Compressor Performance Module

QUATRIX, Inc.

CONTENTS

RECIPAK II: A reciprocating compressor performance program for HP-41 series programmable calculators.

INTRODUCTION

With the purchase of the RECIPAK II program you have access to compressor performance capabilities that have until now been available only on main frame computers. Today, your HP-41 calculator provides a programmed solution to these complex calculations, which through the use of simple prompts, can be used by anyone, regardless of their compressor background.

This manual provides a description of the RECIPAK II program, a set of instructions for using the program, and many example problems, each of which includes a list of keystrokes required for its solution.

RECIPAK II

For a given compressor configuration (either 1, 2, or 3 stage) the program will calculate the CAPACITY and HORSEPOWER for fixed cylinder clearances. Or the program will calculate the required stage 1 clearance to achieve a desired CAPACITY or HORSEPOWER. For 2 and 3 stage compressors the interstage pressures are calculated. For each stage the program calculates inlet CFM, BHP, discharge temperatures, gas compressibilities, and cylinder gas loads.

In addition, the program will correct for water moisture content in each stage; allow the user to specify interstage pressure drops; accomodate multiple cylinders per stage and multiple arrangements of single and double acting cylinders.

All stored data is common to all subprograms. The program is structured with a core of common subroutines and select program options. This ensures maximum flexibility in program use and the evaluation of data with only a minimum set of program commands by the user.

The gas compressibility routine is very accurate for Natural Gas and suitable for a wide range of other gases including CO2 and propane.

All data is retained in registers allowing multiple program runs without reentering of any data. The data for each stage can be used individually or the data can be directly treated as multistage. A data load routine allows quick, sequential input/review of all data registers. A print routine allows hardcopy printout of all data relative to any individual stage or all stages together.

The manual contains many examples of typical compressor applications. The examples include sample input forms, program operating instructions, and the completed performance forms.

Before plugging in your Performance Module, turn the calculator OFF and read the section on Inserting and Removing Application Modules. Before using a particular program, take a few minutes to read the User Instructions and the section on Program usage.

You should first familiarize yourself with a program by running it once or twice while following the complete user instructions in this manual. Thereafter, the program's prompting should provide the necessary instructions; including which variables are to be input, which keys are to be pressed, and which values will be output.

DISCLAIMER

This program was written to provide estimates of reciprocating compressor performance over the widest range of possible operating conditions. The program has been extensively tested and shown to be accurate for general use with most compressor product lines. The program should be checked against the manufacturer's published data to confirm applicability to individual installations. Unusual operating conditions should be verified by the compressor manufacturer.

The RECIPAK II program is not endorsed by any compressor manufacturer. QUATRIX, Inc. assumes no responsibility and shall have no liability from the use of this program or any part thereof.

INSERTING AND REMOVING THE PERFORMANCE MODULE

Read the following instructions before inserting the Performance Module for the first time.

CAUTION

Always turn the HP-41 calculator OFF before inserting or removing any plug-in extension or accessories. Failure to turn the HP-41 OFF could result in damage to both the calculator and the accessory.

To Insert The Performance Module

1) Turn the HP-41 OFF!

2) Remove a port cover. Save the port cover to insert into the empty port when the Performance Module is removed.

3) Insert the Performance Module into the selected port. For HP-41C model calculators the Performance Module must be inserted into a port after the last Memory Module. For example, if a Memory Module is inserted in port 1, then the Performance Module can be placed into any of ports 2, 3, or 4. The port numbers are shown on the back of the calculator. Do not place the Performance Module in a lower numbered port than a Memory Module.

4) Additional application modules can be placed into any port after the last Memory Module. Place port covers over unused ports.

5) Turn the calculator ON and follow the instructions given in this manual for the desired application programs.

To Remove the Performance Module

1) Turn the HP-41 Off! Failure to do so could damage both the calculator and the Module.

2) Grasp the Performance Module handle and pull it from the calculator.

3) Place a port cover into the empty port.

MIXING MEMORY MODULES AND APPLICATION MODULES

Optional accessories, such as the card reader, printer, etc, should be treated in the same manner as an Application Module. That is, they can be placed into any port (and in any order) after the last Memory Module. Also, the HP-41 should be turned OFF before insertion or removal of any accessory.

The HP-41 will also permit gaps in the port sequence when mixing Memory and Application modules. For example, a Memory Module can occupy port 1 with an Application Module in port 4. Ports 2 and 3 could be empty.

PROGRAM USAGE

CATALOG

Use CATALOG 2 to view the program labels in the Performance Module. The program labels can be listed to the calculator display or to the optional printer.

USE OF LABELS

The Performance Module contains multiple subroutines. These routines may require certain flags to be set and require certain data to be stored in specific registers. Thus, these routines are not normally available to the user.

The user should avoid writing or using programs in the calculator which duplicate labels contained in this application module. A complete listing of all program lables is contained in the appendix.

KEY ASSIGNMENT AND USER MODE

This set of application programs does not require the USER MODE to be set. However, if desired, any of the primary program labels can be assigned to user designated keys. This allows for customization of the keyboard to each user's convenience. Refer to the HP Owner's Handbook for complete information on key assignments.

XEQ, ALPHA, and R/S NOTATION

Whenever a statement on the User Instructions says XEQ, ALPHA, or R/S, it means that these labeled keys on the HP-41 are to be pressed. This set of application programs does not require any ALPHA input. ALPHA is only used to provide a name for the program to be executed. To execute any of these programs key as follows:

XEQ ALPHA program name ALPHA

This means that the user is to press the XEQ key, then the ALPHA key, then the individual letters to spell out the specified function or program name, and then the ALPHA key.

PROMPTED OPERATION

Prompts are simply requests for information. The information requested is either an answer to a question ('Y' for yes; 'N' for no) or a request for numeric data.

The clear prompt is 'CLEAR? Y/N:N'. The calculator will stop with this prompt in the ALPHA mode. Keying 'Y' will clear the data registers before continuing with the program. Keying any response other than 'Y' will accept the default 'N' and proceed with the program without clearing the data registers.

A prompt with a numeric value indicates that the memory register associated with the prompt contains the value as displayed. If the value is appropriate for the problem, then press R/S to acknowledge the correct value and wait for the next prompt. If the value is not correct, key in the correct value and follow it with a R/S. The program will store the corrected value and proceed to the next register.

PROGRAM INTERRUPTIONS

These programs have been designed to operate properly without interruption except for initial prompting. There may be instances where you want to change data after program execution has started. Simply press R/S to stop program execution. This does not affect the program, although certain data registers may have been overwritten with calculated data and certain flags may have been set. The program will reset all required flags at the beginning of each run and will also overwrite the proper registers with newly calculated data. User specified input is not affected.

USING OPTIONAL PRINTER

The optional printer can be used to keep a permanent record of the values used in the program calculations. The programs in the Performance Module were designed for use with the printer to be set in the 'MAN' mode. With the printer plugged in and the print mode set to 'NORM' all input values and the corresponding keystrokes will be listed on the printer.

DATA VALIDITY

The program does not check input data for validity. That is, if a data register contains incorrect or unreasonable data, the program will run to completion - assuming no arithmetic errors are made. Examples of unreasonable input are: a piston rod greater than the piston diameter; a negative cylinder diameter; etc.

CLEARANCE

The program will calculate the required average clearance when CAPACITY or BHP are given. No checks are made on clearances so that the calculated clearance may be less than the cylinder base clearance or may even be negative. It is up to the operator to determine if the specified CAPACITY/BHP must be reduced or if the cylinder diameter increased.

VOLUMETRIC EFFICIENCY

There are cases where the specified CAPACITY/BHP would result in gas 'blowing' through an upper stage. There may also be cases where the stage cylinder(s) are not adequate to handle the specified CAPACITY or BHP. These case are indicated by a required volumetric efficiency (VE) in excess of 100%. The program does check VE and will stop anytime any stage or stages have a VE greater than 100%. When the program stops it will display the message "VE > 100%". It is up to the operator to determine if the specified CAPACITY or BHP must be reduced; the cylinder diameter increased; or the compressor operated at base clearances.

CALCULATION ACCURACY

The program uses an iterative routine to balance the compressor when CLEARANCE or BHP are given. Thus, it may be noted that the final CLEARANCE or BHP may be slightly different from the given input values. This difference will be within the specified program accuracy. The number of iterations and the program run time are dependent on the number of digits specified during program operation. The program was written with a display of 'FIX 2'. This may be adjusted by the user by specifying the display format when keying in the stage number in response to the 'STGS' prompt.

For example, to specify 'FIX 3' in EXAMPLE 2

key XEQ ALPHA CLR ALPHA

The program will prompt 'STGS'

key 1 CHS FIX 3 R/S

The program will default to FIX 2 unless specifically set to another format as described above for each run. Note that changing the display format to 3 decimal places does not imply improved accuracy to 3 decimal places in the final results. All calculated values should be appropriately rounded off. For example, 454.843 BHP should be rounded to 455 BHP.

RUNNING TIME

The running (calculating) time for a compressor problem will depend on the display format and the various subroutines required to solve the problem. Single stage problems will run faster than multistage configurations. In general, solving for a given capacity is quicker than solving for either HORSEPOWER or CLEARANCE. This is because most solutions require a first approximation and then several iterations to converge to an acceptable 'answer'. The solution routines are very efficient and most problems converge on the third or fourth iteration. The approximate running time is listed with each example problem.

Note that the running (calculating) time will be subtantially lengthened when the printer, and some other peripherals, are plugged into the calculator. This is true whether the printer is ON or OFF.

SIZE

The minimum number of data storage registers necessary to execute the RECIPAK II program is 065. All data input routines will automatically check the register size. For the HP-41CX and the HP-41C/CV with an Extended Functions Module, the register size is set at 065. Otherwise a message is displayed prompting for setting the size = 065. You may then allocate the proper number of registers and re-execute the program without consequence. Refer to the HP owner's handbook for information on the SIZE function.

