HPRATE
V5.1

AIR CONDITIONER PERFORMANCE RATING

by

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Version 5.1

HPRATE

AIR CONDITIONER PERFORMANCE EVALUATION

INSTALLATION

The *HPRATE* simulation program is a design and rating tool for assessing air conditioner performance.

COMPUTER REQUIREMENTS

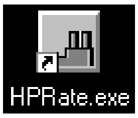
IBM compatible PC.

SOFTWARE INSTALLATION FROM CD

1. Run the program *setup.exe*
2. Copy the file *license.dat* into the directory where you installed *HPRATE*

SETUP A DESK TOP ICON FOR *HPRATE*.

Press the right mouse button when pointing at the windows desk top
select new
select shortcut
select browse
locate the file *HPRATE.EXE*
select open

An icon 

will be placed on the windows desk top

START THE PROGRAM

Double click on the desk top Icon

or

Use Windows Explorer to locate and start *HPRATE.EXE*

CHANGES IN HPRATE VERSION 5

The following changes have been between V4 and V5

- Modelling extended to cover 17 refrigerants

R114	
R12	
R123	
R124	
R125	
R134a	
R143a	
R143a/R125 (50/50)	(R507, AZ50)
R143a/R125 (55/45)	
R143a/R125/R134a (52/44/4)	
R152a	
R22	
R290	(Propane)
R32	
R32/R125 (50/50)	(R410A, AZ20)
R32/R125 (60/40)	
R502	

- Modelling of capillary tubes and TX valves now includes refrigerant mass balance rather than specified conditions.

- Improved heat transfer correlations

BACKWARD COMPATIBILITY

HPRATE5 will read project files created on HPRATE4.

INTRODUCTION

The *HPRATE* simulation package is a graphical interface to the ORNL MkV heat pump model[1]. The program predicts the steady state performance of electrically driven, vapour compression, air-air heat pumps in both heating and cooling modes. The air conditioner performance is evaluated from specified air-on conditions, measured compressor characteristics, measured or default refrigerant circuit operating conditions and physical description of the coils and refrigerant circuit. The features of the model adopted within the *HPRATE* graphical front end allow the user to specify:

System operating conditions

- Indoor and outdoor air wet bulb temperature and dry bulb temperature.
- The arrangement of the compressor and fans relative to the air flow stream.

Compressor characteristics

- Test data for capacity and power consumption for four condenser temperatures and four evaporator temperatures.

Refrigerant flow control devices

- Measured refrigerant super-heat at the compressor inlet and sub-cooling at the condenser exit,

or AS3823.3 default conditions.

- Capillary tube including refrigerant mass balance
- TX valve including refrigerant mass balance

Fin and tube heat exchangers

- Tube size, spacing, number of rows and parallel circuits.
- Fin pitch, thickness, material and type of fin (smooth, wavy or louvred).
- Air flow rates.

Refrigerants

- 17 refrigerants.

Refrigerant lines

- Lengths and diameters of interconnecting pipes.
- Measured pressure drops in pipes and coils or AS3823.3 default conditions.
- Heat losses from suction, discharge and liquid lines.

The output from *HPRATE* includes

- Capacity and EER or COP.
- Compressor power consumption.
- Output dry bulb air temperatures and wet bulb air temperatures.
- Refrigerant states throughout the cycle.
- Sensible and latent cooling capacities
- Heating capacity.

[1] Oak Ridge National Laboratory, Oak Ridge Tennessee USA 37831

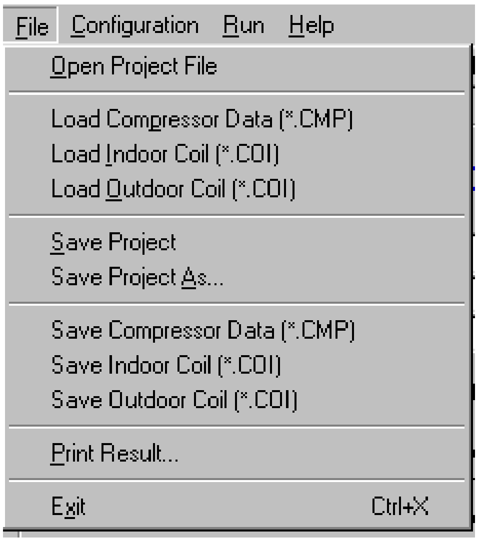
PROGRAM OPERATION

The parameters required for the rating analysis are entered into the six data screens

The program is controlled through four menus

FILE MENU

The File menu is used for saving and loading data files for components or project files

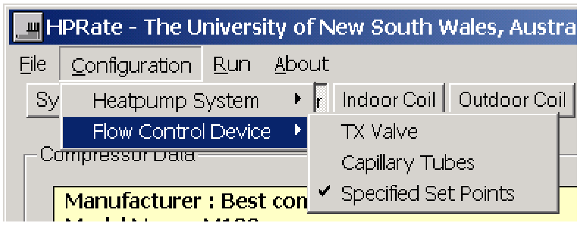


A project file is a complete description of the air conditioning system.
As well as project files the data for individual components (compressor and coils) can be saved and loaded separately. If component files are saved (compressor files and coil files) a system description can be built by loading the data files for the required components in the system.

CONFIGURATION MENU

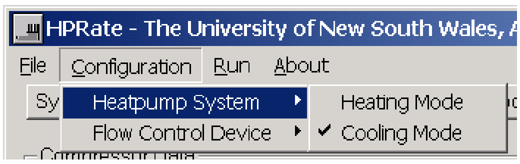
The ***Configuration*** menu is used to select between cooling/heating operation modes.

The refrigerant ***Flow control*** option allows for specification of the superheat and sub-cooling temperature differences (measured or default AS3823 conditions) or specification of the capillary tube characteristics.



NOTE: When the configuration modes are changed the optional parameters (pipe line pressure drop and heat loss from the piping) are reset to the default values. The configuration should thus be selected before data is entered in the menus.

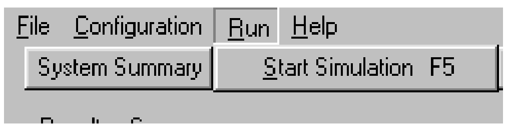
The heating / cooling mode is also selected under the configuration menu



NOTE: The heating/cooling mode should be selected before non-default values are entered for pressure drop, set points or line heat loss. If the heating/cooling mode is changed after entering non-default data then the data will reset to default conditions

RUN MENU

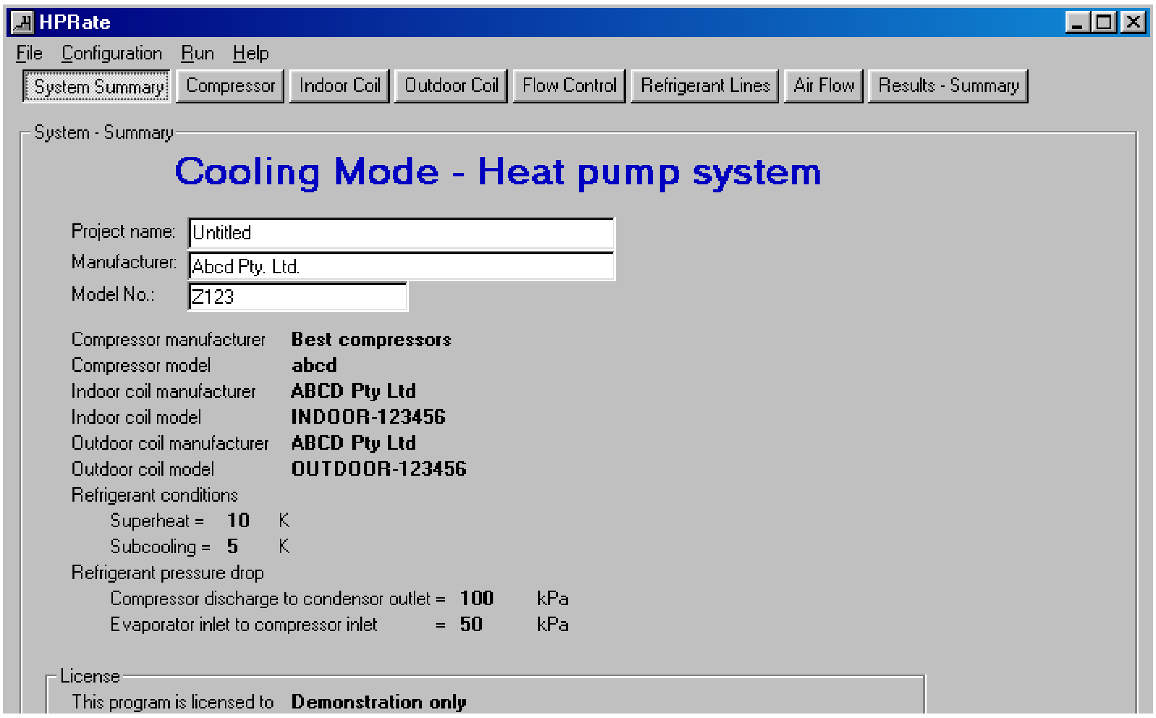
The ***Run*** menu is used to start the program after the data entry is complete (or press F5 in any screen).



