

NIST

CYCLE_D:

NIST Vapor Compression Cycle Design Program

Version 3.0

Users' Guide

P.A. Domanski, Ph.D., P.E.
D.A. Didion, Ph.D., P.E.
Building and Fire Research Laboratory

J. Chi, Ph.D., P.E.
University of the District of Columbia
Washington, DC

March 2003

U.S. Department of Commerce
Technology Administration
National Institute of Standards and Technology
Standard Reference Data Program
Gaithersburg, MD 20899

The National Institute of Standards and Technology (NIST) uses its best efforts to deliver a high quality copy of the Database and to verify that the data contained therein have been selected on the basis of sound scientific judgement. However, NIST makes no warranties to that effect, and NIST shall not be liable for any damage that may result from errors or omissions in the Database.

NIST Standard Reference Database 23 -(c) 1989, 1991, 1993, 1998, 2003 copyright by the U.S. Secretary of Commerce on behalf of the United States of America. All rights reserved. No part of this database may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the distributor.

Certain trade names and company products are mentioned in the text to specify adequately the computer products and equipment needed to use this software. In no case does such identification imply endorsement by the National Institute of Standards and Technology of these computer products and equipment, nor does it imply that the products are necessarily the best available for the purpose.

Microsoft is a registered trademark, and Windows is a trademark of Microsoft Corporation. All other brand and product names are trademarks or registered trademarks of their respective companies.

ACKNOWLEDGMENTS

Version 1.0 of CYCLE_D was developed under partial funding from the Trane Company and the Electric Power Research Institute, with Gary Lange and Terry Statt managing the project, respectively. The authors acknowledge helpful suggestions from Paul Glamm from the Trane Company. J. Wnek made modifications and improvements of the user interface in Version 2.0. Jacek Schnotale and Piotr A. Domanski prepared Version 3.0 by implementing thermodynamic charts and line sizing calculations, and upgrading CYCLE_D to REFPROP7. David Yashar provided comments on Version 3 upgrades.

CONTENTS

INTRODUCTION.....	1
SYSTEM REQUIREMENTS.....	1
INSTALLATION.....	1
MODELING APPROACH.....	2
Refrigerants and Refrigerant Properties.....	2
Condenser and Evaporator.....	2
Compressor.....	3
Suction Line and Discharge Line.....	4
Liquid-Line/Suction-Line Heat Exchanger.....	4
Powers to Indoor Fan, Outdoor Fan, and Controls.....	4
Refrigerant Line Sizing Calculations.....	5
Simulation Results.....	5
Uncertainty of Simulation Results.....	6
USE OF CYCLE_D.....	7
Specifying Input Data.....	8
Toggle Indicators.....	8
Specifying Refrigerant and Cycle Data for the "Compressor Data" Option.....	8
Selecting Compressor and Cycle Data for the "Compressor Map" Option.....	11
Running a Simulation.....	13
Presenting Simulation Results.....	14
General Results.....	14
Refrigerant Parameters on a System Schematic.....	16
Temperature-Entropy and Pressure-Enthalpy Diagrams.....	17
Refrigerant Line Sizing Information.....	18
Managing Files.....	19
Saving the Current Input Data Set and Results.....	19
Loading a File with an Input Data Set.....	20
Exiting CYCLE_D.....	20
Clearing Working Areas.....	20
Quitting CYCLE_D Session.....	20
Diagnostic Messages.....	21
REFERENCE.....	21

Appendix A.	SAMPLE SESSION 1 - Using the "Compressor Data" Option.....	22
	SAMPLE SESSION 2 - Using the "Compressor Map" Option.....	28
Appendix B.	SINGLE-COMPONENT REFRIGERANTS AVAILABLE IN CYCLE_D	32
Appendix C.	FORMAT OF DATA FILE FMAPS.....	33
Appendix D.	NOMENCLATURE USED FOR PRESENTING SIMULATION RESULTS.....	38
Appendix E.	FREQUENTLY ASKED QUESTIONS	40
Appendix F.	CONTACTS.....	43

INTRODUCTION

The CYCLE_D package simulates the vapor compression refrigeration cycles that use pure refrigerants or mixtures of refrigerants. The model can simulate a basic refrigeration cycle as well as a cycle with a liquid-line/suction-line heat exchanger. CYCLE_D operates in a user-friendly Windows environment that facilitates evaluating the performance of selected working fluids at different operating conditions. Calculations are based on refrigerant properties as represented in the NIST Reference Fluid Thermodynamic and Transport Properties – REFPROP, Version 7.0 [1]

SYSTEM REQUIREMENTS

CYCLE_D is designed to run on any personal computer capable of running Microsoft® Windows™ 95, 98, 2000, Me, XP, or NT. A hard disk with four megabytes of available space is required. The screen resolution should be set to 800 x 600 or higher to view its entirety.

CD-Rom Specifications

The program is available on CD-ROM.

INSTALLATION

Insert the CD-ROM in drive (D or E). In Windows 95, 98, 2000, Me, XP, or NT click on the Start button and select Run. In the edit box, type, as appropriate

D:\SETUP or E:\SETUP

and press **ENTER**. Follow the remainder of the Installation instructions. A NIST CYCLE_D Program Group will be created at the end of installation.

To run the program, double-click on the NIST CYCLE_D icon.

MODELING APPROACH

The system simulated by CYCLE_D consists of a compressor, discharge line, condenser, expansion device, evaporator, compressor suction line, and an optional liquid-line/suction-line heat exchanger. The user of the program has to specify the refrigerant and input for the above hardware components except the expansion device (the expansion process is assumed to be isenthalpic). The user can also specify the parasitic power of the indoor fan, outdoor fan, and control unit of the system.

Refrigerants and Refrigerant Properties

CYCLE_D covers 36 single-component refrigerants, which can be selected for simulations as the working fluids or can be combined in a mixture of up to five components. See Appendix B for the list of available refrigerants.

CYCLE_D uses REFPROP 7.0 [1] routines for calculating thermodynamic properties of pure refrigerants and refrigerant mixtures. Among different options available in REFPROP 7.0, CYCLE_D uses the default (NIST recommended) models for property predictions. The reference point for calculating enthalpy and entropy is saturated liquid of a single-component refrigerant or refrigerant mixture at -40 °C (-40 °F) (ASHRAE convention).

Condenser and Evaporator

The condenser and evaporator are represented by specifying the refrigerant temperature in each of these heat exchangers. Zero refrigerant pressure drop is assumed.

Refrigerant temperature in the condenser can be specified to be either a bubble-point temperature, dew-point temperature, or an average temperature. The average temperature is calculated as an arithmetic mean of the dew-point and bubble-point temperatures. Additionally, refrigerant subcooling leaving the condenser can be specified.

Refrigerant temperature in the evaporator can be specified as either a dew-point temperature or an average temperature. The average temperature in the evaporator is calculated as an arithmetic mean of the dew-point temperature and the temperature of refrigerant entering the evaporator. Additionally, refrigerant superheat leaving the evaporator can be specified.

CYCLE_D 2

The above options for specifying the heat exchanger temperature have no significance for single-component refrigerants, but they affect simulations with zeotropic mixtures because zeotropic mixtures undergo a temperature change during a phase change.

It is recognized that evaluation of the average temperature in the condenser and evaporator as a mean of refrigerant temperatures at the end of two-phase processes is a simplification (temperature profile versus enthalpy in a two-phase region is not linear for zeotropes). However, it was opted to use this method to make CYCLE_D compatible with the method used by industry for compressor calorimeter testing.

Compressor

CYCLE_D provides two options for representation of the compressor: "compressor data" option and "compressor map" option.

The "compressor data" option requires input of values of isentropic efficiency of the compression process, compressor volumetric efficiency, electric-motor efficiency, and a target System Cooling Capacity, which is the evaporator capacity adjusted for the heat added by the indoor coil fan. If the value of electric motor efficiency is less than 1, the entire heat rejected by the electric motor is assumed to heat the suction vapor before the compressor suction port.

The "compressor map" option uses compressor-map correlations, which are typically derived from a compressor calorimeter test. Three types of correlations are allowed. CYCLE_D reads the constants for the correlations from a user-prepared data file FMAPS. The allowed correlations and format of file FMAPS are described in Appendix B. Only the refrigerant that was used during the calorimeter tests can be used in the "compressor map" option.

The "compressor map" option also requires input of a value for either System Capacity Multiplier or System Cooling Capacity. If System Capacity Multiplier is specified, its value is used in the simulation as the multiplication factor for compressor capacity (calculated by compressor-maps correlations) and for indoor and outdoor fan powers (entered by the user). Power input to the system control unit is unaffected. If System Cooling Capacity is specified, the simulations are performed for a system with a compressor of identical efficiency characteristics but with adjusted displacement, so the system could provide the target System Cooling Capacity. Power input to the indoor and outdoor fans and system control unit are unaffected by the selected value of the System Cooling Capacity.

Compressor-map equations correlate compressor performance at certain suction superheat and condenser subcooling, which are typically specified by the compressor test procedure. To allow simulations at user-specified conditions, the following steps and assumptions are taken by the model:

- ◆ Isentropic efficiency of the compressor is calculated using the compressor-map correlations at user-specified saturation temperatures (or pressures) and at the superheat and subcooling levels used during calorimeter tests. It is assumed that the isentropic efficiency is not affected by the level of superheat, and the calculated efficiency value is used in the cycle calculations.
- ◆ When calculating refrigerant mass flow rate, it is assumed that compressor volumetric efficiency and speed (RPM) are not affected by the suction vapor superheat. Consequently, the refrigerant mass flow rate at the user-specified superheat equals the value of mass flow rate at the superheat during the calorimeter test, adjusted for the different specific volume of the suction vapor caused by a different superheat.

