World leading supplier of engineering teaching equipment

Fluid Mechanics Range

Hydraulics

Air Flow and Aerodynamics

Fluid mechanics is the branch of physics concerned with the mechanics of fluids – in this case liquids and gases - and the forces on them. It has applications in a wide range of disciplines, including mechanical, civil and chemical engineering.

The P.A. Hilton fluid mechanics products offer an extensive range of teaching equipment for the comprehensive delivery of courses in fluid dynamics.

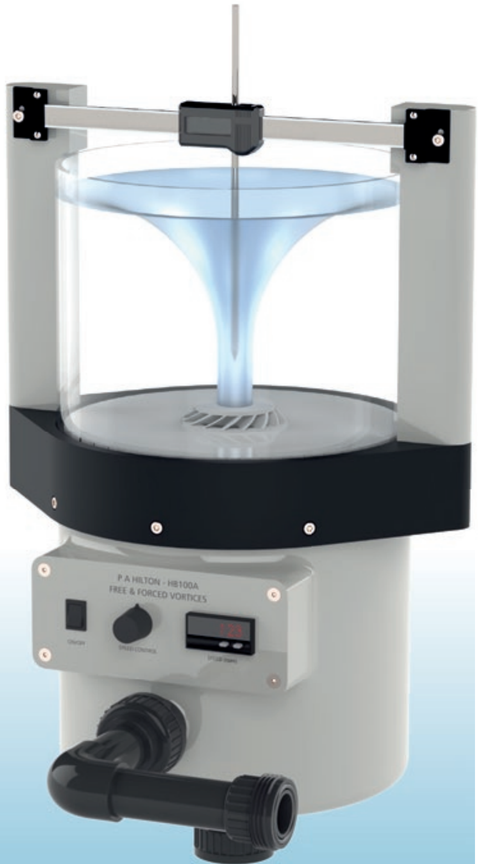
In most instances, a modular base unit allows tutors to change the individual experiment modules on a single, self -contained, base unit. This reduces the cost, experiment set-up time and footprint requirements.

Pressure in a vortex

The fluid motion in a vortex creates a dynamic pressure (in addition to any hydrostatic pressure) that is lowest in the core region, closest to the axis, and increases as one moves away from it, in accordance with Bernoulli's Principle.

One can say that it is the gradient of this pressure that forces the fluid to follow a curved path around an axis.

https://en.wikipedia.org/wiki/Vortex



HB100 Base Unit

- The HB100 Hydraulics Bench is the main source of water supply/flow for all the additional modules within the HB series.
- Mounted on lockable castor wheels and constructed around a sturdy framework onto which all elements of the hydraulics bench are mounted, including water storage tank.
- On/off control on the front of the frame, together with a safety cut out to control the pump.
- Closed system, which minimises the local water requirement but allows large flow rates and pressure ranges to be accommodated.
- Due to its size the unit may be stored under a suitably sized laboratory bench to save space.
- Space is provided for the inclusion of a second pump to boost the water flow rate and allow series/parallel pump experiments together with other optional items

HB100A Free and Forced Vortices

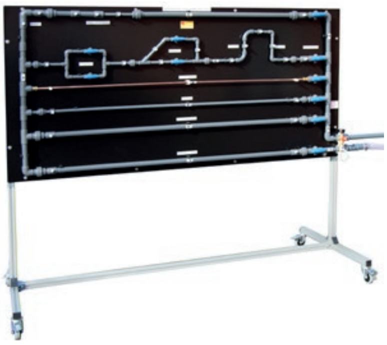
- A benchtop unit designed to help students visualise and analyse key principles relating to free and forced vortices used as part of the following study areas:
  - Bernoulli's theorem
  - Irrational flow
  - Turbulent flow
  - Vector Analysis
  - Helmholtz's Theorem

HB100B Bernoulli's Theorem Demonstrator

- Bernoulli's theorem concerns the conservation of mass and energy through a flowing system and the relationship between the flow velocity and pressure, such that as the velocity of the flow increases the pressure must decrease.
- The unit allows students to look at the conversion of energy in divergent/convergent pipe flow as well as the pressure/velocity distribution, whilst recognising the friction effects that exists within pipe flow.

