

# **GASPROP**

## ***Gas Properties Program***

User Manual



[www.systemek.us](http://www.systemek.us)

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Email: [support@systemek.us](mailto:support@systemek.us)

Web site: [www.systemek.us](http://www.systemek.us)

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# 1. Introduction

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**GASPROP™** calculates the physical and thermodynamic properties of a natural gas mixture, given the compositional data. You can input the mole percentage composition of each component in the natural gas mixture, such as 85% methane, 10% ethane, etc. and the program will calculate the apparent molecular weight and gravity (relative to air =1.00) of the natural gas mixture, along with other properties such as viscosity, specific heats -  $C_p$  and  $C_v$ , the ratio  $C_p/C_v$ , and the Compressibility factor  $Z$  at a specified temperature and pressure. The latter can be calculated using one of the various methods, such as Standing-Katz, CNGA and AGA methods. Calculations are based on a built-in database of 25 gas component properties. You may update the database by adding new components and their properties.

You input the molecular composition of natural gas mixture comprising of various components. For each component such as Methane, Ethane etc. the molecular content is input such that the total equals 100%. The program uses the built-in database of gas properties consisting of molecular weight, gross heating value, viscosity, specific heat, critical temperature and critical pressure. From the database, using the properties of the components, the program calculates the apparent molecular weight of the natural gas mixture, the pseudo-critical temperature and pressures, specific heats and the compressibility factor.

You may use this program in conjunction with SYSTEK's hydraulic simulation model GASPROP, to input a compositional model of the natural gas transported through the pipeline.

The output from the program consists of apparent gas molecular weight, specific heat ratio, reduced temperature and pressure and  $Z$  factor pressure and temperature.

## **Introduction**

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Data is entered using the familiar pull down menus and dialog boxes under the Microsoft Windows operating environment. Default data is provided in most cases. Molecular percentage data is entered using an Excel compatible spreadsheet. The data is stored in a proprietary format with a file name extension .SS3, but the spreadsheet information can be imported and exported with Excel.

The calculated results are displayed on the screen, as well as saved in a disk file for later viewing or printing. A printed hard copy of the calculated results can be created simultaneously with screen output.

This software can be run on Pentium and Athlon based computers and compatibles with a minimum of 1 GB RAM running Microsoft Windows XP/Vista or Windows 7 operating systems. A minimum hard disk space of 25 MB is required for installing the program. Multi-user and network versions of this software are also available. Please contact SYSTEK for information and pricing.

## 2. Getting Started

The software program is supplied on a CD-ROM that must be installed on your computer's hard disk as described below. *If you purchased a USB dongle version (hardware key) follow the installation steps under section 2.1 below. However, if you have an internet authenticated version of the program that does not use a dongle follow the steps under section 2.2.*

*This single user license entitles you to use the software only on one computer at a time. If you purchased a multi-user or network license, you are entitled to use the software on more than one computer as described in other documentation that accompanied the software.*

### 2.1 Installation – USB dongle version

The software is protected by a USB dongle that plugs into your computer's USB port. This dongle is plugged into the USB port *after* the installation of the software. This dongle, shown in the figure below, *must* be in place for the software to operate properly. ***Do not attach the dongle until after the dongle installation step is completed.***



Since the *dongle* is critical to the operation of the software, it must be stored safely when not in use. It is recommended that Laptop computer users remove the *dongle* from the printer port before packing the laptop in its carrying case.

The software will work **only** with the specific USB dongle included with the program CD. If this is an upgrade to the program, you will continue to use the original USB dongle when you first purchased the software. The USB dongles cannot be interchanged. Each dongle is specific to the software.

With one licensed copy, the program may be concurrently installed on more than one computer. However, the software will only run on the computer that has the USB dongle attached.

