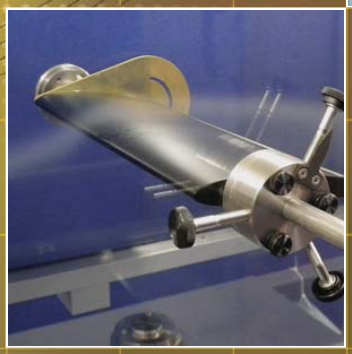
3 Aerodynamics



“ 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

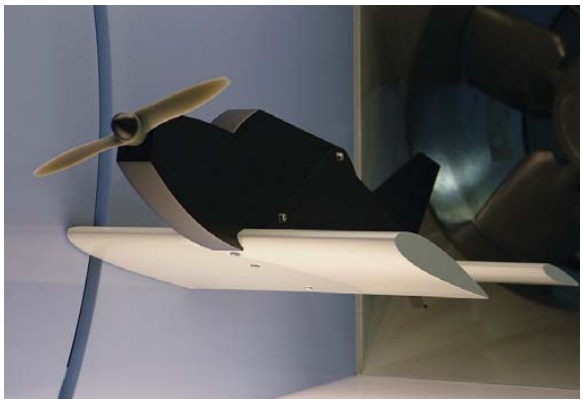
Aerodynamics

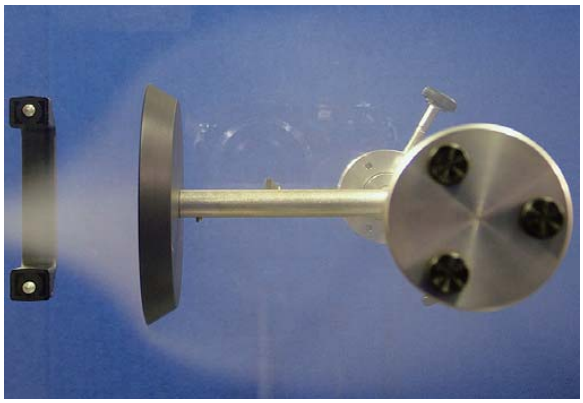
Made for education and training

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 137 for more details.

Centrifugal Fan Module (MFP106)

Automatic data acquisition

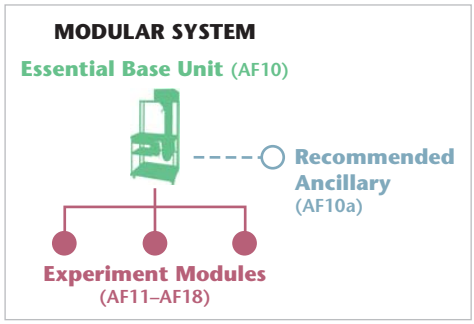
Some of the products in this range work with TecQuipment's unique Versatile Data Acquisition System (VDAS®). See **Section 2** for more details.

Look out for the VDAS® logo: VDAS®

VDAS®	Product	Page
●	**Subsonic Wind Tunnel** (AF100) **Instruments**	46
●	**Nozzle Flow Apparatus** (AF27)	60
●	**Intermittent Supersonic Wind Tunnel** (AF300)	62
●	**Continuous Supersonic Wind Tunnel** (AF02)	65

Modular Air Flow Bench (AF10)

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



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

FEATURES:		BENEFITS:
The base unit of a comprehensive system for teaching aerodynamic principles	→	**Covers all aspects of a basic aerodynamics curriculum**
Works with eight different interchangeable experiment modules, designed to demonstrate specific air flow principles or phenomena	→	Modular design means value for money and cost-effective investment
Easy set-up – all the experiment modules can be fitted and removed in minutes	→	**Optimises experiment time during laboratory sessions**
Simple and safe to use allowing students to gain hands-on practical experience	→	Needs only minimal supervision
Compact, mobile and simple to install	→	**Optimised use of available laboratory space – moveable in and between laboratories**

Continued on next page

Modular Air Flow Bench (AF10)
Continued from previous page

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.

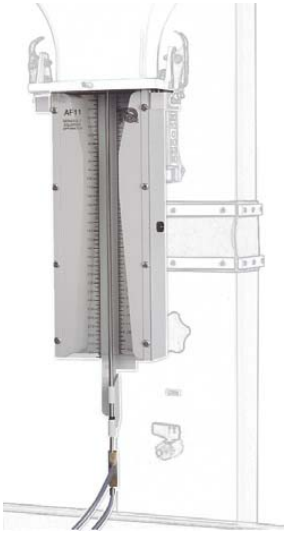
Toggle clamps hold the experiment modules, reducing the need for tools. Pressure measurement connections use reliable quick-release couplings. Both of these features make the changeover from one experiment to another simple and quick.