COMPLETING THE INPUT FORM
DEFINITION OF TERMS

COMMON DATA: REGISTERS 01 TO 10

REG		
01	CAP	CAPACITY in MMSCFD (dry) at 14.7 PSIA and 60 deg F
02	BHP	BHP - Total Compressor HP including gas horsepower, valve losses, and compressor friction including bearings, crosshead, rings, and packing.
03	STR	Compressor piston stroke in inches.
04	RPM	RPM - Compressor operating speed.
05	ROD	Piston rod diameter in inches.
06	SG	Specific Gravity of gas being compressed.
07	K	K-value. Ratio of specific heats of the gas being compressed - usually at an average cylinder temperature of 150 deg F. If the gas consists of only 1 constituent, then the K-value may be obtained by determining the discharge temperature from a temperature - entropy (T-S) chart for that specific gas and solving for K.
08	Pc	Pseudocritical pressure of the gas mixture, in PSIA.
09	Tc	Pseudocritical temperature of the gas mixture, in deg Rankine. Note: K-value, Pc, and Tc for gas mixtures can be calculated in the 'GASES' or 'SG' programs contained in this application module.
10	RH%	Relative Humidity - percent relative humidity of the gas at stage 1 inlet conditions. The dry capacity stored in register 01 is converted to ACFM (wet) at the inlet to each stage. The program works only for 0% or 100% R.H. Any other input value will be assumed to be 100%.

INDIVIDUAL STAGE DATA

registers

11, 25, 39 Pi — Inlet pressure at intake flange of compressor cylinder (PSIA). When the line pressure is given then the inlet pressure should be adjusted to allow for the pressure loss through the pulsation bottle. For a 1% bottle drop use 0.99 X Pi for the pressure at the inlet flange.

12, 26, 40 Ti — Inlet temperature at intake flange of compressor cylinder (deg F). At low temperatures correct for preheat effects. This is always a user input value.

13, 27, 41 Zi — Compressibility of gas at specified inlet pressure and temperature. This is always a program calculated value.

14, 28, 42 Pd — Discharge pressure at discharge flange of the compressor cylinder (PSIA). When the line pressure is given the discharge pressure should be adjusted to allow for the pressure loss through the pulsation bottle. For a 1% bottle drop use 1.01 X Pd for pressure at the discharge flange.

15, 29, 43 Td — Discharge temperature - theoretical adiabatic gas discharge temperature in deg F. The actual operating temperature can be higher or lower than this theoretical value depending on cylinder construction, cooling method (forced, static, etc). This is always a program calculated value.

16, 30 PD% — Interstage pressure drop between stages due to piping, coolers, etc. This value is in % of interstage pressure. This is always a user input value.

17, 31, 45 DIA — Cylinder diameter for each stage, in inches. Even if there are multiple cylinders on a stage, input only the diameter for a single cylinder. This is always a user input value.

18, 32, 46 DISPL — Actual piston displacement for this stage in cubic feet per minute. This entry allows input for multiple cylinders and different cylinder configurations. That is, if there is one cylinder operating singly on the frame end then the input is the piston displacement for that frame end only. If there are multiple cylinders then input the total displacement for all operating ends. If there are two cylinders - one double acting and one single acting - then enter the piston displacement for the 3 operating cylinder ends. Piston displacement varies directly with changes in operating RPM. This is always a user input value.

COMPLETING THE INPUT FORM
DEFINITION OF TERMS

INDIVIDUAL STAGE DATA

registers

19, 33, 47 VS — Valve speed - API average cylinder valve gas speed in feet per minute. Calculate from formula or obtain from a compressor cylinder lineup. This value can be rounded off to the nearest 100 feet per minute; i.e. use 3600 for a valve speed of 3645. Valve speed varies directly with changes in operating RPM. This is always a user input value.

20, 34, 48 CLR% — Average cylinder clearance in % of total swept volume. Minimum cylinder clearances should be obtained from a compressor cylinder lineup. Check with the manufacturer for maximum clearances that can be added to a cylinder. It is not always practical, nor advisable, to add clearance to a cylinder frame end.

21, 35, 49 ICFM — ACFM - actual cubic feet per minute at inlet conditions to each compressor stage. This is a (wet) value corrected for the specified R.H. %. This is always a program calculated value.

22, 36, 50 FHP — Friction HP per stage. This is the frame friction HP including bearing and crosshead friction. This friction HP is assumed to vary directly with changes in operating RPM. This friction HP value can be adjusted to account for special parasitic losses, e.g. engine fans, water pumps, etc. This is always a user input value.

23, 37, 51 BHP — BHP per stage. This is the total BHP for each stage. This is always a program calculated value.

24, 38, 52 GL — Gas Load - This is the cylinder piston rod load due to the differential gas forces acting on the piston areas. This value is the gas load in pounds for one double acting cylinder. This is always a program calculated value.

GENERAL COMMENTS ON PERFORMANCE CALCULATIONS

Compressors with side streams (in or out) must be treated as two compressors with separate calculations for each. Compressors with more than 3 stages should be separated and treated as individual compressors. For example, a four stage compressor could be treated as (2) two stage compressors or as (1) 3 stage and (1) single stage compressors.

After completing a performance problem, review the data checking that the unit or compressor design limitations are not exceeded. Recommended check points are:

1) Cylinder discharge pressures must be less than or equal to the cylinder's rated operating pressure. Remember pressures used in performance calculations are in PSIA while cylinder ratings are usually listed in PSIG.

2) Rod load due to gas forces should be below the maximum allowable rod load for each frame type. It may become necessary to compute the 'net' rod load considering inertia forces. Also, if 'reversal' is suspect, a net rod load diagram may have to be constructed. These conditions should be referred to the compressor manufacturer.

3) Compressor cylinder differential pressure should be less than or equal to the compressor valve differential pressure rating.

4) BHP/THROW should be below the normal maximum value for each frame type.

5) Gas discharge temperatures should be less than the limits recommended by the compressor manufacturer for the gas mixtures and cylinder materials.

6) Volumetric efficiency should generally be greater than 20% per cylinder end.

7) Operating conditions with intake pressures less than 20 PSIA or stage compression ratios less than 1.5 usually require special consideration by the manufacturer's performance programs.

Recipak II Compressor Performance

PROJECT ID _____ DATE _____

PROJECT REF# _____ PERF BY _____

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01		SP. GRAVITY	*06	
HORSEPOWER	02		K-VALUE	*07	
STROKE	*03		CRITICAL PRESS	*08	
RPM	*04		CRITICAL TEMP	*09	
ROD DIA	*05		REL HUMIDITY %	*10	

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	11		25		39	
INLET TEMP	12		26		40	
INLET COMPRS	13		27		41	
DISCH PRESS	14		28		42	
DISCH TEMP	15		29		43	
INTERSTG PD%	16		30		44	
CYL DIA	17		31		45	
CYL DISPL	18		32		46	
VALVE SPEED	19		33		47	
CLEARANCE PCT	20		34		48	
ICFM	21		35		49	
FHP/STG	22		36		50	
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

OPERATING INSTRUCTIONS - PROGRAM 'PDATA'

Introduction

Program 'PDATA' is used to load data into registers for use by the RECIPAK II performance program. The program will prompt for the required input data using English label prompts. For data in stages 1, 2, or 3 the prompt is preceeded by the stage number. This eliminates potential confusion as to which stage the data prompt refers to. The program is for data input and review and does not use the printer, although the printer may remain connected and used in other programs. Program 'PRINT' should be used for hardcopy printout of the performance data registers.

Data values will be displayed with one to three decimal places. Entering the stage number as a negative value (i.e. -1, -2, or -3) will display data values to 3 decimal places. When a data value is displayed, the program will sound a tone indicating the value may be retained or changed. The tone can be turned off by clearing Flag 26.

OPERATING INSTRUCTIONS - PROGRAM 'PDATA'

1 Initialize program
XEQ ALPHA PDATA ALPHA

CLEAR? Y/N:N

2a Key 'Y' to clear the data registers
Y R/S

2b Key R/S to retain all values in data registers
R/S

VIEW STAGE?

3 Key in stage number to be reviewed where n = the stage number
n R/S

n = 0 will prompt for data in registers 1 to 10
1 will prompt for data in registers 11 to 24
2 will prompt for data in registers 25 to 38
3 will prompt for data in registers 39 to 52

saa = XX.X
s is the stage number, 0 does not display as a prefix when viewing data in registers 1 to 10;
aa is the labeled prompt;
XX.X is the register value.

4a If the value displayed is appropriate to the problem, then press R/S to acknowledge the correct value and proceed to the next register. Note: some registers will contain only program calculated values, so no input is required. Key R/S only to proceed to the next register.

4b If the value displayed is not correct, key in the correct value and key R/S to store the corrected value in the current register.
XX.X R/S

5 The program will go to step 4 for sequential review of each data register in the selected stage. When the stage review is complete the program will go to step 3.

OPERATING INSTRUCTIONS - PROGRAM 'CLR', 'CAP', 'BHP'

Introduction

The 'CLR', 'CAP', 'BHP' performance programs use data previously stored by the 'PDATA' program to calculate the performance values for reciprocating compressors. The programs will provide full performance calculations for 1, 2, or 3 stage compressor configurations. See the performance worksheet and its instructions for the data which the program requires for its calculations. The results of the calculations are stored in the appropriate registers and the program stops - displaying the BHP, CAPACITY, and stage 1 CLEARANCE.

The individual data registers can be accessed directly or program 'PDATA' or 'PRINT' can be used to review/display both input and output data.

OPERATING INSTRUCTIONS

1. Complete the compressor performance worksheet.
   See the section on 'Completing the Input Form' for instructions regarding the individual entries.

2. Load Data into the Registers.
   See program 'PDATA' for instructions on loading data into the registers using the English prompts.

   a) Enter Common Data into registers. Registers 03 to 10 are common to all single and multistage calculations.

   b) Enter Individual Stage Information.

