pitot-static tube connects to the instruments on the Axial Fan Module.

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)	155

Materials Testing and Properties





“ The university community has been deriving optimal educational benefits from the use of TecQuipment teaching aids. Latest technology of high quality with robustness, durability, environment friendly and diverse experiment facilities, the TecQuipment products play a significant role in ensuring ‘ease of transfer of technology’. ”

Prof M Alimullah Miyan, International University of Business Agriculture and Technology, Bangladesh

Materials Testing and Properties

Experience

TecQuipment has decades of experience making products that test materials specimens, refining and developing them over time to match the needs of modern engineering courses. These high-quality robust products are made for the teaching laboratory, giving the long term performance and reliability needed for accurate and dependable results.

Broad and progressive range

The range includes products to show key materials principles, such as Hooke's Law and Young's Modulus.

It progresses to complex analysis of stress and strain and testing specimens to destruction.

KEY FEATURES AND BENEFITS:

- **Refined products: refined through experience to meet the needs of a modern materials course.**
- **Broad and progressive range of experiments: teaches the fundamental principles, progressing to complex stress and strain analysis.**
- **Automatic data acquisition: multiple and fast-changing measurements make data acquisition a valuable tool.**

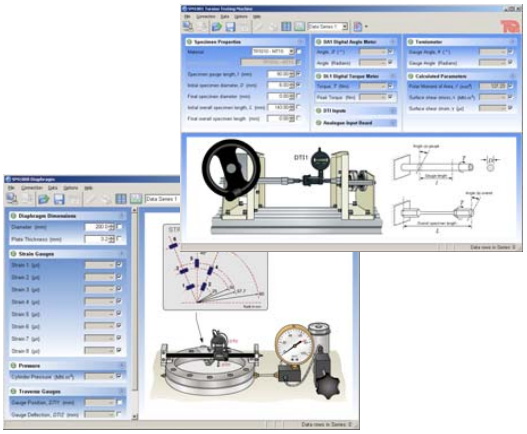
Check out our other ranges

Our **Structures** (Section 9) and **Engineering Science** (Section 4) ranges also include products that demonstrate how the choice of materials affects the performance of structural elements.

Automatic data acquisition

Many of the products in this range work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 1** for more details.

Look out for the VDAS® logo: VDAS®



VDAS®	Product	
●	**Thin Cylinder** (SM1007)	Page 161
●	**Diaphragm** (SM1008)	Page 163
●	**Thick Cylinder** (SM1011)	Page 164
●	**Strain Gauge Trainer** (SM1009)	Page 165
●	**Digital Strain Display** (SM1010)	Page 166
●	**Torsion Testing Machine–30 Nm** (SM1001)	Page 168
●	**Rotating Fatigue Machine** (SM1090)	Page 169
●	**Creep Machine** (SM1006)	Page 170
●	**Bench-Top Tensile Testing Machine** (SM1002)	Page 171
●	**Universal Testing Machine** (SM1000)	Page 173
●	**Unsymmetrical Cantilever Apparatus** (SM1003)	Page 181
●	**Beam Apparatus** (SM1004)	Page 182
●	**Loading and Buckling of Struts** (SM1005)	Page 185

Spring Testing Apparatus (SM110)

Tests extension springs to find their properties. Proves Hooke's Law and the basic rules of spring design.

- Fundamental and accurate test instrument to test single springs and springs in series and parallel
- Tests springs and finds their properties – good for mechanical workshops and classroom use
- Includes a set of different springs to compare spring rates and effect of different spring sizes
- Wide range and variety of experiments
- Supplied with user guide which includes theory, experiments and results
- Easy-to-use, compact instrument that fits on a small bench or desktop
- Ideal for groups of students or classroom demonstrations
- Includes two sets of masses to work with many different springs

The Spring Testing Apparatus uses a fundamental variable mass and scale measurement to test springs. It shows students how to find the properties of a spring and proves some basic laws of physics (Hooke's Law, Newton's Law and spring design rules). It is also a useful tool for a workshop, to check the properties of a spring before it is used, or after it has been used.

The apparatus is a compact metal frame with adjustable feet so the user can make the apparatus level. The back of the frame has a storage area for springs and masses. The front of the frame has a metric scale each side of a large slot, where the test spring hangs.

Students choose a spring and note its dimensions. They then slowly load the spring with the masses (included) and note its extension against the metric scale. Students use their results to find the properties of the spring and compare them with theory and the manufacturer's details. For more advanced studies, students can also do tests on springs in series and parallel.

The user guide (included) gives full details of how to use the equipment, spring theory, experiments and typical results.

Supplied with the apparatus is a set of extension or 'tension' springs. The user can compare different spring rates with different spring sizes to fully understand the basic rules of spring design. Tension springs also have the extra 'initial tension' that other springs do not have which increases students' learning about spring properties.

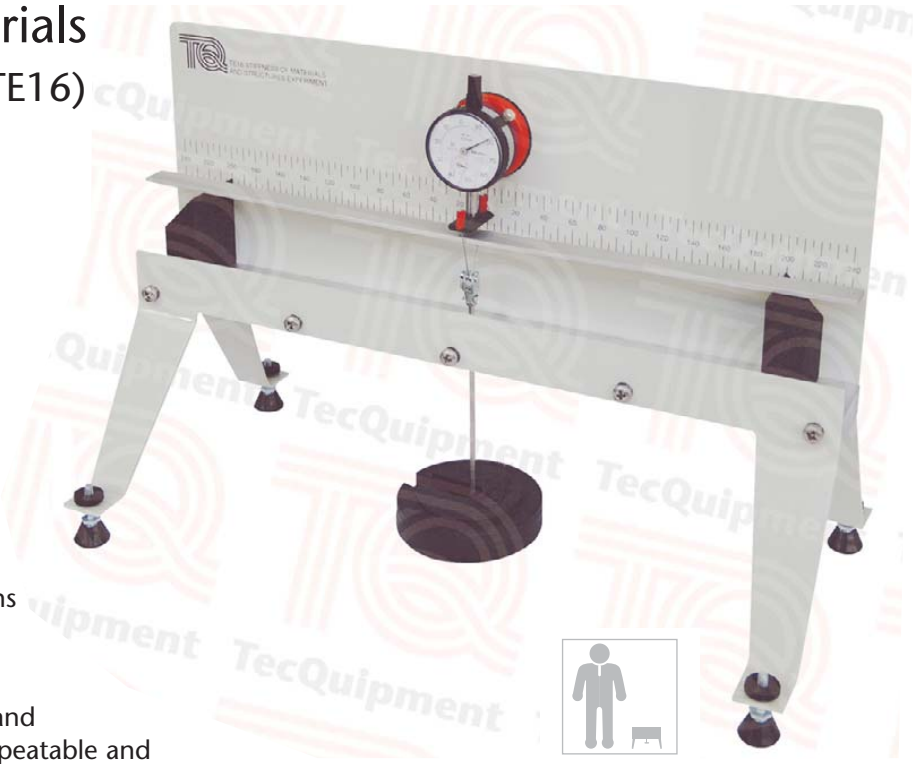
Experiments:

- Spring rate and Hooke's Law
- To prove the basic rules of spring design
- Simple spring scale
- Springs in series
- Springs in parallel

Alternative Products:

	Page
Coil Spring (SM1000f)	175
Spring Tester Kit (ES19)	91

Stiffness of Materials and Structures (TE16)



Bench-mounting apparatus enabling a variety of investigations into material stiffness

- Compact, bench-mounting frame that holds parts for different experiments in stiffness of materials
- Allows investigations into stiffness in bending of beams of different materials and cross-section
- Easy-to-use precision parts and instruments for accurate, repeatable and reliable results
- Simple, rugged, long-lasting and trouble-free parts
- Gives clear, straightforward and effective demonstrations of beam behaviour
- The standard TE16 kit includes test beams of different materials and cross-section
- Optional additional kits (TE16a and TE16b) available for experiments with different beam fixings (cantilever and encastre) and torsional stiffness experiments

A compact, bench-mounting frame that holds different parts for investigations into stiffness of materials. The standard TE16 includes parts for tests in bending of beams of different materials and cross-section. Optional additional kits allow investigations into different beam fixings and torsional stiffness.

The main part is a rigid metal frame. Supplied as standard are two adjustable knife edges that work as simple supports for test beams. A linear scale on the back panel of the frame allows accurate positioning of the knife edges.

The kit also includes weights, a magnetic dial gauge and a set of different beams. Also included in the standard TE16 kit is a vernier gauge for students to accurately measure dimensions of the specimens they test.

Students add different loads to the beams using weights on a hanger. The dial gauge indicator on the back panel accurately measures beam deflection.

The Additional Experimentation Kit (TE16a, available separately) enables further investigations into a simple cantilever, a propped cantilever and an encastre beam.

The Additional Torsion Testing Kit (TE16b, available separately) allows torsion tests on solid rods of different materials and a tube.

Experiments:

Standard TE16 kit:

- Investigation of the stiffness in bending of different materials of the same cross-section (Young's modulus/stiffness)
- Investigation of the stiffness of a single material with different cross-section geometries (second moment of area, or I value)

When used with the optional TE16a:

- Experiments to find the deflected shape of a beam and bending of a beam clamped at one end (a cantilever)
- Comparison of a simply supported beam, a cantilever and an encastre beam

When used with the optional TE16b:

- Experiments to find the relationship between angular deflection and the dimensional and material properties of rods and tubes (torsional stiffness)

Recommended Ancillaries:

- Additional Experimentation Kit (TE16a)
- Additional Torsion Testing Kit (TE16b)

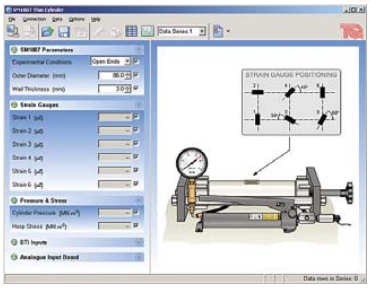
Alternative Products:

	Page
Beam and Leaf Spring (SM1000g)	176
Beam Apparatus (SM1004)	182
Deflection of Beams and Cantilevers Kit (STR4)	209
Continuous and Indeterminate Beams (STR13)	218
Deflection of Beams Kit (ES4)	75
When used with the Additional Torsion Testing Kit (TE16b):	
Torsion Testing Machine – 30 Nm (SM1001)	168
Torsion of Circular Sections (STR6)	211
Torsion of Circular Sections Kit (ES5)	76

Thin Cylinder (SM1007)

Works with VDAS®

Bench-mounted machine to allow students to do stress and strain tests on a thin-walled cylinder



Screenshot of the optional VDAS® software

- For comprehensive analysis of the stresses and strains in a thin-walled cylinder, under internal pressure
- Introduces stress and strain, and how to measure and analyse them
- Includes experiments to find Young's modulus and Poisson's ratio
- Closed-end and open-end conditions to allow circumferential or biaxial stress tests
- High-quality electrical-resistance precision strain gauges measure cylinder strains
- Includes built-in microprocessor-controlled display of strain measurements
- Self-contained, hand-operated hydraulic pressurising system for accurate pressure control

TecQuipment's Thin Cylinder apparatus allows students to perform experiments that examine stress and strain in a thin-walled cylinder. It clearly shows the principles, theories and analytical techniques, and provides effective, practical support to studies.

A sturdy base contains all parts of the Thin Cylinder apparatus. This forms a compact product, ideal for use on a workbench.

The apparatus consists of a thin-walled aluminium cylinder, held in a robust frame. The frame holds the cylinder so that it is free to move along its axis. The cylinder contains oil. To stress the cylinder, students use the hydraulic hand-pump to pressurise the oil. Strain gauges on the cylinder surface measure strain, while a gauge and electronic sensor measure hydraulic pressure.

Students can measure strains with the cylinder in two 'end conditions':

- Open end: the cylinder has no axial load, so there is no direct axial stress.

  or
- Closed end: the cylinder has axial loads, so there is direct axial stress.

Students use a hand-wheel on the frame to set these end conditions.

To perform experiments, students choose either closed or open-end conditions. They set the gauges to zero and use the pump to pressurise the cylinder. They take readings at several stages while they increase the pressure. The results can be taken by hand using the in-built display and pressure gauge, and results plotted by hand. Alternatively, students can use TecQuipment's optional Versatile Data Acquisition System (VDAS®) to capture the data and plot the relevant graphs and export data. They then compare their results with calculations made using stress and strain theory.

Continued on next page

Thin Cylinder (SM1007)
Continued from previous page

A user guide is supplied with the Thin Cylinder apparatus. The guide includes full details of the equipment, detailed experiment procedures, theory and results.

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

Experiments:

Investigations into stresses and strains in a thin cylinder, to give students an understanding of:

- Longitudinal stress, hoop (or circumferential) stress, radial stress and biaxial stress
- The behaviour of the cylinder under both open and closed-end conditions
- The use of strain gauges
- The stress strain relationship and value of Young's modulus for the cylinder material
- Indirect strain and stress
- The value of Poisson's ratio for the cylinder material
- The use of Mohr's circle to calculate the shear strain at any position in the cylinder
- The use of the 'superposition method' to find the principal strains
- The effect of the biaxial stress system
- Sources of error in their experiments

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

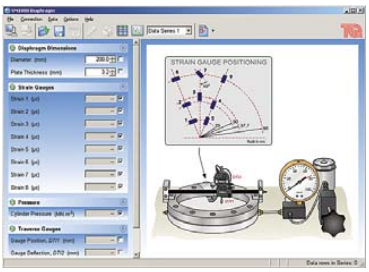
Alternative Product:	Page
• Thick Cylinder (SM1011)	164

Diaphragm (SM1008)

Works with VDAS®

Bench-mounted machine to allow students to do stress, strain and deflection tests on a diaphragm

- Measurement of effect of pressure on surface profile of a diaphragm
- Measurement of circumferential and radial strains of a diaphragm under pressure
- High-quality electrical-resistance precision strain gauges measure diaphragm strains
- Includes built-in microprocessor-controlled display of strain measurements
- Self-contained, hand-operated hydraulic pressurising system for accurate pressure control



Screenshot of the optional VDAS® software

The Diaphragm apparatus allows students to examine the effect of pressure on the surface profile of a diaphragm. They can also determine the distribution of circumferential and radial strains across its diameter.

A sturdy base contains all parts of the Diaphragm apparatus. This forms a compact product, ideal for use on a workbench.

Two heavy flanges clamp the edge of the diaphragm to provide built-in edge conditions. The area directly under the diaphragm contains oil.

Eight strain gauges are cemented to the top surface of the diaphragm in various positions and at different radii. Each strain gauge circuit is a full bridge, with high-stability resistors. The signals from each strain gauge are shown on a digital display.

A digital dial gauge is fitted to a digital position indicator. The dial gauge can be traversed across the diaphragm to measure its surface profile. Both instruments can connect to TecQuipment's optional Versatile Data Acquisition System (VDAS®).

Students use a hydraulic pump to increase the oil pressure under the diaphragm. They record the strain readings and diaphragm profile at different pressures.

The results can be taken by hand using the in-built display and pressure gauge and results plotted by hand. Alternatively, the student can use VDAS® to capture the data and plot the relevant graphs and export data.

A user guide is supplied with the Diaphragm apparatus. The guide includes full details of the equipment, detailed experiment procedures, theory and results.

For quick and reliable tests, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included).

Experiments:

Experiments possible with this apparatus include the effect of pressure on:

- Surface profile – the results are presented as a non-dimensional curve
- Radial and circumferential strains
- Radial and circumferential strain gradients across the diaphragm

Experimental measurements are compared with theory. The student is encouraged to use their results to determine the accuracy of the location of the strain gauges.

Recommended Ancillary: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

Thick Cylinder (SM1011)

Works with VDAS®

Bench-mounted machine to allow students to do stress and strain tests on a thick-walled cylinder

- Ideal for student use and classroom demonstrations
- For comprehensive analysis of the stresses and strains in a thick-walled cylinder, under internal pressure
- Experiment results compared with Lamé predictions
- High-quality electrical-resistance precision strain gauges measure cylinder strains
- Includes built-in microprocessor-controlled display of strain measurements
- Self-contained, hand-operated hydraulic pressurising system for accurate pressure control

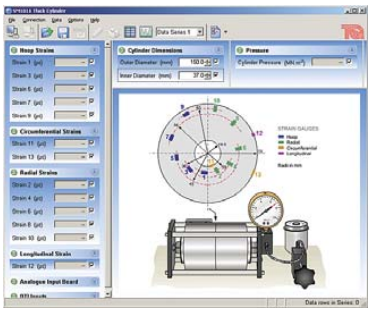
TecQuipment's Thick Cylinder apparatus allows students to examine radial and hoop stresses and strains in the wall of a thick cylinder. They can then compare experiment results with the theoretical Lamé predictions. It clearly shows the principles, theories and analytical techniques, and provides effective, practical support to studies.

A sturdy base contains all parts of the Thick Cylinder apparatus. This forms a compact product, ideal for use on a workbench.

The apparatus consists of a thick-walled aluminium cylinder, held in a robust frame. The cylinder is in two halves, cemented together. One face of the joint has an eccentric shallow groove that contains ten strain gauges at precise radii and orientation. These gauges measure the radial and hoop strains. Jointing cement fills the groove. Strain gauges on the inner and outer walls of the cylinder measure longitudinal and circumferential strains.

The cylinder contains oil. To stress the cylinder, students use a hydraulic hand-pump to pressurise the oil.

To perform experiments, students set the gauges to zero and use the pump to pressurise the cylinder. They take readings at several stages while increasing the pressure. The results can be taken by hand using the in-built display and pressure gauge and plotted by hand. Alternatively, they can use TecQuipment's optional Versatile Data Acquisition System (VDAS®) to capture the data and plot the relevant graphs and export data. They then compare their results with calculations made using theory.



Screenshot of the optional VDAS® software

A user guide is supplied with the Thick Cylinder apparatus. The guide includes full details of the equipment, detailed experiment procedures, theory and results.

For quick and reliable tests, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included).

Experiments:

- Radial and hoop strains throughout the cylinder wall
- Radial and hoop stress distribution in the wall
- Longitudinal stress and strain at the outer surface
- Circumferential stress and strains at the inner and outer surfaces
- Comparison with Lamé predictions
- Principal stresses and maximum shear stress
- Appraisal of accuracy of location of strain gauges

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

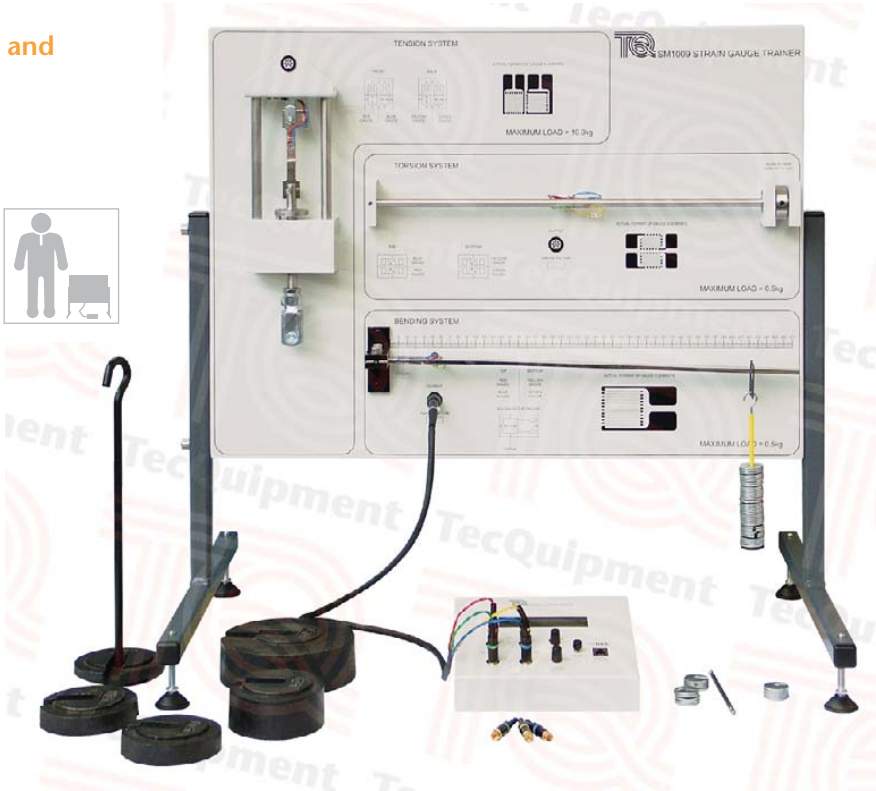
Alternative Product:

	Page
• Thin Cylinder (SM1007)	161

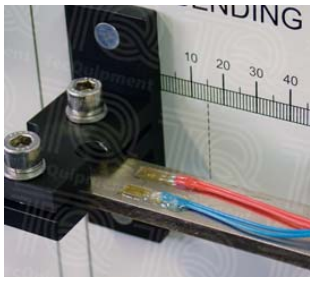
Strain Gauge Trainer (SM1009)

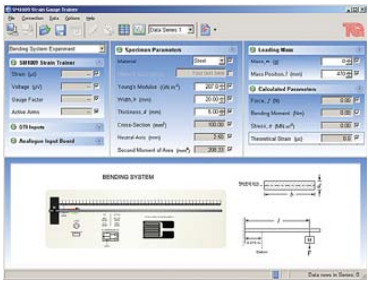
Works with VDAS®

Shows and compares how resistance strain gauges work, and how they measure strains in different structures



- Clear layout with printed graphics to help students understand how strain gauges work
- Includes electronic strain display to show all readings, and automatically calculates strain
- Fully open bridge connection with dummy resistors to allow quarter, half and full-bridge connection to show students how strain bridge connections work
- Uses strain gauges on three different, popular structures for realistic experiments





Screenshot of the optional VDAS® software

The compact Strain Gauge Trainer fits on a bench or desktop. It contains everything needed to show students how resistance strain gauges work on three different structures. It is ideal for groups of two or more students to do experiments and for classroom demonstrations.

Students use the small set of masses to load the bending and torsion systems, and the large set of masses to load the tension system. They use theory and known dimensions to calculate the stresses and strains and compare them with the strains measured by the strain gauges. Students can also connect and compare the performance of quarter, half and full-bridge strain gauge connections for each structure.

The bending system uses gauges to measure direct tensile and compression strain. The torsion system shows the use of shear/torque strain gauges. The tension system shows the use of two gauges at right angles in a 'Tee' rosette.

For more tests with the tension system, TecQuipment can supply optional tension test specimens made of different metals. Students then use their experience from other experiments to calculate and test strains in the different metals and find their values of Young's modulus. The tension system also finds and proves Poisson's ratio for tensile and compressive strains in metals.

The strain display includes a set of high-accuracy dummy strain gauge resistors (plugs) and controls. These allow the student to connect the strain gauges on the structures as quarter, half or full-bridge networks. The strain display works with and gives correct readings for all bridge connections and different gauge factors. An extra setting on the strain display works with the tension system to prove Poisson's ratio. The strain display has a socket for connection to TecQuipment's optional Versatile Data Acquisition System (VDAS®).

The trainer shows students different types of strain gauges. A clear, hard-wearing coating protects each gauge from accidental damage and the environment. Enlarged mimic diagrams on the back plate of the trainer show students what each gauge looks like, how it connects and how it fits on each structure. This helps to show students how it works.

For quick and reliable experiment results, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all the important readings on a computer (computer not included).

The user guide (supplied) shows how to use the equipment and includes theory and experiments.

Continued on next page

Strain Gauge Trainer (SM1009)
Continued from previous page

Experiments:

- Introduction to the equipment and the different bridge connections (quarter, half and full-bridge)
- Strains and stresses in a bending system
- Strains and stresses in a torsion system
- Strains and stresses in a tension system, Poisson's ratio and Young's modulus
- Tensile strains and stresses in different materials (needs optional tensile specimens) and comparison of Poisson's ratio and Young's modulus
- Comparison of different strain measurement systems and how they could measure force

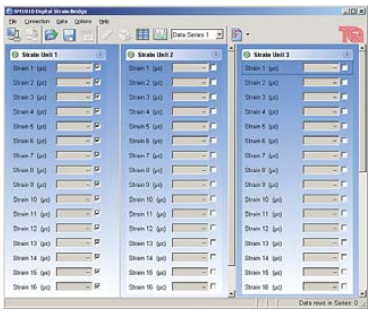
Recommended Ancillaries: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6
- Optional Tension Specimens (SM1009a) – Aluminium, brass and copper

Digital Strain Display (SM1010)

Works with VDAS®

A 16-channel instrument that connects to industry-standard strain gauges to give direct readings of strain



Screenshot of the optional VDAS® software

- Connects to industry-standard metallic foil strain gauges
- Includes two dynamic outputs for transient strain measurement
- Direct connections for half and full strain bridge connections, with internal 'make-up' resistors.
- Supplied with cable, self-locking connectors and a crimp tool to reduce connection problems
- Sixteen channels for multiple readings
- Fully programmable to match most types of strain gauges and connections
- Ideal for use with TecQuipment's Strain Gauge Kit (E19)

For use with most types of metal-foil strain gauges, the Digital Strain Display connects to most types of strain bridge connections to give direct readings of strain.

The Digital Strain Display accepts up to 16 channels from strain gauges connected in quarter, half or full bridge. The display is fully programmable to match the strain gauges and their bridge connections. The display includes precision internal 'make-up' resistors to work with halfbridge connections if needed.

For quarter bridge connection you need suitable external make-up resistors or dummy gauges (not supplied). Two channels include additional individually adjusted dynamic outputs. They can connect to suitable instruments, such as an oscilloscope or a chart recorder (not supplied) for measurement of transient strains.

Supplied with the Digital Strain Display is a reel of cable and connectors to fit the input sockets of the Digital Strain Display. Also supplied is a tool that crimps the connectors to the cable. The connectors are self-locking, reliable, secure and need no soldering.

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

The Digital Strain Display includes a user guide with full description, installation and operating instructions.

Recommended Ancillary: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

Ancillary for: Page

- Strain Gauge Kit (E19) 167

Strain Gauge Kit (E19)

Selection of resistance strain gauges and necessary accessories and consumable materials – for use with TecQuipment's SM1010 Digital Strain Display

- All items compactly housed in portable case
- Selection of strain gauges
- All expendable items required for cementing gauges included
- Reduced risk of spillage of chemicals
- Refills available (E19a)
- Step-by-step instructions supplied

This kit contains a selection of resistance strain gauges, together with all the necessary accessories associated with their application. Each kit is supplied in a PVC carrying case.

The adhesive included is a cyanoacrylate single-agent pressure-sensitive type, and therefore the complete operation of deciding where the gauge is to be placed to taking strain readings can be completed in a few minutes.

Also included are the appropriate cleaning agents, terminal strips and sundry items such as tissues, pressure-sensitive tape etc.

Primarily intended as a convenient form of general-purpose kit, it will prove particularly valuable to:

- the non-specialist, who occasionally applies strain gauge techniques but has not acquired the experience to specify individual items with confidence;
- the specialist who is required to perform strain analysis outside the laboratory at short notice; and
- teaching staff in educational establishments required to demonstrate the technique and to construct experimental apparatus.

Strain Gauge Instrumentation

TecQuipment offers the following instrumentation for monitoring and display of strain:

- Digital Strain Display (SM1010) – see page 166

Contents

30 Bonded resistance strain gauges
1 Mounting panel
1 Bottle cyanoacrylate adhesive
1 Bottle solvent
1 4H pencil and 1 ballpoint pen
1 Bottle acid cleaner and 1 bottle neutralising cleaner
1 Pack adhesive rubber strips
1 Coil brown wire and 1 coil green wire
1 Set terminal tags
1 Pair tweezers
1 Soldering iron and 1 coil solder
1 Pair scissors
1 Magnifier
1 Roll clear adhesive tape
2 Dissecting needles
1 Pack tissues
1 Pair wire strippers
1 Pack cotton applicators
1 Pack abrasive paper
1 Instruction manual

The quantities of all items are adequate for the installation of all the strain gauges.

Recommended Ancillaries:	Page
• Digital Strain Display (SM1010)	166
• Refill Kit for E19 (E19a)	

Torsion Testing Machine – 30 Nm (SM1001)

Works with VDAS®

Bench-mounted machine to allow students to do torsion tests on different materials

- Ideal for student use and classroom demonstrations
- Direct readings of torque and strain on digital displays
- Suitable for destructive tests on specimens
- Forward and reverse loading
- For use with specimens up to 750 mm long
- Wide range of test specimens
- Optional Torsiometer (SM1001a) available for tests which need increased accuracy

The Torsion Testing Machine is a compact machine, ideal for classroom demonstrations and for safe use by small groups of students. Its frame is a rigid, precision-engineered alloy box-section, supported at each end by adjustable feet. It carries two main parts:

- a 'strain head' at one end, and
- a torque reaction and measurement system at the other.

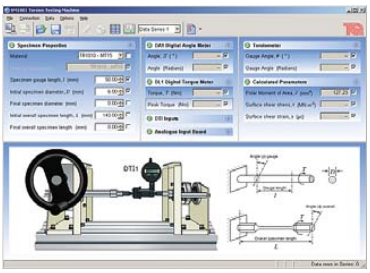
The specimens fit between the strain head and the torque reaction and measurement system.

The strain head is a 60:1 worm drive reduction gearbox, mounted on a platform. The platform can be moved and locked to any point along the frame. To apply torque, students turn a handle at the input of the gearbox. A keyway allows the output shaft of the gearbox to slide freely along its length. This allows for any change in length of the specimen during the tests and for easy insertion of specimens.

An accurate encoder measures the strain (angular movement) at the strain head. The encoder has a digital display and can connect to TecQuipment's Versatile Data Acquisition System (VDAS®).

The torque reaction and measurement system includes a torsion shaft supported by bearings. The shaft reacts on a strain-gauged load cell. A digital display shows the force measured by the load cell. The display can connect to VDAS®.

Hexagonal drive sockets hold the test specimens. The sockets fit on the gearbox output shaft and the torsion shaft. TecQuipment supplies two different sizes of drive sockets.



Screenshot of the optional VDAS® software

For safety, a clear guard protects the user when they perform destructive tests on standard-size specimens.

For increased strain measurement accuracy, use the optional Torsiometer (SM1001a). The increased accuracy is useful to help find the modulus of rigidity (shear modulus). The torsiometer has a digital display of angular movement, calibrated to the strain angle (in radians). The torsiometer can connect to VDAS®.

Experiments:

- Determination of modulus of rigidity (shear modulus) and yield strength (when used with the optional torsiometer)
- Determination of upper and lower yield stresses for normalised steel specimens
- Reversed torsion tests to demonstrate the Bauschinger effect and the effects of residual body and textural stresses on torsional strength
- Comparison of the different elastic and plastic properties of materials (optional specimens required)

Recommended Ancillaries:

	Page
Torsion Test Specimens (TR)	179
Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
Torsiometer (SM1001a) – Mechanical torsiometer for use with 6 mm diameter specimens in both the elastic and plastic regions	

Alternative Products:

	Page
Additional Torsion Testing Kit (TE16b)	160
Torsion of Circular Sections (STR6)	211
Torsion of Circular Sections Kit (ES5)	76

Rotating Fatigue Machine (SM1090)

Demonstrates the failure of materials when subjected to an alternating stress

Works with VDAS®

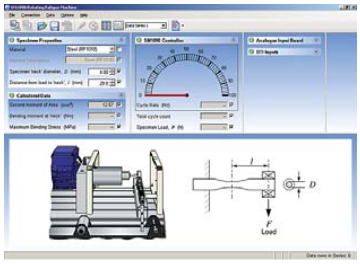
- Compact bench-mounting unit – ideal for student use and classroom demonstrations
- Demonstrates clearly both high and low cycle fatigue
- Adjustable 'dead weight' and load cell system – to apply and measure a consistent and accurate load on the test specimens
- Electronic display of cycle rate, cycle count and load
- Clear guard with interlock – allows you to see the experiment in safety
- Automatic switch stops the experiment when the specimen breaks – lets the equipment run unattended
- Includes tools and two sets of specimens of different metals

This machine demonstrates the fatigue failure of materials when subject to alternating stresses. Based on Wohler's design, it uses a motor to rotate a circular cantilever specimen with a load at it's free end.

It is in two parts: a robust main unit, and a separate control and instrumentation unit. A variable-speed drive controls the motor to allow safe and gradual increase of the cycle rate. The motor turns a compliant coupling and a precision shaft held in sturdy bearings. A collet-type chuck on the end of the shaft grips the specimen with reliable and accurate concentricity. This reduces set up time and unwanted vibration.

The specimens have a special design that creates a point of maximum stress at their midpoint rather than at their ends. This gives a definite point of failure and avoids unwanted stress concentrations.

A gimbal-mounted, self-aligning bearing holds the 'free end' of the specimen. The gimbal assembly links to a shortload arm. This applies a purely vertical load even when the specimen deflects under load. A load cell links the short load arm to a longer load arm. The longer load arm has an integral moveable dead weight that sets the load. The load cell measures the load and an electronic sensor measures shaft rotation.



Screenshot of the optional VDAS® software

The separate control and instrumentation unit shows the load, speed (cycle rate) and the number of cycles. A switch cuts power to the drive motor when the specimen fails, stopping the test. This freezes the cycle display at failure to record the result, even without the operator being present. Unlike some designs, the mechanism shuts off the motor only when the specimen actually breaks (not when the specimen is near to failure).

A removable clear guard covers the rotating parts. It has an interlock switch to stop the motor if you remove the guard.

The machine includes aluminium and steel specimens and tools to fit and remove them. TecQuipment can also supply extra specimens to work with this machine. The base of the main unit includes a handy storage area to store the tools and specimens when not in use.

The control and instrumentation unit connects to TecQuipment's Versatile Data Acquisition System (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included). This may allow you to use a networked computer and remotely monitor your tests. This could be especially useful during tests of long duration.

Note: You must contact your local computer engineer to set up suitable software (not supplied) for remote monitoring.

Experiments:

The user guide includes suggested experiments that show:

- Low and high cycle fatigue
- How to create and use Wohler (S-N) curves for various materials
- Comparison of fatigue properties of various materials

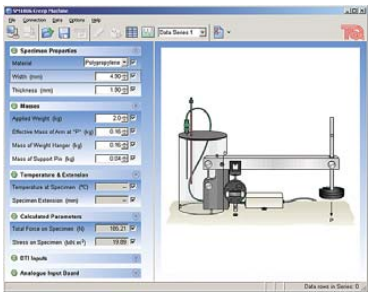
Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
• Additional specimens: RF1010 (steel), RF1020 (aluminium) and RF1030 (brass)	179

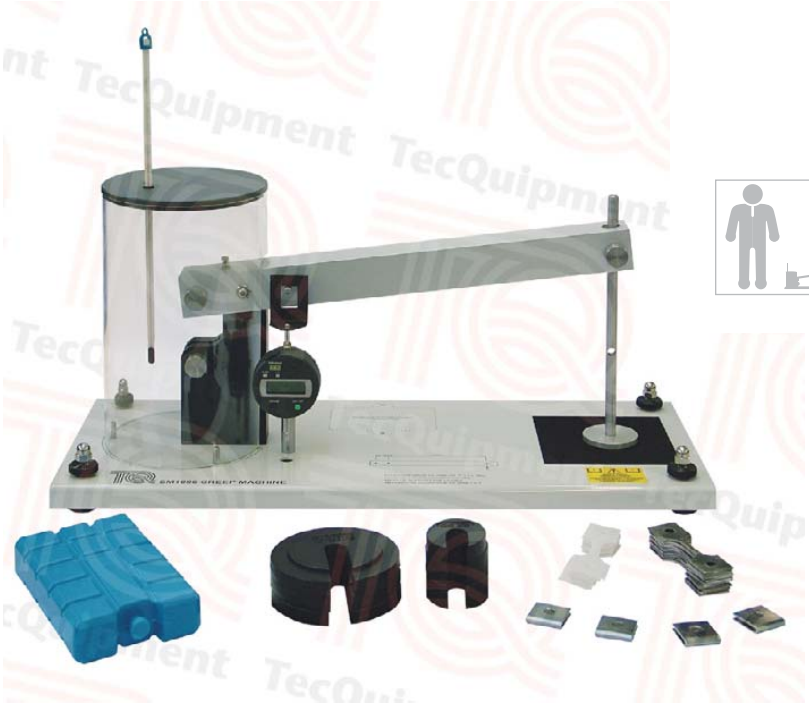
Creep Machine (SM1006)

Works with VDAS®

Bench-mounted machine which demonstrates the phenomenon of creep under different conditions and in different materials



Screenshot of the optional VDAS® software



- Ideal for student use and classroom demonstrations
- Demonstrates the three phases of creep
- Demonstrates effect of temperature on creep
- Compact and easily stored
- Supplied with weights and test specimens
- Inexpensive specimens readily available in lead and plastics

This simple machine uses specimens of lead and different plastics which creep significantly at room temperature and under low loads.

Its main part is a simple lever (load beam) with a mechanical advantage of 8:1. The load beam gives a steady and uniform tensile load. A digital indicator measures the extension (creep) of the specimen under load. To ensure correct loading of the specimen, the load beam has a ball-bearing pivot.

To apply a load, students add weights to a weight hanger and measure time and the creep. For effect-of-temperature tests, the student freezes or heats a cool-pack and places it next to the specimen. They then fit the transparent enclosure to preserve the temperature around the specimen during the test.

Students may record and plot results by hand, using a timer (not supplied) and the readings from the digital indicator and thermometer. Alternatively, the student can use TecQuipment's optional Versatile Data Acquisition System (VDAS®) to capture the data, plot charts and export data.

A user guide is supplied with the Creep Machine. The guide includes full details of the equipment, detailed experiment procedures, theory and results.

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

Note: For connection to VDAS® you need the optional Connectivity Kit (SM1006CK). The kit includes a thermocouple with in-line transmitter, and a lead to connect the digital indicator to VDAS®.

Experiments:

An extensive range of experiments may be carried out with this apparatus, including:

- The normal breaking load of a specimen over a fixed time
- Relationship between breaking load and time for lead specimens
- Time extension curves to show the three phases of creep (primary, secondary and tertiary)
- The effect of temperature on the creep rate of specimens
- Creep recovery

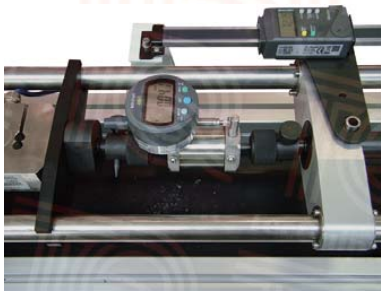
Recommended Ancillaries:

	Page
• Creep Test Specimens (CP)	179
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
and	
• Connectivity Kit (SM1006CK) for connection to VDAS®	

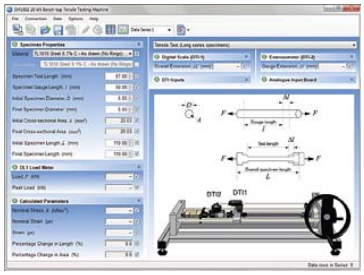
Bench-Top Tensile Testing Machine (SM1002)

Works with VDAS®

A laboratory-scale, hand-driven bench-top tensile testing machine, 20 kN capacity



Optional Extensometer (SM1002a) fitted to TL specimen



Screenshot of the optional VDAS® software

- Bench-top tensile testing machine designed for student use
- Simple hand-operated load application for safe and easy operation
- Digital displays of load and overall displacement
- Supplied with chucks for standard 20 mm^2 specimens
- Complements TecQuipment's Torsion Testing Machine (SM1001)
- Optional Extensometer (SM1002a) for Young's modulus tests
- Optional Compression Cage and Brinell Test Set (SM1002b and SM1002c)
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

A small-scale machine that fits on a bench-top and allows simple tensile tests of metal specimens up to a maximum load of 20 kN. This machine is a good partner to TecQuipment's Torsion Testing Machine (SM1001).

The machine has an extruded aluminium bed that holds the load application and load measuring mechanisms. 'Tie bars' add rigidity to the structure.

The load application mechanism includes a hand-driven worm-and-wheel gearbox, driving a lead screw with approximately 400 mm of travel. The mechanism uses ball races and self-aligning ball thrust races in the direction of loading. These low-friction bearings, with the large handwheel, allow the user to apply maximum load with minimum effort. They also give smooth and progressive operation, necessary to help the user apply a steady strain rate for best results.

The unit also has a smaller 'quick advance' handwheel that allows the user to set the distance between the chucks simply and quickly before each test.

The load measuring mechanism is a strain-gauged load cell that connects to a microprocessor-controlled digital display. The load display unit has a 'peak hold' function to register the maximum load before the specimen breaks.

A sliding digital display measures the tensile displacement (extension) over the entire movement. An optional precision extensometer (SM1002a) is available for increased strain measurement accuracy to allow measurements of the material's Young's modulus.

Both the load, extension and extensometer displays can connect to TecQuipment's optional VDAS®.

Continued on next page

Bench-Top Tensile Testing Machine (SM1002)
Continued from previous page

The tensile specimens mount between the load application mechanism and load cell, in collect chucks via ball-jointed spigots. This ensures purely axial loading.

The equipment includes collect chucks to fit both the long and short style of TecQuipment's 20 mm^2 specimens.

TecQuipment supplies a starter set of tensile specimens with the machine, made of two different carbon steel alloys (each in their as drawn and their annealed condition), brass and aluminium. TecQuipment can also supply extra specimens (contact our sales team for details). The user guide includes drawings to allow the user to make their own specimens, if needed.

For quick and reliable tests, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included).

Experiments:

- Tensile tests up to 20 kN on specimens made of different metals, to find material characteristics such as upper and lower yield strengths, tensile strength and overall extension.
- Tests of Young's modulus (E) for the specimen material (needs SM1002a and TL specimens).

Available Experiment Module:	Page
• Brinell Test Set (SM1002c)	172

Recommended Ancillaries:	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
• Extra TS and TL specimens	180
• Extensometer (SM1002a)	

Alternative Products:	Page
• Universal Testing Machine (SM1000)	173
• Materials Laboratory with Data Capture (MF40)	177
• Tensile Tester Kit (ES6)	77

Brinell Hardness Test Set (SM1002c)

Fits in the Compression Cage (SM1002b) of the Bench Top Tensile Testing Machine (SM1002) for Brinell hardness tests

- Fits in TecQuipment's Bench Top Tensile Testing Machine (SM1002) for Brinell hardness tests of different materials
- Includes specimens of different basic engineering materials
- Includes magnifier with graticule to accurately measure the indentation
- Works with TecQuipment's hardness test specimens (HTP)

An extra experiment module for the test machine, parts of this test set fit into the optional Compression Cage (SM1002b) for simple Brinell hardness tests. The set includes a magnifier with graticule (measurement scale) and test specimens made of basic engineering materials.

An essential ancillary to the Brinell Hardness Test Set, this compression cage fits into the tensile test area of the Bench-Top Tensile Testing Machine (SM1002), adapting the machine for experiments that need a compressive load.

Experiments:

- Brinell hardness tests of different basic engineering materials

Essential Base Unit:	Page
• Bench-Top Tensile Testing Machine (SM1002)	171

Essential Ancillary:

- Compression Cage (SM1002b)

Recommended Ancillary:	Page
• Extra hardness specimens (HTP)	180

Alternative Products:	Page
• Materials Laboratory with Data Capture (MF40)	177
• Brinell Indenter (SM1000e)	174

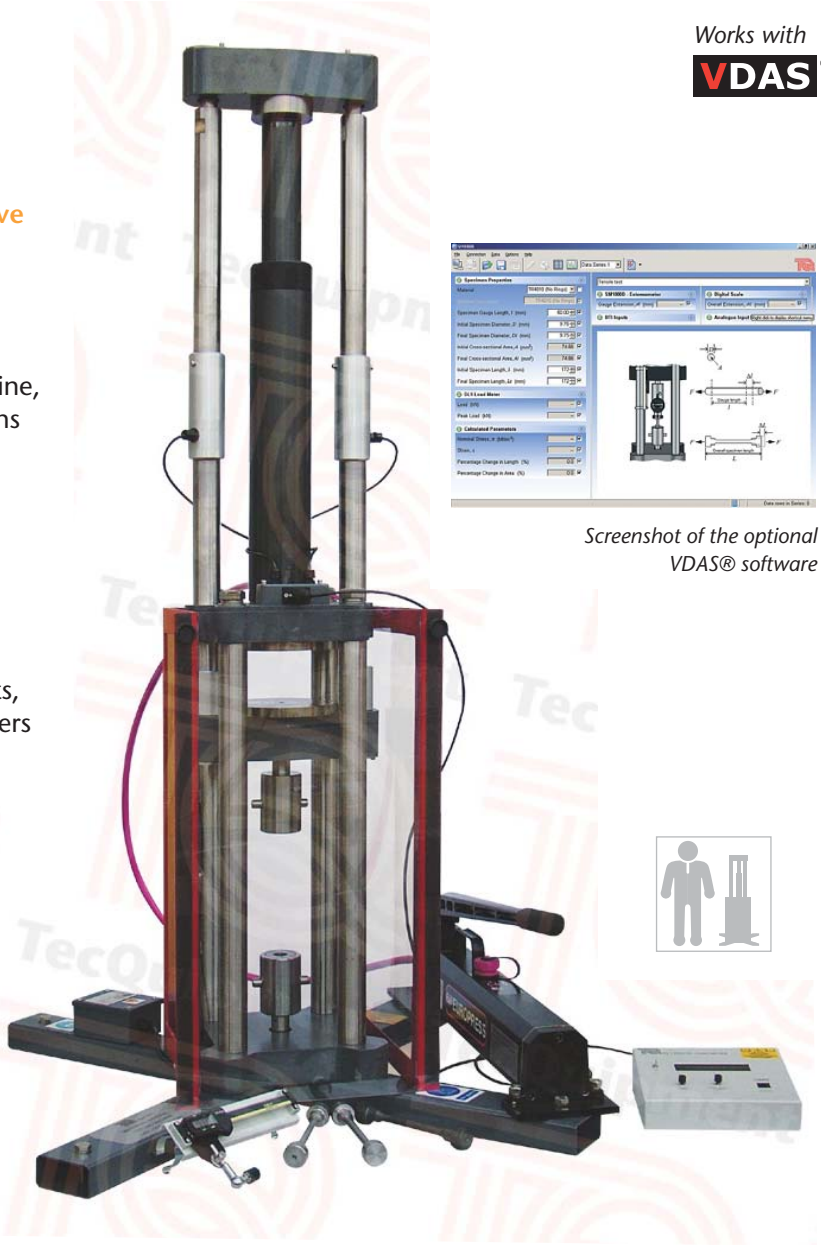
The optional Compression Cage (SM1002b) fits into the tensile test area, adapting the machine for experiments that need a compressive load.