Suction Line and Discharge Line

Pressure drop in the suction and discharge lines can be specified by assigning a value of the corresponding saturation temperature drop of refrigerant. CYCLE_D assumes the lines are adiabatic.

Liquid-Line/Suction-Line Heat Exchanger

The liquid-line/suction-line heat exchanger (LLSL-HX) is specified by the user by assigning an effectiveness value of the heat exchanger. The assignment of effectiveness equal to zero denotes no LLSL-HX in the cycle.

Powers to Indoor Fan, Outdoor Fan, and Controls

The parasitic powers are specified by the user. The indoor and outdoor fan powers are used in the total power calculation and as heat in the capacity calculations for the evaporator and condenser. The control unit power is only used in the total power calculation.

Refrigerant Line Sizing Calculations

After cycle calculations have been completed, CYCLE_D can provide sizing information for the compressor suction and discharge lines and for the liquid line connecting the condenser and expansion valve. This information includes refrigerant velocity and tube lengths and is provided for a range of diameters of straight type L copper tubing. The refrigerant mass flow rate determined during cycle simulations is used in these calculations.

The refrigerant velocity values presented by CYCLE_D are those at tube inlets. Refrigerant velocity varies in a tube because of a pressure drop and change of specific volume. The lowest velocity, critical to oil return, is at the tube inlet because of the lowest specific volume.

The program calculates tube lengths for the respective pressure drops imposed by the user in the simulated cycle (system). For the suction and discharge lines, these pressure drops are specified in the Cycle Data dialog box in terms of refrigerant dew point and bubble point temperature losses. For the liquid line, CYCLE_D calculates the line length for the pressure drop that would result in bringing the subcooled refrigerant to flashing. Tube length calculations assume adiabatic tubes, lubricant-free refrigerant, and use refrigerant parameters corresponding to the average of inlet and outlet pressures.

The program does not provide line length values for zero pressure drops; i.e., for zero condenser subcooling for the liquid line, and for zero drop in saturation temperatures for the vapor lines. Also, the program does not provide results for the liquid and suction lines if the system employs a liquid-line/suction-line heat exchanger.

Simulation Results

Simulation results are generated in two categories: (1) for the thermodynamic cycle and (2) for the compressor and system. The cycle category presents the results obtained per unit mass of refrigerant. These results reflect refrigerant parameters only and are not affected by the parasitic energy input to the indoor fan, outdoor fan, and controls. The compressor and systems results are calculated for the System Cooling Capacity or System Capacity Multiplier as specified at input. CYCLE_D calculates line sizing information using the thermodynamic parameters identifying the thermodynamic cycle and the refrigerant mass flow rate cycle needed to obtain the target system capacity. The naming convention used for simulation results is explained in Appendix D.

Uncertainty of Simulation Results

Simulation results uncertainties are directly related to the uncertainties or thermodynamic properties calculated by the NIST REFPROP 7.0 [1] property routines incorporated into the CYCLE_D package. CYCLE_D uses the database's default property models, which should provide the most accurate predictions. The user should be aware that the uncertainties in these models vary considerably depending on the refrigerant, property, and thermodynamic state. It is thus impossible to give a simple, global statement of uncertainties. Even for the most-studied fluids with equations of state based on accurate, wide-ranging data, uncertainties are complicated functions of the temperature and pressure. For details, refer to the original literature sources listed in [1].

USE OF CYCLE_D

This section explains how to use the CYCLE_D package: How to specify a cycle/system; How to run a simulation; How to present simulation results; and How to manage input/output files. If the user needs additional information after going through this tutorial, he may refer to CYCLE_D's on-line help.

Once CYCLE_D is properly installed on your computer, it can be started by double clicking on the **CYCLE_D** icon.

The Opening Screen is displayed. Click on the **OK** button to proceed.

The CYCLE_D main dialog box (Figure 1) appears. In this dialog box, click on the appropriate control buttons, icons, or menu items to perform the tasks explained in the remaining part of this section.

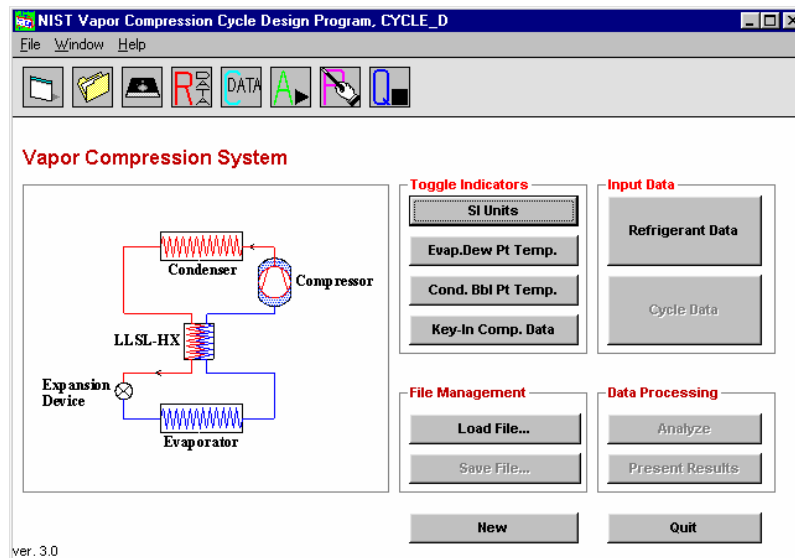


Figure 1. CYCLE_D main dialog box

Note: CYCLE_D 3.0 is designed to accept only a period “.” as a decimal point regardless of the settings on the user’s system.

Specifying Input Data

Toggle Indicators

Click on the unit indicator on the CYCLE_D main dialog box to select SI or British Units.

Click on the evaporator indicator button to define the refrigerant temperature in the evaporator as either the dew point or average temperature.

Click on the condenser indicator button to define the refrigerant temperature in the condenser as either a bubble-point or average temperature.

Click on the compressor indicator button to select the "compressor data" option (**Key-In Comp. Data** button) or "compressor map" option (**Use Comp. Maps** button). Toggling this button toggles the **Refrigerant Data/Compressor Maps** button, which must be used next.

Specifying Refrigerant and Cycle Data for the "Compressor Data" Option

A refrigerant must be specified if the "compressor data" option is selected. (For the "compressor map" option, each compressor is associated with the refrigerant specified in file FMAPS.) Click on the **Refrigerant Data** control button, the **R-DATA** icon, or the **Window/Refrigerant Data** menu item in the CYCLE_D main dialog box to display the Input Refrigerant Data dialog box shown in Figure 2.

In this dialog box, type the number of refrigerant components in the working fluid. Enter 1 if you are using a single-component refrigerant. Click on the **Click Me** button.

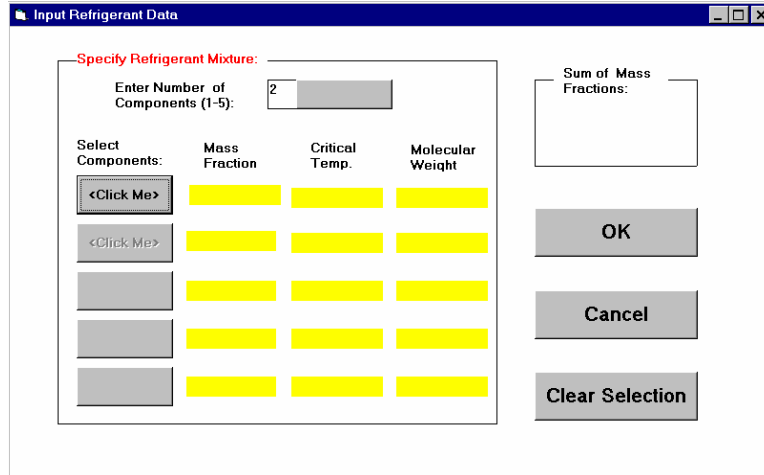


Figure 2. Input for Refrigerant Data dialog box

Clicking on the button under Select Components brings up the Select Refrigerants dialog box shown in Figure 3.

Click in the box shown in Figure 3 on the name of the refrigerant to be selected.

In the Component Mass Fraction entry box, type in the component mass fraction in decimals, and click on the **OK** button to return to the Input Refrigerant Data dialog box.

Click in the box shown in Figure 3 on the name of the refrigerant to be selected.

In the Component Mass Fraction entry box, type in the component mass fraction in decimals, and click on the **OK** button to return to the Input Refrigerant Data dialog box

Upon completion of the refrigerant data entry, click on the **OK** button to return to the CYCLE_D main dialog box.

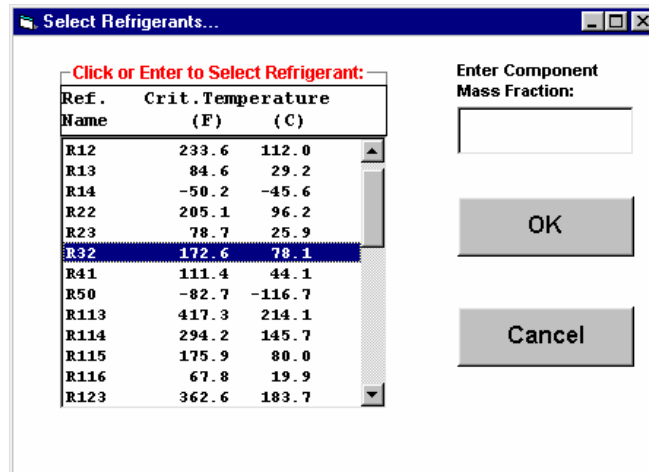


Figure 3. Select Refrigerants dialog box

Click on the **Cycle Data** button, the **C-DATA** icon, or the **Window/Cycle Data** menu item in the CYCLE_D main dialog box to display the Cycle Data dialog box shown in Figure 4.

