Heat Exchanger Service Unit H102

H102 shown fitted with H102C Shell & Tube Heat Exchanger

- ***Many types of Heat Exchanger can be used on the Common Service Unit.***
- ***Safe and Suitable For Unsupervised Student Operation.***
- ***Responds Rapidly to Control Changes.***
- ***Negligible Operating and Maintenance Costs.***
- ***Optional Computerised Data Acquisition Upgrade***
- ***Two year Warranty.***

Introduction

Heat Exchangers are a vital component in many industrial processes enabling heat to be transferred from one fluid to another.

Four of the most common types found in industry are Concentric Tube, Shell and Tube, Plate and Jacketed Vessel. Student engineers need to be aware of the characteristics of these and other heat exchangers if they are to be involved in the design, operation or service of any heat transfer process.

The Hilton Heat Exchanger Service Unit is bench mounted, fully instrumented and operates from conventional single phase electrical supply and mains water. Using optional modules, the Service Unit enables students to investigate the performance of each of these common heat exchangers and their variants.

The unit will be of particular interest to those studying:

- Mechanical Engineering
- Nuclear Engineering
- Chemical Engineering
- Control and Instrumentation
- Plant and Process Engineering
- Building Services
- Engineering Physics
- Refrigeration
- Marine Engineering

Experimental Capabilities

For detailed descriptions and experimental capabilities refer to individual data sheets for each optional heat exchanger.

Description

Service Unit H102 (Shown with Optional H102C Fitted)

A bench mounted, reinforced plastic panel with an integral electrical console that provides services for any of the optional heat exchangers.
Temperature controlled hot water is provided from an electrically heated tank by a continuously rated fixed speed pump. Mains cold water is pressure regulated. Hot and Cold flow is controlled and measured using variable area flowmeters. The optional heat exchangers are connected to the service unit using non-drip, self sealing couplings.

Electrical safety is provided by double pole overload and earth leakage circuit breakers. The hot water system is equipped with a safety temperature limiting device.

The standard instrumentation consists of up to 12 type T thermocouples, displayed on a digital panel meter, and two flowmeters for hot and cold fluids. These enable all relevant heat transfer calculations to be made. Optional Heat exchangers in some cases add other measurement configurations.
An optional Computerised Data Acquisition Upgrade HC103A is available to allow all available parameters to be recorded on a computer in real time.

Specification

Heat Exchanger Service Unit H102

General

A fully instrumented bench top heat exchanger service unit providing circulated hot water and controlled cold water flows for many types of individual optional heat exchangers. Optional computerised data acquisition of all measured parameters available.

Detailed

A bench mounted heat exchanger service unit comprising a reinforced plastic instrument panel with electric water heater and circulating pump providing temperature controlled hot water from self sealing quick release couplings. Controlled and measured cold water is taken from the local supply.
Internal electric and mechanical safety devices to allow for unsupervised operation by students.
Instrumentation to measure up to 12 temperatures and the relevant flow rates of the hot and cold fluids through the heat exchanger under test.

Optional Heat Exchangers Include:-

Concentric Heat Exchanger	**H102A**
Plate Heat Exchanger	**H102B**
Shell & Tube Heat Exchanger	**H102C**
Jacketed Vessel	**H102D**
Extended Concentric Heat Exchanger	**H102E**
Extended Plate Heat Exchanger	**H102F**
Water to Water Turbulent Flow Heat Exchanger (Nu, Re, Pr Investigation)	**H102G**
Coiled Concentric Tube Heat Exchanger	**H102H**
Recycle Loops	**H102J**
Film and Dropwise Condensation	**H102K**

Supplied with a detailed experimental operating and maintenance manual giving example experimental results and sample calculations.
Accessories and spares for two years normal operation together with a full two year warranty.
Optional computerised data acquisition of all measured parameters is available with a 21 channel data logger and menu driven software.
Refer to the optional Heat Exchanger specifications for detailed capabilities

Dimensions

Height: 760mm Depth: 485mm
Width: 760mm Weight: 39kg.