Universal Testing Machine (SM1000)

Works with VDAS®

A compact machine for compressive and tensile tests on different materials and structures

- Compact bench-mounting machine, ideal for classroom demonstrations and student experiments
- Finds tensile properties and compressive properties of many materials and structures
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®) to log experiment results, and automatically calculate answers and create charts of your results
- Includes set of tensile test specimens of different grades of steel for comparison experiments
- TecQuipment can supply range of optional parts for experiments in beam deflection, hardness testing and spring rate and deflection
- Optional Extensometer (SM1000d) available for accurate tests to find Young's modulus of tensile specimen



Screenshot of the optional VDAS® software

The Universal Testing Machine is ideal for classroom demonstrations and for safe use by small groups of students. It fits onto any suitable strong desk or bench top, but TecQuipment offers the optional Support Table and Cupboard (SM1000a).

A steel frame with four columns supports a hydraulic ram. The ram pushes up a loading platform. The area above the loading platform is for compression tests on a wide range of materials such as wood, brick and mortar. The space below the platform is for tensile tests.

A high-impact strength clear-plastic guard protects the user during tests.

During tests, force sensors measure the load applied by the ram. A digital load meter shows the real-time force and stores the peak force. A digital displacement indicator measures and displays the vertical movement of the loading platform or part of the structure under test.

Students use the force and the dimensions of the part under test to find the applied stress. They also use the vertical displacement to find the strain.

For accurate measurements of the small changes in length of a specimen tested in its elastic region, TecQuipment offers the optional Extensometer (SM1000d). Students use this to find the Young's modulus of a tensile test specimen.

Students can use the Universal Testing Machine to test many materials, engineering parts and structures, but TecQuipment also offers optional parts for the machine. These allow students to do Brinell hardness tests on materials, and tests on coil springs, leaf springs and beams.

Included with the Universal Testing Machine is a set of different grade steel tensile test specimens. These allow students to compare the tensile qualities of steel in its 'as drawn' state and 'normalised' steel. You can order extra specimens, and the user guide includes a diagram to help you create your own tensile test specimens from suitable materials.

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 important readings on a computer (computer not included).

Continued on next page

Universal Testing Machine (SM1000)
Continued from previous page

Experiments:

- Tensile tests on different materials
- Compression tests on different materials

Available Experiment Modules:

	Page
• Brinell Indenter (SM1000e)	174
• Coil Spring (SM1000f)	175
• Beam and Leaf Spring (SM1000g)	176

Recommended Ancillaries:

	Page
• Bench-mounted version of the Versatile Data Acquisition System (VDAS-B)	6
• Support Table and Cupboard (SM1000a) – A steel-frame table with a pre-drilled work-top to accept the Universal Testing Machine. Includes a cupboard underneath.	
• Extensometer (SM1000d) – A precision sliding gauge with a digital indicator	
• Tensile test (TH) specimens	179

Alternative Products:

	Page
• Materials Laboratory with Data Capture (MF40)	177
• Bench-Top Tensile Testing Machine (SM1002)	171
• Tensile Tester Kit (ES6)	77

Brinell Indenter (SM1000e)

Fits in the Universal Testing Machine (SM1000) for Brinell hardness tests

- Fits in the compressive test area of TecQuipment's Universal Testing Machine (SM1000) for Brinell hardness tests of different materials
- Includes magnifier with graticule to accurately measure the indentation
- Includes specimens of different basic engineering materials
- Works with TecQuipment's hardness test specimens (HTP)

The Brinell Indenter (SM1000e) fits in the area above the loading platform of TecQuipment's Universal Testing Machine (SM1000).

The indenter uses a hardened steel ball in a holder that pushes down onto a suitable test specimen and creates a small dent. The hand-held magnifier has a measurement scale or 'graticule' for accurate measurement of the dent. Using the dimensions of the dent, the indenter ball and the force applied gives the Brinell hardness number of the specimen material. TecQuipment includes a set of their hardness test specimens (HTP) with this product.

Experiments

- Brinell hardness tests of different basic engineering materials

Essential Base Unit:

	Page
• Universal Testing Machine (SM1000)	173

Recommended Ancillary:

	Page
• Extra hardness specimens (HTP)	180

Alternative Products:

	Page
• Materials Laboratory with Data Capture (MF40)	177
• Brinell Hardness Test Set (SM1002c)	172

Coil Spring (SM1000f)

Fits in the Universal Testing Machine (SM1000) for compression spring tests on a coiled spring

- Fits in the compressive test area of TecQuipment's Universal Testing Machine for tests on a coiled compression spring
- Includes fittings to hold the spring securely
- Shows Hooke's Law and how to find 'spring rate' by experiment
- Heavy-duty coil spring for a more practical experience

The Coil Spring (SM1000f) fits in the area above the loading platform of TecQuipment's Universal Testing Machine (SM1000).

The spring is of the same heavy-duty design as those used in vehicle suspensions. This give students a better understanding of a 'real world' engineering component.

Two metal 'bosses' hold the spring securely in the testing machine, which compresses the spring. The digital indicator of the testing machine measures the change in spring length (displacement) for a given change in applied force. Students use the displacement and force values to find the actual spring rate and compare it with the theoretical value, based on the spring dimensions. The experiment helps to show Hooke's Law for the relationship between force and displacement on a spring.

Experiments

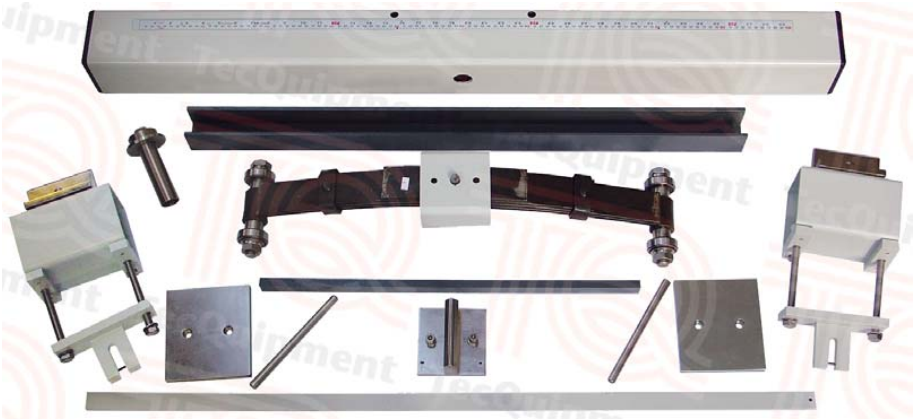
- Compression tests on a coiled spring

Essential Base Unit:	Page
Universal Testing Machine (SM1000)	173

Alternative Products:	Page
Spring Testing Apparatus (SM110)	159
Spring Tester Kit (ES19)	91

Beam and Leaf Spring (SM1000g)

Fits in the Universal Testing Machine (SM1000) for tests on bending beams and a leaf spring



- Fits in the compressive test area of TecQuipment's Universal Testing Machine for bending tests on a leaf spring and beams
- Includes two different test beams – flat steel and channel section aluminium
- Knife-edge supports for the beams, and rollers for the leaf spring for accurate results
- Heavy-duty box-section beam to support the tests
- Includes tools needed to fit the parts to the testing machine
- Heavy-duty leaf spring for a more practical experience

The Beam and Leaf Spring (SM1000g) parts fit into the compressive test area of TecQuipment's Universal Testing Machine (SM1000).

The heavy-duty box-section support beam works as the main support underneath the test beams and the leaf spring during the tests.

The spring is of the same heavy-duty design as those used in vehicle suspensions. This give students a better understanding of a 'real world' engineering component.

For beam tests, the test beam rests across two knife-edge supports fixed to the support beam. This forms a 'simply supported beam'. The testing machine applies a compressive bending force and measures the beam deflection. Students may adjust the position of the knife-edge supports to set the length of beam under test.

For leaf spring tests, the spring rests on its rollers on two flat supports fixed to the support beam. Again, the testing machine applies a compressive force and measures the leaf spring deflection.

For the beams, students use the deflection and force values to find the relationship between force and deflection for the different beams. They can then compare the results with those predicted by theory.

For the leaf spring, students use the deflection and force values to find actual leaf 'spring rate'.

TecQuipment includes the spanner and hexagon tools needed to fix the parts to the testing machine.

Experiments

- Beam bending tests on beams of different shape, material and length
- Spring rate tests on a leaf spring

Essential Base Unit:

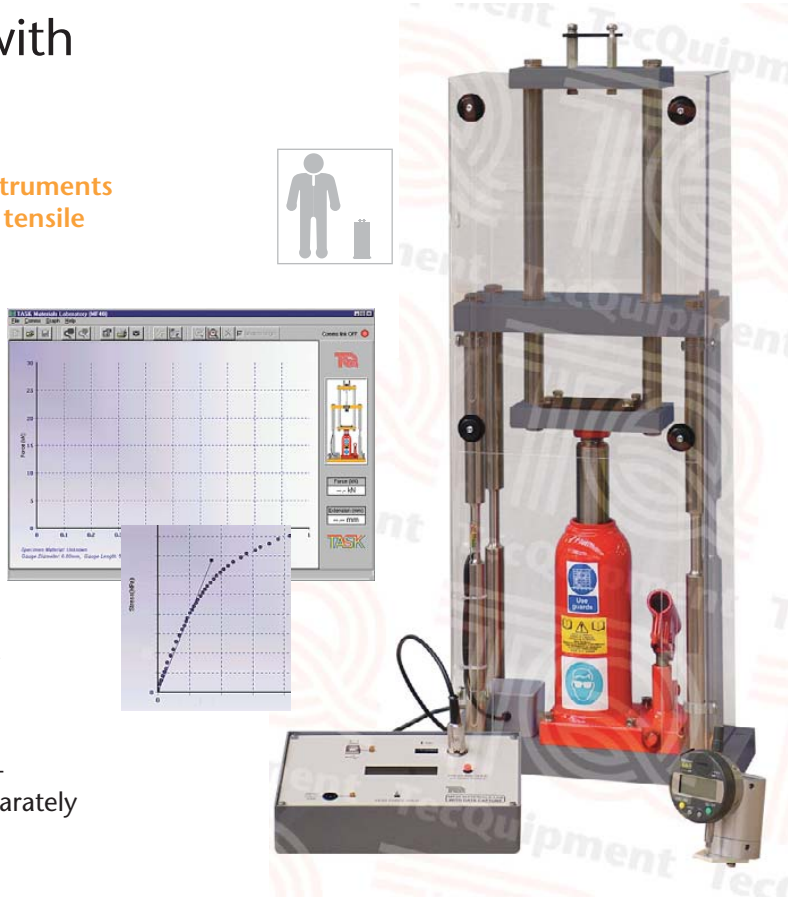
	Page
Universal Testing Machine (SM1000)	173

Alternative Products:

	Page
Beam Apparatus (SM1004)	182
Deflection of Beams and Cantilevers (STR4)	209
Deflection of Beams Kit (ES4)	75
Continuous and Indeterminate Beams (STR13)	218
Stiffness of Materials and Structures (TE16)	160
Plastic Bending of Beams (STR15)	221

Materials Laboratory with Data Capture (MF40)

A hydraulic machine with electronic instruments and software, it tests the hardness and tensile properties of materials.



- Ideal for classroom demonstrations and for use by small groups of students
- For Brinell Hardness tests and tensile tests of materials
- Includes an Extensometer for accurate tensile test results
- Electronic instruments with digital displays for easy use – includes a 'peak hold' function to store the maximum force (load) during a test
- Supplied with a set of test specimens – additional test specimens available separately
- Supports all teaching levels up to and including first year university courses
- Includes software to automatically record results and produce charts (you need a suitable computer – not supplied)

A hydraulic tensile and Brinell hardness testing machine. The machine tests any suitably shaped specimens of various materials. The material must not exceed the maximum strength or hardness limits specified. TecQuipment can also supply additional low-cost test specimens.

The main parts of the equipment are a:

- load frame,
- display unit with a digital display of force (load),
- ball indenter for Brinell hardness tests, and an
- extensometer with a digital display for tensile tests.

The load frame bolts to a bench (template included). To apply loads, students pump a handle connected to a hydraulic ram. The display unit shows force and works as an interface to send data to a suitable computer (computer not included). The extensometer has a digital display of extension and connects to the display unit for data capture.

Included is TecQuipment's MF40 software to allow students to use the equipment with a suitable computer (computer not included). The software records the data and produces detailed graphs of force against elongation and stress against strain.

Typically, students will work in small groups, with one student working the hydraulic ram, while others note readings or use the software.

To do a hardness test, students put a hardness specimen on the platen and lock the guard in position. They apply a suitable load with the ball indentor and measure the impression in the specimen. They then use an equation to calculate Brinell hardness.

To do a tensile test, students fit a specimen to the machine, attach the extensometer to the specimen, and zero the display unit and extensometer. They then lock the guard and apply loads, taking various readings, until the specimen breaks. Students use the results to find the ultimate tensile strength, the proof stress and Young's modulus of the material.

The Materials Laboratory comes with a teacher guide that shows experiment methods, information, references and tips. A student guide shows students how to do the experiments.

Experiments:

- Tensile testing to destruction and Brinell hardness testing of various specimens
- Modulus of elasticity
- Yield stress
- Ultimate tensile stress
- Percentage elongation
- Brinell hardness test and hardness number derivation

Recommended Ancillaries: Page

- Computer (not supplied by TecQuipment)
- Additional tensile test specimens of different materials: 180

  ML1MS – Mild Steel
  ML2CS – Carbon Steel
  ML3SS – Stainless Steel
  ML4AL – Aluminium
  ML5BR – Brass
- Hardness test specimens of different materials: 180

  HTPAL – Aluminium
  HTPBR – Brass
  HTPMS – Mild Steel
  HTPNY – Nylon

Alternative Products: Page

- Universal Testing Machine (SM1000) 173
- Bench-top Tensile Testing Machine (SM1002) 171
- Tensile Tester Kit (ES6) 77

Energy Absorbed at Fracture (TE15)

Compact, bench-mounting apparatus for introducing students to impact testing

- Small-scale, convenient, bench-mounting impact tester
- Ideal introduction to commonly used material impact testing techniques
- Many safety features including enclosure of all moving parts and mechanically interlocked guard
- Allows investigations into resistance of materials to crack propagation and influence of temperature on fracture properties
- Includes digital display of energy absorbed at impact, and angular position before and after impact
- Visually effective, interesting and motivating experiments
- Ideal for student group work or classroom demonstrations

A small-scale, bench-mounting, notched-bar impact tester. The equipment provides an effective, convenient and safe introduction to the principles of common impact testing techniques, enabling investigations into the resistance of materials to crack propagation and the influence of temperature on fracture properties.

The apparatus consists of a main unit, an instrumentation unit and a power supply. The main unit consists of a pendulum supported in a rigid frame by low-friction bearings. The pivot arrangement includes an angular encoder to measure the angular position of the pendulum over its range of movement. The apparatus is fully enclosed with an interlocked guard covering all moving parts. Adjustable feet on the base of the unit enable accurate levelling of the equipment.

To perform a test, students raise the pendulum to the start position, where it is held by an electromagnet. They then clamp a specimen in a holder, which safely slots into the base of the frame at the lowest point of the pendulum swing. The separate instrumentation unit controls the release of the pendulum and measures and displays its angular position before and after the impact. The unit also directly displays energy absorbed by the impact in Joules.

The equipment is designed to fracture plain carbon steel, brass, copper or aluminium specimens. Lengths of each of these materials are included, along with a hacksaw and cutting jig to enable cost-effective and convenient manufacture of test specimens. The cutting jig ensures repeatability of the notch position in each specimen and therefore valid comparisons of test results.

As well as comparing impact properties of each material, by heating and cooling specimens before testing, students can investigate the brittle-ductile transition in steel.

Note: Separate heating and cooling vessels (not included) are required for tests at different temperatures. A pair of specimen tongs is included for safe handling of hot or cold specimens.

The equipment is supplied with a comprehensive user guide which includes equipment description and technical specification, installation and assembly, background theory, experiment procedures with results, and maintenance instructions.

Experiments:

- Introduction to the principles of common impact testing methods, such as Izod and Charpy tests
- Investigations into the resistance of materials to crack propagation
- Influence of temperature on the fracture properties of materials

Recommended Ancillary:

- Heating vessel and cooling vessel for specimens (not supplied by TecQuipment)

Tensile Test Specimens (TH)

Tensile test specimens of different grade steel for use with TecQuipment's Universal Testing Machine (SM100 or SM1000)

TH4010: 0.1% carbon steel, as drawn. To British Standard Specification 220M07. Has no identity rings.

TH4015: 0.1% carbon steel, normalised at 900°C. To British Standard Specification 220M07. Has one identity ring.

TH4035: 0.4% carbon steel, normalised at 860°C. To British Standard Specification 212M36. Has two identity rings.

Charpy and Izod Test Specimens (ZC)

Izod and Charpy test specimens of different grades of steel for use with suitable Izod and Charpy impact test machines

ZC1010 (Izod): 0.4% carbon steel, normalised at 860°C. To British Standard Specification 080M40. Three notches, Code Z.

ZC1040 (Izod): 0.4% carbon steel, oil quenched 840°C and tempered at 400°C. To British Standard Specification 080M40. Three notches, Code Z4.

ZC1070 (Izod): 0.4% carbon steel, oil quenched 840°C and tempered at 680°C. To British Standard Specification 080M40. Three notches, Code Z7.

ZC3010 (Charpy): 0.4% carbon steel, normalised at 860°C. To British Standard Specification 080M40. One notch, Code Z.

ZC3040 (Charpy): 0.4% carbon steel, oil quenched 840°C and tempered at 400°C. To British Standard Specification 080M40. One notch, Code Z4.

ZC3070 (Charpy): 0.4% carbon steel, oil quenched 840°C and tempered at 680°C. To British Standard Specification 080M40. One notch, Code Z7.

Creep Test Specimens (CP)

Creep test specimens of different materials for use with TecQuipment's Creep Machine (SM106 or SM1006)

CP1010: Lead, to British Standard BS1178

CP1020: Polypropylene

CP1025: Nylon 66 (unfilled)

CP1030: Unplasticised PVC

Torsion Test Specimens (TR)

Torsion test specimens of different metals for use with TecQuipment's Torsion Testing Machine (SM1 or SM1001)

TR1010: 0.1% carbon steel, as drawn. To British Standard Specification 220M07. Code MT15

TR1011: 0.1% carbon steel, normalised at 900°C. To British Standard Specification 220M07. Code MT15N

TR1020: 0.4% carbon steel, as drawn. To British Standard Specification 212M36. Code MT40

TR1021: 0.4% carbon steel, normalised at 860°C. To British Standard Specification 212M36. Code MT40N

TR1040: Half-hard brass. 60% copper, 40% zinc. To British Standard Specification CZ121. Code MTX

TR1050: Cast iron, grade 180. To British Standard BS1452. Code MTC1

Rotating Fatigue Specimens (RF)

Fatigue test specimens of different metals for use with TecQuipment's Rotating Fatigue Machine (SM1090)

RF1010: Mild Steel

RF1020: Aluminium

RF1030: Brass

Tensile Test Specimens (TL and TS)

Long (TL) and short (TS) tensile test specimens of different metals for use with TecQuipment's Tensile Testing Machine (SM1002). Will also fit Hounsfield or Monsanto tensometer.

TL1010 and TS1010: 0.1% Carbon Steel. As drawn. To British Standard Specification 220M07 or 230M07. 0 rings.

TL1011 and TS1011: 0.1% Carbon Steel. Normalised at 900°C. To British Standard Specification 220M07 or 230M07. 1 ring.

TL1020 and TS1020: 0.4% Carbon Steel. As drawn. To British Standard. Specification 080M040. 2 rings.

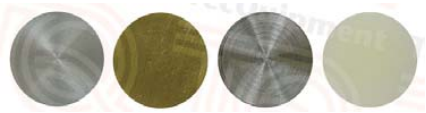
TL1021 and TS1021: 0.4% Carbon Steel. Normalised at 860°C. To British Standard Specification 080M040. 3 rings.

TL1030 and TS1030: Aluminium 2011–T3. 0 rings.

TL1040 and TS1040: Half hard Brass. To British Standard Specification CZ121. 0 rings.

Hardness Test Specimens (HTP)

Hardness test specimens of different materials for use with the Materials Laboratory with Data Capture (MF40), Bench-Top Tensile Testing Machine (SM1002) and Brinell Indenter (SM1000e)



HTPAL: Aluminium (6026-T9)

HTPBR: Brass (CZ121/CW614N)

HTPMS: 0.1% Carbon steel (230M07)

HTPNY: Nylon 6

Tensile Test Specimens (ML)

Tensile test specimens of different materials for use with the Materials Laboratory with Data Capture (MF40)

ML1MS: Mild steel – specification EN1A or 230M07

ML2CS: Carbon steel – specification EN8 or 080M40

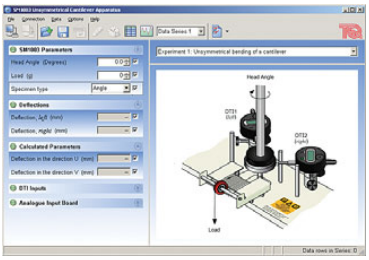
ML3SS: Stainless steel – specification SAE303

ML4AL: Aluminium – specification 2011-T3

ML5BR: Brass – specification CZ121

Unsymmetrical Cantilever Apparatus (SM1003)

Examines and displays bending of an unsymmetrical cantilever



Screenshot of the optional VDAS® software

Works with VDAS®

- Ideal for student use and classroom demonstrations
- Bench-mounting apparatus
- Self-contained – needs no other parts
- Explains 'shear centre' and the use and construction of Mohr's circle
- Supplied with structural and stress analysis textbook with full theory
- Supplied with set of different specimens

The Unsymmetrical Cantilever Apparatus allows students to load a cantilever and accurately measure its deflection in any coplanar direction.

Students mount a test beam vertically in a frame. The top of the test beam fixes to a holding ring that can rotate through 360 degrees.

Students apply a horizontal load in set increments (weights included) to the bottom (free end) of the test beam. Digital indicators measure the test beam deflections in two directions, at right-angles to each other. Each indicator has a socket for connection to TecQuipment's optional Versatile Data Acquisition System (VDAS®) and a suitable computer (computer not included).

Students apply loads to the beam in set increments and record its displacement. Students can then rotate the beam to another position and repeat the experiment. This allows students to use the Mohr's circle method to find the principal second moments of area of each section.

To find the shear centre of a test beam, students attach a cross-piece to the free end. The cross-piece allows students to apply loads at different positions across and outside the section of the cantilever.

The equipment includes a user guide which describes how to assemble and use the equipment, with practical theory, experiment procedures and typical results. The textbook, 'Structural and Stress Analysis' by T H G Megson, is included with the equipment.

For quick and reliable tests, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included).

Experiments:

Investigations into bending of unsymmetrical cantilevers, including:

- Vertical and horizontal displacement measurement for varying angles of applied load
- Demonstration that maximum and minimum vertical deflection occurs when horizontal deflection is zero
- Use of Mohr's circle
- Experimental and theoretical determination of the principal moments of area of test sections
- Location of shear centre of each section

Recommended Ancillaries: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

  and

- Connectivity Kit (SM1003CK) for connection to VDAS®

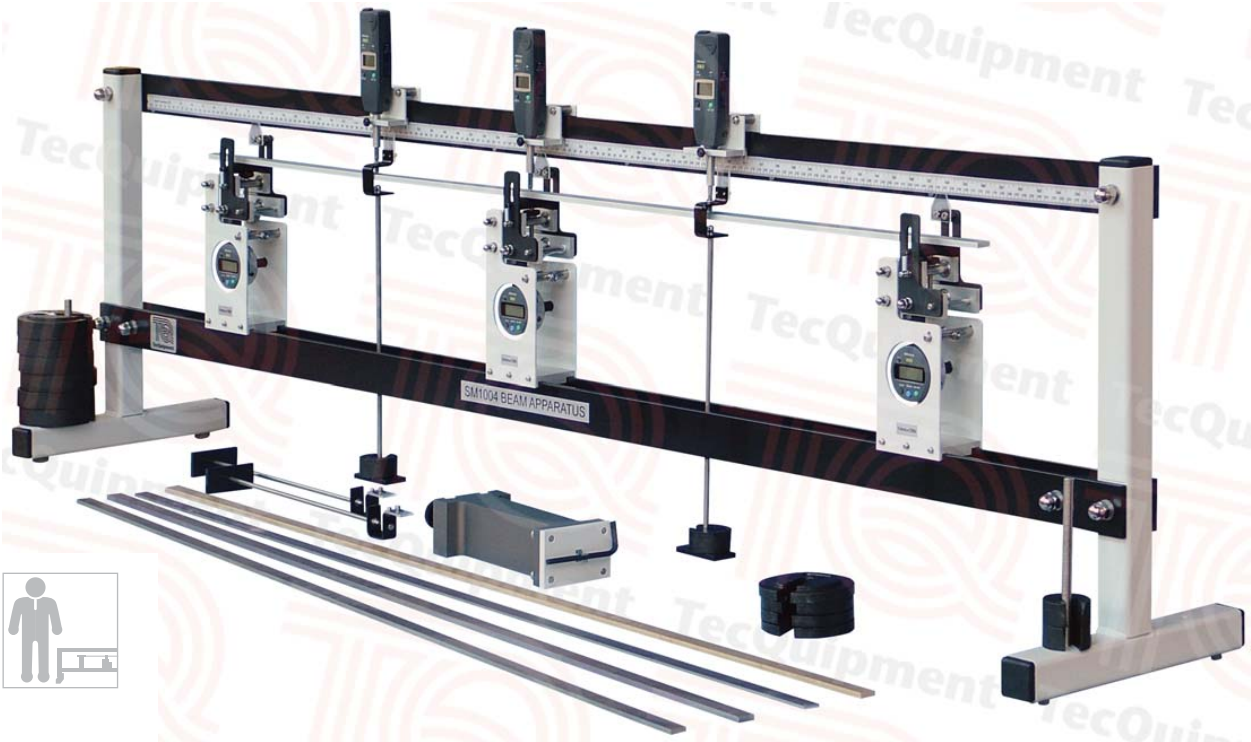
Alternative Product: Page

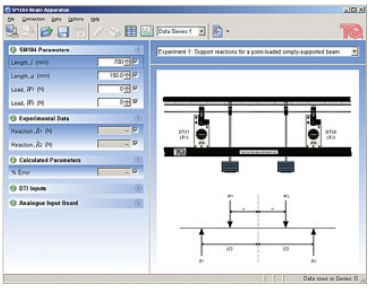
- Unsymmetrical Bending and Shear Centre (STR7) 212

Beam Apparatus (SM1004)

Works with VDAS®

Examines the deflection and forces on different types of beams for a wide range of supports and loads





Screenshot of the optional VDAS® software

- Ideal for student use and classroom demonstrations
- Includes textbook with full theory
- Self-contained – needs no other parts
- Made for maximum flexibility and ease of use for extensive range of experiments
- Simply supported and cantilever beam tests with up to four supports with any loading
- Three load cells with digital indicators measure reaction forces or act as rigid sinking supports
- Precision digital indicators for accurate deflection measurements

The Beam Apparatus allows an extensive range of experiments to cover virtually all course requirements relating to bending of beams. The basic unit provides facilities for supporting beams on simple, built-in and sinking supports, applying point loads, and measuring support reactions and beam deflections. It includes five different test beams. A pack of ten additional specimen beams (SM1004a) is available for further experiments.

The Beam Apparatus can be used for an almost limitless number of experiments ranging from determination of the elastic modulus for beams of different materials, through to studies of continuous beams with any loading. Great care has been taken at the design stage to ensure maximum flexibility and ease of use.

The main frame of the apparatus consists of an upper cross-member carrying graduated scales and two lower members bolted to T-legs to form a rigid assembly. The three load cells and cantilever-support pillar slide along the lower members and can be clamped firmly in any position. The load cells have direct digital readout and each is fitted with a hardened steel knife edge which can be adjusted to set the initial level or to simulate a sinking support. Locking pins can convert each load cell to a rigid support when required.

The cantilever support is a rigid pillar with a sturdy clamping arrangement to hold the beams when built-in end

conditions are required. Four weight hangers and a set of weights are supplied to apply static loads. Three digital indicators measure all beam deflections. The indicators mount on magnetic carriers that slide along the upper cross-member. The indicators, carriers, load cells and weight hangers all have cursors that register on the scale (located on the upper cross-member) to ensure easy, accurate positioning. All digital indicators and load cells have sockets for connection to TecQuipment's optional Versatile Data Acquisition System (VDAS®).

The standard test beams are in three thicknesses and include three different materials. They are suitable for the complete range of experiments covering different loading and support configurations. The optional set of beams provide for experiments on different types of beam including compound, channel and non-uniform beams of various materials.

The Beam Apparatus comes complete with the laboratory handbook 'Structural and Stress Analysis' by T H G Megson, and a comprehensive user guide.

For quick and reliable tests, TecQuipment's optional VDAS® gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer (computer not included).

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
and	
• Connectivity Kit (SM1004CK) for connection to VDAS®	
• Additional Specimen Beams (SM1004a)	

Alternative Products:

	Page
• Stiffness of Materials and Structures (TE16)	160
• Beam and Leaf Spring (SM1000g)	176
• Deflection of Beams and Cantilevers (STR4)	209
• Continuous and Indeterminate Beams (STR13)	218
• Deflection of Beams Kit (ES4)	75

Experiments:

- Verification of the bending equation
- Determination of flexural rigidity and elastic modulus (Young's modulus)
- Verification of static equilibrium
- Deflection of beams on two simple supports with point loads
- Reciprocal properties for loads and deflection
- Simple and propped cantilevers with any loading
- Continuous beams – statically indeterminate cases for simply supported beams and cantilevers on more than two supports with any loading (including measurement of unknown reactions)
- Simply supported and cantilever beams with sinking supports

With the SM1004a Specimen Beams, these additional experiments can be done:

- The effects of material and section shape on flexural rigidity
- Bending characteristics of a brass/steel compound beam, with and without shearing connection between the two layers
- Equivalent sections – characteristics of a metal-faced wooden beam
- Deflections on a non-uniform (tapered) beam or cantilever

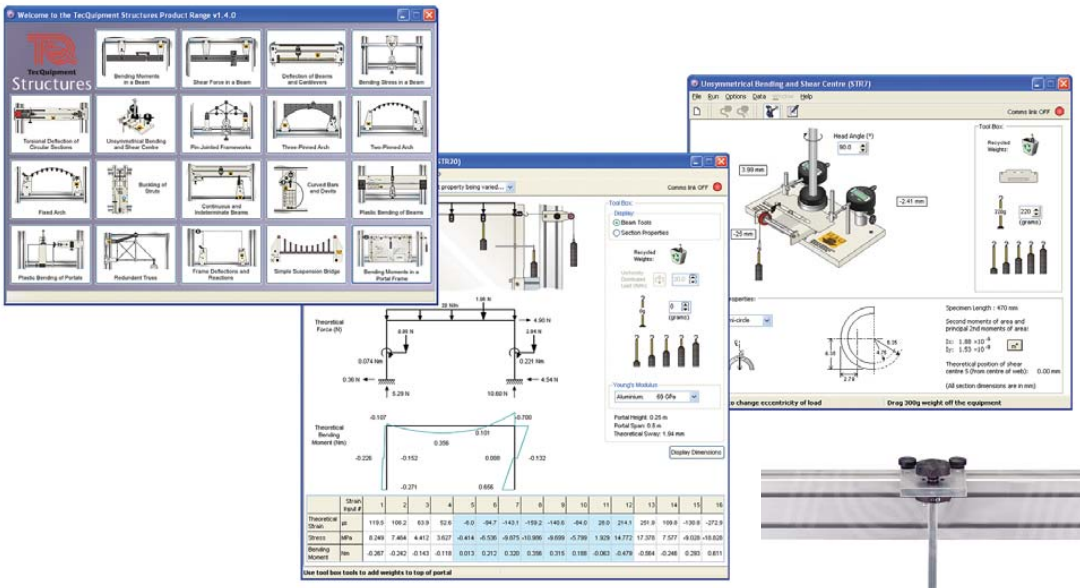
Have you seen our Structures range?

This cost-effective and flexible teaching system consists of 19 different desk-mounting hardware experiment modules, supported by full automatic data acquisition, including accurate simulation software.

The equipment uses the latest developments in educational design to teach many structural engineering principles, from simple bending moments and equilibrium to indeterminate structures and plastic collapse.

Turn to **Section 9** to see the full range.

Continuous and Indeterminate Beams (STR13)



You can see for yourself our highly realistic simulation software by requesting a copy of our **FREE** demonstration CD.

Unsymmetrical Bending and Shear Centre (STR7)

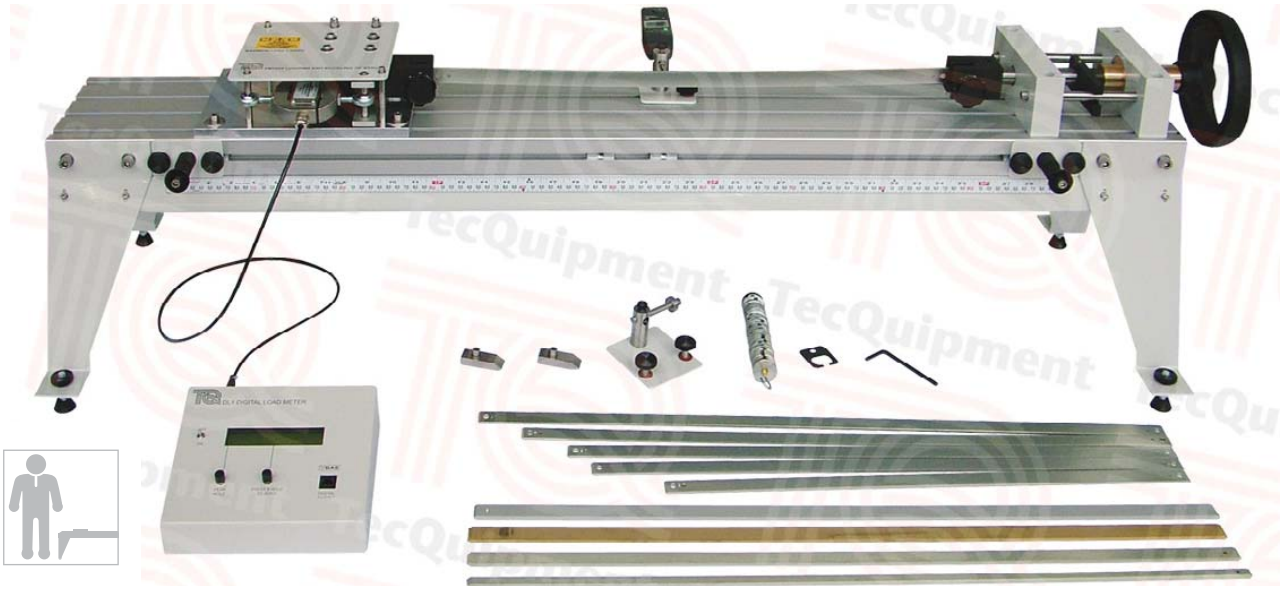
Visit our website at **www.tecquipment.com** or use the contact details below.

T +44 115 972 2611
F +44 115 973 1520
W www.tecquipment.com
E info@tecquipment.com

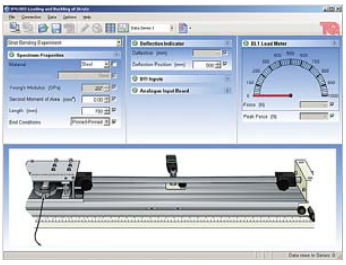
Loading and Buckling of Struts (SM1005)

Works with VDAS®

Tests different types of struts and shows how they deflect under load



- Full analysis of buckling (crippling) of struts
- Can also test struts as simply supported beams – to extend experiments and find flexural rigidity of the struts
- Buckling tests cover pinned and clamped (encastre) ends for various strut lengths and cross sections
- Special end fittings allow tests with eccentric loading
- Electronic load cell and digital display for accurate measurement of end load
- Digital dial gauge measures lateral deflection at any point along a strut
- Range of ten struts supplied as standard
- Extra specimen struts available for more advanced experiments



Screenshot of the optional VDAS® software

The Loading and Buckling of Struts apparatus allows tests on a full range of struts. It shows load and deflection characteristics and buckling loads for various strut lengths, cross-sections and end conditions. It also allows studies of the effect of eccentric loading. An optional set of extra specimens (SM1005a) allows extra tests to show students some of the more complicated problems found in strut design.

The main part of the apparatus is a precision-engineered, rigid aluminium base, with legs and levelling feet. At one end is a loading device which uses a screw to apply loads to the struts. The screw is in fixing blocks with bearings to give precise and easy load application.

At the opposite end is the load-measuring device. This is a precision mechanism that resists the bending moments produced by the struts as they deflect, and transmits the pure axial force to an electronic load cell. This gives an accurate measurement of buckling load. A digital load meter (DL1, included) shows the load.

Students may move the load-measuring device along the base to work with struts of different lengths and fixing conditions. A digital dial indicator fixed to a movable slide measures the deflected shapes of the struts. A scale shows the position of the indicator. The digital load meter and the digital dial indicator can connect to TecQuipment's optional Versatile Data Acquisition System (VDAS®).

Holders are at both the loading and load-measuring ends. They allow students to create any combination of 'pinned' or clamped-end conditions for the strut under test.

Continued on next page

Strut Apparatus (SM1005)
Continued from previous page

Supplied is a set of special end fittings for tests with various eccentricities to show the effect of eccentric loading. The equipment includes a lateral pull attachment for students to apply light biasing loads, or larger side loads, as needed.

Students can also set up the apparatus to examine flexural rigidity and general beam deflection theory. The standard set of ten struts (included) covers the primary variables of length, cross-section and end conditions. The optional set of additional struts (SM1005a) includes struts of different materials, typical engineering sections, and two special struts. The two special struts show how buckling loads may be lower than the ideal values because of two reasons:

- Flexure of the end fixings
- Imperfect shearing connections between the parts of a compound strut

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 important readings on a computer (computer not included).

Experiments :

With the standard set of ten specimens:

- Demonstration of buckled (crippled) shape of struts with different end conditions
- Determination of load/deflection curves and buckling loads for struts of different lengths and cross-sections, with any combination of 'pinned' or clamped end fixings
- Investigation of the effects of side load and eccentric loading on strut buckling characteristics
- Flexural rigidity and buckling loads for struts of different materials
- The use of Southwell's method to estimate buckling loads and strut eccentricities from experimental results
- Determination of flexural rigidity and comparison with calculated values
- Deflections of a simply supported beam with a point load including the verification of general deflection formulae, and the deflected shape.

With the SM1005a optional set of additional struts:

- Flexural rigidity and buckling loads for struts of a further range of different materials
- Tests on typical engineering sections (circular, angle, channel and irregular section specimens), the significance of the neutral axes, combined bending and twisting due to eccentric loading
- The effect of flexibility in end fixings
- Tests on a compound strut with imperfect shearing connections between the two components

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
• Set of Additional Struts (SM1005a)	

Alternative Product:

	Page
• Buckling of Struts (STR12)	217

7 Renewable Energy

“ The TecQuipment teaching solutions and scalable teaching equipment has allowed the Thermal Engineering and Energy Department to provide training up to Masters degree level with continuous and undeniable quality. ”

Prof Jean-Noël Blanchard, IUT Orleans, France

Renewable Energy

Products for the future

TecQuipment recognises the importance of products that demonstrate future technologies. The Renewable Energy range covers three key methods used to harness and convert solar energy. These include:

- Photovoltaic (conversion to electricity)
- Focusing (to a collector)
- Flat plate collection (direct water heating)

Automatic data acquisition VDAS®

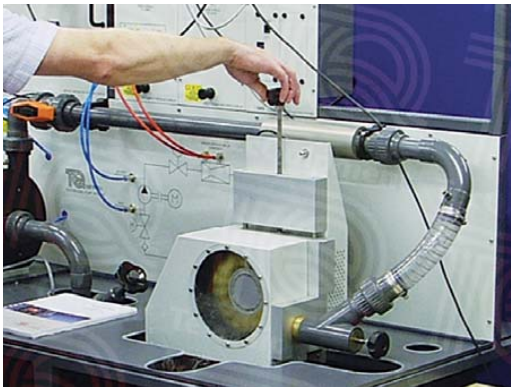
All the Renewable Energy products work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 1** for more details.

KEY FEATURES AND BENEFITS:

- **Photovoltaic, focusing and flat plate energy collection: demonstrate three key methods used in harnessing solar energy.**
- **Automatic data acquisition: monitoring solar energy collection can lead to long-term experiments, making automatic data acquisition a valuable tool.**
- **Safe and easy set up: low temperatures, safe connections and simple hand-operated controls allow you to set up an experiment safely and quickly.**

Check out our other ranges:

Other TecQuipment products link directly to renewable energy. For example, our **Modular Fluid Power** products (pages 141–156) includes turbines to harness the energy in water. The **Aerodynamics** (Section 2) and **Fluid Mechanics** (Section 5) ranges include experiments to show how shapes affect air and water flow. These are essential tools for engineers when designing wind or water energy systems.

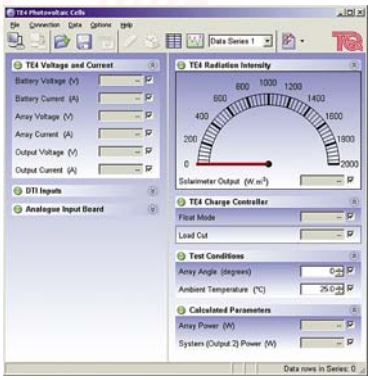


Photovoltaic Cells (TE4)

Works with VDAS®

Shows students the performance and use of photovoltaic cells to capture solar energy

- Demonstrates the performance of high-efficiency photovoltaic cell array and battery storage system
- Includes solarimeter, charge controller and control module with digital displays and d.c. outputs
- One of several TecQuipment products that show use of renewable, environment-friendly solar energy
- Supplied with both high and low-rated batteries to allow students to investigate charge and discharge cycle of the system in a typical laboratory session as well as longer cycles
- Includes three different types of electrical load
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software



Screenshot of the optional VDAS® software

Shows students how well a photovoltaic cell array and battery storage system works. It uses a commercially available solar panel made from high-efficiency cells.

The solar panel is on a wheeled, lightweight frame that allows adjustment of the panel angle relative to the sun. A solarimeter on the frame measures incident radiation. The panel recharges a choice of two batteries through a charge controller. The charge controller recharges the battery at the correct rate of charge without damage to the battery. The frame holds a high-performance, deep-cycling battery in a storage box. The equipment also includes a second lower-rated battery. This allows students to examine the charge and discharge cycle of the system in a typical laboratory session.

A control module contains the charge controller. The control module has digital displays and shows the panel and battery storage performance. It has indicators to show when the charge controller is in float mode and load cut mode. It also has two power outputs.

Output 1 allows direct connection of external loads to the solar array, for direct load experiments. Output 2 allows connection through the charge controller to show how it works with a load and a battery.

A separate loading unit includes:

- a variable resistive load to show battery performance;
- an inverter to show practical conversion to a.c. voltages;
- four switchable lamps to show a practical application.

The equipment works with TecQuipment's Versatile Data Acquisition System (VDAS®). This allows accurate, real-time data capture, monitoring, display, calculation and charting of all the important readings on a suitable computer (computer not included).