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.

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
- 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

Available Experiment Modules:	Page
• Bernoulli's Equation (AF11)	38
• Drag Force (AF12)	39
• Round Turbulent Jet (AF13)	40
• Boundary Layer (AF14)	41
• Flow Around a Bend (AF15)	42
• Jet Attachment (AF16)	42
• Flow Visualisation (AF17)	43
• Tapped Aerofoil (AF18)	44

Recommended Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

Alternative Products:	Page
• Subsonic Wind Tunnel (AF100)	46
• Flight Demonstration Wind Tunnel (AF41)	57
• Flow Visualisation Wind Tunnel (AF80)	59

EXPERIMENTS:

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

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.

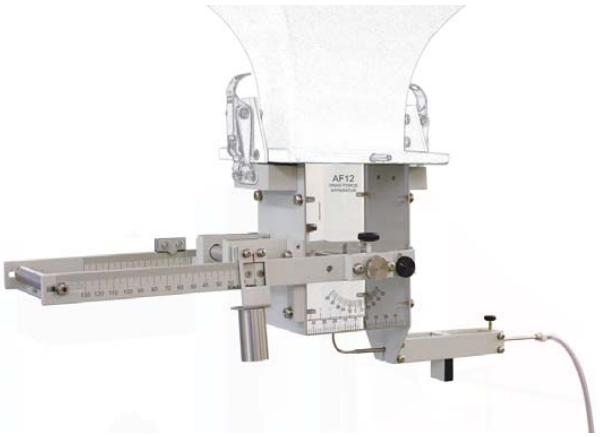
Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

Alternative Product:	Page
• Venture Meter (H5)	100

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
- Test duct has transparent sides with clearly printed scales – allows students to see the experiment and accurately position the models and the Pitot tube

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.**

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.

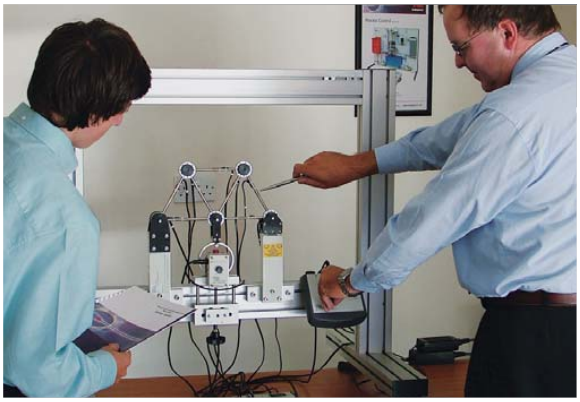
Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

Alternative Products:	Page
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Three-dimensional Drag Models (AF109)	50

Equipment training

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



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
- Quick-release coupling fitted to the Pitot tube to allow rapid and reliable connection to the AF10a Manometer

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.**

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.

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

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
- Test section has a transparent front – students can see the experiment and the position of the Pitot tube clearly

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.**

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.

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

Alternative Product:	Page
• Flat Plate Boundary Layer Model (AF106)	50

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

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
- 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)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

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
- Transparent fronted test duct with clearly printed scales allows the experiment to be clearly seen and components accurately positioned
- Effectively demonstrates the Coanda effect

EXPERIMENTS:

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

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.

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

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)
- 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

EXPERIMENTS:

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

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.

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Alternative Product:	Page
• Flow Visualisation Wind Tunnel (AF80)	59

Products precision-engineered and checked for quality

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

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)
- 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

EXPERIMENTS:

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

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.

Essential Base Unit:	Page
• Modular Air Flow Bench (AF10)	37

Essential Ancillary:	Page
• Multi-tube Manometer (AF10a)	45

Alternative Product:	Page
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49

Standard features for all our products:

Supplied with comprehensive user guide

5-YEAR WARRANTY TecQuipment

Five-year warranty

Intertek UKAS MANAGEMENT SYSTEMS

Manufactured in accordance with the latest European Union directives

Multi-tube Manometer (AF10a)