Services Required

Electrical: A: 220-240 Volts, Single Phase, 50Hz (With earth/ground).
Line current up to10A at 230v

B: 110-120 Volts, Single Phase, 60Hz (With earth/ground).
Line current up to 20A at 110v

Water: 3 litres m^{-1} at a minimum of 10m head.
Open drain for this flow rate.

Accessories and Spares

Unit supplied with:
One experimental operating and maintenance manual in either English, Spanish or French. Accessories and spares for 2 years normal operation. List available on request.

Ordering Information

Order as: Heat Exchanger Service Unit H102

Electrical Specification
Either: **A**: 220-240 Volts, Single Phase, 50Hz (With earth/ground).
B: 110-120 Volts, Single Phase, 60Hz (With earth/ground).

Language
Either: English, Spanish, French.

Optional Heat Exchangers, Order as:

Concentric Heat Exchanger	H102A
Plate Heat Exchanger	H102B
Shell & Tube Heat Exchanger	H102C
Jacketed Vessel	H102D
Extended Concentric Heat Exchanger	H102E
Extended Plate Heat Exchanger	H102F
Water to Water Turbulent Flow Heat Exchanger	H102G
Coiled concentric Tube Heat Exchanger	H102H
Recycle Loops	H102J
Film and Dropwise Condensation	H102K

Shipping Specifications

Service Unit H102

Net Weight:	39kg.
Approximate Gross Weight:	82kg.
Packing Case Dimensions:-	0.92 x 0.65 x 1.05m
Packing Case Volume:	$0.32m^3$

For shipping details of the optional heat exchangers please refer to P.A.Hilton Ltd.

Also Available On Request

Further detailed specification.
Additional copies of instruction manual.
Recommended list of spares for 5 years operation.

Optional Extra H102A
Concentric Tube Heat Exchanger

A clear acrylic tube containing cold water surrounds an inner stainless steel tube in which the hot water flows. Total heat transfer area of approximately 24000mm^2. Six thermocouples measure hot and cold inlet, mid-point and exit temperatures. Self sealing quick release connections enable rapid connection to the H102 and conversion from parallel to counter current flow. **An extended version with 3 pairs of intermediate points and a total of 10 thermocouples is also available as H102E.**

Experimental Capabilities

- Demonstration of indirect heating or cooling by transfer of heat from one fluid stream to another when separated by a solid wall
- Conducting an energy balance across a concentric tube heat exchanger and calculate the overall efficiency at different fluid flow rates.
- To demonstrate the differences between counter-current flow and co-current flows and the effect on heat transfer, temperature efficiencies and temperature profiles through a concentric tube heat exchanger.
- To determine the overall heat transfer coefficient for a concentric tube heat exchanger using the logarithmic mean temperature difference for counter-current and co-current flows.
- To investigate the effect of changes in hot fluid and cold fluid flow rate on the temperature efficiencies and overall heat transfer coefficient.
- To investigate the effect of driving force (difference between hot stream and cold stream temperature) with counter-current and co-current flow

Optional Extra H102B
Plate Heat Exchanger

Multiple brazed stainless steel plates arranged for multi-pass operation with passes in series give a total heat transfer area of approximately 24000mm^2. Four thermocouples measure hot and cold fluid entry and exit temperatures. Self sealing quick release connections enable rapid connection to the H102 and conversion from parallel to counter-current flow. **An extended version with intermediate measuring points and a total of 6 thermocouples is available as H102F.**

Experimental Capabilities

- Demonstration of indirect heating or cooling by transfer of heat from one fluid stream to another when separated by a solid wall
- Conducting an energy balance across plate exchanger and calculate the overall efficiency at different fluid flow rates.
- To demonstrate the differences between counter-current flow and co-current flows and the effect on heat transfer, temperature efficiencies and temperature profiles through a plate heat exchanger.
- To determine the overall heat transfer coefficient for a plate heat exchanger using the logarithmic mean temperature difference for counter-current and co-current flows.
- To investigate the effect of changes in hot fluid and cold fluid flow rate on the temperature efficiencies and overall heat transfer coefficient.
- To investigate the effect of driving force (difference between hot stream and cold stream temperature) with counter-current and co-current flow

Optional Extra H102C
Shell and Tube Exchanger

A thick walled glass shell with 2 baffles contains cold water, which passes over 7 stainless steel tubes through which hot water flows. Tube bundle length of 205mm giving total heat transfer area of approximately 24000 mm^2. Four thermocouples measure hot and cold fluid entry and exit temperatures. Self sealing quick release connections enable rapid connection to the H102 and conversion from parallel to counter-current flow.