Experiments:

- Performance of the solar panel
- Demonstration of float mode
- Demonstration of load cut

Recommended Ancillary:

	Page
Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Alternative Products:

	Page
Focusing Solar Energy Collector (TE38)	190
Flat-Plate Solar Energy Collector (TE39)	191

Focusing Solar Energy Collector (TE38)

Works with VDAS®

Shows how a focusing solar energy collector works and allows students to study its performance

- Mobile, self-contained focusing solar energy collector specially designed for educational use
- Shows principles, advantages and limitations of focusing solar energy collectors
- One of several TecQuipment products that show use of renewable, environmentally friendly solar energy
- Can connect to TecQuipment's optional Versatile Data Acquisition System (VDAS®) for automatic data acquisition
- Includes four different sizes of collector for studies of different energy concentration ratios
- Removable transparent cover allows students to compare properties of shielded and unshielded collectors

Screenshot of the optional VDAS® software

A focusing solar energy collector on a mobile frame. Specially designed for educational use, the apparatus shows the principles, advantages and limits of this method of capturing solar energy.

It is a highly polished stainless-steel parabolic reflector, supported on trunnion bearings on a turntable. By adjusting the horizontal and vertical position of the reflector, students focus solar energy onto an energy collector. The energy collector is a copper cylinder with an embedded thermocouple which measures the cylinder temperature. To enable students to compare different concentration ratios, TecQuipment supplies four different sizes of energy collector. Also supplied is a removable transparent cover for the collector, so students can study the properties of shielded and unshielded collectors.

Attached to the reflector carrier is a solarimeter (pyranometer) which measures the incident solar radiation. An extra thermocouple measures ambient temperature for reference. The cylinder thermocouple, the solarimeter and the ambient temperature thermocouple connect to a display unit. The display unit shows ambient temperature, collector temperature and solar intensity from the solarimeter. It also has a socket for connection to TecQuipment's optional Versatile Data Acquisition System (VDAS®).

The equipment works with TecQuipment's bench-mounted version of the Versatile Data Acquisition System (VDAS-B, not included). This allows accurate, real-time data capture, monitoring, display, calculation and charting of all important readings on a suitable computer (computer not included).

Experiments:

- Demonstrations of the performance, advantages and limitations of a focussing solar energy collector
- Understanding the effective use of the direct component of solar radiation
- Measurement of the efficiency of the collector with and without a transparent cover
- Measurement of the maximum possible energy collector temperature

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6
• Stopwatch (SW1)	94

Alternative Products:

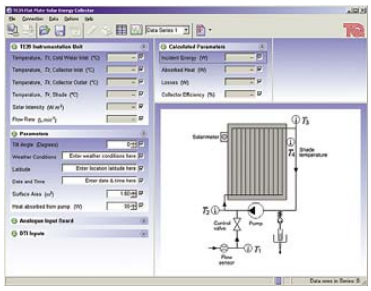
	Page
• Photovoltaic Cells (TE4)	189
• Flat-Plate Solar Energy Collector (TE39)	191

Flat-Plate Solar Energy Collector
(TE39)

Works with VDAS®

Shows how a flat plate solar energy collector works and allows students to study its performance

- Educational flat plate solar energy collector with full instrumentation
- Allows students to investigate the effective use of a renewable, environment friendly energy source
- Purpose designed and built solar panel for high quality
- One of several TecQuipment products that show the use of renewable, environment-friendly solar energy
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)
- Includes digital display of flow, radiation intensity and temperatures at different points throughout the apparatus



Screenshot of the optional VDAS® software

This equipment shows how a flat plate solar energy collector works. It allows students to measure and find the efficiency and heat losses of a flat plate solar energy collector.

The collector has a purpose designed and built panel for quality and reliability. The panel has a thin sheet metal absorber backed by riser tubes and insulating material to reduce heat loss to the rear. A box with a clear cover encloses the panel, forming the collector. A sturdy mobile frame supports the collector. To allow users to adjust its angle, the frame has a hinge.

Cold mains water enters the collector. Sunlight energy heats the water in the collector. The heated water returns to a pump that mixes the heated water with the incoming cold water. A pressure sensitive valve allows the heated water to leave the equipment at the same rate as cold water enters it. A flow transducer measures the water flow rate and a solarimeter (or pyranometer) measures incident radiation. Thermocouples measure the water temperature at all the important points, and the shade temperature.

The separate Instrumentation Unit displays the temperatures from the thermocouples, the flow rate and the radiation intensity. It includes a switch to control the pump and a socket for connection to TecQuipment's optional VDAS®.

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

To compare efficiencies, the Flat Plate Solar Energy Collector is an ideal companion to TecQuipment's Focusing Solar Energy Collector (TE38).

Experiments:

- Efficiency of the collector
- Efficiency and heat losses

Also, students can do further experiments on the effect of collector angle.

Recommended Ancillary: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

Alternative Products: Page

- Photovoltaic Cells (TE4) 189
- Focusing Solar Energy Collector (TE38) 190

TecQuipment Document Packs

– making it clear for the customer

We send document packs with all TecQuipment manufactured products.

Document packs contain:

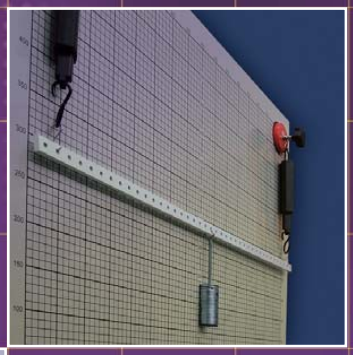
- **Packing contents list** (PCL) – shows you what parts we pack with the product.
- **Test certificate** – shows you that we've thoroughly tested the product before we send it to you.
- **User guides*** and **safety information** – show you how to use the product safely and learn how it works.

Some packs also include **compact discs** (CD-ROMs) with TecQuipment software (for example, VDAS®).

At TecQuipment we continually improve our user guides so they include pictures of the products, clear diagrams and plain English text. This helps you to understand the product more clearly. Where necessary, the guides include theory, suggested experiments and typical results to help students understand what the product teaches.

*Some products may not need user guides, as their details are already shown in their parent product, for example the optional pumps on the MFP103.

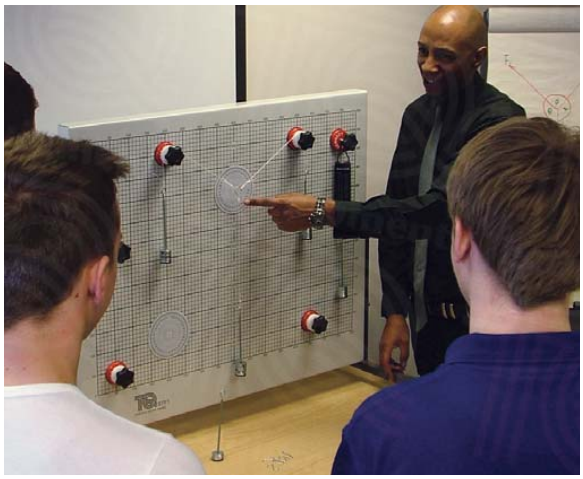
Statics Fundamentals



“ The School of Engineering at the University of Lincoln is the first new Engineering School in the UK for more than 20 years and collaborates closely with industry to produce graduates who are not only academically excellent, but ‘industry ready’.
TecQuipment products form the practical basis of our Static Mechanics and Dynamic Mechanics curriculum and help to demonstrate fundamental aspects of thermodynamic theory to our undergraduate students. ”

Daniel Stones, Technician, University of Lincoln

Statics Fundamentals



KEY FEATURES AND BENEFITS:

- **Flexibility: share one work panel between experiments kits, or one work panel for each kit.**
- **Hands-on: large tactile parts for students to fit and adjust.**
- **Highly visual: for classroom demonstrations or groups of students.**

Flexible, modular and expandable

Each experiment kit fits onto a common work panel. This allows you to choose whether to have just one work panel shared between all four kits or a work panel for each kit.

Visual and hands-on

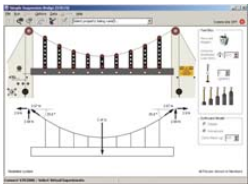
The Statics Fundamentals products continue TecQuipment's core value of creating 'hands-on' equipment. Students or teachers assemble and adjust the parts for highly visual and tactile experiments.

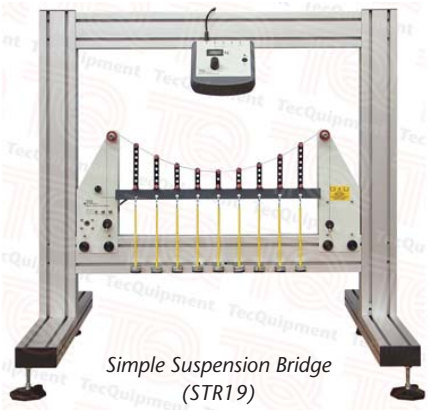
Check out our other ranges:

The **Structures** range is a cost-effective and flexible teaching system consisting of 19 different desk-mounting hardware experiment modules, supported by full automatic data acquisition, including accurate simulation software.

The equipment uses the latest developments in educational design to teach many structural engineering principles, from simple bending moments and equilibrium, to indeterminate structures and plastic collapse.

Turn to Section 9 to see the full range.





Simple Suspension Bridge (STR19)

Our **Engineering Science** range is a modular system of experiment kits that covers many of the underlying mechanical engineering topics that students need to be familiar with, including:

- **Materials testing**
- **Forces and moments**
- **Simple machines**
- **Vibration**
- **Mechanisms**
- **Friction**

The system is suitable for use on courses from foundation level up to hands-on technology familiarisation programmes at post-graduate level.

Turn to Section 4 to see the full range.

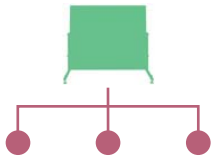
Forces Kit (ES2)

Statics Work Panel (STF1)

Work panel for use with TecQuipment's Statics Fundamentals (STF) range

MODULAR SYSTEM

Essential Base Unit (STF1)



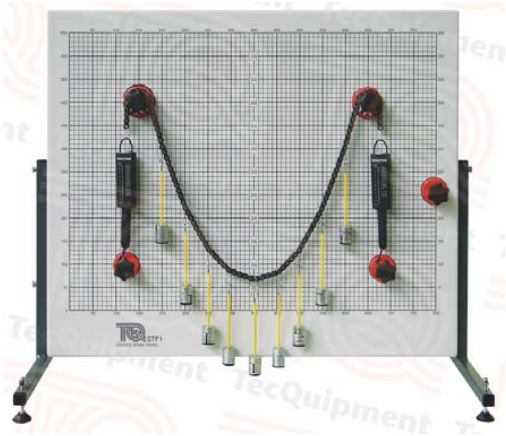
Experiment Kits
(STF2–STF5)

- Easy-to-assemble work panel that holds TecQuipment's interchangeable Statics Fundamentals (STF) range experiment kits
- Large size – ideal for classroom demonstrations
- Clear metric grid allows repeatable positioning of experiment parts and helps take accurate results
- Robust panel made of steel to work with the magnetic parts of the kits – students can quickly set up, remove or change experiments

For use with TecQuipment's Statics Fundamentals range, the work panel fits on most desk or bench tops.

Students or teachers fit the magnetic parts of their Statics Fundamentals kits to the Work Panel (STF1) to study or demonstrate one of the fundamental topics of static forces.

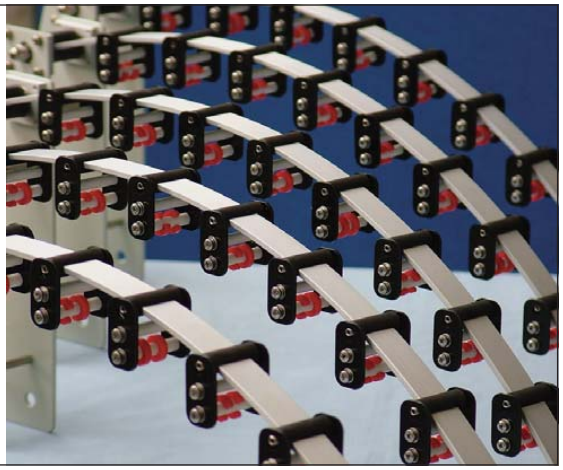
Available Experiment Kits:	Page
• Suspension Cable Demonstration (STF2)	196
• Equilibrium of a Rigid Body (STF3)	197
• Equilibrium of Forces (STF4)	199
• Equilibrium of a Beam (STF5)	200



One of the Statics Fundamentals experiment kits shown fitted to the work panel

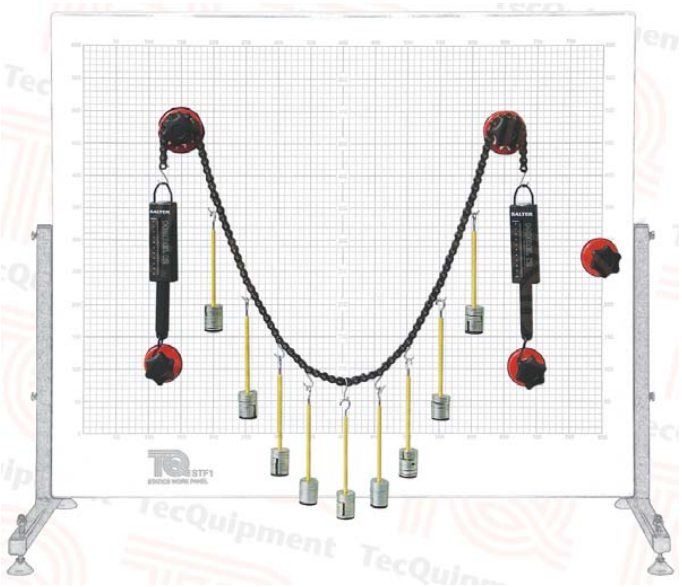
Manufacturing in quantity to improve delivery and prices

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

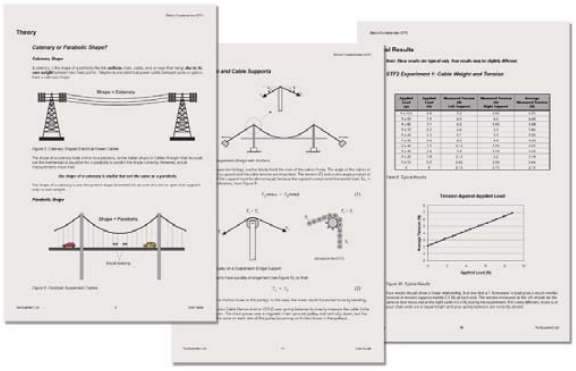


Suspension Cable Demonstration (STF2)

Shows the tensions and shapes in a suspension cable, comparing them with theory



- One of a series of kits for experiments in statics fundamentals topics
- Fits to the Work Panel (STF1) for a complete range of suspension cable experiments
- Hands-on approach for improved understanding
- Highly visual and robust – ideal for classroom demonstrations and for use by small groups of students
- Magnetic bases allow accurate and easy positioning of the experiment's parts
- Supplied in a hard-wearing storage tray
- Includes a fully illustrated user guide



Example pages from the user guide

For use with the Work Panel (STF1), the kit allows several experiments with a suspension cable.

Students or teachers fit the magnetic parts of the kit to the work panel to study or demonstrate the shapes and tensions in a suspension cable.

The kit compares a suspension cable with a catenary cable and analyses results using catenary and parabolic theory.

It includes a roller chain (the cable), held by magnetically mounted sprocket pulleys, and a set of weight hangers and weights. Spring balances measure the tension in the cable.

The versatility of the kit means that you can create symmetrical and non-symmetrical cables, with point loads or with evenly-spread loads.

TecQuipment supplies each kit with a fully illustrated user guide containing theory, experiments and typical results.

Experiments:

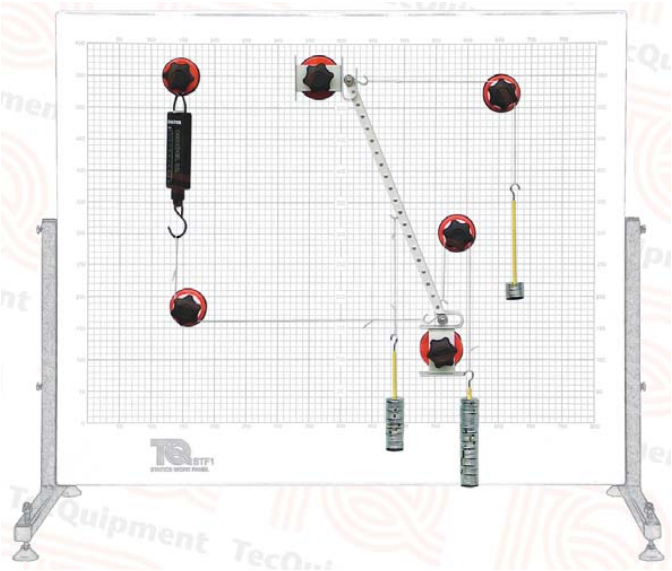
- Analysis using catenary and parabola theory
- Cable weight and tension
- Comparison of a symmetrical suspension cable and catenary
- Unsymmetrical suspension cable
- A point load on a suspension cable

Essential Base Unit:	Page
Work Panel (STF1)	195

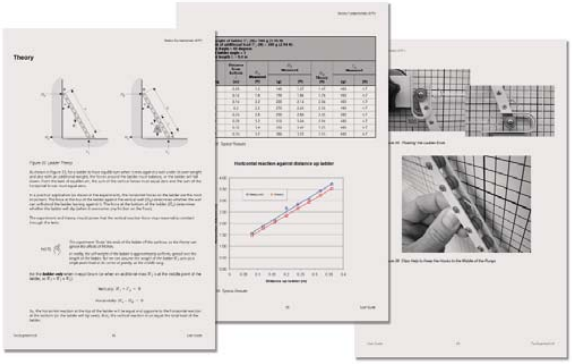
Alternative Product:	Page
Simple Suspension Bridge (STR19)	226

Equilibrium of a Rigid Body (STF3)

Shows the forces around a ladder-type structure



- One of a series of kits for experiments in statics fundamentals topics
- Fits to the Work Panel (STF1) for a complete range of experiments that explore the classic 'forces around a ladder' problem
- Hands-on approach for improved understanding
- Highly visual and robust – ideal for classroom demonstrations and for use by small groups of students
- Magnetic bases allow accurate and easy positioning of the experiment's parts
- Supplied in a hard-wearing storage tray
- Includes a fully illustrated user guide



Example pages from the user guide

For use with the Work Panel (STF1), the kit allows several experiments with a rigid body – a ladder structure.

Students or teachers fit the magnetic parts of the kit to the Work Panel (STF1) to study or demonstrate the forces around an inclined ladder-type structure.

The kit holds a model ladder at different angles, with or without a 'climbing mass', and measures the horizontal and vertical forces.

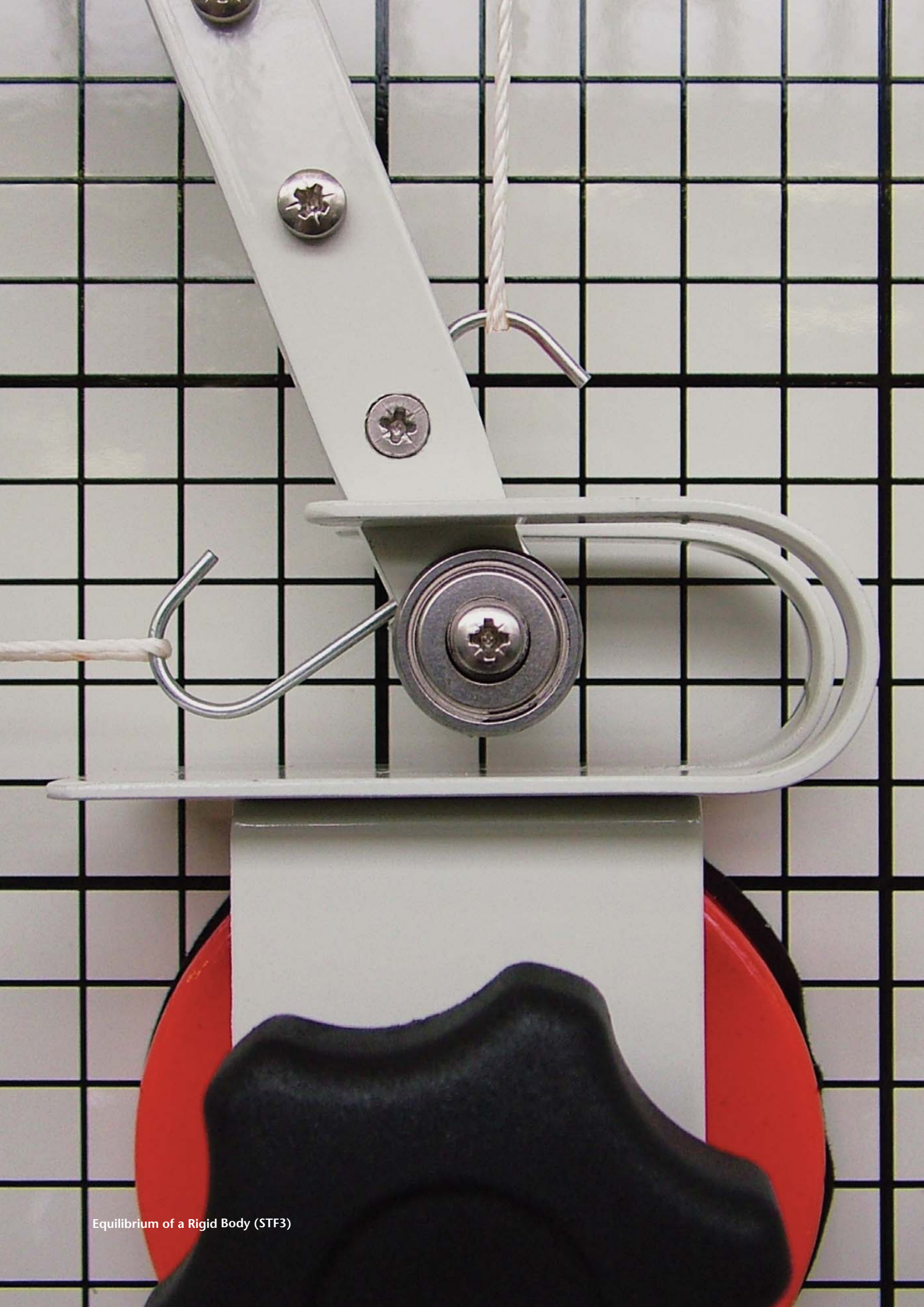
The versatility of the kit means that you can adjust the ladder angle between more than 15 to 45 degrees and try it with or without a climbing mass at any position along its length.

TecQuipment supplies each kit with a fully illustrated user guide containing theory, experiments and typical results.

Experiments:

- Horizontal and vertical reaction forces on a ladder
- Safe angles for a ladder
- A climbing mass on a ladder
- A ladder at different angles

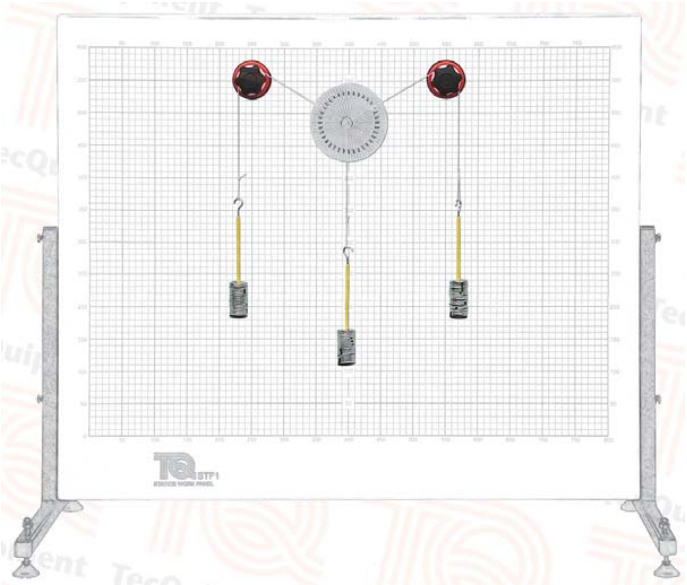
Essential Base Unit:	Page
• Work Panel (STF1)	195



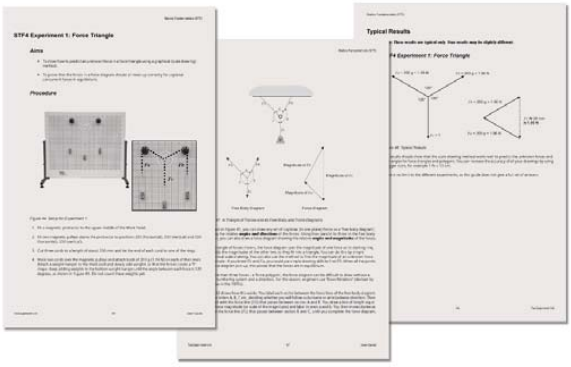
Equilibrium of a Rigid Body (STF3)

Equilibrium of Forces (STF4)

For experiments with three or more coplanar forces at equilibrium



- One of a series of kits for experiments in statics fundamentals topics
- Fits to the Work Panel (STF1) for a complete range of experiments that explore three or more coplanar forces in equilibrium
- Hands-on approach for improved understanding
- Highly visual and robust – ideal for classroom demonstrations and for use by small groups of students
- Magnetic bases allow accurate and easy positioning of the experiment's parts
- Supplied in a hard-wearing storage tray
- Includes a fully illustrated user guide



Example pages from the user guide

For use with the Work Panel (STF1), the kit allows several experiments with forces pulling on one or more points at different angles.

Students or teachers fit the magnetic parts of the kit to the Work Panel (STF1) to study or demonstrate three coplanar concurrent forces (triangle of forces) or more (force polygons).

The kit uses masses, hooks, pulleys and cords to apply forces on a single point (concurrent). Students may also set it to apply forces to two points (non-concurrent). Students measure the forces at equilibrium and compare with theoretical values. The kit introduces Bow's Notation and the drawing method of finding the forces.

The versatility of the kit means that you can set up to five forces at any angles, using its cords, rings, magnetic mounts, magnetic protractors, pulleys, weights and a spring balance.

TecQuipment supplies each kit with a fully illustrated user guide containing theory, experiments and typical results.

Experiments:

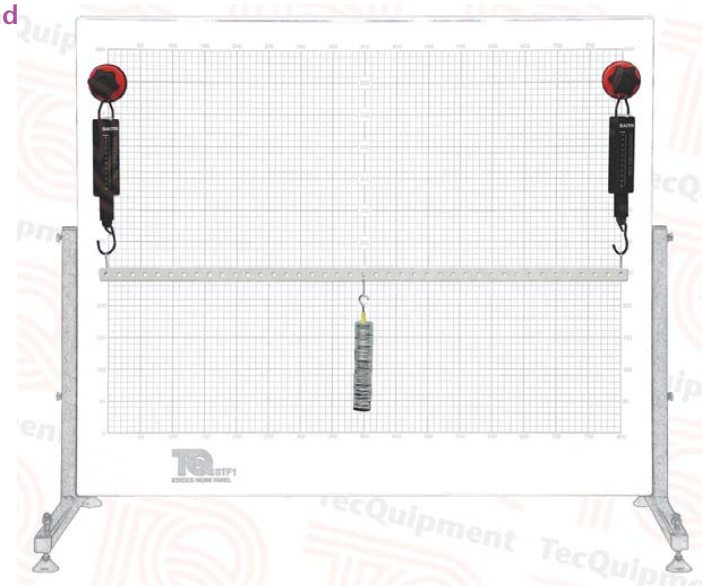
- Concurrent and non–concurrent coplanar forces
- An introduction to Bow's Notation and graphical analysis
- Force triangles, polygons and link polygons

Essential Base Unit:	Page
• Work Panel (STF1)	195

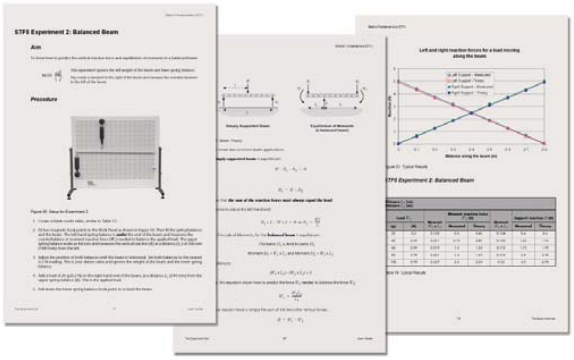
Alternative Product:	Page
• Forces Kit (ES2)	73

Equilibrium of a Beam (STF5)

For experiments with forces, moments and reactions around a beam at equilibrium



- One of a series of kits for experiments in statics fundamentals topics
- Fits to the Work Panel (STF1) for a complete range of experiments that explore the forces, moments and reactions around a rigid beam at equilibrium
- Hands-on approach for improved understanding
- Highly visual and robust – ideal for classroom demonstrations and for use by small groups of students
- Magnetic bases allow accurate and easy positioning of the experiment's parts
- Supplied in a hard-wearing storage tray
- Includes a fully illustrated user guide



Example pages from the user guide

For use with the Work Panel (STF1), the kit allows several experiments with a rigid beam.

Students or teachers fit the magnetic parts of the kit to the Work Panel (STF1) to study or demonstrate forces, moments and reaction forces around a rigid beam at equilibrium.

The kit uses masses, magnetic mounts and spring balances to apply forces to a rigid beam. Students measure the forces around the beam at equilibrium and compare with theoretical values found from theory of moments and equilibrium.

The versatility of the kit means that you can set up several different ways of supporting the beam, including simply supported or balanced.

TecQuipment supplies each kit with a fully illustrated user guide containing theory, experiments and typical results.

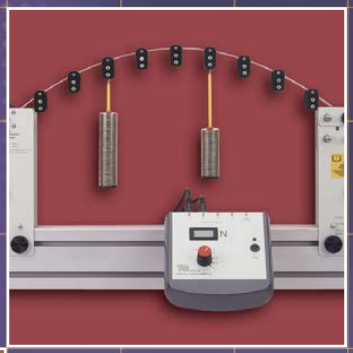
Experiments:

- Using moments and the theory of equilibrium to find beam reaction and other unknown forces
- Simply-supported beams
- Balanced beams

Essential Base Unit:	Page
• Work Panel (STF1)	195

Alternative Product:	Page
• Moments Kit (ES3)	74

Structures



“ The robust, well designed and ‘user friendly’ nature of their equipment has played a significant role in ensuring that our students get the most from their course and the best start in their engineering careers.

TecQuipment’s highly commendable commitment to in-house R&D and manufacturing processes safeguards the consistent high quality of their products which, combined with their excellent after-sales service, gives us the confidence to invest further with them as we seek to expand in the future. ”

Daniel Stones, Technician, University of Lincoln

The Structures modular teaching system

TecQuipment's modular Structures range offers a cost-effective, flexible teaching system that we believe is the most advanced product in its field.

The range teaches basic principles to more advanced theory. It has 19 desk-mounting hardware experiment modules supported by full automatic data acquisition, and TecQuipment's powerful and popular Structures Software (STRS).

You can use the hardware modules and the Structures Software together or as stand-alone products. However, using both with automatic data acquisition gives a powerful teaching solution.

In addition, the products include a full selection of user guides, student guides, lecturer guides, textbook and other supporting material. These work together so anyone using the equipment gets the best from it – teachers and students alike.

Structures modular system	Test Frame (STR1)	Experiment modules (STR2–STR20)	Structures Software (STRS)	Automatic Data Acquisition (STR2000)	Personal computer (not supplied by TecQuipment)
Structures hardware experiments	●	●			
Structures hardware and virtual experiments	●	●	●		●
Complete Structures system with virtual experiments and ADA	●	●	●*	●	●
Structures virtual experiments only			●		●

TecQuipment's modular Structures range means you can choose the right combination of products that best suits your teaching needs

* Structures Software included as standard with the STR2000

Flexible and modular

A key feature of this range is its flexibility. The hardware modules and instrumentation fix simply to an ergonomic test frame (STR1). They are easily removed and swapped for another experiment, making sensible use of laboratory space and time. The Structures Software fully supports each hardware module, and one experiment can show several principles. And because the range is modular, you can buy additional hardware modules as you need them.

Authentic software simulation

By providing virtual experiments, the Structures Software offers an affordable, versatile and effective method for students to quickly learn structures principles. Not only does it allow students the flexibility of working away from the laboratory, it also expands experiments beyond the limits of the hardware.

Automatic data acquisition

The use of digital instrumentation, automatic data acquisition and software mean students learn efficiently and make the best use of laboratory time. And there are no difficult-to-read instruments or abstract experiment set-ups to distract them.

High functionality, affordably priced

High-quality design and manufacture, combined with modularity, extensive capabilities, choice of hardware and software, plus TecQuipment's determination to provide superb value for money, mean our Structures range provides an unsurpassed teaching solution at an unbeatable price.

Structures Test Frame (STR1)

A strong frame that holds the experiments of TecQuipment's Structures range

- Holds the interchangeable experiment modules and instruments of TecQuipment's Structures range
- Strong, bench-mounting frame
- Easy-to-use fixings and slots so students can quickly set up, remove or change experiments
- Also ideal for holding experiments during storage
- Supplied as a kit with instructions for use
- Includes textbook with full theory and explanations of different structures

A lightweight yet strong bench-mounting frame that holds interchangeable experiment modules and instrumentation from the TecQuipment Structures range.

The frame has specially designed slots and self-positioning nuts that hold the Structures experiments and instruments.

This fixing system is quick and easy to use. It allows students to change, position and secure each experiment. Adjustable feet support the frame to allow students to level the apparatus before use.

Supplied in kit form with instructions for use and a textbook.

Available Experiment Modules:	Page
• One or more Structures experiment modules (STR2–STR20)	207–227

Digital Force Display (STR1a)

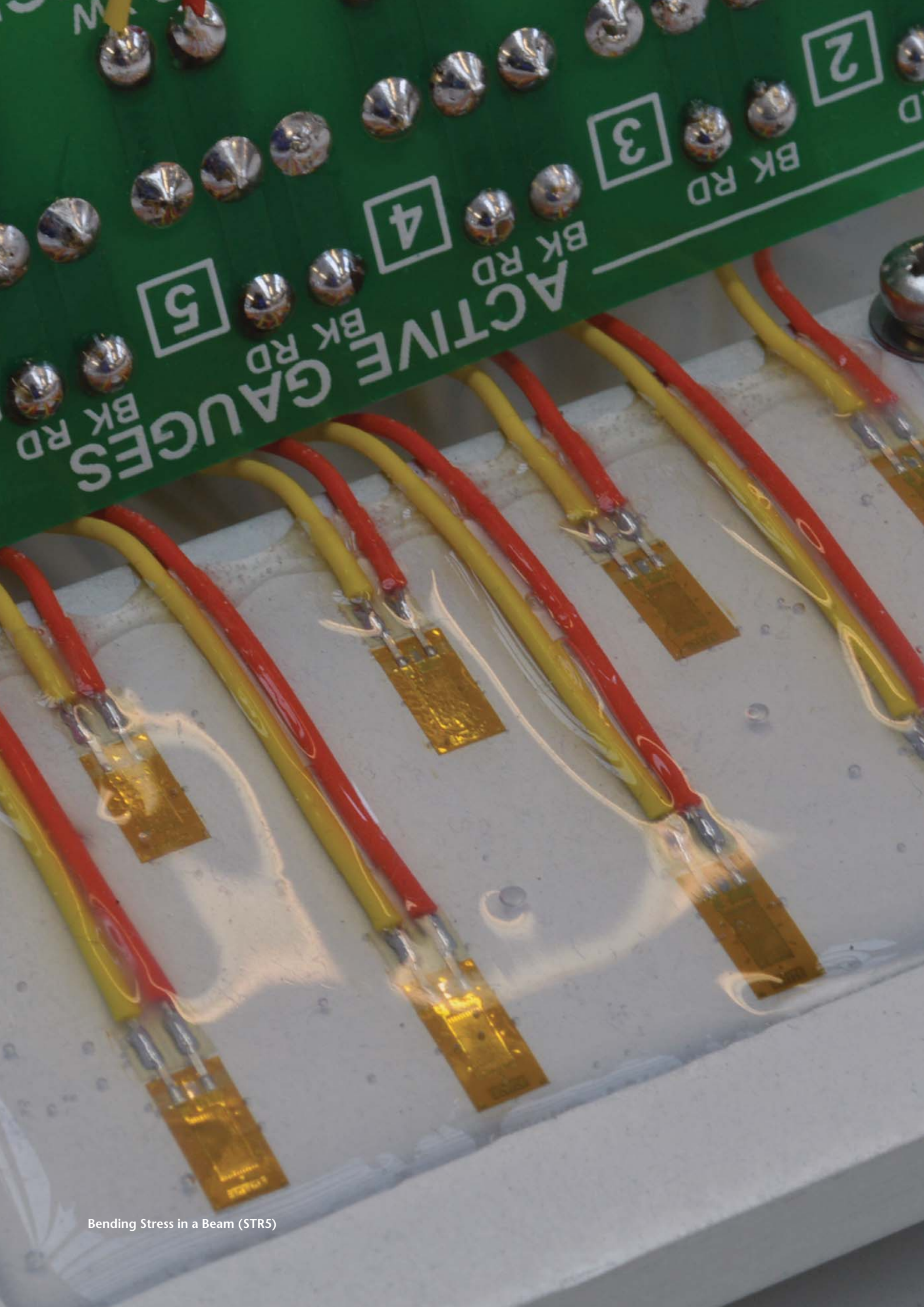
For use with TecQuipment's Structures range, this display shows the forces from up to four force sensors on the Structures experiments

- Works with many experiments from TecQuipment's Structures range
- Fits onto the Structures Test Frame (STR1) to give a tidy work area
- Real-time display of each of up to four forces
- Can connect to TecQuipment's Automatic Data Acquisition Unit (STR2000) to automatically measure all four forces at the same time

The Digital Force Display fixes to a Structures Test Frame (STR1, available separately). This keeps the experiments tidy and saves space around the work area. The display measures up to four forces from sensors on many of the experiments in the TecQuipment Structures range.

A four-way selector switch selects the displayed force. The display automatically adjusts its range to the force. Includes an output to the Automatic Data Acquisition Unit (STR2000, available separately). When used with the STR2000, the Digital Force Display outputs all four force signals at the same time to the Structures Software.

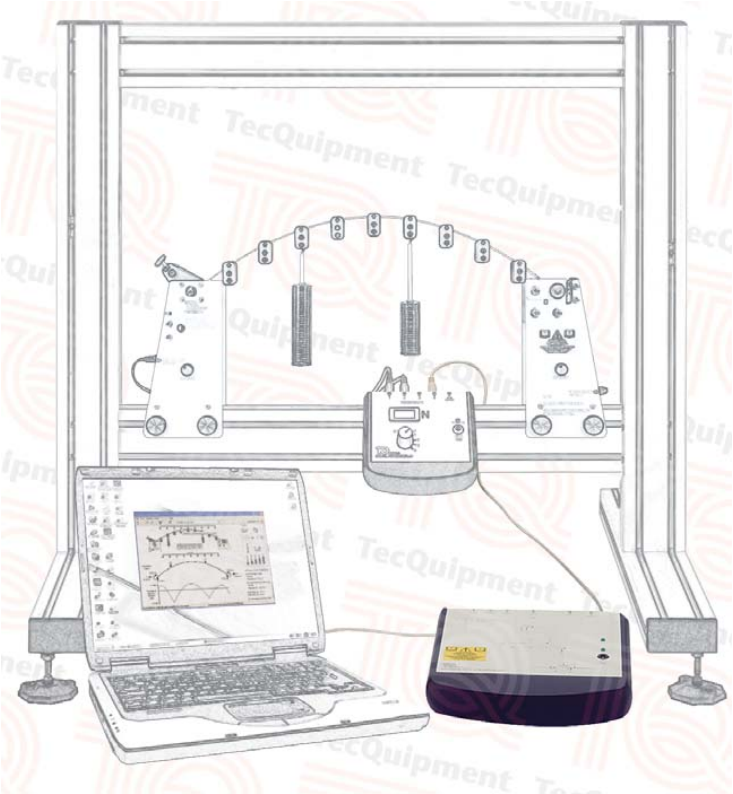
Ancillary for:	Page
• One or more Structures experiment modules (STR2–STR20)	207–227



Bending Stress in a Beam (STR5)

Automatic Data Acquisition Unit (STR2000)

Connects any of the Structures range experiments to a computer – includes TecQuipment's Structures Software for automatic data acquisition and virtual experiments



The STR2000 computer interface unit shown transmitting data from one of the Structures hardware experiment modules to the Structures Software

- Computer interface and TecQuipment's Structures Software (STRS) to display and collect data from any of the experiment modules in TecQuipment's Structures range (STR2 to STR20)
- Includes TecQuipment's powerful Structures Software to do two things: display and collect data, and allow 'virtual' simulated experiments
- Interface unit links to load cells and other instruments in the Structures range to send data to a suitable computer
- Allows students to compare results from actual experiments with results from simulation software
- Simple connection to most modern computers – no need to add any extra circuit boards
- Fully automatic – needs no adjustments or complicated set-up procedures on your computer

The Automatic Data Acquisition Unit is an interface box with software that connects experiments from the TecQuipment Structures range to a suitable computer (computer not included). It allows data logging, analysis and extra 'virtual' simulated experiments. It accepts inputs from a digital force display, a digital strain display, an angular sensor and digital deflection indicators. It converts these inputs into the correct data signals for the computer. The software can then analyse the data and create tables and charts. The software can also simulate experiments which students can perform using the hardware, so they can compare simulated and real results.

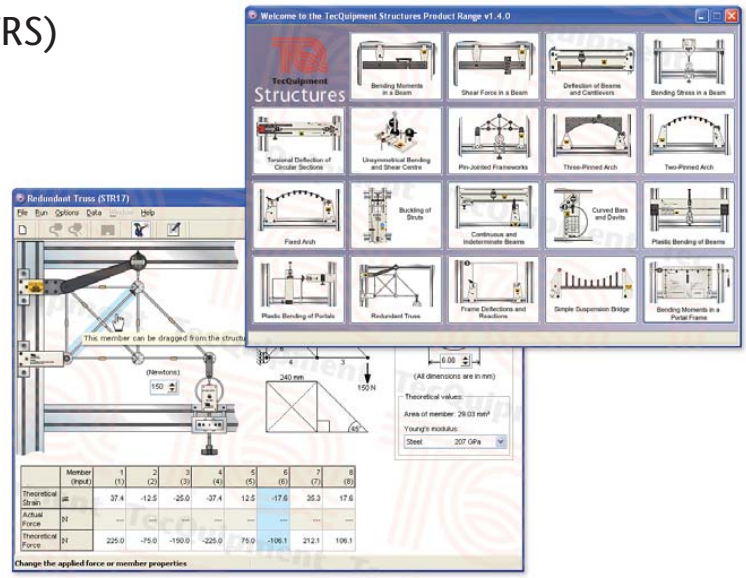
Essential Ancillary:

- Suitable computer (not supplied by TecQuipment)

Ancillary for:	Page
One or more experiment modules from the Structures range (STR2–STR20)	207–227

Structures Software (STRS)

Software that allows computer simulation of structures. Simulates and extends TecQuipment's Structures range



- High-quality structures teaching software for students of mechanical, civil and structural engineering
- Accurately simulates all 19 of TecQuipment's Structures range experiments
- Includes user guides with suggested experiments and typical answers
- Gives virtual experiments that extend beyond the limits of the experiment hardware
- Easy to use, easy to understand
- Single-user and networked options available
- Ideal companion to TecQuipment's Structures range of teaching hardware

TecQuipment's Structures Software is ideal for students of civil, mechanical and structural engineering. It allows them to perform computer-simulated experiments which study the principles of structures.

The Structures Software is the ideal companion to TecQuipment's hardware modules (STR2 to STR20). It includes a simulated form of each hardware module. The software is a useful tool when used on stand-alone or networked computers. TecQuipment offers different network licences, determined by your needs.

The Structures Software expands the scope of each experiment beyond the limits of the hardware. It mimics the hardware but allows students to change and extend many parts of the experiment. Depending on the experiment module, the student can alter different parts of each experiment, including the:

- type and number of supports;
- shape of the structure or specimen;
- material of the structure or specimen;
- Young's modulus of the structure or specimen.

The software also allows students to apply a greater range of loads, often including uniformly distributed loads (which the students cannot apply in many of the hardware experiments). Students can see, tabulate and graph data, reducing the time needed for them to get, process and show results. They can study and compare the properties of a wide variety of different structures.

Note: You can buy the Structures Software (STRS) by itself, but it is also included free with the Automatic Data Acquisition Unit (STR2000).

Included are a student guide, with suggested experiments, and a lecturer guide with typical answers.

