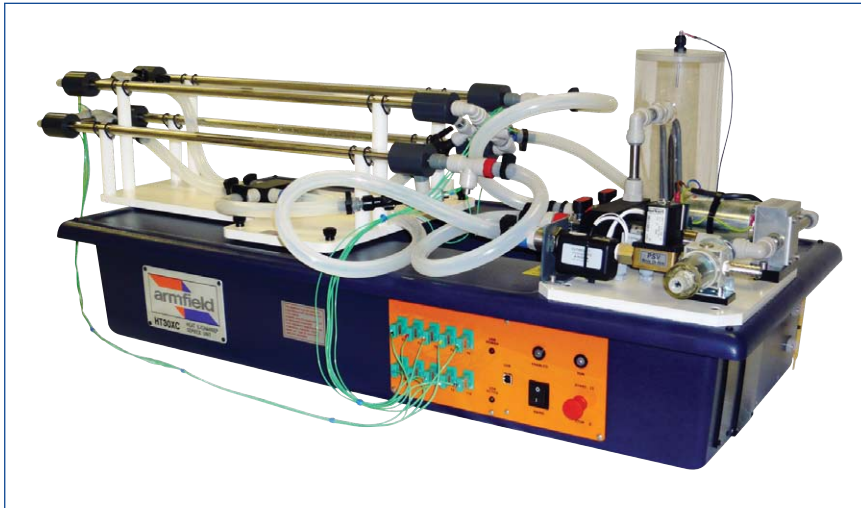




# armfield

## COMPUTER CONTROLLED HEAT EXCHANGER SERVICE MODULE



**HT30XC series**  
issue 2

HT30XC Service Unit fitted with HT36 Tubular Heat Exchanger

*A range of small scale heat exchangers, designed to illustrate the principles and techniques of indirect heat transfer between fluid streams. Different types of heat exchanger can be mounted on a common bench-top service unit. Small scale versions of commonly used industrial heat exchangers are available (including plate, tubular and 'shell and tube') for analysis and comparison. The equipment is controlled by a user supplied personal computer, which serves as the operator interface. Full data logging, control and educational software is supplied with the equipment. In addition, the equipment has been fitted with failsafe systems, including a watchdog circuit, which allows for safe operation from a remote computer.*

### KEY FEATURES

- *Small scale, bench top equipment*
- *Fast response times allow in depth investigations in a short time*
- *Representative of industrial heat exchangers*
- *Multiple, industrially representative heat exchangers available*
- *All functions computer controlled, including reversing of one of the fluid streams for co-current and counter-current investigations*
- *Standard USB interface*
- *Safety functions implemented to allow for remote operation by computer*
- *Full educational software with data logging, control, graph plotting, and detailed 'Help'*
- *Suitable for project work. The service bench provides facilities for evaluating in-house heat exchanger designs*

## HT30XC Service Unit



### DESCRIPTION

*The HT30XC is a service unit, to allow the operation of one of the Armfield range of small scale heat exchanger systems. It provides controlled cold water flow, bi-directional hot water flow and the instrumentation required to do a series of in-depth investigations into heat exchanger performance. The individual heat exchangers can be quickly changed over, to allow comparisons between different types of heat exchanger to be made.*

*The HT30XC requires a user supplied personal computer for the operator interface. The interface to this computer is USB, allowing for simple interfacing and setting up. Once the appropriate heat exchanger has been installed and setup, all other functions can be performed under computer control. Appropriate measures have been implemented so that in the case of computer failure or communications breakdown, the system shuts itself down in a safe manner.*

### Hardware Description

*The service unit provides two fluid streams to the heat exchanger, a hot water stream and a cold water stream. The hot water stream is heated in a vessel fitted with an electric heater. The heater is switched on and off by a solid state relay (SSR) which is under software control. A thermostat limits the maximum water temperature to 75°C for operator safety.*

*A gear pump circulates water from the vessel, through the heat exchanger and back into the heater vessel. Both the pump speed and direction are under software control, allowing for co-current and counter-current investigations over a wide range of flow rates.*

*The cold water stream is generated from a mains water supply. The flow through the heat exchanger is adjusted by a variable flow valve, again under software control. A manually adjustable pressure regulator is used to minimise the effect of mains pressure fluctuations.*