DATA INPUT SCREENS

The six data input screens and the result screen are selected using the tabs at the top of *HPRATE* window.

SYSTEM SUMMARY



When the program starts a system description is loaded. The data can be edited by entering new values on the six input screens or by loading component files for the required compressor and coils.

The primary input screens are

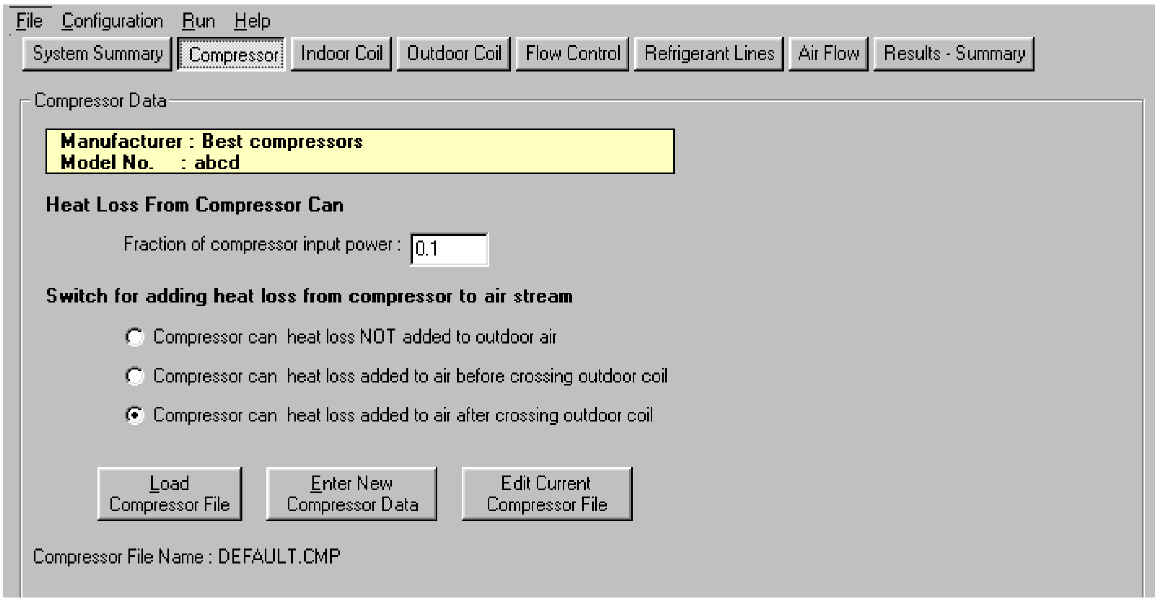
Compressor
Indoor coil
Outdoor coil
Flow control
Refrigerant lines
Air flow

The data in all these screens must be modified to describe your particular system.

After a new system description has been entered the data can be saved using the ***File – Save Project As*** command on the main system screen. System descriptions can be loaded using the ***File - Open Project File*** option. Coil and compressor files can be individually loaded using the ***File - Load Outdoor Coil*** option etc.
Note: If you cannot see Project Files in your directory change the Windows settings for viewing files as outlined in Appendix 2.

COMPRESSOR DATA.

Test data for the compressor is entered via the ***Compressor*** screen.

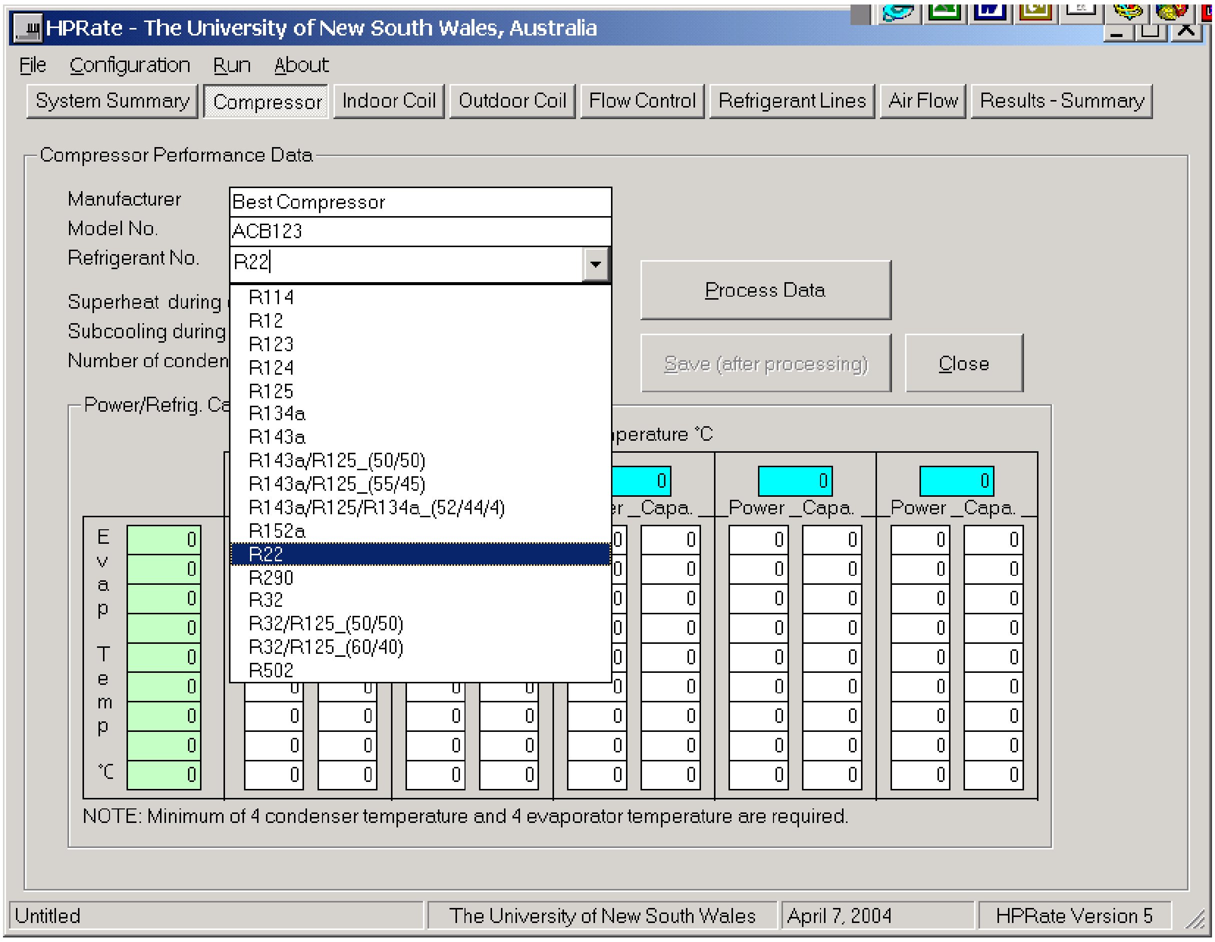


The compressor heat loss and the location of the compressor relative to the air stream are entered on the ***Compressor*** data screen. Heat loss from compressor is typically 0.1 to 0.2 depending on airflow over the compressor.

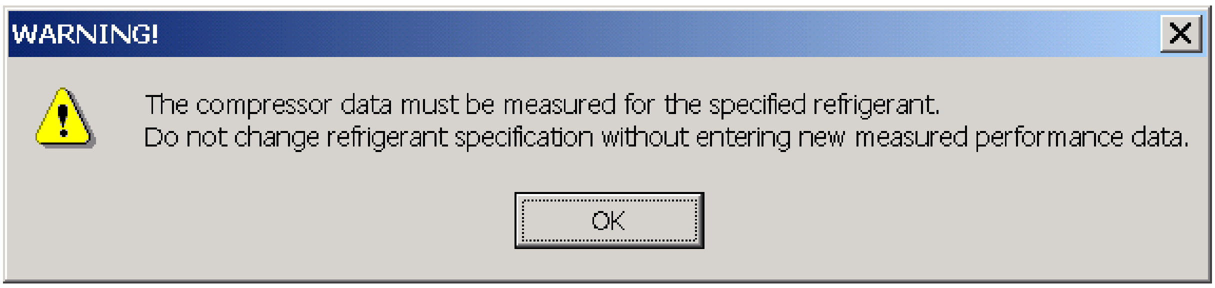
A menu for entering test data for a new compressor is opened by selecting.