HB100C Flow Measurement Demonstrator

- The unit demonstrates the theory of flow through different types of meters.
- The relationship between the flow velocity and pressure can clearly be studied and understood through this practical demonstration.
- The unit allows students to look at the pressure/velocity distribution, whilst recognising the friction effects that exists within pipe flow.



HB100D Pressure Losses in Bends and Fittings

- Comprises different diameter, roughness and material pipes, along with long and short radius bends, parallel sections and constrictions.
- The unit also has an expandable top section for looking at different options or students' own designs.
- Determination of Reynolds number in a variety of pipe sizes
- Calculation of theoretical pressure loss in a pipe using Bernoulli's equation – comparison with practical measured pressure drop.

HB100E Stability of Floating Bodies

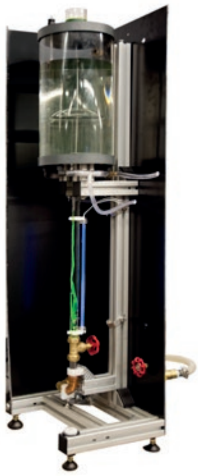
- The unit comes with 3 different hull designs for comparison testing. A calibrated weight set is supplied as well as an integral digital inclinometer.
- Determination of the metacentric height and the centre of buoyancy by analytical means.
- Calculating the righting moment for angles up to 10°
- Experimental determination of the metacentric height

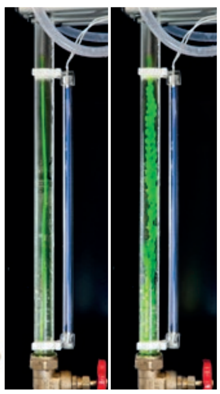
HB100F Centre of Pressure Module

- A bench mounted unit with a graduated scale on the side of the float measuring in millimetres.
- A set of weights is supplied for testing as well as the counterbalance loading system and an Instruction manual for measuring the hydrostatic pressure in liquids.
- An important experiment for ship building, maritime structures, chemical engineering and tank design.

HB100G Impact of a Jet

- The apparatus can be operated from HB100 Hydraulics Bench or independently from a local water source.
- It is used to investigate the forces applied on different designed deflectors being impacted by a constant jet of water.





Laminar Flow   Turbulent Flow

HB100J Osborne Reynolds Apparatus

- The apparatus can be operated from HB100 Hydraulics Bench or independently from a local mains water source.
- The Apparatus is used for the illustration and investigation of Laminar and Turbulent flow with the active flow visible thanks to a dye injection system.

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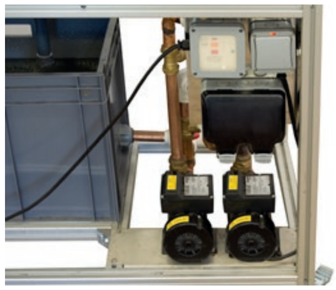
HB100K Flow Meter Module

- A variable area flow meter for measuring the flow rate from the HB100 and can be mounted with ease on top of the standard frame.
- The unit comes with a graduated scale on the clear plastic casing measuring in litres/minute.
- The HB100K is essential for operation of certain modules.



HB100L Series /Parallel Pump Module

- This module can be mounted with ease on the existing unit with pre-existing holes for simple and quick installation. Additional pipework and valves allow the unit to be simply switched between series and parallel modes. The additional pump allows an increase in the flow rate/pressure to enabler a wider range of experiments to be performed across all of the options available with the HB100.
- With the addition of options HB100K and HB100M the classic experiments investigating pressure and flow characteristics of series and parallel pump may be performed.

HB100M Pressure and Throttle Module

- Can be mounted with ease on the HB100 and left in position if required.
- With the addition of the HB100K the pressure and flow characteristics of the standard pump may be investigated.
- With the further addition of the HB100L, the classic experiments investigating pressure and flow characteristics of series and parallel pump may be performed.

F110 Pressure Measurement Bench

- The Hilton F110 Pressure Measurement Bench allows students to investigate measurement of one of the fundamental parameters that will be present in almost every branch of engineering and physics. The unit is bench mounted and self-contained having its own means of pressure generation.
- The unit allows the investigation of, manometer pressure measurement methods, pressures above and below atmospheric pressure and the investigation of manometer fluid density effect.
- A bench top, panel mounted U tube and inclined tube manometer together with a positive pressure Bourdon tube pressure gauge and compound (positive and negative) pressure gauge.
- A means of creating measurable pressures is also provided. The manometers allow investigation of the use of U and inclined tubes for pressure measurement and demonstrate the use of fluids of different density.
- All of the manometers and the panel mounted pressure gauges may be interconnected and linked to the common pressure source supplied. The action of the supplied pressure source may be reversed to generate pressures below atmospheric pressure. This allows the concept of "gauge" and absolute pressure to be investigated.