3. Execute the program.

   Program 'CAP'
   uses register 01 - MMSCFD (dry) at 14.7 PSIA and 60 deg F
   This data is required only if program 'CAP' is selected, i.e. the program will calculate BHP and stage 1 CLEARANCE when the specified compressor configuration is operating at this total capacity.

   Program 'BHP'
   uses register 02 - total compressor BHP.
   This data is required only if program 'BHP' is selected, i.e. the program will calculate CAPACITY and stage 1 CLEARANCE when the specified compressor configuration is operating at this total BHP.

Program 'CLR'

Multistage uses register 20 - average stage 1 cylinder clearance in percent.

Single stage uses one of registers 20, 34, or 48 - average cylinder clearance in percent.

The 'CLR' program will calculate the CAPACITY and BHP when the specified compressor configuration is operating at the clearances given for each individual stage.

4. 'STGS' PROMPT

Single stage

Single stage calculations may be performed on any of the three sets of registers.

at the 'STGS' prompt entering a -1 will use registers 11 to 24
entering a -2 will use registers 25 to 38
entering a -3 will use registers 39 to 52

Multistage:

two stage configurations will use registers 11 to 38
three stage configurations will use registers 11 to 52

at the 'STGS' prompt entering a 1 will use registers 11 to 24
entering a 2 will use registers 11 to 38
entering a 3 will use registers 11 to 52

Examples of each program option are given. These examples include the required input and the required keystrokes. For each example, the required input is marked with an '*' on the example worksheet. Each example includes a page 'A' and a page 'B'. Page A shows the data in each register before the performance calculation. Page B shows the data in all registers after the performance run.

We suggest that the user actually load the example input and perform the keystrokes for solution to gain familiarity with program operation.

OPERATING INSTRUCTIONS - PROGRAM 'PRINT'

Introduction

The program 'PRINT' is used to provide a labeled, hardcopy printout of the data register values used in the compressor performance programs (CAP, CLR, and BHP). If the printer is plugged in, the values for each selected stage are printed. Entering the stage number as a negative value (i.e. -1, -2, or -3) will print the data values to 3 decimal places.

Prompted Operation

1 Plug in printer and set to 'MAN' mode.

2 Initialize program
XEQ ALPHA PRINT ALPHA

PRINT STAGE?

3 Key in the stage number to be printed.
n R/S

n = 0 will print data in registers 1 to 10
1 will print data in registers 11 to 24
2 will print data in registers 25 to 38
3 will print data in registers 39 to 52

After each listing the program will return to step 3 for additional listings. Stage listings do not have to be sequential - they are specified individually and may be in any order.

OPERATING INSTRUCTIONS - PROGRAM 'GDATA'

Introduction

Program 'GDATA' is used to load data into registers for use by the 'GASES' gas properties program. The program will prompt for each gas in the gas mix using English label prompts. The required input is the mol % (volume percent) of each gas in the gas to be analyzed. The sum of the inputs should total 100%. The program does not check for this total and will not provide any corrections.

For each gas type the program will display the gas name and the mol % currently assigned to that gas. When the data value is displayed, the program will sound a tone indicating the value may be retained or changed. The tone can be turned off by clearing Flag 26.

The program is for data input and review. If the printer is plugged in, the program will print the gas name and mol % for all gases in the mix which are not equal to zero. The gas value is printed for each gas when its value is changed or added. If the printer is not used, then the values are displayed on the calculator. All data values are displayed to 3 decimal places.

The program uses registers 11 to 35 for storage and thus, may write over data used by other programs. Usually though, the 'GASES' program is run first followed by multiple compressor performance runs.

OPERATING INSTRUCTIONS - PROGRAM 'GDATA'

1 Initialize program
XEQ ALPHA GDATA ALPHA

CLEAR? Y/N:N

2a Key 'Y' to clear the data registers
Y R/S

2b Key R/S to retain all values in data registers
R/S

% GAS = XX.X
Gas is the gas name;
XX.X is the mol % of that gas stored in the current register.

3a If the value displayed is appropriate to the problem, then press R/S to acknowledge the correct value and proceed to the next register.

3b If the value displayed is not correct, key in the correct value and key R/S to store the corrected value in the current register.
XX.X R/S

4 The program will go to step 3 for sequential review of each data register in the selected stage. When the last gas is displayed, the program will return to step 2.

If the printer is plugged in, all non-zero gases and their values will print for hardcopy output.

OPERATING INSTRUCTIONS - PROGRAM 'GASES'

Introduction

The 'GASES' program uses data previously stored by the 'GDATA' program to calculate properties of a gas mixture. The properties calculated are:

> Total mol %; specific gravity (AIR = 1.0); k-value; pseudo-critical pressure and temperature; low heat value; and high heat value.

The properties required by the compressor performance program are automatically stored into the correct registers for later use. The stored values are the specific gravity, k-value, and pseudocritical pressure and temperature.

If the printer is plugged in, the program will provide a printout of each calculated gas property. If the printer is not used, then the values are displayed on the calculator display. The name of each gas is briefly displayed as its individual calculations are made within the program.

Note: The program 'GTABLE' is a subroutine called by the 'GASES' program. Program 'GTABLE' will provide unpredictable results if run alone.

OPERATING INSTRUCTIONS - PROGRAM 'GASES'

1 Store the mol % (volume percent) of each gas in the mixture using the 'GDATA' program.

2 Initialize program
XEQ ALPHA GASES ALPHA

Note that the program will briefly display the name of each gas as its individual properties are used within the program.

3a If the printer is plugged in, all of the calculated values are printed.

3b If the printer is not used, each property is displayed. Key R/S to step from one display to the next.

TOT% = 100.00 Total of all gases stored in registers 11 to 35.
R/S

SG = X.XX Specific gravity of given gas mix. (AIR = 1.0)
Also stored in register 06
R/S

K = X.XX k-value; ratio of specific heats of the gas mix.
Also stored in register 07
R/S

Pc = XXX.X Pseudocritical pressure of gas mix - PSIA.
Also stored in register 08
R/S

Tc = XXX.X Pseudocritical temperature of gas mix - deg Rankine.
Also stored in register 09
R/S

LHV = XXX.X Low (net) heat value of gas mix - BTU/cubic foot of gas at 14.7 PSIA and 60 deg F. Also stored in register 61.
R/S

HHV = XXX.X High (gross) heat value of gas mix - BTU/ cubic foot of gas at 14.7 PSIA and 60 deg F. Also stored in register 62.

OPERATING INSTRUCTIONS - PROGRAM 'SG'

Introduction

The 'SG' program is used to provide estimates of gas properties when only the specific gravity of the gas mix is known. The properties calculated are molecular weight, k-value, and pseudocritical pressure and temperature. The properties required by the compressor performance program are automatically stored into the correct registers for later use. The stored values are specific gravity; k-value; and pseudocritical pressure and temperature.

If no input is provided to the prompt, then 0.65 specific gravity is assumed and used in the calculations.

The estimating equations were obtained from a linear regression of the pseudocritical properties curves for natural gases (FIG 16-6) of the GPSA Engineering Data Book, Rev 1976.

Prompted Operation

1 Initialize program
XEQ ALPHA SG ALPHA

SP GR?

2a Key in the specific gravity to be used to estimate the gas properties.
X.XX R/S

2b Key R/S only to use 0.65 for the specific gravity.

MW = XX.X — This is the molecular weight of a gas mix with the given specific gravity.
R/S

K = X.XX — k-value; ratio of specific heats of the gas mix. Also stored in register 07
R/S

Pc = XXX.X — Pseudocritical pressure of gas mix - PSIA. Also stored in register 08
R/S

Tc = XXX.X — Pseudocritical temperature of gas mix - deg Rankine. Also stored in register 09

OPERATING INSTRUCTIONS - PROGRAM 'BARO'

Introduction

The compressor performance program requires all pressures to be input in absolute values, i.e. PSIA. Program 'BARO' is provided to calculate the barometric (atmospheric) pressure which is to be added to the gauge pressures obtained from an operating compressor.

Prompted Operation

1 Initialize program
XEQ ALPHA BARO ALPHA

ALT - FT?

2 Key in the altitude of the site in feet above sea level.
XXXX R/S

PSIA = XXX

This is the barometric (atmospheric) pressure in PSIA at the given altitude.

PROGRAM INSTRUCTIONS - PROGRAM 'DATA'

Introduction

Program 'DATA' is provided as a general purpose routine for input or review of data registers. After prompting for a beginning register number, the program will sequentially display the register number and its data value. All data values are displayed to 3 decimal places. When a data value is displayed, the program will sound a tone indicating the value may be retained or changed. The tone can be turned off by clearing Flag 26. The program is for data input and review and does not use the printer, although the printer may remain connected and used in other programs.

Prompted Operation

1 Initialize program.
    XEQ ALPHA DATA ALPHA

CLEAR? Y/N:N

2a Key 'Y' to clear the data registers.
    Y R/S

2b Key R/S only to retain all values in the data registers.

BEGIN REG?

3a Key in register number to begin the review, where n is a register number from 1 to 64.
    n R/S

3b Key R/S only to begin the review with register 1.

n = XX.X

    n is the current register number
    XX.X is the register value

4a If the value displayed is appropriate to the problem, then press R/S to acknowledge the correct value and proceed to the next register.

4b If the value displayed is not correct, key in the correct value and key R/S to store the corrected value in the current register.
    XX.XX R/S

5 The program will go to step 4 for sequential review of each data register. After register 64 is displayed, the program will return to step 3.

OPERATING INSTRUCTIONS - PROGRAM 'GETRD, SAVERD, DROPRD'

Introduction

There are many occassions where it is desireable to save a particular compressor configuration and its performance data. For multiple compressor evaluations, reloading a multistage configuration saves rekeying all data when only a few items have to be changed. Compressor stations with multiple compressors could save each configuration separately and reload them into the calculator as needed. The data registers can be saved on HP magnetic cards, HP cassette tape, or in the calculator extended memory module.