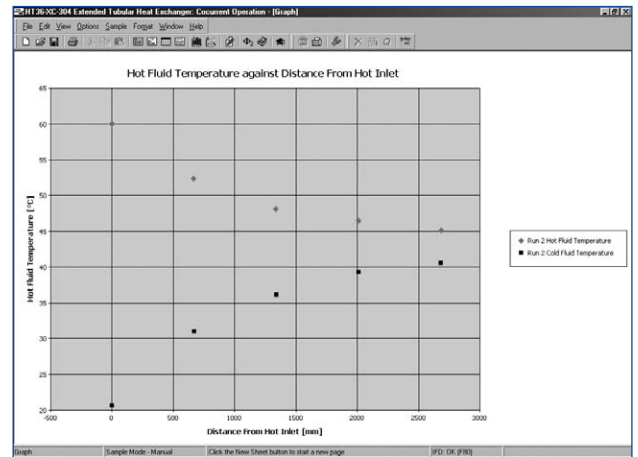
*Conditioning circuits for up to 10 K-type thermocouples are included, (the thermocouples themselves are supplied with the heat exchangers). The instrumentation also includes flowmeters to measure the flow rates of the two fluid streams.*

*Switching on the unit puts it into 'Standby' mode. From this mode it is necessary for a regular series of pulses to be received from the software (via the built in USB interface) to fully power up the unit. This ensures that unless the control software is running, the heaters, the pump and the cold water control valve cannot be switched on. The unit also includes an emergency stop switch. All electrical circuits are located in a bench mounted ABS supporting base, and protected by a Residual Current Device for operator safety. The ABS base includes a drip tray and drain tap in case of water spillage or leakage.*

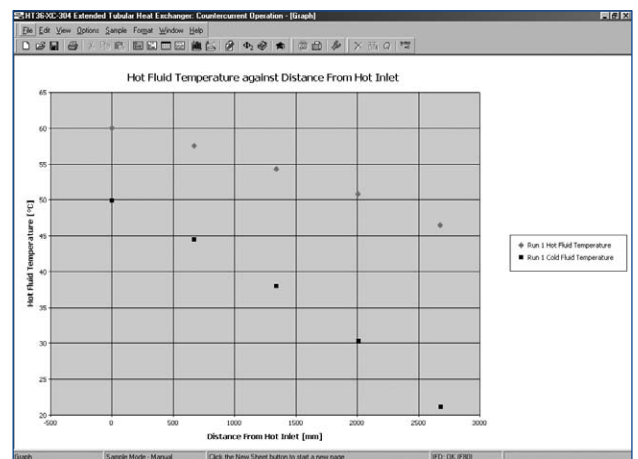
## Software Description

Full educational software is provided with the HT30XC for all the Armfield heat exchangers. Separate programs are provided for each exchanger, and each program contains a selection of separate exercises that can be performed. The actual details are exercise specific, but typically the following interfaces are available:

- All the temperatures and flow rates are displayed on a diagrammatic representation of the equipment.
- A software 'button' switches the equipment from 'standby' mode to fully on.
- The cold water flow control valve is operated by using up/down arrows or typing in a value between 0 and 100%. The actual flow rate can be read directly in L/min.
- The hot water flow rate is set by entering a required set point into a PID control function. This use of PID control ensures the flow is stable despite changes in the viscosity of the water due to heating.
- The heater is again controlled in a PID loop, by setting a required temperature set point.
- Data from the sensors is logged into a spreadsheet format, under operator control.
- Sophisticated graph plotting facilities are provided. Comparisons between data taken on different runs can be displayed.
- Student questions and answers, including a layered 'Hint' facility.
- Processing of measured values to obtain calculated values (this can be linked to the questions and answers to ensure student understanding).
- The data samples (measured and calculated) can be saved, or exported directly in Microsoft Excel format.
- Data from the sensors can be displayed



Typical co-current results from HT36



Typical counter-current results from HT36

independently from the data logging. This can be in bar graph format, or a recent history graphical display (useful to check for temperature stability prior to taking a sample).

- Presentation screens are available, giving an overview of the software, the equipment, the procedure and the associated theory. This is backed up by a detailed 'Help' facility giving in-depth guidance and background information.

## ARMSOFT Armfield software

For further details of the comprehensive capabilities of Armfield software please visit: [www.armfield.co.uk/armsoft\\_datasheet.html](http://www.armfield.co.uk/armsoft_datasheet.html)

## User Defined Software and/or Remote Operation

Included separately on the software CD are the 'drivers' required to allow other software applications to communicate with the HT30XC via the USB interface. This allows users to write their own software instead of using the Armfield provided software. This software can be written in many different systems. Typically LabView, MatLab, 'C', 'C++', Visual Basic, Delphi, and any other software environment which allows calls to external drivers can be used.