The cycle parameters to be entered are: compressor data, suction and discharge line pressure losses, evaporator and condenser operational conditions, and parameters for cycle auxiliaries. Move from one entry box to another using the **ENTER** key, the **TAB** key or the mouse.

After completing cycle data entry, click on the **OK** button to return to the CYCLE_D main dialog box. The **Cancel** button can be used to cancel the cycle data entry and return to the CYCLE_D main dialog box.

Refrigerant Data		
Comp't No. = 1	Ref.Name	Mass Fraction
1st Component:	R32	1.
2nd Component:	XXX	XXX
3rd Component:	XXX	XXX
4th Component:	XXX	XXX
5th Component:	XXX	XXX

Compressor Data	
Isentropic Efficiency (Fraction):	<input type="text"/>
Volumetric Efficiency (Fraction):	<input type="text"/>
Electric Motor Efficiency (Fraction):	<input type="text"/>
System Cooling Capacity (kW):	<input type="text"/>

Suction Line Pressure Drop	
Dew Point Temperature Loss (C):	<input type="text"/>

Discharge Line Pressure Drop	
Bubble Point Temp. Loss (C):	<input type="text"/>

Cycle Parameters	
Evaporator Dew Point Temp. (C):	<input type="text"/>
Evaporator Superheat (C):	<input type="text"/>
Condenser Bubble Pt. Temp. (C):	<input type="text"/>
Condenser Subcooling (C):	<input type="text"/>

HX, Fans and Controls	
Effectiveness of suction/discharge lines HX (Fraction):	<input type="text"/>
Indoor Fan Power (kW):	<input type="text"/>
Outdoor Fan Power (kW):	<input type="text"/>
Power for Controls (kW):	<input type="text"/>

Figure 4. Cycle Data dialog box for the "compressor data" option

Selecting Compressor and Cycle Data for the "Compressor Map" Option

To use the "compressor map" option, the compressor toggle button has to display "Use Comp. Maps." Click on the **Compressor Maps** control button, the **R-DATA** icon or the **Window/Refrigerant Data** menu item in the main dialog box to display the Select Compressor Maps dialog box shown in Figure 5.

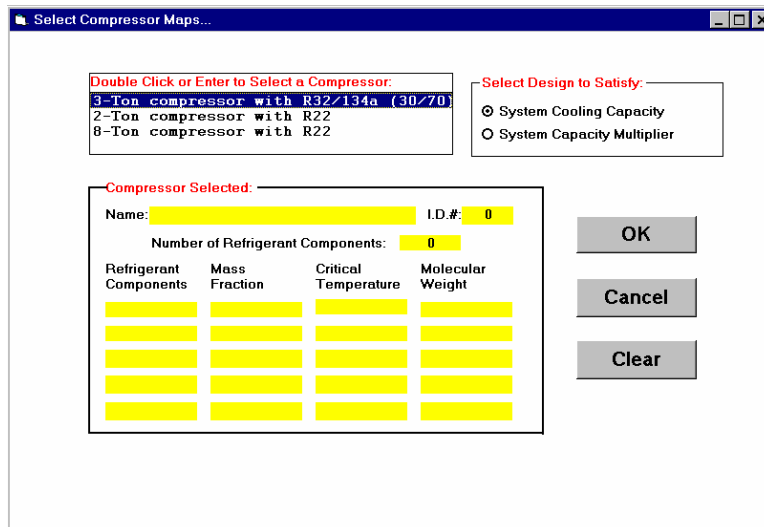


Figure 5. Compressor Maps selection dialog box

In this box, double click on the name of the compressor to be selected. The information for the selected compressor is automatically entered in the appropriate boxes. Also, click on an appropriate button to choose the System Cooling Capacity or System Capacity Multiplier option.

Click on the **OK** button to return to the CYCLE_D main dialog box. The **Cancel** button can be used to cancel the "compressor map" selection and return to the CYCLE_D main dialog box.

Continue to specify cycle parameters by clicking on the **Cycle Data** button, the **C-DATA** icon or the **Window/Cycle Data** menu item in the main dialog box to display the **Cycle Data** dialog box as shown in Figure 6.

The cycle parameters to be entered are: suction and discharge line pressure losses, evaporator and condenser operational conditions, and parameters for cycle auxiliaries. Move from one data value to another using the **ENTER** key, the **TAB** key or the mouse.

Cycle Data

OK Cancel

Refrigerant Data

Comp't No. = 2	Ref.Name	Mass Fraction
1st Component:	R32	.3
2nd Component:	R134a	.7
3rd Component:	XXX	XXX
4th Component:	XXX	XXX
5th Component:	XXX	XXX

Compressor Data

Compressor ID: #1

3-Ton compressor with R32/134a (30/70)

System Cooling Capacity (kW):

Suction Line Pressure Drop

Dew Point Temperature Loss (C):

Discharge Line Pressure Drop

Bubble Point Temp. Loss (C):

Cycle Parameters

Evaporator Dew Point Temp. (C):

Evaporator Superheat (C):

Condenser Bubble Pt. Temp. (C):

Condenser Subcooling (C):

HX, Fans and Controls

Effectiveness of suction/discharge lines HX (Fraction):

Indoor Fan Power (kW):

Outdoor Fan Power (kW):

Power for Controls (kW):

Figure 6. Cycle Data dialog box for the "compressor map" option

Running a Simulation

Click on the **Analyze** control button, the **A** icon, or the **Window/Model Analysis** menu item in the CYCLE_D main dialog box to perform cycle simulations using the selected input data.

Presenting Simulation Results

General Results

When calculations are completed, click on the **Present Results** control button, the **P** icon or the **Window/Results Presentation** menu item in the CYCLE_D main dialog box to display simulation results shown in Figure 7.

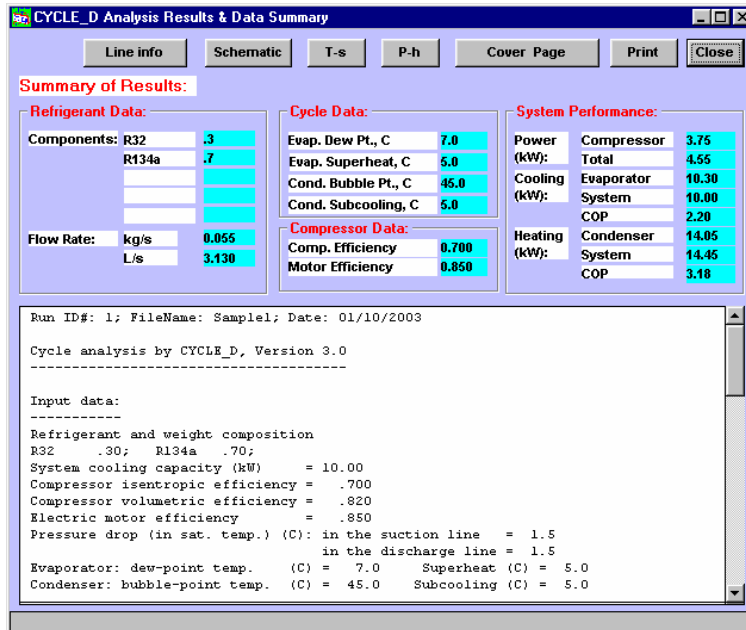


Figure 7. Simulation results window

Note that the scroll bar in Figure 7 can be used to scroll the report on the screen. To obtain a hard copy of the results, click on the **Print** button of the results screen.

A cover page can be prepared using the window that can be accessed by clicking on the **Cover Page** control button of Figure 7.

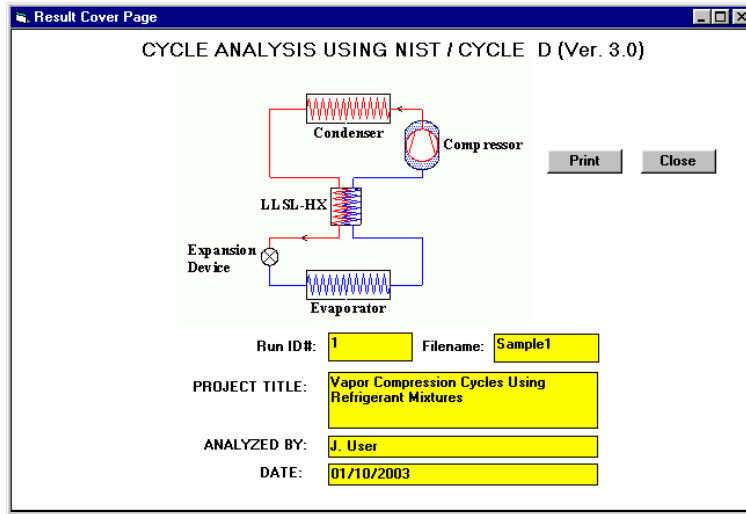


Figure 8. Results Cover Page dialog box

To return to the simulation results window, click on the **Close** button on cover page.

