THERMODYNAMICS

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BAE Systems Defence Information, Training and Services have recently used TecQuipment to support training activities in the Kingdom of Saudi Arabia through the procurement of two gas turbine trainers. Throughout the procurement, manufacturing and installation period TecQuipment have performed well and supported extra requirements such as product safety justification reports. The experience and expertise of their commissioning engineer was first class and in-country activities went well.

N CHERRY
TRAINING PROCUREMENT WARTON, BAE SYSTEMS (OPERATIONS) LIMITED

THERMODYNAMICS

SAFE, PRACTICAL AND REALISTIC

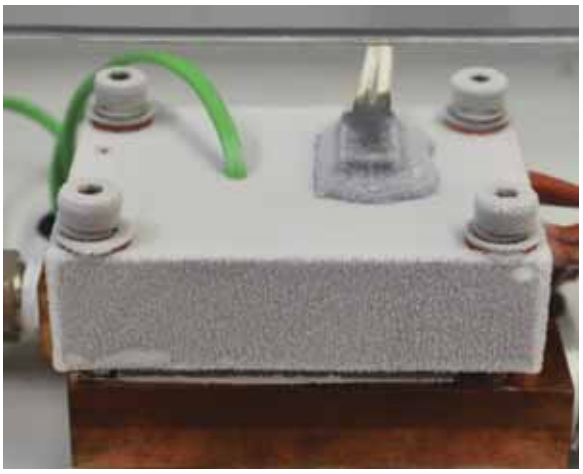
As thermodynamics experiments can often take many hours, the range has been designed to reduce the experiment time to a practical and realistic level, with safety as the key aspect.

BROAD RANGE

This broad range of experimental apparatus allows the comprehensive teaching of thermodynamics, from principles through to complex systems.

KEY FEATURES AND BENEFITS:

- **SAFE AND PRACTICAL DESIGN:** Reduced experiment times.
- **BROAD RANGE OF PRODUCTS:** Covers from basic principles to gas turbines.
- **AUTOMATIC DATA ACQUISITION:** Thermodynamics experiments need several minutes of constant monitoring to achieve thermal equilibrium, making automatic data acquisition a useful tool.



AUTOMATIC DATA ACQUISITION VDAS®

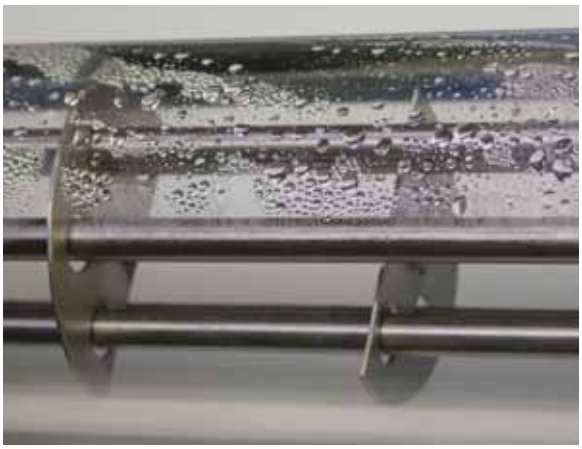
Check out the products in this range that work with TecQuipment's unique Versatile Data Acquisition System (VDAS®).

SEE PAGE 293

MODULAR FLUID POWER

Our Modular Fluid Power range includes products that can be analysed in terms of thermodynamic performance, such as compressors.

SEE PAGES 132-146



VDAS® TD1000

IDEAL GASES – BOYLE'S LAW

Demonstrates the relationship between pressure and volume of an ideal gas at a fixed temperature.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- A self-contained bench-top experiment – no power supply needed
- Highly visual experiment using a 'liquid piston' for reliability and accurate, repeatable results
- Includes a thermocouple and digital display to help maintain constant temperature and demonstrate how compression and decompression of a gas can affect its temperature
- Supplied with hand-operated pumps to compress or decompress the gas (air) above and below atmospheric pressure

LEARNING OUTCOMES:

- Demonstrations of gas temperature change during compression and decompression
- Proving Boyle's law by experiment

The bench-mounted equipment includes a backplate that holds two clear-walled cylinders containing oil (supplied). Students use hand-operated pumps (supplied) to increase or decrease the pressure in the left-hand cylinder (the reservoir) which moves a "liquid piston" of oil in the right-hand cylinder (the test cylinder). This piston compresses or decompresses a trapped column of air in the test cylinder.

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

ALTERNATIVE PRODUCTS:

- Ideal Gases – Gay-Lussac's Law (TD1001) 238
- Expansion of Perfect Gas (TD1004) 239

VDAS® TD1001

IDEAL GASES – GAY-LUSSAC'S LAW

Demonstrates the relationship between pressure and temperature of a fixed volume of ideal gas.

- Demonstrates Gay-Lussac's law relating pressure and temperature of an ideal gas (air)
- Simple and safe – needs no tools, uses low pressures and a thermally-insulated heater
- Includes thermocouples and a pressure sensor connected to a digital display
- Electronic controller to accurately regulate temperature

LEARNING OUTCOMES :

- Demonstrates change of pressure of a fixed volume of gas during heating
- Proving Gay-Lussac's law by experiment
- The principle of a vapour pressure thermometer

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

The bench-mounted equipment includes a backplate that holds a low-pressure vessel. The vessel holds a fixed volume of air surrounded by an insulated heater, controlled by an electronic temperature controller.

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

ALTERNATIVE PRODUCTS:

- Ideal Gases – Boyle's Law (TD1000) 237
- Expansion of Perfect Gas (TD1004) 239

VDAS® TD1004

EXPANSION OF PERFECT GAS

Bench-top apparatus to demonstrate the behaviour and expansion processes of a perfect gas.

SCREENSHOT OF THE VDAS® SOFTWARE

- A self-contained bench-top experiment, for convenient use in a laboratory
- Highly visual experiment with accurate and repeatable results
- Simple and safe to use – needs no tools
- Supplied with an electric pump for easy compression and decompression of the gas (air)
- VDAS® connectivity included featuring data acquisition via USB

The apparatus consists of two frame-mounted, interconnected transparent and rigid vessels, with one vessel equipped for operation under pressure and the second vessel under vacuum.

LEARNING OUTCOMES:

- The non-flow energy equation
- Clément Desormes experiment
- The behaviour of a perfect gas and its describing equations
- Adiabatic reversible process (isentropic expansion)
- Constant volume process
- Constant internal energy process
- Polytropic process

ALTERNATIVE PRODUCTS:

- Ideal Gases – Boyle's Law (TD1000) 237
- Ideal Gases – Gay-Lussac's Law (TD1001) 238

VDAS® TE78

FILMWISE AND DROPWISE CONDENSATION AND BOILING

Demonstrates heat transfer during different boiling and condensing processes.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- Has a glass vessel so students can see what is happening
- Demonstrates nucleate, film and sub-cooled boiling
- Demonstrates condensation on different surface finishes
- Demonstrates filmwise and dropwise condensation

LEARNING OUTCOMES:

- Boiling heat transfer
- Condensing heat transfer

Gives students an understanding of heat transfer during boiling and condensing. The equipment heats and condenses water, and includes a separate control module with a digital display.