Experiments:

Computer-simulated examination of a wide variety of structures principles, including:

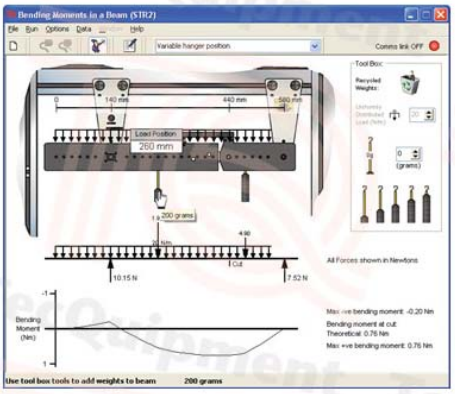
- Bending moments in a beam
- Shear force in a beam
- Deflection of beams and cantilevers
- Bending stress in a beam
- Torsional deflection of circular sections
- Unsymmetrical bending and shear centre
- Pin-jointed frameworks
- Three-pinned arch
- Two-pinned arch
- Fixed-arch
- Buckling of struts
- Continuous and indeterminate beams
- Curved bars and davits
- Plastic bending of beams
- Plastic bending of portals
- Redundant truss
- Frame deflections and reactions
- Simple suspension bridge
- Bending moments in a portal frame

Essential Ancillary:

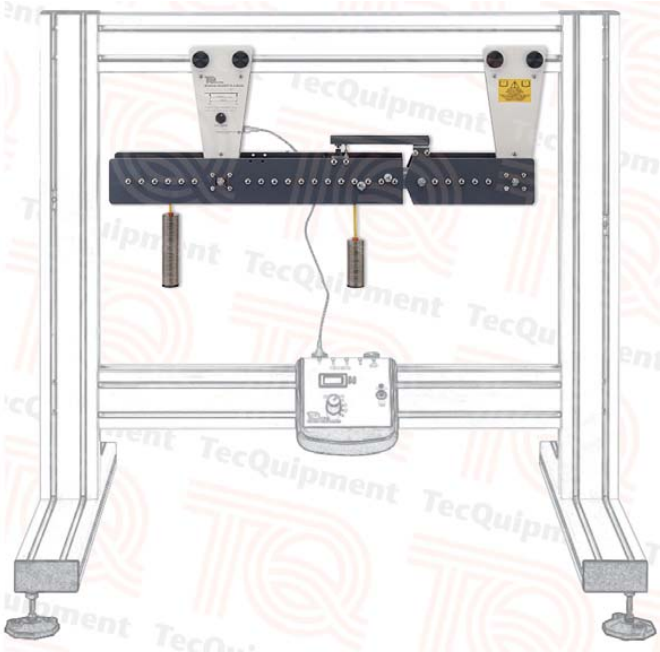
- Suitable computer (not supplied by TecQuipment)

Bending Moments in a Beam (STR2)

Shows and proves the basic theory of bending moments in a beam



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into bending moments in a beam
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware is a simply supported beam 'cut' by a pivot. The beam fixes to the Structures Test Frame (STR1, available separately). Students apply loads at set positions using hangers holding various masses. To stop the beam collapsing, a moment arm bridges the cut onto a load cell thus reacting (and measuring) the bending moment force. A Digital Force Display (STR1a, available separately) displays forces during experiments.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Bending moment variation at the point of loading
- Variation of bending moment away from the point of loading
- Examination of various other loading cases, including loads traversing the beam

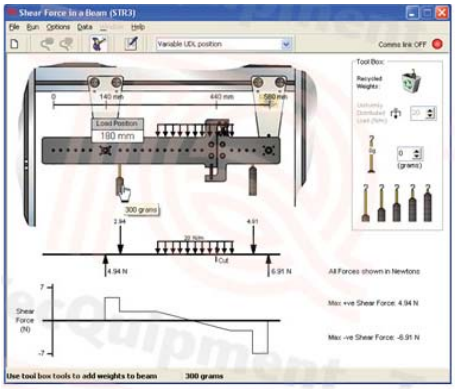
Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

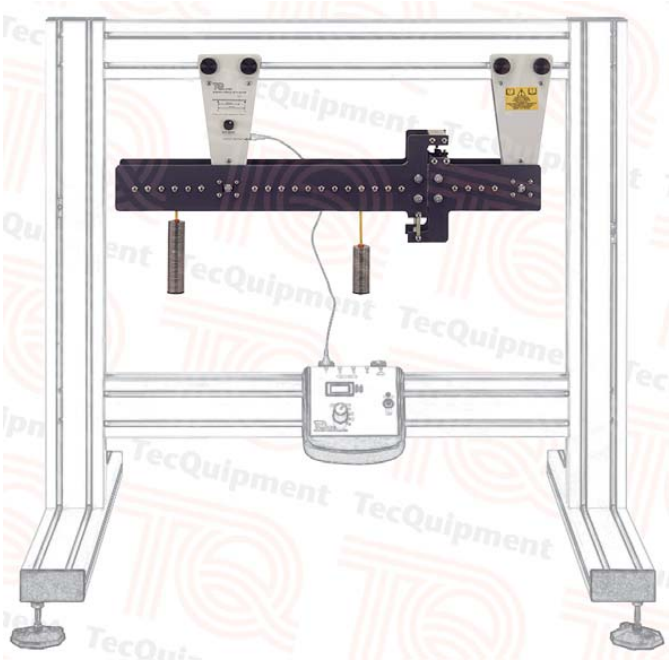
Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

Shear Force in a Beam
(STR3)

Shows and proves the basic theory of shear force in a beam



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into shear force in a beam
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware is a simply supported beam with a 'cut'. The beam fits onto a Structures Test Frame (STR1, available separately).

A mechanism bridges the cut, which stops the beam collapsing and allows movement in the shear direction only. An electronic load cell measures the force, and connects to a Digital Force Display (STR1a, available separately). Students apply loads at set positions using hangers holding various masses.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Shear force variation with an increasing point load
- Variation of shear force for various loading conditions
- Examination of various other loading cases and their effect on shear force, including loads traversing the beam

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Essential Ancillary: Page

- Digital Force Display (STR1a) 203

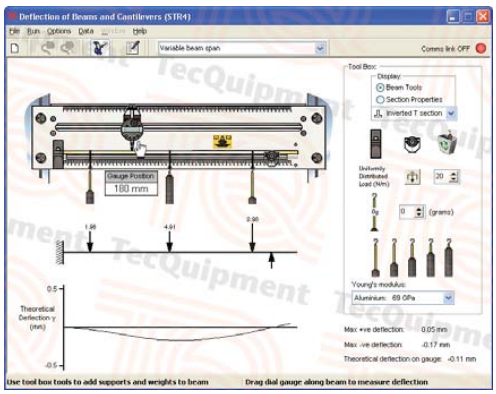
Recommended Ancillaries: Page

- Structures Software (STRS) for virtual experiments 206

  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Deflection of Beams and Cantilevers (STR4)

For study of beam deflection under different loads and fixing conditions



Screenshot of the optional TecQuipment Structures Software

- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into deflections of beams and cantilevers
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit including TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system

The experiment hardware consists of a backboard that fixes to the Structures Test Frame (STR1, available separately). Test beams fit onto the backboard using a rigid clamp and knife-edge supports. Students apply loads at any position using hangers holding various masses. Mounted on a trammel, a digital deflection indicator traverses the beam. The indicator measures beam deflection. Scales on the backboard show the position of the indicator, the loads and supports.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Examination of:

- Beam deflections
- General bending formulae
- Beam end rotations
- Elastic moduli (Young's modulus) for various materials

Typical conditions are:

- Cantilever
- Propped cantilever
- Encastré beam
- Simply supported beam

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Recommended Ancillaries: Page

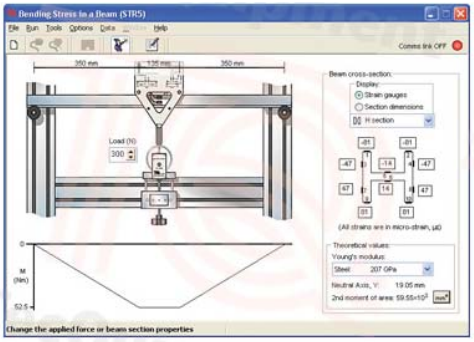
- Structures Software (STRS) for virtual experiments **or** 206
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Products: Page

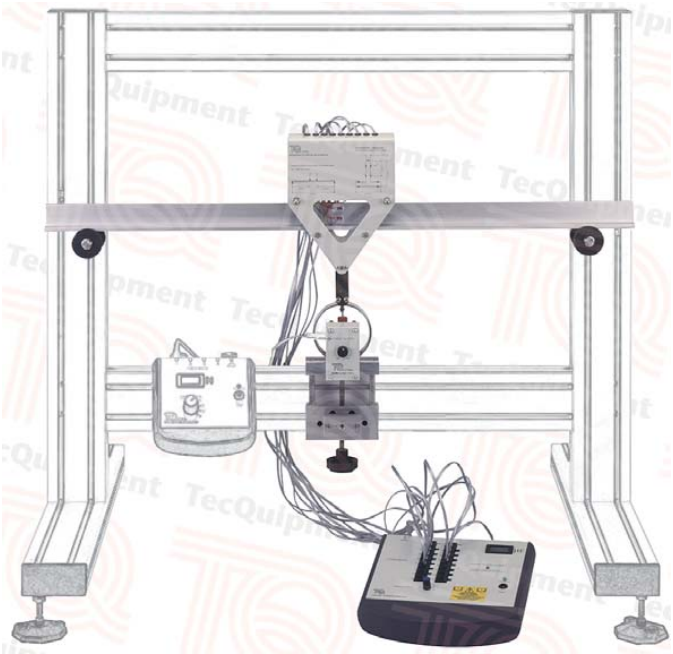
- Stiffness of Materials and Structures (TE16) 160
- Continuous and Indeterminate Beams (STR13) 218
- Beam Apparatus (SM1004) 182
- Beam and Leaf Spring (SM1000g) 176
- Deflection of Beams Kit (ES4) 75

Bending Stress in a Beam (STR5)

For study of stress distribution across the section of a beam



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into bending stress in a beam
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit including TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system

The experiment hardware is a T-beam that fits onto a Structures Test Frame (STR1, available separately).

Students adjust a load cell that bends the beam and, when connected to the optional Digital Force Display (STR1a, available separately), it measures the bending force (load). Strain gauges and a digital strain bridge measure the strains in the beam. Dummy strain gauges compensate for temperature variation and balance the strain bridges. The equipment includes a lead for connection to the Digital Force Display (STR1a, available separately).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests that you do with the hardware. They also extend the choice of tests than that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Study of:

- Second moment of area
- Converting strains to stresses
- Strain gauges
- The neutral axis
- The bending equation

Essential Base Unit:

	Page
• Structures Test Frame (STR1)	203

Essential Ancillary:

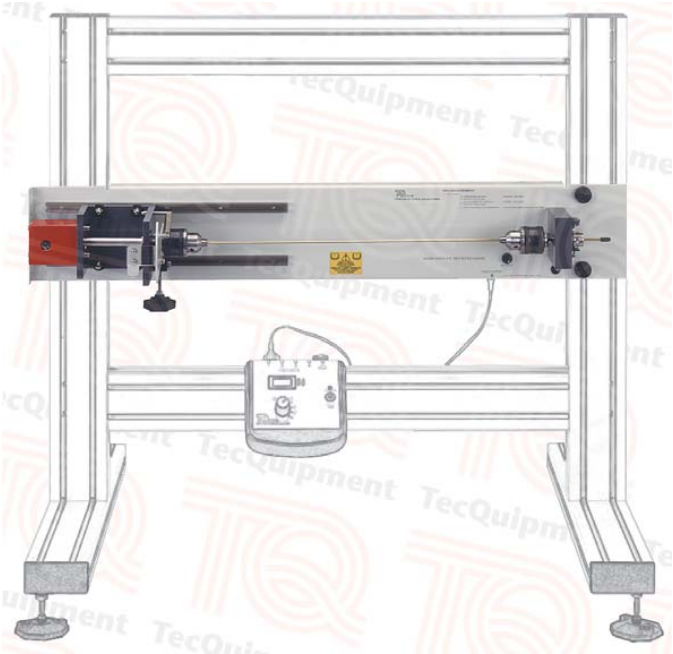
	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:

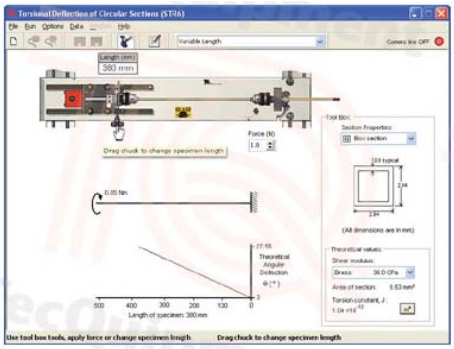
	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

Torsion of Circular Sections (STR6)

For study of torque and deflection in different materials with circular section



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into torsion of circular sections
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system



Screenshot of the optional TecQuipment Structures Software

The experiments hardware fits onto a Structures Test Frame (STR1, available separately). It examines the behaviour in the elastic region of solid and tubular-section specimens.

Two chucks on a backboard hold a test specimen. A mechanism on one chuck applies torque manually to the specimen. A protractor scale on this chuck measures angular movement. A load cell on the other chuck measures torque. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a, available separately). To vary the test length of a specimen, one chuck can traverse the backboard. Included is an electronic angular transducer for use with the optional Automatic Data Acquisition Unit (STR2000).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software which displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Study of:

- The relationship between specimen length, torque and angular deflection
- The behaviour of specimens of different material and sections
- General torsion theory
- Shear modulus
- Polar moment of inertia

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

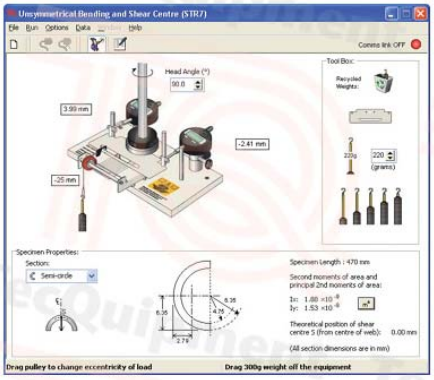
Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

Alternative Products:	Page
• Additional Torsion Testing Kit (TE16b)	160
• Torsion Testing Machine (SM1001)	168
• Torsion of Circular Sections Kit (ES5)	76

Unsymmetrical Bending and Shear Centre (STR7)

For study of vertical and horizontal deflection of different asymmetric (unsymmetrical) sections

- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into unsymmetrical bending and shear centre
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). It examines the vertical and horizontal deflection of different asymmetrical sections at various angles and loads.

Two multi-way chucks hold a test specimen vertically. One chuck has an indexing system for rotating the beam in set increments. This changes the angle of loading. The other chuck and a weight hanger applies a variable load. Two digital deflection indicators measure deflection in the x and y directions. An interchangeable plate allows students to find the shear centre of the specimen.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Study of:

- Horizontal and vertical deflection of different asymmetrical sections at various angles
- Horizontal and vertical deflection of different asymmetrical sections under various loads
- Relationship between the vertical and horizontal deflections and the principal moments of area of each section
- Shear centre of various asymmetrical sections

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Recommended Ancillaries: Page

- Structures Software (STRS) for virtual experiments 206

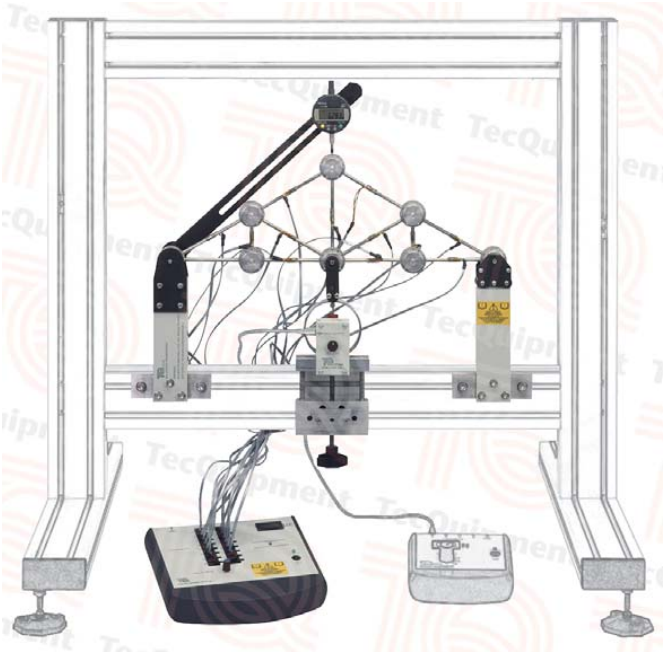
  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Product: Page

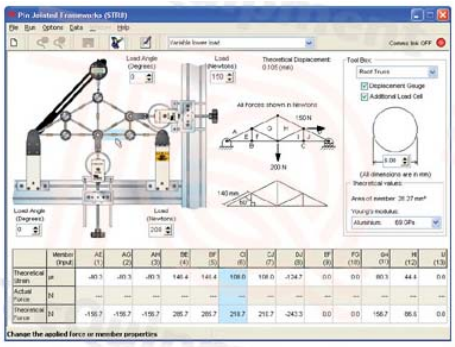
- Unsymmetrical Cantilever (SM1003) 181

Pin-Jointed Frameworks
(STR8)

For study of the strains, stresses, forces and deflections in various pin-jointed frameworks



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into pin-jointed frameworks
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective structures teaching system



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students use stainless-steel members to build different pin-jointed frameworks. The members join by slotting the ends into bosses.

The equipment includes two framework supports: a pivoting support, and a pivoting and rolling support. Each member has a strain gauge attached that connects to a digital strain bridge. A load cell applies loads to the structure at various angles. When connected to the optional Digital Force Display (STR1a), the load cell measures the applied load. To apply loads simultaneously, extra load cells are available (STR8a).

A digital deflection indicator measures the deflection and the digital strain bridge shows the strains in the members. From this, students can calculate the forces in the members.

TecQuipment supplies the members in a custom-made storage tray to avoid accidental damage. A second tray stores the joint bosses and other loose items.

Included is a lead to connect the load cell to a Digital Force Display (STR1a, available separately). The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Study of Bow's notation, strains, stresses, forces and deflections in various frameworks, including a Warren girder and roof truss
- Comparison of different frameworks

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

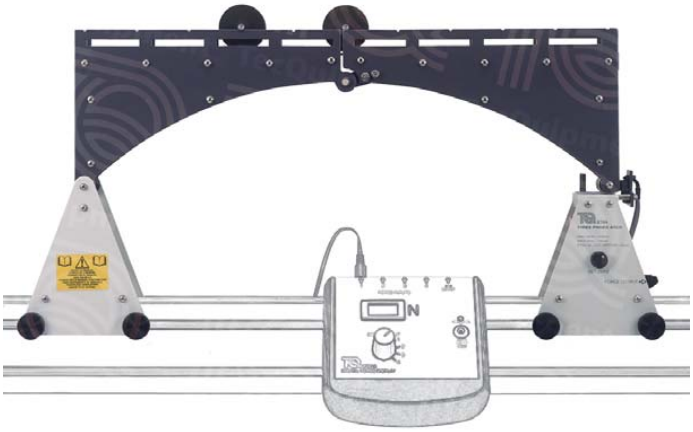
Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205
• Additional Load Cell (STR8a)	

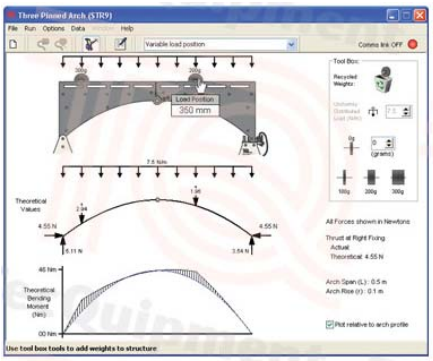
Alternative Product:	Page
• Redundant Truss (STR17)	224

Three-Pinned Arch (STR9)

For studying the characteristics of a three-pinned arch under various load conditions



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into three-pinned arches
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students apply various loads at set positions along the top of a simple 'determinate' three-pinned arched structure. They can also apply a uniformly distributed load (UDL).

The structure has a pivot at one end and at the crown. The arch rolls against a load cell at the opposite end. The load cell connects to a Digital Force Display (STR1a, available separately) to measure and display the thrust reaction. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Studies of:

- The characteristics of a three-pinned arch
- The relationship between applied loads and horizontal thrust produced from a simple determinate arched structure

Also:

- Appreciation of footing stability and economy.

Essential Base Unit:

	Page
• Structures Test Frame (STR1)	203

Essential Ancillary:

	Page
• Digital Force Display (STR1a)	203

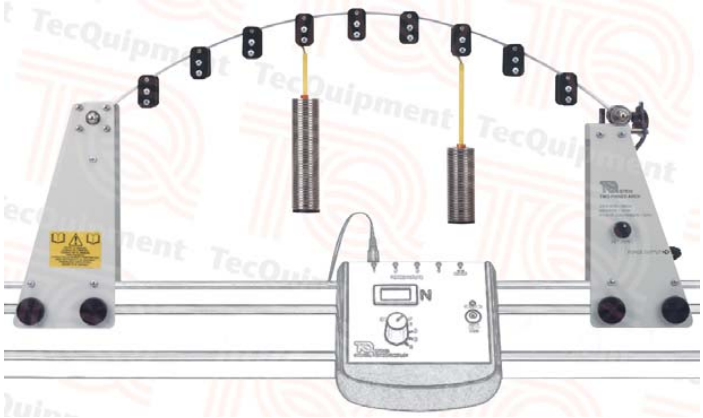
Recommended Ancillaries:

	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

Alternative Products:

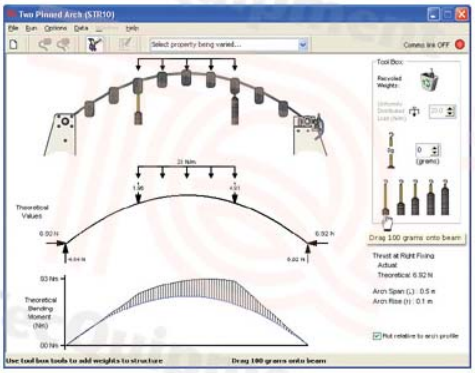
	Page
• Two-Pinned Arch (STR10)	215
• Fixed Arch (STR11)	216

Two-Pinned Arch (STR10)



For studies of the characteristics of a two-pinned arch under various load conditions

- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into two-pinned arches
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to the arch at set positions along its span.

One end of the arch is pivoted, the other end rolls against a load cell. When connected to a Digital Force Display (STR1a, available separately), the load cell measures the thrust reaction. The equipment includes a lead to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Demonstration of the characteristics of a two-pinned arch
- Examination of the relationship between applied loads and horizontal thrust produced from a redundant (in one degree) arched structure
- Comparison of behaviour to simplified theory based on the Secant assumption

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

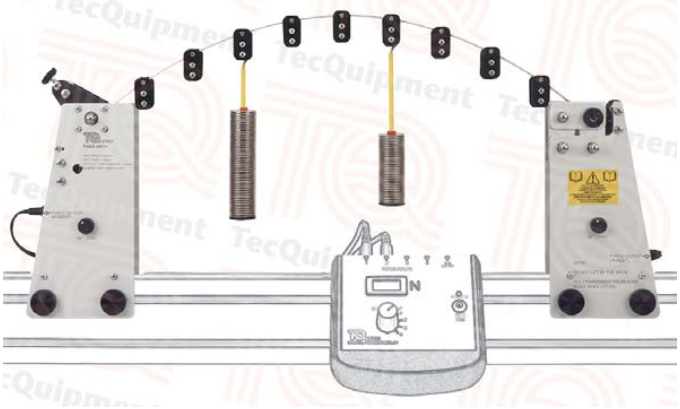
Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

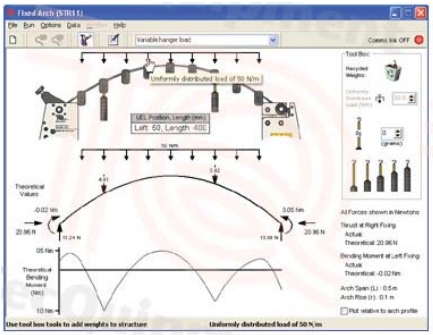
Alternative Products:	Page
• Three-Pinned Arch (STR9)	214
• Fixed Arch (STR11)	216

Fixed Arch (STR11)

For studying the characteristics of a fixed arch under various load conditions



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into a fixed arch
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). To load the arch, students fit masses on weight hangers to set positions along the arch span.

Both ends of the arch are fixed. At one end of the arch, a moment arm rests on a load cell. This measures the fixed moment reaction. At the other end, a load cell measures the horizontal thrust. The equipment includes leads to connect the load cells to a Digital Force Display (STR1a, available separately).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Demonstration of the characteristics of a fixed arch
- Examination of the relationship between applied loads, horizontal thrust and fixing moment produced from a fixed (thus redundant in three degrees) arched structure.
- Comparison of behaviour to simplified theory based on the Secant assumption.

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Essential Ancillary: Page

- Digital Force Display (STR1a) 203

Recommended Ancillaries: Page

- Structures Software (STRS) for virtual experiments 206

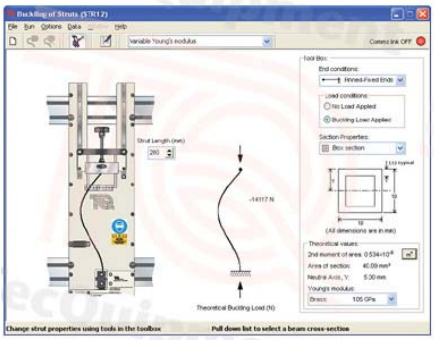
  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Products: Page

- Three-Pinned Arch (STR9) 214
- Two-Pinned Arch (STR10) 215

Buckling of Struts (STR12)

For studying buckling of slender columns and relationships between length, end-fixing conditions and buckling load



Screenshot of the optional TecQuipment Structures Software

- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into buckling of struts
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students compress aluminium columns (struts) using a screw mechanism. The equipment uses chucks to hold the struts and allows different end-fixing conditions. An integral load cell connected to a Digital Force Display (STR1a, available separately) displays the load on the strut as it is compressed. A magnetic deflection scale shows how much the strut buckles. Students continue compressing the strut until reaching the critical buckling load. They then repeat the experiment using different strut lengths or fixing conditions, analysing their results.

The equipment includes strut storage space and five different sizes of aluminium strut.

The lecturer guide provides details of the equipment including sample experiment results.The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Euler buckling loads
- Relationship between strut length and collapse load
- Relationship between various end-fixing conditions and collapse load
- Nature of deflection and deflected shapes with various end-fixing conditions

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Essential Ancillary: Page

- Digital Force Display (STR1a) 203

Recommended Ancillaries: Page

- Structures Software (STRS) for virtual experiments 206

  or

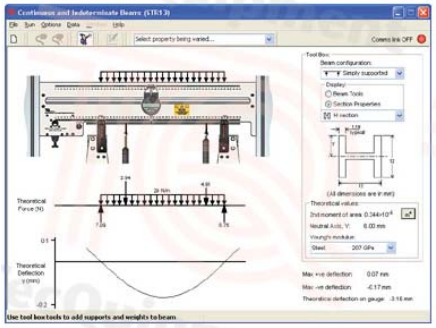
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Product: Page

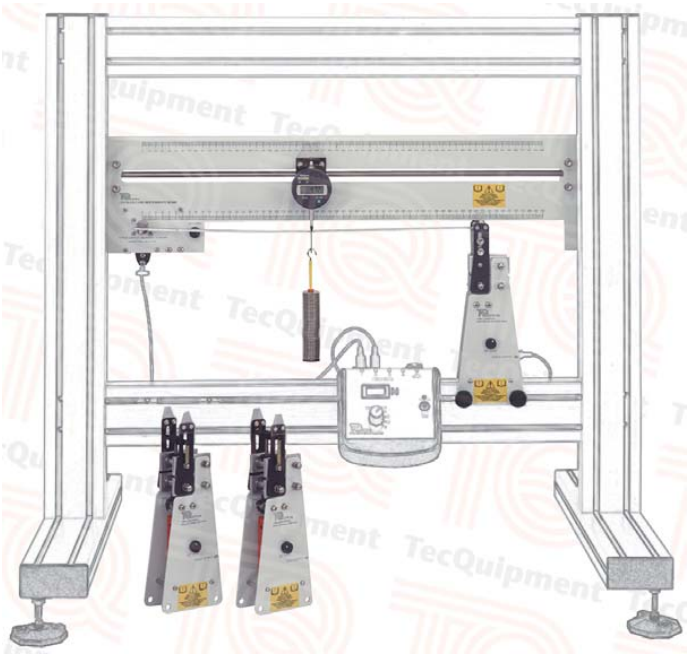
- Loading and Buckling of Struts (SM1005) 185

Continuous and Indeterminate Beams (STR13)

Versatile equipment for a wide variety of beam experiments, from simple cases to complex problems



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into continuous and indeterminate beams
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit including TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students rest a beam on up to three 'piers'. The piers are movable, so students can arrange them in many different positions under the beam. Students use masses on weight hangers to load the beam.They can also attach the flexible beam to a backboard to measure deflection or fixing moment.

The piers each contain a load cell to measure vertical reactions. These connect to a Digital Force Display (STR1a, available separately). Two of the load cells have knife-edge supports, which students can either fix or allow to sink by a set displacement. The third pier load cell allows students to either clamp the beam (encastré fixing) or rest the beam on a knife edge. The unique design of this equipment allows the load cell to resist the bending moment while accurately measuring the vertical reaction. To measure beam deflection, the backboard has a digital indicator which students move along the beam. The backboard also has a mechanism for measuring the fixing moment of a propped cantilever or a fixed beam.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Reactions of a simply supported beam
- Reactions of a two-span continuous beam
- Reactions and fixing moments of a fixed beam and a propped cantilever
- Reaction and fixing moment of a propped cantilever with a sinking support
- Relationship between load and deflection for beams and cantilevers

This equipment allows many possible experiment configurations, using a stiff (rigid) beam, or a significantly more flexible beam.

Essential Base Unit:

	Page
• Structures Test Frame (STR1)	203

Essential Ancillary:

	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:

	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

Alternative Products:

	Page
• Stiffness of Materials and Structures (TE16)	160
• Beam and Leaf Spring (SM1000g)	176
• Beam Apparatus (SM1004)	182
• Deflection of Beams and Cantilevers (STR4)	209
• Deflection of Beams Kit (ES4)	75

Have you also seen our Materials Testing and Properties range?

The Materials Testing and Properties range (Section 6) also extends into the area of structures and structural elements and includes the following free-standing products:

Unsymmetrical Cantilever Apparatus (SM1003) – **Page 181**
Examines and displays bending of an unsymmetrical cantilever

Beam Apparatus (SM1004) – **Page 182**
Examines the deflection and forces on different types of beams for a wide range of supports and loads

Loading and Buckling of Struts (SM1005)
– Page 185
Tests different types of struts and shows how they deflect under load

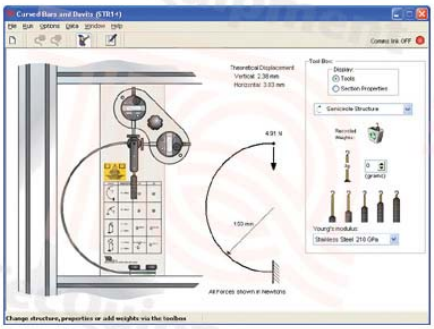
VDAS®

The above equipment is compatible with TecQuipment's Versatile Data Acquisition system (VDAS®). This gives accurate real-time data capture, monitoring and display, calculation and charting of all important readings on a computer – see page 6.

Curved Bars and Davits
(STR14)

For students to investigate two common curved structures and two common davit structures

- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into curved bars and davits
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Included are four different structures. Students attach one of the structures in front of the hardware module, directly onto the test frame. They then apply loads to the structure using masses on hangers.

Two digital deflection indicators, set at 90 degrees to each other on the backboard, contact the structure and so measure horizontal and vertical deflection. The digital deflection indicators are on a magnetic base so students can move them to anywhere on the backboard.

As students load a structure they note the horizontal and vertical deflections, thus investigating the structure behaviour. They then compare this behaviour with theoretical predictions.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Investigation of the relationship between load, horizontal deflection and vertical deflection for:

- Curved davit
- Angled davit
- Semicircle structure
- Quarter-circle structure

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

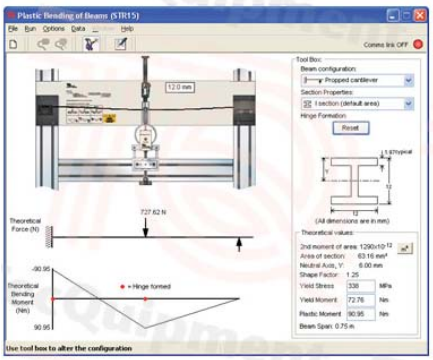
Recommended Ancillaries: Page

- Structures Software (STRS) for virtual experiments 206

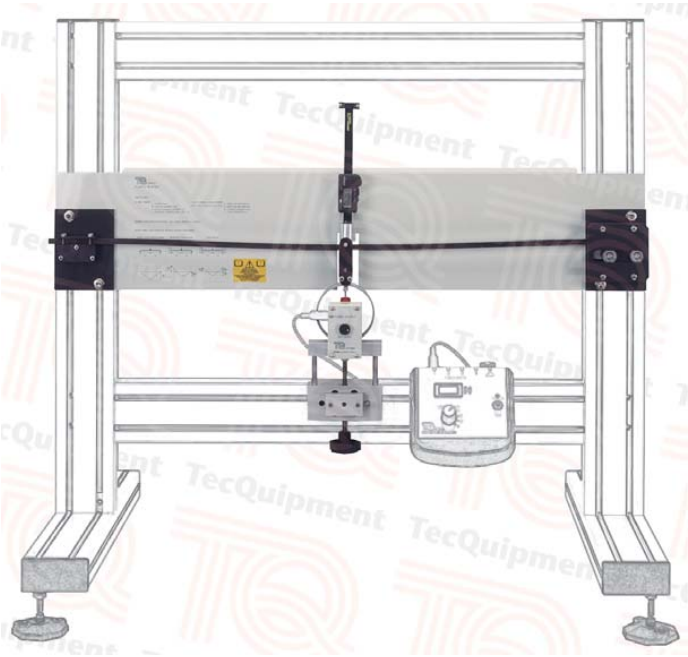
  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Plastic Bending of Beams
(STR15)

Introduces students to plastic theory and limit state design



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into plastic bending of beams
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students fix a specimen beam in chucks at both ends of a backboard. The chucks can either clamp the beam (encastré fixing), or hold it on a knife-edge. The students then load the beam using a screw mechanism and electronic load cell.

The load cell connects to a Digital Force Display (STR1a, available separately) which displays the load as the beam deforms. A long-travel digital deflection indicator on the backboard measures specimen deformation. To compensate for the specimen shortening as it deforms, one of the chucks moves along the backboard, relative to the deformation.

Students continue to apply a load until the specimen beam is in the fully plastic condition, that is, the beam has undergone plastic collapse. They then compare the beam behaviour with theoretical predictions based on traditional yield stress theory.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Relationship between load and deflection for beams loaded to the plastic condition
- Introduction to form factor
- Introduction to limit state design
- Relationship between maximum loading and plastic hinge formation for a simply supported beam, a propped cantilever and a fixed beam

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Essential Ancillary: Page

- Digital Force Display (STR1a) 203

Recommended Ancillaries: Page

- Specimen Beams Pack (STR15a)
- Structures Software (STRS) for virtual experiments 206

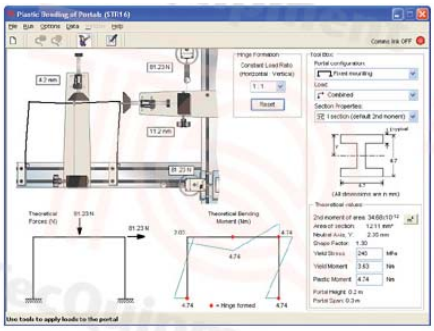
  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Product: Page

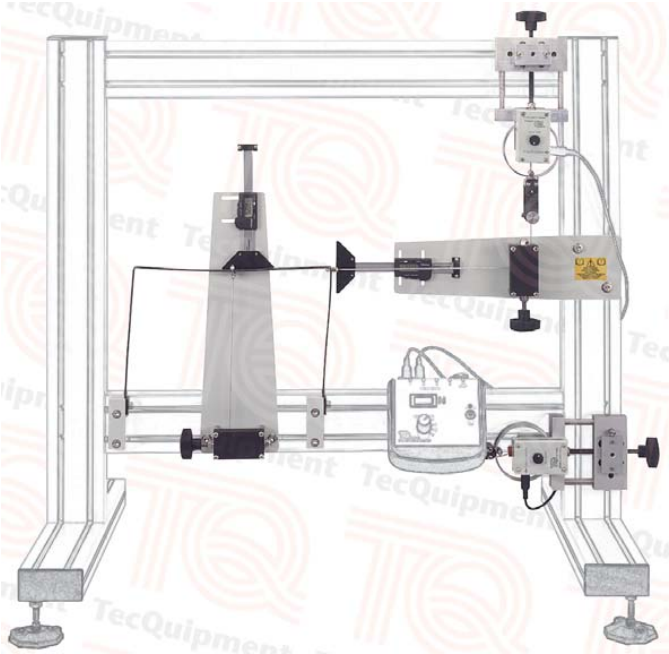
- Beam and Leaf Spring (SM1000g) 176

Plastic Bending of Portals (STR16)

For studying plastic theory and limit state design in portal frames



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into plastic bending of portals
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Students fix a specimen portal frame (two uprights with a cross-beam at the top) to the bottom cross-piece of a test frame. The test frame also holds horizontal and vertical screw mechanisms with electronic load cells for loading the portal frame.

Students set the portal frame load conditions by arranging the load cell screw mechanisms to provide either single or combined loads. They then load the portal frame manually by adjusting the screw mechanisms. The electronic load cells connect to a Digital Force Display (STR1a, available separately) that shows the horizontal and vertical loads as the portal frame deforms. Two long-travel digital deflection indicators measure the portal frame deformation.

Students continue to load the portal frame until it is in the fully plastic condition, that is, it has undergone plastic collapse. They monitor the collapse load, deformations, and note where plastic hinges formed during collapse. Packs containing 12 extra specimen portal frames are available separately (STR16a).

Ideally, students should use the Plastic Bending of Beams experiment (STR15) before progressing to Plastic Bending of Portals. The Plastic Bending of Beams experiment provides a basic understanding of underlying principles, such as plastic deformation and form factor.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Relationship between load and deflection for portal frames loaded to the plastic condition
- Introduction to limit state design
- Relationship between maximum loading and plastic hinge formation in portal frames loaded vertically from the centre, horizontally from one corner, and equally from both positions
- Interaction between horizontal and vertical loading in terms of plastic hinge position and mode of collapse

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Essential Ancillary: Page

- Digital Force Display (STR1a) 203

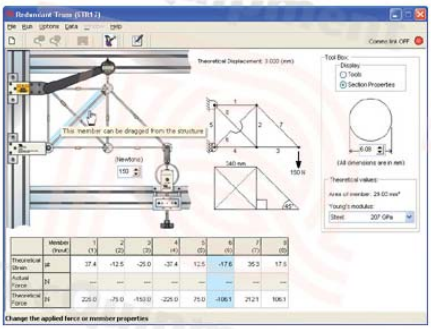
Recommended Ancillaries: Page

- Specimen Portal Frame Pack (STR16a)
- Structures Software (STRS) for virtual experiments 206

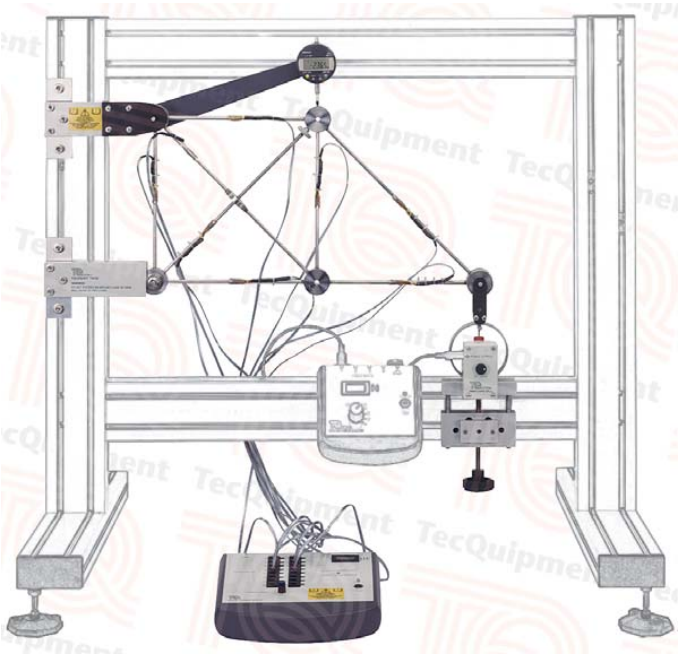
  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Redundant Truss (STR17)

For studying determinate and indeterminate structures



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into determinate and indeterminate structures
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm the results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). Two supports hold the top and base of one side of a structure. The top support allows pivoting, the base support allows pivoting and rolling. Initially, one of the members is missing from the structure, making it determinate. To make the structure indeterminate, students refit the missing member.

Students manually apply a load to one end of the determinate framework using a screw-thread and electronic load cell. The load cell connects to a Digital Force Display (STR1a, available separately) which shows the applied load.

Each member of the structure has strain gauges attached. These each connect to a digital strain bridge which shows the member strains. Students use the strains to help them calculate the forces in the structure. A digital deflection indicator measures displacement in the structure.

Students note applied load, strains and deflection in a determinate framework. They then repeat the experiment with the frame made indeterminate, and analyse and compare their results.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Study of strains, stresses, forces and deflections in a:

- statically determinate structure; and
- statically indeterminate structure.

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

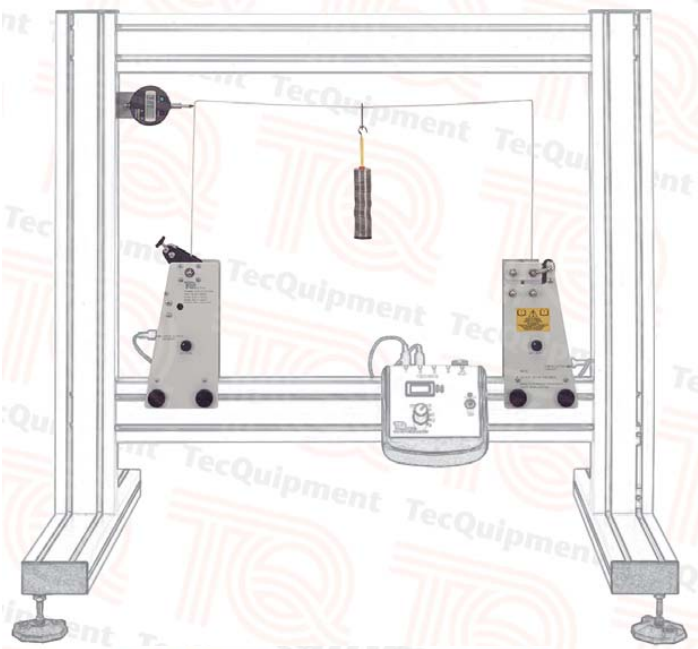
Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

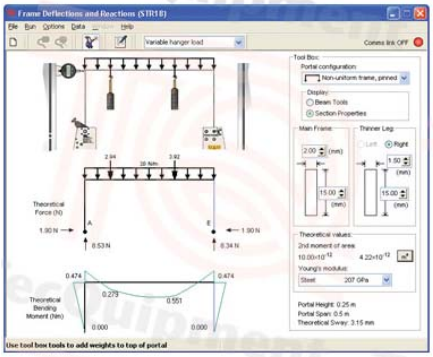
Alternative Product:	Page
• Pin-Jointed Frameworks (STR8)	213

Frame Deflections and Reactions (STR18)

For studying rectangular portals subjected to vertical loads



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into frame deflections and reactions
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm the results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system



Screenshot of the optional TecQuipment Structures Software

The experiment hardware fits onto a Structures Test Frame (STR1, available separately). The hardware includes two rectangular portal frames with the same dimensions. However, one of the frames has a constant second moment of area, while the other has one leg with a smaller second moment of area.

Students clamp each leg of one of the portal frames to supports attached to the test frame. They then load the top of the portal frame using masses on a hanger. Load cells on the supports connect to a Digital Force Display (STR1a, available separately). These measure the moment at one end of the portal frame and the horizontal reaction at the other. A digital deflection indicator measures sway at the top of the portal frame.

Students use the results of moments and reactions to plot bending moment diagrams. They compare the bending moment diagrams, the direction of sway (and its causes) to theoretical calculations. They then repeat the experiment using the other portal frame.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, we can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

Study and comparison of load, horizontal reactions, fixing moments, sway and shear forces in a:

- rectangular portal with a uniform section; and
- rectangular portal with a non-uniform section.