Experimental Capabilities

- Demonstration of indirect heating or cooling by transfer of heat from one fluid stream to another when separated by a solid wall.
- Conducting an energy balance across a shell and tube exchanger and calculate the overall efficiency at different fluid flow rates
- To demonstrate the differences between counter-current flow and co-current flows and the effect on heat transfer, temperature efficiencies and temperature profiles through a shell and tube heat exchanger.
- To determine the overall heat transfer coefficient for a shell and tube heat exchanger using the logarithmic mean temperature difference to perform the calculations (for counter-current and co-current flows).
- To investigate the effect of changes in hot fluid and cold fluid flow rate on the temperature efficiencies and overall heat transfer coefficient.
- To investigate the effect of driving forces (difference between hot stream and cold stream temperature) with counter-current and co-current flow.

Optional Extra H102D
Jacketed Vessel

A vessel with a clear top has a glass outer jacket. Hot water may pass through this or through a heat transfer coil inside the vessel to provide external or internal heating. The vessel contents of up to 2 litres are agitated by a variable speed stirrer, and may be batch or continuous feed. Six thermocouples measure hot inlet and exit temperatures from the jacket and coil, cold fluid inlet and vessel contents temperatures. Quick release connections enable rapid connection to the H102 and conversion from heating jacket to heating coil.

Experimental Capabilities

- Demonstration of indirect heating or cooling by transfer of heat from one fluid stream to another when separated by a solid wall.
- Investigation of the heating characteristics of a stirred vessel containing a fixed batch of liquid when heated using hot fluid circulating through a submerged coil.
- Investigation of the heating characteristics of a stirred vessel containing a fixed batch of liquid when heated using hot fluid circulating through an outer jacket.
- To investigate the change in overall heat transfer coefficient and logarithmic mean temperature difference as a batch of fluid in the vessel changes temperature.
- To perform an energy balance, calculate the overall efficiency and determine the overall heat transfer coefficient for a continuous flow in a stirred vessel when heated using a submerged coil.
- To perform an energy balance, calculate the overall efficiency and determine the overall heat transfer coefficient for a continuous flow in a stirred vessel when heated using an outer jacket.
- To investigate the effect of stirring on the heat transfer characteristics of a stirred vessel.

Optional Extra H102E
Extended Concentric Tube Heat Exchanger

An extended version of the H102A Concentric Tube Heat Exchanger with 3 pairs of intermediate points giving 10 thermocouples in total. In conjunction with the H102A this allows investigation of the effects of increased heat transfer area and the plotting of more points on the temperature distribution graph.

Experimental Capabilities
The experimental capabilities of the H102E are similar to those of the H102A but also allow students to make the direct comparison of test results on a heat exchanger with a doubled surface area.

Optional Extra H102F
Extended Plate Heat Exchanger

An extended version of the H102B Plate Heat Exchanger with a total of 6 thermocouples. In conjunction with the H102B this allows investigation of the effects of increased heat transfer area

Experimental Capabilities
The experimental capabilities of the H102F are similar to those of the H102B but also allow students to make the direct comparison of test results on a heat exchanger with a doubled surface area.

Optional Extra H102G

Water-Water Turbulent Flow Heat Exchanger

This is a highly advanced concentric tube heat exchanger with hot water flowing through the central tube while cooling water flows through the annular space.

The heat exchanger has been divided into three equal sections in order to allow examination of the intermediate stream temperature conditions and temperature distribution through the heat exchanger.

Thermocouples sense the hot and cold stream temperatures at the four stations **and the inner tube wall temperatures on entry and exit.**

The addition of the central tube surface temperatures at inlet and exit allow detailed investigation of the surface heat transfer coefficient inside and outside the central tube.

This allows advanced students to investigate the Nusselt, Reynolds, Prandtl relationship
$Nu = k\ Re^a\ Pr^b$.