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

HIGH QUALITY - SHORT LEAD TIMES

To ensure high quality and short lead times, products are designed and manufactured in the in-house facility near Nottingham in the UK.

VDAS® TD1011

EMISSIVITY – NATURAL CONVECTION AND RADIATION

Demonstrates students how different types of heat can transfer over a range of pressures.

SCREENSHOT OF THE VDAS® SOFTWARE

- Helps students to understand natural 'free' convection, radiation, emissivity and the Stefan Boltzman equation
- Includes a pressure vessel to allow tests above and below atmospheric pressure
- All instruments and vacuum pump included
- Test results are accurate enough to allow extrapolation down to a complete vacuum
- VDAS® connectivity included featuring data acquisition via USB

LEARNING OUTCOMES:

- Determination of emissivity
- Verification of the Stefan Boltzmann constant

The Natural Convection and Radiation equipment allows the study of heat transfer at different pressures and partial vacuums. It demonstrates the differences between radiation and natural 'free' convection. It allows students to find the emissivity of a surface and verify the Stefan Boltzman equation. It also gives students an understanding of the non-dimensional characteristics using Nusselt, Grasof, Prandtl and Knudsen numbers.

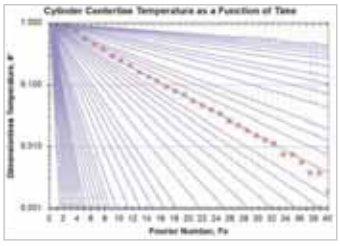
ALTERNATIVE PRODUCTS:

- Free and Forced Convection (TD1005) 249
- Radiant Transfer Experiments (TD1003) 256

VDAS® TD1009

UNSTEADY STATE HEAT TRANSFER

Measures unsteady state heat transfer to bodies of different shape and thermal conductivity.



HEISLER CHART CREATED BY THE VDAS® SOFTWARE

TEST SHAPES

- Includes TecQuipment's Versatile Data Acquisition System (VDAS®)
- Includes a set of different solid shapes of different materials – for multiple experiments
- Simple to use – needs no tools
- Water temperature controller for consistent results
- Clear digital displays of all readings – a computer is not required to operate or take readings from the equipment

LEARNING OUTCOMES:

- Transient temperature changes with sudden immersion (unsteady state)
- How shape and surface area affect heat transfer
- How materials of different thermal conductivity affect heat transfer

A sturdy, bench-mounting frame contains a hot water vessel and instrumentation. The test shapes are of different dimensions and material to give different heat transfer areas and thermal conductivities. This gives multiple experiments in heat transfer.

TD1

FORCED CONVECTION HEAT TRANSFER

Demonstrates forced convection in pipes and heat transfer theory.

- Constant-speed fan with variable flow-control valve for better flow control
- Heater interlock for safety
- Includes Pitot tube traverse for velocity profile measurements, and traversing thermocouple to measure temperature distribution across the test pipe
- Includes thermocouples along the test pipe to measure heat transfer

LEARNING OUTCOMES:

- Derivation of the value of Nusselt number (Nu) and comparison with empirical formula
- Calculation of the local heat transfer coefficient (h)
- Determination of the Stanton number (St)
- Calculation of the friction factor (f) and comparison with experimental value
- Determination of the validity of the Reynolds analogy for air

A basic knowledge of forced convection heat transfer theory is valuable in many engineering fields, especially heat-exchanger design. TecQuipment's Forced Convection Heat Transfer apparatus allows students to examine the theory and associated formulae related to forced convection in pipes.

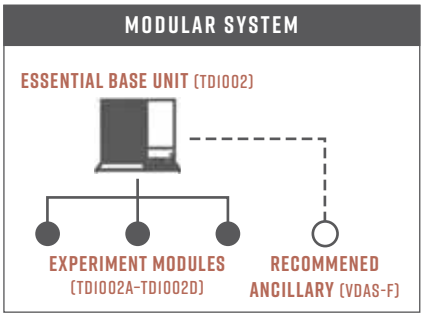
ALTERNATIVE PRODUCTS:

- Cross-Flow Heat Exchanger (TE93) 255
- Free and Forced Convection (TD1005) 249
- Water-to-Air Heat Exchanger (TD1007) 257

VDAS® TD1002

HEAT TRANSFER EXPERIMENTS BASE UNIT

Base unit for a range of optional experiments that study different methods of heat transfer.



FEATURES:		BENEFITS:
A self-contained bench-top base unit with four optional experiments	→	Modular approach reduces total laboratory costs
Foolproof fittings allow students to change and connect the optional experiments quickly and easily (needs no tools)	→	Simple and safe to use – self-sealing connectors prevents spillage of water
Clear digital displays of all readings	→	No computer needed to operate it or take readings – simplified approach enhances student learning
The experiments each have a bedplate with a clear schematic diagram to show students how they connect, and the measuring point positions	→	Maximises teaching effectiveness – simple to set up and students can easily understand the experiment

The Heat Transfer Experiments Base Unit (TD1002) is the core of the TD1002 range. It provides cold water and heater power to the optional experiments and all the instruments needed to measure their performance.

AVAILABLE EXPERIMENT MODULES:

RECOMMENDED ANCILLARIES:

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

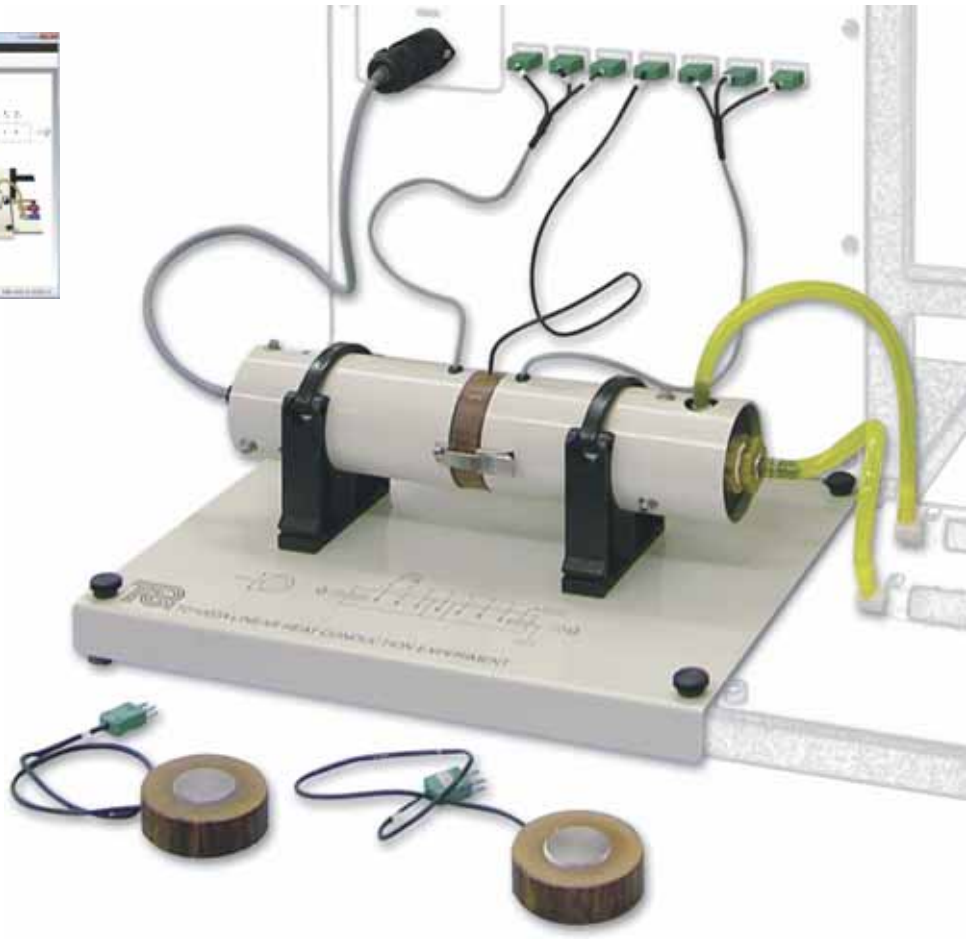
ALTERNATIVE PRODUCTS:

TD1002A

LINEAR HEAT CONDUCTION EXPERIMENT

Introduces students to the principles of linear heat conduction and thermal conductivity.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE



- One of four optional experiments for the Heat Transfer Experiments Base Unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Demonstrates the principles of linear heat conduction along a rod of uniform diameter
- Clear schematic printed on the baseplate aids student understanding

LEARNING OUTCOMES:

- Demonstration and calculations of linear heat conduction
- Calculation of the thermal conductivity (k value)
- Demonstration of the effectiveness of thermal paste
- Demonstration and calculations of thermal resistances (R value) in series
- Demonstration of 'thermal lag'

This experiment has a solid brass bar of circular cross-section, made in two sections with an interchangeable middle section. It mounts on a base plate with a clear schematic of the experiment layout.

ESSENTIAL BASE UNIT:

- Heat Transfer Experiments Base Unit (TD1002) 244

TD1002B

RADIAL HEAT CONDUCTION EXPERIMENT

Introduces students to the principle of radial heat conduction and thermal conductivity.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- One of four optional experiments for the Heat Transfer Experiments Base Unit (TD1002)
- Fits quickly and easily onto the base of the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Demonstrates the principles of radial heat conduction around a disc of uniform diameter
- Clear schematic printed on the baseplate aids student understanding

LEARNING OUTCOMES:

- Demonstration and calculations of radial heat conduction
- Calculation of the thermal conductivity (k value)

This experiment has a solid brass disc with an electric heater (heat source) at its centre and a circular cross-section cooling tube (heat sink) around its circumference. It mounts on a base plate with a clear schematic of the experiment layout.

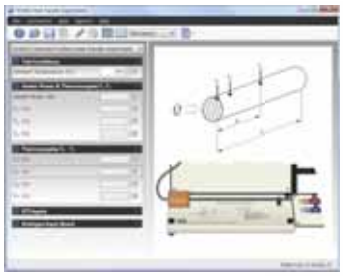
ESSENTIAL BASE UNIT:

- Heat Transfer Experiments Base Unit (TD1002) 244

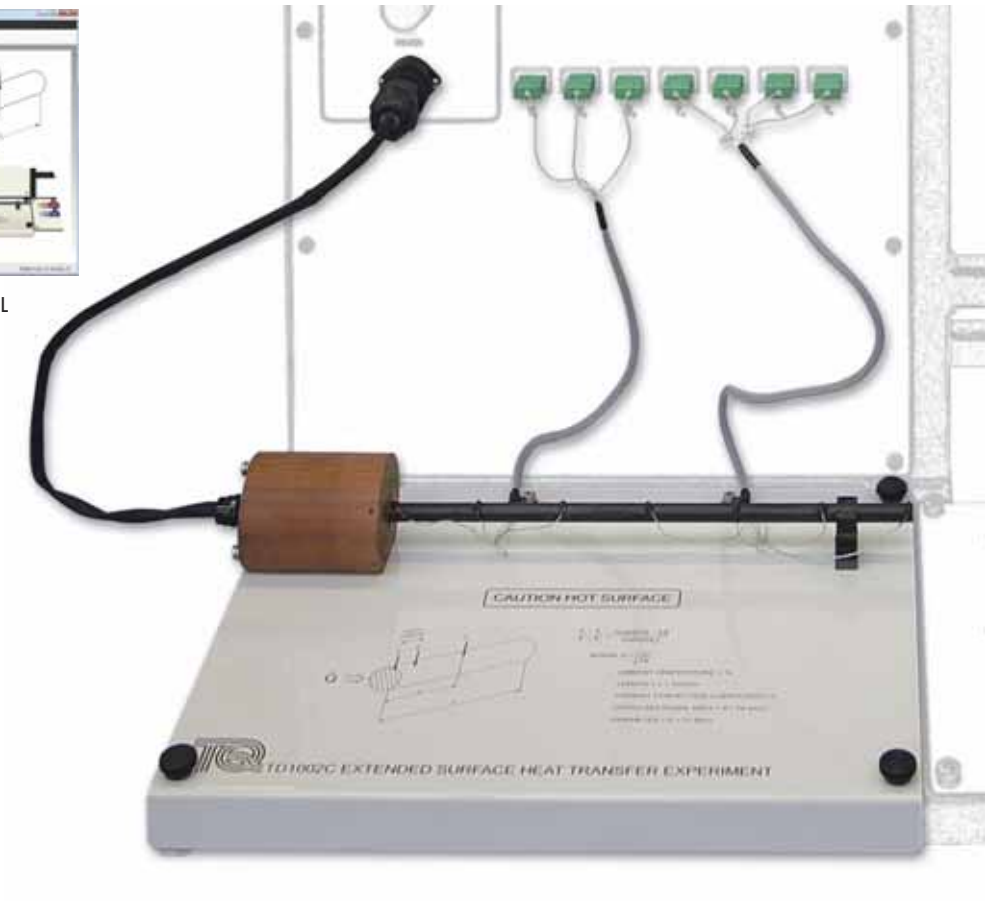
TD1002C

EXTENDED SURFACE HEAT CONDUCTION EXPERIMENT

Demonstrates an example of conduction combined with losses due to radiation and convection.



SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE



- One of four optional experiments for the Heat Transfer Experiments base unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Demonstrates how a long thin rod conducts heat along it and how heat is lost due to radiation and convection
- Clear schematic printed on the baseplate aids student understanding

LEARNING OUTCOMES:

- To demonstrate how heat transfers from the surface of a solid bar or rod.
- To demonstrate the temperatures on, and heat flow through, the solid bar to its surroundings.

This experiment has a thin solid bar with an electric heater (heat source) at one end. It mounts on a base plate with a clear schematic of the experiment layout.