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

- Uses water for safety and simplicity
- Inclinable for increased sensitivity
- Adjustable height datum and levelling feet
- 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)	37
• Bernoulli's Equation (AF11)	38
• Drag Force (AF12)	39
• Round Turbulent Jet (AF13)	40
• Boundary Layer (AF14)	41
• Flow Around a Bend (AF15)	42
• Tapped Aerofoil (AF18)	44

Always here to help you

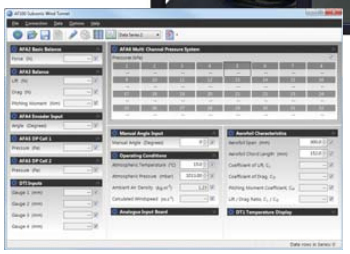
Whether you have a technical enquiry, need spare parts or support material you can contact our Customer Care team at:

customer.care@tecquipment.com

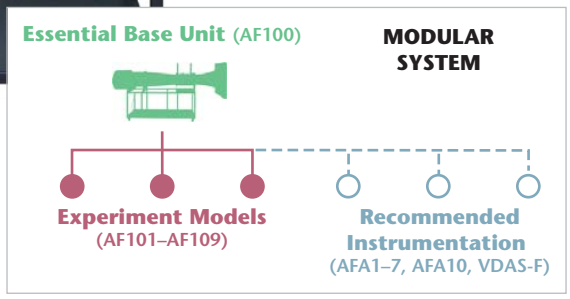
Subsonic Wind Tunnel (AF100)

Works with VDAS®

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



Screenshot of the optional VDAS® software



FEATURES:		BENEFITS:
Compact, open-circuit wind tunnel	→	**Cost effective and maximises students' practical time compared to full-scale wind tunnels**
Operates at meaningful Reynolds number	→	Allows direct comparison to real world applications
Wide variety of experiments	→	**Comprehensive solution for aerodynamic curricula**
High levels of safety	→	Students can work with minimal supervision
Controls and instrumentation conveniently mount on a separate, free-standing frame	→	**No need for extra modules or interface cards**

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 force**
- **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**

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.

Model car in the wind tunnel

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).

Available Experiment Models:	Page
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Flat Boundary Layer Model (AF106)	50
• Aircraft Model – Low Wing (AF107)	50
• Aircraft Model – High Wing (AF108)	50
• Three-Dimensional Drag Models (AF109)	50

Smoke trail around the Low Wing Aircraft Model (AF107)

Recommended Instrumentation:	Page
• Multi-Tube Manometer (AFA1)	51
• Basic Lift and Drag Balance (AFA2)	52
• Three-Component Balance (AFA3)	53
• Balance Angle Feedback Unit (AFA4)	54
• Differential Pressure Transducer (AFA5)	54
• 32-Way Pressure Display Unit (AFA6)	55
• Pitot-Static Traverse (300 mm) (AFA7)	56
• Smoke Generator (AFA10)	51
• Versatile Data Acquisition System (VDAS-F)	32

Alternative Products:	Page
• Modular Air Flow Bench (AF10)	37
• Flight Demonstration Wind Tunnel (AF41)	57
• Flow Visualisation Wind Tunnel (AF80)	59
• Supersonic Wind Tunnel – Intermittent (AF300)	62
• Supersonic Wind Tunnel – Continuous (AF302)	65

Continued on next page

Subsonic Wind Tunnel (AF100)
continued from previous page

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.

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 and are 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)
- 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

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 section (cambered) aerofoil with 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.

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.

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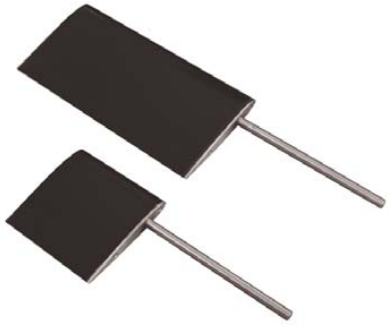
Subsonic Wind Tunnel Models (AF101–AF109)
Continued from previous page

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

- 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

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.

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	46
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49
• Boundary Layer Model (AF106)	50

Alternative Products:	Page
• Differential Pressure Transducer (AFA5)	54
• 32-Way Pressure Display Unit (AFA6)	55

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

- 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.

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	46
• Flight Demonstration Wind Tunnel (AF41)	57

Alternative Products:	Page
• Flow Visualisation (AF17)	43
• Flow Visualisation Wind Tunnel (AF80)	59

Basic Lift and Drag Balance (AFA2)

Works with VDAS®

Measures lift and drag forces on models mounted in TecQuipment's 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.