Refrigerant Parameters on a System Schematic

Click on the **Schematic** control button in the simulation results window (Figure 7) to review refrigerant pressure, temperature, enthalpy, and entropy displayed for the cycle key locations on the system schematic.

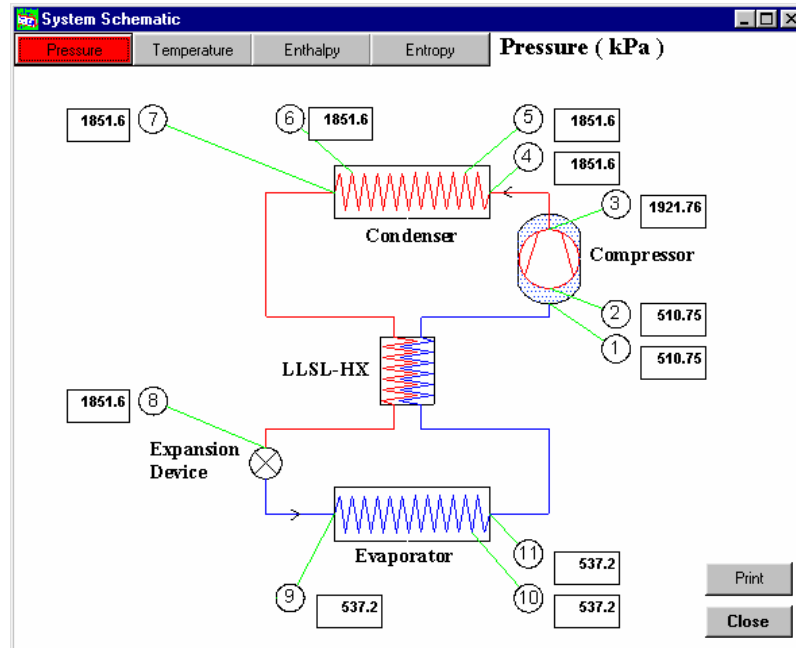


Figure 9. System schematic with refrigerant thermodynamic properties at key locations of the thermodynamic cycle

Temperature-Entropy and Pressure-Enthalpy Diagrams

Click on the **T-s** or **P-h** control buttons in the simulation results window (Figure 7) to display respective thermodynamic diagrams. The **Options** button allows for adjusting the temperature and entropy scales. The **Copy** button copies the plot in the computer's clipboard so that it can be pasted into another application.

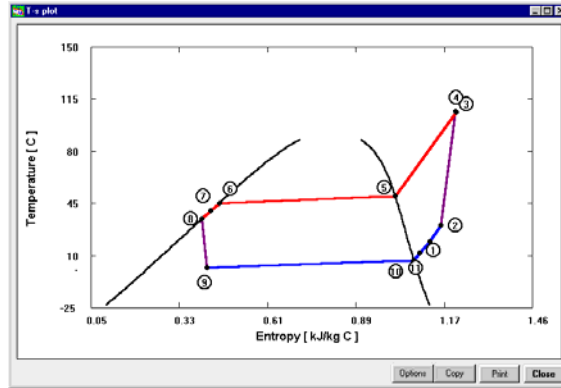


Figure 10. Temperature-entropy diagram

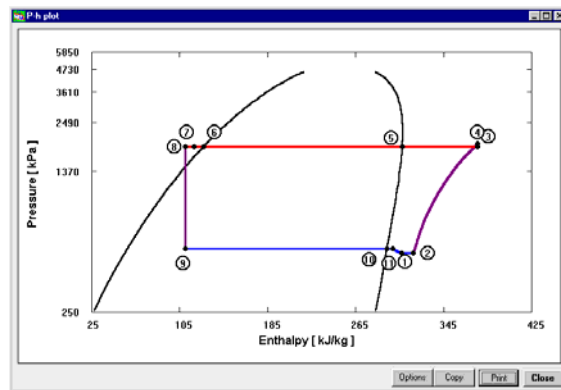
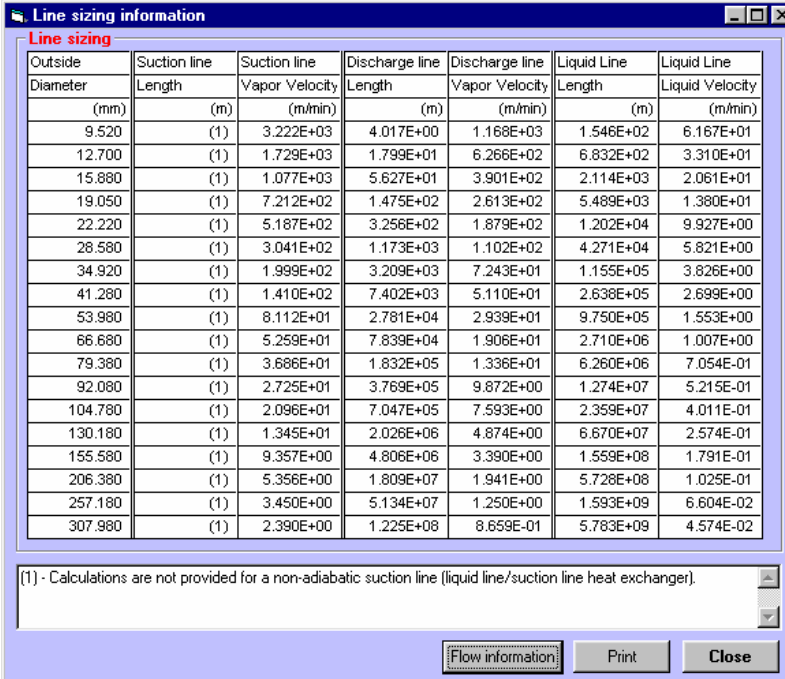


Figure 11. Pressure-enthalpy diagram

Refrigerant Line Sizing Information

Click on the **Line info** control button in the simulation results window (Figure 7) to display refrigerant line sizing information shown in Figure 12. The **Flow information** button opens a window (shown in Figure 13), which displays the refrigerant mass flow rate and pressure drops used in calculations. Tube lengths displayed in Figure 12 are the lengths that realize the pressure drops presented in Figure 13. Hence, these lengths are the maximum tube lengths that can be applied if the pressure drop must not exceed the pressure drop values imposed in the simulation (Figure 13).

Note: The refrigerant line sizing information was generated using several simplifications. This information is included in CYCLE_D for general orientation and should not be used as strict design criteria for field application.



Outside Diameter (mm)	Suction line Length (m)	Suction line Vapor Velocity (m/min)	Discharge line Length (m)	Discharge line Vapor Velocity (m/min)	Liquid Line Length (m)	Liquid Line Liquid Velocity (m/min)
9.520	(1)	3.222E+03	4.017E+00	1.168E+03	1.546E+02	6.167E+01
12.700	(1)	1.729E+03	1.799E+01	6.266E+02	6.832E+02	3.310E+01
15.880	(1)	1.077E+03	5.627E+01	3.901E+02	2.114E+03	2.061E+01
19.050	(1)	7.212E+02	1.475E+02	2.613E+02	5.489E+03	1.380E+01
22.220	(1)	5.187E+02	3.256E+02	1.879E+02	1.202E+04	9.927E+00
28.580	(1)	3.041E+02	1.173E+03	1.102E+02	4.271E+04	5.821E+00
34.920	(1)	1.999E+02	3.209E+03	7.243E+01	1.155E+05	3.826E+00
41.280	(1)	1.410E+02	7.402E+03	5.110E+01	2.638E+05	2.699E+00
53.980	(1)	8.112E+01	2.781E+04	2.939E+01	9.750E+05	1.553E+00
66.680	(1)	5.259E+01	7.839E+04	1.906E+01	2.710E+06	1.007E+00
79.380	(1)	3.686E+01	1.832E+05	1.336E+01	6.260E+06	7.054E-01
92.080	(1)	2.725E+01	3.769E+05	9.872E+00	1.274E+07	5.215E-01
104.780	(1)	2.096E+01	7.047E+05	7.593E+00	2.359E+07	4.011E-01
130.180	(1)	1.345E+01	2.026E+06	4.874E+00	6.670E+07	2.574E-01
155.580	(1)	9.357E+00	4.806E+06	3.390E+00	1.559E+08	1.791E-01
206.380	(1)	5.356E+00	1.809E+07	1.941E+00	5.728E+08	1.025E-01
257.180	(1)	3.450E+00	5.134E+07	1.250E+00	1.593E+09	6.604E-02
307.980	(1)	2.390E+00	1.225E+08	8.659E-01	5.783E+09	4.574E-02

(1) - Calculations are not provided for a non-adiabatic suction line (liquid line/suction line heat exchanger).

Figure 12. Refrigerant line sizing information

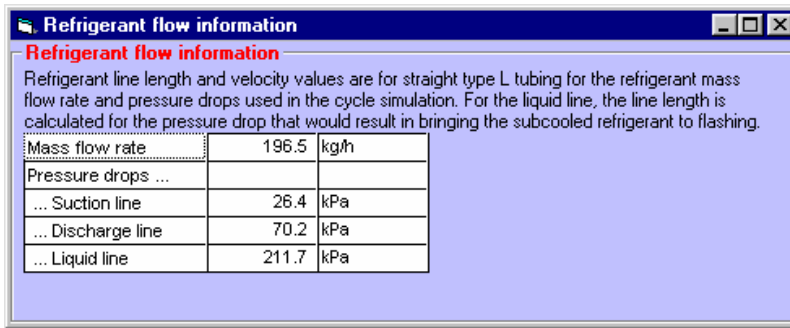


Figure 13. Refrigerant flow information

Managing Files

Saving the Current Input Data Set and Results

Click on the **Save File** control button, the **Disk** icon or the **File/Save** menu item in the CYCLE_D main dialog box to display the **Save File** dialog box shown in Figure 14.

