Refrigeration Laboratory Unit R715

Figure 1: R715

- ***Complete analysis of the Vapour-Compression Refrigeration/Heat Pump Cycle.***
- ***Adjustable evaporator load and condensing temperature.***
- ***Clear display of all parameters including Electrical Input, Refrigerant Flow, Water Flow, Motor Torque and Rotational Speed, Pressures & Temperatures.***
- ***Allows a complete refrigerant pressure-enthalpy cycle diagram to be drawn at all operating conditions.***
- ***Optional Computerised Data Acquisition Upgrade.***
- ***Two year warranty.***

Introduction

The vapour compression refrigeration cycle is used in many industrial, medical and domestic situations throughout the world. Air conditioning, food and medical preservation and transport all rely on the use of refrigeration plant. It is essential therefore that student engineers intending to design or utilise such plant are fully aware of the parameters affecting the performance of the vapour compression refrigeration cycle.

The Hilton Refrigeration Laboratory Unit R715 has been designed to allow students to fully investigate the performance of a vapour compression cycle under various conditions of evaporator load and condenser pressure. All of the relevant parameters are instrumented and the unit is completely safe for operation by students.

The unit forms an essential part of laboratory training for students studying:

- **Refrigeration**
- **Air Conditioning**
- **Building Services**
- **Mechanical Engineering**
- **Marine Engineering**
- **Plant and Process Engineering**
- **Food Processing**
- **Chemical Engineering.**

Experimental Capabilities

- Production of a vapour compression cycle diagram under various conditions.
- Production of an energy balance for the refrigerator.
- Investigation of the variation in refrigerator “duty” or cooling ability for various condensing temperatures.
- Investigation of the variation in refrigeration Coefficient of Performance for the various condensing temperatures.
- Investigation of the variation in Coefficient of Performance based on electrical, shaft and indicated power.
- Determination of the overall heat transfer coefficient for the condenser cooling coil.
- Investigation of the performance of the thermostatic expansion valve.
- Investigation of the heat delivered to the cooling water with variation in condensing temperature.
- Investigation of the Coefficient of Performance as a Heat Pump for various condensing temperatures.
- Investigation of power input based on electrical, shaft and indicated power.

Description

An attractive glass reinforced plastic panel houses a belt driven twin cylinder reciprocating compressor. This is driven by a trunnion-mounted electric motor connected to a spring balance. By measuring the motor torque and speed, the shaft power required to drive the compressor can be determined.

Refrigerant **R134a** vapour is drawn into the compressor from the evaporator mounted on the front of the panel. Work is done on the gas and its pressure and temperature are raised. This hot, high pressure gas discharges from the compressor and flows into the panel mounted water cooled condenser. A measured and controllable flow of cooling water passes through a coil sealed inside the condenser cylinder. The hot gas desuperheats and then condenses to a liquid on the surface of the cooling coil. The condensed liquid collects at the base of the cylinder where it is sub cooled and may be observed through a sight glass. This liquid then flows through a refrigerant filter/dryer and a variable area flowmeter to the thermostatic expansion valve. Here it passes through a controlled orifice, which allows its pressure to fall from that of the condenser to that of the evaporator.

The liquid immediately starts to boil and takes in heat to accomplish this at low temperature. In order to allow control and measurement of the heat input at the evaporator, two electric heater elements are used. These are located inside the copper tube carrying the low temperatures liquid/vapour mixture from the expansion valve. The voltage across the heater elements may be varied from zero to that of the

mains supply voltage by adjustment of a voltage controller situated on the front panel. Measurement of the power is carried out by a panel mounted digital wattmeter. A change over switch allows the electrical power input to the motor to be measured.

The sensing bulb of the thermostatic expansion valve is mounted on the exit pipe from the evaporator and this detects the degree of superheat of the gas leaving the evaporator and entering the compressor. If the superheat is low the valve will close and reduce the flow and if too high the reverse will occur. By this means stability is maintained under all conditions of operation.