The Bourdon pressure gauge uses the principle that a flattened tube tends to straighten or regain its circular form in cross-section when pressurised. This change in cross-section may be hardly noticeable, involving moderate stresses within the elastic range of easily workable materials.

The strain of the material of the tube is magnified by forming the tube into a C shape or even a helix, such that the entire tube tends to straighten out or uncoil elastically as it is pressurised.

Eugène Bourdon patented his gauge in France on 1948, and it was widely adopted because of its superior sensitivity, linearity and accuracy.

F110A Optional Extra Deadweight Tester

- An optional bench mounted deadweight tester (F110A) with weights and a Bourdon tube pressure gauge with clear front panel to allow viewing of the dial mechanism is also available to illustrate the calibration of a Bourdon tube pressure gauge.
- The deadweight calibrator F110A introduces students to the concept of Pressure = Force/ Area by allowing calibration of a Bourdon tube pressure gauge. A set of precision weights allow discrete points of known pressure to be generated. To assist in student understanding the Bourdon gauge has a clear front, allowing viewing of the tube and pointer mechanism.

F110B Optional Extra Pressure Transducer & Digital Display

- The F110B when connected to the F110A allows students to calibrate an electronic transducer and relate the pressure points to the electronic signal

F100 Airflow system

- This flexible Air Flow System has an expandable range of optional experimental modules designed for student use. In conjunction with the F100 base unit, the optional modules allow the investigation of the fundamental aspects of air flow, aerodynamics and heat transfer.

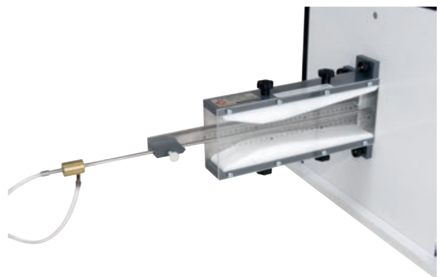
F100 Base unit

- The base unit consists of a small footprint, high volume high pressure centrifugal fan with adjustable flow control, inlet and outlet couplings. The Hilton Airflow System F100 is available with an extensive range of optional accessories that makes the unit a very flexible and economic investment

*Note Base shown with F100B accessory which is sold separately

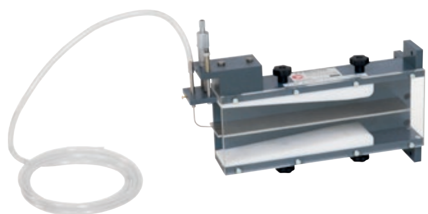
F100A Multi tube manometer

- Multi-tube manometer with a common reservoir that may be used to give a graphic display of pressure distribution on multi-point pressure tapings. The device allows up to 16 pressures to be monitored simultaneously either relative to atmospheric pressure or another pressure, via the common reservoir.
- This unit is a recommended accessory for all of the following optional items (except for the F100H) and is essential, if a similar unit is not available locally.



F100B Bernoulli's Equation

- A convergent divergent duct section that connects to the Hilton Airflow System F100 using a flexible coupling. The device has a pitot-static tube that can be moved axially along the duct to allow total and static pressure due to the variation in duct cross section.
- The measured pressure changes may be compared with the Bernoulli equation predictions.



F100C Boundary layer investigation

- A reversible flat plate located inside a rectangular duct. The plate has one smooth and one artificially roughened face. The duct has removable profile plates that can establish an increasing or decreasing pressure gradient in the direction of flow.
- To investigate the growth of the boundary layer profile in a variety of conditions along the plate a micro-pitot tube is provided. This may be moved toward the plate in measured intervals using a micro meter adjustment allowing the growth of the boundary layer along the plate to be investigated.

F100D Round Turbulent Jet Investigation

- A round parallel tube with a sharp-edged discharge is used to create a turbulent jet using the air from the Air flow System F100. A pitot tube is attached to a measuring frame that allows the device to be traversed horizontally and axially over the whole flow field.
- By this method the velocity profile at various axial distances from the jet, the pressure loss and entrained mass may be investigated.