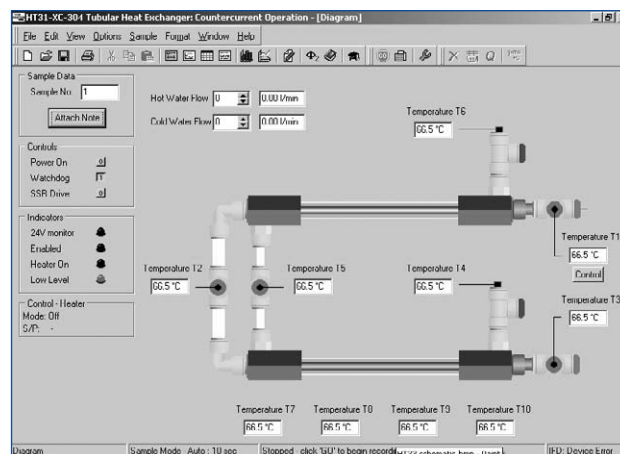
In this way the user can write software to suit their specific requirements, in an environment which they are fully familiar with and which is compatible with their other equipment.

An extension of this methodology allows the equipment to be operated remotely, such as over a Local Area Network (LAN) or even over the internet. The HT30XC is ideal for this remote operation as it has been designed to ensure that the unit shuts down safely in the event of a communications failure. It has also been designed so that once the heat exchanger has been installed and configured, all the controls to perform a series of investigations are under software control, and so the student does not need to be present with the equipment.

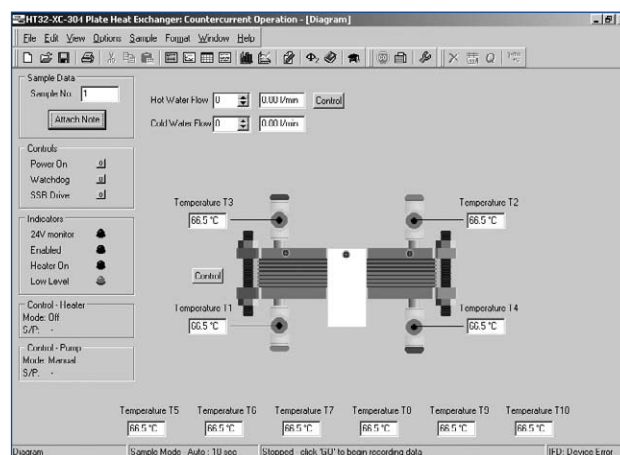
In a typical installation, the HT30XC would be connected to a local PC via the USB bus. The local PC would be connected to the users' PC's via a LAN (Local Area Network). The operator interface software would be run on the remote (users) PC and communicate to the control software on the local PC. (Armfield do not provide the software to implement this type of system).

For remote use, the appropriate heat exchanger would be installed onto the service unit, and the cold water pressure regulator adjusted to match the heat exchanger to the cold water supply. The unit is then switched on and remains in 'Standby' mode until appropriate software is run requesting the unit to power up fully. With the HT31, HT32 and HT33, Heat Exchangers, all functions can then be operated remotely.

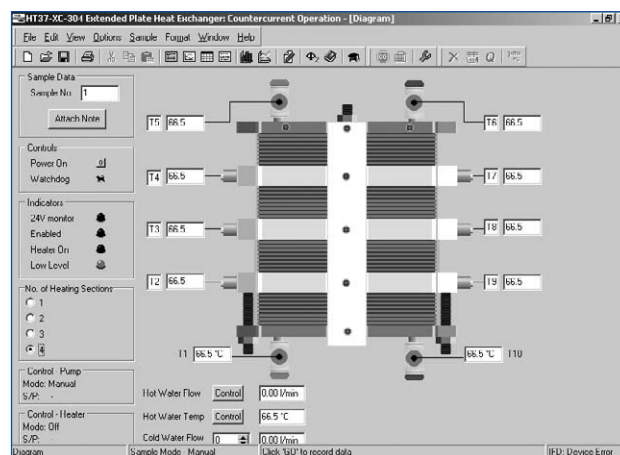
The HT34, HT36 and HT37 Heat Exchangers can be configured in different ways, and so the required configuration has to be manually implemented locally. However once this has been done, a full set of investigations can be performed for that configuration, including co-current and counter-current flows.