SELECTION OF REFRIGERANT

The refrigerant is selected on the compressor input data page. The refrigerant number must correspond with the data entered for the compressor performance. The refrigerant number cannot be changed without re-entering new data for the compressor.

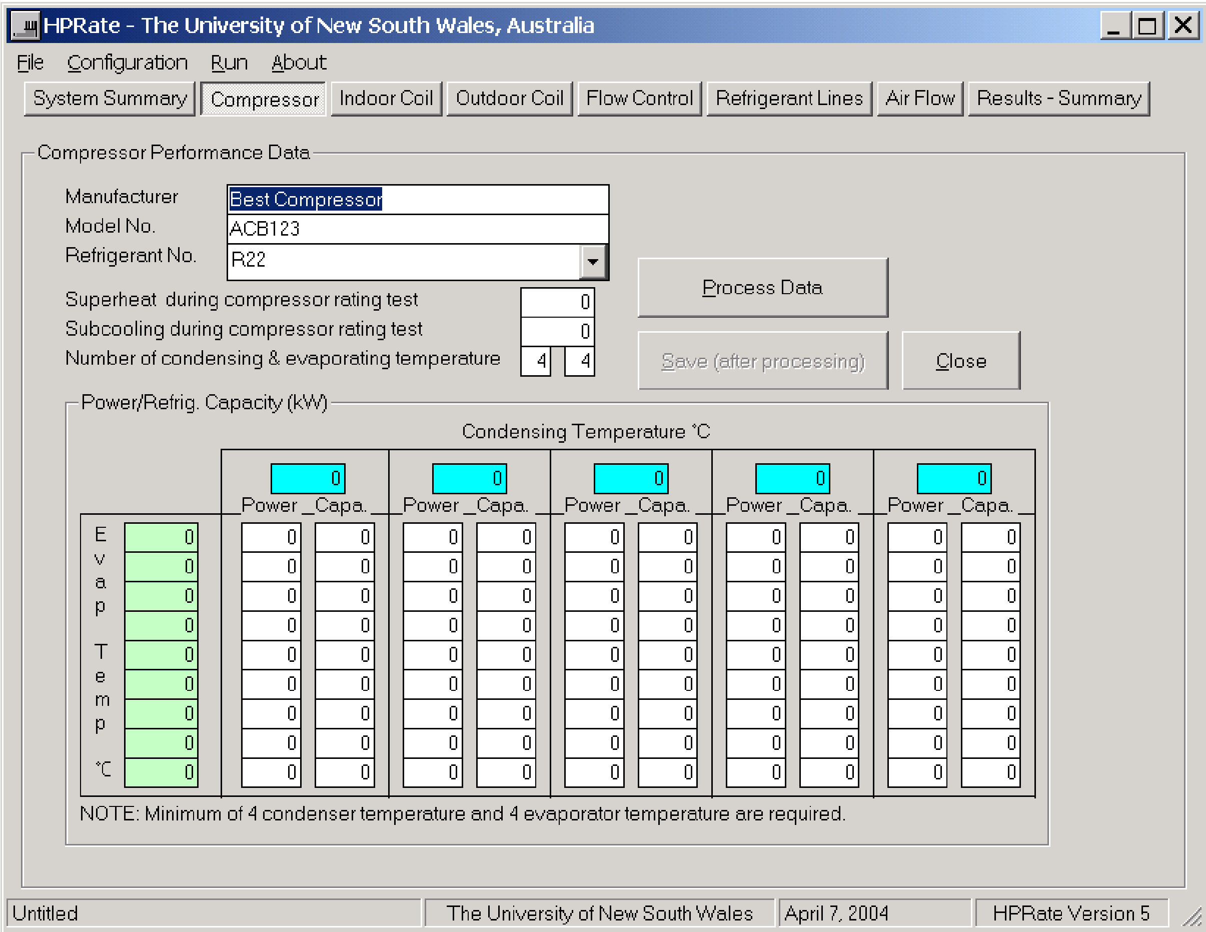


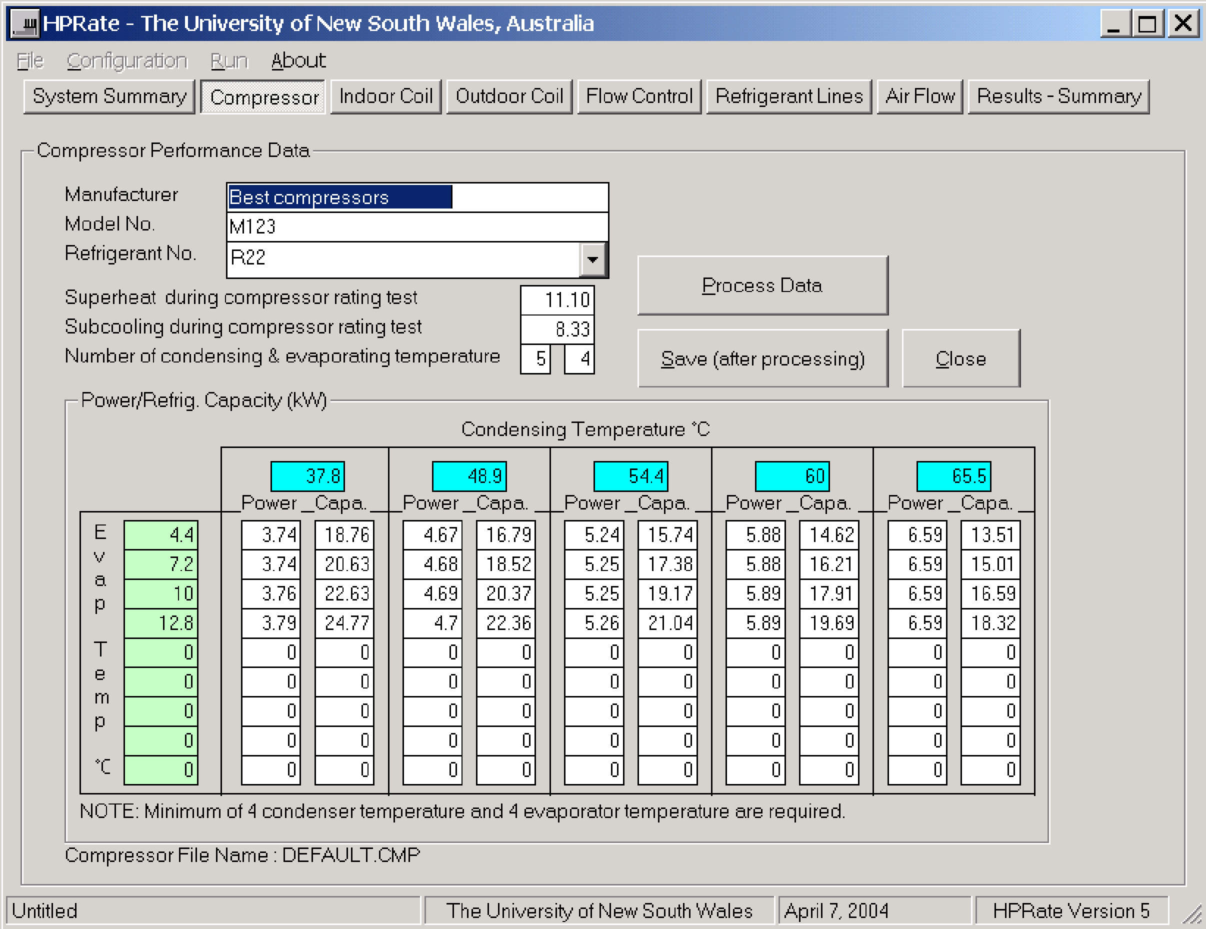
If the refrigerant number is changed after entering compressor performance data the following warning message is issued.



The result will not be valid if the compressor performance data was not measured with the indicated refrigerant.