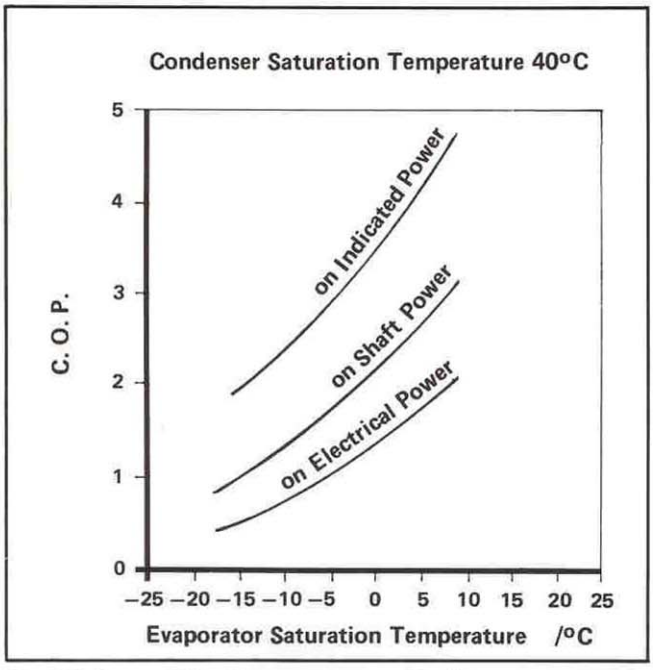
A panel mounted digital temperature indicator allows measurement of all the relevant system temperatures and a digital tachometer indicates the rotational speed of the compressor. Individual pressure gauges indicates the pressure in the condenser and evaporator.

Optional Data Acquisition Upgrade
An optional computerised data acquisition upgrade RC716A is available to enable all relevant system parameters to be automatically recorded on a PC for further analysis and display. Data may also be transferred to spreadsheet format for complex analysis and calculation. This upgrade can be factory fitted prior to delivery or supplied later as a user installed upgrade.

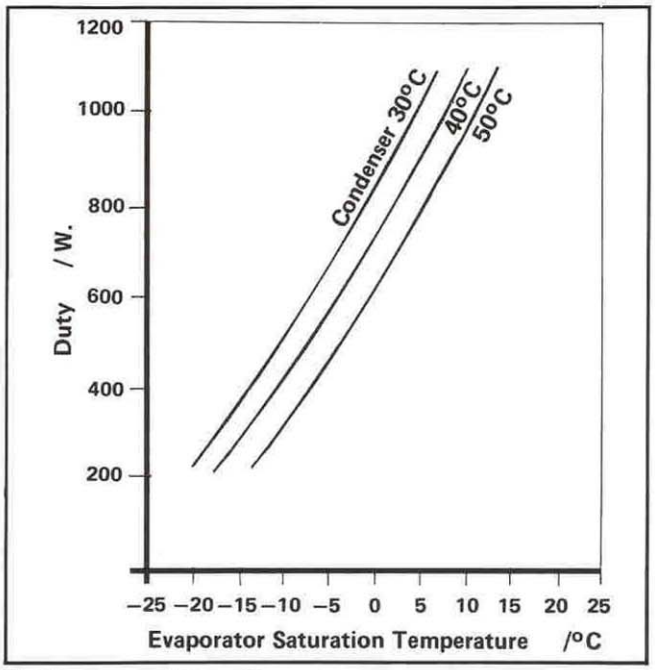
Operation

The Refrigeration Laboratory Unit has three controls. Firstly a combined miniature circuit breaker and switch turns on both the compressor motor and the supply to the electrically heated evaporator. A combined variable area water flowmeter and valve allow control of the condenser pressure. A panel mounted voltage controller allows control of the evaporator load from zero to full power of approximately 1500 Watts. Combined operation of the voltage controller and condenser cooling water flow allows control of the unit over a large range of conditions.