Mimic diagram of HT31



Mimic diagram of HT32



Mimic diagram of HT33

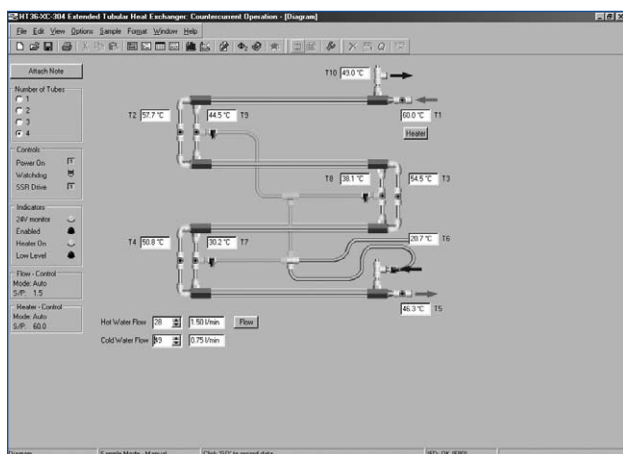


## HEAT EXCHANGER OPTIONS



HT36 connections

A wide selection of heat exchanger options are available for use with the HT30XC, ranging from simple exchangers to demonstrate co-current and counter-current flow, to reconfigurable systems with interim temperature measurements, capable of being used for in-depth heat exchanger analysis. The heat exchangers are easily interchanged, with quick release fittings on the flexible interconnecting tubes, and a simple location system using thumbscrews to secure the exchangers onto the service unit.



Mimic diagram of HT36

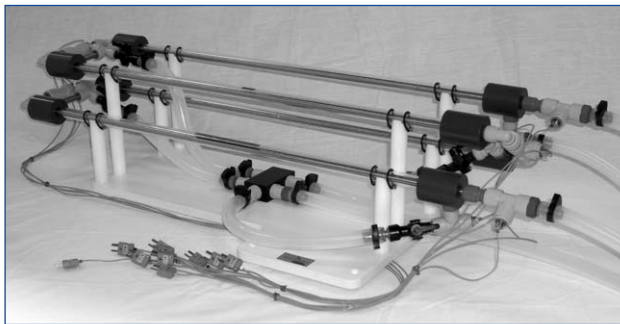
## INSTRUCTIONAL CAPABILITY

*Training exercises which are common to each of the heat exchangers when used with the HT30XC:*

- Demonstration of indirect heating/cooling by transfer of heat from one fluid stream to another when separated by a solid wall.
- Energy balance determination (heat balance) and calculation of efficiencies by measuring the flow rates and temperature changes in the hot and cold fluid streams.
- Introduction to different types of heat exchanger and comparison of the differences in operation and performance.
- Using the Logarithmic Mean Temperature Difference (LMTD) in heat transfer calculations.
- Definition and measurement of Overall Heat Transfer Coefficient (U).
- Demonstration of the differences between counter-current and co-current operation, (not relevant for some HT34 configurations).
- Demonstration of the transition from linear to turbulent flow.
- Effect of hot and cold fluid flow rate on the heat transfer coefficient.
- Effect of driving force (temperature differential) on the heat transfer coefficient.
- Investigation of heat loss and reduction in heat transfer coefficient due to fouling of the heat transfer surfaces (suitable student project using user induced fouling).

**Additional training exercises using the HT36 Extended Tubular Heat Exchanger:**

- Demonstration of temperature overlaps between fluid streams in countercurrent operation.
- Temperature profiles along the effective length of the heat exchanger in both counter-current and co-current operation
- Comparing the effect of different heat transfer areas.



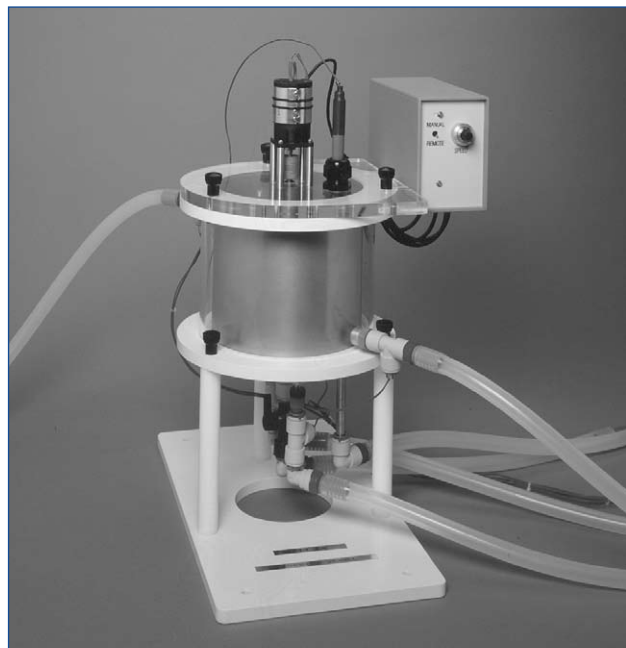
**Additional training exercises using the HT37 Extended Reconfigurable Plate Heat Exchanger:**

- Temperature profiles along the effective length of the heat exchanger in both counter-current and co-current operation.
- Demonstration of temperature overlaps between fluid streams in counter-current operation.
- Use of LMTD correction factor when calculating the Overall Heat Transfer Coefficient.
- Comparing the effect of different heat transfer areas.
- The use of a regeneration stage for energy efficiency, when heating and subsequently cooling a product stream.
- Project work to implement a wide variety of plate configurations, giving series, parallel and combined fluid passes.