Type in a file name. CYCLE_D adds an extension .mdl to the name when the file is saved. For example, if "Sample1" is typed, the current cycle data and results are saved in file samp1.mdl. At the same time CYCLE_D creates the file sample1.spr in which all the results are saved in one-column format convenient for retrieval by a spreadsheet program.

Click on the **OK** button to return to the CYCLE_D main dialog box.

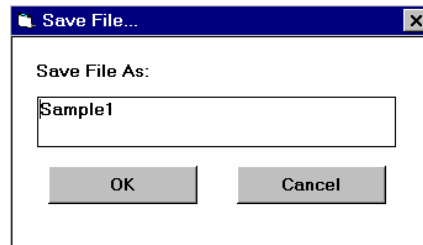


Figure 14. Save File dialog box

Loading a File with an Input Data Set

Previously stored data sets can be retrieved, modified, and used for simulations. To retrieve a data file, click on the **Load File** control button, the **Open File** icon or the **File/Load** menu item in the CYCLE_D main dialog box to display the **Load File** dialog box shown in Figure 15.

Click on the file name to open.

Click on the **OK** button to return to the CYCLE_D main dialog box.

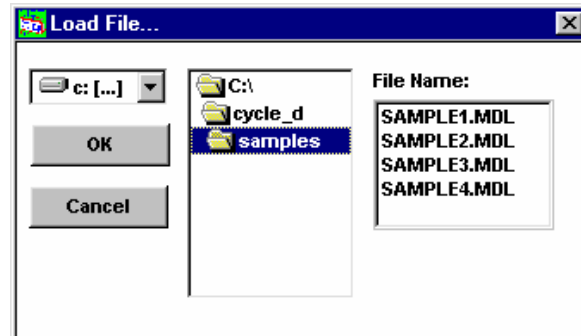


Figure 15. Load File dialog box

Exiting CYCLE_D

Clearing Working Areas

Click on the **New** button, the first icon on the left, or **New** under the **File** menu item in the CYCLE_D main dialog box.

Quitting CYCLE_D Session

Click on the **Quit** button, the **Q** icon or **Exit** under the **File** menu item in the CYCLE_D main dialog box.

Diagnostic Messages

CYCLE_D provides stable solutions if the specified cycle operating conditions do not extend beyond the range for which NIST REFPROP 7.0 property routines were validated for a particular working fluid (pure refrigerant or refrigerant mixture). If a cycle simulation is not successfully completed, diagnostic messages are written in the file ERREF.INF.

Refrigerant property routines can become unstable in the neighborhood of the critical point. If the user-specified condenser temperature results in the dew-point temperature being within 15 °C (27 °F) of the critical temperature, CYCLE_D displays a warning to this effect. Simulations of the transcritical cycle are not allowed.

REFERENCE

[1] Eric W. Lemmon, Mark O. McLinden, Marcia L. Huber, 2002, NIST Reference Fluids Thermodynamic Properties - REFPROP, Ver. 7.0, NIST Standard Reference Database 23, National Institute of Standards and Technology, Gaithersburg, Maryland, U.S.A.

Appendix A

SAMPLE SESSIONS

SAMPLE SESSION 1 - Using the "Compressor Data" Option

On the CYCLE_D main dialog box, select the following options from the toggle indicators: SI Units, Evap. Dew Pt. Temp., Cond. Bbl Pt temp., and Key-In Comp. Data. Then, click on the **Refrigerant Data** button, the **R-Data** icon, or the **Window/Refrigerant Data** menu item. The Input **Refrigerant Data** dialog box is displayed. Enter 2 for the number of refrigerant components in the working fluids. Click on the **Click Me** button next to the entry box. The button under Select Components is now active, and the **Click Me** is displayed as shown in Figure A1.

Select Components:	Mass Fraction	Critical Temp.	Molecular Weight
<Click Me>			
<Click Me>			

Figure A1. Input Refrigerant Data dialog box

Click on the **Click Me** button and the Select Refrigerants dialog box is displayed. Click on refrigerant R32 and enter 0.3 in the Component Mass Fraction entry box as shown in Figure A2.

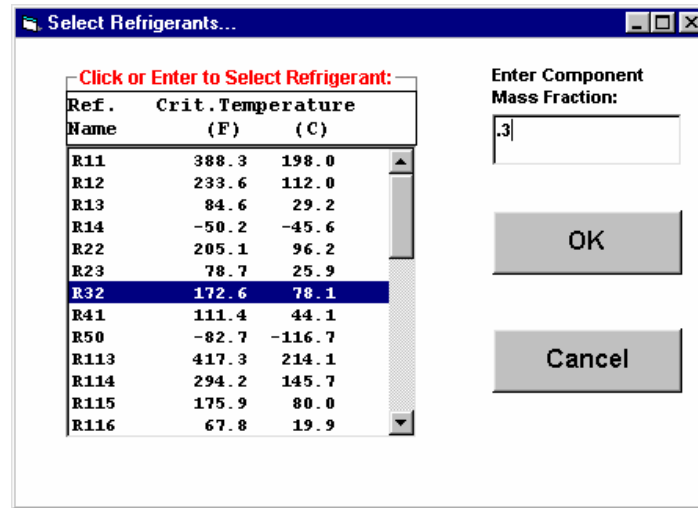


Figure A2. Select Refrigerants dialog box

Click on the **OK** button to return to the Input **Refrigerant Data** dialog box. The information on the first refrigerant is now displayed in the appropriate boxes. Proceed to click on the second button, which has a **Click Me** on it. Double click on R134a in the Select Refrigerants dialog box. The remaining mass fraction is computed automatically and displayed in the Component Mass Fraction entry box.

Click on the **OK** button to return to the **Input Refrigerant Data** dialog box shown in Figure A3. Click on the **OK** button to return to the **CYCLE_D** main dialog box.

Specify Refrigerant Mixture:

Enter Number of Components (1-5):

Select Components:	Mass Fraction	Critical Temp.	Molecular Weight
R32	0.3000	78.1	52.0
R134a	0.7000	101.1	102.0

Sum of Mass Fractions: 1.0000

OK

Cancel

Clear Selection

Figure A3. Input Refrigerant Data dialog box

Next, click on the **Cycle Data** button, the **C-DATA** icon, or the **Window/Cycle Data** and the **Cycle Data** dialog box is displayed. Enter the cycle parameters as shown in Figure A4. The **ENTER** key, the **TAB** key or the mouse can be used to move from one entry box to the next.

Upon completion of cycle data entry, click on the **OK** button to return to the CYCLE_D main dialog box. The **Cancel** button can be used to cancel the cycle data entry.

The screenshot shows a dialog box titled "Cycle Data" with "OK" and "Cancel" buttons at the top right. The dialog is divided into several sections:

- Refrigerant Data:** A table with columns "Comp't No. -", "Ref.Name", and "Mass Fraction".

Comp't No. -	Ref.Name	Mass Fraction
1st Component:	R32	.3
2nd Component:	R134a	.7
3rd Component:	XXX	XXX
4th Component:	XXX	XXX
5th Component:	XXX	XXX
- Compressor Data:**
 - Isentropic Efficiency (Fraction): 0.700
 - Volumetric Efficiency (Fraction): 0.820
 - Electric Motor Efficiency (Fraction): 0.850
 - System Cooling Capacity (kW): 10.00
- Suction Line Pressure Drop:** Dew Point Temperature Loss (C): 1.5
- Discharge Line Pressure Drop:** Bubble Point Temp. Loss (C): 1.5
- Cycle Parameters:**
 - Evaporator Dew Point Temp. (C): 7.0
 - Evaporator Superheat (C): 5.0
 - Condenser Bubble Pt. Temp. (C): 45.0
 - Condenser Subcooling (C): 5.0
- HX, Fans and Controls:**
 - Effectiveness of suction/discharge lines HX (Fraction): 0.300
 - Indoor Fan Power (kW): 0.30
 - Outdoor Fan Power (kW): 0.40
 - Power for Controls (kW): 0.10

Figure A4. Cycle Data dialog box for the "compressor data" option

Click on the **Analyze** button, the **A** icon, or the **Window/Model Analysis**.

When the data analysis is completed, click on the **Present Results** button, the **P** icon, or the **Window/Results Presentation** menu item in the Cycle_D main dialog box to display simulation results (Figure A5).