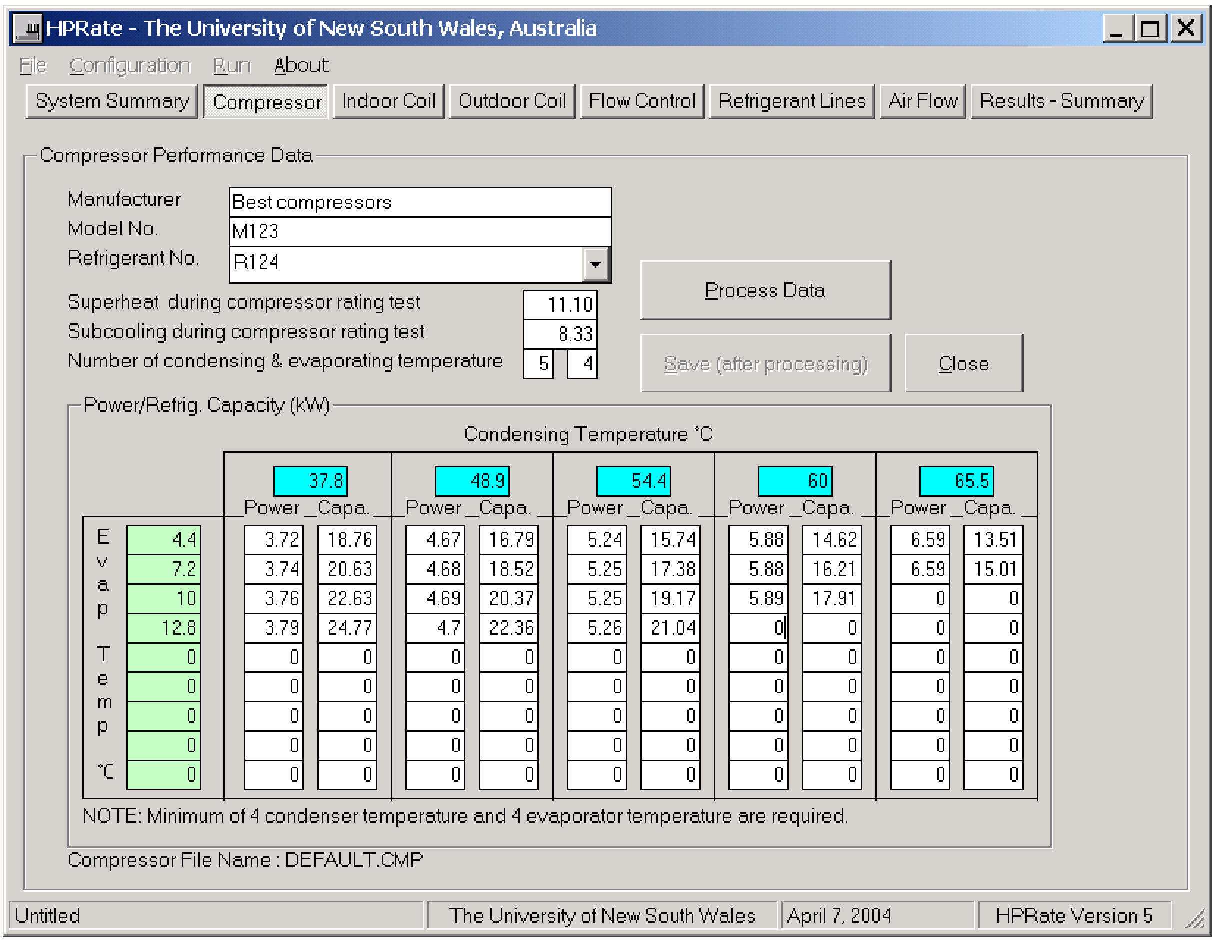
Enter values for electrical power input and refrigeration capacity in the table as follows





Spaces in the table do not have to be filled completely, zero power and capacity values are ignored. ***Data for a minimum of four condensing and four evaporating temperatures is required***. Condensing and evaporating temperatures should cover the expected temperature range for the application. For AS3823 MEPS rating the compressor data must be available for condenser temperatures equal to the rating point condenser temperature ±10K and the evaporator temperatures equal to the rating point temperature ±10K.

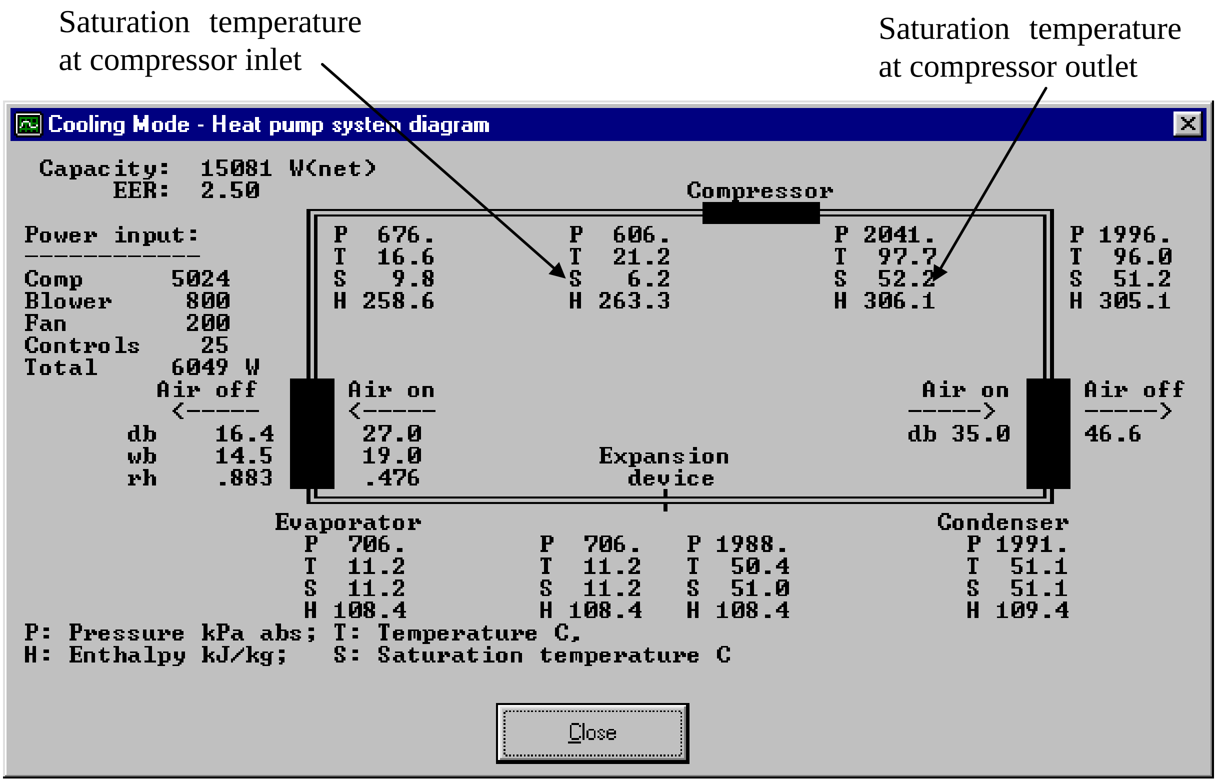
Some times compressor performance data is not available for high condensing temperatures and high evaporating temperatures. For such cases the compressor performance data file would look like the following. A reduced data set such as shown below is acceptable provided data is entered for at least four evaporator temperatures and at least four condenser temperatures and data for a minimum of ten operating points is entered. The data must cover the actual operating point of the system; see Cross Check of Operating Point and Compressor Data.



When all the data has been entered the system performance can be determined by selecting ***Process Data***. Do not process the data until all the data has been entered. Ensure that the boxes listing ***Number of condensing & evaporating temperatures*** corresponds with the actual number of temperatures entered in the compressor data fields.

Cross check of operating point and compressor data

To obtain an accurate simulation result the system saturation temperatures at the compressor inlet and outlet should be within the range of the condensing and evaporating temperature data entered for the compressor. If the operating point is outside the specified compressor data range then the simulation result may be in error due to extrapolation of the compressor performance curves. If this occurs then more data points must be entered for the compressor to cover the calculated conditions and the simulation run repeated. The system saturation temperatures at the compressor inlet and outlet are displayed on the ***Result - Cycle Details*** screen.

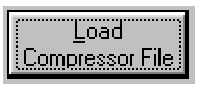


Saving compressor data

When the new data is successfully processed the Save button will become active and the data can be saved. By saving the data compressor in a separate file (type .CMP) a library of compressor files can be established and read into *HPRATE* as required.