*A lost or damaged dongle is equivalent to losing the software. A replacement dongle can only be obtained at the full retail price of the software. In other words, the dongle costs as much as the software itself.*

*Before starting the installation process, close all running applications and turn off any virus checking software, if currently present on the hard disk. If you want to ensure that the program disk is free of any virus you may run the virus scanning software and check the program CD prior to starting installation.*

**Step-1:**

Insert the software CD into the CD-ROM drive. If *Autostart* is enabled on the CD-ROM drive, setup will start automatically. If not, from the **Start** button choose **Run**.

Type the following in the resulting screen:

G:\setup and press Enter

Where G represents the drive letter for your CD-ROM drive.

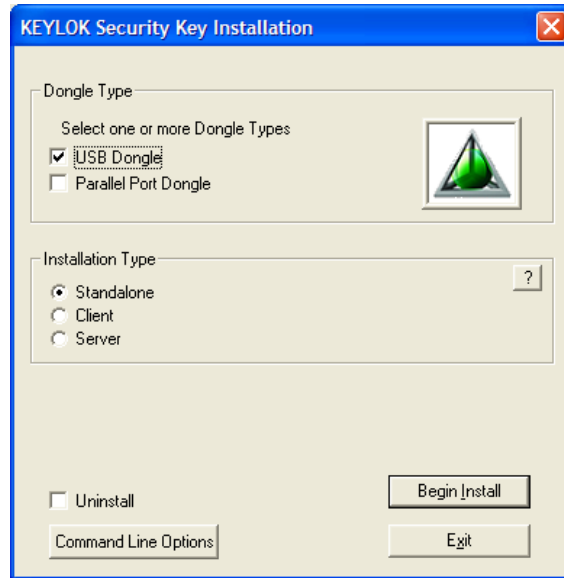
Follow the subsequent screen instructions to continue with the installation process.

**Step-2:**

After the software is installed, the Dongle Installation will automatically start.

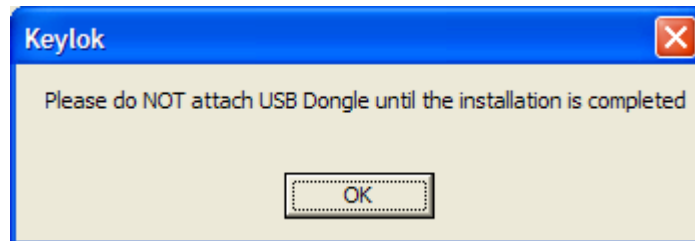
***Do not attach the dongle until after the dongle installation step is completed.***

Initially, the screen below is displayed:

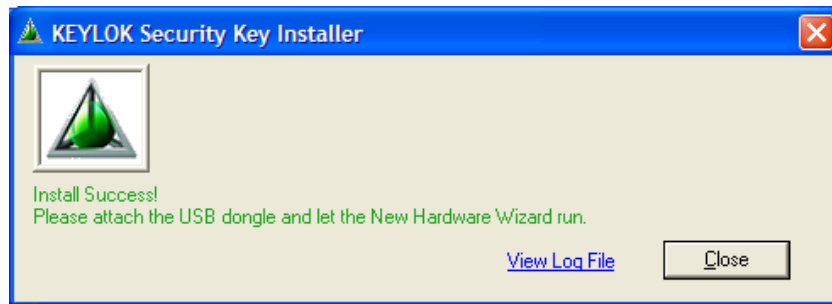


Choose the **USB Dongle** type and **Standalone** installation type as shown and click **Begin Install**.

Next, the following screen is displayed. Click OK to confirm.



When the dongle installation is completed (may take a few minutes), and a message is displayed to this effect, you should attach the dongle to one of the USB ports as directed in screen below.



The computer will recognize the dongle and the software driver will be installed automatically.

After the setup is completed and you start GASPROP software from the Windows Start button, the User Registration screen will prompt you to enter your name, company and the software serial number.

***The serial number found on the software CD container must be entered exactly.*** Otherwise the installation will be incomplete.

The Licensed User is eligible to receive **free** technical support for one year from the date of purchase. After this period, the User may sign up for an annual Software Maintenance Program.