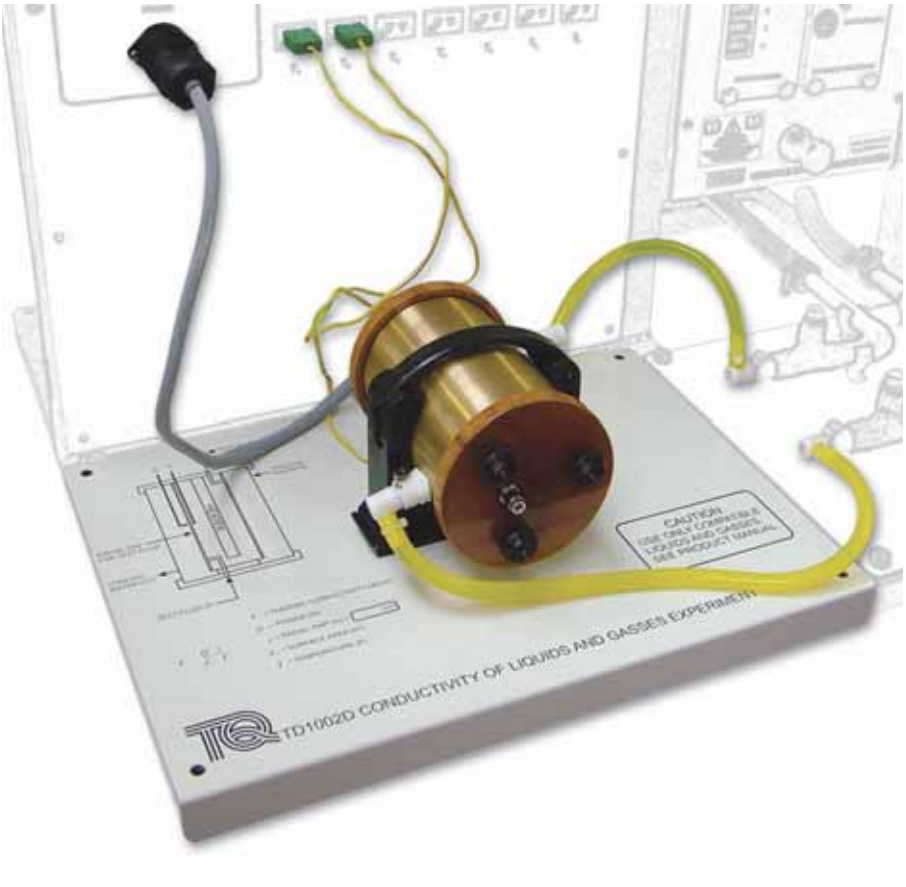
ESSENTIAL BASE UNIT:

- Heat Transfer Experiments Base Unit (TD1002) 244

TD1002D

CONDUCTIVITY OF LIQUIDS AND GASES EXPERIMENT

Allows students to test various fluids to find their thermal conductivity.



SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- One of four optional experiments for the Heat Transfer Experiments base unit (TD1002)
- Fits quickly and easily onto the Heat Transfer Experiments Base Unit and water connections have self-sealing quick connectors – needs no tools
- Allows students to measure the thermal conductivity of various compatible liquids and gases
- Clear schematic printed on the baseplate aids student understanding

LEARNING OUTCOMES:

- Calibration of the unit using air as the known medium.
- Finding the thermal conductivity (k) of various liquids and gases and comparing them to typical published values .

This experiment has three concentric cylinders. The inner cylinder contains an electric heater (the heat source). The test liquid or gas forms a second, thin cylinder around the heat source. The third cylinder, cooled by water, surrounds them both to make a heat sink. The whole assembly is mounted on a base plate with a clear schematic of the experiment layout.

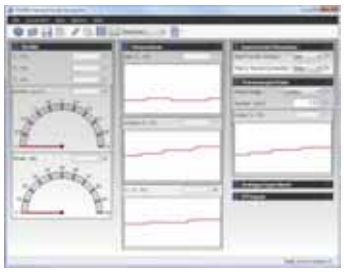
ESSENTIAL BASE UNIT:

- Heat Transfer Experiments Base Unit (TD1002) 244

VDAS® TD1005

FREE AND FORCED CONVECTION

Illustrates free and forced convection from different heat transfer surfaces.



SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- Includes three of the most common heat transfer surfaces – flat plate, pinned and finned
- Thermocouples and a sensitive anemometer measure temperatures and air velocity – shown on a digital display
- Additional hand-held thermocouple probe included – to measure temperatures along the length of the pins and fins of two heat transfer surfaces
- Variable-speed fan and variable-power heat source for a range of tests

LEARNING OUTCOMES:

- Comparing free and forced convection for different surfaces
- Comparison of free convection from vertical and horizontal (finned) surfaces
- Comparison of heat transfer surface efficiency
- Comparing the coefficient of heat transfer and Nusselt number for forced and free convection
- Temperature distribution along finned and pinned surfaces

The bench-top equipment includes a vertical duct that holds the chosen heat transfer surface and all instruments needed. TecQuipment include three different common heat transfer surfaces with the equipment.

RECOMMENDED ANCILLARIES:

- Bench-mounted version of the Versatile Data Acquisition System (VDAS-B) 293

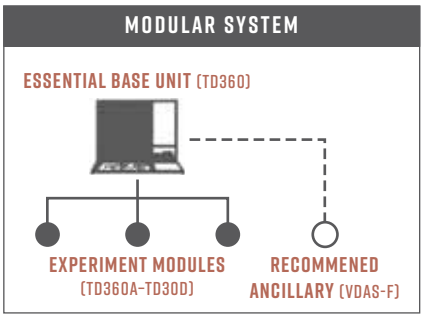
ALTERNATIVE PRODUCTS:

- Forced Convection Heat Transfer (TD1) 243
- Heat Transfer Experiments (TD1002) 244
- Emissivity – Natural Convection and Radiation (TD1011) 241
- Cross-Flow Heat Exchanger (TE93) 255
- Water-to-Air Heat Exchanger (TD1007) 257

VDAS® TD360

BENCH-TOP HEAT EXCHANGERS SERVICE MODULE

Examines and compares small-scale heat exchangers to help students understand how they work.



FEATURES:		BENEFITS:
A bench-top service module with optional small-scale demonstration heat exchangers – designed for teaching	→	Efficient use of valuable laboratory space
Optional heat exchangers include most common types used in industry (tubular, plate, shell and tube, and a jacketed vessel with coil and stirrer)	→	Qualitative and quantitative comparison of main heat exchanger designs
Foolproof fittings allow students to change and connect the optional experiments quickly and easily (needs no tools)	→	Simple and safe to use – self-sealing connectors prevents spillage of water
Heat-exchangers each have a bedplate with a clear schematic diagram to help students understand how to connect it	→	Easy to set up and operate – maximises students' practical time

The Bench-top Heat Exchangers Service Module (TD360) is the core of the bench-top heat exchangers range. It provides hot and cold water to the heat exchangers and all the instruments needed to measure their performance.