**Additional training exercises using the HT34 Jacketed Vessel:**

- Introduction to heat exchange in a batch or continuously fed stirred vessel and comparison of the differences in operation and performance when using a heating jacket or heating coil.
- Effects of stirring and vessel contents (volume) on the heat transfer characteristics.



**Additional training exercises using a user provided heat exchanger:**

- Any of the above exercises can be performed, where appropriate, using a user provided heat exchanger having appropriate characteristics, dimensions and fittings. The service unit will support evaluation of experimental heat exchangers constructed as design exercises by students.

## ORDERING SPECIFICATION - HT30XC

- *A lightweight bench top service unit, designed to accommodate a range of different small scale heat exchangers.*
- *Comprises hot water vessel, hot water recirculation pump, cold water control system, computer interface and all necessary instrumentation.*
- *The hot water vessel is made from clear acrylic (for visibility) and includes a 2kW heater with thermostatic over-temperature cut-out and low water level detection.*
- *The hot water pump is bi-directional (to allow co-current and counter-current investigations without re-configuring the hardware) and the flow rate is under computer control.*
- *The cold water system includes a manually adjustable pressure regulator and a flow control valve which is under computer control.*
- *Flow rates for both fluid streams in excess of 5L/min are achievable, but this may be restricted by some designs of heat exchanger (e.g. HT32 & HT36 Plate Heat Exchangers).*
- *Up to 10 temperatures (K-type thermocouples) can be monitored using the service unit. Operating range, 0-75°C, resolution 0.1°C.*
- *Two flow meters are included. Operating range 0.2 to 9 L/min, resolution 0.1 L/min.*
- *All data is available to a (user supplied) Windows PC, via a USB interface. This computer is also used to control the flow rates, hot water temperature, and hot water direction.*
- *Full software for educational use is included.*
- *Ability for users to write and use their own software (Eg. Labview).*
- *Includes failsafe hardware facilities for remote operation, Eg. over the internet, when used with the customers software.*
- *A comprehensive instruction manual is included.*

## SERVICES REQUIRED

*Single phase electricity supply:*

*HT30XC-A: 230V, 50Hz, 10Amp*

*HT30XC-B: 115V, 60Hz, 20Amp*

*HT30XC-G: 230V, 60Hz, 10Amp*

*Cold water supply and drain:*

*5 Litres/minute at 1bar Gauge (min)*

## OVERALL DIMENSIONS

*Height: 0.45m (service unit only)*

*Width: 1.0m*

*Depth: 0.5m*

## SHIPPING SPECIFICATION

*Volume: 0.33m<sup>3</sup>*

*Gross Weight: 33kg*

## ESSENTIAL/OPTIONAL EQUIPMENT

*The user must have access to a PC with a free USB port, running Windows 98, or later.*

*At least one heat exchanger module is required, additional heat exchangers are optional.*

## HT31/HT36 TUBULAR HEAT EXCHANGERS

### HT31 - Tubular Heat Exchanger

### HT36 - Extended Tubular Heat Exchanger

The tubular heat exchanger is the simplest form of heat exchanger and consists of two concentric (coaxial) tubes carrying the hot and cold fluids. In these miniature versions the tubes are separated into sections to reduce the overall length and to allow the temperature at points along both fluid streams to be measured.

Two versions are available, the HT31 is a basic version with two sections and a single interim temperature measurement point. The HT36 is a more sophisticated unit with four longer tube sections, giving four times the overall heat transfer area and three interim temperature measurement points in each fluid stream.

The HT36 has sufficient heat transfer area to demonstrate the classic counter current flow conditions where the outlet of the heated stream is hotter than the outlet of the cooled stream.

### TECHNICAL DESCRIPTION

On both heat exchangers the inner tube is used for the hot fluid and the outer annulus for cold fluid. This minimises heat loss from the exchanger without the need for additional insulation. The inner tubes are constructed from stainless steel and the outer annulus from clear acrylic, providing visualisation of the heat exchanger construction and minimising thermal losses. The tubes can be dismantled for cleaning.

### ORDERING SPECIFICATIONS

- A small scale Tubular Heat Exchanger system for use with an Armfield Heat Exchange Service Unit to teach the fundamental concepts of heat exchangers.
- Comprises a number of sections of concentric tubes, the outer section constructed from clear acrylic for visibility and the inner tube from stainless steel.
- The tubes are easily dismantled for cleaning.
- A comprehensive instruction manual is included.

### ESSENTIAL ARMFIELD ACCESSORIES

HT36 requires the Armfield HT30XC, Computer Controlled Heat Exchanger Service Unit.

HT31 can be used with either the HT30XC or the HT30X Heat Exchanger Service Unit.