***Put your original software CD-ROM away safely.***

## **Manual Installation of dongle files**

***If for some reason the dongle installation does not start automatically then you must manually start the dongle program (Keylok.exe) from the Start/Run button as follows:***

**Keylok /B** and press enter

*The above must be executed from the SYSTEK folder containing the Keylok.exe program. After this go back to Step 2 above to continue installation.*

After the setup is completed, the **User Registration screen** will prompt you to enter your name, company name and the program serial number. ***The serial number found on the program CD container must be entered exactly.*** Otherwise the installation will be incomplete.

Once installation is completed, a program icon and program folder will be automatically created. You may launch the program from the Windows **Start** button. You may also create a shortcut to the program on your desktop.

## **2.2 Installation – Internet Authenticated Version**

*Before starting the installation process, close all currently running programs and turn off any virus checking software, if present on the hard disk. If you want to ensure that the program disk is free of any virus you may run the virus scanning software and check the program CD prior to starting installation.*

Insert the software CD into the CD-ROM drive. If *Autostart* is enabled on the CD-ROM drive, setup will start automatically. If not, from the Windows **Start** button choose **Run**.

Type the following in the resulting screen:

G:\setup and press Enter

Where G represents the drive letter for your CD-ROM drive.

Follow the subsequent screen instructions to continue with the installation process.

After the setup is completed, the **User Registration screen** will prompt you to enter your name, company name and the program serial number. ***The serial number found on the program CD container must be entered exactly.*** Otherwise the installation will be incomplete.

*You must be connected to the Internet to register the program and obtain a license. Otherwise you will not be able to run the software after installation.*

Once installation is completed, a program icon and program folder will be automatically created. You may launch the program from the Windows **Start** button. You may also create a shortcut to the program on your desktop.

## **2.3 Retaining/Releasing - Internet Authenticated Version**

To launch the program, you will either use the Windows **Start** button or click the program icon from the Program menu. If the program is properly registered and the license obtained, you will be able to start the program.

When you quit the program, you will be prompted to either retain control or release control of the program in the event you want to use the current license on another computer. *This enables you to quit the program on your work computer, release control and restart the program on your home computer or on a laptop while traveling. However each time you quit the program you must release control if you want to run the program on another computer. Also, internet access is required to do this.*

Remember that once a program is registered and control is retained on the computer, the license can only be released from *that* computer. If you have multiple SYSTEK programs installed on your computer, you can use the utility program called **SYSTEK Control Panel** to release or retain control of selected SYSTEK programs. This program `ControlPanel.exe` is located in the GASPROP folder.

## **2.4 Installation on a Network**

If you are licensed to use the program in a network environment, the software may be installed on multiple workstations on your network. The software can then be run from any workstation on the network, subject to the maximum user limit programmed during the installation process and in accordance with your license. **PLEASE REVIEW SEPARATE DOCUMENTATION ON LAN/WAN INSTALLATION SUPPLIED WITH PROGRAM.**

## 2.5 Uninstallation

Prior to uninstalling **GASPROP**, save all data files (TOT files), Gasdatabase.SS6, GasdatabaseM.SS6 and simulation reports that you may need for later use. To **uninstall** the software from the hard disk, go to the Windows **Start button** and choose **Settings**. Next select the **Control Panel** and click on **Add/Remove Programs**. Follow subsequent instruction to uninstall **GASPROP**.

*You can no longer run the program, until you **re-install** it again as described in the *Installation section*.*

***Put your original program disk away safely.***

# 3. Features

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**GASPROP** is used to calculate the properties of a natural gas mixture, from the properties of its components. It calculates the molecular weight, specific gravity, viscosity, specific heats, gross heating value and the compressibility factor at a specified temperature and pressure. Despite the complexity of the program it is very user friendly. Online HELP is available in the General Help menu under menu item Help and the program has extensive error checking features.