AVAILABLE EXPERIMENT MODULES:

- Concentric Tube Heat Exchanger (TD360a) 251
- Plate Heat Exchanger (TD360b) 252
- Shell and Tube Heat Exchanger (TD360c) 253
- Jacketed Vessel with Coil and Stirrer (TD360d) 254

RECOMMENDED ANCILLARIES:

- Frame-mounted version of the Versatile Data Acquisition System (VDAS-F) 293

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

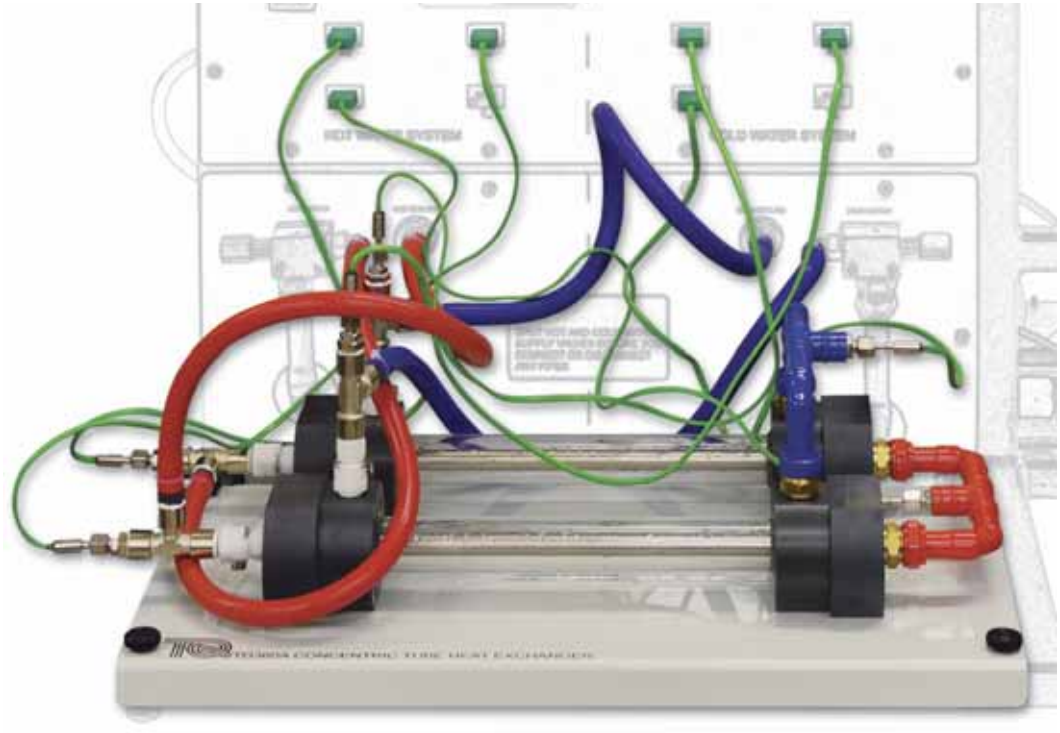
ALTERNATIVE PRODUCTS:

- Cross-Flow Heat Exchanger (TE93) 255
- Water-to-Air Heat Exchanger (TD1007) 257

TD360A

CONCENTRIC TUBE HEAT EXCHANGER

Illustrates how a simple concentric shell and tube heat exchanger works.



- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

LEARNING OUTCOMES:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if two or more optional heat exchangers have been bought).

This is the simplest of the optional heat exchangers. It has two tubes, one inside the other. One tube carries hot fluid, the other carries cold fluid.

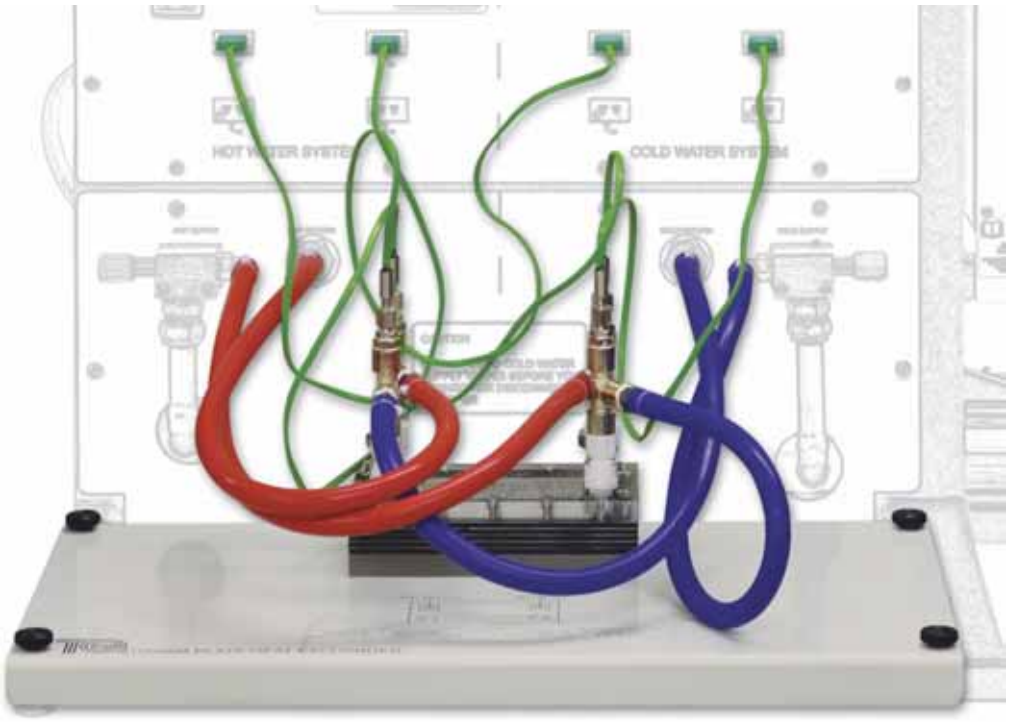
ESSENTIAL BASE UNIT:

- Service Module (TD360) 250

TD360B

PLATE HEAT EXCHANGER

Illustrates how a compact plate heat exchanger works.



- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

LEARNING OUTCOMES:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if two or more optional heat exchangers have been bought).

This heat exchanger is a set of metal plates separated by spacers (gaskets). The plates and gaskets have holes that make the hot and cold flow run on alternate sides of the plates, thereby transferring heat.