The core tube temperatures also allow students to plot hot stream, cold stream and core tube temperatures for both con-current and counter-current flow.
The unit incorporates an extended range flowmeter in order to allow investigation of low and high range Reynolds numbers.

The PID temperature control on the H102 Heat Exchanger Service Unit allows investigation of turbulent flow conditions at a range of fixed Prandtl numbers.

Investigations using these two methods of control allow students to experimentally determine the constants in one of the classic empirical equations for turbulent heat transfer in a tube.

$$Nu = 0.023\ Re^{0.8}\ Pr^{0.4}$$

Experimental Capabilities

- Determination of heat transfer rate, logarithmic mean temperature difference, overall heat transfer coefficient and 4 point hot and cold stream temperature profiles.

- Determination of surface heat transfer coefficient inside and outside the tube, and of the effect of fluid velocity.
- Comparison of performance in concurrent and in counter-current flow.

- Investigation of the relationship between Nusselt (Nu), Reynolds (Re) and Prandtl (Pr) Numbers for Reynolds Numbers up to 65000 and for Prandtl Numbers between 2.5 and 5.0.

- Determination of the constants in $Nu = k\ Re^a\ Pr^b$.

Optional Extra H102H

Coiled Concentric Tube Heat Exchanger

An example of an industrial coiled concentric tube heat exchanger with turbulence enhancing tubes.

The heat exchanger is fully instrumented using the Heat Exchanger Service Un it H102 with thermocouples on the inlet and outlet of both the hot and cold streams.

The heat exchanger can be arranged so that either hot or cold streams are in the inner tube.
With either configuration both co-current and counter-current flow can be established.

The heat exchanger is deliberately not insulated so that heat losses in all of the configurations can be investigated.

Experimental Capabilities

- Demonstration of indirect heating or cooling by transfer of heat from one fluid stream to another when separated by a solid wall.

- Conducting an energy balance across a shell and tube exchanger and calculate the overall efficiency at different fluid flow rates

- To demonstrate the differences between counter-current flow and co-current flows and the effect on heat transfer, temperature efficiencies and temperature profiles through a shell and tube heat exchanger.

- To determine the overall heat transfer coefficient for a shell and tube heat exchanger using the logarithmic mean temperature difference to perform the calculations (for counter-current and co-current flows).

- To investigate the effect of changes in hot fluid and cold fluid flow rate on the temperature efficiencies and overall heat transfer coefficient.

- To investigate the effect of driving forces (difference between hot stream and cold stream temperature) with counter-current and co-current flow.

All of the above procedures may be undertaken with the hot fluid in the inner tube and cold fluid in the outer tube; or, with hot fluid in the outer tube and the cold flow in the inner tube.

Optional Extra H102J
Recycle Loops

Recycling can be used in many engineering applications and is important when applied to thermodynamic processes as it can result in reduced energy requirements.

For example in most air conditioning applications a proportion of the already treated air within a building will be recycled and mixed with fresh incoming air before being returned to the building.

If the proportion of recycling is too low then the energy requirement is likely to rise whereas if the proportion of recycled air is high then "sick building" syndrome can occur where bad smells and micro-biological problems can arise.

In chemical engineering processes where a reaction requires both time and temperature to be controlled recycling can be used to ensure a longer residence time for mixing and reactions to occur. In addition the energy requirement is vastly reduced from the alternative option of utilising a batch process.

Experimental Capabilities

- Investigation and Understanding Of The Recycle Process.
- Steady State Heat and Mass Balances
- Investigation of Responses to Changes in Bleed Flow Rate, Heat Input or Recycle Rate

Optional Extra H102K
Film & Dropwise Condensation

Vapour may condense onto a cooled surface in two distinct modes known as **filmwise** and **dropwise**. For the same temperature difference between the vapour and the surface, dropwise condensation is several more times effective than filmwise. However it involves special surface finishes or treatment in order to maintain dropwise condensation and for this reason, though desirable, it seldom occurs in real plant operation.
The process of dropwise condensation is enhanced by the special water cooled condenser surface finish that prevents wetting of the surface. Condensation then occurs in droplets which grow and fall under gravity. These falling droplets wipe the surface clean ready for more droplets to form. This continuous cleaning puts the water cooled surface in direct contact with the vapour.
The duplicate filmwise condenser is not specially treated and allows condensation to form as a film. This effectively grows and runs down the condenser gaining thickness as it falls. The film effectively acts as a resistance to heat transfer, as heat must be conducted through this film to the internal cooling water.