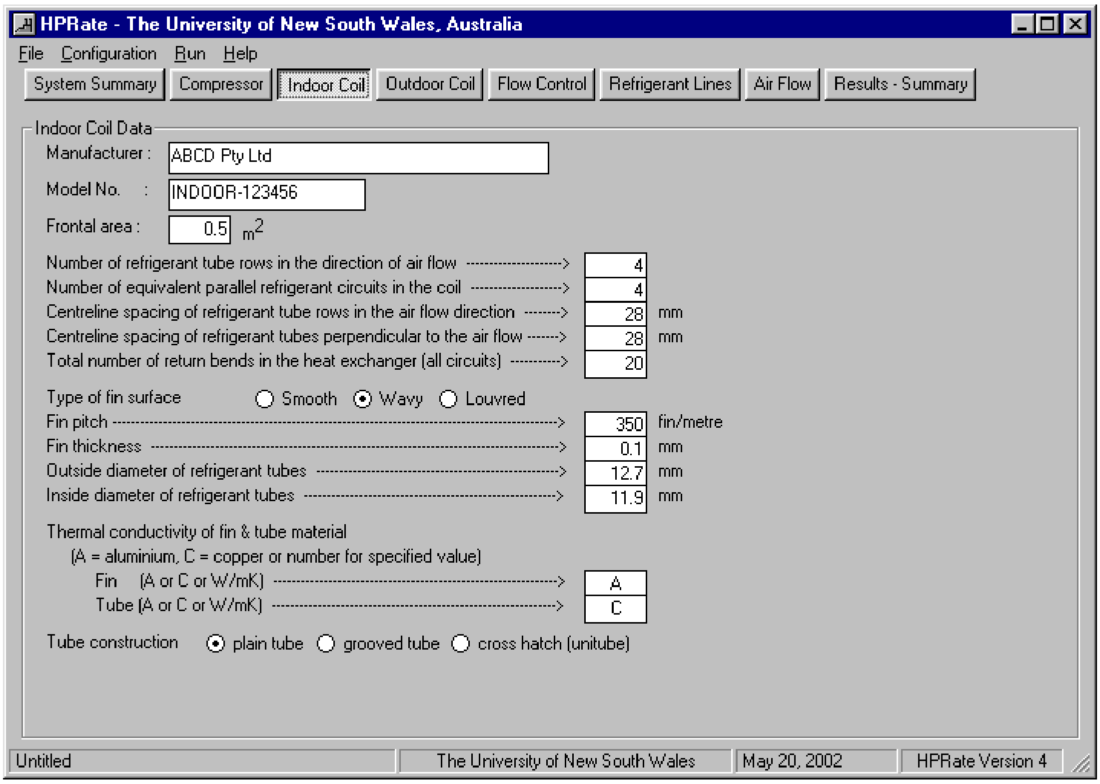
Loading a compressor file

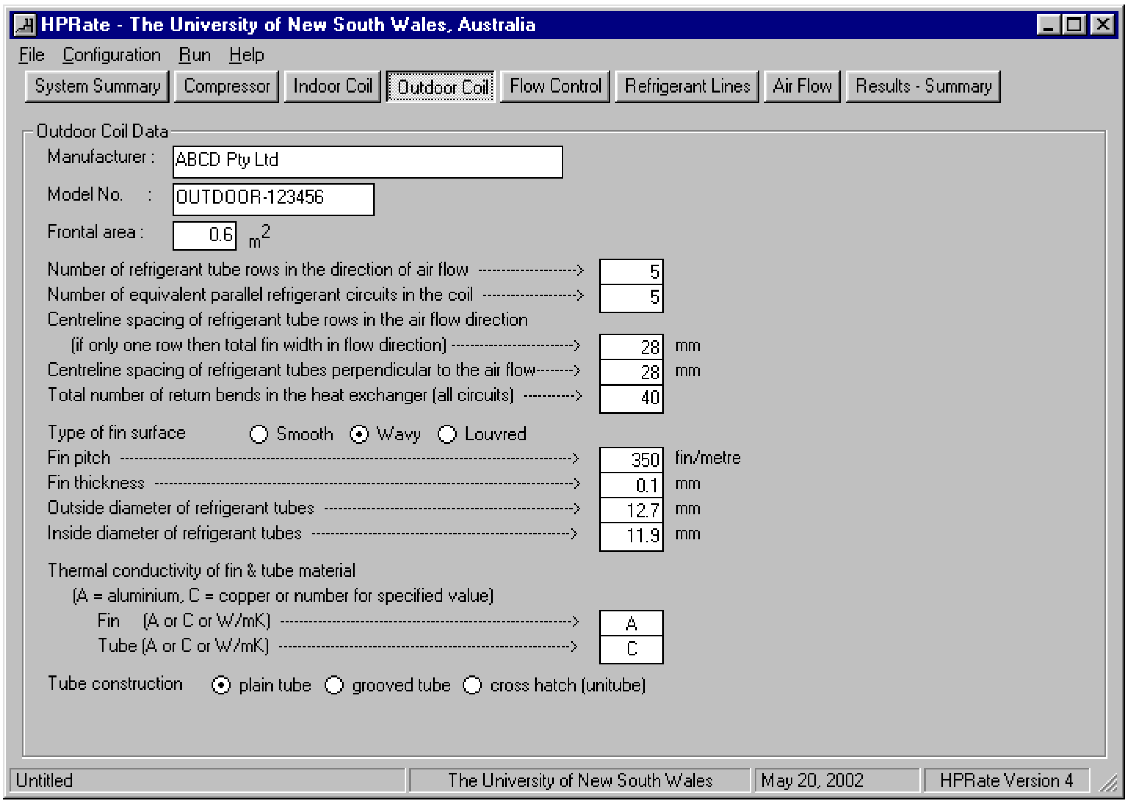
Compressor data that has been previously saved can be selected using the ***Load Compressor File*** button, or the ***File–Load Compressor Data*** option.

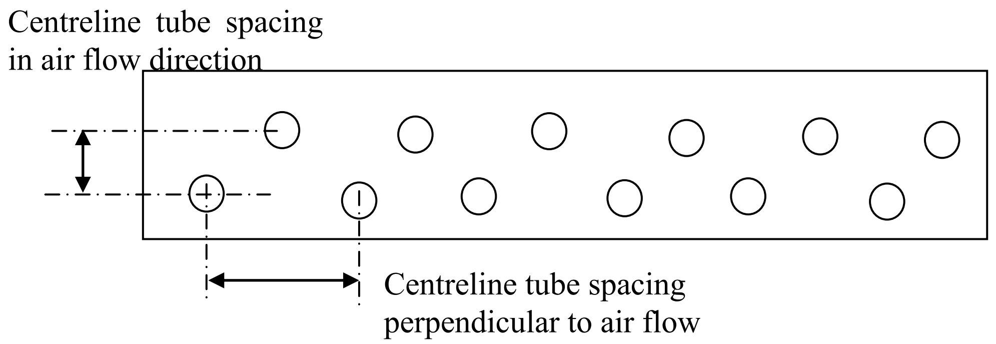


COIL DATA

The coil data is entered in the ***Indoor Coil*** and ***Outdoor Coil*** data screens.







For a single row coil the row spacing dimension becomes the width of the fins in the direction if the air flow through the coil.

The refrigerant tube diameter should be measured after tube expansion.

The *Total number of return bends in the heat exchanger* is the sum of the number of return bends on both sides of the coil. See Appendix 1 for details of modelling systems with multiple compressors with interlaced coils.

Saving coil data

Coil data can be saved as a separate file (*.COI) so it can be loaded into other system descriptions.
To save coil data select ***File – Save Indoor Coil*** or ***File – Save Outdoor Coil***

Alternatively the coil data can be saved as part of a Project file using the ***File – Save Project*** option.

Loading a coil file

Coil data that has been previously saved can be loaded using the ***File Load Indoor Coil***, or the ***File–Load Outdoor*** option.

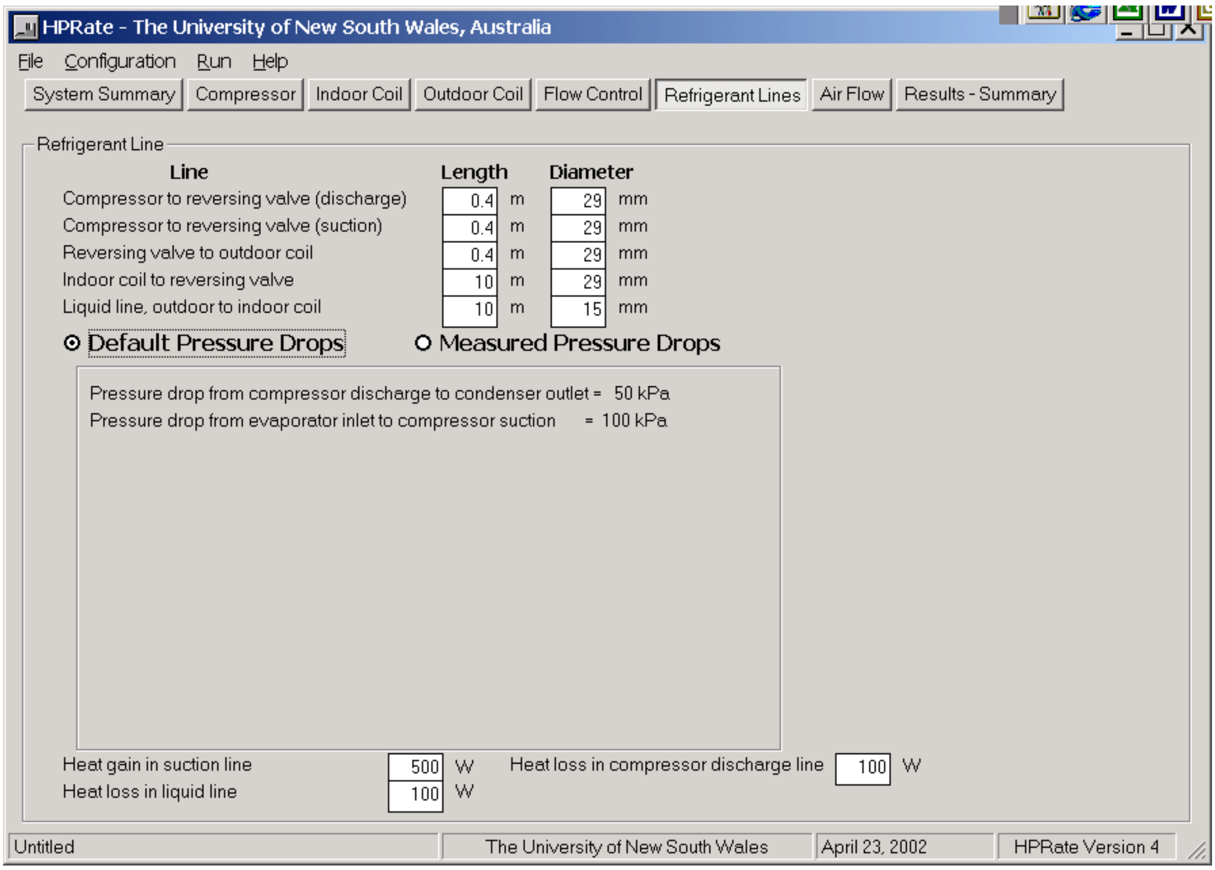
REFRIGERANT LINES.