*Here is a sampling of some of the features:*

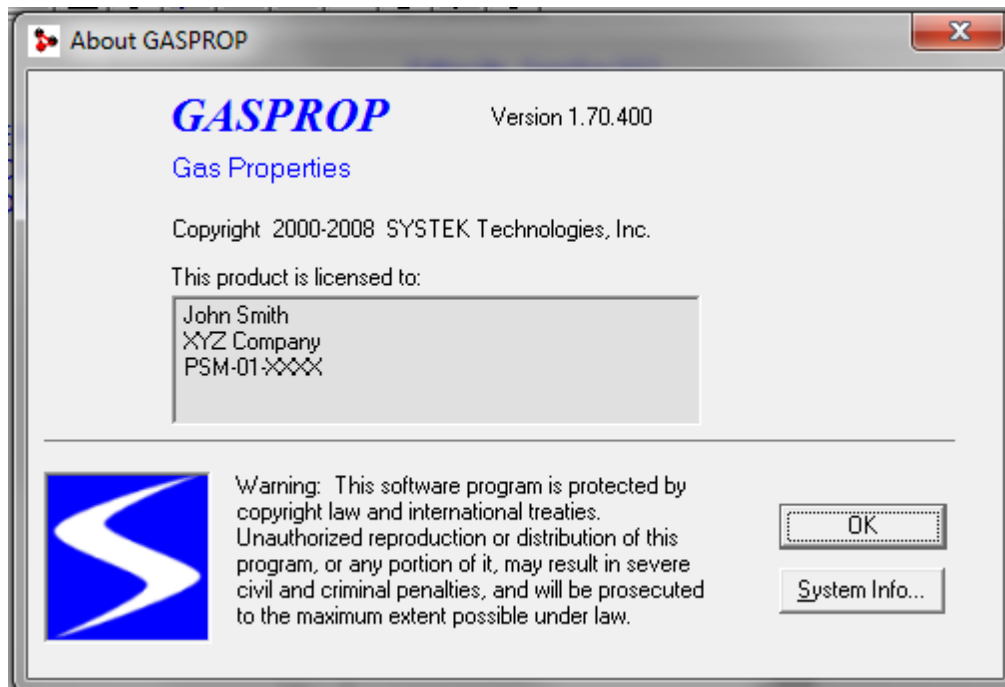
- Calculates molecular weight for the gas mixture based on the component mole-percentages in a spreadsheet. This is the main data file for each set of calculations. It is important to enter the component data such that the total mole percent equals 100%. If not, a warning message prompts you to correct the data entries. *The data entered cannot be in mole-fractions.*
- An Excel compatible spreadsheet data entry makes it easy to make changes easily and save the properties of the gases mixture.
- Compressibility factor calculations are based on Standing-Katz, CNGA and AGA Methods. The recommended option is Standing-Katz method.
- GASPROP comes with a database of gas component properties, such as molecular weights, specific heats, heating values, viscosity and critical temperatures and pressures. Currently this database cannot be edited. In a future version, this database will be editable and the user may make changes or add new components to the database.