The 'GETRD, SAVERD, and DROPRD' ' programs are not included in the RECIPAK II Performance Module. However, for convenience a program listing is provided in the appendix for those with an HP-41CX or an HP-41C/CV with the HP82180 extended memory module.

The 'SAVERD' program will save registers 1 to 64 by filename into the extended memory. If the filename does not exist, it is created and then the register values are saved.

The 'GETRD' program will load data by filename from the extended memory into registers 1 to 64 in the calculator.

The 'DROPRD' program will purge a file by filename from the extended memory module.

KEYSTROKE OPERATION

To save data registers to file 'EXAMPLE'.

XEQ ALPHA SAVERD ALPHA	SAVE FILE?
EXAMPLE R/S	EXAMPLE SAVED

To load data registers from file 'EXAMPLE'.

XEQ ALPHA GETRD ALPHA	GET FILE?
EXAMPLE R/S	EXAMPLE LOADED

To purge the extended memory data file 'EXAMPLE'.

XEQ ALPHA DROPRD ALPHA	DROP FILE?
EXAMPLE R/S	EXAMPLE DROPPED

OPERATING INSTRUCTIONS - PROGRAM 'PP'

Introduction

Often gas mixes being compressed contain moisture in the form of water vapor. Program 'PP' will calculate the partial (vapor) pressure of water at any given temperature. Program 'PP' is not included in the Performance Module but a program listing is provided in the appendix for convenience in converting 'wet' capacities to 'dry' capacities.

The compressor capacity in dry units is the same in all stages. However, the total water vapor content of the gas will vary from stage to stage. This is because enough water will condense between stages to maintain 100% relative humidity at the inlet conditions of each stage (assuming the gas is 100% saturated at stage 1 inlet). The capacity values in the performance module are always given in dry values with a specified relative humidity. If the gas has water content, then the program will automatically add enough water vapor to the inlet volume of each stage to achieve 100% R.H.

The appendix contains formulas for calculating relative humidity and converting from wet to dry capacities.

Keystroke Operation for 90 deg F example

```
XEQ ALPHA  PP ALPHA                    DEG-F
   90  R/S                             PSIA= 0.6984
```

OPERATING INSTRUCTIONS - 'GDATA, GASES'

EXAMPLE 1 - GAS ANALYSIS

1. Given a gas analysis as follows:

GAS	MOL%
Nitrogen	.49
Carbon Dioxide	.23
Methane	82.94
Ethane	7.84
Propane	4.14
i-Butane	.86
n-Butane	1.36
i-Pentane	.47
n-Pentane	.42
Hexane	1.25

2. Determine the properties of the gas mixture.

KEYSTROKES	DISPLAY
XEQ ALPHA GDATA ALPHA	CLEAR? Y/N:N
Y R/S	%N2= 0.0
.49 R/S	%CO2= 0.0
.23 R/S	%H2S= 0.0
R/S	%METH= 0.0
82.94 R/S	%ETH= 0.0
7.84 R/S	%PROP= 0.0
4.14 R/S	%IBUT= 0.0
.86 R/S	%NBUT= 0.0
1.36 R/S	%IPEN= 0.0
.47 R/S	%NPEN= 0.0
.42 R/S	%HEX= 0.0
1.25 R/S	%HEP= 0.0
XEQ ALPHA GASES ALPHA	TOT%= 100.00
R/S	SG= 0.72
R/S	K= 1.23
R/S	Pc= 665.98
R/S	Tc= 394.00
R/S	LHV= 1131.42
R/S	HHV= 1248.01

Note that SG, K, Pc, Tc values are automatically stored in the required registers.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 2 - Single stage, Clearance given

INTRODUCTION

Given a 5-1/2" stroke compressor with two 13 inch diameter pistons operating at 1000 RPM. Both 13 inch cylinders are operating at an average clearance of 14.4%. The manufacturer's data specifies a valve speed of 5700 FPM and a piston displacement of 833.7 CFM per cylinder. The frame friction horsepower for a compressor of this type is 6 HP per throw.

Recent gage readings are

inlet pressure	100 PSIG
inlet temperature	105 deg F
discharge pressure	350 PSIG

The compressor is compressing Natural Gas with a specific gravity of 0.65. The gas is dry, i.e. the Relative Humidity of the gas is 0%.

The altitude of the compressor station is 3200 feet above sea level.

PROBLEM

Determine the compressor throughput in MMSCFD and the required compression horsepower.

KEYSTROKE SOLUTION

Refer to the individual program operating instructions for additional information.

XEQ ALPHA CLRG ALPHA Clearing all data registers will ensure that your calculator display will agree with the example displays given below.

KEYSTROKES	DISPLAY
1. Determine the gas properties.	
XEQ ALPHA SG ALPHA	SP GR?
.65 R/S	MW=18.831
R/S	K=1.256
R/S	Pc=669.190
R/S	Tc=373.500

Note that the SG, K, Pc, Tc values are automatically stored in the required registers.

2. Determine the barometric pressure.

XEQ ALPHA BARO ALPHA	ALT-FT
3200 R/S	PSIA=13.084

3. Determine the compressor inlet and discharge pressure in PSIA. Assume 1% pressure drop in the pulsation bottles on inlet and discharge.

Inlet Pressure:

Pi = .99 X (100 + 13.084) = 111.954 PSIA

Discharge Pressure:

Pd = 1.01 X (350 + 13.084) = 366.715 PSIA

4. Complete the input form. See the Input Form instructions for additional information regarding the individual data entries. Refer to the Example 2A Worksheet for the data register format.

5. Input data into the registers.

XEQ ALPHA PDATA ALPHA	CLEAR? Y/N:N
R/S	VIEW STAGE?
0 R/S	MM=0
R/S	BHP=0
R/S	STR=0
5.5 R/S	RPM=0
1000 R/S	ROD=0
2.125 R/S	SG=0.650
R/S	K=1.256
R/S	Pc=669.19
R/S	Tc=373.50
R/S	RH%=0
R/S	VIEW STAGE?
1 R/S	1.PI=0
111.95 R/S	1.TI=0
105 R/S	1.ZI=0
R/S	1.Pd=0
366.72 R/S	1.Td=0
R/S	1.PD%=0
R/S	1.DIA=0
13 R/S	1.DISPL=0
1667.4 R/S	1.VS=0
5700 R/S	1.CLR%=0
14.4 R/S	1.ICFM=0
R/S	1.FHP=0
12 R/S	1.HP=0

6. Run the 'CLR' program (i.e. cylinder clearances are given) to determine the compressor throughput and compression horsepower.

XEQ ALPHA	CLR ALPHA	STGS
1 R/S		BHP=963.096
R/S		MM=12.359
R/S		CL%=14.400

keying R/S again will automatically go to program PDATA for a review of the individual data registers.

Example 2B is the completed worksheet with all data register values filled in. Registers marked with an '*' are required input for this example. All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 2A

DESCRIPTION: 13" & 13" X 5-1/2
Single Stage
Clearances Given

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01		SP. GRAVITY	*06	.650
HORSEPOWER	02		K-VALUE	*07	1.256
STROKE	*03	5.500	CRITICAL PRESS	*08	669.19
RPM	*04	1000	CRITICAL TEMP	*09	373.50
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	* 11	111.95	25		39	
INLET TEMP	* 12	105.00	26		40	
INLET COMPRS	13		27		41	
DISCH PRESS	* 14	366.72	28		42	
DISCH TEMP	15		29		43	
INTERSTG PD%	16		30		44	
CYL DIA	* 17	13.000	31		45	
CYL DISPL	* 18	1667.40	32		46	
VALVE SPEED	* 19	5700	33		47	
CLEARANCE PCT	* 20	14.40	34		48	
ICFM	21		35		49	
FHP/STG	* 22	12.00	36		50	
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 2B

DESCRIPTION: 13" & 13" X 5-1/2
Single Stage
Clearances Given

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	12.359	SP. GRAVITY	*06	.650
HORSEPOWER	02	963	K-VALUE	*07	1.256
STROKE	*03	5.500	CRITICAL PRESS	*08	669.19
RPM	*04	1000	CRITICAL TEMP	*09	373.50
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	* 11	111.95	25		39	
INLET TEMP	* 12	105.00	26		40	
INLET COMPRS	13	.984	27		41	
DISCH PRESS	* 14	366.72	28		42	
DISCH TEMP	15	260	29		43	
INTERSTG PD%	16	0	30		44	
CYL DIA	* 17	13.000	31		45	
CYL DISPL	* 18	1667.40	32		46	
VALVE SPEED	* 19	5700	33		47	
CLEARANCE PCT	* 20	14.40	34		48	
ICFM	21	1208.51	35		49	
FHP/STG	* 22	12.00	36		50	
BHP/STG	23	963	37		51	
GAS LOAD	24	34160	38		52	

NOTES:

Run time: approximately 39 seconds
Items marked with an * are required input
All other registers contain program calculated values.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 3 - Single stage, Horsepower given

INTRODUCTION

Given the data and results of EXAMPLE 2, rerun the program to limit the compression horsepower to 900 BHP.

KEYSTROKES	DISPLAY
This assumes that data from Example 2 is still in the calculator registers.	
900 STO 02	900
XEQ ALPHA BHP ALPHA	STGS
1 R/S	BHP=899.988
R/S	MM=11.499
R/S	CL%=17.586

keying R/S again will automatically go to program PDATA for a review of the individual data registers.