### OVERALL DIMENSIONS

<b>HT31:</b>	<b>HT36:</b>
Height: 0.16m	Height: 0.2m
Width: 0.51m	Width: 0.95m
Depth: 0.39m	Depth: 0.4m

### SHIPPING SPECIFICATION

<b>HT31:</b>	<b>HT36:</b>
Volume: 0.05m <sup>3</sup>	Volume: 0.1m <sup>3</sup>
Gross weight: 4kg	Gross Weight: 10kg

	HT31	HT36
Temperature measurement points	<b>6 off:</b> <ul style="list-style-type: none"> <li>● Hot fluid inlet</li> <li>● Hot fluid mid-position</li> <li>● Hot fluid outlet</li> <li>● Cold fluid inlet</li> <li>● Cold fluid mid-position</li> <li>● Cold fluid outlet</li> </ul>	<b>10 off:</b> <ul style="list-style-type: none"> <li>● Hot fluid inlet</li> <li>● Hot fluid interim positions (3)</li> <li>● Hot fluid outlet</li> <li>● Cold fluid inlet</li> <li>● Cold fluid interim positions (3)</li> <li>● Cold fluid outlet</li> </ul>
Number of tube sections	2	4 (can also be configured for 1, 2 or 3 sections)
Heat transfer area	0.02m <sup>2</sup>	0.08m <sup>2</sup> max



## **HT32/HT37 PLATE HEAT EXCHANGERS**

### **HT32 - Plate Heat Exchanger**

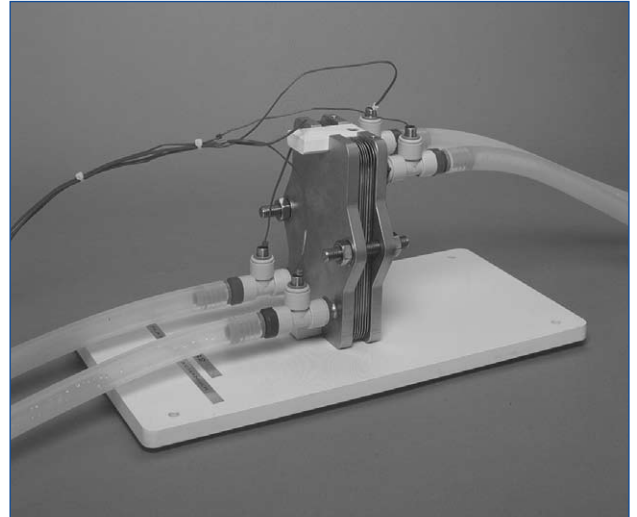
### **HT37 - Extended Reconfigurable Plate Heat Exchanger**

*The plate heat exchanger is extremely versatile and commonly used in the food and chemical processing industries where different combinations of plates and gaskets can be arranged to suit a particular application. The miniature exchanger supplied consists of a pack of plates with sealing gaskets held together in a frame between end plates. Hot and cold fluids flow between channels on alternate sides of the plates to promote heat transfer.*

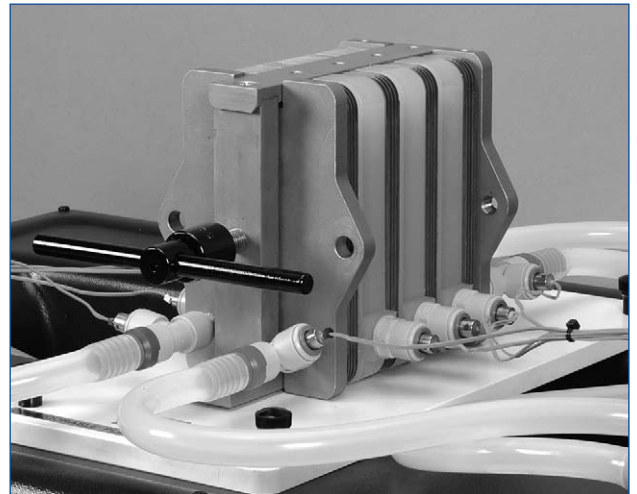
*The HT37 is designed to be reconfigurable by the student, and can accommodate up to four sections of heating, each section providing an additional temperature measurement point for each fluid stream. In order to make the unit easy to reconfigure, these sections are supplied as pre-assembled groups of plates complete with an intermediate plate (containing the temperature measurement points). Using the four heating sections provided, students can compare heat exchangers of different heat transfer area and different numbers of passes. A quick release clamp system allows the different arrangements to be changed quickly and easily without using tools.*

*Also supplied is a pre-assembled regeneration section to demonstrate this important energy efficient method of heating. The regeneration section can be used in conjunction with one, two or three of the standard heating sections in different configurations.*