F100E Flow Around a Bend Investigation

- A 90-degree bend of constant cross section has air blown through it from the Airflow System F100. Along the inner and outer radius at strategic points, static pressure tapping points are located. When connected to a suitable multi-tube manometer the static pressure profile along the inner and outer radius of the bend may be measured at a range of air velocities.

F100F Jet Attachment Investigation

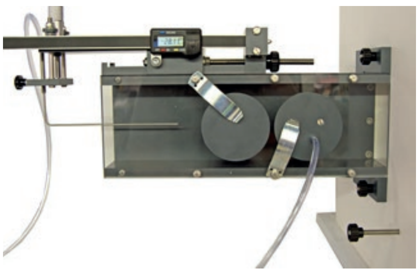
- A rectangular slit directs an air jet towards a Y shaped duct with two outlet passages. The shape of the duct may be changed by tilting and sliding moveable elements to allow students to investigate the Coanda effect of jet attachment to a wall. By blowing air from one side or another at the jet the airflow can be directed down either of the Y shaped passages as in a pneumatic flip-flop.

F100G Drag Force Investigation.

- A short duct with integral load balance allows the drag of a body to be directly measured at a range of approach velocities. The bodies include an aerofoil, cylinder and plate. The cylinder has a radial tapping to allow investigation of the pressure distribution around the cylinder.
- The unit allows the determination of the boundary layer drag on circular (and non–circular) cylinder(s) using the Pitot–Traverse method and Direct force measurement
- Practical experience in the use of Pitot tubes which should give students an understanding of the role probe alignment has on accuracy in the collection of pressure data.

F100H Flow Visualisation Investigation.

- The Optional Flow Visualisation Investigation duct has been designed for operation with the Hilton Airflow System F100. The duct allows students to investigate simple flow visualisation techniques including smoke and cotton thread.
- A smoke generator generates a visual oil mist that is introduced into the airstream ahead of the test shape through a number of fine nozzles. The resulting smoke filaments clearly show streamlines around the test shapes.



F100J Principles of Airflow, Pressure and Velocity Distribution (Pitot-Traverse

- A Pitot tube may be traversed across the air duct in both the free stream condition and behind a cylinder in cross flow allowing the velocity distribution to be measured. A cylinder with local static pressure tapping allows the pressure distribution around a cylinder in cross flow to be measured and compared with the theoretical distribution.

F100K Principles of Airflow, Friction Losses in Bends, and Pipe Elements

- A series of straight pipe sections, bends and different air inlet shapes that are equipped with static pressure tapings to allow air pressure drops due to pipe friction to be measured at a range of air velocities. The air flow rate may be measured using a standard orifice using the differential pressure.

F100M Principles of Airflow, Fan Test and Flow Measurement

- Measurement of fan air flow rate using an intake orifice plate, and an iris diaphragm at a range of air flow rates in order to determine the fan characteristics.
- The components allow students to quantitatively investigate three methods of flow measurement, the orifice plate, conical inlet and pitot static tube. The unit also allows students to utilise the flow measuring devices in conjunction with the fan throttle supplied in order to estimate the fan performance under a range of conditions.

F300 Compressible Flow Range

- The phenomenon of compressible flow, sonic velocity and supersonic flow is possibly one of the most demanding areas of study for many students. The Hilton Compressible Flow range F300 and its collection of optional accessories enable students to safely and clearly investigate the fundamentals of compressible flow, air turbines and a variety of heat transfer experiments.

F300 Base Unit

- The main unit consists of an instrumentation and control console that supplies a variable flow of compressed air to the range of optional modules. The unit provides common instrumentation for all of the options. Specialised instruments are included as required with the modules.
- Optional data acquisition is available for F300C, F300D, F300E, F300F

F300A Nozzle Performance Test Module

- A series of convergent and convergent-divergent nozzles may be installed in one of two locations in a high-pressure measuring chamber. A pressure regulator, throttle valve and back pressure valve allow the air flow rate, inlet and discharge (or back) pressure to be varied.
- **Standard unit includes convergent – divergent ducts designed to produce Mach 1.0 at the throat and supersonic velocities downstream.**
- Inlet and outlet air pressures, temperatures and air flow rate are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module.