Example 3B is the completed worksheet with all data register values filled in. Registers marked with an '*' are required input for this example. All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 3A

DESCRIPTION: 13" & 13" X 5-1/2
Single Stage
Horsepower Given

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01		SP. GRAVITY	*06	.650
HORSEPOWER	*02	900	K-VALUE	*07	1.256
STROKE	*03	5.500	CRITICAL PRESS	*08	669.19
RPM	*04	1000	CRITICAL TEMP	*09	373.50
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	* 11	111.95	25		39	
INLET TEMP	* 12	105.00	26		40	
INLET COMPRS	13		27		41	
DISCH PRESS	* 14	366.72	28		42	
DISCH TEMP	15		29		43	
INTERSTG PD%	16		30		44	
CYL DIA	* 17	13.000	31		45	
CYL DISPL	* 18	1667.40	32		46	
VALVE SPEED	* 19	5700	33		47	
CLEARANCE PCT	20		34		48	
ICFM	21		35		49	
FHP/STG	* 22	12.00	36		50	
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 3B

DESCRIPTION: 13" & 13" X 5-1/2
Single Stage
Horsepower Given

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	11.499	SP. GRAVITY	*06	.650
HORSEPOWER	*02	900	K-VALUE	*07	1.256
STROKE	*03	5.500	CRITICAL PRESS	*08	669.19
RPM	*04	1000	CRITICAL TEMP	*09	373.50
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	* 11	111.95	25		39	
INLET TEMP	* 12	105.00	26		40	
INLET COMPRS	13	.984	27		41	
DISCH PRESS	* 14	366.72	28		42	
DISCH TEMP	15	260	29		43	
INTERSTG PD%	16	0	30		44	
CYL DIA	* 17	13.000	31		45	
CYL DISPL	* 18	1667.40	32		46	
VALVE SPEED	* 19	5700	33		47	
CLEARANCE PCT	20	17.59	34		48	
ICFM	21	1124.46	35		49	
FHP/STG	* 22	12.00	36		50	
BHP/STG	23	900	37		51	
GAS LOAD	24	34150	38		52	

NOTES:

Run time: approximately 63 seconds
Items marked with an * are required input
All other registers contain program calculated values.

EXAMPLE 4

Two stage, Capacity Given, Interstage Pressure Fixed

INTRODUCTION

The CAP and BHP programs in the RECIPAK II Performance Module will calculate the required single stage or stage 1 clearance. However, it is often necessary to calculate added clearances for upper stage cylinders to avoid exceeding certain compressor design limitations, e.g. cylinder rated discharge pressures; cylinder gas rod loads; gas discharge temperatures; frame HP; etc. In these instances fixed interstage pressures can be input and each stage can be treated individually. This permits calculation of the required clearances for each stage. Further calculations are unnecessary since the performance will be as indicated if these exact clearances can be added to the compressor. However, if volume bottles of these approximate sizes are available, then the program can easily be rerun as multistage to evaluate such changes.

Consider a two stage 6 inch stroke compressor with a 26 inch and a 15 inch cylinder. The 26 inch cylinder has a 140 PSIG rated discharge pressure. The compressor frame also has a 50,000 lb. rod load limit. To provide a safety margin, the stage 1 discharge pressure will be fixed at 120 PSIG (134.7 PSIA). With a 44.7 PSIA inlet pressure the stage 1 rod load will be approximately 48,000 lbs.

See the EXAMPLE 4A worksheet for the specific gas and cylinder data.

Determine the clearances required in the stage 1 and 2 cylinders to achieve the specified capacity of 9.25 MMSCFD.

KEYSTROKES	DISPLAY
Clearing all data registers will ensure that your calculator display will agree with the example displays given below.	
1. Input data into the registers.	
XEQ ALPHA PDATA ALPHA	CLEAR? Y/N:N
Y R/S	VIEW STAGE?
0 R/S	MM=0.00
9.25 R/S	BHP=0.00

	R/S	STR=0.00
6	R/S	RPM=0.00
1000	R/S	ROD=0.00
2.5	R/S	SG=0.00
.714	R/S	K=0.00
1.258	R/S	Pc=0.00
648.78	R/S	Tc=0.00
364.66	R/S	RH%=0.00
100	R/S	VIEW STAGE?
1	R/S	1.PI=0.00
44.7	R/S	1.TI=0.00
80	R/S	1.ZI=0.00
	R/S	1.Pd=0.00
134.7	R/S	1.Td=0.00
	R/S	1.PD%=0.0
3	R/S	1.DIA=0.00
26	R/S	1.DISPL=0.00
3670	R/S	1.VS=0.00
3870	R/S	1.CLR%=0.00
	R/S	1.ICFM=0.00
	R/S	1.FHP=0.00
6.5	R/S	1.HP=0.00

2. Calculate Stage 1 performance.

XEQ ALPHA CAP ALPHA		STGS
1 CHS	R/S	BHP=634.370
	R/S	MM=9.250
	R/S	CL%=24.755

3. Input Stage 2 Data.

XEQ ALPHA PDATA ALPHA		CLEAR? Y/N:N
	R/S	VIEW STAGE?
2	R/S	2.PI=0.00
130.7	R/S	2.TI=0.00
130	R/S	2.ZI=0.00
	R/S	2.Pd=0.00
364.7	R/S	2.Td=0.00
	R/S	2.PD%=0.00
	R/S	2.DIA=0.00
15	R/S	2.DISPL=0.00
1210.1	R/S	2.VS=0.00
3940	R/S	2.CLR%=0.00
	R/S	2.ICFM=0.00
	R/S	2.FHP=0.00
6.5	R/S	2.HP=0.00

4. Calculate stage 2 performance.

XEQ ALPHA CAP ALPHA	STGS
2 CHS R/S	BHP=633.960
R/S	MM=9.250
R/S	CL%=21.972

keying R/S again will automatically go to program PDATA for a review of the individual data registers.

Example 4B is the completed worksheet with all data register values filled in. Registers marked with an '*' are required input for this example. All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 4A

DESCRIPTION: 26 & 15 x 6

TWO STAGE
CAPACITY GIVEN, INTERSTAGE PRESSURE FIXED

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	9.250	SP. GRAVITY	*06	.714
HORSEPOWER	02		K-VALUE	*07	1.258
STROKE	*03	6.000	CRITICAL PRESS	*08	648.78
RPM	*04	1000	CRITICAL TEMP	*09	364.66
ROD DIA	*05	2.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	44.70	*25	130.70	39	
INLET TEMP	*12	80.00	*26	130.00	40	
INLET COMPRS	13		27		41	
DISCH PRESS	*14	134.70	*28	364.70	42	
DISCH TEMP	15		29		43	
INTERSTG PD%	*16	3.000	30		44	
CYL DIA	*17	26.000	*31	15.000	45	
CYL DISPL	*18	3670.00	*32	1210.10	46	
VALVE SPEED	*19	3870	*33	3940	47	
CLEARANCE PCT	20		34		48	
ICFM	21		35		49	
FHP/STG	*22	6.5	*36	6.5	50	
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 4B

DESCRIPTION: 26 & 15 x 6

TWO STAGE
CAPACITY GIVEN, INTERSTAGE PRESSURE FIXED

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	9.250	SP. GRAVITY	*06	.714
HORSEPOWER	02	634	K-VALUE	*07	1.258
STROKE	*03	6.000	CRITICAL PRESS	*08	648.78
RPM	*04	1000	CRITICAL TEMP	*09	364.66
ROD DIA	*05	2.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	44.70	*25	130.70	39	
INLET TEMP	*12	80.00	*26	130.00	40	
INLET COMPRS	13	.993	27	.985	41	
DISCH PRESS	*14	134.70	*28	364.70	42	
DISCH TEMP	15	217	29	268	43	
INTERSTG PD%	*16	3.000	30	.00	44	
CYL DIA	*17	26.000	*31	15.000	45	
CYL DISPL	*18	3670.00	*32	1210.10	46	
VALVE SPEED	*19	3870	*33	3940	47	
CLEARANCE PCT	20	24.75	34	21.97	48	
ICFM	21	2209.14	35	823.64	49	
FHP/STG	*22	6.5	*36	6.5	50	
BHP/STG	23	634	37	634	51	
GAS LOAD	24	47930	38	41919	52	

NOTES:

STAGE -1 Run time: Approximately 42 seconds.
STAGE -2 Run time: Approximately 42 seconds.
Items marked with an * are required input
All other registers contain program calculated values.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 5

Two Stage, Capacity Given

INTRODUCTION

In Example 4 the required stage 2 clearance is close to the cylinder's base clearance. To avoid a cylinder modification, rerun the program as a multistage calculation using base clearances on stage 2.

KEYSTROKES	DISPLAY
This assumes that data from Example 4 is still in the data registers.	
19.75 STO 34	19.750
XEQ ALPHA CAP ALPHA	STGS
2 R/S	BHP=1269.555
R/S	MM=9.250
R/S	CL%=25.696

Keying R/S again will automatically go to program PDATA for a review of the individual registers.

Example 5B is the completed worksheet with all data register values filled in.