*Plate heat exchangers can be implemented in a wide variety of configurations, with parallel passes, serial passes, or combinations of both. For more advanced investigations into these effects, (e.g. for project work) a further twelve loose plates are supplied with the HT37.*



HT32 Plate Heat Exchanger



HT37 with four heating sections installed

*These can be used in conjunction with the plates from the pre-assembled modules to investigate these other configurations.*

*The HT32 has a single heating section configured for multi-pass operation with passes in series. It comprises seven individual plates, which are clamped together using two stainless steel threaded bars and nuts. It is possible to dismantle and reassemble the heat exchanger using only three plates to demonstrate a single pass.*

## TECHNICAL DETAILS

The plates used in these heat exchangers have been specifically developed by Armfield for use in miniature heat exchanger systems. They are fabricated from 316 stainless steel, with a pressed chevron pattern to promote turbulence and provide multiple support points. Silicone rubber gaskets are used on each plate to seal the adjacent flow channels from each other.

### Plate details:

Plate overall dimensions: 75mm x 115mm

Effective diameter: 3.0mm

Plate thickness: 0.5mm

Wetted perimeter: 153.0mm

Projected heat transmission area: 0.008m<sup>2</sup> per plate

The plates are mounted in a frame incorporating fixed and moving end plates with connections for hot and cold fluids.

The exchangers are easily dismantled for inspection of the heat transfer surfaces.

## ORDERING SPECIFICATION

- A small scale plate heat exchanger system for use with an Armfield Heat Exchange Service Unit to teach the fundamental concepts of heat exchangers.
- Comprises a number of stainless steel plates, each with a pressed chevron pattern and a food grade silicon rubber sealing gasket, mounted in a frame.
- Easily dismantled for cleaning.
- A comprehensive instruction manual is included.

## ESSENTIAL ARMFIELD ACCESSORIES

HT37 requires the Armfield HT30XC, Computer Controlled Heat Exchanger Service Unit.

HT32 can be used with either the HT30XC or the HT30X Heat Exchanger Service Unit.

## OVERALL DIMENSIONS

<b>HT32:</b>	<b>HT37:</b>
Height: 0.17m	Height: 0.17m
Width: 0.18m	Width: 0.18m
Depth: 0.39m	Depth: 0.39m

## SHIPPING SPECIFICATION

<b>HT32:</b>	<b>HT37:</b>
Volume: 0.03m <sup>3</sup>	Volume: 0.03m <sup>3</sup>
Gross weight: 6kg	Gross Weight: 9.5kg

	HT32	HT37
Number of plates	7 (5 effective plates)	Reconfigurable up to 20 plates (12 effective plates)
Heat transfer area	0.04m <sup>2</sup>	0.096m <sup>2</sup> (max)
Heat exchanger configuration	Single heating stage	Configurable sections, with a separate regeneration section
Temperature measurement points	<b>4 off:</b> <ul style="list-style-type: none"><li>● Hot fluid inlet</li><li>● Hot fluid outlet</li><li>● Cold fluid inlet</li><li>● Cold fluid outlet</li></ul>	<b>Up to 10 off:</b> <ul style="list-style-type: none"><li>● Hot fluid inlet</li><li>● Hot fluid interim positions (up to 3)</li><li>● Hot fluid outlet</li><li>● Cold fluid inlet</li><li>● Cold fluid interim positions (up to 3)</li><li>● Cold fluid outlet</li></ul>
Clamping mechanism	Dual screw threads with nuts	Quick release, hand operated, no tools required
Project work		12 additional plates (supplied loose) give the option of exploring many different configurations

## HT33 - SHELL & TUBE HEAT EXCHANGER

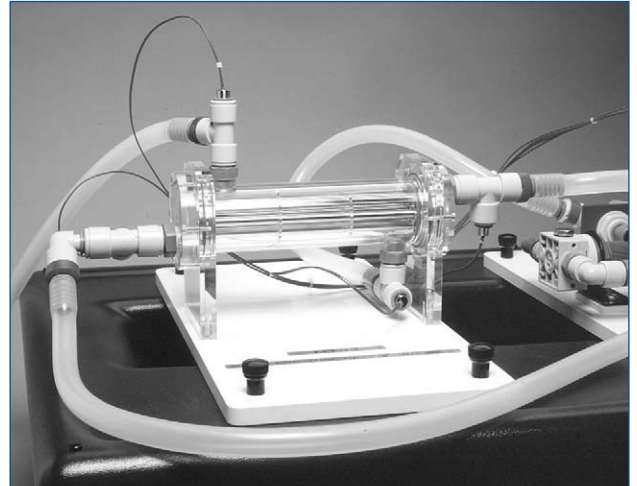
The shell and tube heat exchanger is commonly used in the food and chemical process industries. This type of exchanger consists of a number of tubes in parallel enclosed in a cylindrical shell. Heat is transferred between one fluid flowing through the tubes and another fluid flowing through the cylindrical shell around the tubes.