## Running the Program

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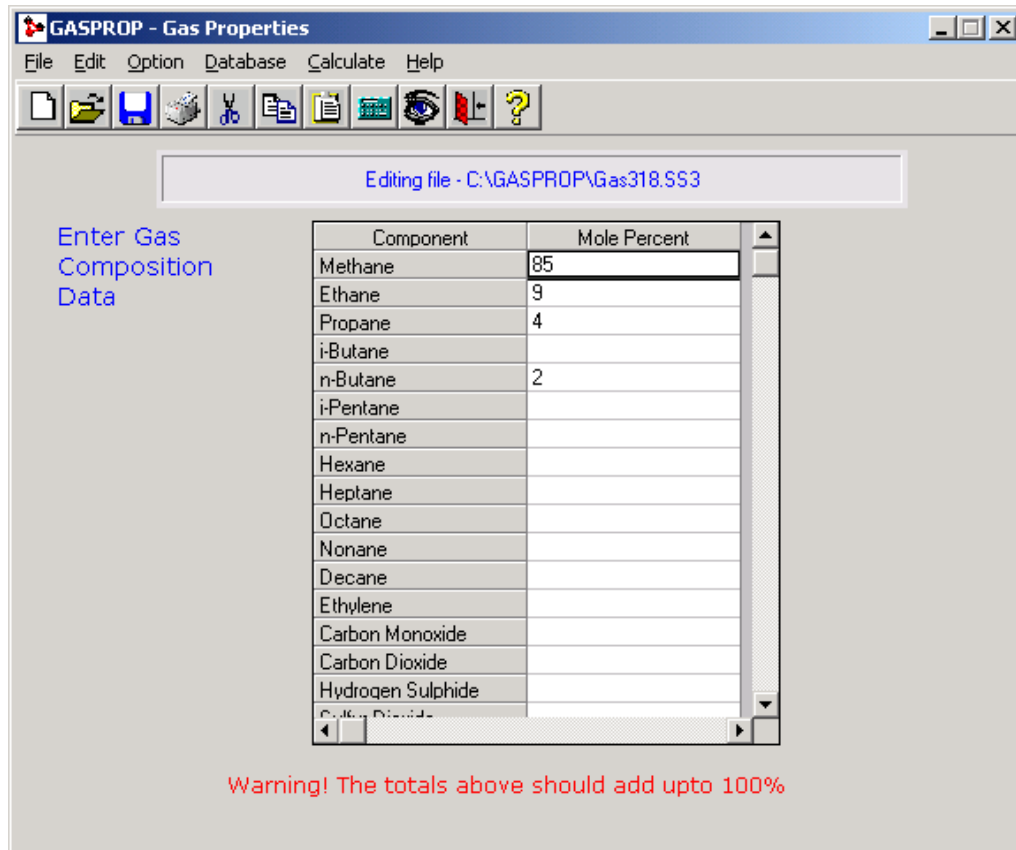
To run the program, click on the **GASPROP** program icon or select **File/Run** and type the appropriate sub-directory name and filename, such as: `C:\GASPROP\GASPROP.EXE` and press Enter.

The initial program screen will be momentarily displayed as follows:



## Running the Program

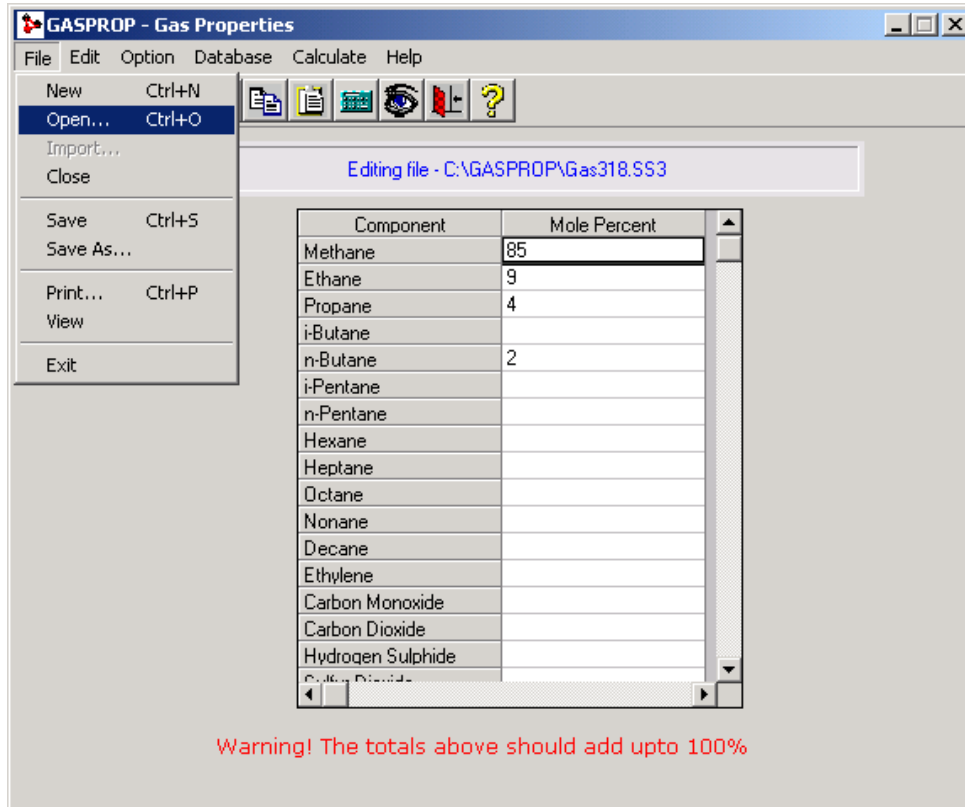
The pull down menus (such as File, Edit etc.) can be accessed by using the mouse or pressing Alt together with the underlined letter of each menu item ( **F** for file, **E** for Edit, **O** for option etc.).