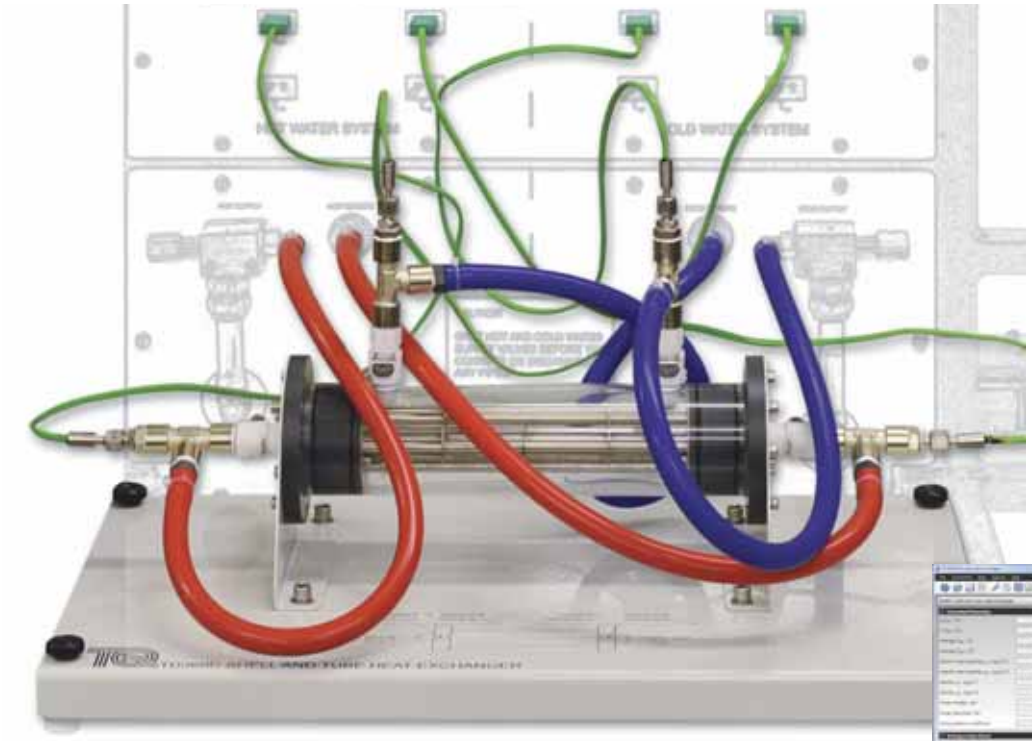
ESSENTIAL BASE UNIT:

- Service Module (TD360) 250

TD360C

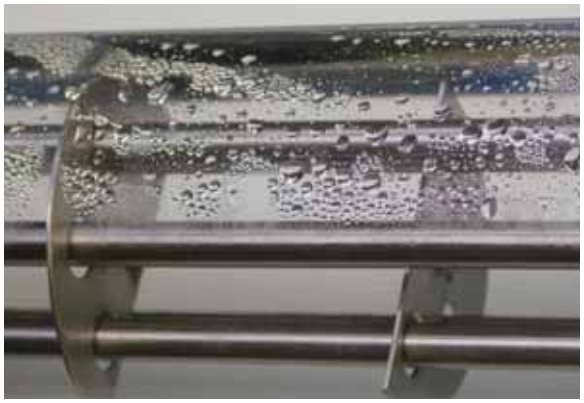
SHELL AND TUBE HEAT EXCHANGER

Illustrates how a compact shell and tube bundle heat exchanger works.



SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear outside casing, so students can see its construction
- Bedplate with a clear schematic diagram to help students understand how to connect the heat exchanger



LEARNING OUTCOMES:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Energy balance and efficiency calculations.
- Demonstration of parallel-flow and counter-flow operation of heat exchangers.
- Measurement of the heat transfer coefficient, and the effect of fluid flow rates and the driving force (temperature differential) upon it.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if two or more optional heat exchangers have been bought).

This heat exchanger is one of the most common types used in industry. This is because it is compact, but can work at higher pressures than other designs. It is a large tube (shell) which surrounds several smaller tubes (a bundle).

ESSENTIAL BASE UNIT:

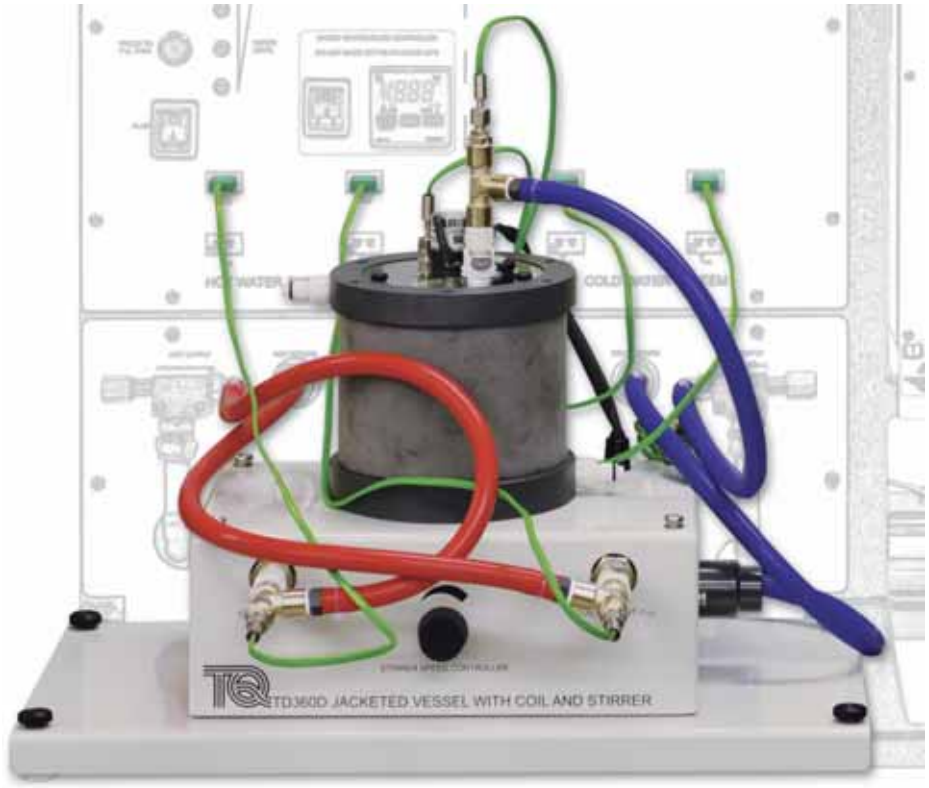
- Service Module (TD360) 250

TD360D

JACKETED VESSEL WITH COIL AND STIRRER

Illustrates how a 'jacketed vessel' heat exchanger works and how stirring affects heat transfer.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE



- One of a set of optional heat exchangers for use with TecQuipment's TD360 Service Module
- Simple and safe to use – foolproof fittings allow students to change and connect the heat exchanger quickly and easily (needs no tools)
- Clear top cover, so students can see its construction
- Jacketed vessel with internal coil and stirrer for batch or continuous heating tests

LEARNING OUTCOMES:

- Demonstration of heat transfer from one fluid to another through a solid wall.
- Introduction to the logarithmic mean temperature difference in heat exchangers.
- Comparison of different types of heat exchanger in terms of performance, size and relative cost (only if two or more optional heat exchangers have been bought).
- Flow-through and batch heating, with or without stirring, using a heating jacket or a coil.