The miniature exchanger supplied is designed to demonstrate liquid to liquid heat transfer in a 1-7 shell and tube heat exchanger (one shell and 7 tubes with two transverse baffles in the shell).

### TECHNICAL DETAILS

The accessory consists of a miniature shell and tube heat exchanger with the following features:

- Hot fluid in the inner tubes and cold fluid in outer shell to minimise heat loss from the exchanger without the need for additional insulation.
- Seven stainless steel tubes, 6.35mm OD.
- The outer annulus, end caps and baffles constructed from clear acrylic to allow visualisation of the heat exchanger construction and minimise thermal losses.
- Nominal combined heat transfer area of 20,000mm<sup>2</sup>, (equivalent to that of the HT31 Tubular Heat Exchanger for direct comparison).
- Cold fluid (cold water) enters one end of the shell at the bottom and exits at the opposite end at the top having flowed over and under two transverse baffles inside the shell.
- Thermocouples are installed at the following 4 locations:
  - ☐ Hot fluid
  - ☐ Hot fluid outlet
  - ☐ Cold fluid inlet
  - ☐ Cold fluid



### ORDERING SPECIFICATION

- A miniature shell and tube heat exchanger for use with an Armfield Heat Exchanger Service Unit.
- Comprises an outer shell and 7 internal tubes. There are two transverse baffles inside the shell.
- Four temperature sensors are supplied in tappings at fluid inlets and outlets.
- The heat exchanger is constructed from stainless steel tube and clear acrylic. It is mounted on a PVC baseplate which is designed to be installed on the plinth of the Heat Exchanger Service Unit without the need for tools.
- The stainless steel tubes can be removed from the heat exchanger for cleaning.
- A comprehensive instruction manual is included.

### ESSENTIAL ARMFIELD ACCESSORIES

HT30XC or HT30X Heat Exchanger Service Unit.

### OVERALL DIMENSIONS

Height: 0.19m  
Width: 0.43m  
Depth: 0.39m

### SHIPPING SPECIFICATION

Volume: 0.06m<sup>3</sup>  
Gross Weight: 5kg

## HT34 - JACKETED VESSEL WITH COIL & STIRRER

Vessel Heating or cooling of a process liquid in a tank, either batchwise or with continuous product feed, is common practice throughout

industry. The characteristics of the heat transfer using an external jacket or internal coil can be demonstrated together with the effect of stirring the vessel contents.



### TECHNICAL DETAILS

The accessory consists of a jacketed vessel with the following features:

- The vessel consists of a stainless steel wall with PVC base and clear acrylic top. A glass outer jacket allows the wall of the vessel to be surrounded with hot fluid for indirect heating from the outside. Alternatively, a stainless steel coil inside the vessel allows the cold fluid contained within the vessel to be indirectly heated from inside.
- The vessel incorporates a variable speed stirrer and baffle arrangement to allow thorough mixing of the vessel contents when required.
- An adjustable overflow allows the volume of liquid inside the vessel to be varied with a maximum capacity of 2 litres and a minimum of 1 litre.

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- The vessel can be operated batchwise by simply filling to the overflow or with continuous feed of cold liquid to the base of the vessel, the excess liquid flowing from the overflow to drain.
- Thermocouples are installed at the following six locations:
  - Vessel contents (cold fluid)
  - Hot fluid inlet to jacket
  - Hot fluid outlet from jacket
  - Hot fluid inlet to coil
  - Hot fluid outlet from coil
  - Cold fluid inlet to vessel
- Quick release hot and cold fluid connections allow rapid connection to HT30X and conversion from heating jacket to heating coil.

### ORDERING SPECIFICATION

- Miniature jacketed vessel heat exchanger system for use with an Armfield Heat Exchanger Service unit
- Comprises processing vessel with outer jacket, inner coil, variable speed stirrer and baffle.
- K-Type thermocouples measure the vessel contents and the inlet and outlet temperature of both fluid streams (6 in total).
- The Heat Exchanger is designed to be installed on the service unit without the need for tools.
- A comprehensive instruction manual is included.

### ESSENTIAL ARMFIELD ACCESSORIES

HT30XC or HT30X Heat Exchanger  
Service Unit.

### OVERALL DIMENSIONS

Height: 0.40m

Width: 0.18m

Depth: 0.39m

### SHIPPING SPECIFICATION

Volume: 0.10m<sup>3</sup>

Gross Weight: 9kg

Specifications may change without notice.  
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