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

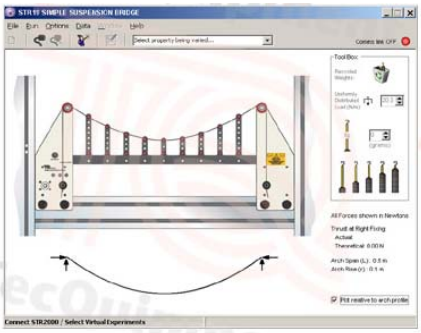
Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

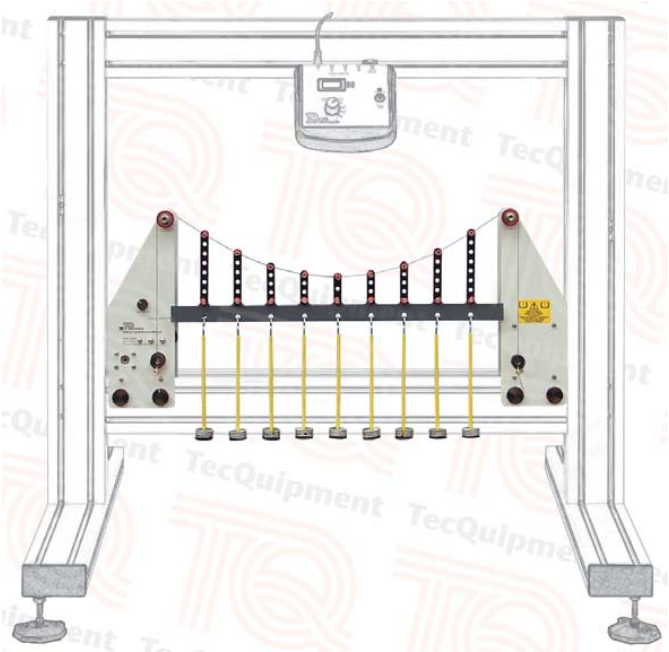
Alternative Product:	Page
• Bending Moments in a Portal Frame (STR20)	227

Simple Suspension Bridge
(STR19)

For studying characteristics of a simple suspension bridge



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into a simple suspension bridge structure
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments, that simulate and confirm the results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to a rigid deck, joined to a parabolic cable via hangers.

The suspension cable passes over pulleys at each end. One end is rigidly fixed. The other end connects to a mechanism bearing on a load cell. When connected to a Digital Force Display (STR1a, available separately), the load cell measures the cable tension. The equipment includes a signal cable to connect the load cell to a Digital Force Display (STR1a).

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the students' learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Demonstration of the characteristics of a simple suspension bridge
- Examination of the relationship between applied loads and the suspension cable tension
- Observation of the stability of the structure
- Comparison of behaviour to simplified cable theory

Essential Base Unit:	Page
• Structures Test Frame (STR1)	203

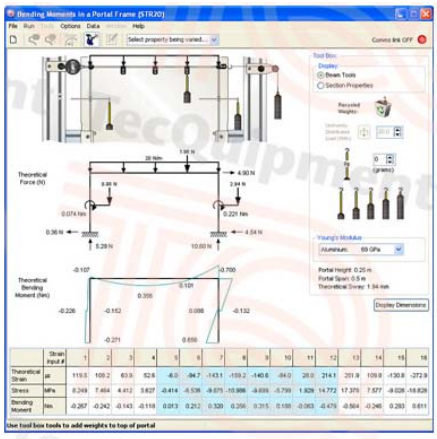
Essential Ancillary:	Page
• Digital Force Display (STR1a)	203

Recommended Ancillaries:	Page
• Structures Software (STRS) for virtual experiments	206
or	
• Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments	205

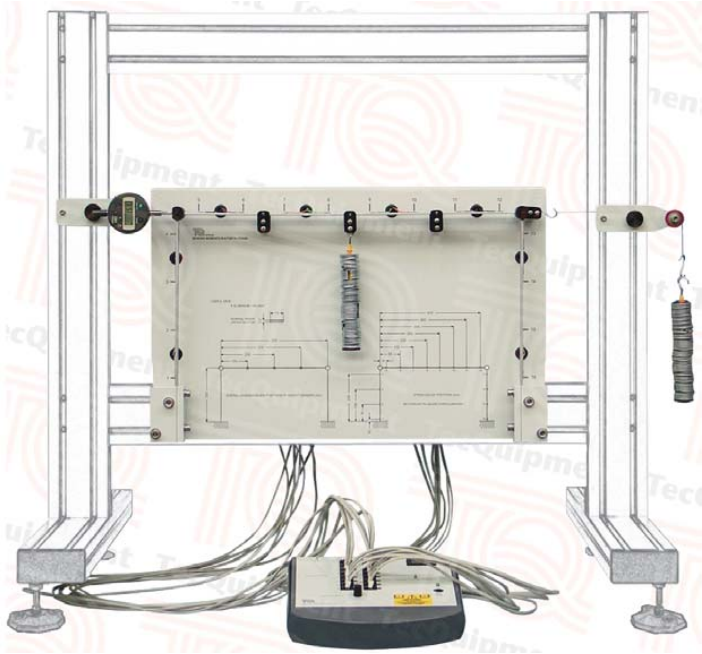
Alternative Product:	Page
• Suspension Cable Demonstration (STF2)	196

Bending Moments in a Portal Frame (STR20)

For studying bending moments and sway in portal frames



Screenshot of the optional TecQuipment Structures Software



- High-quality structures teaching module for students of mechanical, civil and structural engineering
- Allows safe and practical experiments into bending moments of a portal frame
- Realistic and verifiable experiment results
- Optional TecQuipment's Structures Software package for extra 'virtual' experiments that simulate and confirm the results from your hardware and allow extended experiments
- Optional STR2000 unit with TecQuipment's Structures Software package for automatic data acquisition and virtual experiments
- One of many interchangeable experiment modules from TecQuipment's modern, flexible and cost-effective Structures teaching system
- Ideal for classroom demonstrations, or students working in pairs or small groups

The experiment hardware fits onto the Structures Test Frame (STR1, available separately). Students use masses on weight hangers to apply various loads to a portal frame. A backplate holding the portal fits to the test frame. The portal has three members: a horizontal beam and two vertical members or 'legs' joined at two upper corners. All members are of the same material and have the same flexural rigidity (IE value).

The backplate holds the bottom of the portal legs to form rigid fixings. The portal has 16 strain gauges: eight along its horizontal member and four along each vertical member. The gauges connect to the Structures digital strain display (supplied) to display their measured strain. As students apply loads, they use the measured strain to find the bending moment at the gauge positions and plot them on a diagram. They can then check the diagram against one created from theory.

The hardware includes a digital indicator to measure horizontal deflection (sway) in the portal. It also includes a pulley bracket so students can apply horizontal loads and compare sway direction with that predicted from theory. The hardware also includes two removable moment arms. Students may fit one or both moment arms to the frame to simulate internal or external floor supports on the sides of a portal structure. Students can find the bending moments caused by these supports and compare with theory.

The lecturer guide provides details of the equipment including sample experiment results. The student guide describes how to use the equipment and gives experiment procedures.

Continued on next page

Bending Moments in a Portal Frame (STR20)
Continued from previous page

For extra 'virtual' experiments, TecQuipment can supply the optional TecQuipment Structures Software (STRS), for use on a suitable computer. The virtual experiments simulate the tests you can perform with the hardware. They also extend the choice of tests beyond that available using only the hardware, for example: higher loads, uniform loads or different test specimens. This extends the student's learning experience.

For automatic data acquisition of your experiment results, TecQuipment can supply the optional Automatic Data Acquisition Unit (STR2000). Supplied as standard with the STR2000 is TecQuipment's Structures Software that displays and logs your experiment results and gives the extra virtual experiments.

Experiments:

- Strain gauge linearity
- Using strain measurement to find the bending moment
- Bending moments and sway for vertical and horizontal loads
- Bending moments for internal and external moments on vertical members
- Comparison of ideal and non-ideal structures

Essential Base Unit: Page

- Structures Test Frame (STR1) 203

Recommended Ancillaries: Page

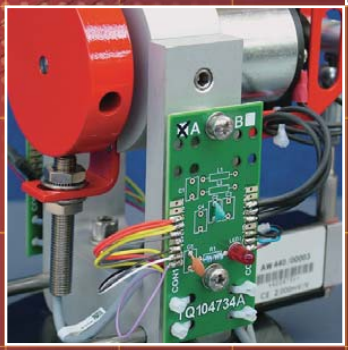
- Structures Software (STRS) for virtual experiments 206

  or
- Automatic Data Acquisition Unit (STR2000) for automatic data acquisition **and** virtual experiments 205

Alternative Product: Page

- Frame Deflections and Reactions (STR18) 225

Theory of Machines



“ I have the pleasure to express my full satisfaction with the smooth functioning of the TecQuipment laboratory educational equipment supplied to IUBAT Departments of Mechanical and Civil Engineering. I particularly appreciate TecQuipment’s local agent Sine Waves Ltd for assisting IUBAT with free installation, commissioning, testing along with comprehensive training. ”

Prof M Alimullah Miyan, International University of Business Agriculture and Technology, Bangladesh

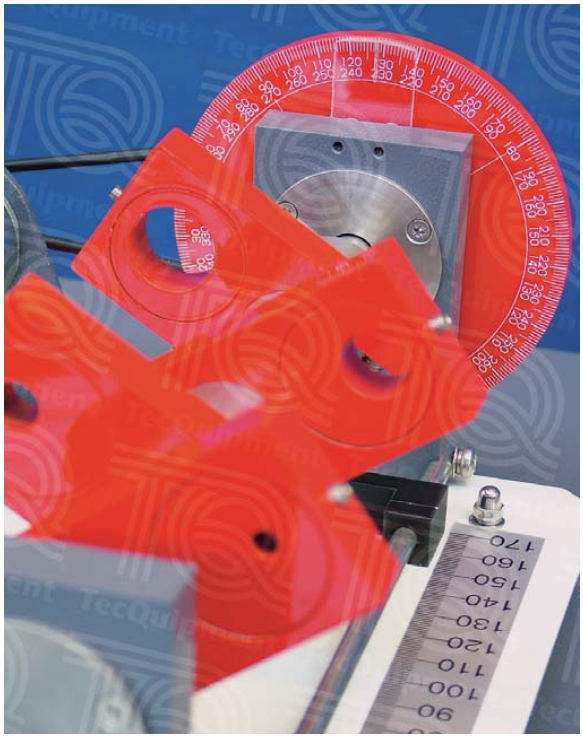
Theory of Machines

Basic and advanced

The Theory of Machines range includes equipment that teaches the basics of machine engineering such as vibration and motion, to more advanced studies of friction in bearings.

Safe yet highly visual

For clarity and understanding, most of the equipment includes fast moving parts. TecQuipment's products always include safety by design, using interlocked guards to prevent accidents, while still allowing students to see what is happening.



KEY FEATURES AND BENEFITS:

- **Basic to advanced teaching: equipment to suit teaching from fundamental to advanced principles.**
- **Safety by design: some equipment uses highly visual rotating parts, but interlocked guards prevent accidents.**
- **Automatic data acquisition: fast-moving equipment often needs multiple fast measurements, making data acquisition a powerful tool.**

Engineering Science

Our Engineering Science range also includes products that demonstrate some of the fundamental principles of simple machines, such as pulleys and gears.

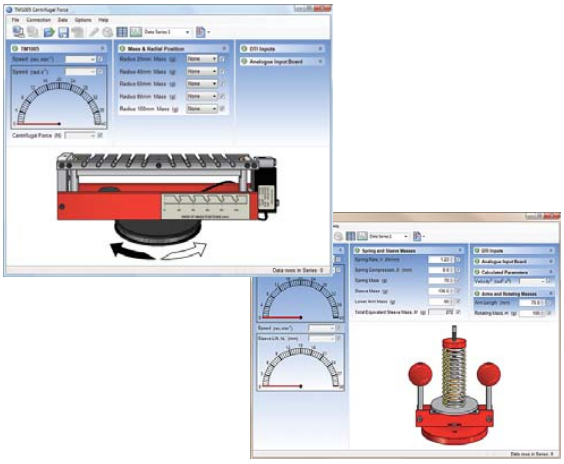
See **Section 4** for more details.

Automatic data acquisition

Some of the products in this range work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 1** for more details.

Look out for the VDAS® logo: VDAS®

VDAS®	Product	
●	**Air Bearing Apparatus** (TE96)	Page 231
●	**Gyroscope** (TM1004)	Page 241
●	**Centrifugal Force** (TM1005)	Page 242
●	**Governors** (TM1027)	Page 243



Air Bearing Apparatus (TE96)

Works with VDAS®

Shows the performance of and pressure distribution around a gas (air) lubricated bearing

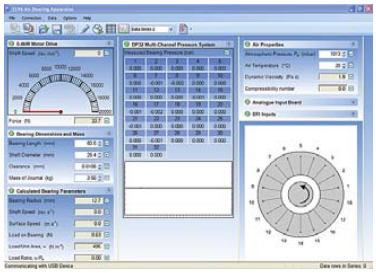
- Shows the performance of a self-acting, gas (air) lubricated journal bearing
- Self-contained and bench-mounting – includes all instrumentation needed for tests
- Fully guarded for safety
- Connects to TecQuipment's optional Versatile Data Acquisition System (VDAS®) for automatic data acquisition
- Variable bearing load and speed, for a range of tests
- Includes a multi-channel digital pressure display
- Shows the onset of bearing 'whirl'

A self-contained product that shows how a self-acting gas-lubricated journal bearing works. It also shows the onset of 'whirl'.

The main part has a variable-speed motor that turns a belt drive. The belt drive turns a precision bearing shaft. The shaft has a high-quality surface finish and spins inside a vertically loaded bush. A hand-operated load control and load cell allow the user to apply and measure the load on the bearing bush. The bush has pressure tappings equally spaced around its circumference. The tappings connect to a multi-channel digital pressure display unit.

A motor drive module allows the user to vary the bearing speed. A speed sensor and the bearing bush load cell connect to the motor drive module. This module displays the bearing speed and the load measured at the load cell.

Both the motor drive module and the pressure display module fit into an instrument frame that has extra space for the optional frame-mounted VDAS-F. Both modules include sockets to connect to the optional VDAS-F.



Typical screenshot of the optional VDAS® software

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

Note: TecQuipment's VDAS® software includes a bar chart display of pressures. This display works with this product to see the pressure distribution around the bearing as a realtime image – ideal for classroom demonstrations.

Experiments:

- Demonstrate how a vertical load affects the pressure distribution around an air-lubricated journal bearing.
- Demonstrate how bearing speed, and therefore compressibility number, affects the pressure distribution in the bearing, and how this compares with theory.
- Demonstrate the onset of 'whirl'.

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

Alternative Products:

	Page
• Michell Pad Apparatus (TE99)	233
• Journal Bearing Demonstration (TM25)	234

Hertzian Contact Apparatus (TE98)

Self-contained unit that allows a practical examination of Hertz's theories of contact between materials

- Helps engineers study and predict contact shapes between common machined surfaces and materials
- Compact, self-contained unit
- No electricity or external services needed
- Uses flexible material to produce magnified and easily viewed results
- Controllable hydraulic pressure system for repeatable results
- Easy-to-use, simple design
- Range of experiments

The Hertzian Contact Apparatus is a self-contained and easy-to-use unit that shows the nature of contact between two surfaces. It compares experiment results with predictions based on Hertz's original theories. This helps engineers to predict contact areas between common machined surfaces and materials, for example different types of bearings.

The apparatus has two pads with curved contact surfaces. The upper pad (made of a transparent plastic material) has compound radii. The lower pad (made of an opaque flexible material) has a simple radius. A hand-operated hydraulic pump and cylinder force the two pads together. Students may rotate the lower pad and a pointer shows the angle of rotation. This allows the study of the effect of different relative curvatures.

A contact shape (or 'zone') forms between the pads. The contact zone may be circular or elliptical, depending on the relative angular position of the two pads. Supplied is a transparent scale to measure the contact shape and angle.

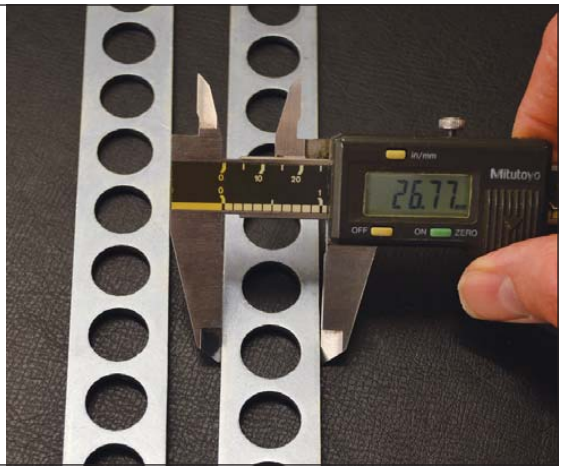
The hydraulic system includes a pressure-relief valve to prevent damage to the equipment.

Experiments:

- The effect of varied pressure with constant angle
- The effect of varied angle (different relative curvature) with constant pressure

Checked and rechecked for quality

100% of all the products we manufacture and processes we use are checked, tested and audited to ensure they are of the highest quality.



Michell Pad Apparatus (TE99)

Shows the pressure distribution across the film of oil in a Michell tilting pad slider bearing. Helps to prove Reynold's equation for pressure gradient in fluid film.

- Proven design, based on a machine created by the Department of Mechanical Engineering, Imperial College, London
- Accurately mimics a Michell tilting pad, fluid-lubricated slider bearing
- Helps prove Reynold's equation for pressure gradient in a fluid film
- Includes variable-speed motor control
- Fully adjustable pad (tilt) angle
- Includes oil and a viscometer

The Department of Mechanical Engineering (Imperial College, London) created the original design for this apparatus. It mimics a tilting pad, fluid-lubricated slider bearing, invented by A G M Michell.

The bench-mounting unit has an aluminium plate (pad) mounted above a continuous-loop flat belt. The belt runs in an oil reservoir to provide a continuous supply of oil under the pad. This creates a pressurised film of oil between the pad and the belt.

A set of 13 graduated tubes shows the oil pressure across and along the film under the pad.

Included is a variable-speed control to control the speed of the motor that turns the belt. Students vary the belt speed to find the relationship between sliding speed, oil viscosity and pressure distribution.

Two eccentric shafts hold the pad so students can adjust the angle of tilt of the pad. This helps students to find the relationship between pressure distribution and film thickness. Micrometers measure the leading and trailing edge positions of the pad.

Included with the apparatus is a container of oil and a viscometer to measure the viscosity of the oil.

Experiments:

Study of:

- Pressure distributions in a tilting pad bearing
- Influence of sliding speed and viscosity on the pressure distribution in the bearing and comparison with calculations based on Reynold's equation.
- Relationship between pressure and the film thickness at the trailing edge of the pad

Alternative Products:

Alternative Products:	Page
Air Bearing Apparatus (TE96)	231
Journal Bearing Demonstration (TM25)	234

Journal Bearing Demonstration (TM25)

Shows the pressures around a journal bearing at different speeds

- Acrylic bearing allows clear observation of oil film at all times
- Pressure profiles, along and around the bearing, continuously monitored on large manometer panel
- Theoretical pressure profiles (Sommerfeld analysis) may be tested and compared with practical results
- Exaggerated clearance makes oil wedge clearly visible
- Shaft/bearing eccentricity easily visible and can be determined by experiment
- Provides striking demonstration of self-excited vibrations (half-speed whirl)
- Fully adjustable speed, direction and loads
- Ideal for group studies and demonstrations

This floor-standing apparatus allows students to study the performance of a journal bearing during different test conditions.

The apparatus consists of a plain steel shaft encased in a clear acrylic shell and directly driven by an electric motor. The bearing is freely supported on the motor shaft and sealed with a rubber diaphragm. The clearance is especially large to clearly show the oil in the bearing. Supplied with the equipment is a container of suitable oil.

A control unit adjusts the motor speed, which can run in both directions. A display shows the motor speed.

An adjustable reservoir supplies oil to a low-pressure region at both ends of the bearing.

The bearing contains 12 equi-spaced pressure tappings around its circumference and four additional ones along its top side and on a vertical radial plane. All are connected by light and flexible plastic tubes to the rear manometer panel, to clearly show the pressure head of oil at all 16 points at all times.

Students load the bearing by attaching weights (included) to arms connected to the bearing.

A strong steel frame with a worktop holds the bearing, the motor, the manometer panel and the control unit.

Experiments:

Simple demonstrations:

- Observation of oil wedge (film thickness) and hence eccentricity variations for different speeds and loads
- Observation of the pressure profiles at these conditions
- Observation of the critical bearing whirl

Experiments:

- Measuring pressure profiles for chosen conditions and plotting the cartesian and polar pressure curves
- Measuring pressure profiles for chosen conditions and plotting the theoretical Sommerfeld curve
- Measuring shaft speed and journal speed at the critical whirl

All tests may be conducted for either direction of rotation of the shaft.

Recommended Ancillary:

	Page
• Stroboscope (ST1)	295

Alternative Products:

	Page
• Air Bearing Apparatus (TE96)	231
• Michell Pad Apparatus (TE99)	233

Whirling of Shafts (TM1001)

Shows 'whirling' in different horizontal shafts with different fixings (end conditions), loaded and unloaded

- Self-contained bench-mounting unit for experiments that predict and show 'whirling' in different length and diameter shafts with different end conditions
- Very visual apparatus – ideal for demonstrations to groups of students
- Shows first and second mode whirl speeds and how to predict them
- Extra bearings and weights (included) give a choice of free-free, fixed-free and fixed-fixed end conditions and experiments with loaded shafts and eccentric loading
- Includes all tools needed for easy experiment setup
- Supplied with different shafts to study how length and diameter affects whirling
- Fully guarded and interlocked for safety
- Optional stroboscope to 'freeze' the image of the shaft to see its shape clearly

TecQuipment's Whirling of Shafts apparatus (TM1001) shows how shafts vibrate transversely and 'whirl' at a certain rotation frequency. This helps engineers understand possible problems with long shafts and allow for them in their designs.

The equipment is in two parts and fits on a bench or desktop.The main part is a solid alloy frame that holds a variable-speed motor which turns the horizontal test shaft. Two bearings hold the shaft – one bearing at the 'driven end' and the other bearing at the 'tail end' of the shaft.

The tail end bearing slides in its housing to allow the shaft length to change as it 'whirls'. Similar to a beam on two simple knife-edge supports, both bearings allow free angular shaft movement (free ends condition).

Also supplied with the equipment are extra bearings that restrict angular movement when fitted, to give 'fixed ends'. Two movable nylon bushes help to prevent the shaft whirling amplitude from reaching excessive levels.

A movable cord plate allows students to control the shaft in some experiments, to help reach the second mode whirl speed. A sensor at the driven end measures the shaft speed and sends its signal to the control and instrumentation unit display.

A removable safety guard with magnetic interlock surrounds the shaft and only allows the motor to work when fitted. The separate control and instrumentation unit contains the drive for the variable-speed motor and a display to show the shaft speed. It also includes a trigger output for the optional stroboscope.

When used in a darkened classroom, the optional stroboscope gives an impressive demonstration of how the shaft shape changes as it reaches its whirling speeds.

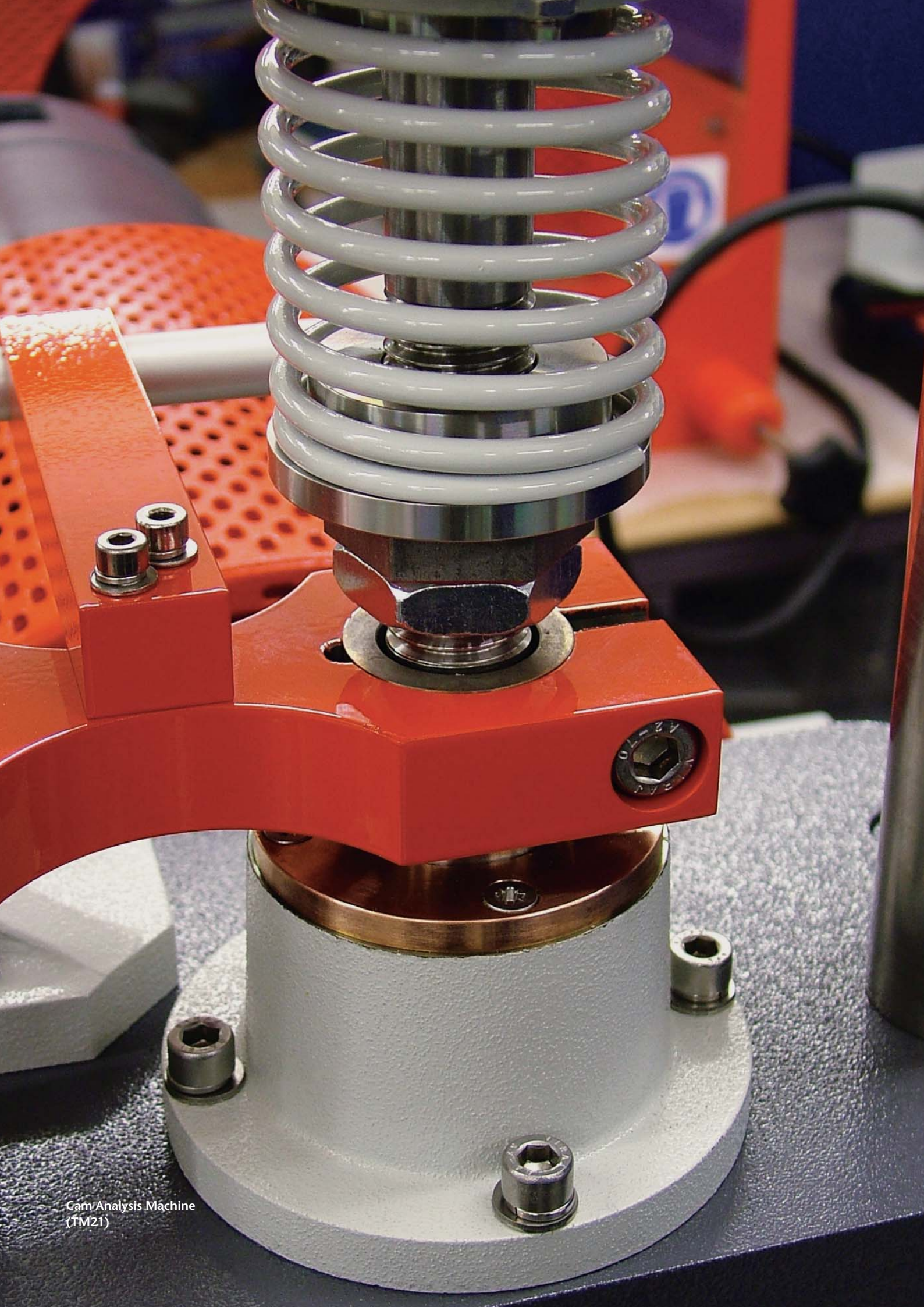
Supplied with the apparatus is a set of test shafts of different length and diameter to show how these properties affect whirling. Also supplied is a set of weights to show how concentrated loads affect whirling. One weight has an extra hole to make it an eccentric load. This helps to show the phase difference between the load and the deflection (you need the optional stroboscope to see this clearly).

Experiments:

- Basic whirling demonstration
- The effect of shaft length and diameter
- The effect of end conditions (fixings)
- Loaded shaft (one and two masses)
- Eccentric loading

Recommended Ancillary: Page

- Stroboscope (ST1) 295



Cam Analysis Machine
(TM21)

Cam Analysis Machine (TM21)

Studies the dynamic behaviour of different cams and followers

Includes Motor Speed Control (E3)

- Studies the dynamic behaviour of cam followers
- Clearly shows follower 'bounce'
- Includes different cams and followers
- Variable follower inertia and compression spring rate
- Includes drum recorder to trace movement of the follower, even at bounce
- Bench-mounted and suitable for classroom demonstrations
- Heavy, robust construction for accurate results

The main part of the product is a geared motor coupled to an extension shaft with a tapered end which carries a cam.

A vertical compression spring pushes a cam follower onto the cam face. A nut adjusts the spring tension. Students can add different weights (included) to alter the inertia of the follower. Included with the product is a selection of springs, followers and cams.

A timing belt from the cam shaft drives a cylindrical drum carrying chart paper. A pen traces a record of the cam follower amplitude.

Included is an optical tachometer to measure the cam shaft speed. A heavy flywheel reduces any speed fluctuations. A motor speed control (E3, included) varies the speed of the cam shaft and the direction of rotation. A guard covers the moving parts to protect the user.

Experiments:

- Tests to check the theory for predicting lift with different spring rates, tensions, follower weights and speeds.
- Finding follower velocity, acceleration and inertia forces
- Demonstration of follower bounce

Alternative Product: Page

- Cam and Crank and Toggle Kit (ES12) 83

Geared System (TM18)

Studies gear systems, from basic principles to gear system design

- Comprehensive range of experiments – from basic principles to introducing gear system design
- Studies simple and compound gear trains
- Transparent cover allows students to see the gear train working
- Completely self-contained, robust, bench-mounted product – no ancillaries needed
- Fully investigates each gear system, including finding the dynamic mechanical efficiency and mass moment of inertia
- Includes dynamometer and comprehensive control and instrumentation unit
- Interlocked safety guards protect students from moving parts
- Quick and convenient changeover of gear systems

A robust, bench-mounting product that allows students to perform a comprehensive range of experiments on geared systems in safety. Students study different simple and compound gear trains. They can fully examine each system, including the dynamic mechanical efficiency and comparison of theoretical and experimentally determined mass moments of inertia.

The main part is a gear unit on a rigid base plate. A variable-speed, trunnion-mounted motor drives the gears. A friction brake unit loads the gears and measures power and torque. A separate control and instrumentation unit displays the important measurements and includes a variable-speed drive to control the motor speed.

The gear unit includes three shafts supporting the gears. The first and third shaft each have a single sliding gear, while the middle shaft has two differently sized fixed gears. A simple alignment mechanism allows students to quickly and conveniently change the gear ratios using the sliding gears. The shafts all run on maintenance-free ball races with low-friction shields. The surfaces of the gears have a special coating that reduces wear. Sensors on the gear unit connect to the control and instrumentation unit.

The gear unit, motor and brake unit locate in machined slots in the base plate. Couplings allow quick and easy connection and alignment to the motor.

For efficiency tests, students use the motor to drive the gear system. An electronic load cell measures input power and torque. The brake unit measures the output power and torque.

To find inertias, students accelerate the system with falling masses and a heavy steel drum. The drum attaches to the centre shaft of the gear unit. A sensor connects to the instrumentation unit which calculates acceleration.

The apparatus includes interlocks and guards to prevent students touching any moving parts.

Experiments:

- Mechanical efficiency of a geared system
- The effect of speed on the mechanical losses and efficiency of a simple geared system
- Simple and compound gear trains
- Inertia of a drum
- Inertia of a shaft with friction
- Combined inertias of a geared system

Alternative Product:

Page

- Gears Trains Kit (ES13) 84

Balance of Reciprocating Masses (TM1022)

A model four-cylinder engine that shows the primary and secondary forces and moments when balancing reciprocating masses

- Model four-cylinder engine assembly held on a cantilever supported on a bench-mounted pillar
- Includes a control and instrumentation unit to process the force and moment signals – also has an electronic drive control to adjust and display the engine speed accurately
- Shows both primary and secondary forces and moments and how to balance them
- Simulates one, two and four-cylinder engines
- Variable crank angle settings and additional piston masses – for a range of tests
- Highly visual - ideal for classroom demonstrations
- Works with an oscilloscope (OS1) to show dynamic force and moment waveforms for popular engine arrangements and compare them with theory

A bench-mounting model four-cylinder engine that shows primary and secondary forces and moments in reciprocating masses and how to balance them. This product is an excellent follow-on from the Static and Dynamic Balancing equipment (TM1002).

A robust support pillar fixes to a suitable table or bench (not supplied) with a low natural frequency. The pillar holds a cantilever that holds a model four-cylinder engine. The model engine has a crankshaft, connecting rods, bushes (as big-end bearings), pistons and a cylinder block.

A separate control and instrumentation unit (included) controls a motor that turns the engine crankshaft. The crankshaft has adjustable sections. Students can rotate each section relative to the others to change the crank angles. To avoid affecting the experiments, TecQuipment balances the crank sections for all crank angles, even allowing for the connecting rods.

The crankshaft includes a sensor that works with the control and instrumentation unit to measure and display engine speed. It also helps to give a trigger output at top dead centre of the first piston. Each piston includes a tapped hole to allow students to add weights (included) to vary its mass.

The supporting pillar fixes to a workbench, so the engine's centre of mass is on the cantilever axis. Strain gauges on the cantilever detect the bending and torsional strains. The gauges connect to the control and instrumentation unit that calibrates and processes their signals and gives outputs for the oscilloscope (OS1).

Students first find the engine's resonant speeds. They then experiment with different engine arrangements to understand balancing and how to allow for unbalanced reciprocating masses. A removable transparent guard with a safety interlock protects students from the moving crankshaft.

Experiments:

- Primary and secondary forces and moments in popular engine configurations – one, two and four-cylinder
- Primary and secondary forces and moments for different crank settings
- The effect of adding additional mass to one or more pistons for any chosen crank setting
- Comparing calculated forces and moments with actual results

Essential Ancillary: Page

- Oscilloscope (OS1) – needed to see the dynamic force and moment waveforms and amplitudes 295

Alternative Product: Page

- Static and Dynamic Balancing (TM1002) 240

Static and Dynamic Balancing (TM1002)

For experiments in balancing a rotating mass system, statically and dynamically

- Self-contained bench or desktop mounting unit, suitable for student use and for classroom demonstrations
- Demonstrates balancing a horizontal shaft with two, three or four rotating masses
- Independent analysis of static and dynamic balancing
- Includes four removeable rotating masses (balance blocks) with different inserts for a range of moments
- Protractor, horizontal scale and sliding indicator to help accurately position the rotating masses
- Flexible mountings allow test shaft assembly to vibrate in dynamic balancing tests
- Fully interlocked transparent safety cover

This product allows students to do experiments in balancing a rotating mass system and check their results against accepted theory.

A sturdy base unit holds a test assembly on four flexible mounts. The test assembly includes a balanced steel shaft mounted horizontally on low-friction bearings. The equipment includes a set of four rotating masses (balance blocks). The balance blocks fix in any horizontal position and relative angle on the shaft. Each block contains a different (and removable) circular insert, allowing students to create four blocks of different mass and moment. Without the inserts, the blocks become four identical masses for simple balancing tests.

Students fit an extension shaft and pulley (supplied) to the end of the balance shaft. They then add weights (supplied) to a cord wound round the pulley to measure accurately the moment of each balance block.

The test assembly includes a protractor at the end of the shaft and a linear scale with slider under the shaft. These allow accurate measurement of balance block angles and horizontal positions.

An electric motor and belt turns the shaft to test for dynamic balancing. The flexible mounts allow the assembly to vibrate, showing imbalance during dynamic balancing tests. Students remove the belt to check for static balance (the shaft should remain static at any angular position).

A transparent safety dome covers the whole rotating assembly. An interlock shuts off power to the motor when the dome is not fitted.

Experiments:

- Demonstration of simple static and dynamic balancing of two, three and four rotating masses
- Dynamic balancing of rotating mass systems by calculation and vector diagrams (triangle and polygon)

Alternative Product:

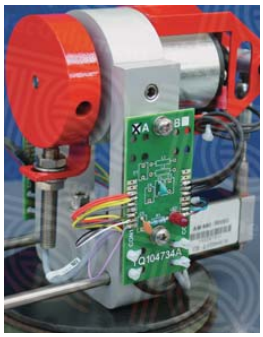
Page

- Balance of Reciprocating Masses (TM1022) 239

Gyroscope (TM1004)

Works with VDAS®

For experiments in gyroscopic couple and velocities of rotor and precession

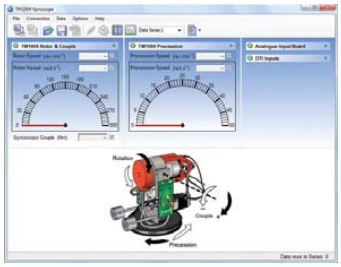


- Shows the relationship between gyroscopic couple, and the velocities of rotor and precession
- Portable, self-contained bench-top unit, suitable for classroom demonstrations and use by small groups of students
- Interlocked, transparent dome allows students to see the gyroscope spinning in safety
- Works in both clockwise and anticlockwise directions for a full range of tests
- Unique multifunction controls for coarse and fine adjustment of velocity and direction
- Direct measurement of gyroscopic tilting force, couple and velocities (speeds) shown on digital displays
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

A base unit supports a gimbal frame, holding a gyroscope assembly that spins and precesses under a clear dome.

The rotor of an electric motor shares a horizontally supported shaft with a flywheel, forming the gyroscope. A second electric motor turns a belt that turns a turntable under the gyroscope, causing precession about a vertical axis. Both motors work in clockwise and anticlockwise rotation and with variable velocity. Sensors measure the rotational velocity of the rotor and precession.

A sensor measures the gyroscope's up or down tilting force at a known distance from the gyroscope pivot. This allows calculation of the torque or 'gyroscopic couple'.



Screenshot of the optional VDAS® software

The clear dome includes an interlock that shuts off power to the motors. This allows students to see the gyroscope and use it in safety, while still giving them access to examine the mechanism.

The base unit includes motor controls and displays of rotor and precession velocity (speed), force and couple. The controls include unique direction, coarse and fine velocity adjustment and 'press to stop' functions.

The equipment works with TecQuipment's Versatile Data Acquisition System (VDAS® available separately). Using VDAS® enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a computer (not supplied) making tests quick and reliable.

Experiments:

- Direction of gyroscopic couple (in relation to precession and rotor spin directions).
- Magnitude of gyroscopic couple (in relation to precession and rotor spin velocities).

Recommended Ancillary: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

Centrifugal Force (TM1005)

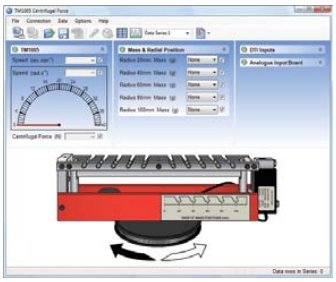
Works with VDAS®

For experiments in centrifugal force and angular velocity

- Shows the relationship between centrifugal force, mass of a rotating body, its distance from the axis, and its angular velocity
- Balanced arm mechanism for accurate readings
- Portable, self-contained bench-top unit, suitable for classroom demonstrations and use by small groups of students
- Interlocked, transparent dome allows students to see the mechanism spinning in safety
- Unique multifunction control for coarse and fine adjustment of velocity and direction
- Includes a set of weights for different experiments
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

A base unit supports a mechanism that rotates under a clear dome. An electric motor turns a belt that turns a turntable under the mechanism. The motor works in clockwise and anticlockwise rotation and with variable velocity. A sensor measures the rotational velocity of the mechanism.

The mechanism has three balance arms. Two (the outside) arms hold any of a selection of masses (supplied) at any of five radial positions. A sensor measures the centrifugal force due to the selected mass as it rotates about the given radii. The other (central) arm holds equal and radially opposite masses to balance the first mass. This prevents unwanted vibrations, which would also affect measurement accuracy.



Screenshot of the optional VDAS® software

The clear dome includes an interlock that shuts off power to the motor. This allows students to see the mechanism rotating and use it in safety, while still giving them access to change the masses and their positions.

The base unit includes the motor control and a display of velocity (speed) and centrifugal force. The motor control includes unique direction, coarse and fine velocity adjustment and 'press to stop' functions.

The equipment works with TecQuipment's Versatile Data Acquisition System (VDAS® available separately). Using VDAS® enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a computer (not supplied) making tests quick and reliable.

Experiments:

Finding the relationship between centrifugal force, the mass of a rotating body, its distance from the axis of rotation (radial position) and the speed of rotation.

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

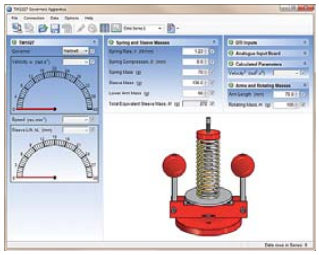
Alternative Product:

	Page
• Centrifugal Force Kit (ES16)	88

Governors (TM1027)

Works with VDAS®

Shows how different governors work, including Hartnell, Porter and Proell governors



Screenshot of the optional VDAS® software

Includes three different governors (one shown already fitted)

- Portable, self-contained bench-top unit, suitable for classroom demonstrations and use by small groups of students
- Demonstrates the effects of speed, mass, geometry and other variables of governor characteristics
- Includes three easy-to-fit governors: Hartnell, Porter and Proell
- Unique multi-function control for coarse and fine adjustment of velocity and direction
- Interlocked, transparent dome allows students to see the governors spinning in safety
- Includes additional weights to change the mass of the Porter and Proell governor sleeves
- Supplied with different springs and rotating masses for the Hartnell governor
- Works with TecQuipment's Versatile Data Acquisition System (VDAS®)

A base unit contains a variable-speed motor. The motor turns each of three different governors: Proell, Porter and Hartnell. **Note:** you test one governor at a time.

Each governor uses rotating weights (masses) and levers to raise a 'sleeve'. The Porter and Proell governors raise the sleeve against the action of gravity. The Hartnell governor raises the sleeve against a compression spring. A sensor measures the position (lift) of each governor sleeve as it rises.

Additional weights (supplied) allow the user to vary the mass of the sleeve of the Porter and Proell governors. Additional springs (supplied) allow the user to vary the spring rate of the Hartnell governor. Users may also adjust the arm length and rotating mass of the Hartnell governor.

The clear dome includes an interlock that shuts off power to the motor. This allows students to see the governors and use them in safety while still giving them access to examine or adjust them.

The base unit includes a motor control and a display of governor velocity (speed) and sleeve lift. The control includes unique direction, coarse and fine velocity adjustment and 'press to stop' functions.

The equipment works with TecQuipment's Versatile Data Acquisition System (VDAS® available separately). Using VDAS® enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a computer (not supplied) making tests quick and reliable.

Experiments:

- Finding characteristic curves of governor speed against sleeve lift.
- Comparison of governor types in terms of sensitivity, stability and effort.
- On the Porter and Proell governors, the effects of varying centre sleeve mass.
- On the Hartnell governor, the effect of varying:
  - arm length
  - spring rate
  - spring compression
  - rotating mass
- Demonstration of the isochronous condition (Hartnell governor).

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Universal Vibration Apparatus
(TM16 Range)

A range of products that fits onto a sturdy steel frame. The range gives different experiments in vibrations, oscillations and simple harmonic motion.

Picture shows the frame and cupboard (TM16a) and the forced vibration experiment

- Cost-effective range of precision-engineered products for experiments in vibration in different mechanical systems
- Economical modular system – you only need to buy the products which match your course
- Fully mobile frame for easy use including storage cupboard to store additional products
- Only needs few simple tools (included) to set up each experiment
- Optional products accurately locate in fixing positions on the frame for easy setup
- Gives experiments with many different systems, including pendulums, mass-spring systems, beams and shafts

The TM16 range is a series of products that teach different aspects of vibrations and oscillations in mechanical systems. These include pendulums, mass-spring systems and shafts and beams. The TM16 range is a modular system, based around the Frame and Cupboard (TM16a).

TecQuipment supplies the products as packages which match a range of experiments. Refer to the selection matrix on page 246 to choose the correct product packages to match the experiments you need.

The Frame and Cupboard (TM16a) is needed for all experiments; you then choose the other products you require. Alternatively, you may select the complete package (TM16), which includes everything you need (except the stroboscope) to do all the experiments.

Experiments:

Using the optional products:

- Simple pendulum
- Compound pendulum
- Centre of percussion
- Determination of the acceleration due to gravity by means of a Kater (reversible) pendulum
- Bifilar suspension
- Mass-spring systems
- Torsional oscillations of a single rotor
- Torsional oscillations of a single rotor with viscous damping
- Torsional oscillations of a two-rotor system
- Transverse vibration of a beam with one or more bodies attached
- Undamped vibration absorber
- Forced vibration of a rigid body-spring system with negligible damping
- Free damped vibrations of a rigid body-spring system
- Forced damped vibration of a rigid body-spring system

Products:

Frame and Cupboard (TM16a)

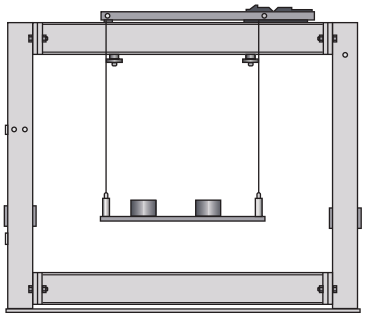
A heavy, sturdy steel frame with small wheels and a useful cupboard to store your optional products. The top of the cupboard is a useful work area. The bottom of the frame has adjustable feet to help you level and steady the frame.

The upper part of the frame is the 'window', where you fit most of the other (optional) experiments. Some experiments fit to the side of the frame.

Pendulum Experiments (TM16b)

Fits in the window of the frame. Studies different pendulums, their characteristics and behaviour. Includes:

- Simple wooden and steel pendulums
- A bob pendulum and Kater pendulum
- A wooden compound pendulum
- A bifilar suspension bar



A typical pendulum experiment

Mass-Spring System (TM16c)

Fits in the window of the frame. Studies different springs with different loads to find periodic time and deflection and spring stiffness. Includes masses and three different springs.

Free and Forced Vibrations (TM16d)

Fits in the window of the frame. Studies free and forced vibrations in a beam and spring system. Includes:

- A long steel beam and supports
- Different springs and masses
- A damping dashpot and a drum recorder

Lateral Vibrations (TM16e)

Fits in the window of the frame. Studies lateral (transverse) vibrations in a beam. Includes:

- A long steel beam and supports
- A spring and masses
- A damping dashpot

Motor and Speed Control (TM16f)

The motor fits onto other ancillaries to give controlled, forced vibrations at a known frequency. The speed control sits on the top of the cupboard. The speed control adjusts the speed of the motor and gives power for the drum recorder of the TM16d. It also gives an output to help trigger the optional stroboscope (ST1).