Recipak II Compressor Performance

EXAMPLE No: 5A

DESCRIPTION: 26 & 15 x 6

TWO STAGE
CAPACITY GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	9.250	SP. GRAVITY	*06	.714
HORSEPOWER	02		K-VALUE	*07	1.258
STROKE	*03	6.000	CRITICAL PRESS	*08	648.78
RPM	*04	1000	CRITICAL TEMP	*09	364.66
ROD DIA	*05	2.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	44.70	25		39	
INLET TEMP	*12	80.00	*26	130.00	40	
INLET COMPRS	13		27		41	
DISCH PRESS	14		*28	364.70	42	
DISCH TEMP	15		29		43	
INTERSTG PD%	*16	3.000	30		44	
CYL DIA	*17	26.000	*31	15.000	45	
CYL DISPL	*18	3670.00	*32	1210.10	46	
VALVE SPEED	*19	3870	*33	3940	47	
CLEARANCE PCT	20		*34	19.75	48	
ICFM	21		35		49	
FHP/STG	*22	6.5	*36	6.5	50	
EHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 5B

DESCRIPTION: 26 & 15 x 6

TWO STAGE
CAPACITY GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	9.250	SP. GRAVITY	*06	.714
HORSEPOWER	02	1270	K-VALUE	*07	1.258
STROKE	*03	6.000	CRITICAL PRESS	*08	648.78
RPM	*04	1000	CRITICAL TEMP	*09	364.66
ROD DIA	*05	2.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	44.70	25	127.38	39	
INLET TEMP	*12	80.00	*26	130.00	40	
INLET COMPRS	13	.993	27	.985	41	
DISCH PRESS	14	131.20	*28	364.70	42	
DISCH TEMP	15	213	29	272	43	
INTERSTG PD%	*16	3.000	30	.00	44	
CYL DIA	*17	26.000	*31	15.000	45	
CYL DISPL	*18	3670.00	*32	1210.10	46	
VALVE SPEED	*19	3870	*33	3940	47	
CLEARANCE PCT	20	25.70	*34	19.75	48	
ICFM	21	2209.14	35	845.80	49	
FHP/STG	*22	6.5	*36	6.5	50	
BHP/STG	23	620	37	650	51	
GAS LOAD	24	46073	38	42489	52	

NOTES:

Run time: Approximately 2 minutes 17 seconds
Items marked with an * are required input
All other registers contain program calculated values.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 6

Two stage, Clearance Given

INTRODUCTION

Given a two stage compressor operating with the gas analysis given in Example 1. The configuration is as follows:

	Stage 1	Stage 2
cylinder diameter (two per stage)	9.50	7.00
cylinder displacement - CFM total	791.82	420.66
valve speed - FPM	5400	3760
clearance - average PCT	14.80	20.10
frame friction HP	10.80	10.80
inlet temperature - deg F	104	130
stage 1 inlet pressure - PSIA	265	
stage 2 discharge pressure - PSIA		1015
interstage pressure drop - PCT	2.0	
compressor RPM	900	900
stroke - inches	5.50	5.50
rod diameter - inches	2.125	2.125

Determine the compressor throughput in MMSCFD and the required compression horsepower - BHP.

KEYSTROKES	DISPLAY

Clearing all data registers will ensure that your calculator display will agree with the example displays given below.

Use the gas properties calculated in Example 1. Specifically:

SG = 0.716
K = 1.228
Pc = 665.98
Tc = 394.00
RH% = 0.00

1. Input data into the registers.

XEQ ALPHA PDATA ALPHA	CLEAR? Y/N:N
Y R/S	VIEW STAGE?
0 R/S	MM=0.00
R/S	BHP=0.00
R/S	STR=0.00
5.5 R/S	RPM=0.00
900 R/S	ROD=0.00
2.125 R/S	SG=0.00
.716 R/S	K=0.00
1.228 R/S	Pc=0.00
665.98 R/S	Tc=0.00
394 R/S	RH%=0.00
R/S	VIEW STAGE?
1 R/S	1.PI=0.00
265 R/S	1.TI=0.00
104 R/S	1.ZI=0.00
R/S	1.Pd=0.00
R/S	1.Td=0.00
R/S	1.PD%=0.0
2 R/S	1.DIA=0.00
9.5 R/S	1.DISPL=0.00
791.82 R/S	1.VS=0.00
5400 R/S	1.CLR%=0.00
14.8 R/S	1.ICFM=0.00
R/S	1.FHP=0.00
10.8 R/S	1.HP=0.00
R/S	1.GL=0.00
R/S	VIEW STAGE?
2 R/S	2.PI=0.00
R/S	2.TI=0.00
130 R/S	2.ZI=0.00
R/S	2.Pd=0.00
1015 R/S	2.Td=0.00
R/S	2.PD%=0.00
R/S	2.DIA=0.00
7 R/S	2.DISPL=0.00
420.66 R/S	2.VS=0.00
3760 R/S	2.CLR%=0.00
20.1 R/S	2.ICFM=0.00
R/S	2.FHP=0.00
10.8 R/S	2.HP=0.00

XEQ ALPHA CLR ALPHA	STGS
2 R/S	BHP=1472.335
R/S	MM=16.785
R/S	CL%=14.349

keying R/S again will automatically go to program PDATA for a review of the individual data registers.

Example 5B is the completed worksheet with all data register values filled in. Registers marked with an '*' are required input for this example. All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 6A

DESCRIPTION: 9.5 & 9.5 & 7.0 & 7.0 x 5-1/2

TWO STAGE
FIXED CLEARANCES

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01		SP. GRAVITY	*06	.716
HORSEPOWER	02		K-VALUE	*07	1.228
STROKE	*03	5.500	CRITICAL PRESS	*08	665.98
RPM	*04	900	CRITICAL TEMP	*09	394.00
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	265.00	25		39	
INLET TEMP	*12	104.00	*26	130.00	40	
INLET COMPRS	13		27		41	
DISCH PRESS	14		*28	1015.00	42	
DISCH TEMP	15		29		43	
INTERSTG PD%	*16	2.000	30		44	
CYL DIA	*17	9.500	*31	7.000	45	
CYL DISPL	*18	791.82	*32	420.66	46	
VALVE SPEED	*19	5400	*33	3760	47	
CLEARANCE PCT	*20	14.80	*34	20.10	48	
ICFM	21		35		49	
FHP/STG	*22	10.8	*36	10.8	50	
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 6B

DESCRIPTION: 9.5 & 9.5 & 7.0 & 7.0 x 5-1/2

TWO STAGE
FIXED CLEARANCES

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	16.785	SP. GRAVITY	*06	.716
HORSEPOWER	02	1472	K-VALUE	*07	1.228
STROKE	*03	5.500	CRITICAL PRESS	*08	665.98
RPM	*04	900	CRITICAL TEMP	*09	394.00
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	265.00	25	525.87	39	
INLET TEMP	*12	104.00	*26	130.00	40	
INLET COMPRS	13	.955	27	.925	41	
DISCH PRESS	14	536.39	*28	1015.00	42	
DISCH TEMP	15	183	29	207	43	
INTERSTG PD%	*16	2.000	30	.00	44	
CYL DIA	*17	9.500	*31	7.000	45	
CYL DISPL	*18	791.82	*32	420.66	46	
VALVE SPEED	*19	5400	*33	3760	47	
CLEARANCE PCT	*20	14.35	*34	20.10	48	
ICFM	21	671.94	35	343.18	49	
FHP/STG	*22	10.8	*36	10.8	50	
BHP/STG	23	773	37	699	51	
GAS LOAD	24	20124	38	20636	52	

NOTES:

Run time: Approximately 4 minutes 44 seconds
Items marked with an * are required input
All other registers contain program calculated values.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 7

Two Stage, Capacity Given

INTRODUCTION

Given the data and results of Example 6, rerun the program to determine the stage 1 average clearance required to limit the compressor capacity to 15 MMSCFD with a stage 2 discharge pressure of 1115 PSIA

KEYSTROKES	DISPLAY
This assumes that data from Example 6 is still in the data registers.	
15 STO 01	15.000
1115 STO 28	1115.000
XEQ ALPHA CAP ALPHA	STGS
2 R/S	BHP=1416.033
R/S	MM=15.000
R/S	CL%=28.425

Keying R/S again will automatically go to program PDATA for a review of the individual registers.

Example 7B is the completed worksheet with all data register values filled in.

Recipak II Compressor Performance

EXAMPLE No: 7A

DESCRIPTION: 9.5 & 9.5 & 7.0 & 7.0 x 5-1/2

TWO STAGE
CAPACITY GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	15.000	SP. GRAVITY	*06	.716
HORSEPOWER	02		K-VALUE	*07	1.228
STROKE	*03	5.500	CRITICAL PRESS	*08	665.98
RPM	*04	900	CRITICAL TEMP	*09	394.00
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	265.00	25		39	
INLET TEMP	*12	104.00	*26	130.00	40	
INLET COMPRS	13		27		41	
DISCH PRESS	14		*28	1115.00	42	
DISCH TEMP	15		29		43	
INTERSTG PD%	*16	2.000	30		44	
CYL DIA	*17	9.500	*31	7.000	45	
CYL DISPL	*18	791.82	*32	420.66	46	
VALVE SPEED	*19	5400	*33	3760	47	
CLEARANCE PCT	20		*34	20.10	48	
ICFM	21		35		49	
FHP/STG	*22	10.8	*36	10.8	50	
PHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 7B

DESCRIPTION: 9.5 & 9.5 & 7.0 & 7.0 x 5-1/2

TWO STAGE
CAPACITY GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	*01	15.000	SP. GRAVITY	*06	.716
HORSEPOWER	02	1416	K-VALUE	*07	1.228
STROKE	*03	5.500	CRITICAL PRESS	*08	665.98
RPM	*04	900	CRITICAL TEMP	*09	394.00
ROD DIA	*05	2.125	REL HUMIDITY %	*10	0

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	265.00	25	500.39	39	
INLET TEMP	*12	104.00	*26	130.00	40	
INLET COMPRS	13	.955	27	.929	41	
DISCH PRESS	14	510.40	*28	1115.00	42	
DISCH TEMP	15	177	29	225	43	
INTERSTG PD%	*16	2.000	30	.00	44	
CYL DIA	*17	9.500	*31	7.000	45	
CYL DISPL	*18	791.82	*32	420.66	46	
VALVE SPEED	*19	5400	*33	3760	47	
CLEARANCE PCT	20	28.43	*34	20.10	48	
ICFM	21	600.49	35	323.51	49	
FHP/STG	*22	10.8	*36	10.8	50	
EHP/STG	23	658	37	758	51	
GAS LOAD	24	18281	38	25374	52	

NOTES:

Run time: Approximately 2 minutes 38 seconds
Items marked with an * are required input
All other registers contain program calculated values.

OPERATING INSTRUCTIONS - 'CLR, CAP, BHP'

EXAMPLE 8

Three Stage, Horsepower Given, Multiple Discharge Pressures

INTRODUCTION

Given a 3 stage integral compressor. Run a performance calculation to load to the engine horsepower of 1750 over a discharge pressure range of 1215 PSIA to 1515 PSIA.

Use the calculated values to construct a graph of the MMSCFD, BHP, and CLEARANCE as a function of compressor discharge pressure.