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	46
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Three-dimensional Drag Models (AF09)	50

Alternative Products:	Page
• Three-Component Balance (AFA3)	53

Three-Component Balance (AFA3)

Works with VDAS®

Measures lift, drag and pitching moment of models in TecQuipment's 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.

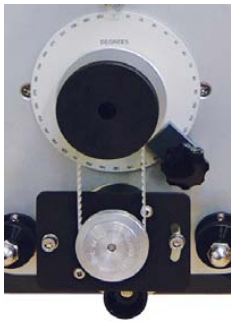
The Angle Feedback Unit (AFA4, available separately) fits onto the Three-Component Balance and transmits the rotational angle of the test model back to the automatic data acquisition unit.

Recommended Ancillary:	Page
• Balance Angle Feedback Unit (AFA4)	54

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	46
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Aircraft Model – Low Wing (AF107)	50
• Aircraft Model – High Wing (AF108)	50
• Three-dimensional Drag Models (AF109)	50

Alternative Product:	Page
• Basic Lift and Drag Balance (AFA2)	52

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)	53

Differential Pressure Transducer (AFA5)

Works with VDAS®

Microprocessor-controlled pressure measurement and display unit for use with TecQuipment's 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
- 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.

Ancillary for:	Page
• Subsonic Wind Tunnel (AF100)	46
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Boundary Layer Model (AF106)	50
• Aircraft Model – Low Wing (AF107)	50
• Aircraft Model – High Wing (AF108)	50
• Three-Dimensional Drag Models (AF109)	50

Alternative Products:	Page
• Multi-Tube Manometer (AFA1)	51
• 32-Way Pressure Display Unit (AFA6)	55

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)

- 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
- 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)	46
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49
• Boundary Layer Model (AF106)	50

Alternative Products:	Page
• Multi-Tube Manometer (AFA1)	51
• Differential Pressure Transducer (AFA5)	54

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For the latest news, updates and product information visit our website at:

www.tecquipment.com

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)

- 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)

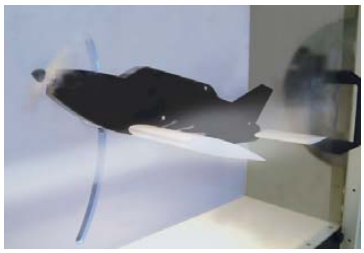
The pressure signals from the Pitot-Static Traverse may be output to TecQuipment's optional Versatile Data Acquisition System (VDAS®) to allow computer-based data acquisition and display. Using VDAS® enables accurate real-time data capture, monitoring, display, calculation and charting of all relevant 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)	46
• Cylinder Model with Pressure Tapping (AF101)	49
• 150 mm Chord NACA0012 Aerofoil with Tappings (AF102)	49
• 150 mm Chord NACA2412 Aerofoil with Variable Flap (AF103)	49
• 150 mm Chord NACA0012 Aerofoils (AF104)	50
• 100 mm Diameter Flat Plate (AF105)	50
• Aircraft Model – Low Wing (AF107)	50
• Aircraft Model – High Wing (AF108)	50
• Three-Dimensional Drag Models (AF109)	50

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.

- 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
- Adjustable centre of gravity of the model



With the Smoke Generator (AFA10)

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.**

Continued on next page

Flight Demonstration Wind Tunnel (AF41)
Continued from previous page

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.

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.

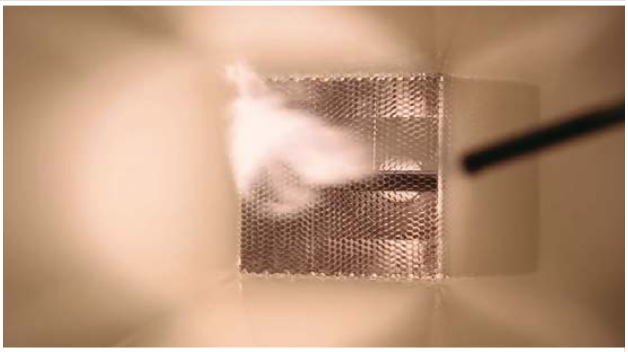
Recommended Ancillaries:	Page
• Two-Pen Chart Recorder (AF41a)	
• Smoke Generator (AFA10)	51