F300B Nozzle Pressure Distribution Module

- Two convergent-divergent nozzles of with the same throat diameter but different discharge area and a single convergent nozzle having the same diameter are supplied and fit in the common test section. All three nozzles have axial static pressure tapings allowing the approach, throat and divergent section pressures to be measured. The variation of pressure ratio and mass flow may be investigated for all three nozzles.
- Standard unit includes convergent – divergent ducts designed to produce Mach 1.0 at the throat and supersonic velocities downstream.

F300C Experimental Impulse Turbine

- Application of the First law of Thermodynamics to a simple open system undergoing a steady flow process
- Features an impulse turbine with 4 separate nozzles and control valves, a throttle valve and belt brake dynamometer. Inlet and outlet air pressures, temperatures and air flow rate, turbine torque and speed are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module.

F300D Experimental Reaction Turbine Module

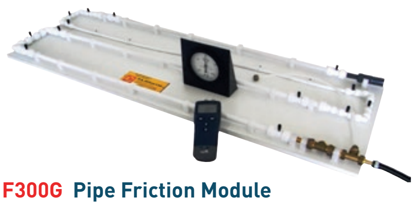
- Application of the First law of Thermodynamics to a simple open system undergoing a steady flow process.
- A single stage, radial flow, two jet reaction turbines with a throttle valve and belt brake dynamometer. Inlet and outlet air pressures, temperatures and air flow rate, turbine torque and speed are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module.

F300E Fluidisation / Fluid Bed Heat Transfer Module

- A glass cylindrical chamber with an air distribution plate at the bottom end allows the granular material supplied to be fluidised by a controlled and measured air flow. An adjustable cylindrical heater with surface thermocouple and power meter can be immersed at any level in, or out of the bed to allow measurement of the local heat transfer coefficient.
- A moveable pressure tapping and separate thermocouple allow the pressure and temperature within the bed at any depth to be measured. The pressures, temperatures and air flow rate are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module.

F300F Vortex Tube Refrigerator Module

- A compressed air vortex tube has two outlet ports that can be adjusted to vary the proportion of flow that leaves from the hot and cold exit points.
- Using a common compressed air source at ambient temperature, the cold stream can reach temperatures below -30°C and the hot stream temperatures above 50°C.
- The effect of air supply pressure on the performance can be investigated together with the overall refrigerating effect. The pressures, temperatures and air flow rate are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module.



F300G Pipe Friction Module

- A series of four straight tubes of different diameters with end pressure tapings allow pressure losses in a straight pipe to be investigated at a range of Reynolds numbers. Bends, sudden enlargements and contractions are included to allow investigation of pressure loss and recovery.
- The unit is driven by an ejector (jet pump) allowing investigation of entrainment ratio and ejector performance.
- The pressures, temperatures and air flow rate are recorded by a combination of instrumentation on the Compressible Flow Range F300 base unit and the optional module. A digital handheld manometer is also supplied.

Note that the F865 Two Stage Compressor Unit can be used as a suitable air supply for the entire Compressible Flow Range.

Compressors and pumps, when undergoing a steady-flow process, consume power. The isentropic efficiency of a compressor or pump is defined as the ratio of the work input to an isentropic process, to the work input to the actual process between the same inlet and exit pressures.

F860 Single Stage Compressor Test Unit

- Allows Investigation of a Single Stage Compressor at a Range of Delivery Pressures.
- Safe and Suitable for Student Operation.
- Instrumentation Allows Detailed Analysis of Compressor Performance.
- Optional Computerised Data Acquisition Upgrade

F865 Two Stage Compressor Test Unit

- Allows Investigation of a Single and Two Stage Compressor (with, or without intercooling) at a Range of Delivery Pressures.
- Safe and Suitable for Student Operation.
- Instrumentation Allows Detailed Analysis of Compressor Performance.
- Optional Computerised Data Acquisition Upgrade

B500 Ventilation Trainer

- A realistically scaled ventilation training unit capable of enabling students to study both basic airflow and fluid mechanics as well as the more complex process of commissioning and balancing a multi-ducted air distribution system.
- The unit consists of a forward curved variable speed centrifugal fan and integral control console together with a rectangular air intake and filter holder.
- A portable manometer, pitot static tube and handheld anemometer allow a large range of experiments to be undertaken.