Vibration Absorber (TM16g)

Fits under the motor of the Motor and Speed Control (TM16f), and onto the beam of the Lateral Vibrations ancillary (TM16e) to study how to 'tune' two bodies to absorb vibrations. It consists of two masses fitted at equal distances on a leaf spring assembly.

Torsional Oscillations (TM16h/i)

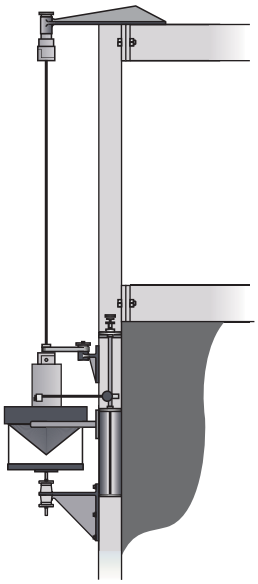
Fits in the window of the frame. Studies oscillations (simple harmonic angular motion) in a twisting shaft. Includes:

- Three different shafts
- Two different flywheels and inertia weights
- Shaft clamps

Damped Torsional Oscillations (TM16k)

Fits on the side of the frame. Studies how oil can dampen the angular oscillations of a twisting shaft (viscous damping). Includes:

- A pen recorder and dashpot
- Three different shafts
- An oil reservoir assembly and oil
- Clamps to hold the parts to the frame



A typical damped torsional oscillations experiment

Essential Ancillary: Page

- Stroboscope (ST1) – needed for some experiments 295

Continued on next page

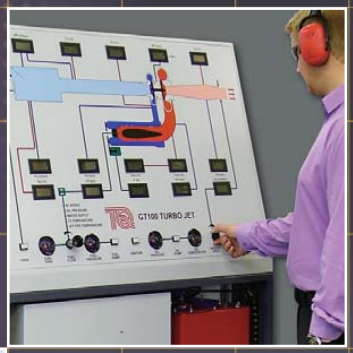
Universal Vibration Apparatus (TM16 range)
Continued from previous page

Selection matrix

	Products									
Experiments	TM16a	TM16b	TM16c	TM16d	TM16e	TM16f	TM16g	TM16h/i	TM16k	ST1
• Simple pendulum • Compound pendulum • Centre of percussion • Determination of the acceleration due to gravity by means of a Kater (reversible) pendulum • Bifilar suspension	●	●								
• Mass spring systems	●		●							
• Forced vibration of a rigid body-spring system with negligible damping • Free damped vibrations of a rigid body-spring system • Forced damped vibrations of a rigid body-spring system	●		●	●		●				
• Transverse vibration of a beam with one or more bodies attached	●			●	●	●				●
• Undamped vibration absorber	●			●	●	●	●			●
• Torsional oscillations of a single rotor • Torsional oscillations of a two-rotor system	●							●		
• Torsional oscillations of a single rotor with viscous damping	●							●	●	

Note: The TM16 (complete package) includes the TM16a, b, c, d, e, f, g, h/i, k but not the ST1

11 Thermodynamics and Heat Transfer



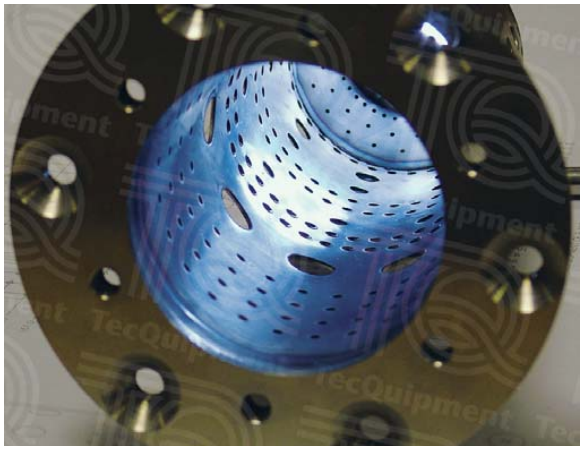
“ BAE Systems Defence Information, Training and Services have recently used TecQuipment to support training activities in the Kingdom of Saudi Arabia through the procurement of two gas turbine trainers. Throughout the procurement, manufacturing and installation period TecQuipment have performed well and supported extra requirements such as product safety justification reports. The experience and expertise of their commissioning engineer was first class and in-country activities went well. ”

N Cherry, Training Procurement Warton, BAE Systems (Operations) Limited

Thermodynamics and Heat Transfer

Safe, practical and realistic

Guided by educational experts and students, TecQuipment has developed and expanded this range to include an extensive selection of high-quality robust products. Our experience has shown that thermodynamics experiments can take many hours, so our designs reduce the experiment time to a practical and realistic level, with safety as the key aspect.



KEY FEATURES AND BENEFITS:

- **Safe and practical design: reduced experiment times.**
- **Broad range of products: covers from basic principles to gas turbines.**
- **Automatic data acquisition: thermodynamics experiments need several minutes of constant monitoring to achieve thermal equilibrium, making automatic data acquisition a useful tool.**

Modular fluid power

Our Modular Fluid Power range includes products that can be analysed in terms of thermodynamic performance, such as compressors.

See **pages 141–156** for more details.

Broad range

Over the last decade, TecQuipment has improved and grown this range to include a broad range of products that now cover topics starting from thermodynamic principles up to complex systems such as gas turbines.

Automatic Data Acquisition

VDAS® Most of the Thermodynamic and Heat Transfer products work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 1** for more details.

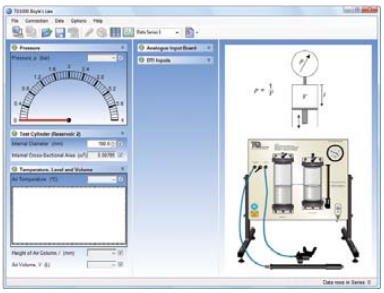
ADA TecQuipment's gas turbine products work with our unique Gas Turbine software.

VDAS®	ADA	Product	
●		**Boyle's Law** (TD1000)	Page 249
●		**Gay Lussac's Law** (TD1001)	Page 250
●		**Boiling and Condensing Heat Transfer** (TE78)	Page 251
●		**Natural Convection and Radiation** (TE85)	Page 252
●		**Thermal Conductivity Experiment** (TE19)	Page 253
●		**Heat Transfer Experiments** (TD1002)	Page 255
●		**Free and Forced Convection** (TD1005)	Page 260
●		**Bench-top Heat Exchangers** (TD360)	Page 261
●		**Cross-Flow Heat Exchanger** (TE93)	Page 266
●		**Radiant Transfer Experiments** (TD1003)	Page 267
●		**Water-to-Air Heat Exchanger** (TD1007)	Page 269
●		**Temp Measurement and Calibration** (TD400)	Page 271
●		**Marcet Boiler** (TD1006)	Page 273
●		**Steam Motor and Energy Conversion** (TD1050)	Page 274
●		**Small Engine Test Set** (TD200)	Page 275
●		**Regenerative Engine Test Set** (TD300)	Page 281
●		**Automatic Volumetric Fuel Gauge** (DVF1)	Page 287
	●	**Turbojet Trainer** (GT100)	Page 289
	●	**Turbojet Trainer with Reheat** (GT100RS)	Page 290
	●	**Two-Shaft Gas Turbine** (GT185)	Page 292

Boyle's Law Apparatus (TD1000)

Works with VDAS®

Shows the relationship between pressure and volume of an ideal gas at a fixed temperature



Screenshot of the optional VDAS® software

- A self-contained bench-top experiment – no power supply needed
- Highly visual experiment using a "liquid piston" for reliability and accurate, repeatable results
- Simple and safe to use – needs no tools
- Includes a thermocouple and digital display to help maintain constant temperature and show how compression and decompression of a gas can affect its temperature
- Supplied with hand-operated pumps to compress or decompress the gas (air) above and below atmospheric pressure
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The bench-mounting equipment includes a backplate that holds two clear-walled cylinders containing oil (supplied). Students use hand-operated pumps (supplied) to increase or decrease the pressure in the left-hand cylinder (the reservoir) which moves a "liquid piston" of oil in the right-hand cylinder (the test cylinder). This piston compresses or decompresses a trapped column of air in the test cylinder.

The equipment uses normal, clean, dry air as it behaves as an ideal gas over the range of pressures used in this equipment.

A digital indicator measures the change in height of the trapped air column. When multiplied by the cross-sectional area of the column, this gives the change in volume. A mechanical pressure gauge measures the pressure of the trapped air.

A thermocouple and digital display measure the temperature of the trapped air to make sure that students maintain a constant air temperature during tests. They also help to demonstrate the change in air temperature during demonstrations.

Students maintain a constant temperature while recording the changes in volume with applied pressure. They then plot the results to prove Boyle's Law.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Note: For connection to VDAS® you need the optional Connectivity Kit (TD1000CK). The kit includes an electronic pressure transducer, a thermocouple amplifier and a lead to connect the digital indicator to VDAS®.

Experiments:

- Demonstrations of gas temperature change during compression and decompression.
- Proving Boyle's Law by experiment.

Recommended Ancillaries: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

and

- Connectivity Kit (TD1000CK) for connection to VDAS®

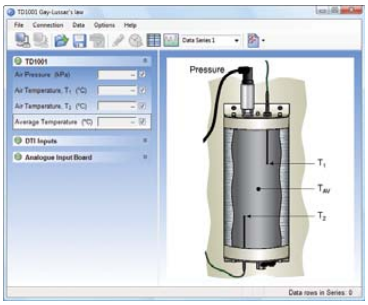
Alternative Product: Page

- Gay-Lussac's Law (TD1001) 250

Gay-Lussac's Law (TD1001)

Works with VDAS®

Shows the relationship between pressure and temperature of a fixed volume of ideal gas



Screenshot of the optional VDAS® software

- Self-contained bench-top module
- Demonstrates Gay-Lussac's Law relating pressure and temperature of an ideal gas (air)
- Simple and safe – needs no tools, uses low pressures and a thermally-insulated heater
- Includes thermocouples and a pressure sensor connected to a digital display
- Electronic controller to accurately regulate temperature
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The bench-mounting equipment includes a backplate that holds a low-pressure vessel. The vessel holds a fixed volume of air surrounded by an insulated heater, controlled by an electronic temperature controller.

A hand-operated valve at the bottom of the vessel allows students to normalize the air in the vessel to ambient conditions.

The equipment uses normal, clean, dry air as it behaves as an ideal gas over the range of pressures used in this equipment.

A thermocouple measures the temperature of the heater surface for the controller. Two thermocouples measure the temperature of the air in the vessel. A pressure transducer measures the pressure of the heated air in the vessel. A digital display shows the absolute pressure, both temperatures and their average value.

Students set the controller for the range of temperatures needed during the experiment. They then record the changes in pressure as the temperature increases and plot the results to prove Gay-Lussac's Law.

The experiment can also work in reverse; students heat the vessel, open the valve to normalise the air in the vessel, then shut the valve. They then record the pressure and temperature drop as the vessel cools naturally. This gives a different starting point and results which will fall below local ambient. Due to the slow nature of natural cooling, the optional VDAS® is helpful in this test to log results automatically.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Experiments:

- Demonstrates change of pressure of a fixed volume of gas during heating.
- Proving Gay-Lussac's Law by experiment
- The principle of a vapour pressure thermometer

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

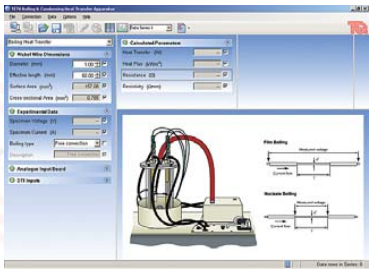
Alternative Product:

	Page
• Boyle's Law Apparatus (TD1000)	249

Boiling and Condensing Heat Transfer (TE78)

Works with VDAS®

Shows heat transfer during different boiling and condensing processes



Screenshot of the optional VDAS® software

- Bench-mounting apparatus that shows heat transfer during different boiling and condensing processes
- Includes digital display of temperatures, flow rate and power
- Has a glass vessel so students can see what is happening
- Shows nucleate, film and sub-cooled boiling
- Works with TecQuipment's optional Versatile Data Acquisition System (VDAS®) for automatic data acquisition
- Shows condensation on different surface finishes
- Shows filmwise and dropwise condensation

Gives students an understanding of heat transfer during boiling and condensing.

The equipment heats and condenses water, and includes a separate control module with a digital display. Heating and condensing takes place inside a partially filled glass vessel. A heater coil heats the water. For boiling heat transfer experiments, students adjust the current in a resistant wire heater element in the water. The temperature of the wire reaches significantly higher than 100°C.

Students watch the boiling process and note the different boiling processes. They note the free convection (before boiling) and the other stages (during boiling).

These include:

- Sub cooled boiling – small bubbles form and rise
- Nucleate boiling – large bubbles form and rise
- Film boiling – unstable and stable, where a vapour blanket forms and heat transfer by radiation becomes important

For condensing heat transfer experiments, water condenses on two water-cooled, vertical cylinder specimens. The cooling water flow rate and its temperature change at each cylinder helps students to find the heat transfer.

To show the effect of surface finish on heat transfer, one specimen has a gold plating and the other has an oxidised finish. They show clearly the difference between filmwise and dropwise condensation.

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 important readings on a suitable computer (computer not included).

Experiments:

- Boiling heat transfer
- Condensing heat transfer

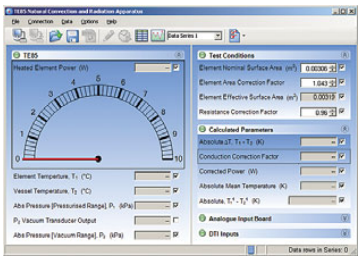
Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Natural Convection and Radiation (TE85)

Works with VDAS®

Shows students how different types of heat can transfer over a range of pressures



Screenshot of the optional VDAS® software

- A self-contained, mobile, compact unit for ease of use and storage
- Helps students to understand natural 'free' convection, radiation, emissivity and the Stefan-Boltzman equation
- Includes a pressure vessel to allow tests above and below atmospheric pressure
- All instruments and vacuum pump included
- Can connect to TecQuipment's optional Versatile Data Acquisition System (VDAS®) for automatic data acquisition
- Test results are accurate enough to allow extrapolation down to a complete vacuum

The Natural Convection and Radiation equipment allows the study of heat transfer at different pressures and vacuum. It shows the differences between radiation and natural 'free' convection. It allows students to find the emissivity of a surface and verify the Stefan-Boltzman equation. It also gives students an understanding of the non-dimensional characteristics using Nusselt, Grasof, Prandtl and Knudsen numbers.

A small heated element hangs in the centre of a pressure vessel. The heater has a matt black surface. Attached to its surface is a thermocouple to measure the temperature.

The vessel's inside is also black, and it has a thermocouple fitted to its wall to measure the temperature in the vessel. The vessel may be charged with compressed air up to 1 bar (gauge) or evacuated down to about 5 Pa (absolute). Students can extrapolate the results down to a total vacuum (no convection). This allows them to isolate the heat transfer by radiation.

Instruments and a digital display measure and display the temperatures, pressures and power to the element. To give accurate measurements of pressure and vacuum, the equipment has two different pressure transducers – one for pressures above atmospheric and one for pressures below atmospheric.

The equipment also includes a socket for connection to TecQuipment's Versatile Data Acquisition System (VDAS®). Included is a vacuum pump, and a regulator for an external compressed air supply (up to 10 bar). The system includes a pressure-relief valve to protect the equipment and the user.

The equipment works with TecQuipment's Versatile Data Acquisition System (VDAS-B, not included). VDAS® allows accurate real-time data capture, monitoring, display, calculation and charting of all the important readings on a computer (computer not supplied).

Experiments:

- Determination of emissivity
- Verification of the Stefan-Boltzmann constant

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

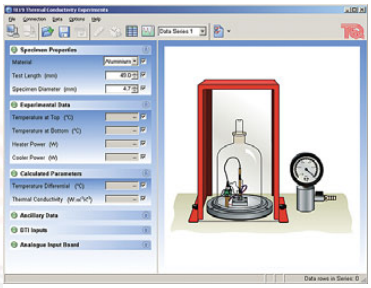
Alternative Products:

	Page
• Free and Forced Convection (TD1005)	260
• Radiant Transfer Experiments (TD1003)	267

Thermal Conductivity Experiment (TE19)

Works with VDAS®

Shows heat conduction in different metals at ambient temperature



Screenshot of the optional VDAS® software

- Bench-mounting apparatus which demonstrates heat conduction along metal test specimens
- Uses low temperatures to reduce heat losses for accurate results
- Test area pressure can be reduced to a vacuum for accurate results (needs optional vacuum pump)
- Supplied with selection of different metal specimens
- Specimens are reusable and easily changed
- Connects to TecQuipment's optional Versatile Data Acquisition System (VDAS®) for automatic data acquisition

The Thermal Conductivity Experiment is in two parts:

- Base unit with a Peltier cooler, a vacuum gauge and a moulded glass dome (vacuum vessel).
- Separate control module, with heater and cooler controls and a multi-line display. It also includes a connection for TecQuipment's optional VDAS® and a suitable computer (not supplied) for automatic data acquisition.

Included with the equipment are specimens of different metals. Each specimen has a small resistive heater at one end; the other end clamps to the cooler of the base unit. The heater at one end and the cooler at the other give a controlled heat flow along the specimen. Attached to the specimen are two thermocouples at a precise distance apart, near to each end. Students use the temperature difference between the thermocouples to find the thermal conductivity of the material. They then compare it with other materials and with given values.

The glass dome covers the area around the specimen. The students use a suitable vacuum pump (RE19, available separately) to remove the air inside the dome. This reduces heat loss due to convection to give more accurate results.

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 important readings on a suitable computer (computer not included).

Experiments:

- Thermal conductivity of different metals

Essential Ancillary:

	Page
Laboratory Vacuum Pump (RE19)	295

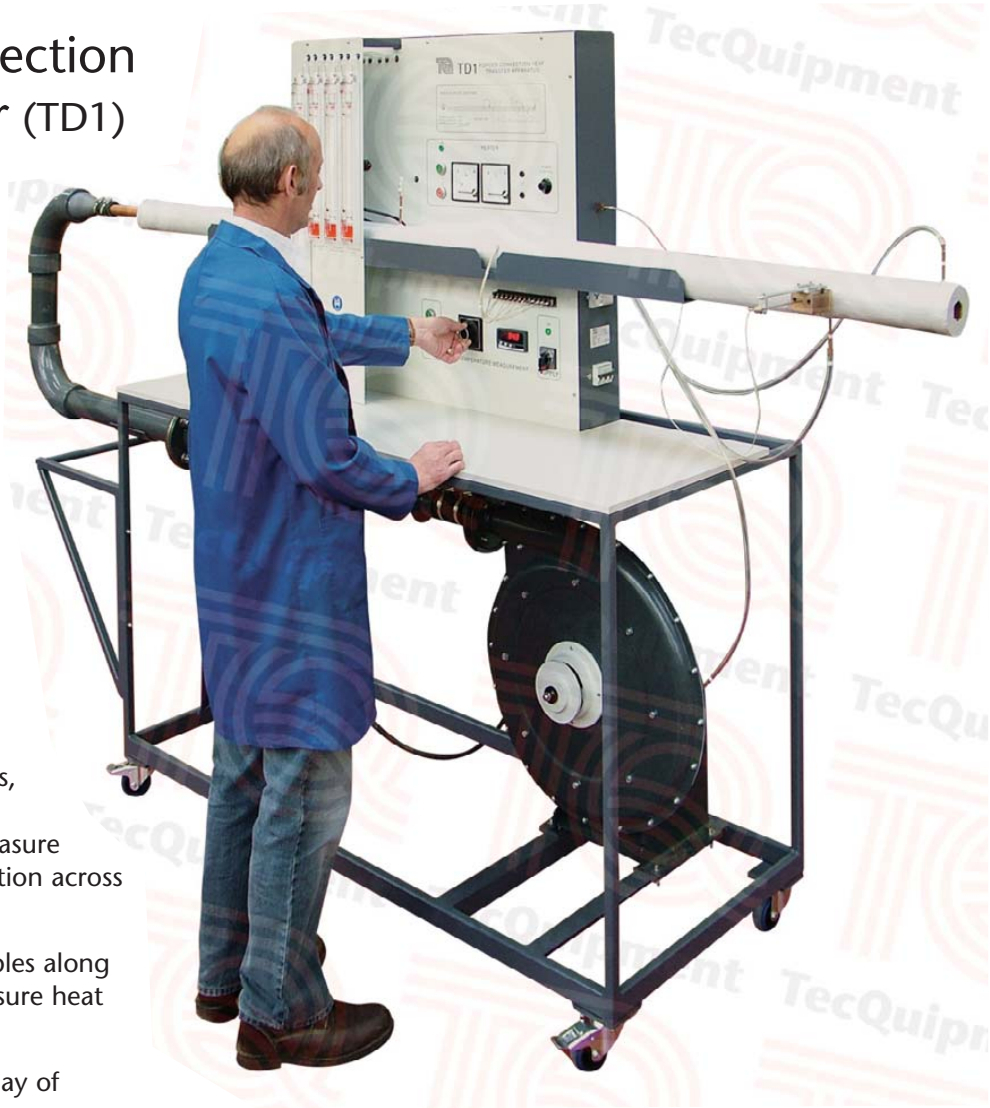
Recommended Ancillary:

	Page
Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Alternative Products:

	Page
Linear Heat Conduction Experiment (TD1002a)	256

Forced Convection Heat Transfer (TD1)



Shows forced convection in pipes and heat transfer theory

- Constant-speed fan with variable flow-control valve for better flow control
- Heater interlock for safety
- Includes Pitot tube traverse for velocity profile measurements, and traversing thermocouple to measure temperature distribution across the test pipe
- Includes thermocouples along the test pipe to measure heat transfer
- Accurate digital display of temperatures
- Includes manometers and an orifice to measure pressures and air flow rate

A basic knowledge of forced convection heat transfer theory is valuable in many engineering fields, especially heat-exchanger design. TecQuipment's Forced Convection Heat Transfer apparatus allows students to examine the theory and associated formulae related to forced convection in pipes.

The TD1 is a frame holding a motor-driven fan, piping and instrumentation panel. It also has a large work surface for student convenience.

The fan runs at a constant speed and draws air through a control valve. The air then moves into a U-shaped pipe. An orifice plate in the pipe connects to a manometer on the instrumentation panel to measure the air flow rate. A larger manometer on the instrumentation panel measures the fan pressure drop.

The U-shaped pipe connects to a smaller diameter, insulated and electrically heated copper 'test pipe'. Students control the power input to the test pipe heater using a variable transformer, while noting the power using instrumentation on the panel. The test pipe discharges to atmosphere.

Pressure tappings at each end of the test pipe connect to a manometer on the instrument panel to measure test length pressure drop. A thermometer measures the air temperature at the inlet to the test pipe. Thermocouples measure the temperature at various points along the test pipe wall. Further thermocouples measure temperature at various points within the test pipe insulation. Students use a digital indicator on the instrumentation panel to display thermocouple temperature readings.

To avoid overheating, a motor starter, isolator and safety interlock prevent the heater working unless there is a suitable flow of air.

The instrument panel also includes a manometer which connects to a Pitot tube traverse assembly to measure the velocity profile across the test pipe.

Experiments:

- Derivation of the value of Nusselt number (Nu) and comparison with empirical formula
- Calculation of the local heat transfer coefficient (h)
- Determination of the Stanton number (St)
- Calculation of the friction factor (f) and comparison with experimental value
- Determination of the validity of the Reynolds analogy for air

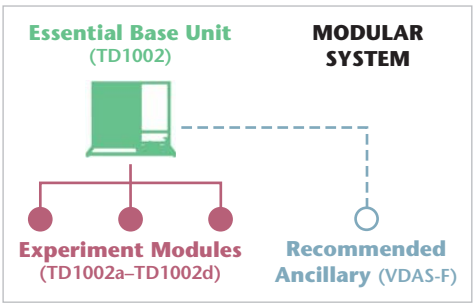
Alternative Products:

- Cross-Flow Heat Exchanger (TE93) 266
- Free and Forced Convection (TD1005) 260
- Water-to-Air Heat Exchanger (TD1007) 269

Heat Transfer Experiments Base Unit (TD1002)

Works with VDAS®

Base unit for a range of optional experiments that study different methods of heat transfer



- A self-contained bench-top base unit with four optional experiments
- Simple and safe to use – foolproof fittings allow students to change and connect the optional experiments quickly and easily (needs no tools)
- Clear digital displays of all readings – you do not need a computer to work it or take readings
- The experiments each have a bedplate with a clear schematic diagram to show students how they connect, and the measuring point positions
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

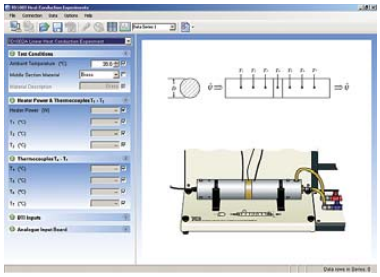
The Heat Transfer Experiments Base Unit (TD1002) is the core of the TD1002 range. It provides cold water and heater power to the optional experiments and all the instruments needed to measure their performance.

The base unit's water system connects to a suitable cold water supply and drain. It includes a hand-operated valve to help give a controllable water flow and a simple return pipe, both colour-coded.

The water connections to the optional experiments are self-sealing quick connectors – for safety and simplicity. The inlet and outlet fluid streams have different colours to reduce errors. Changing an experiment takes less than a minute.

The base unit provides a variable and measured electrical current to the heater in each experiment and works with a safety switch to stop the heater from becoming too hot. It also includes sockets for the thermocouples built into each optional experiment.

Clear, multi-line digital displays on the base unit show the temperatures and heater power of each experiment.



Screenshot of the optional VDAS® software

A spare area to the right of the base unit frame allows you to fit the optional VDAS-F hardware.

Each optional experiment is on a bedplate that has a clear schematic diagram showing the connections and measuring point positions. The bedplate fixes to the base unit with thumbscrews (students need no tools).

Note: You need at least one of the optional experiments. You cannot do experiments with just the base unit.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

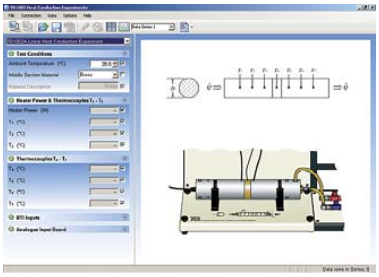
Available Experiment Modules:	Page
• Linear Heat Conduction Experiment (TD1002a)	256
• Radial Heat Conduction Experiment (TD1002b)	257
• Extended Surface Heat Transfer Experiment (TD1002c)	258
• Conductivity of Liquids and Gasses Experiment (TD1002d)	259

Recommended Ancillary:	Page
• VDAS-F (frame-mounted version of the Versatile Data Acquisition System)	6

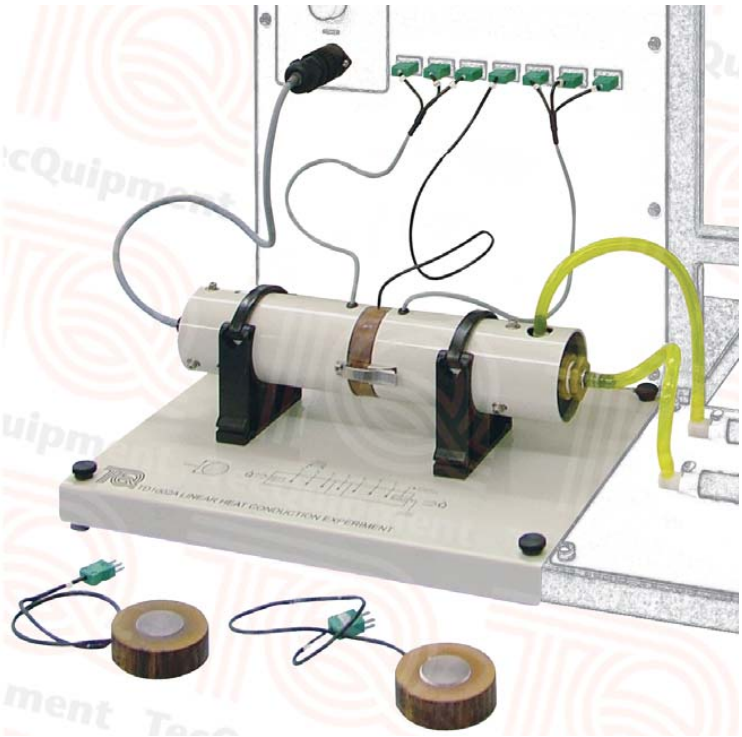
Alternative Product:	Page
• Free and Forced Convection (TD1005)	260
• Radiant Transfer Experiments (TD1003)	267

Linear Heat Conduction Experiment (TD1002a)

Introduces students to the principles of linear heat conduction and thermal conductivity



Screenshot of the optional VDAS® software



- One of four optional experiments for the Heat Transfer Experiments Base Unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Shows the principles of linear heat conduction along a rod of uniform diameter
- Clear schematic printed on the baseplate aids student understanding
- Allows the thermal conductivity of various materials to be measured
- Safe, low-voltage heater with over-temperature cut-out

This experiment has a solid brass bar of circular cross-section, made in two sections with an interchangeable middle section. It mounts on a base plate with a clear schematic of the experiment layout. The first brass section includes three thermocouples and the electric heater (heat source). The second brass section includes a small water-cooled chamber (heat sink) and three more thermocouples. The interchangeable middle sections (supplied) are of different metals:

- Brass – so the bar becomes one length of brass
- Aluminium
- Stainless steel
- Copper

Each middle section has a thermocouple. The electric heater and thermocouples connect to sockets on the Heat Transfer Experiments Base Unit, which also supplies the cold water feed and drain for the heat sink. Students turn on the cooling water flow and adjust the heater power until the experiment reaches equilibrium and then record the temperatures as the heat conducts along the bar. Insulation around the bar reduces heat loss by convection and radiation, so that the results should match the theory for simple linear conduction only.

Experiments:

- Demonstration and calculations of linear heat conduction
- Calculation of the thermal conductivity (k value)
- Demonstration of the effectiveness of thermal paste
- Demonstration and calculations of thermal resistances (R value) in series
- Demonstration of 'thermal lag'

Essential Base Unit: Page

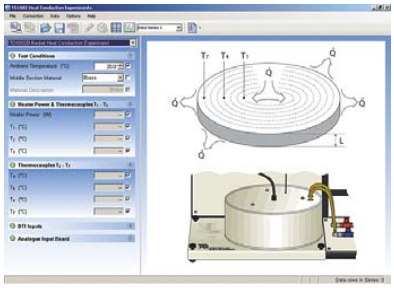
- Heat Transfer Experiments Base Unit (TD1002) 255

Alternative Product: Page

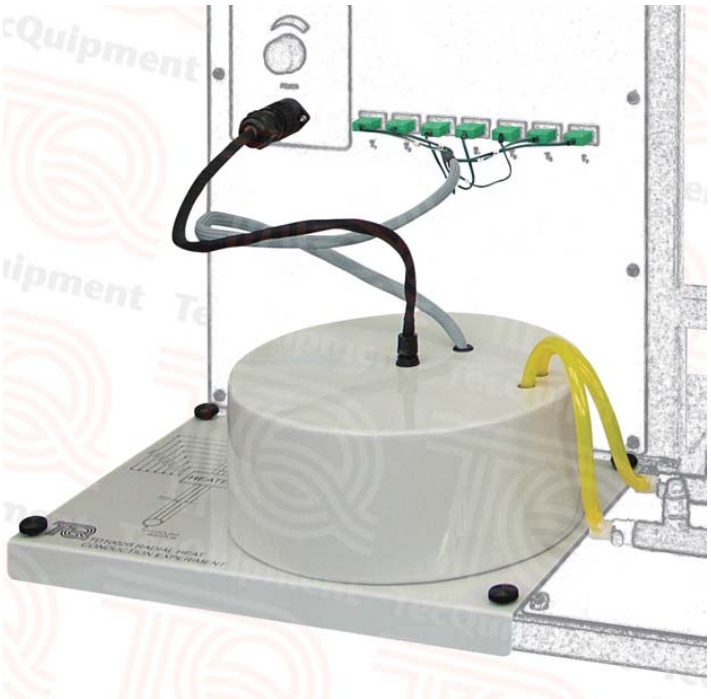
- Thermal Conductivity Experiment (TE19) 253

Radial Heat Conduction Experiment (TD1002b)

Introduces students to the principle of radial heat conduction and thermal conductivity



Screenshot of the optional VDAS® software



- One of four optional experiments for the Heat Transfer Experiments Base Unit (TD1002)
- Fits quickly and easily onto the base of the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Shows the principles of radial heat conduction radially around a disc of uniform diameter
- Clear schematic printed on the baseplate aids student understanding
- Allows the thermal conductivity of the disc material to be measured
- Safe, low-voltage heater with over-temperature cut-out

This experiment has a solid brass disc with an electric heater (heat source) at its centre and a circular cross-section cooling tube (heat sink) around its circumference. It mounts on a base plate with a clear schematic of the experiment layout.

The electric heater and thermocouples connect to sockets on the Heat Transfer Experiments Base Unit, which also supplies the cold water feed and drain for the heat sink

Students turn on the cooling water flow and adjust the heater power until the experiment reaches equilibrium. At equally spaced radii on the disc, seven thermocouples measure the temperature as the heat conducts radially outwards from the heater. Insulation around the disc reduces heat loss by convection and radiation, so that the results should match the theory for simple radial conduction only.

Experiments:

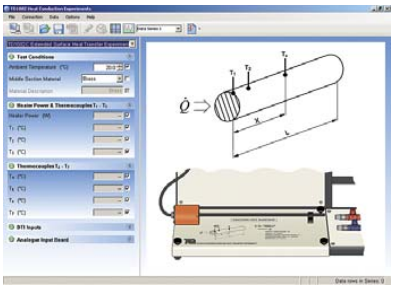
- Demonstration and calculations of radial heat conduction.
- Calculation of the thermal conductivity (k value).

Essential Base Unit:

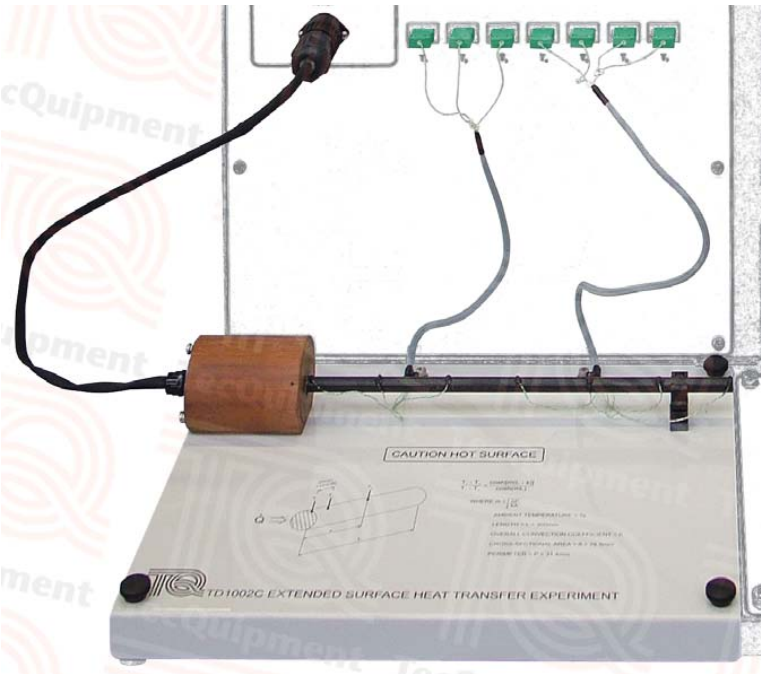
	Page
• Heat Transfer Experiments Base Unit (TD1002)	255

Extended Surface Heat Conduction Experiment (TD1002c)

Shows students an example of conduction combined with losses due to radiation and convection



Screenshot of the optional VDAS® software



- One of four optional experiments for the Heat Transfer Experiments base unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Shows how a long thin rod conducts heat along it and how heat is lost due to radiation and convection
- Clear schematic printed on the baseplate aids student understanding
- An ideal practical example of combined heat transfer
- Safe, low-voltage heater with over-temperature cut-out

This experiment has a thin solid bar with an electric heater (heat source) at one end. It mounts on a base plate with a clear schematic of the experiment layout. The bar has a matt black coating for a consistent and predictable emissivity value. Thermocouples measure the temperature along the surface of the bar at equally spaced intervals. The electric heater and thermocouples connect to sockets on the Heat Transfer Experiments Base Unit.

Heat conducts along the bar and transfers to the local surroundings by natural convection and radiation. Students use initial test results to predict the temperatures and heat flow along the bar.

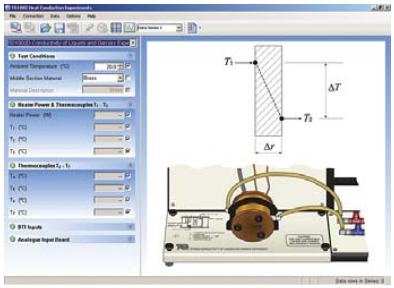
Experiments:

- To show how heat transfers from the surface of a solid bar or rod.
- To show the temperatures on, and heat flow through, the solid bar to its surroundings.

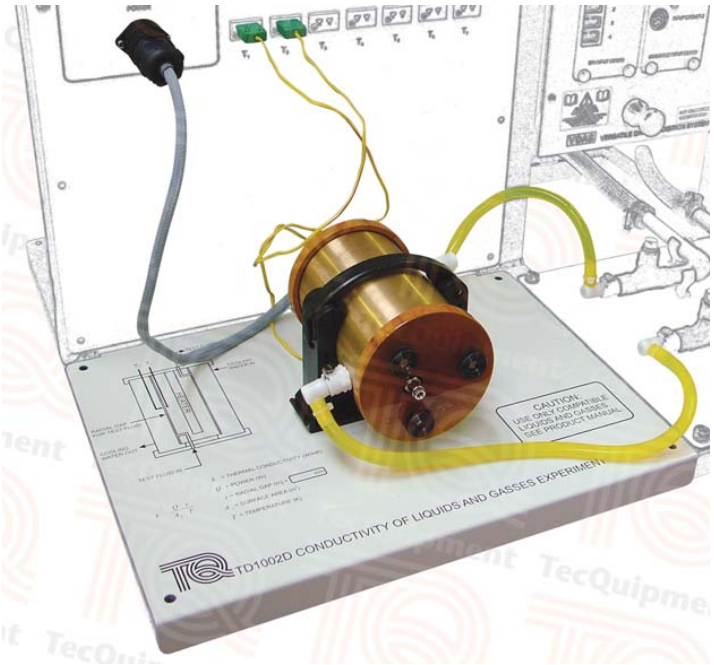
Essential Base Unit:	Page
• Heat Transfer Experiments Base Unit (TD1002)	255

Conductivity of Liquids and Gasses Experiment (TD1002d)

Allows students to test various fluids to find their thermal conductivity



Screenshot of the optional VDAS® software



- One of four optional experiments for the Heat Transfer Experiments base unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Allows students to measure the thermal conductivity of various compatible liquids and gasses
- Clear schematic printed on the baseplate aids student understanding
- Easy to disassemble and clean
- Safe, low-voltage heater with over-temperature cut-out

This experiment has three concentric cylinders. The inner cylinder contains an electric heater (the heat source). The test liquid or gas forms a second, thin cylinder around the heat source. The third cylinder, cooled by water, surrounds them both to make a heat sink. The whole assembly is mounted on a base plate with a clear schematic of the experiment layout.

Heat passes by conduction from the heat source, through the test liquid or gas, to the heat sink. Thermocouples measure the temperature on the inside and outside edges of the cylinder of test liquid or gas.

The electric heater and thermocouples connect to sockets on the Heat Transfer Experiments Base Unit, which also supplies the cold water feed and drain for the heat sink

Caps of thermally-insulating material at the ends of the cylinders reduce heat loss, but students do an initial experiment to calibrate the equipment to allow for heat losses and improve experiment accuracy. One end cap is removable to allow the unit to be easily cleaned when changing from one fluid to another.

Students turn on the cooling water and the heater and measure the temperatures at each side of the test gas or liquid. They then compare their results with those predicted from theory for conduction in liquids and gasses.

Note: The TD1002d equipment is made of brass, aluminium, tufnol, nylon and nickel-plated parts. For safety reasons and to avoid damage to the equipment, only use test fluids that will not damage or react with the materials used to make the TD1002d. TecQuipment does not supply and cannot be held responsible for the test fluids that you use.

Suitable test fluids include:

- Normal, dry air
- Carbon dioxide
- Castor oil

Experiments:

- Calibration of the unit using air as the known medium
- Finding the thermal conductivity (k) of various liquids and gasses and comparing them to typical published values

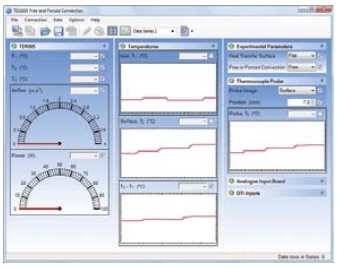
Essential Base Unit: Page

- Heat Transfer Experiments Base Unit (TD1002) 255

Free and Forced Convection (TD1005)

Works with VDAS®

Shows free and forced convection from different heat transfer surfaces



Screenshot of the optional VDAS® software

- Self-contained, bench-top mounting
- Includes three of the most common heat transfer surfaces – flat plate, pinned and finned
- Simple and safe to use
- Thermocouples and a sensitive anemometer measure temperatures and air velocity – shown on a digital display
- Additional hand-held thermocouple probe included – to measure temperatures along the length of the pins and fins of two heat transfer surfaces
- Variable-speed fan and variable-power heat source for a range of tests
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The bench-top equipment includes a vertical duct that holds the chosen heat transfer surface and all instruments needed.

TecQuipment include three different common heat transfer surfaces with the equipment:

- A flat plate
- A pinned surface – similar to a tubular heat exchanger
- A finned surface – similar to the fins on air-cooled engines or electrical heat sinks

Each surface has its own built-in variable-power electric heater. Students choose which surface they need to test and fit it to the duct using simple fixings.

For free convection tests, the heated air rises from the surface and up the duct. For forced convection tests, a variable-speed fan draws air up through the duct and across the surface. Thermocouples measure the air temperature upstream and downstream of the surface and the temperature at the heat transfer surface. The downstream probe moves in a traverse mechanism to measure the temperature distribution across the duct, allowing calculation of the bulk outlet temperature. An additional probe allows students to measure the temperature distribution along the extended surfaces of the pinned and finned heater transfer surfaces. A sensitive anemometer measures the air velocity.

Two controls allow students to set different air velocities and heater power for a full range of tests.

A digital display shows the heater power, air velocity and the temperatures measured by the thermocouples.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Experiments:

- Comparing free and forced convection for different surfaces
- Comparison of free convection from vertical and horizontal (finned) surfaces
- Comparison of heat transfer surface efficiency
- Comparing the coefficient of heat transfer and Nusselt Number for forced and free convection
- Temperature distribution along finned and pinned surfaces

Recommended Ancillary:

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• Bench-mounted version of the Versatile Data Acquisition System (VDAS-B)	6

Alternative Products:

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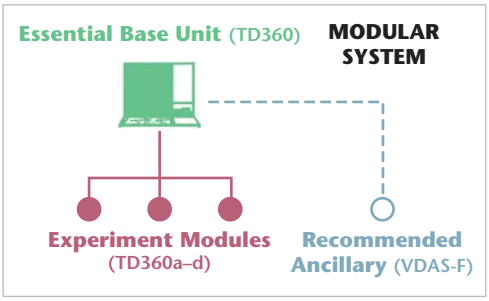
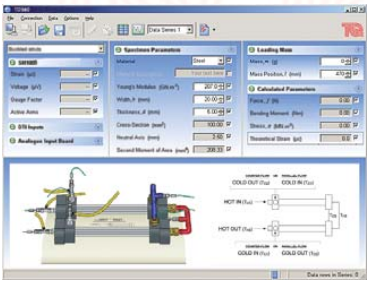
• Forced Convection Heat Transfer (TD1)	254
• Heat Transfer Experiments (TD1002)	255
• Natural Convection and Radiation (TE85)	252
• Cross-Flow Heat Exchanger (TE93)	266
• Water-to-Air Heat Exchanger (TD1007)	269

Bench-top Heat Exchangers Service Module (TD360)

Works with VDAS®

Examines and compares small-scale heat exchangers to help students understand how they work





Screenshot of the optional VDAS® software

- A bench-top service module with optional small-scale demonstration heat exchangers – designed for teaching
- Optional heat exchangers include the most common types used in industry (tubular, plate, shell and tube, and a jacketed vessel with coil and stirrer)
- Simple and safe to use – foolproof fittings allow students to change and connect the optional heat exchangers quickly and easily (needs no tools)
- The service module has clear digital displays of all readings – you do not need a computer to work it or take readings
- Optional heat exchangers have clear outside casings, so students can see their construction
- Heat-exchangers each have a bedplate with a clear schematic diagram to help students understand how to connect it
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The Bench-top Heat Exchangers Service Module (TD360) is the core of the bench-top heat exchangers range. It provides hot and cold water to the heat exchangers and all the instruments needed to measure their performance.