Specification of refrigerant line lengths and diameters (ID) and pressure drops are entered in the Refrigerant Lines screen.

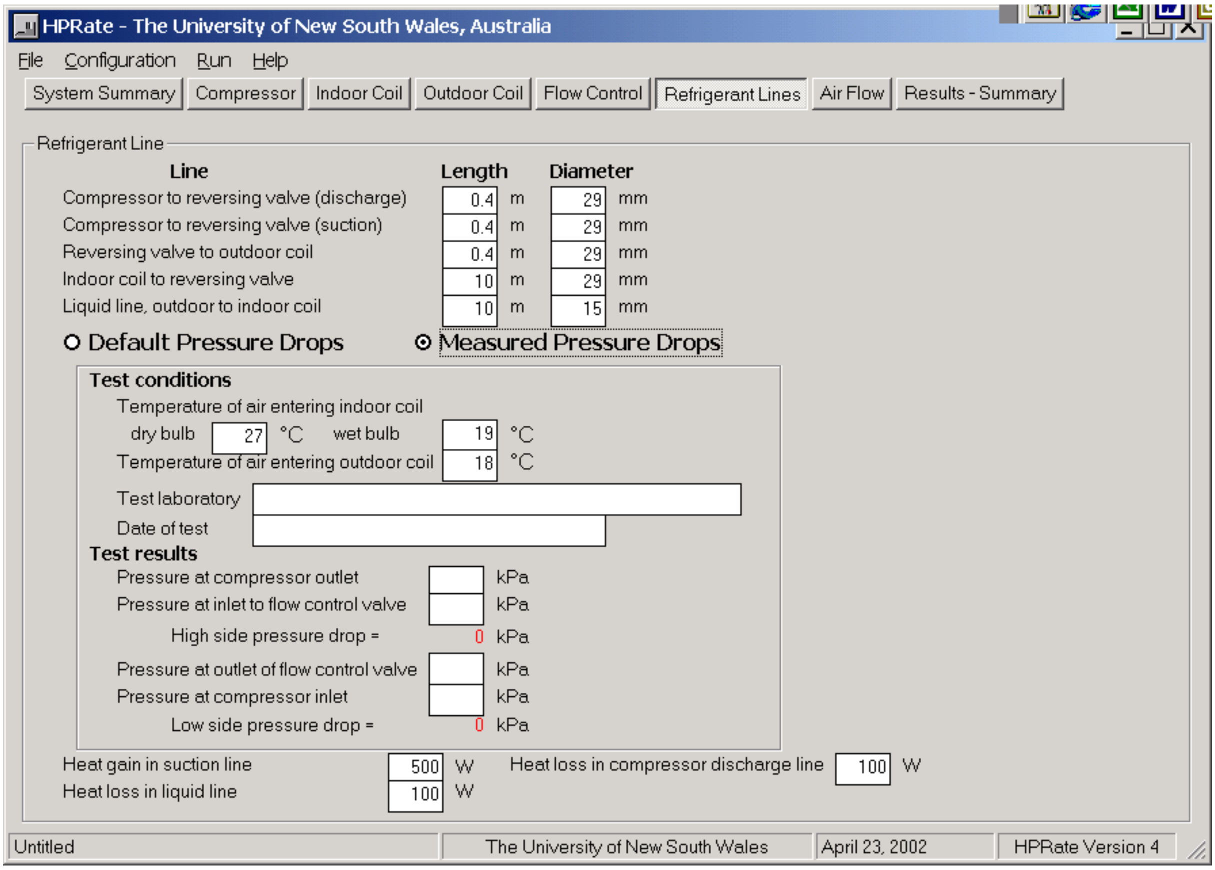
Pressure drop in refrigerant circuit.

The pressure drop in the refrigerant circuit is a function of the coil manifold design, reversing valve construction, accumulator construction, tubing sizes and plumbing fittings. As the influence of construction details on pressure drop cannot be reliably specified the pressure drops on the high and low sides should be measured when the system is operating under standard rating conditions. Typical pressure drops are 50 kPa on the high side and 100 kPa on the low side. If no measurements are available these values should be used in the *HPRATE* program.

Default pressure drops in refrigerant circuit



User supplied test data for refrigerant circuit pressure drops.



Heat loss/gain from refrigerant lines

The heat loss is calculated from the tube dimensions, insulation conductivity, insulation thickness and operating temperature of the lines. The operating temperature of each line can be obtained from the detailed refrigerant conditions screen.

Heat gain in the suction line $= \dfrac{\pi L\left(T_a - T_{is}\right)}{\dfrac{\ln\left(d_o/d_i\right)}{2k} + \dfrac{1}{h_o d_o}}$

Heat loss in compressor discharge line $= \dfrac{\pi L\left(T_{ic} - T_a\right)}{\dfrac{\ln\left(d_o/d_i\right)}{2k} + \dfrac{1}{h_o d_o}}$

Heat loss in liquid line $= \dfrac{\pi L\left(T_{il} - T_a\right)}{\dfrac{\ln\left(d_o/d_i\right)}{2k} + \dfrac{1}{h_o d_o}}$

Note: Internal heat transfer coefficient is neglected.

Where

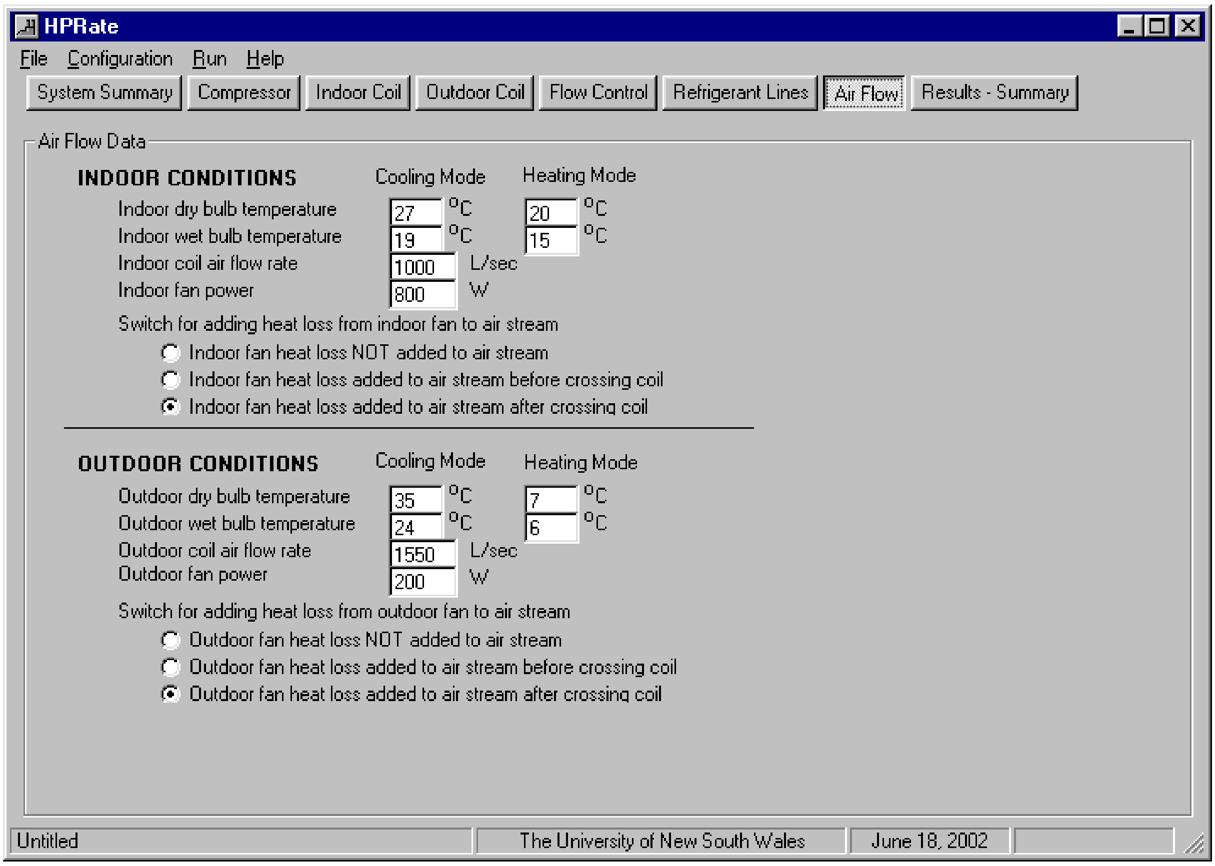
L = length of the line
d_o = outside diameter of insulation
d_i = inside diameter of insulation
T_{is} = refrigerant temperature in the suction line
T_{ic} = refrigerant temperature in the compressor discharge line
T_{il} = refrigerant temperature in the liquid line
T_a = air temperature outside the line (varies between inside and outside sections of piping)
k = thermal conductivity of insulation material
h_o = outside heat transfer coefficient (default value = 10 W/m^2 K)