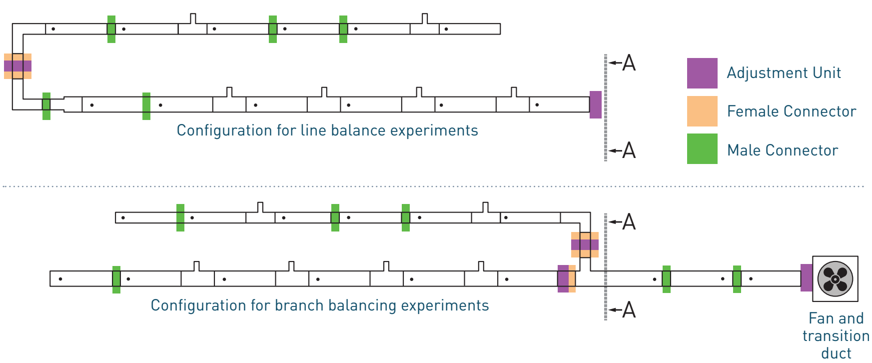
B500B (Optional Extra)

- The optional extra duct configuration B500B allows the addition of a third parallel branch and two air supply units.

B500C (Optional Extra)

- The optional extra duct configuration B500C allows the addition of a 6m branch and two air supply units.

B500 Component Layouts



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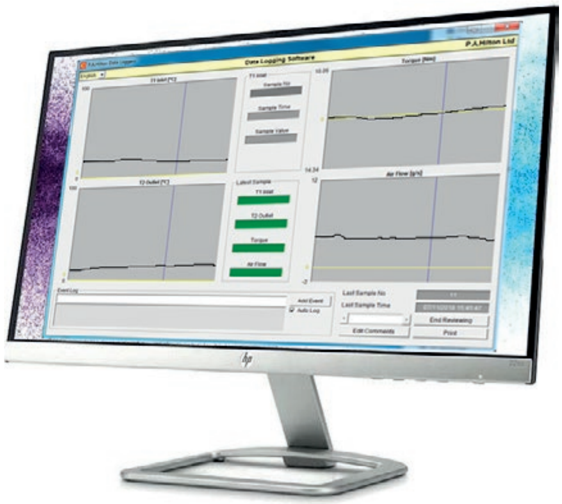
A polytropic process is any thermodynamic process that can be expressed by the following equation:
pV^n = constant

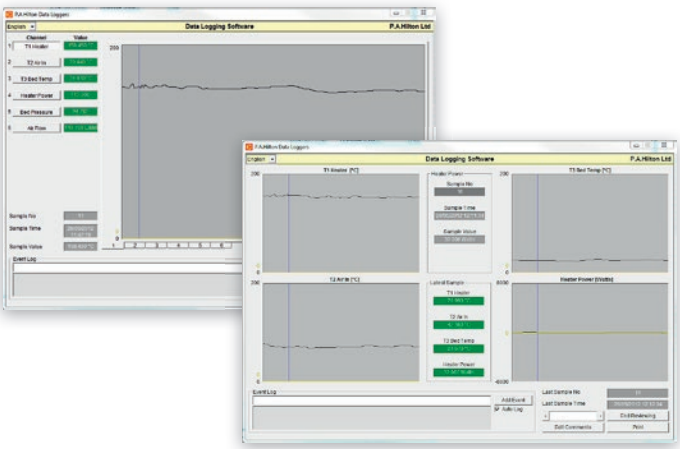
The polytropic process can describe gas expansion and compression which include heat transfer.

https://en.wikipedia.org/wiki/Polytropic_process

Hilton Data Acquisition

- Available for specific units within the F300 range of units – F300C, F300D, F300E, F300F when used with a data logged F300 base unit.
- Software can measure relevant performance areas dependent upon experiment being utilised, such as temperature, watts, load airflow speed and pressure. These parameters can be measured displayed, recorded, printed and graphically/numerically displayed on a host computer or laptop.
- Data files can be exported to a spreadsheet programme.
- Allows for rapid data acquisition where equipment maybe being used for research.





In engineering analysis, isentropic efficiency is a parameter to measure the degree of degradation of energy in steady-flow devices. It involves a comparison between the actual performance of a device and the performance that would be achieved under idealized circumstances for the same inlet and exit states. Although there exists heat transfer between the device and its surroundings, most steady-flow devices are intended to operate under adiabatic condition. Hence, normally an isentropic process is chosen to serve as the idealized process.

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