All fluid connections to the optional heat exchangers are self-sealing quick connectors – for safety and simplicity. The hot and cold fluid streams have different connectors to reduce errors. Changing a heat exchanger takes less than one minute.

The service module's hot water system includes a tank with a PID-controlled electric heater, a pump and tank level indicators. An electrically operated valve opens to let water in to fill the tank. The tank has protection in case of over-temperature, low water level and over-filling.

The hot water system gives stable flow rates and temperatures. The service module's cold water circuit has a flow regulator and connection for an external mains water supply. Both the cold and hot water system have precision needle valves and turbine flow meters to control and measure the flow rates. Thermocouples at the connectors measure hot and cold inlet and outlet fluid stream temperatures. Some of the heat exchangers also have built-in thermocouples for extra temperature measurements.

Clear, multi-line digital displays show the temperatures and flow rates of the fluid streams.

All optional heat exchangers have the same nominal heat transfer area and wall thickness, so students can compare them directly. Each heat exchanger is on a bedplate that has a clear schematic diagram showing the connections. The bedplate fixes to the service module with thumbscrews (students need no tools).

Note: You need at least one of the optional heat exchangers to do experiments. TecQuipment recommends that you buy the Concentric Tube Heat Exchanger (TD360a) first, because it has extra temperature measuring points. You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Continued on next page

Bench-top Heat Exchangers Service Module
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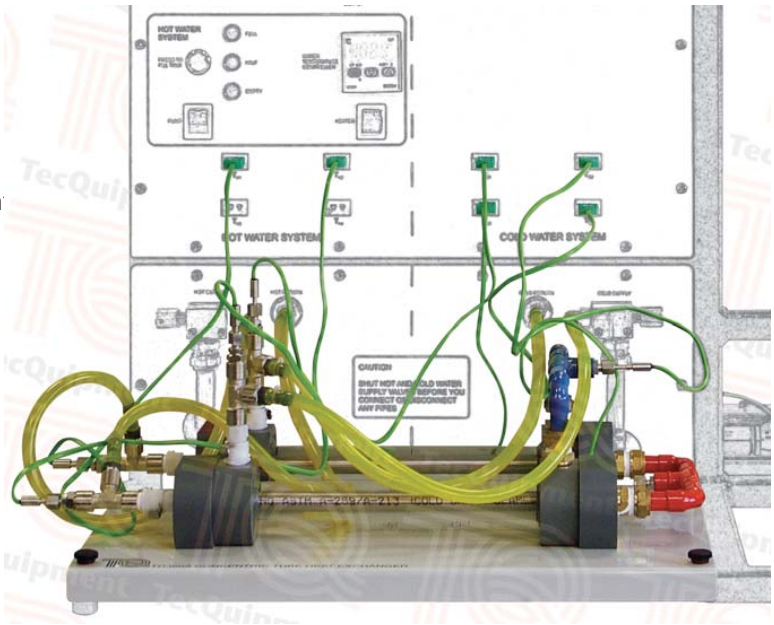
Available Experiment Modules:	Page
• Concentric Tube Heat Exchanger (TD360a)	262
• Plate Heat Exchanger (TD360b)	263
• Shell and Tube Heat Exchanger (TD360c)	264
• Jacketed Vessel with Coil and Stirrer (TD360d)	265

Recommended Ancillary:	Page
• Frame-mounted version of the Versatile Data Acquisition System (VDAS-F)	6

Alternative Product:	Page
• Cross-Flow Heat Exchanger (TE93)	266
• Water-to-Air Heat Exchanger (TD1007)	269

Concentric Tube Heat Exchanger (TD360a)

Shows how a simple concentric shell and tube heat exchanger works



- One of a set of optional heat exchangers for use with TecQuipment TD360 Service Module
- Popular type heat exchanger, used in industry but designed for teaching
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger
- Corrosion-resistant materials for use with ordinary clean water at safe temperatures

This is the simplest of the optional heat exchangers. It has two tubes, one inside the other. One tube carries hot fluid, the other carries cold fluid. Heat transfers between them. TecQuipment's heat exchanger is in two equal parts joined by intermediate pipes. This allows two extra measurement points at the midpoint (plus the standard four points at the connectors). This gives more useful experiment results, to show more clearly how the fluid temperatures change during heat transfer.

The Service Module (TD360) provides hot and cold water to the heat exchanger and all the instruments needed to measure its performance. All fluid connections to the heat exchanger are self-sealing quick connectors – for safety and simplicity. The hot and cold fluid streams have different connectors to reduce errors. Connecting the heat exchanger takes less than one minute.

The heat exchanger is on a bedplate that has a clear schematic diagram showing the connections. The bedplate fixes to the service module with thumbscrews (students need no tools).

Experiments:

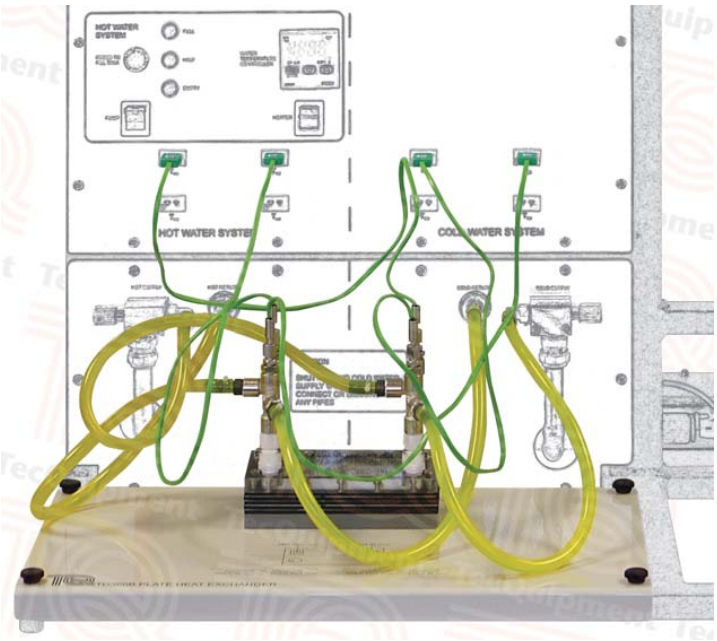
- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if you have two or more optional heat exchangers).

Essential Base Unit:	Page
• Service Module (TD360)	261

Plate Heat Exchanger (TD360b)

Shows how a compact plate heat exchanger works

- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Popular type heat exchanger, used in industry but designed for teaching
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger
- Corrosion-resistant materials for use with ordinary clean water at safe temperatures



This heat exchanger is a set of metal plates separated by spacers (gaskets). The plates and gaskets have holes that make the hot and cold flow run on alternate sides of the plates, therefore transferring heat. The metal plates have flow disturbers on their sides to help improve the heat transfer. Plate heat exchangers are compact and therefore good for applications with limited space. It is also easy to alter their design to change their capacity – you simply add or remove plates and spacers.

The Service Module (TD360) provides hot and cold water to the heat exchanger and all the instruments needed to measure its performance. All fluid connections to the heat exchanger are self-sealing quick connectors – for safety and simplicity. The hot and cold fluid streams have different connectors to reduce errors. Connecting the heat exchanger takes less than one minute.

The heat exchanger is on a bedplate that has a clear schematic diagram showing the connections. The bedplate fixes to the Service Module with thumbscrews (students need no tools).

Experiments:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if you have two or more optional heat exchangers).

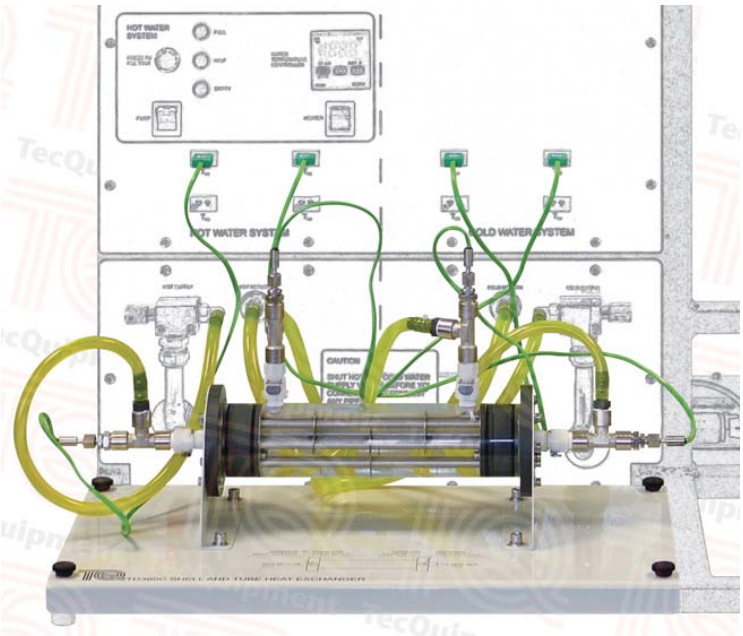
Essential Base Unit: Page

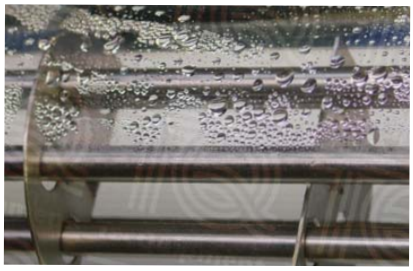
- Service Module (TD360) 261

Shell and Tube Heat Exchanger (TD360c)

Shows how a compact shell and tube bundle heat exchanger works

- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Popular type heat exchanger, used in industry but designed for teaching
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger
- Corrosion-resistant materials for use with ordinary clean water at safe temperatures





This heat exchanger is one of the most common types used in industry. This is because it is compact, but can work at higher pressures than other designs. It is a large tube (shell) which surrounds several smaller tubes (a bundle). One fluid passes through the shell, and the other fluid passes through the tube bundle, therefore transferring heat. Baffles around the bundle help to create a turbulent mixed flow.

The Service Module (TD360) provides hot and cold water to the heat exchanger and all the instruments needed to measure its performance. All fluid connections to the heat exchanger are self-sealing quick connectors – for safety and simplicity. The hot and cold fluid streams have different connectors to reduce errors. Connecting the heat exchanger takes less than one minute.

The heat exchanger is on a bedplate that has a clear schematic diagram showing the connections. The bedplate fixes to the Service Module with thumbscrews (students need no tools).

Experiments:

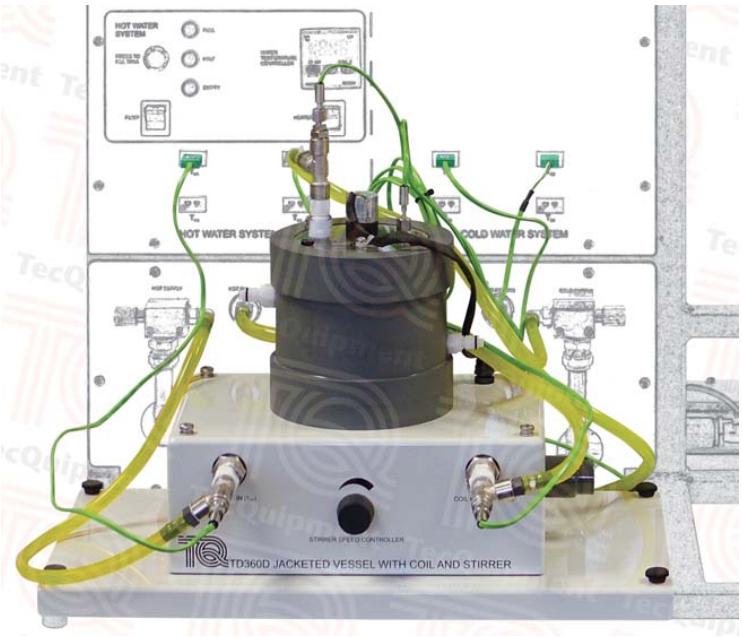
- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if you have two or more optional heat exchangers).

Essential Base Unit:	Page
• Service Module (TD360)	261

Jacketed Vessel with Coil and Stirrer (TD360d)

Shows how a 'jacketed vessel' heat exchanger works and how stirring affects heat transfer

- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Popular type heat exchanger, used in industry but designed for teaching
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear top cover, so students can see its construction
- Jacketed vessel with internal coil and stirrer for batch or continuous heating tests
- Corrosion-resistant materials for use with ordinary clean water at safe temperatures



This heat exchanger mimics those used in the process industry. It can show heat transfer by using the outer skin (or 'jacket') of the vessel, or by a coil inside the vessel. You can set a continuous feed to the vessel for heating, or you set a fixed batch for heating. The unit has an extra thermocouple to measure the batch temperature. It also has a motorised stirrer to show how stirring affects heat transfer.

The Service Module (TD360) provides hot and cold water to the heat exchanger and all the instruments needed to measure its performance. All fluid connections between the Service Module and the heat exchanger are self-sealing quick connectors – for safety and simplicity. The hot and cold fluid streams have different connectors to reduce errors.

The bedplate fixes to the Service Module with thumbscrews (students need no tools).

Experiments:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if you have two or more optional heat exchangers).
- Flow-through and batch heating, with or without stirring, using a heating jacket or a coil.

Essential Base Unit:

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• Service Module (TD360)	261

Cross-Flow Heat Exchanger (TE93)

For studies into the principles and performance of heat exchangers

Works with VDAS®

Screenshot of the optional VDAS® software

- For full understanding of heat exchange by forced convection and measurement of heat transfer
- Enables rapid assessment of heat transfer rates
- Robust, bench-mounting product
- Consists of wind tunnel with fully controllable air flow and heat-exchanger rod matrix
- Separate pre-heated element with built-in thermocouple can take the place of any heat exchanger rod
- Includes comprehensive, accurate and easy-to-read digital instrumentation on separate instrumentation unit
- Instrumentation unit also includes controlled heat source to pre-heat element
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software

For comprehensive studies into the principles and performance of heat exchangers. The equipment allows students to quickly assess heat transfer rates by forced convection. They monitor the rate of cooling of a body of known thermal capacity in an air flow.

The apparatus is bench mounting. It is a horizontal wind tunnel with a contraction cone, a working section, a diffuser, a constant speed fan, and an exhaust with silencer. A variable slide valve controls the air flow.

The working section includes a series of rods arranged in a matrix and at right-angles to the direction of air flow. To do experiments, students can remove any one of these rods and replace it with a cylindrical copper element. The copper element is of known thermal capacity and includes a built-in thermocouple. Students insert the element, which has been pre-heated to a specific temperature, into the working section at a known air velocity. They measure the time taken for the temperature to drop and determine the heat transfer rate.

A second thermocouple at the inlet to the wind tunnel measures the temperature of air entering the heat exchanger. The base of the working section includes two static pressure tappings: one before the rods and one afterwards. These enable students to measure the static pressure difference across the rods. A Pitot traverse can measure air velocity at any vertical point in the working section, either before or after the rods.

The equipment includes a separate instrumentation unit. The instrumentation unit has two inputs for the thermocouples, and two pairs of quick-release couplings for connection to the pressure tappings. It also includes a controlled heat source for the copper element.

A digital display on the front of the instrumentation unit allows students to view all experimental data. In addition, the equipment is fully compatible with our Versatile Data Acquisition System (VDAS®), and can quickly and conveniently connect to a bench-mounting interface unit (VDAS-B, not included). Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant parameters on a computer (PC available separately).

Experiments:

Typical experiments include:

- Determining the pressure losses created by the heat exchange rods and creating a chart of pressure drop against upstream pressure.
- Calculating the inlet velocity and the mean velocity through the rods.
- Determining the rate at which the heated rod cools down, within a bank of rods and by itself.
- Plotting 'cooling curves' and using them to find the coefficient of heat transfer (h) for the heated rod at various positions in the heat exchanger.
- Determining the velocity distribution (profile) downstream of the rods.
- Converting results into dimensionless values (typically using Nusselt, Prandtl and Reynolds equations).
- Comparing results and producing heat transfer coefficient curves.

Recommended Ancillary:

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• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Alternative Products:

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• Forced Convection Heat Transfer (TD1)	254
• Bench-top Heat Exchangers (TD360)	261
• Free and Forced Convection (TD1005)	260
• Water-to-Air Heat Exchanger (TD1007)	269

Radiant Transfer Experiments (TD1003)

Works with VDAS®

Shows the laws of radiant transfer from heat and light sources

Screenshot of the optional VDAS® software

- A self-contained bench-top unit to demonstrate the laws of radiant transfer
- Simple to use and needs no tools – all interchangeable parts fit and slide on an aluminium frame. A separate box includes controls and displays of experiment readings.
- Uses a safe, low-voltage heat source and thermopile (heat flux sensor) for radiant heat transfer experiments
- Includes plates of different heat absorption properties and apertures for extra experiments in heat transfer
- Uses a safe, low-voltage 'integrating sphere' light source and lux meter (light meter) for light transfer experiments
- Includes different optical filters for extra experiments in light transfer
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The equipment has two parts: an aluminium experiment frame and a control box. The frame holds all the experiment parts and allows the user to slide the parts along easily for experiments of transfer over distances. The control box contains the electrical controls and displays of the measured readings.

The user fits different parts to the frame to measure the radiant transfer from light and heat sources.

The heat source uses a variable low-voltage electric heater on a flat plate, creating a black body heat source of variable temperature. A thermocouple measures the heat source temperature. A moveable thermopile measures the heat radiation from the heat source at varying distances. TecQuipment includes plates with different apertures, surface finishes and thermocouples. They allow extra experiments that show how surface finish affects emissivity and absorptivity, and the area factor for heat transfer.

The light source uses a low-voltage lamp inside an integrating sphere to create a diffuse light. Students can rotate the light source through a range of angles (shown on a protractor scale) for experiments in light direction. A moveable lux meter measures the light radiation from the light source at varying distances. TecQuipment includes different optical filters (coloured, neutral density and infra-red block). They allow extra experiments that show how optical filters affect light transfer.

A clear, multi-line digital display on the control box shows temperatures and light or heat radiation.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Continued on next page

Radiant Transfer Experiments (TD1003)
Continued from previous page

Experiments:

Heat:

- Inverse Square Law (or Lambert's Distance Law/Area Law) – showing radiation is inversely proportional to distance squared.
- Stefan-Boltzmann Law – showing the relationship between radiation and source temperature.
- Kirchhoff's Law – showing that a body with good emissivity also has good absorptivity.
- Area Factor – showing that radiation transfer depends on the exposed area of the radiant source.

Light:

- Inverse Square Law (or Lambert's Distance Law/Area Law) – showing radiation is inversely proportional to distance squared.
- Lambert's Direction Law (or Cosine Law) – showing that radiation is proportional to the cosine of the angle between the emitter and the receiver.
- Transmittance and Absorbance – showing that optical filters can reduce light intensity.

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Bench-mounted version (VDAS-B)	6

Alternative Products:

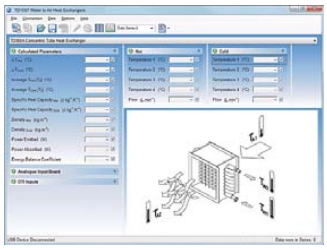
	Page
• Heat Transfer Experiments (TD1002)	255
• Natural Convection and Radiation (TE85)	252

Water-to-Air Heat Exchangers (TD1007) NEW!

Works with VDAS®

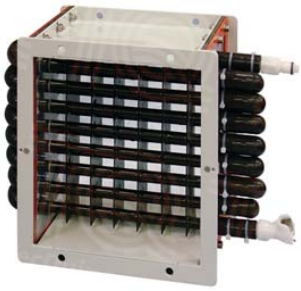
Shows how cross-flow water-to-air heat exchangers work

- A self-contained bench-top unit for demonstration heat exchangers – designed for teaching
- Includes one heat exchanger as standard for a full range of experiments
- Two additional heat exchangers available for extended experiments
- Heat exchangers have transparent sides and schematic diagrams to help students understand how they work and how to connect them
- Simple and safe to use – quick-release and self-sealing fittings allow students to connect and change the heat exchangers quickly and easily – needs no tools
- Clear digital displays of all readings – you do not need a computer to work it or take readings
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)



Screenshot of the optional VDAS® software

16-Tube Heat Exchanger (TD1007a)



16-Tube Finned Heat Exchanger (TD1007b)

Many thermodynamic applications use water-to-air heat exchangers. Examples include using circulated water to heat or cool air in a HVAC installation, or to cool hot water using a flow of air, as in the radiator of a combustion engine.

The TecQuipment Water-to-Air Heat Exchanger mirrors air heating and water cooling applications. It fits on a bench top and includes a hot water supply, a cooling air duct and all instruments needed for tests on cross-flow heat exchangers. The heat output of the design produces good results without greatly affecting the temperature of a reasonable size classroom or laboratory.

Continued on next page

Water-to-Air Heat Exchangers (TD1007)
Continued from previous page

It's hot water system includes a tank with a PID-controlled electric heater for stable temperatures, a pump and tank level indicators. An electrically operated valve opens to let water in to fill the tank. The tank has protection in case of over temperature, low water level and overfilling. A precision needle valve and flow meter control and measure the water flow rate.

The cooling air passes down a vertical duct containing an orifice plate which connects to a differential pressure transducer. The air then passes through a fixed speed centrifugal fan and along a horizontal duct containing the heat exchanger. The air exits the duct through a hand-operated slide-valve. Students use the orifice and valve to measure and control the air flow.

Thermocouples at the water connectors and in the air duct measure hot and cold inlet and outlet fluid stream temperatures. Clear, multiline digital displays show the temperatures, water flow rate and orifice pressure (to calculate air flow).

For safety and simplicity, the heat exchangers have self-sealing quick connectors for their water supply. Quick-release clamps and locating dowels hold the heat exchanger in the air duct. Students need no tools to fit and change the heat exchangers.

Each heat exchanger includes a mimic diagram that attaches to a space on the main unit panel. The diagram gives useful information to the student, including how to connect the heat exchanger. Each heat exchanger has transparent sides so students can easily see their construction and understand how they work.

The equipment includes one heat exchanger as standard. It has 32 tubes in two banks of 16, allowing the addition of a thermocouple at the mid point. TecQuipment supplies two different heat exchangers as optional extras. One (TD1007a) has a single bank of 16 tubes, giving half the heat transfer area of the standard heat exchanger. The other (TD1007b) also has a single bank of 16 tubes, but includes fins to increase the heat transfer area to equal that of the standard 32 tube heat exchanger.

The different heat exchanger options give students a better understanding of how they work and how size and construction may affect practical applications.

The equipment includes a space for TecQuipment's optional VDAS-F. You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Experiments:

- Heat transfer between fluids through a solid wall
- Energy balance and efficiency
- Finding the heat transfer coefficient and Log Mean Temperature Difference (LMTD)
- Effect of water temperature (the 'driving force')
- Comparison of heat exchangers of different construction and heat transfer area (needs optional TD1007a and TD1007b)

Recommended Ancillaries: Page

- 16-Tube Heat Exchanger (TD1007a)
- 16-Tube Finned Heat Exchanger (TD1007b)
- VDAS-F (frame-mounted version of the Versatile Data Acquisition System) 6

Alternative Products: Page

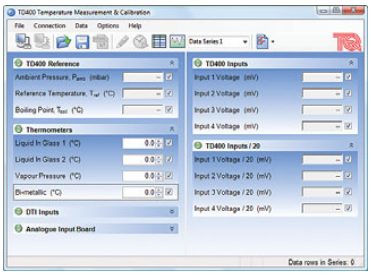
- Bench-Top Heat Exchangers (TD360) 261
- Cross-Flow Heat Exchanger (TE93) 266
- Free and Forced Convection (TD1005) 260
- Forced Convection Heat Transfer (TD1) 254

Temperature Measurement and Calibration (TD400)

Works with VDAS®

Studies the accuracy, linearity and important characteristics of popula temperature measuring devices

- Self-contained bench-mounting unit for experiments with eight different popular temperature measuring devices
- Uses a platinum resistance thermometer as a reference to accurately calibrate the other devices
- Shows how electrical resistance devices and thermocouples work, their characteristics and how to connect them correctly to reduce measurement errors
- Includes liquid-in-glass thermometers with safe non-toxic liquid – no mercury
- Built-in water heater tank with protective guard and drain tap for safe experiments
- Built-in pressure sensor (barometer) with display of local water boiling temperature
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)



Screenshot of the optional VDAS® software

The Temperature Measurement and Calibration apparatus (TD400) fits on a desk or bench top. It includes eight different temperature measurement devices and shows their characteristics and how to calibrate them against a standard.

The built-in precision reference sensor works as an accurate temperature reference. A display shows the temperature from the reference sensor and the local (barometric) pressure from the built-in pressure sensor. The display also calculates the local boiling point of water based on the barometric pressure.

Students add crushed ice (not supplied) to the insulated icebox and clean water to the fully guarded water heater tank. A carefully rated immersion heater in the tank heats the water steadily up to boiling, giving time to take accurate results. The water heater tank includes a water level float switch and a safety temperature cut-out switch to turn off the heater in case of low water level. The water heater tank has a drain tap for connection to a suitable container or local water drain. This helps students to change the heated water safely and quickly, reducing experiment time. As an extra reference, a liquid crystal temperature indicator strip on the front of the heater tank shows its temperature during experiments.

The equipment includes a thermowell that works with the gas (vapour) thermometer to show temperature lag. Sockets on the front panel connect to electronic circuits and a multi-line display that work with the electrical resistance and thermocouple devices. The sockets include resistances to simulate a resistance device and show the problems of adding resistances (for example, long wires) to your measuring circuits.

The electronic circuits also include:

- an amplifier to increase the output of the thermocouples for more useful voltage measurement;
- constant current and voltage sources, and a resistive bridge.

These show the problems with different measurement circuits and power sources for electrical temperature measurement devices.

This equipment connects to TecQuipment's Versatile Data Acquisition System (VDAS®).

Experiments:

- Simulation of two, three and four wire connection of a platinum resistance thermometer (PRT)
- Constant current and voltage sources
- Calibration and linearity of temperature measurement devices and temperature lag
- Thermocouples in series, parallel and the Seebeck effect
- Resistance in thermocouple circuits

Recommended Ancillary: Page

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 6

Humidity Measurement Bench (TE6)

Shows the principles of humidity measurement and compares different methods of measurement

- Shows how to measure and calculate relative humidity (moisture content) of air
- Allows students to compare different humidity-measuring instruments
- Includes air filter to reduce effects of air particles
- Includes mechanical and electronic instruments to measure temperature and humidity
- Variable flow-rate fan to show the effect of air flow on humidity measurement
- Compact unit on mobile frame for ease of use and storage

The Humidity Measurement Bench allows students to compare different methods of humidity measurement. It shows the differences in accuracy between instruments and their ease of use. It also includes a fan to show the effects of air flow on the different instruments.

A mobile frame holds a stainless-steel duct and an electric fan. The main part is the stainless-steel duct that contains a selection of instruments to measure humidity and temperature. A removable plastic window in the duct gives access for students to take readings and change instruments.

A fan mounted underneath the duct supplies the duct with a flow of air. This allows students to study the effect of air flow on the instruments. A slide valve on the fan controls the air flow rate. An orifice plate and manometer measure the flow rate. An air filter in the air flow path stops dirt or other particles affecting the instruments.

The duct includes an extra port. It allows students to introduce low-pressure steam into the duct, to increase the range of experiments (steam generator not included).

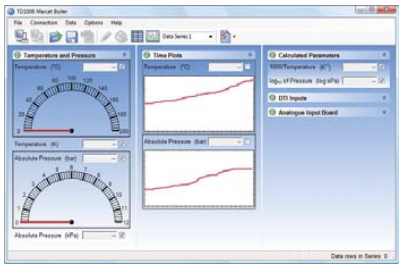
Experiments:

- Measurement of air flow rate in a duct
- Measurement of relative humidity using different types of instrumentation
- Comparison of measurement methods for accuracy and ease of use

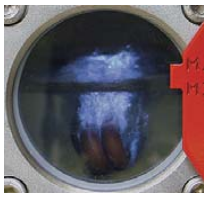
Marcet Boiler (TD1006)

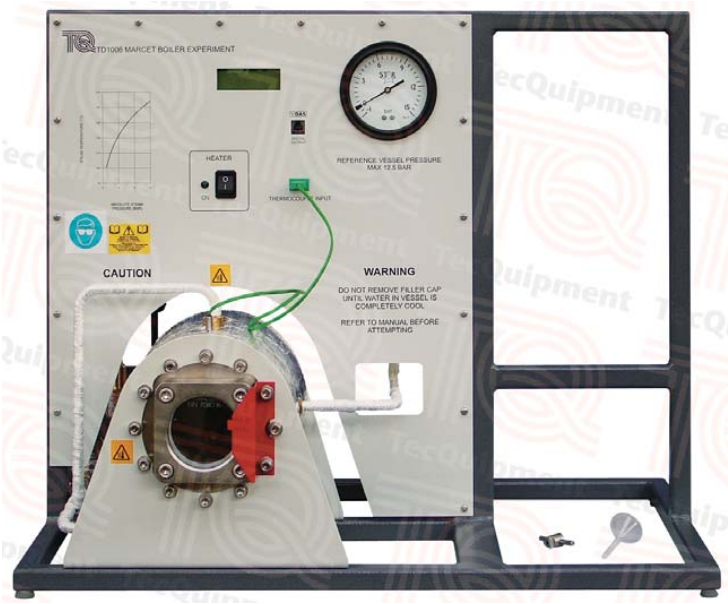
Works with VDAS®

Shows the pressure and temperature relationship for saturated steam



Typical screenshot of the optional VDAS® software





- Compact, bench-top unit
- Based on the classic Marcet boiler experiment
- Stainless steel vessel (boiler) for long life and ease of maintenance
- Proves the Antoine Equation for saturated steam
- Vessel (boiler) has viewing window to see the boiling process and the water level
- Simple and safe to use – includes temperature cut-out switches and a pressure-relief valve
- Electronic sensors measure boiler temperature and pressure – shown on a digital display in both SI and traditional units (including absolute values)
- Can connect to TecQuipment's Versatile Data Acquisition System (VDAS®)

The Marcet Boiler is a simple experiment to show the relationship between pressure and temperature for saturated (wet) steam for comparison with published results.

The apparatus consists of a rigid frame containing an insulated pressure vessel (boiler) and an instrumentation and control unit. The frame also has extra space for the optional VDAS® interface.

The electrically-heated boiler holds water. As the water temperature increases, so does the pressure in the boiler. A transducer and a thermocouple measure the boiler pressure and temperature. A digital display shows the values in both SI and traditional units (including absolute values).

The boiler includes a special-purpose glass window. It allows students to see the internal construction of the vessel, to see the boiling process and to check the water level.

For sound engineering practice, a mechanical Bourdon-type gauge also displays the pressure. It works independent of the electrical supply so the user can always see the pressure in the vessel.

The electrical heater has a thermostat to limit the maximum heater temperature. A pressure-relief valve limits the maximum boiler pressure. For safety, the equipment includes high-temperature pipe to direct any vented steam away from the working area to a suitable drain.

The design includes all possible safety and low-maintenance features, specially for educational use. TecQuipment has checked the corrosion-resistant, high-grade stainless steel boiler against the latest European safety standards.

You can do tests with or without a computer connected. However, for quicker tests with easier recording of results, 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).

Experiments:

- Variation of saturated steam pressure with temperature
- Confirmation of the Antoine Equation

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

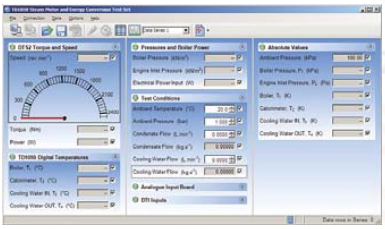
Alternative Product:

	Page
• Steam Motor and Energy Conversion Test Set (TD1050)	274

Steam Motor and Energy Conversion Test Set (TD1050)

Works with VDAS®

A laboratory-scale steam plant that shows fundamental thermodynamic principles of energy conversion and mechanical power measurement



Screenshot of the optional VDAS® software

- Ideal for students to gain insight into the first and second laws of thermodynamics
- Introduces students to industry-standard methods of analysing steam plant performance, including Rankine cycle analysis and using the Willans line
- Uses a simple two-cylinder steam motor and an electrically heated boiler for easy understanding of the main parts of a steam plant
- Self-contained in a mobile frame that includes all instruments needed for experiments
- Allows students to copy the Marcet boiler experiment to prove the pressure-temperature relationship for saturated steam
- Connects to TecQuipment's optional Versatile Data Acquisition System (VDAS®)

A mobile laboratory-scale steam plant for experiments in thermodynamic principles. It helps students to understand:

- Thermodynamic laws of energy conservation
- Steady flow energy equation
- Thermal efficiency and the control surface
- Rankine cycle analysis
- The Willans line

A mobile frame contains all the parts of the test set. An electric pump draws from a reservoir (included) to deliver water to an electrically heated boiler. The boiler includes a safety valve, water level gauge and 'blow-down cock'. The boiler produces steam to turn a two-cylinder steam motor. The used steam from the motor outlet passes through a mains water-cooled condenser, then down to a waste tank or to a measuring vessel (supplied). TecQuipment supplies a stopwatch and thermometer to allow accurate measurement of the flow and temperature of the condensate (steam flow).

The equipment includes all instruments needed for the experiments. These include a band-brake dynamometer with a digital torque and speed display, to measure and display motor speed, torque and power. Thermocouples connect to a digital temperature display to measure and display temperatures at key points in the test set. A throttling calorimeter allows students to measure the dryness fraction of the steam.

Two mechanical gauges show the boiler and engine inlet pressures. A meter shows the electrical power supplied to the heaters in the boiler.

For quicker tests with easier recording of results, 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).

Experiments:

- Steam plant performance, including the Rankine cycle analysis and the Willans line
- Marcet boiler experiment on saturated steam (pressure temperature relationship)

Recommended Ancillary:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

Alternative Product:

	Page
• Marcet Boiler (TD1006)	273

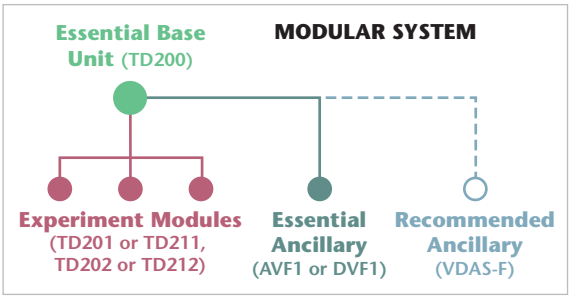
Small Engine Test Set
(TD200)

Works with VDAS®

Versatile engine test bed and instrumentation for investigations into the fundamental features of internal combustion engines

Shown fitted with one of the optional engines

Screenshot of the optional VDAS® software



- Enables wide range of investigations into the characteristics of four-stroke, single-cylinder petrol and diesel engines
- Four-stroke diesel and four-stroke petrol engines available separately
- Includes comprehensive instrumentation
- Optional ancillaries available to extend range of study even further
- Test bed trolley mounted for mobility
- Quick, convenient and accurate engine mounting and changeover
- Robust, simple hydraulic dynamometer
- No need for large electrical supplies
- Instrumentation and test bed are separate to avoid vibration being transmitted to measuring devices
- Self-sealing couplings enable quick and efficient connection and disconnection of fuel lines with minimum loss or spillage of fuel
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software

Continued on next page

Small Engine Test Set (TD200)
Continued from previous page

A versatile hydraulic engine test bed with comprehensive instrumentation. The equipment requires minimum services, installation and outlay. When used with one of TecQuipment's optional single-cylinder engines, it safely and effectively enables study and demonstrations of the most important features of the engine. In addition, optional ancillaries are available to extend the range of study, demonstrations and investigations even further.

The equipment is fully compatible with TecQuipment's optional Versatile Data Acquisition System (VDAS®). This enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a suitable computer (computer not included) making tests quick and reliable.

The main components of the test set are a:

- heavy fabricated portable bed, and
- a bench-mounted instrumentation frame.

The bed sits on a trolley for portability. It includes a robust, precision-machined, trunnion-mounted hydraulic dynamometer. A significant advantage of using a hydraulic dynamometer is that no large electrical supplies are required as the engine power is dissipated into the water used to load the dynamometer.

The dynamometer applies load according to the flow rate and level of water in the casing. An accurate needle valve controls the flow rate and level. An electronic load cell measures torque. The engines (available separately) are supplied pre-mounted on a sturdy precision base plate. When the engine is initially mounted onto the test bed or exchanged with an alternative engine, dowels and slots locate the engine quickly, accurately and reliably. To enable students to measure air flow, an air box and orifice plate are located underneath the engine bed on the trolley.

The instrumentation is mounted in a sturdy frame. The frame has a single power inlet and several power outlets to supply the various display units (either those provided as standard or those provided as optional extras). The instrumentation and test bed are separate in order to avoid vibration being transmitted from the engine to the measuring devices.

The engines (available separately) include an exhaust thermocouple, dynamometer coupling, hoses and fittings. TecQuipment can also supply the engines with pre-modified cylinder heads and cranks for connection to TecQuipment's Engine Cycle Analyser (ECA100, available separately). Each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engines can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

Experiments:

A comprehensive range of investigations into the features of single-cylinder, four-stroke petrol and diesel engines including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies
- Willans line for a diesel engine

By using the recommended ancillaries and engine choices students can investigate more features including:

- Plotting p-θ and p-V diagrams
- Engine cycle analysis
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Available Experiment Modules:	Page
• Four-Stoke Petrol Engine (TD201 or TD211)	277 /279
• Four-Stroke Diesel Engine (TD202 or TD212)	278 /280

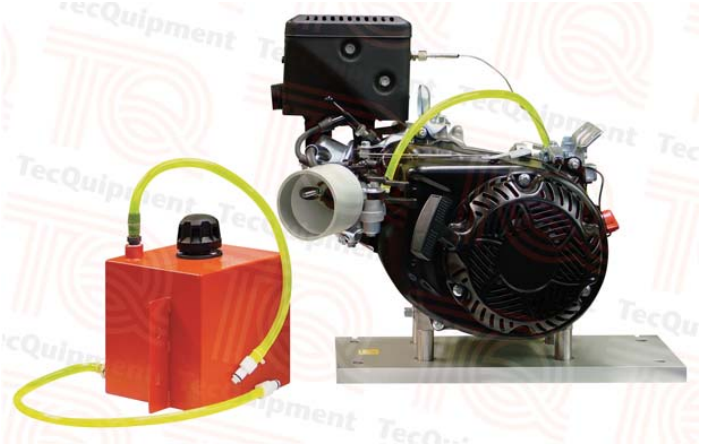
Essential Ancillaries:	Page
• Manual Volumetric Fuel Gauge (AVF1) **or**	286
• Automatic Volumetric Fuel Gauge with Digital Read-Out (DVF1)	287

Recommended Ancillary:	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6

Alternative Product:	Page
• Regenerative Engine Test Set (TD300)	281

Four-Stroke Petrol Engine (TD201)

A four-stroke, single-cylinder petrol engine for use with TecQuipment's Small Engine Test Set (TD200)



- For safe and effective studies and demonstrations of a four-stroke, single-cylinder petrol engine
- For use with TecQuipment's small engine test set (TD200)
- High-quality yet cost-effective engine specially modified for educational use
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality and cost-effective four-stroke, single-cylinder petrol engine for use with TecQuipment's Small Engine Test Set (TD200). Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test set dynamometer and all essential hoses and fittings. In addition, each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engine can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine is mounted on a sturdy precision bed plate. The bed plate has dowels and slots which align and locate it accurately with the dynamometer test set. This minimises the time spent replacing one engine with another.

Experiments:

When used with TecQuipment's Small Engine Test Set (TD200), investigations into the performance and characteristics of a four-stroke petrol engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies

Essential Base Unit:

	Page
• Small Engine Test Set (TD200)	275

Alternative Products:

	Page
• Four-Stroke Diesel Engine (TD202)	278
• Modified Four-Stroke Petrol Engine (TD211)	279
• Modified Four-Stroke Diesel Engine (TD212)	280
• Four-Stroke Petrol Engine (TD301)	283
• Four-Stroke Diesel Engine (TD302)	284

Equipment training

We can 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.

Four-Stroke Diesel Engine (TD202)

A four-stroke, single-cylinder diesel engine for use with TecQuipment's Small Engine Test Set (TD200)

- For safe and effective studies and demonstrations of a four-stroke, single-cylinder diesel engine
- For use with TecQuipment's Small Engine Test Set (TD200)
- High-quality yet cost-effective engine specially modified for educational use
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality, cost-effective four-stroke, single-cylinder diesel engine for use with TecQuipment's Small Engine Test Set (TD200). Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test bed dynamometer and all essential hoses and fittings.

In addition, each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engine can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine is mounted on a sturdy precision bed plate. The bed plate has dowels and slots which align and locate it accurately with the dynamometer test set. This minimises the time spent replacing one engine with another.

Experiments:

When used with TecQuipment's Small Engine Test Set (TD200), investigations into the performance and characteristics of a four-stroke diesel engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies
- Willans line

Essential Base Unit:

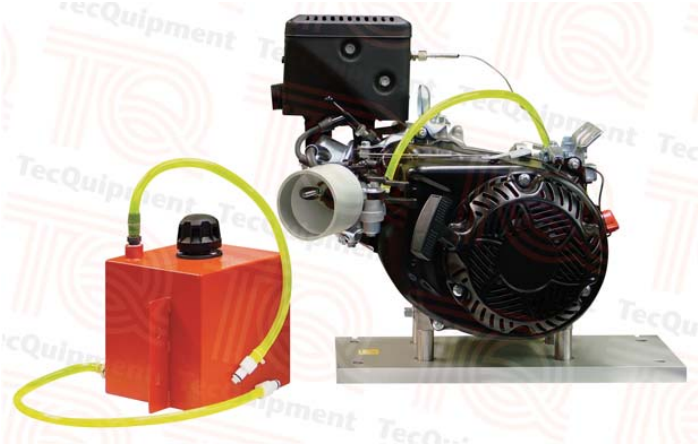
Essential Base Unit:	Page
Small Engine Test Set (TD200)	275

Alternative Products:

Alternative Products:	Page
Four-Stroke Petrol Engine (TD201)	277
Modified Four-Stroke Petrol Engine (TD211)	279
Modified Four-Stroke Diesel Engine (TD212)	280
Four-Stroke Petrol Engine (TD301)	283
Four-Stroke Diesel Engine (TD302)	284

Modified Four-Stroke Petrol Engine (TD211)

A four-stroke, single-cylinder petrol engine with modified cylinder head and crank, for use with TecQuipment's Small Engine Test Set (TD200)



- For safe and effective studies and demonstrations of a four-stroke, single-cylinder petrol engine
- For use with TecQuipment's Small Engine Test Set (TD200)
- Modified for use with optional Pressure (ECA101) and Crank Angle (ECA102) Transducers and Engine Cycle Analyser (ECA100)
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality and cost-effective four-stroke, single-cylinder petrol engine for use with TecQuipment's Small Engine Test Set (TD200). Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test set dynamometer and all essential hoses and fittings. In addition, each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engines can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine has a modified cylinder head and crank. These allow use with the Cylinder Head Pressure Transducer (ECA101 available separately) and the Crank Angle Encoder (EA102 available separately). These can then connect to the Engine Cycle Analyser (ECA100 available separately) to extend the range of experiments possible.

The engine is mounted on a sturdy precision bedplate. The bedplate has dowels and slots which align and locate it accurately with the dynamometer test set. This minimises the time spent replacing one engine with another.

Experiments:

When used with TecQuipment's Small Engine Test Set (TD200), investigations into the performance and characteristics of a four-stroke petrol engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies

When used with TecQuipment's Small Engine Test Set (TD200), Cylinder Head Pressure Transducer (ECA101), Crank Angle Encoder (ECA102) and Engine Cycle Analyser (ECA100), students can investigate further features including:

- Plotting p-θ and p-V diagrams
- Engine cycle analysis
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Essential Base Unit:

	Page
• Small Engine Test Set (TD200)	275

Recommended Ancillary:

	Page
• Engine Cycle Analyser (ECA100)	288
• Cylinder Head Pressure Transducer (ECA101)	
• Crank Angle Encoder (ECA102)	

Alternative Products:

	Page
• Four-Stroke Petrol Engine (TD201)	277
• Four-Stroke Diesel Engine (TD202)	278
• Modified Four-Stroke Diesel Engine (TD212)	280
• Four-Stroke Petrol Engine (TD301)	283
• Four-Stroke Diesel Engine (TD302)	284

Modified Four-Stroke Diesel Engine (TD212)

A four-stroke, single-cylinder diesel engine with modified cylinder head and crank, for use with TecQuipment's Small Engine Test Set (TD200)

- For safe and effective studies and demonstrations of a four-stroke, single-cylinder diesel engine
- For use with TecQuipment's Small Engine Test Set (TD200)
- Modified for use with optional Pressure (ECA101) and Crank Angle (ECA102) Transducers and Engine Cycle Analyser (ECA100)
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality and cost-effective four-stroke, single-cylinder diesel engine for use with TecQuipment's Small Engine Test Set (TD200). Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test bed dynamometer and all essential hoses and fittings. In addition, each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engine can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine has a modified cylinder head and crank. These allow use with the Cylinder Head Pressure Transducer (ECA101 available separately) and the Crank Angle Encoder (EA102 available separately). These can then connect to the Engine Cycle Analyser (ECA100 available separately) to extend the range of experiments possible.