KEYSTROKES	DISPLAY
1. Input data into the registers. Example worksheet 8A provides the specific gas and compressor data. Refer to program PDATA and previous examples 1 through 7 for information on data input.	
2. Calculate the performance data.	
1750 STO 02	1750.000
1215 STO 42	1215.000
XEQ ALPHA BHP ALPHA	STGS
3 R/S	BHP=1751.291
R/S	MM=11.167
R/S	CL%=19.836
1750 STO 02	1750.000
1315 STO 42	1315.000
XEQ ALPHA BHP ALPHA	STGS
3 R/S	BHP=1752.151
R/S	MM=10.829
R/S	CL%=22.358
1750 STO 02	1750.000
1415 STO 42	1415.000
XEQ ALPHA BHP ALPHA	STGS
3 R/S	BHP=1752.530
R/S	MM=10.523
R/S	CL%=24.799

1750 STO 02	1750.000
1515 STO 42	1515.000
XEQ ALPHA BHP ALPHA	STGS
3 R/S	BHP=1753.300
R/S	MM=10.246
R/S	CL%=27.142

Keying R/S again will automatically go to program PDATA for a review of the individual registers.

Example 8B is the completed worksheet with all data register values filled in.

Recipak II Compressor Performance

EXAMPLE No: 8A

DESCRIPTION: 20.5 & 11.5 & 7.5 x 15

THREE STAGE
HORSEPOWER GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01		SP. GRAVITY	*06	.600
HORSEPOWER	*02	1750	K-VALUE	*07	1.275
STROKE	*03	15.000	CRITICAL PRESS	*08	671.56
RPM	*04	330	CRITICAL TEMP	*09	358.00
ROD DIA	*05	3.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	95.00	25		39	
INLET TEMP	*12	120.00	*26	120.00	*40	120.00
INLET COMPRS	13		27		41	
DISCH PRESS	14		28		*42	1450.00
DISCH TEMP	15		29		43	
INTERSTG PD%	*16	2.500	*30	1.70	44	
CYL DIA	*17	20.500	*31	11.500	*45	7.50
CYL DISPL	*18	1863.40	*32	567.50	*46	225.50
VALVE SPEED	*19	3000	*33	2300	*47	2200
CLEARANCE PCT	20		*34	16.80	*48	36.50
ICFM	21		35		49	
FHP/STG	*22	15.0	*36	15.0	*50	15.0
BHP/STG	23		37		51	
GAS LOAD	24		38		52	

NOTES:

Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 8R

DESCRIPTION: 20.5 & 11.5 & 7.5 x 15

THREE STAGE
HORSEPOWER GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	11.167	SP. GRAVITY	*06	.600
HORSEPOWER	*02	1751	K-VALUE	*07	1.275
STROKE	*03	15.000	CRITICAL PRESS	*08	671.56
RPM	*04	330	CRITICAL TEMP	*09	358.00
ROD DIA	*05	3.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	95.00	25	262.04	39	620.26
INLET TEMP	*12	120.00	*26	120.00	*40	120.00
INLET COMPRS	13	.990	27	.972	41	.936
DISCH PRESS	14	268.60	28	630.80	*42	1215.00
DISCH TEMP	15	266	29	241	43	211
INTERSTG PD%	*16	2.500	*30	1.70	44	.00
CYL DIA	*17	20.500	*31	11.500	*45	7.50
CYL DISPL	*18	1863.40	*32	567.50	*46	225.50
VALVE SPEED	*19	3000	*33	2800	*47	2200
CLEARANCE PCT	20	19.84	*34	13.90	*48	17.60
ICFM	21	1351.66	35	475.65	49	192.81
FHP/STG	*22	8.0	*36	8.0	*50	8.0
BHP/STG	23	726	37	590	51	435
GAS LOAD	24	58067	38	40679	52	32098

NOTES:

Run time: Approximately 8 minutes 16 seconds
Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 8C

DESCRIPTION: 20.5 & 11.5 & 7.5 x 15

THREE STAGE
HORSEPOWER GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	10.829	SP. GRAVITY	*06	.600
HORSEPOWER	*02	1752	K-VALUE	*07	1.275
STROKE	*03	15.000	CRITICAL PRESS	*08	671.56
RPM	*04	330	CRITICAL TEMP	*09	358.00
ROD DIA	*05	3.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	95.00	25	255.73	39	617.07
INLET TEMP	*12	120.00	*26	120.00	*40	120.00
INLET COMPRS	13	.990	27	.972	41	.936
DISCH PRESS	14	262.13	28	627.56	*42	1315.00
DISCH TEMP	15	262	29	244	43	223
INTERSTG PD%	*16	2.500	*30	1.70	44	.00
CYL DIA	*17	20.500	*31	11.500	*45	7.50
CYL DISPL	*18	1863.40	*32	567.50	*46	225.50
VALVE SPEED	*19	3000	*33	2800	*47	2200
CLEARANCE PCT	20	22.36	*34	13.90	*48	17.60
ICFM	21	1310.73	35	473.06	49	168.00
FHP/STG	*22	8.0	*36	8.0	*50	8.0
BHP/STG	23	668	37	587	51	477
GAS LOAD	24	55932	38	40937	52	36626

NOTES:

Run time: Approximately 8 minutes 16 seconds
Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 8D

DESCRIPTION: 20.5 & 11.5 & 7.5 x 15

THREE STAGE
HORSEPOWER GIVEN

ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	10.523	SP. GRAVITY	*06	.600
HORSEPOWER	*02	1753	K-VALUE	*07	1.275
STROKE	*03	15.000	CRITICAL PRESS	*08	671.56
RPM	*04	330	CRITICAL TEMP	*09	358.00
ROD DIA	*05	3.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	95.00	25	250.05	39	614.85
INLET TEMP	*12	120.00	*26	120.00	*40	120.00
INLET COMPRS	13	.990	27	.973	41	.936
DISCH PRESS	14	256.30	28	625.31	*42	1415.00
DISCH TEMP	15	258	29	247	43	234
INTERSTG PD%	*16	2.500	*30	1.70	44	.00
CYL DIA	*17	20.500	*31	11.500	*45	7.50
CYL DISPL	*18	1863.40	*32	567.50	*46	225.50
VALVE SPEED	*19	3000	*33	2800	*47	2200
CLEARANCE PCT	20	24.80	*34	13.90	*48	17.60
ICFM	21	1273.66	35	470.48	49	183.38
FHP/STG	*22	8.0	*36	8.0	*50	8.0
BHP/STG	23	654	37	584	51	515
GAS LOAD	24	54008	38	41239	52	41121

NOTES:

Run time: Approximately 8 minutes 16 seconds
Items marked with an * are required input
All other registers contain program calculated values.

Recipak II Compressor Performance

EXAMPLE No: 8E

DESCRIPTION: 20.5 & 11.5 & 7.5 x 15

THREE STAGE
HORSEPOWER GIVEN

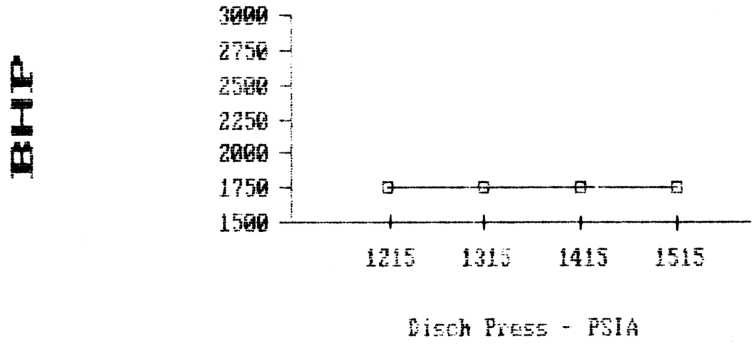
ITEM	REG#	DATA	ITEM	REG#	DATA
MMSCFD	01	10.246	SP. GRAVITY	*06	.600
HORSEPOWER	*02	1753	K-VALUE	*07	1.275
STROKE	*03	15.000	CRITICAL PRESS	*08	671.56
RPM	*04	330	CRITICAL TEMP	*09	358.00
ROD DIA	*05	3.500	REL HUMIDITY %	*10	100

ITEM	REG#	DATA	REG#	DATA	REG#	DATA
INLET PRESS	*11	95.00	25	244.96	39	613.56
INLET TEMP	*12	120.00	*26	120.00	*40	120.00
INLET COMPRS	13	.990	27	.973	41	.936
DISCH PRESS	14	251.09	28	623.99	*42	1515.00
DISCH TEMP	15	255	29	250	43	245
INTERSTG PD%	*16	2.500	*30	1.70	44	.00
CYL DIA	*17	20.500	*31	11.500	*45	7.50
CYL DISPL	*18	1863.40	*32	567.50	*46	225.50
VALVE SPEED	*19	3000	*33	2800	*47	2200
CLEARANCE PCT	20	27.14	*34	13.90	*48	17.60
ICFM	21	1240.18	35	467.93	49	178.97
FHP/STG	*22	8.0	*36	8.0	*50	8.0
BHP/STG	23	624	37	581	51	548
GAS LOAD	24	52289	38	41582	52	45583

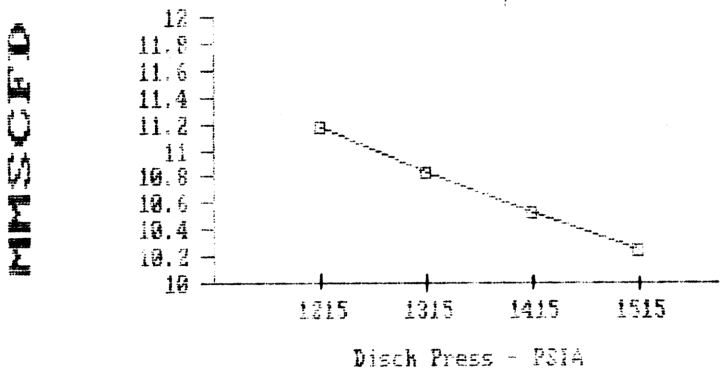
NOTES:

Run time: Approximately 8 minutes 16 seconds
Items marked with an * are required input
All other registers contain program calculated values.