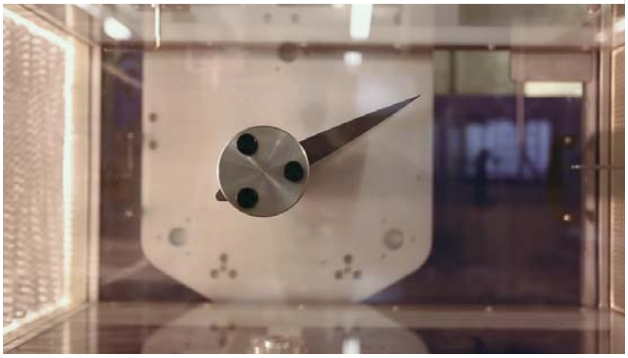
Alternative Products:	Page
• Modular Air Flow Bench (AF10)	37
• Subsonic Wind Tunnel (AF100)	46
• Flow Visualisation Wind Tunnel (AF80)	59

Now you can see our products in action...

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

www.youtube.com/c/tecquipment





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

EXPERIMENTS:

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

- **Boundary layers**
- **Separation**
- **Rotational flow**

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.

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

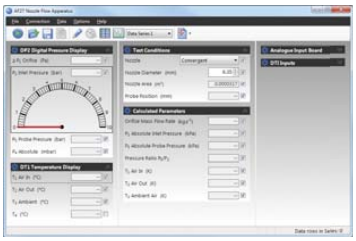
Alternative Products:

	Page
• Flow Visualisation (AF17)	43
• Subsonic Wind Tunnel (AF100)	46
• Flight Demonstration Wind Tunnel (AF41)	57

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 optional VDAS® software

- 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
- 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

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**

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).

Essential Ancillary:

- Compressor (AF27a)

Recommended Ancillary:

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

Alternative Products:

	Page
• Supersonic Wind Tunnel – Intermittent (AF300)	62
• Supersonic Wind Tunnel – Continuous (AF302)	65

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)

Screenshot of the VDAS® software

- 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
- Supplied with set of different liners for controlled subsonic and supersonic air flow
- Induction flow for better air flow and accurate results

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).**

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).

Essential Ancillaries:	Page
• Air Compressor Receiver and Dryer (AF300b)	
• Versatile Data Acquisition System – Frame-mounted version (VDAS-F)	32

Recommended Ancillary:	Page
• Schlieren Apparatus (AF300a)	64

Alternative Products:	Page
• Subsonic Wind Tunnel (AF100)	46
• Nozzle Flow Apparatus (AF27)	60
• Continuous Supersonic Wind Tunnel (AF302)	65

TecQuipment Document Packs

Making it clear for the customer

We send document packs with all TecQuipment products* which 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 (e.g. 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.

Schlieren Apparatus (AF300a)

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

- 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.

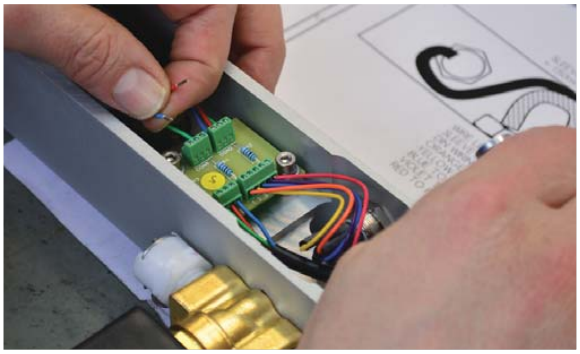
The apparatus includes digital imaging equipment to record the images; this is useful when using an intermittent supersonic wind tunnel.

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)	62

Accuracy, reliability and quality – time after time

Our modern, in-house production facility, based near Nottingham in the UK, ensures all parts are made to the very highest quality.

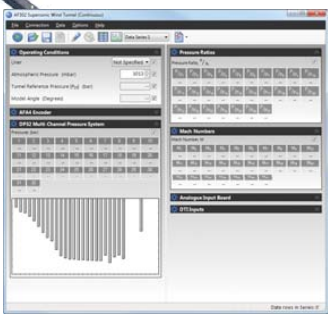


Continuous Supersonic Wind Tunnel (AF302)

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

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)**

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Continuous Supersonic Wind Tunnel (AF302)
Continued from previous page

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.

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.

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

Recommended Ancillary:	Page
• Schlieren Apparatus AF302a	66

Alternative Products:	Page
• Subsonic Wind Tunnel (AF100)	46
• Nozzle Flow Apparatus (AF27)	60
• Intermittent Supersonic Wind Tunnel (AF300)	62

Schlieren Apparatus (AF302a)

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

- 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)	65