For cooling
T_a = 35°C for lines outside the conditioned space
T_a = 27°C for lines inside the conditioned space

For heating
T_a = 8.3°C for lines outside the heated space
T_a =21°C for lines inside the heated space

AIR FLOW SPECIFICATION.

The air-on conditions for cooling and heating are specified in the ***Air Flow*** menu



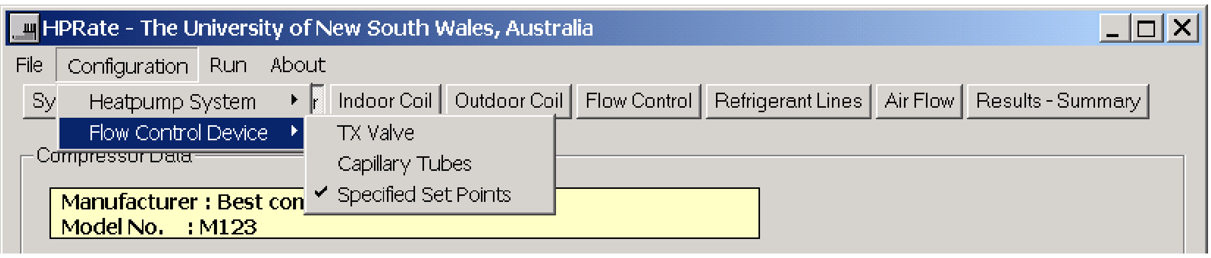
The position of the fan motor with respect to the airflow is also specified in this screen.

FLOW CONTROL

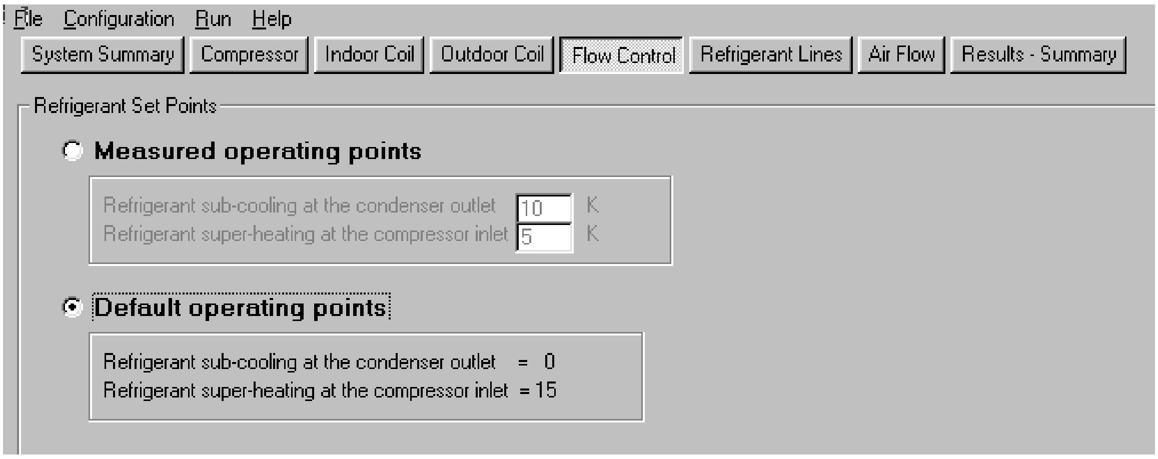
The refrigerant flow control can be selected from

Specified super-heat and sub-cooling temperatures (Set points)
Capillary tube
TX Valve

The flow control mode is selected from the menu under the ***Configuration*** button on the primary screen.



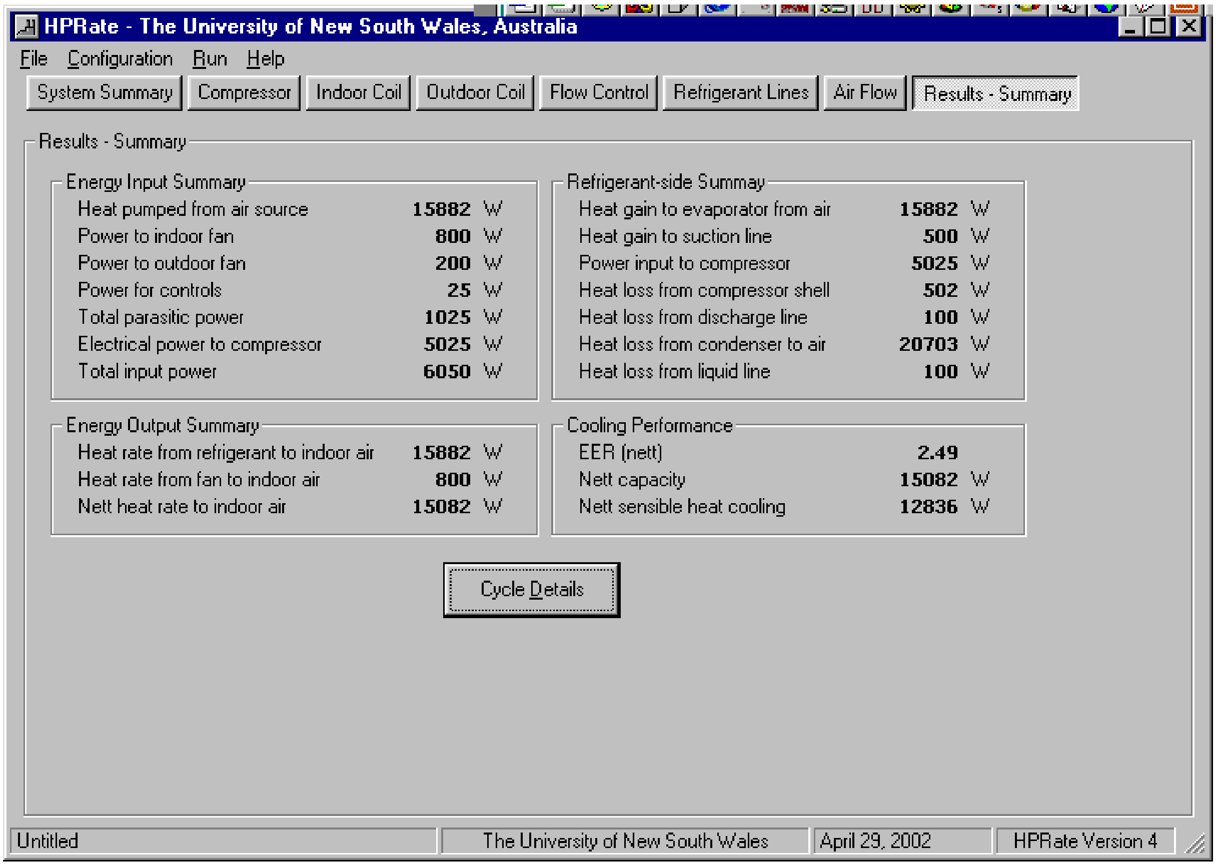
Specified set points



Under the Australian MEPS program the *Specified Set Points* option must be selected.