Experimental Results



Coefficient of Performance as a Refrigerator
(Based on Electrical, Shaft & Indicated Power)



Refrigerator "Duty"
(i.e Cooling Ability)

Specification

General

A fully instrumented refrigerant R134a vapour compression refrigerator with belt driven compressor, electrically heated evaporator, thermostatic expansion valve and water cooled condenser. Operating parameters can be varied by adjustment of condenser cooling water flow and electrically heated evaporator supply voltage.

Components have a low thermal mass resulting in immediate response to control variations and rapid stabilisation.

Instrumentation includes all relevant temperatures, condenser pressure, evaporator pressure, refrigerant and cooling water flow rates, evaporator and motor power, motor torque and compressor speed.

Detailed

Panel: High quality glass reinforced plastic on which the following components are mounted.
Refrigerant: R134a
Digital Thermometer: 6 way type K indicator with 0.1ºC resolution.
Wattmeter: Allows measurement of the power input to either evaporator or motor.
Voltage Controller: To vary evaporator load.
Variable Area Flowmeters: (2) Variable area types to indicator R134a and H_20 flow rates.
Pressure Gauges: (2) to indicate R134a pressure in evaporator and condenser.
Spring Balance and Tachometer: Together allow measurement of power required to drive the compressor.
Expansion Valve: Thermostatically controlled type.
Evaporator: Electrically heated device.
Compressor: (Internally mounted) Twin cylinder belt driven unit.
Safety: Condenser pressure and evaporator heater temperature limited by automatic cutouts. All electrical components connected to common earth. Unit protected by miniature circuit breaker and residual current circuit breaker.

Dimensions

Height: 92cm Depth: 48.5cm
Width: 106cm Weight: 93kg

Optional Data Acquisition Upgrade

An optional Data Acquisition Upgrade RC716A comprising of an electronic data logger, menu driven software and all necessary transducers, allows all relevant parameters to be simultaneously displayed and recorded on a suitable PC. The software allows review and printing of data and transfer to spreadsheets for complex analysis and calculation.

Accessories and Spares

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

Services Required

Electrical: A: 2.5Kw 220-240 Volts, Single Phase 50Hz (With earth/ground).

B: 2.5kW 110-120 Volts, Single Phase, 60Hz (With earth/ground).

C 2.5kW 220 Volts, Two Phases, 50/60Hz (With earth/ground).

Water: 3 litres/min at 24m head

Ordering Information

Order as: R715 Refrigeration Laboratory Unit.
Optional : RC716A Data Acquisition Upgrade.

Electrical Specification

Either: **A**: 2.5Kw 220-240 Volts, Single Phase 50Hz (With earth/ground

B: 2.5kW 110-120 Volts, Single Phase, 60Hz (With earth/ground).

C: 2.5kW 220 Volts, Two Phases, 50/60Hz (With earth/ground).

Language

Either: English, Spanish or French.

Shipping Specifications

Net Weight: 93kg. (approx.)
Approximate Gross Weight: 151kg. (approx.)
Packing Case Dimensions: 122 x 65 x 122 cm (approx.)
Packing Case Volume: 1.00 m^3 (approx.)

Also Available On Request

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

Optional Extra RC716A
Data Acquisition Upgrade

Hardware details
The Optional Computerised Data Acquisition Upgrade RC716A consists of a 21 channel Hilton Data logger (D103), together with pre-configured, ready to use, Windows TM compatible educational software.

Factory fitted coupling points on the R715 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 R715.

Software Details
The pre-configured menu driven Software supplied with the Computer Upgrade RC716A allows all recommended experiments involving the electronic transducers and instruments on the R715 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 RC716A package allows the D103 to be disconnected from the R715 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 R715A package from teaching and demonstration into the field of research and postgraduate study.

***New for 2013:* p-h software also available. Contact a sales representative for more details**

Computer Hardware Requirements
The menu driven Software supplied with the Computer Upgrade RC716A 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 RC716A

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

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P.A.HILTON Ltd.