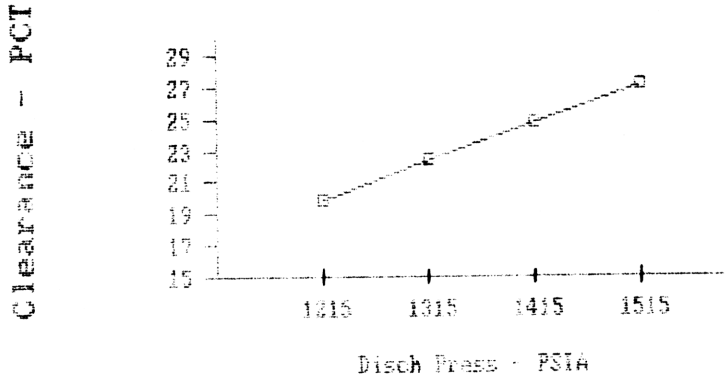
Example 8 BHP



Example 8 MMSCFD



Example 8 CLR%



APPENDIX A

PROGRAM DATA

SIZE = 065

Statistics register = 57

FLAGS USED:

00 SET = single stage
00 CLEAR = multistage
01 SET = clearance given
02 SET = capacity given
03 SET = BHP given

05, 09, 10 subroutine use
21 printer enable
22 numeric input
25 error subroutines
26 audio enable
55 printer existence

REGISTERS Used

See the performance work sheet for registers 01 to 52; all other registers are for scratch use by subroutines.

PROGRAM LABELS

The following is a listing of all labels used in the RECIPAK II Peformance Module.

CLR	CAP	BHP
GASES	SG	BARO
DATA	PDATA	GDATA
PRINT	GTABLE	

* Note: Program GTABLE is not a user program.

APPENDIX B - GTABLE

GTABLE is not a user program. It is a subroutine called by the program 'GASES'. 'GTABLE' will provide unpredictable results if run alone.

COMPONENT	SYMBOL	PROMPT	REGISTER	MW	Mcp	Tc	Pc	LHV	HHV
NITROGEN	N2	%N2	11	28.02	6.98	227.00	492.00	.00	.00
CARBON DIOXIDE	CO2	%CO2	12	44.01	9.37	545.00	1073.00	.00	.00
HYDROGEN SULPHIDE	H2S	%H2S	13	34.08	8.28	673.00	1306.00	588.00	637.00
METHANE	C1H4	%METH	14	16.04	8.95	344.00	673.00	909.00	1010.00
ETHANE	C2H6	%ETH	15	30.07	13.77	550.00	708.00	1618.00	1769.00
PROPANE	C3H8	%PROP	16	44.09	19.53	666.00	617.00	2316.00	2517.00
I-BUTANE	C4H10	%IBUT	17	58.12	25.75	735.00	529.00	3001.00	3253.00
N-BUTANE	C4H10	%NBUT	18	58.12	25.81	766.00	551.00	3011.00	3262.00
I-PENTANE	C5H12	%IPEN	19	72.15	31.67	830.00	483.00	3698.00	4000.00
N-PENTANE	C5H12	%NPEN	20	72.15	31.82	846.00	489.00	3707.00	4009.00
HEXANE	C6H14	%HEX	21	86.17	38.17	915.00	440.00	4404.00	4756.00
HEPTANE	C7H16	%HEP	22	100.20	47.49	973.00	397.00	5100.00	5503.00
OCTANE	C8H18	%OCT	23	114.22	57.00	1025.00	362.00	5796.00	6249.00
NONANE	C9H20	%NON	24	128.76	47.00	1071.00	332.00	6493.00	6997.00
DECANE	C10H22	%DEC	25	142.29	52.30	1112.00	304.00	7190.00	7743.00
OXYGEN	O2	%O2	26	32.00	7.07	278.00	732.00	.00	.00
HYDROGEN	H2	%H2	27	2.02	6.94	83.00	327.00	274.00	324.00
HELIUM	He	%He	28	4.00	5.00	24.00	151.00	.00	.00
WATER	H2O	%H2O	29	18.02	8.94	1165.00	3187.00	.00	49.40
CARBON MONOXIDE	CO	%CO	30	28.01	6.97	242.00	507.00	320.00	320.00
ETHYLENE	C4H4	%ETHY	31	28.05	11.39	510.00	742.00	1499.00	1599.00
PROPYLENE	C3H6	%PROPY	32	42.08	16.79	657.00	667.00	2183.00	2334.00
BUTYLENE	C4H8	%BUTY	33	56.10	22.78	756.00	583.00	2879.00	3080.00
AIR	N2+O2	%AIR	34	28.97	6.98	239.00	547.00	.00	.00
AMMONIA	NH3	%NH3	35	17.03	8.94	730.00	1639.00	359.00	433.00

APPENDIX C

Formulas for Reciprocating Compressor Performance

Compression Ratio

$$R = \frac{Pd}{Pi}$$

Specific Gravity

$$SG = \frac{\text{Molecular Weight}}{28.97}$$

Cylinder Inlet Capacity

$$ICFM = \frac{MMSCFD \times 10^{6} \times Pi \times (Ti + 460) \times Zi}{1440 \times (Pi - PP) \times 520 \times Zs}$$

Volumetric Efficiency

$$VE\% = \frac{100 \times ICFM}{DISPL}$$

Theoretical adiabatic gas discharge temperature - deg F

$$Td = \left[(Ti + 460) \times R^{(k-1)/k} \right] - 460$$

Valve Gas Speed, API average

Double acting cylinder

$$VS = \frac{DISPL \times 144}{N \times (ILA + DLA)}$$

Single acting cylinder

$$VS = \frac{DISPL \times 288}{N \times (ILA + DLA)}$$

where N = the number of valves per corner (usually the number of inlet valves per end)
ILA = inlet valve lift area, sq. inches
DLA = discharge valve lift area, sq. inches

Piston Rod Gas Loading

Double acting cylinders

GL(compression) = (Pi X AFE) - (Pd X AOE)
GL(tension) = (Pd X AFE) - (Pi X AOE)

Single acting frame end (with outer end vented to inlet pressure)

GL(compression) = (Pi X AFE) - (Pi X AOE)
GL(tension) = (Pd X AFE) - (Pi X AOE)

where AOE = area of outer end of piston, sq. inches
AFE = area of frame end of piston, sq. inches

positive numbers indicate tension loading (i.e. load acting in a line away from the compressor frame)
negative numbers indicate compression loading (i.e. load acting in a line towards the compressor frame.)

Relative Humidity of gas at compressor inlet

$$RH\% = \frac{(\text{mol}\% \text{ of } H_2O \text{ in gas}) \times Pi}{PP}$$

where PP is the partial (vapor) pressure of water at the compressor inlet temperature

To convert from MMSCFD (wet) to MMSCFD (dry)

$$\text{MMSCFD (dry)} = \frac{Pi - (PP \times RH\% / 100)}{Pi} \times \text{MMSCFD (wet)}$$

Average cylinder clearance %

$$CLA = \frac{(AOE \times CLOE) + (AFE \times CLFE)}{AOE + AFE}$$

Outer end clearance %

$$CLOE = \frac{((CLA \times (AOE + AFE)) - (AFE \times CLFE)}{AOE}$$

Frame end clearance %

$$CLFE = \frac{((CLA \times (AOE + AFE)) - (AOE \times CLOE)}{AFE}$$

Where area of outer end, $AOE = .7854 \times DIA^2$

and area of frame end, $AFE = .7854 \times (DIA^2 - ROD^2)$

K-value (Ratio of Specific Heats)

$$K = \frac{Mcp}{Mcp - 1.99}$$

where Mcp is the Molar Specific Heat of the gas mixture (usually at 150 degrees F average cylinder temperature.)

If the gas consists of only 1 component, the K-value may be obtained by determining the discharge temperature from a Temperature-Entropy chart for that specific gas and solving for K using the following formula.

$$K = \frac{Ln\ (R)}{Ln\left[\frac{R \times (Ti + 460)}{(Td + 460)}\right]}$$

where Ln is the logarithm (base e) of the quantity shown in the parenthesis.

APPENDIX D - PROGRAM LISTINGS

```
△ 1 LBL "PP"
  2 90
  3 "DEG-F"
  4 PROMPT
  5 100
  6 /
  7 ENTER
  8 ENTER
  9 ENTER
 10 .2097
 11 *
 12 .05748
 13 +
 14 *
 15 .3588
 16 +
 17 *
 18 .201
 19 +
 20 *
 21 .09896
 22 +
 23 *
 24 .02341
 25 +
 26 "PSIA= "
 27 ARCL X
 28 PROMPT
 29 GTO "PP"
```

```
△ 1 LBL "SAVERD"
  2 "SAVE"
  3 XEQ 08
△ 4 LBL 00
  5 SF 25
  6 0
  7 SEEKPTA
  8 FS?C 25
  9 GTO 01
 10 064
 11 CRFLD
 12 GTO 00
△13 LBL 01
 14 1.064
 15 SAVERX
 16 "⊢ SAVED"
 17 GTO 10
△18 LBL "GETRD"
 19 "GET"
 20 XEQ 08
 21 0
 22 SEEKPTA
 23 1.064
 24 GETRX
 25 "⊢LOADED"
 26 GTO 10
```

```
△27 LBL "DROPRD"
 28 "DROP"
 29 XEQ 08
 30 PURFL
 31 "⊢DROPPED"
 32 GTO 10
△33 LBL 08
 34 "  FILE?"
 35 CF 23
 36 AON
 37 PROMPT
 38 AOFF
 39 FS? 23
 40 RTN
△41 LBL 09
 42 CLA
 43 STOP
 44 GTO 09
△45 LBL 10
 46 CLX
 47 TONE 0
 48 PROMPT
 49 GTO 09
```

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