The engine is mounted on a sturdy precision bed plate. The bed plate has dowels and slots which align and locate it accurately with the dynamometer test set. This minimises the time spent replacing one engine with another.

Experiments:

When used with TecQuipment's Small Engine Test Set (TD200), investigations into the performance and characteristics of a four-stroke diesel engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies
- Willans line

When used with TecQuipment's Small Engine Test Set (TD200), Cylinder Head Pressure Transducer (ECA101), Crank Angle Encoder (ECA102) and Engine Cycle Analyser (ECA100), students can investigate further features including:

- Plotting p-θ and p-V diagrams
- Engine cycle analysis
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Essential Base Unit:

	Page
• Small Engine Test Set (TD200)	275

Recommended Ancillary:

	Page
• Engine Cycle Analyser (ECA100)	288
• Cylinder Head Pressure Transducer (ECA101)	
• Crank Angle Encoder (ECA102)	

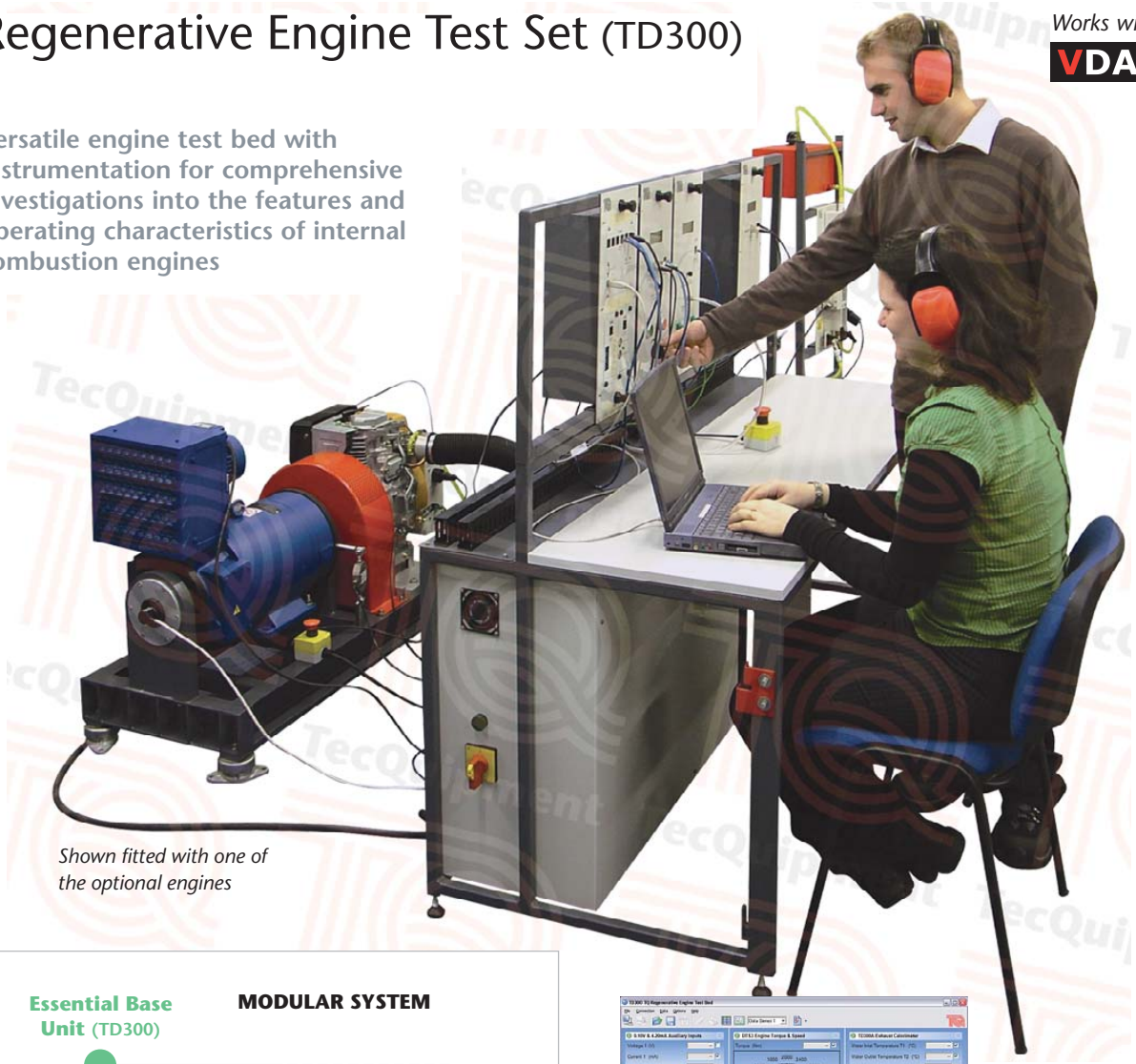
Alternative Products:

	Page
• Four-Stroke Petrol Engine (TD201)	277
• Four-Stroke Diesel Engine (TD202)	278
• Modified Four-Stroke Petrol Engine (TD211)	279
• Four-Stroke Petrol Engine (TD301)	283
• Four-Stroke Diesel Engine (TD302)	284

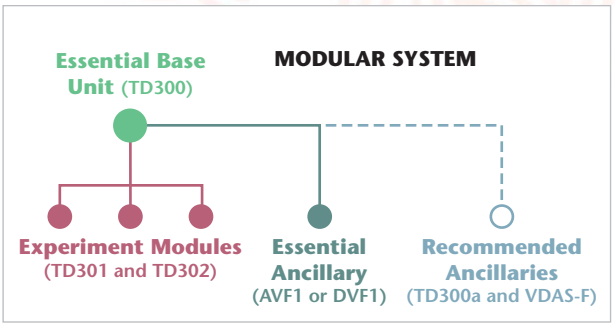
Regenerative Engine Test Set (TD300)

Works with VDAS®

Versatile engine test bed with instrumentation for comprehensive investigations into the features and operating characteristics of internal combustion engines



Shown fitted with one of the optional engines



Screenshot of the optional VDAS® software

- Enables wide range of investigations into the characteristics of four-stroke single-cylinder petrol and diesel engines
- For use with engines up to 10 kW: four-stroke diesel and four-stroke petrol engines (available separately)
- Ideal for group demonstrations and student projects
- Includes comprehensive control console and instrumentation
- Optional ancillaries available to extend range of study even further
- Quick, convenient and accurate engine mounting and changeover
- Test bed includes anti-vibration mounts
- Uses four-quadrant drive to start and load the engine, giving excellent stability
- Self-sealing couplings enable quick and efficient connection and disconnection of fuel lines with minimum loss or spillage of fuel
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software

Continued on the next page

Regenerative Engine Test Set (TD300)
Continued from previous page

A versatile regenerative engine test set with comprehensive controls and instrumentation. When used with one of TecQuipment's optional single-cylinder engines (rated up to 10 kW), it safely and effectively enables study and demonstrations of the features and characteristics of the engine. In addition, optional ancillaries are available to extend the range of study, demonstrations and investigations even further.

The equipment is fully compatible with TecQuipment's optional Versatile Data Acquisition System (VDAS®). This enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a suitable computer (computer not included) making tests quick and reliable.

The main components of the system are a:

- heavy fabricated floor-mounting bed,
- control console with instrumentation frame, and a
- frame which supports the fuel tank and fuel gauge.

The bed is held on anti-vibration mounts. It includes a robust trunnion-mounted d.c. machine. An electronic load cell connected to the machine measures the driving torque of the test engine. The engines (available separately) are supplied pre-mounted on a sturdy precision base plate. When the engine is initially mounted onto the test bed or exchanged with an alternative engine, dowels and slots locate the engine quickly, accurately and reliably.

Each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engines can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The control console has an electrical cabinet which houses a four-quadrant drive to start and load the engine. The motor can also be used to drive the engine while the fuel and ignition are off, so students can establish frictional losses. The control console includes an air box and orifice plate to enable students to measure air flow. The instrumentation and display units are mounted on a sturdy frame, which is part of the control console. The control console also includes a convenient work top for use as a writing desk, or for positioning other equipment such as a computer (computer not included).

The control console and test bed are separate in order to avoid vibration being transmitted from the engine to the measuring devices. In addition, it allows the instrumentation to be thermally and acoustically screened from the test bed, using suitable shielding or a wall. The engines (available separately) include an exhaust thermocouple, dynamometer coupling, colour-coded fuel tank, hoses and fittings. They also have modified cylinder heads and cranks for connection to TecQuipment's Engine Cycle Analyser (ECA100, available separately). An Exhaust Gas Calorimeter (TD300a) is also available separately to enable students to measure energy lost through exhaust gases and to determine the energy balance of the engine.

Experiments:

A comprehensive range of investigations into the features of single-cylinder, four-stroke petrol and diesel engines including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies

By using the recommended ancillaries and engine choices,students can investigate more features including:

- Plotting p-θ and p-V diagrams
- Engine cycle analysis
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Available Experiment Modules:

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• Four-stroke petrol engine (TD301)	283
• Four-stroke diesel engine (TD302)	284

Essential Ancillaries:

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• Manual Volumetric Fuel Gauge (AVF1)	286
or	
• Automatic Volumetric Fuel Gauge with Digital Read-out (DVF1)	287

Recommended Ancillaries:

	Page
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	6
• Exhaust Gas Calorimeter (TD300a)	285

Alternative Product:

	Page
• Small Engine Test Set (TD200)	275

Four-Stroke Petrol Engine (TD301)

A four-stroke, single-cylinder petrol engine with modified cylinder head and crank, for use with TecQuipment's Regenerative Engine Test Set (TD300)

- For safe and effective studies and demonstrations of a four-stroke, single-cylinder petrol engine
- For use with TecQuipment's Regenerative Engine Test Set (TD300)
- Modified for use with optional Pressure (ECA101) and Crank Angle (ECA102) Transducers and Engine Cycle Analyser (ECA100)
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality, cost-effective four-stroke, single-cylinder petrol engine for use with TecQuipment's Regenerative Engine Test Set (TD300).

Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test set dynamometer and all essential hoses and fittings. In addition, each engine includes a colour-coded fuel tank with self-sealing couplings. The couplings ensure the engine can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine has a modified cylinder head and crank. These allow use with the Cylinder Head Pressure Transducer (ECA101 available separately) and the Crank Angle Encoder (ECA102 available separately). These can then connect to the Engine Cycle Analyser (ECA100 available separately) to extend the range of experiments possible.

The engine is mounted on a sturdy precision bed plate. The bed plate has dowels and slots which align and locate it accurately with the dynamometer. This minimises the time spent replacing one engine with another.

If a mains power failure or emergency stop occurs, interlocking relays on the engine immediately cut the ignition. In addition, to prevent transmission of accidentally ignited flames or explosions, the air inlet includes a flame arrestor.

Experiments:

When used with TecQuipment's Regenerative Engine Test Set (TD300), investigations into the performance and characteristics of a four-stroke petrol engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies

When used with TecQuipment's Regenerative Engine Test Set (TD300), Cylinder Head Pressure Transducer (ECA101), Crank Angle Encoder (ECA102) and Engine Cycle Analyser (ECA100), students can investigate further features including:

- Plotting p-θ and p-V diagrams
- The thermodynamic cycle of an internal combustion engine
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Essential Base Unit:

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• Regenerative Engine Test Set (TD300)	281

Recommended Ancillary:

	Page
• Cylinder Head Pressure Transducer (ECA101)	288
• Crank Angle Encoder (ECA102)	
• Engine Cycle Analyser (ECA100)	

Alternative Products:

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• Four-Stroke Petrol Engine (TD201)	277
• Four-Stroke Diesel Engine (TD202)	278
• Modified Four-Stroke Petrol Engine (TD211)	279
• Modified Four-Stroke Diesel Engine (TD212)	280
• Four-Stroke Diesel Engine (TD302)	284

Four-Stroke Diesel Engine (TD302)

A four-stroke, single-cylinder diesel engine with modified cylinder head and crank, for use with TecQuipment's Regenerative Engine Test Set (TD300)

- For safe and effective studies and demonstrations of a four-stroke, single-cylinder diesel engine
- For use with TecQuipment's Regenerative Engine Test Set (TD300)
- Modified for use with optional Pressure (ECA101) and Crank Angle (ECA102) Transducers and Engine Cycle Analyser (ECA100)
- Wide range of investigations possible
- Quickly and accurately mounts on the test bed
- Includes colour-coded fuel tank with quick-release couplings

High-quality, cost-effective four-stroke, single-cylinder diesel engine for use with TecQuipment's Regenerative Engine Test Set (TD300). Adapted specially for education to enable effective laboratory testing and demonstrations, the engine includes an exhaust thermocouple, a half-coupling to link to the test bed dynamometer, and all essential hoses and fittings. In addition, each engine includes a colour-coded fuel tank with self-sealing couplings.

The couplings ensure the engine can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel. For convenience and safety, the fuel tank can be removed for filling or for storage in a fuel locker when not in use. Removing the fuel tank also prevents unauthorised use of the equipment.

The engine has a modified cylinder head and crank. These allow use with the Cylinder Head Pressure Transducer (ECA101 available separately) and the Crank Angle Encoder (ECA102 available separately). These can then connect to the Engine Cycle Analyser (ECA100 available separately) to extend the range of experiments possible.

The engine is mounted on a sturdy precision bed plate. The bed plate has dowels and slots which align and locate it accurately with the dynamometer test set. This minimises the time spent replacing one engine with another.

If a mains power failure or emergency stop occurs, interlocking relays on the engine immediately cut the fuel supply. In addition, to prevent transmission of accidentally ignited flames or explosions, the air inlet includes a flame arrestor.

Experiments:

When used with TecQuipment's Regenerative Engine Test Set (TD300), investigations into the performance and characteristics of a four-stroke diesel engine, including:

- Torque, speed and power relationship
- Brake mean effective pressure
- Engine performance curves
- Air and fuel consumption
- Volumetric and thermal efficiencies

When used with TecQuipment's Regenerative Engine Test Set (TD300), Cylinder Head Pressure Transducer (ECA101), Crank Angle Encoder (ECA102) and Engine Cycle Analyser (ECA100) students can investigate further features including:

- Plotting p-θ and p-V diagrams
- The thermodynamic cycle of an internal combustion engine
- Indicated mean effective pressure
- Indicated power
- Comparison of brake and indicated mean effective pressures
- Mechanical efficiency of the engine

Essential Base Unit:

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Regenerative Engine Test Set (TD300)	281

Recommended Ancillaries:

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Cylinder Head Pressure Transducer (ECA101)	288
Crank Angle Encoder (ECA102)	
Engine Cycle Analyser (ECA100)	

Alternative Products:

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Four-Stroke Petrol Engine (TD201)	277
Four-Stroke Diesel Engine (TD202)	278
Modified Four-Stroke Petrol Engine (TD211)	279
Modified Four-Stroke Diesel Engine (TD212)	280
Four-Stroke Petrol Engine (TD301)	283

Exhaust Gas Calorimeter
(TD300a)

Works with VDAS®

For use with TecQuipment's Regenerative Engine Test Set (TD300) to measure the heat content of engine exhaust gases

- Safely and effectively measures the heat content of TecQuipment's test engine exhaust gases
- For use with TecQuipment's Regenerative Engine Test Set (TD300) and Test Engines (TD301 and TD302)
- Specially designed for educational use
- Wide range of investigations possible
- Uses electronic transducers and a digital display for ease of use and accuracy
- Separate instrumentation unit conveniently mounts on test set console frame
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software

An exhaust gas calorimeter for use with TecQuipment's Regenerative Engine Test Set (TD300). The equipment measures the heat content of exhaust gases and enables students to determine the energy lost to exhaust in the energy balance for single-cylinder, four-stroke petrol (TD301, available separately) and diesel (TD302, available separately) engines.

The main components of the Exhaust Gas Calorimeter are:

- Gas-to-water shell and multi-tube heat exchanger
- Control valve
- Instrumentation unit

The heat exchanger is mounted on a sturdy base plate. Exhaust gases from the test engine mounted on the test set flow through the tubes. A jacket of constantly flowing cooling water surrounds the tubes, and the heat content of the gases is assessed by measuring the cooling water flow rate and the inlet and outlet temperatures.

A hand-operated valve, which mounts on the control console of the test set, controls the flow of cooling water through the heat-exchanger jacket. Thermocouples measure the temperature of gas and water at the inlet and outlet. A turbine flow meter measures the flow rate. For safety, the heat exchanger also includes a pressure-relief valve in case insufficient cooling water is flowing.

The instrumentation consists of a digital, four-channel temperature and flow display unit. This unit mounts on the instrumentation rail of the test set console frame and allows easy and accurate display and monitoring of data. In addition, the Exhaust Gas Calorimeter is fully compatible with TecQuipment's optional Versatile Data Acquisition System (VDAS®).

VDAS® enables accurate real-time data capture, monitoring and display, calculation and charting of all relevant parameters on a suitable computer (computer not included) making tests quick and reliable.

Experiments:

When used with TecQuipment's Regenerative Engine Test Set (TD300), the Exhaust Gas Calorimeter enables students to assess the heat lost to exhaust in the energy balance for single-cylinder, four-stroke petrol (TD301) and diesel (TD302) engines.

Ancillary for:

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• Regenerative Engine Test Set (TD300)	281

Manual Volumetric Fuel Gauge (AVF1)

Convenient and accurate fuel gauge for use with TecQuipment engine test sets

- Volumetric fuel gauge for use with TecQuipment's Small Engine Test Set (TD200) and Regenerative Engine Test Set (TD300) and engines
- Convenient and accurate measurement of fuel consumption
- Easy to install and use
- Self-sealing couplings enable quick and efficient connection and disconnection of fuel lines with minimum loss or spillage of fuel

An easy-to-use, accurate volumetric fuel gauge for use with TecQuipment's engine test sets and engines (TD200 and TD300 series).

The fuel gauge consists of a precision-calibrated two-bulb pipette and control valves. It mounts on the instrumentation frame of the test set and connects between the fuel tank and the engine under test. All connections are made using self-sealing couplings. The couplings ensure the fuel gauge can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel.

Fuel enters the pipette from the tank. The fuel supply from the tank is then cut off via a valve so that the engine draws fuel from the pipette only. Students record the time taken to consume a set volume of fuel, from which they can accurately calculate the flow rate.

Suitable for use with petrol or diesel.

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Essential Ancillary:	Page
• Stopwatch (SW1)	94

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.

Automatic Volumetric Fuel Gauge with Digital Read-Out (DVF1)

Works with VDAS®

Automatic fuel gauge for use with TecQuipment's Engine Test Sets (TD200 and TD300 series)

- Automatic volumetric fuel gauge
- For use with TecQuipment's Small Engine Test Set (TD200) and Regenerative Engine Test Set (TD300)
- Accurately and automatically calculates fuel consumption
- Directly displays fuel consumption on digital read-out
- Can cycle continuously or run once only
- Fully compatible with TecQuipment's Versatile Data Acquisition System (VDAS®) and software
- Self-sealing couplings enable quick and efficient connection and disconnection of fuel lines with minimum loss or spillage of fuel

An automatic volumetric fuel gauge for use with TecQuipment's Small Engine Test Set (TD200) and Regenerative Engine Test Set (TD300). The gauge accurately calculates fuel consumption and displays it directly on a digital read-out.

The Automatic Volumetric Fuel Gauge consists of a:

- precision two-bulb pipette with sensors;
- digital read-out unit which displays fuel consumption and allows data to be transferred to a suitable computer (computer not included) via TecQuipment's Versatile Data Acquisition System (VDAS®).

The gauge mounts on the instrumentation frame of the test set and connects between the fuel tank and the engine under test. Fuel enters the pipette from the tank. A solenoid valve automatically shuts off the fuel supply from the tank so that the engine draws the fuel from the pipette. Sensors arranged on the pipette record the time taken to consume a set volume of fuel, and the instrumentation unit automatically calculates the fuel consumption. The solenoid valve then opens and the pipette re-fills. The unit can be set to continuously cycle in this manner or cycle once only.

All connections are made using self-sealing couplings. The couplings ensure the fuel gauge can be connected and disconnected quickly and efficiently with minimum loss or spillage of fuel.

Suitable for use with petrol or diesel.

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Product development

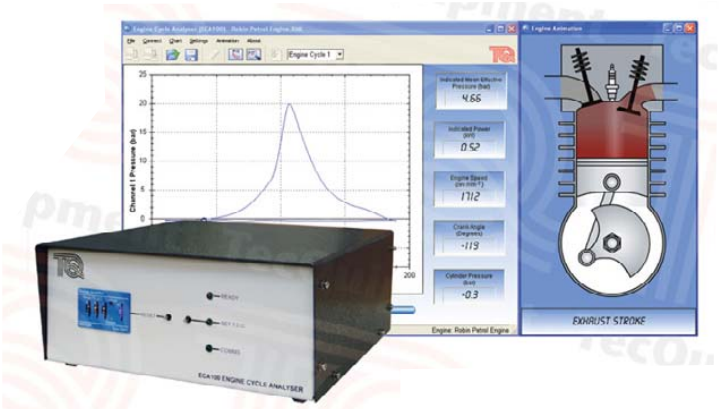
The information contained in this publication has been carefully prepared and is correct at the time of printing. TecQuipment, however, operates a continual product improvement process and therefore reserves the right to modify and update equipment to ensure it continues to meet your needs.

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

www.tecquipment.com

Engine Cycle Analyser
(ECA100)

Hardware and software to measure internal combustion engine cylinder pressure and crank angle



- Significantly enhances practical investigations, demonstrations and studies of internal combustion engines
- For use with TecQuipment's Small Engine Test Set (TD200) and Regenerative Engine Test Set (TD300) and engines
- Can also be used with other engines fitted with suitable cylinder head transducers and crank angle encoders
- Includes powerful Windows®-based software specially designed for educational use
- Automatic calculation and real-time display of p-θ plots and p-V plots and other important parameters
- Snap-shot, replay and animation functions
- Accurate, clear animations of crank, piston, inlet and exhaust valve positions help students visualise the engine cycle
- Students can export data for further analysis

Ideal for student experiments, laboratory demonstrations or project work,TecQuipment's Engine Cycle Analyser enables students to investigate a variety of engine performance characteristics.

The versatile equipment consists of both hardware and software specially designed for educational use. It enables students to investigate the relationship between crank angle or volume and the cylinder pressure in an internal combustion engine. The equipment is primarily for use with TecQuipment engine test sets and engines (TD200 and TD300 series) but it can also be used with other engines fitted with compatible cylinder head transducers and crank angle encoders.

The equipment consists of a hardware unit with connectors and leads, plus Windows®-based data acquisition and analysis software. The hardware consists of a microprocessor-based signal conditioning unit with high-speed PC interface, housed in a rugged, protective enclosure. It accepts and conditions signals from the Cylinder Head Pressure Transducer (ECA101) and Crank Angle Encoder (ECA102), available separately. The cylinder pressure input includes a precision charge amplifier with a digital thumb-wheel for calibration. As well as crank angle position, the signal from the Crank Angle Encoder is also used to determine engine speed.

Note: Although interchangeable between engines, TecQuipment recommends that you buy and fit one ECA101 and one ECA102 to each of your test engines. This will reduce setting up time and any chance of damage.

The output from the hardware unit connects to a computer (computer not included) running the Engine Cycle Analyser software. The hardware unit includes LED indicators to show the processor readiness, encoder top dead-centre position and PC communication status.

The software provides real-time display of pressure versus crank angle (p-θ)and pressure versus volume (p-V) plots. It performs calculations on the data to accurately display indicated mean effective pressure (IMEP) and indicated power for comparison with brake mean effective pressure (BMEP), and brake power to determine the mechanical efficiency of the test engine.

The software has useful snap-shot, replay and animation functions to help students visualise and better understand the engine cycle. The snap-shot and replay allow students to capture several engine cycles and study them using an animation showing the relative position of the crank, piston, inlet and exhaust valves. The software also allows students to create and recall engine configuration files for convenient entry of test engine data needed for calculations such as crank radius and engine swept volume. Data can also be exported to other software for further analysis.

Experiments:

When used with suitable test engines, the analyser allows investigations into a variety of internal combustion engine characteristics, including:

- The thermodynamic cycle of an internal combustion engine.
- Calculation of indicated mean effective pressure and indicated power.
- Comparison of indicated mean effective pressure and brake mean effective pressure.
- Mechanical efficiency of the test engine.
- Further work using exported data such as combustion analysis.

Essential Ancillaries:

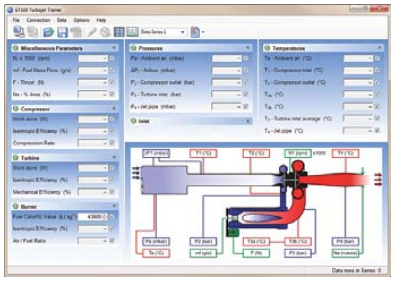
- Cylinder Head Pressure Transducer (ECA101)*
- Crank Angle Encoder (ECA102)*
- Suitable Computer

  * **TecQuipment also offers a complete package (the ECA100S). This includes the ECA100, one ECA101 and one ECA102.**

Ancillary for: Page

Turbojet Trainer (GT100) ADA

Allows detailed experiments that show how a single-shaft gas turbojet works, and tests its performance



Screenshot of the GT100 software

- Uses industrial parts, powered by kerosene for realistic tests and results
- Fully interlocked starting procedure and automatic shut-down
- Automatic data acquisition (ADA) included (supplied with software)
- Supplied with 'Gas Turbine Theory' textbook
- Full schematic coloured instrumentation panel diagram shows students what each part does
- Well-proven design – versions installed in universities, technical colleges and military training establishments in 30 countries worldwide

A self-contained, fully instrumented, educational single-shaft gas turbine. Powered by kerosene, the experimental abilities of this high-quality apparatus enable comprehensive, practical investigations into the principles and performance of single-shaft gas turbines.

It consists of a steel frame that holds a gas generator, combustion chamber, oil and fuel tanks, pumps, ancillaries and guards. Above these is an instrumentation and control panel with schematic diagram. The clearly labelled front panel with mimic diagram includes the instrument displays, controls and warning lights.

Air passes into an air box, into a compressor, then into the combustion chamber. A pump transfers fuel from the fuel tank to spray through a special nozzle into the combustion chamber. A high-energy spark ignites the air and fuel mixture which flows to a radial flow turbine, then a variable area propelling nozzle. The exhaust gases then discharge to a suitable exhaust system.

The combustion chamber gives excellent combustion, low pressure loss and good flame stability over a wide range of conditions. A fuel flow-control valve on the instrumentation and control panel regulates the speed. This design reduces the possibility of over-speed. The equipment has an oiling system including filters and water-cooled oil.

Starting is semi-automatic and fully interlocked, controlled by a start-up and shut-down logic system. For protection of the equipment and user, it shuts down the turbine if the user makes an error. Digital indicators show shaft speed, pressures, temperatures and fuel flow. Analogue indicators show fuel level, fuel pressure, oil temperature, oil pressure and hours run.

This equipment connects to a suitable computer (computer not included) and includes dedicated, user-friendly data acquisition software. This allows students to display, graph and analyse all relevant variables, and save their results for later analysis. The data acquisition system includes adaptors and leads, and the software is supplied on CD-ROM.

Supplied with the equipment is a detailed textbook that covers the theory and use of gas turbines.

Experiments:

Various investigations into single-shaft turbine thrust jet performance, including:

- Effect on thrust generation by variation in rotational speed and propelling nozzle area
- Isentropic, polytropic and mechanical efficiencies of compressor, combustion chamber and turbine
- Pressure ratios of turbine, compressor and non-dimensional characteristics
- Combustion chamber pressure losses and combustion efficiencies
- Specific fuel consumption, thermal efficiency, air standard cycle, work ratio and heat balance

Recommended Ancillary:

- Suitable computer

Alternative Products:

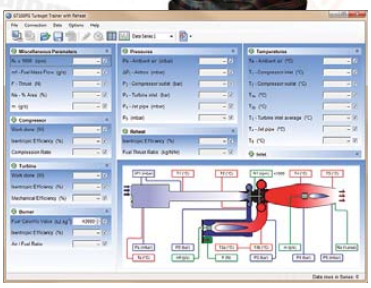
Alternative Products:	Page
Turbojet Trainer with Reheat (GT100RS)	290
Two-Shaft Gas Turbine (GT185)	292

Turbojet Trainer with Reheat (GT100RS)

ADA

Allows detailed experiments that show how a single-shaft gas turbojet with reheat (afterburner) works, and tests its performance

- Uses industrial parts, powered by kerosene for realistic tests and results
- Includes reheat (afterburner) section
- Fully interlocked starting procedure and automatic shut-down
- Automatic Data Acquisition (ADA) included (supplied with software)
- Supplied with 'Gas Turbine Theory' textbook
- Full schematic coloured instrumentation panel diagram shows students what each part does
- Well proven design – versions installed in universities, technical colleges and military training establishments in 30 countries worldwide



Screenshot of the GT100RS software

A self-contained, fully instrumented, educational single-shaft gas turbine with reheat. Powered by kerosene, the experimental abilities of this high-quality apparatus enable comprehensive practical investigations into the principles, and performance of single-shaft gas turbines with reheat.

This product helps students to understand the use of this 'engine' with additional exhaust nozzle control, on practical applications such as jet aircraft.

A steel frame holds a gas generator, combustion chamber, oil and fuel tanks, pumps, ancillaries and guards. Above these is an instrumentation and control panel with schematic diagram. The clearly labelled control panel with mimic diagram includes the instrument displays, controls and warning lights.

Air passes into an air box, through a calibrated nozzle into a compressor, then into the combustion chamber. A pump transfers fuel from the fuel tank to spray through a special nozzle into the combustion chamber. A high-energy spark ignites the air and fuel mixture, that flows to a radial flow turbine, then to the reheat section. This increases the temperature and velocity of the gas. It then passes through a variable area propelling nozzle. The exhaust gases then discharge to a suitable exhaust system. The combustion chamber gives excellent combustion, low pressure loss and good flame stability over a wide range of conditions. A fuel flow control valve on the instrumentation and control panel regulates the turbine speed. This design reduces the possibility of overspeed. A separate control adjusts the fuel flow to the reheat section. A second high-energy spark in the reheat section ignites the reheat fuel. This creates a secondary burn (or afterburn), using some of the remaining oxygen in the hot exhaust gases leaving the turbine.

The equipment has an oiling system including filters and water-cooled oil.

A PLC (programmable logic controller) controls the turbine start up and shut down. For protection of the equipment and user, it shuts down the turbines if the user makes an error. It also switches on cooling fans after running.

Digital and analogue indicators show all the important readings from the sensors around the equipment, such as pressures, temperatures, fuel flow and level.

This equipment connects to your computer (computer not supplied) and includes dedicated, user-friendly data acquisition software. This allows students to display, graph and analyse all relevant variables, and save their results for later analysis. The data acquisition system includes adaptors and leads, and the software is supplied on CD-ROM.

Supplied with the equipment is a detailed textbook that covers the theory and use of gas turbines.

Experiments:

Turbine, reheat and nozzle tests to find key performance information such as:

- Specific thrust and fuel consumption
- Pressure losses and ratios
- Thermal, propulsive, isentropic and mechanical efficiencies
- Work and power
- Thrust with and without reheat
- How the variable area nozzle affects thrust

Recommended Ancillary:

- Suitable computer

Alternative Products:

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• Turbojet Trainer (GT100)	289
• Two-Shaft Gas Turbine (GT185)	292

TecQuipment Document Packs

– making it clear for the customer

We send document packs with all TecQuipment manufactured products.

Document packs contain:

- **Packing contents list** (PCL) – shows you what parts we pack with the product.
- **Test certificate** – shows you that we've thoroughly tested the product before we send it to you.
- **User guides*** and **safety information** – show you how to use the product safely and learn how it works.

Some packs also include **compact discs** (CD-ROMs) with TecQuipment software (for example, VDAS®).

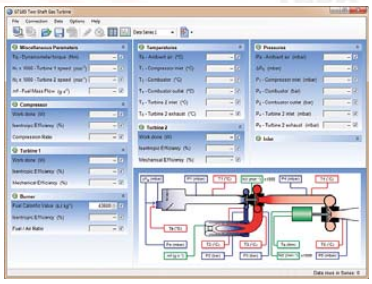
At TecQuipment we continually improve our user guides so they include pictures of the products, clear diagrams and plain English text. This helps you to understand the product more clearly. Where necessary, the guides include theory, suggested experiments and typical results to help students understand what the product teaches.

*Some products may not need user guides, as their details are already shown in their parent product, for example the optional pumps on the MFP103.

Two-Shaft Gas Turbine
(GT185) ADA

Allows detailed experiments that show how a two-shaft gas turbine works, and tests its performance

- Uses industrial parts, powered by kerosene for realistic tests and results
- Fully interlocked starting procedure and automatic shut-down
- Automatic Data Acquisition (ADA) included (supplied with software)
- Direct-coupled (no belts) eddy current dynamometer for accurate loading, speed control and true shaft power measurement
- Supplied with 'Gas Turbine Theory' textbook
- Full schematic instrumentation panel diagram shows students what each part does
- Well proven design – versions installed in universities, technical colleges and military training establishments in 30 countries worldwide



Screenshot of the GT185 software

A self-contained, fully instrumented, educational two-shaft gas turbine. Powered by kerosene, the experimental abilities of this high-quality apparatus enable comprehensive practical investigations into the principles, and performance of two-shaft gas turbines.

This product helps students to understand the use of this 'engine' with a secondary power turbine, on practical applications such as helicopters or electrical power generators.

A steel frame holds a gas generator, power turbine, combustion chamber, oil and fuel tanks, pumps, ancillaries and guards. Above these is an instrumentation and control panel with schematic diagram. The clearly labelled control panel with mimic diagram includes the instrument displays, controls and warning lights.

Air passes through a calibrated nozzle and air box, into a compressor, then into the combustion chamber. A pump transfers fuel from the fuel tank to spray through a special nozzle into the combustion chamber. A high-energy spark ignites the air and fuel mixture, that flows to a gas generator turbine. The combustion chamber gives excellent combustion, low pressure loss and good flame stability over a wide range of conditions. A fuel flow control valve on the instrumentation and control panel regulates the turbine speed. This design reduces the possibility of overspeed.

Hot gas from the gas generator turbine passes through a short duct to the power turbine. The short duct reduces heat losses to atmosphere. The exhaust gases then discharge to a suitable exhaust system.

The power turbine couples direct to an eddy current dynamometer, so there are no belts to adjust. A load cell on the dynamometer measures torque and a sensor measures the dynamometer speed, to allow calculation of true shaft power. A control on the instrumentation and control panel adjusts the load of the dynamometer (and therefore speed of the power turbine).

The equipment has an oiling system including filters and water-cooled oil.

A PLC (programmable logic controller) controls the turbine start up and shut down. For protection of the equipment and user, it shuts down the turbines if the user makes an error. It also switches on cooling fans after running.

Digital and analogue indicators show all the important readings from the sensors around the equipment, such as pressures, temperatures, fuel flow and level.

This equipment connects to your computer (computer not supplied) and includes specialist, user-friendly data acquisition software. This allows students to display, graph and analyse all relevant variables, and save their results for later analysis. Supplied on a CD-ROM, the data acquisition system includes a connection cable.

TecQuipment supply a detailed textbook with the equipment. The textbook covers the theory and use of gas turbines.

Experiments:

Turbine tests to find key performance information such as:

- Specific fuel consumption
- Pressure losses and ratios
- Thermal, isentropic and mechanical efficiencies
- Work and power

Combustion chamber:

- Pressure loss
- Combustion efficiency
- Air and fuel ratio

Recommended Ancillary:

- Suitable computer

Alternative Products:

	Page
• Turbojet Trainer (GT100)	289
• Turbojet Trainer with Reheat (GT100RS)	290

Have you seen the following?

These products also cross over into the subject of thermodynamics – please turn to the Fluid Mechanics section for full details.

Works with VDAS®

Reciprocating Compressor Module (MFP104) – Page 151

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

Centrifugal Compressor Module (MFP105) – Page 152

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

Two-Stage Compressor Test Set (GT103)

Shows how single and two-stage compressors work, and their thermodynamic properties

- Compact, mobile unit
- Works as single-stage, two-stage or two-stage intercooled compressor
- Independently controlled compressor units, both with variable-speed dynamometer drives
- Clear, fully-instrumented control panel with mimic diagram
- Low-noise footprint
- Completely fail-safe operation – interlocks and pressure-relief valves prevent misuse

This test set has two independently-controlled, motor-driven compressors, intercooler and air receiver. It works as a single-stage, two-stage or two-stage compressor with intercooler. All controls and instrumentation are on an easy-to-operate mimic panel.

Electric motors and low-maintenance toothed belts drive two twin-cylinder, air-cooled reciprocating compressors.

Electronic drive units independently control both motors. Meters show motor electrical power consumption of each motor. A close-coupled load cell on each motor measures torque. A sensor on each motor measures speed, shown by a digital indicator. The product of the torque and speed gives true shaft power.

To allow students to study different types of air compressor systems, diverter valves allow air to move in different directions. These include:

- From the first stage to the receiver
- Directly to the second stage
- To the second stage, by means of the integral water-cooled intercooler

Independent control of the two compressor speeds allows flexibility to match the two compressors under different conditions. Interlocks allow safe changes from one method of operation to another while the equipment works, and prevent misuse. For safety, all pressurised lines have relief valves.

To help produce pressure and volume diagrams, TecQuipment offers the optional Pressure Indicator (GT103a). It fits to an adaptor on each of the two compressors to measure the pressure changes during a compression cycle. One pressure indicator is enough to test each compressor, one at a time. However, you may choose to use two for convenience.

Experiments:

A range of experiments and tests based on:

- Volumetric, mechanical and isothermal efficiency
- Indicated work done
- Motor output power (compressor shaft power)
- Pressure ratio
- Temperature ratio
- Inlet dryness calculations
- P-V indicator diagram (needs optional pressure indicator)
- Effect of inter-stage cooling on compressor total power requirements and effect on cycle temperatures
- Effect of two-stage compression and inter-stage pressure on power requirements

Recommended Ancillary:

- Pressure Indicator (GT103a)

Note: You need a modern computer with a spare USB 2.0 socket to setup and analyse the pressure indicator results.

Alternative Product: Page

- Reciprocating Compressor Module (MFP104) 151

General-Purpose Ancillaries and Instruments

The following items are ancillaries to some of the other products and product ranges in this guide. Some will only work with TecQuipment products, and some will also work as general-purpose laboratory equipment.

Please note:

The specifications of these ancillary products are correct at the time of printing.

They are designed or chosen to work with the correct TecQuipment products or product ranges. But if you need to use any of these ancillaries as general-purpose laboratory equipment, please check its datasheet or ask our experts at TecQuipment **before you order**.

This symbol means that we keep an up-to-date datasheet on our website (www.tecquipment.com).

This symbol means that you must contact TecQuipment or your distributor for the latest specification.

Oscilloscopes

Dual Beam Storage Oscilloscope (H405a)

A two-channel 50 MHz digital storage oscilloscope with printout.

Works with several TecQuipment products and is good for general-purpose use.

Oscilloscope (OS1)

A single-channel 10 MHz analogue oscilloscope.

Works with several TecQuipment products and is good for general-purpose use.

Pressure Instruments and Equipment

Compressor (CE1B)

A laboratory-scale compressor. It gives ten litres a minute flow at a pressure of 3 bar (45 PSIG).

Works with several TecQuipment products and is good for general-purpose use.

Laboratory Vacuum Pump (RE19)

A laboratory-scale vacuum pump. It pumps a maximum of 40 litres a minute (approximately).

Works with several TecQuipment products and is good for general-purpose use.

Stroboscopes and Tachometers

Stroboscope (ST1)

A portable, mains-powered stroboscope that gives 60 to 7,500 flashes a minute in one continuous range. Includes a display of flash speed and works with an internal or external trigger.

Works with several TecQuipment products and is good for general-purpose use.

Optical Tachometer (OT1)

A hand-held, battery-powered optical tachometer with a digital display and a speed range of 3 to 99999 rev.min^{-1} (rpm). It works with reflective surfaces or stick-on reflective tape.

Works with several TecQuipment products and is good for general-purpose use.

Contacting TecQuipment

Customer Care

There is a dedicated team of people at TecQuipment that are committed to providing a high level of after-sales care and support to all our customers, past and present.

We aim to support the equipment we have manufactured for as long as we can. Being a long-standing quality manufacturer we still have serviceable equipment that is over 50 years old in some laboratories.

For all after-sales queries please contact:

customer.care@tecquipment.com

or use the form on our website at: **www.tecquipment.com**

After sales queries can be:

- Requests for manuals and user guides
- Quotes for spares and consumables
- Post-sales technical advice and support

To be able to access this range of services you must provide us with the following vital information:

- Your name and contact details
- The model/type and serial number of the equipment in question*
- The approximate year of supply
- The exact nature of the request, with any results and supporting information. Clear digital photographs are extremely useful for our experts to spot problems, identify parts and solve issues quickly.

For all pre-sales queries please contact your local agent or:
sales@tecquipment.com

Pre-sales queries can be:

- Requests for data sheets, catalogues and further information
- Technical advice for product selection prior to purchase
- Prices and quotations

* Please see below the guide to our serial plates. The serial number is vital for us to be able to trace the year of manufacture and date of dispatch, other items on the same order, appropriate parts lists and manuals. Providing the serial number at the first point of contact will reduce the time it takes for us to respond to your query.

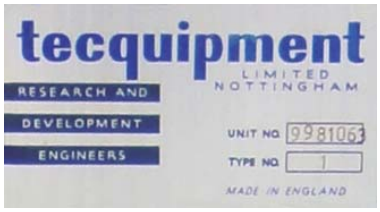
Guide to TecQuipment Serial No Plates

These are the serial number plates used on TecQuipment products from the 1960s to the present day. They are in approximate date order of use but some were used concurrently.

Self-adhesive
Black and silver / blue and silver
Two sizes

Information:
TecQuipment

Example Serial No:
9981063



Cast brass
Black and white
120 mm x 60 mm
80 mm x 40 mm

Information:
TecQuipment
Product reference
Serial number
Date

Example Serial No:
TM16 088

Aluminium
Self-adhesive
Hand engraved
80 mm x 60 mm
60 mm x 45 mm

Information:

TecQuipment
Product reference / type
Volts
Amps
Serial number
Frequency
Phase

Example Serial No:

061

Plastic
Self-adhesive
Black and silver
Hand written black on clear backing
70 mm x 40 mm

Information:

TQ TecQuipment Ltd
Model / Serial No
Supply V Hz A Ω

Example Serial No:

L6268/9

Foil
Self-adhesive
Black and silver
Hand written
50 mm x 25 mm

Information:

Model
Serial No
Supply
Frequency

Example Serial No:

F7561/3

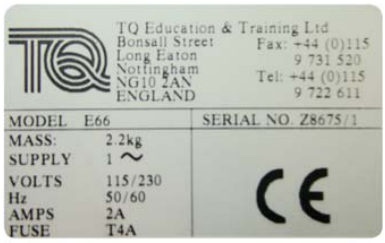
Foil
Self-adhesive
Black and silver
Printed text
70 mm x 40 mm

Information:

TecQuipment Ltd **or** TQ Education and Training Ltd
Model
Mass
Supply
Volts
Hz
Amps
Fuse
Serial No
CE Mark (if applicable)

Example Serial No:

Z8675/1



Foil
Self-adhesive
Black and silver
Printed text
70 mm x 40 mm

Information:

TecQuipment Ltd **or** TQ Education and Training Ltd
Model
Mass
Supply
Volts
Hz
Amps
Fuse
Serial No
CE Mark (if applicable)

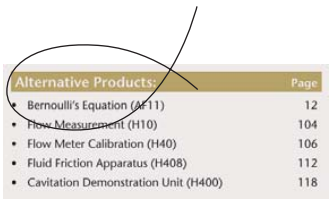
Example Serial No:

TQ038922-01

Jacketed Vessel with Coil and Stirrer (TD360d)

Keyword Index

Please note: For ease of use we have only shown the main TecQuipment products relating to the keywords in this index. However, there may be other similar products that are also suitable for your needs. These are listed as alternative products in the main pages of this guide.



Alternative Products:	Page
• Bernoulli's Equation (AF11)	12
• Flow Measurement (H10)	104
• Flow Meter Calibration (H40)	106
• Fluid Friction Apparatus (H408)	112
• Cavitation Demonstration Unit (H400)	118

A

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S

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V

W

Y

Product List

This is a list of our main line items so some ancillary products may not appear. Please refer to the main line item to find any ancillaries (for example, to find AF80a look at AF80). Alternatively, check our website (**www.tecquipment.com**) or contact our expert Sales team.

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Z