RESULT FILE

A typical result screen for a cooling analysis is shown below



Printing results

The result summary page can be printed by the ***File – Print Result*** option.

Saving results

The result summary and the cycle details can be saved to an ASCII file with the ***File – Save Project*** option. This file can be read into a word-processor or a text editor.

Copying results screen into WORD document

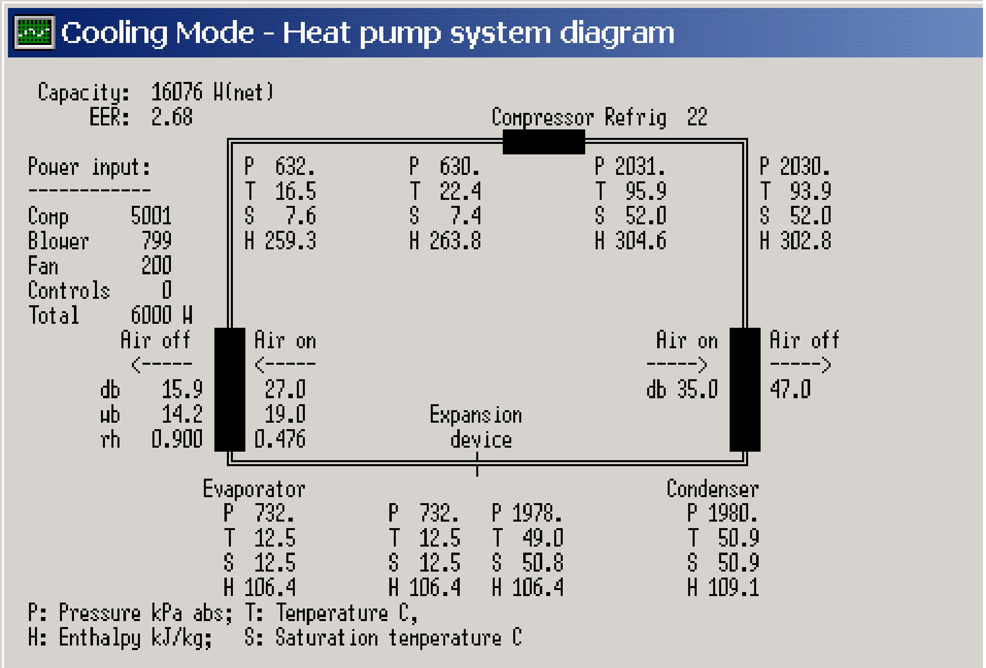
The active screen can be copied into a WORD document as follows

Press **Alt** and **Print Scrn** keys together

Move to the WORD document and select Edit Paste.

DETAILED REFRIGERANT CIRCUIT CONDITIONS

Details of the pressure, temperature, saturation temperature and enthalpy around the refrigerant circuit, together with the air-on and air-off conditions are shown in the ***Results – Cycle Details*** screen shown below



The results and refrigerant circuit conditions can be saved to file with the ***File – Save Project As*** command. This file is in text format and can be read into a word processor.

Copying detailed results screen into WORD document

The active screen can be copied into a WORD document as follows

Press **Alt** and **Print Scrn** keys together

Move to the WORD document and select **Edit Paste**.

REFERENCES

AS3823.1.1-2012 Australian/New Zealand Standard.
Performance of electrical appliances – Airconditioners and heat pumps.
Part 1.2 Non–Ducted airconditioners and air-to-air heat pumps – Testing and rating for performance.

AS3823.1.2-2012 Australian/New Zealand Standard.
Performance of electrical appliances – Airconditioners and heat pumps.
Part 1.2 Test methods – Ducted airconditioners and air-to-air heat pumps – Testing and rating for performance.

AS3823.3 - 2002 Australian/New Zealand Standard.
Performance of electrical appliances – Airconditioners and heat pumps.
Part 3: Calculation of performance for minimum energy performance standard requirements.

ORNL HEAT PUMP DESIGN MODEL. Description of Heat Pump Specification Data.
Mark V Version 95d.

PROGRAM SUPPORT

Email t_design@tpg.com.au

APPENDIX 1
MODELLING OF MULTI-COMPRESSOR SYSTEMS WITH INTERLACED COILS

Although HPRATE does not model multiple compressor products with interlaced coils the program can be used to rate systems that have two or more identical compressors using the following procedure.

Coil parameters for a system with N identical compressor circuits.

- Enter performance data for one of the compressors
- Set the coil *frontal area* to the interlaced coil face area divided by N
- Set the *number of equivalent parallel refrigerant circuits* to the actual number of parallel circuits in one of the compressor loops
- Set the *total number of return bends* for the coil to the total number of return bends in the coil (sum of number of return bends on both sides of the coil) divided by N.
- Set the *spacing of the tubes perpendicular to the airflow direction* to the actual tube spacing in the interlaced coil.
- Set *fan power* to the total input fan power divided by N.

Results

- *EER* is the value determined by the HPRATE model.
- *Capacity* of the system is N times the capacity reported by the HPRATE model.
- *Power input* to the system is N times the power reported by the HPRATE model.

APPENDIX 2
MODELLING REQUIREMENTS FOR DUCTED SYSTEMS

The indoor fan power to be specified for the rating is set in AS2832 part 1.2 as the power required to overcome the coil pressure drop plus a duct pressure drop allowance specified in AS2832.1.2 appendix ZZ, as shown below.

Standard capacity ratings (kW)	**Minimum external static pressure (Pa)**
<8	25
8 to <12	37
12 to <20	50
20 to <30	62
30 to <45	75
45 to <82	100

For equipment tested without an air filter installed, the minimum external static pressure shall be increased by 10 Pa.

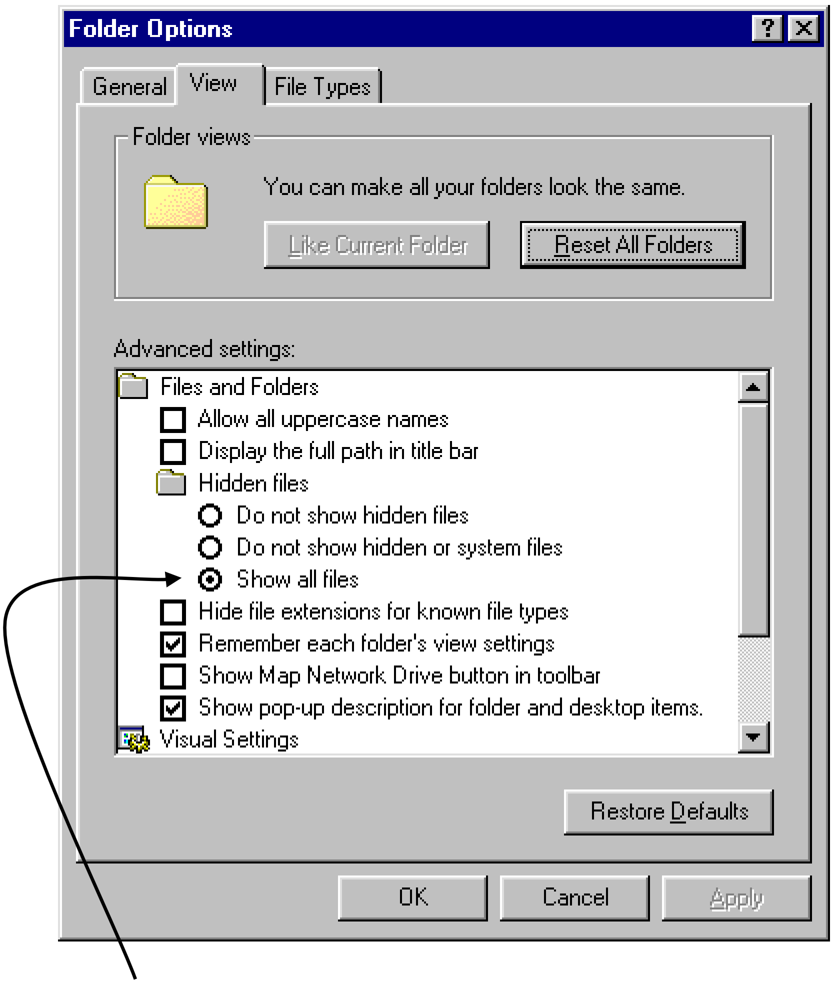
APPENDIX 3
MAKING PROJECT FILES VISIBLE IN WINDOWS EXPLORER

If Windows Explorer file management is set to hide system files then you will not be able to find *HPRATE project files* that you have saved. (*HPRATE* will find the files but you will not see them in Windows Explorer).

To make project files (file type *.SYS) visible in Windows Explorer make the following changes to Windows settings.

Select
- Start
- Settings
- Folder Options
  - View

You should see the following window



Ensure that the *Show all files* button is selected.