This heat exchanger mimics those used in the process industry. It can demonstrate heat transfer by using the outer skin (or 'jacket') of the vessel, or by a coil inside the vessel. You can set a continuous feed to the vessel for heating, or you set a fixed batch for heating.

ESSENTIAL BASE UNIT:

- Service Module (TD360) 250

VDAS® TE93

CROSS-FLOW HEAT EXCHANGER

For studies into the principles and performance of heat exchangers.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- For full understanding of heat exchange by forced convection and measurement of heat transfer
- Consists of wind tunnel with fully controllable air flow and heat exchanger rod matrix
- Separate pre-heated element with built-in thermocouple can take the place of any heat exchanger rod
- Instrumentation unit also includes controlled heat source to pre-heat element

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

ALTERNATIVE PRODUCTS:

- Forced Convection Heat Transfer (TD1) 243
- Bench-top Heat Exchangers (TD360) 250
- Free and Forced Convection (TD1005) 249
- Water-to-Air Heat Exchanger (TD1007) 257

For comprehensive studies into the principles and performance of heat exchangers. The equipment allows students to quickly assess heat transfer rates by forced convection. They monitor the rate of cooling of a body of known thermal capacity in an air flow.

LEARNING OUTCOMES:

Typical experiments include:

- Determining the pressure losses created by the heat exchange rods and creating a chart of pressure drop against upstream pressure.
- Calculating the inlet velocity and the mean velocity through the rods.
- Determining the rate at which the heated rod cools down, within a bank of rods and by itself.
- Plotting 'cooling curves' and using them to find the coefficient of heat transfer (h) for the heated rod at various positions in the heat exchanger.
- Determining the velocity distribution (profile) downstream of the rods.
- Converting results into dimensionless values (typically using Nusselt, Prandtl and Reynolds equations).
- Comparing results and producing heat transfer coefficient curves.

VDAS® TD1003

RADIANT TRANSFER EXPERIMENTS

Demonstrates the laws of radiant transfer from heat and light sources.

- Uses a safe, low-voltage heat source and thermopile (heat flux sensor) for radiant heat transfer experiments
- Includes plates of different heat absorption properties and apertures for extra experiments in heat transfer
- Uses a safe, low-voltage 'integrating sphere' light source and lux meter (light meter) for light transfer experiments
- Includes different optical filters for extra experiments in light transfer

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

LEARNING OUTCOMES:

HEAT:

- Inverse square law (or Lambert's distance law/area law) – demonstrating that radiation is inversely proportional to distance squared.
- Stefan Boltzmann law – demonstrating the relationship between radiation and source temperature.
- Kirchhoff's law – demonstrating that a body with good emissivity also has good absorptivity.
- Area factor – demonstrating that radiation transfer depends on the exposed area of the radiant source.

LIGHT:

- Inverse square law (or Lambert's distance law/area law) – demonstrating radiation is inversely proportional to distance squared.
- Lambert's direction law (or cosine law) – demonstrating that radiation is proportional to the cosine of the angle between the emitter and the receiver.
- Transmittance and absorbance – demonstrating that optical filters can reduce light intensity.

The equipment has two parts: an aluminium experiment frame and a control box. The frame holds all the experiment parts and allows the user to slide the parts along easily for experiments of transfer over distances. The control box contains the electrical controls and displays of the measured readings.

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

ALTERNATIVE PRODUCTS:

- Heat Transfer Experiments (TD1002) 244
- Emissivity – Natural Convection and Radiation (TD1011) 241

DATASHEETS ONLINE

Download comprehensive product datasheets for full technical specifications.

TECQUIPMENT.COM

VDAS® TD1007

WATER-TO-AIR HEAT EXCHANGER

Illustrates how cross-flow water-to-air heat exchangers work.

16-TUBE HEAT EXCHANGER (TD1007A)

FINNED HEAT EXCHANGER (TD1007B)

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

FEATURES:		BENEFITS:
Includes one heat exchanger as standard	→	Complete experiment 'out of the box'
Two additional heat exchangers available for extended experiments	→	Allows quantitative comparison of different designs of heat exchanger
Heat exchangers have transparent sides and schematic diagrams	→	Enhanced learning capabilities – helps students understand how they work and how to connect them
Foolproof fittings allow students to change and connect the optional experiments quickly and easily (needs no tools)	→	Simple and safe to use – self-sealing connectors prevents spillage of water

CONTINUED ON NEXT PAGE

LEARNING OUTCOMES:

- Heat transfer between fluids through a solid wall
- Energy balance and efficiency
- Finding the heat transfer coefficient and Log Mean Temperature Difference (LMTD)
- Effect of water temperature (the 'driving force')
- Comparison of heat exchangers of different construction and heat transfer area (needs optional TD1007a and TD1007b)

Many thermodynamic applications use water-to-air heat exchangers. Examples include using circulated water to heat or cool air in an HVAC installation, or to cool hot water using a flow of air, as in the radiator of a combustion engine.

The TecQuipment Water-to-Air Heat Exchanger mirrors air heating and water cooling applications. It fits on a bench top and includes a hot water supply, a cooling air duct and all instruments needed for tests on cross-flow heat exchangers. The heat output of the design produces good results without greatly affecting the temperature of a reasonably-sized classroom or laboratory.

RECOMMENDED ANCILLARIES:

- 16-Tube Heat Exchanger (TD1007a)
- 16-Tube Finned Heat Exchanger (TD1007b)
- VDAS-F (frame-mounted version of the Versatile Data Acquisition System) 293

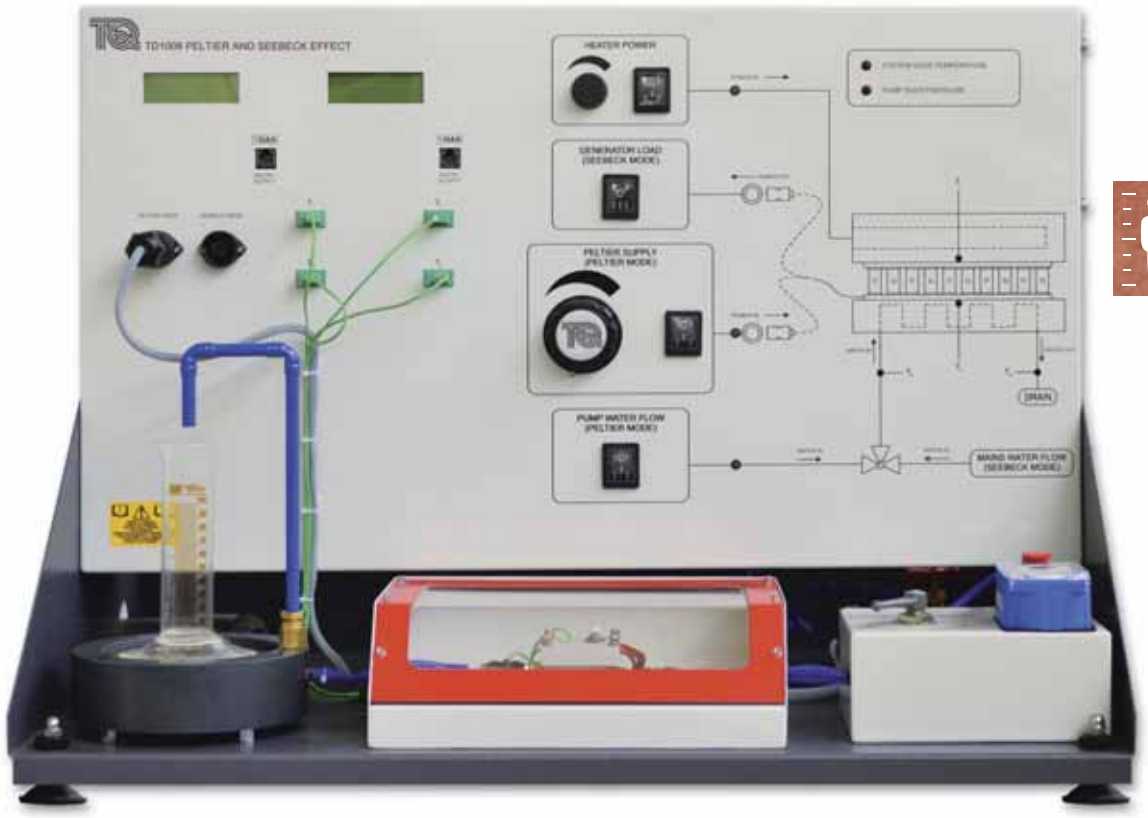
ALTERNATIVE PRODUCTS:

- Bench-Top Heat Exchangers (TD360) 250
- Cross-Flow Heat Exchanger (TE93) 255
- Free and Forced Convection (TD1005) 249
- Forced Convection Heat Transfer (TD1) 243

VDAS® TD1008

PELTIER AND SEEBECK EFFECT

Examines the performance of a thermoelectric device when connected for Peltier or Seebeck tests as a heat pump or generator.



SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

ICE CRYSTALS FORMING ON THE MODULE

- Connects for both Peltier or Seebeck tests – giving a full set of experiments
- Schematic diagram and transparent guard to help students understand the device construction and allow simple demonstrations
- A switchable load, variable heat source and device power supply for multiple test conditions
- Clear, multiline digital displays of all readings – you do not need a computer to operate it or collect data

LEARNING OUTCOMES:

- Seebeck coefficient and the performance of a thermoelectric generator (TEG)
- Peltier heat pump tests and the performance of a thermoelectric cooler (TEC)
- Coefficient of performance (COP) and energy balance
- Comparisons of manufacturers' data, theoretical performance and results from experiments
- Observation of the Lenz and Thomson effects
- Simple cooling demonstrations (determined by local conditions)

The increasing need for smaller and more portable electrically powered equipment has produced a need for low maintenance, smaller and more portable cooling. To satisfy this need, manufacturers now use solid-state thermoelectric devices in computers, portable refrigerators and cool boxes.

RECOMMENDED ANCILLARIES:

- VDAS-B (bench-mounted version of the Versatile Data Acquisition System) 293

VDAS® TD400

TEMPERATURE MEASUREMENT AND CALIBRATION

Studies the accuracy, linearity and important characteristics of popular temperature measuring devices.

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

- Uses a platinum resistance thermometer as a reference to accurately calibrate the other devices
- Demonstrates how electrical resistance devices and thermocouples work, their characteristics and how to connect them correctly to reduce measurement errors
- Hand-held digital thermometer for thermal infrared measurements
- Built-in water heater tank with protective guard and drain tap for safe experiments
- Built-in pressure sensor (barometer) with display of local water boiling temperature

LEARNING OUTCOMES:

- Simulation of two, three and four wire connection of a platinum resistance thermometer (PRT)
- Constant current and voltage sources
- Calibration and linearity of temperature measurement devices and temperature lag
- Thermal infrared temperature measurement on surfaces of different emissivity
- Thermocouples in series, parallel and the Seebeck effect
- Resistance in thermocouple circuits

The Temperature Measurement and Calibration apparatus fits on a desk or bench top. It includes eight different temperature measurement devices and demonstrates their characteristics and how to calibrate them against a standard.

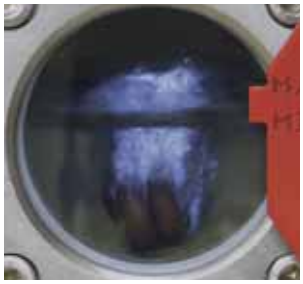
RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Bench-mounted version (VDAS-B) 293

VDAS® TD1006

SATURATED STEAM – THE MARCET BOILER

Illustrates the pressure and temperature relationship for saturated steam.



- Proves the Antoine equation for saturated steam
- Vessel (boiler) has viewing window to see the boiling process and the water level
- Simple and safe to use – includes temperature cut-out switches and a pressure-relief valve
- Electronic sensors measure boiler temperature and pressure – shown on a digital display in both SI and traditional units (including absolute values)

LEARNING OUTCOMES:

- Variation of saturated steam pressure with temperature
- Confirmation of the Antoine equation

SCREENSHOT OF THE OPTIONAL VDAS® SOFTWARE

The Marcet boiler is a simple experiment to demonstrate the relationship between pressure and temperature for saturated (wet) steam for comparison with published results.

The apparatus consists of a rigid frame containing an insulated pressure vessel (boiler) and an instrumentation and control unit. The frame also has extra space for the optional VDAS® interface.

RECOMMENDED ANCILLARIES:

- Versatile Data Acquisition System – Frame-mounted version (VDAS-F) 293

ALTERNATIVE PRODUCTS:

- Superheated Steam Plant Performance (TD1050) 277

GT103

TWO-STAGE COMPRESSOR TEST SET

Illustrates how single and two-stage compressors work, and the thermodynamic properties.

- Works as single-stage, two-stage or two-stage intercooled compressor
- Independently controlled compressor units, both with variable-speed dynamometer drives
- Clear, fully-instrumented control panel with mimic diagram
- Completely fail-safe operation – interlocks and pressure-relief valves prevent misuse

This test set has two independently-controlled, motor-driven compressors, intercooler and air receiver. It works as a single-stage, two-stage or two-stage compressor with intercooler. All controls and instrumentation are on an easy-to-operate mimic panel.

RECOMMENDED ANCILLARIES:

- Pressure Indicator (GT103a)

NOTE: You need a modern computer with a spare USB 2.0 socket to setup and analyse the pressure indicator results.

ALTERNATIVE PRODUCTS:

- Reciprocating Compressor Module (MFP104) 141

LEARNING OUTCOMES:

A range of experiments and tests based on:

- Volumetric, mechanical and isothermal efficiency
- Indicated work done
- Motor output power (compressor shaft power)
- Pressure ratio
- Temperature ratio
- Inlet dryness calculations
- P-V indicator diagram (needs optional pressure indicator)
- Effect of inter-stage cooling on compressor total power requirements and effect on cycle temperatures
- Effect of two-stage compression and inter-stage pressure on power requirements