Thermocouples are fitted to the surfaces of both condensers allowing the direct comparison of surface temperatures in both filmwise and dropwise condensation. The H102 standard instrumentation allows heat transfer rates and surface heat transfer coefficients from both condensers to be compared.

Experimental Capabilities

- Visual observation of filmwise and dropwise condensation and .nucleate boiling.
- Measurement of heat flux and surface heat transfer coefficient in both filmwise and dropwise condensation at pressures up to atmospheric.
- Investigation of the saturation pressure/temperature relationship for water between ambient temperature (20-30°C) and 100°C.
- Demonstration and investigation of the effect of air in condensers.
- Demonstration of Dalton's law.

Optional Extra HC103A

Data Acquisition Upgrade

Hardware details

The Optional Computerised Data Acquisition Upgrade HC103A consists of a 21 channel Hilton Data logger (D103), together with pre-configured, ready to use, Windows™ compatible educational software.

Factory fitted coupling points on the H102 allow installation of the upgrade to the unit at any time in the machine's extensive life.

The Hilton Data logger (D103) connects, using the cable supplied, to a standard USB port on the user-supplied PC. If more than one logger is required connection is via a second USB port or standard USB hub.

The combined educational software and hardware package allows immediate computer monitoring and display of all relevant parameters on the H102.

Software Details

The pre-configured menu driven Software supplied with the Computer Upgrade HC103A allows all recommended experiments involving the electronic transducers and instruments on the H102 to be carried out with the aid of computerised data acquisition, data storage and on-screen data presentation. This enhances student interest and speeds comprehension of the principles being demonstrated.

Students are presented with either raw data for later hand calculation or alternatively data may be transferred to most spreadsheets for computerised calculation and graphical presentation.

Data may be stored on disc and displayed at any time using the software supplied. Alternatively data may be transferred to any compatible spreadsheet together with individual time and date stamp on each reading for complex analysis.

Additional Data Logging Facility Supplied As Standard

The D103 is the third generation of Hilton Data Logger. It comprises an industrially proven 21 channel interface with 8 thermocouples (type T and K as standard) / differential voltage inputs (±100mv DC), 8 single ended DC voltage inputs (±8v), 4 logic or frequency inputs and one mains voltage input. In addition there are on board 12v DC, ±5V DC and ±15v DC power supplies for most commercially available transducers.

The Hilton Data Logging software supplied as standard with the HC103A package allows the D103 to be disconnected from the H102 and used together with most standard transducers as a stand-alone computer data logger for the instrumentation and monitoring of existing laboratory equipment using locally sourced industrial transducers. The software is also backwards compatible with our many second generation D102 data loggers that are already in use worldwide.

Full data logger command protocol and communications details are provided in an extensive user manual that allows other software applications to communicate with the logger via the USB interface. Users can write their own software, typically in LabView, Matlab, C, C++, Visual Basic etc. This further expands the student project capabilities of the HC103A package from teaching and demonstration into the field of research and postgraduate study.

Computer Hardware Requirements

The menu driven Software supplied with the Computer Upgrade HC103A will operate on a PC which has at least 0.5Gb Mb ram, VGA graphics, 1Gb hard drive, CD drive and an available USB port. The software is Windows 2000, XP and 7 compatible.

Ordering Information

Order as: Data Acquisition Upgrade HC103A

P.A.HILTON Ltd.

Horsebridge Mill, King's Somborne,
Stockbridge, Hampshire, SO20 6PX, England.

Telephone: National (01794) 388382
International +44 1794 388382

Fax: National (01794) 388129
International +44 1794 388129

E-mail: **sales@p-a-hilton.co.uk**
Website: www.p-a-hilton.co.uk

SCAN ME WITH A SMARTPHONE