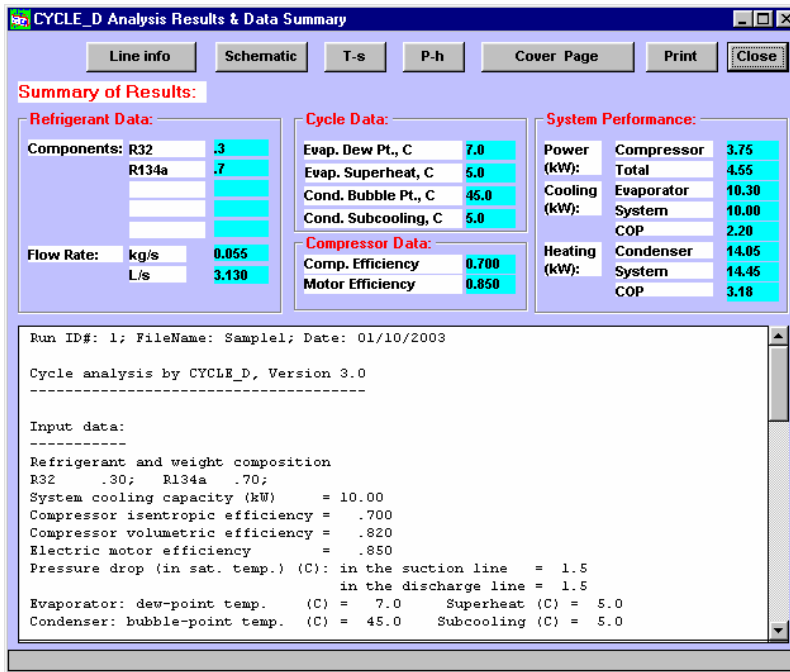


Figure A5. Simulation results window for the "compressor data" option

The scroll bar in Figure A5 can be used to view the rest of the analyzed data. A hard copy of the analyzed data can be obtained by clicking on the **Print** button. Table A1 shows a hard copy of the results obtained for the input data shown in Figure A5. The use of other buttons is explained in the section entitled Running a Simulation (page 13).

Click on the **Close** button to return to the CYCLE_D main dialog box.

Table A1. Hard copy of simulation results for the “compressor data” option

Run ID#: 1; FileName: Sample1; Date: 01/01/2002

Cycle analysis by CYCLE_D, Version 3.0

 Input data:

Refrigerant and weight composition

R32 .30; R134a .70;

System cooling capacity (kW) = 10.00

Compressor isentropic efficiency = .700

Compressor volumetric efficiency = .820

Electric motor efficiency = .850

Pressure drop (in sat. temp.) (C): in the suction line = 1.5

in the discharge line = 1.5

Evaporator: dew-point temp. (C) = 7.0 Superheat (C) = 5.0

Condenser: bubble-point temp. (C) = 45.0 Subcooling (C) = 5.0

Effectiveness of the l1sl heat exchange = .30

Parasitic powers (kW): indoor fan = .300 outdoor fan = .400

controls = .100

-----THERMODYNAMIC CYCLE RESULTS-----

STATE	T (C)	P (kPa)	H (kJ/kg)	V (m ³ /kg)	S (kJ/kg C)	XQ
1 Compr. shell inlet	19.8	510.8	307.0	5.45E-2	1.12945	1.000
2 Cylinder inlet	30.6	510.8	317.3	5.73E-2	1.16398	1.000
3 Cylinder outlet	107.0	1921.8	375.7	1.79E-2	1.21101	1.000
4 Condenser inlet	106.3	1851.6	375.7	1.87E-2	1.21438	1.000
5 Cond. sat. vapor	50.0	1851.6	307.5	1.32E-2	1.01937	1.000
6 Cond. sat. liquid	45.0	1851.6	126.8	9.70E-4	.45583	.000
7 Condenser outlet	40.0	1851.6	118.3	9.47E-4	.42888	.000
8 Exp. device inlet	35.0	1851.6	110.0	9.26E-4	.40236	.000
9 Evaporator inlet	2.1	537.2	110.0	1.14E-2	.41713	.000
10 Evap. sat. vapor	7.0	537.2	293.8	4.81E-2	1.07847	1.000
11 Evaporator outlet	12.0	537.2	298.8	4.95E-2	1.09619	1.000

Work = 68.67 kJ/kg Qevap = 188.73 kJ/kg Qcond = 257.40 kJ/kg
 COPc = 2.748 COPh = 3.748

Two-phase glide: evaporator = 4.9 C condenser = 5.0 C

Condenser superheat = 56.2 C P(3)/P(2) = 3.76

Liquid line subcooling due to l1sl heat transfer = 5.0 C

Suction vapor superheat due to l1sl heat transfer = 8.4 C

Volumetric capacity: cooling heating
 @ vol. eff. = .82 2698.6 kJ/m³ 3680.6 kJ/m³

-----COMPRESSOR AND SYSTEM RESULTS-----

Compressor power = 3.748 kW
 Compressor COP: COPc = 2.748 COPh = 3.748

Refrigerant mass flow rate = 5.4576E-02 kg/s Total power = 4.548 kW

Cooling capacity: evaporator= 10.300 kW system = 10.000 kW

Heating capacity: condenser = 14.048 kW system = 14.448 kW

System COP: COPc,sys = 2.199 COPh,sys = 3.177

SAMPLE SESSION 2 - Using the "Compressor Map" Option

On the CYCLE_D main dialog box, select the following options from the toggle indicators: British Units, Evap. Dew Pt. Temp., and Cond. Bbl Pt temp. Also, click on the **Key-in Comp. Data** to toggle the button to **Use Comp. Maps**. Then, click on the **Compressor Maps** button, the **R-DATA** icon, or the **Window/Compressor Maps** menu item in the main dialog box to display the **Select Compressor Maps** dialog box.

In this dialog box, a compressor and the type of system desired can be chosen by double clicking on the name and single clicking on the proper circular buttons. In this example, the first compressor and the System Cooling Capacity are selected (Figure A6). When the selection is completed, click on the **OK** button to return to the **CYCLE_D** main dialog box. The **Cancel** button can be used to cancel the selection entry.

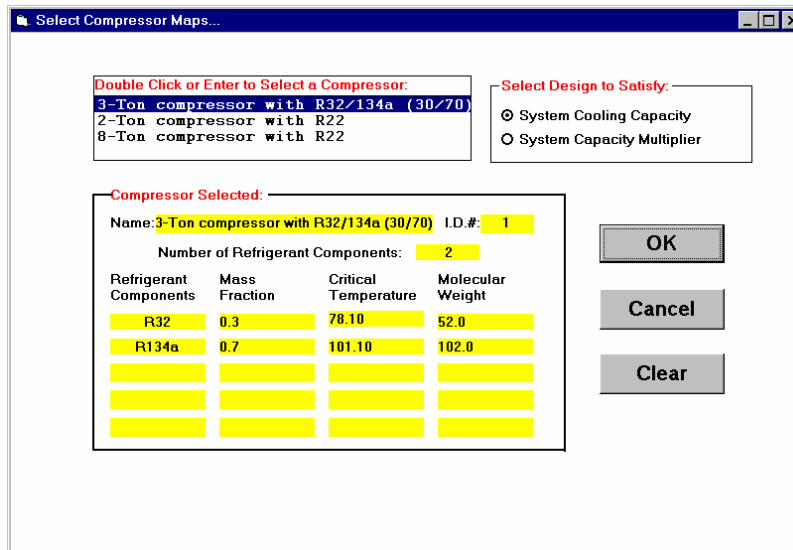


Figure A6. Select Compressor Maps dialog box

Click on the **Cycle Data** button, the **C-DATA** icon, or the **Window/Cycle Data** menu item in the main dialog box, and the **Cycle Data** dialog box is displayed.

Enter the cycle parametric values as shown in Figure A7. Note that the **ENTER** key, the **TAB** key or the mouse can be used to move from entry box to the next. Click on the **OK** button to return to the main dialog box. To cancel the data entry, click on the **Cancel** button.

Refrigerant Data		
Comp't No. -	Ref.Name	Mass Fraction
1st Component:	R32	.3
2nd Component:	R134a	.7
3rd Component:	XXX	XXX
4th Component:	XXX	XXX
5th Component:	XXX	XXX

Compressor Data	
Compressor ID:	#1
3-Ton compressor with R-32/R-134a	
System Cooling Capacity (Tons):	2.84

Suction Line Pressure Drop	
Dew Point Temperature Loss (F):	2.7

Discharge Line Pressure Drop	
Bubble Point Temp. Loss (F):	2.7

Cycle Parameters	
Evaporator Dew Point Temp. (F):	46.4
Evaporator Superheat (F):	10.8
Condenser Bubble Pt. Temp. (F):	131.0
Condenser Subcooling (F):	10.8

HX Fans and Controls	
Effectiveness of suction/discharge lines HX (Fraction):	0.300
Indoor Fan Power (kW):	0.30
Outdoor Fan Power (kW):	0.40
Power for Controls (kW):	0.10

Figure A7. Cycle Data dialog box for the "compressor map" option

Click on the **Analyze** button, the **A** icon, or the **Window/Model Analysis** in the Cycle_D main dialog box.

When the data analysis is completed, click on the **Present Results** button, the **P** icon, or the **Window/Results Presentation** menu item in the Cycle_D main dialog box to display simulation results (Figure A8).

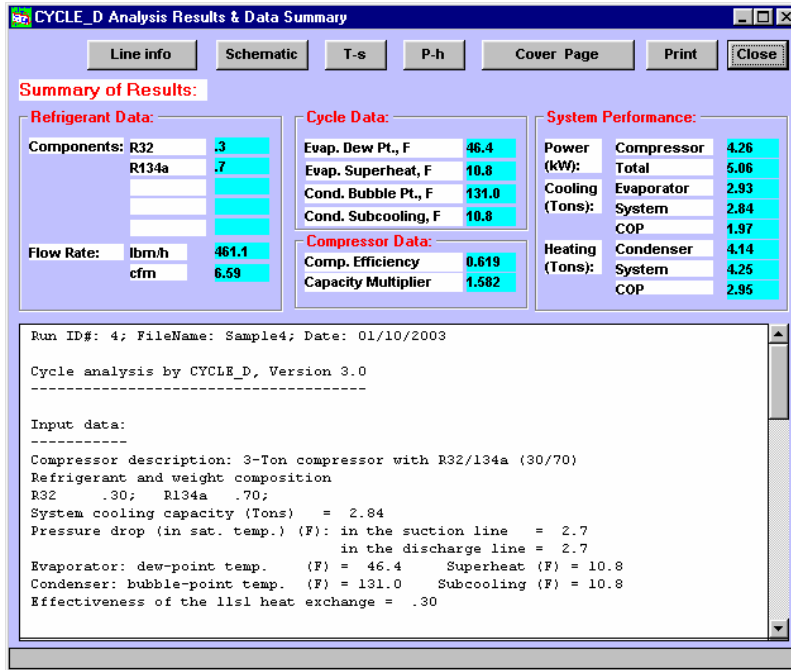


Figure A8. Simulation results window for the "compressor map" option

The scroll bar in Figure A8 can be used to view the rest of the analyzed data. A hard copy of the analyzed data can be obtained by clicking on the **Print** button. Table A2 shows a hard copy of the results obtained for the input data shown in Figure A7. The use of other buttons is explained in the section entitled Running a Simulation (page 13).

Click on the **Close** button to return to the CYCLE_D main dialog box.

Table A2. Hard copy of simulation results for the "compressor map" option

Run ID#: 4; FileName: Sample4; Date: 01/10/2003

Cycle analysis by CYCLE_D, Version 3.0

Input data:

Compressor description: 3-Ton compressor with R32/134a (30/70)
Refrigerant and weight composition
R32 .30; R134a .70;
System cooling capacity (Tons) = 2.84
Pressure drop (in sat. temp.) (F): in the suction line = 2.7
 in the discharge line = 2.7
Evaporator: dew-point temp. (F) = 46.4 Superheat (F) = 10.8
Condenser: bubble-point temp. (F) = 131.0 Subcooling (F) = 10.8
Effectiveness of the l1sl heat exchange = .30

Parasitic powers (kW): indoor fan = .300 outdoor fan = .400
 controls = .100

-----THERMODYNAMIC CYCLE RESULTS-----

STATE	T (F)	P (psi)	H (Btu/lb)	V (ft3/lb)	S (Btu/lb F)	XQ
1 Compr. shell inlet	74.9	76.6	133.5	8.58E-1	.27183	1.000
2 Cylinder inlet	74.9	76.6	133.5	8.58E-1	.27183	1.000
3 Cylinder outlet	244.8	350.8	165.0	2.40E-1	.29012	1.000
4 Condenser inlet	244.8	338.6	165.0	2.40E-1	.29012	1.000
5 Cond. sat. vapor	139.3	338.6	132.4	1.61E-1	.23970	1.000
6 Cond. sat. liquid	131.0	338.6	62.0	1.63E-2	.12147	.000
7 Condenser outlet	120.2	338.6	57.4	1.58E-2	.11349	.000
8 Exp. device inlet	109.5	338.6	53.0	1.53E-2	.10581	.000
9 Evaporator inlet	38.2	80.6	53.0	2.13E-1	.11081	.000
10 Evap. sat. vapor	46.4	80.6	126.5	7.45E-1	.25724	1.000
11 Evaporator outlet	57.2	80.6	129.1	7.71E-1	.26231	1.000

Work = 31.54 Btu/lb Qevap = 76.12 Btu/lb Qcond = 107.66 Btu/lb
 COPc = 2.414 COPh = 3.414
Two-phase glide: evaporator = 8.2 F condenser = 8.3 F
Condenser superheat = 105.6 F P(3)/P(2) = 4.58
Liquid line subcooling due to l1sl heat transfer = 10.7 F
Suction vapor superheat due to l1sl heat transfer = 18.9 F
Volumetric capacity: cooling heating
 @ vol. eff. = 1.00 88.7 Btu/ft3 125.5 Btu/ft3

-----COMPRESSOR AND SYSTEM RESULTS-----

Compressor power = 4.262 kW
Compressor COP: COPc = 2.414 COPh = 3.414
 cfm = 6.593 cfm/ton = 2.254
Isentropic efficiency = .619

Refrigerant mass flow rate = 461.1 lb/h Total power = 5.062 kW
Cooling capacity: evaporator = 35.104 kBtu/h system = 34.080 kBtu/h
Heating capacity: condenser = 49.646 kBtu/h system = 51.011 kBtu/h
 System COP: COPc,sys = 1.973 COPh,sys = 2.953
System capacity multiplier = 1.58

Appendix B

SINGLE-COMPONENT REFRIGERANTS AVAILABLE IN CYCLE_D

<u>Short Name</u>	<u>Full Chemical Name</u>	T _{crit} (°C)	T _{crit} (°F)
R11	trichlorofluoromethane	198.0	388.3
R12	dichlorodifluoromethane	112.0	233.6
R13	chlorotrifluoromethane	29.2	84.6
R14	tetrafluoromethane	-45.6	-50.2
R22	chlorodifluoromethane	96.2	205.1
R23	trifluoromethane	25.9	78.7
R32	difluoromethane	78.1	172.6
R41	fluoromethane	44.1	111.4
R50	methane	-116.7	-82.7
R113	1,1,2-trichloro-1,2,2-trifluoroethane	214.1	417.3
R114	1,2-dichloro-1,1,2,2-tetrafluoroethane	145.7	294.2
R115	chloropentafluoroethane	80.0	175.9
R116	hexafluoroethane	19.9	67.8
R123	1,1-dichloro-2,2,2-trifluoroethane	183.7	362.6
R124	1-chloro-1,2,2,2-tetrafluoroethane	122.3	252.1
R125	pentafluoroethane	66.2	151.1
R134a	1,1,1,2-tetrafluoroethane	101.1	213.9
R141b	1,1-dichloro-1-fluoroethane	204.2	399.6
R142b	1-chloro-1,1-difluoroethane	137.1	278.8
R143a	1,1,1-trifluoroethane	72.9	163.2
R152a	1,1-difluoroethane	113.3	235.9
R170	ethane	32.2	89.9
R218	octafluoropropane	161.5	72.0
R227ea	1,1,1,2,3,3,3-heptafluoropropane	102.8	217.0
R236ea	1,1,1,2,3,3-hexafluoropropane	139.3	282.7
R236fa	1,1,1,3,3,3-hexafluoropropane	124.9	256.9
R245ca	1,1,2,2,3-pentafluoropropane	174.4	346.0
R245fa	1,1,1,3,3-pentafluoropropane	154.1	309.3
R290	propane	96.7	206.1
RC318	octafluorocyclobutane	115.2	239.4
R600	butane	152.0	305.6
R600a	or isobutane 2-methylpropane	134.7	274.5
R717	ammonia	132.3	270.1
R718	water	374.0	705.1
R744	carbon dioxide	31.1	87.9
R1270	or propylene propene	92.4	198.4

Appendix C

FORMAT OF DATA FILE FMAPS

This appendix contains the format of the compressor data file and explanation of the three types of compressor correlations used. Table C1 of this appendix presents an example of file FMAPS.

Format of FMAPS

The format is explained below line-by-line. In the following lines, ALPHA is an alphanumeric input of 27 characters describing a given line input. All inputs are separated by commas.

Line 1: ALPHA, NCOMPR

NCOMPR = number of sets of compressor data coded in this data file

Input data for compressor No. 1

Line 2: ALPHA, N, CNAME

N = compressor ID number (N=1 for compressor No. 1)

CNAME = alphanumerics describing the compressor, up to 40 characters

Line 3: ALPHA, RNAME(1), RNAME(2), RNAME(3), RNAME(4), RNAME(5)

RNAME = mixture component name per Appendix B. Insert a comma for each non-existing component (for mixtures comprising less than five components).

Line 4: ALPHA, XW(1), XW(2), XW(3), XW(4), XW(5)

XW = weight composition (decimal fraction). Input 0. for each non-existing component (for mixtures comprising less than five components).

Line 5: ALPHA, TSUP, TSUB

TSUP = refrigerant superheat at the compressor shell inlet (°F)

TSUB = refrigerant subcooling at the condenser outlet (°F)

Line 6: ALPHA, ICOR

ICOR = type of correlation (explained later in this appendix)

= 1. for the ARI correlation

= 2. for the pressure-based correlation

= 3. for the modified temperature-based correlation

Line 7: ALPHA, QC(1), QC(2), QC(3), QC(4), QC(5)

QC = first five capacity coefficients

Line 8: ALPHA, QC(6), QC(7), QC(8), QC(9), QC(10)

QC = sixth, seventh, eighth, ninth, and tenth capacity coefficient. (Number of coefficients varies with a type of correlation. Input only those needed. Disregard remaining input fields.)

Line 9: ALPHA, PC(1), PC(2), PC(3), PC(4), PC(5)

PC = first five power coefficients

Line 10: ALPHA, PC(6), PC(7), PC(8), PC(9), PC(10)

PC = sixth, seventh, eighth, ninth, and tenth power coefficient. (Number of coefficients varies with a type of correlation. Input only those needed. Disregard remaining input fields.)

Line 11: !

!= exclamation mark in the first column is used to separate data for two compressors. More than one line with the exclamation mark may be used.

Input data for compressor No. 2

Repeat lines 2 through 11

Input data for compressor No. 3 and other compressors

Repeat lines 2 through 11

Compressor correlations

Line 6 of file FMAPS identifies the compressor correlation by the numbers 1., 2. or 3.

Number 1. is reserved for the correlation described by the ARI Standard 540 [1]. The form of the correlation is as follows:

$$X = B1 + B2 \cdot T_s + B3 \cdot T_d + B4 \cdot T_s^2 + B5 \cdot T_s \cdot T_d + B6 \cdot T_d^2 + B7 \cdot T_s^3 + B8 \cdot T_d \cdot T_s^2 + B9 \cdot T_s \cdot T_d^2 + B10 \cdot T_d^3$$

where

B1-B10 = correlation coefficients
 T_s = evaporator average temperature in two-phase region (°F)
 T_d = condenser average temperature in the two-phase region (°F) (note that the definitions for T_s and T_d are expanded here to reflect the current industry practice of testing compressors with zeotropic mixtures)

X = represents (as designated): cooling capacity (W) or power input (W)

Number 2. is reserved for the pressure-based correlation in the following form:

$$X = B1 + B2 \cdot P_d + B3 \cdot P_s + B4 \cdot P_d^{0.9} + B5 \cdot P_s^{0.89} + B6 \cdot P_s \cdot P_d$$

where

B1-B6 = correlation coefficients
 P_s = suction pressure (psia)
 P_d = discharge pressure (psia)
X = represents (as designated): cooling capacity (W) or power input (W)

Number 3. denotes the modified temperature-based correlation in the following form:

$$X = B1 + B2 \cdot T_d + B3 \cdot T_d^2 + B4 \cdot T_s + B5 \cdot T_s \cdot T_d + B6 \cdot T_s \cdot T_d^2 + B7 \cdot T_s^2 + B8 \cdot T_d \cdot T_s^2 + B9 \cdot T_s^2 \cdot T_d^2$$

where

- B1-B9 = correlation coefficients
- T_s = evaporator average temperature in two-phase region (°F)
- T_d = condenser average temperature in the two-phase region (°F) (note that the definitions for T_s and T_d are expanded here to reflect the current industry practice of testing compressors with zeotropic mixtures)
- X = represents (as designated): cooling capacity (W) or power input (kW)

Reference

Positive Displacement Refrigerant Compressors and Compressor Units, Standard ANSI/ARI 540-99, <http://www.ari.org/std/individual/>, Air-Conditioning and Refrigeration Institute, Arlington, VA, 1999

Table C1. An example of the FMAPS file with three types of compressor maps

FMAPS. Number of data sets		,3												
Compressor ID & description		,1,3-Ton compressor with R32/134a												
Mixture components		,R32, R134a,,,												
Weight composition		,.3,.7,0.,0.,0.												
Refrigerant superht,subcool		,20.,15.												
Type of correlation		,1.												
Capacity coefficients		#1-5 ,2.600837E+4,6.325344E+2,-1.879509E+2,3.865663E+0,-3.048128E-1												
Power coefficients		#1-5 ,2.900670E-2,5.791969E-3,1.337252E-2,-2.172101E-2,2.105673E-3												
		,2.527163E+3,2.117606E+1,-4.088669E+1,-3.145744E-1,-1.425794E-1												
		,4.856668E-1,-2.268928E-3,3.730925E-3,1.225102E-3,-1.752733E-3												
		,1.												
Compressor ID & description		,2,2-Ton compressor with R22												
Mixture components		,R22,,,,												
Weight composition		,1,0.,0.,0.,0.												
Refrigerant superht,subcool		,20.,15.												
Type of correlation		,2.												
Capacity coefficients		#1-5 ,6649.24023,347.78201,1043.34998,-679.32202,-907.62701												
Power coefficients		#1-5 ,-.64056												
		,-.1173.55005,-47.60690,-209.98399,86.1496,356.92999												
		,.08501												
1	5	30	35	40	45	50	55	60	65	70	75	80	85	90
Compressor ID & description		,3,8-Ton compressor with R22												
Mixture components		,R22,,,,												
Weight composition		,1,0,0,0,0.												
Refrigerant superht,subcool		,20.,15.												
Type of correlation		,3.												
Capacity coefficients		#1-5 ,.715680E+5,-.390240E+3,-.272030E+0,.223900E+4,-.121320E+2												
Power coefficients		#.161440E-1,.146820E+2,110490E-1,-.258940E-3												
		,.774470E+0,.789630E-1,-.447650E-3,-.880930E-1,-.178110E-2												
		,.437810E-10,-.779540E-3,-.392560E-9,.131150E-11												

Appendix D

NOMENCLATURE USED FOR PRESENTING SIMULATION RESULTS

This appendix presents the symbol convention used for simulation results in the order they appear on the printout. Self-explanatory output is omitted here. Note that the printout varies somewhat between simulation options.

Thermodynamic Cycle Results

T	=	temperature
P	=	pressure
H	=	specific enthalpy
V	=	specific volume
S	=	specific entropy
XQ	=	mass-based quality
Work	=	specific work of compression, $H(3)-H(2)$
Qevap	=	specific evaporator capacity, $H(11)-H(9)$
Qcond	=	specific condenser capacity, $H(4)-H(7)$
COPc	=	coefficient of performance in the cooling mode
COPh	=	coefficient of performance in the heating mode
Two-phase glide, evaporator	=	temperature difference between saturated vapor and evaporator inlet, $T(10)-T(9)$
Two-phase glide, condenser	=	temperature difference between saturated vapor and saturated liquid, $(5)-T(6)$
Condenser superheat	=	temperature difference between condenser inlet and saturated vapor, $T(4)-T(5)$
$P(3)/P(2)$	=	compression pressure ratio
Volumetric capacity, cooling	=	$Q_{evap}/V(2)$
Volumetric capacity, heating	=	$Q_{cond}/V(2)$

Compressor and System Results

cfm = compressor volumetric output

cfm/ton = $\text{cfm}/(\text{cooling capacity of evaporator in tons})$
{1 ton = 12000 Btu/h}

Total power = sum of powers of compressor, indoor fan, outdoor fan,
and controls

$\text{COP}_{c,\text{sys}}$ = $(\text{system cooling capacity})/(\text{total power})$

$\text{COP}_{h,\text{sys}}$ = $(\text{system heating capacity})/(\text{total power})$

Appendix E

FREQUENTLY ASKED QUESTIONS

There are a number of built-in checks and warnings in CYCLE_D. Efforts have been made in developing the system to make the checks self-explanatory. Presented below are: (1) an explanation of consistency in units, (2) some examples of the run time checks and warnings, and (3) common errors and courses of action.

(1) Systems of Units

Users may select either British or SI units.

British Units:

By selecting "British units," **temperatures** are entered in **degrees F**.

SI Units:

By selecting "SI units," **temperatures** are entered in **degrees C**.

Common Bases:

In both systems, mass composition and efficiency values are entered as decimals not greater than unity. (**Note, decimals, not percent**)

(2) Checks And Warnings

The following are examples of checks and warnings built into the CYCLE_D system:

1. In selecting the number of refrigerants in the mixture, the number must be from 1 to 5.
2. When one refrigerant is selected twice in a model, a warning is given.
3. If the sum of refrigerant mass fractions is greater than unity, data are rejected and a warning is issued.
4. Compressor isentropic efficiency values must be greater than or equal to one half and less than or equal to unity.
5. Compressor volumetric efficiency values must be greater than or equal to one half and less than or equal to unity.
6. Compressor motor efficiency values must be greater than or equal to one half and less than or equal to unity.
7. The suction line dew point temperature loss must be less than the refrigerant critical temperature.
8. The discharge line bubble point temperature loss must be less than the refrigerant critical temperature.
9. The bubble point temperature of refrigerant in the condenser must be greater than the dew point temperature of refrigerant in the evaporator.
10. The CYCLE_D control buttons, icons and file options are sequentially enabled and disabled to ensure orderly processing of data entry, cycle analysis and file management.

(3) Troubleshooting Guide

Common Errors

Solutions

Text Box of results Window is empty.

Simulation calculations are still in progress. Wait for calculations to finish and then request results presentation.

or

The input data set is incomplete. Go back to the CYCLE_D main dialog box. Press the refrigerants And compressor buttons to check and complete input data specification.

Mathematical Error occurs.

Units inconsistency, (e.g., under British system of units, temperature was entered in degrees K). Check and correct wrong entries.

or

Specified evaporator or condenser saturation temperature is too low for the refrigerant selected (it may be below the triple point). Make sure that the assigned operational conditions are appropriate.

or

Operating conditions outside the range for which REFPROP property routines were validated for the selected refrigerant. Check diagnostic messages written in file ERREF.INF.

Calculations do not start.

Insufficient computer memory size for performing cycle simulation. Install additional RAM or re-configure the computer to optimize the memory usage.

or

Attempt to run two CYCLE_D packages at the same time. Close extra models or exit windows and start again.

Appendix F

CONTACTS

If you have comments or questions about the database, the Standard Reference Data Program would like to hear from you. Also, if you should have any problems with the diskettes or installation, please let us know by contacting:

Joan Sauerwein
National Institute of Standards and Technology
Standard Reference Data Program
100 Bureau Drive, Stop 2310
Gaithersburg, MD 20899-2310
Phone: (301) 975-2008
Fax: (301) 926-0416
Website: <http://www.nist.gov/srd>

If you have questions or problems pertaining to the data or use of the database program, contact:

Piotr A. Domanski
National Institute of Standards and Technology
Building and Fire Research Laboratory
100 Bureau Drive, Stop 8631
Gaithersburg, MD 20899-8631
e-mail: piotr.domanski@nist.gov