## Running the Program

The menu bar along the top has several pull down options under each menu item, such as *File*, *Edit* etc. as explained below:

The pull down menu under **File** has the following :



- New** - To create a new pipeline data file.
- Open** - To open and edit an existing data file.
- Close** - To close a data file.
- Save** - To save the current data file onto the disk drive under the current file name.
- Save As** - To save a data file under a new name.
- Print** - To print the spreadsheet data file.
- View** - To view the last output file.
- Exit** - To quit the program

## Running the Program

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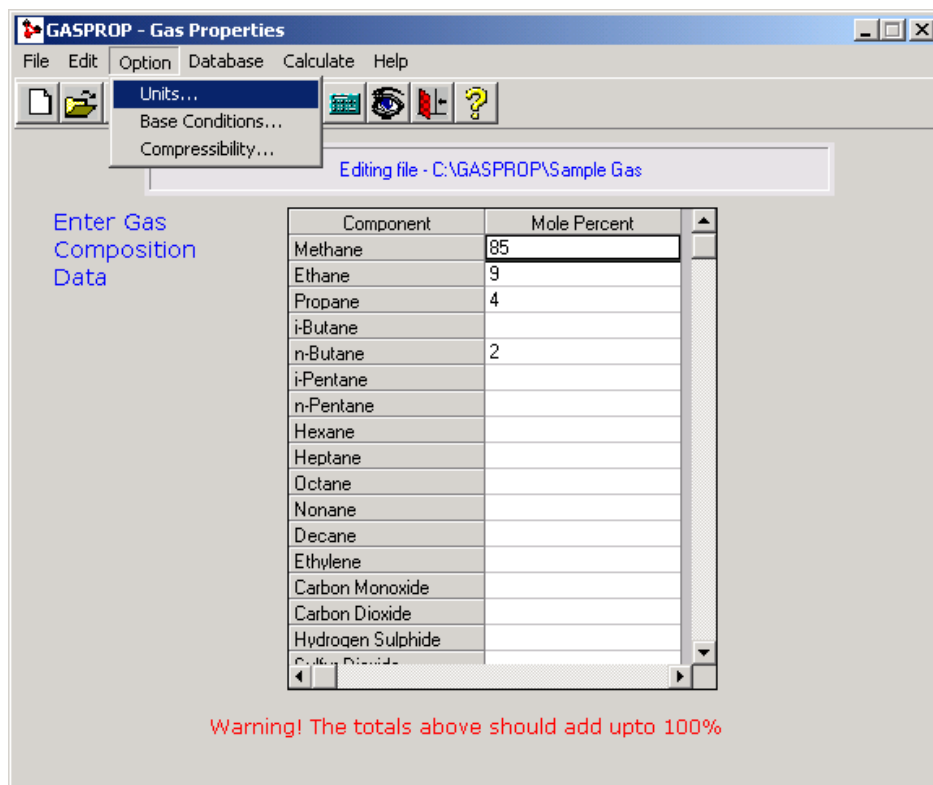
The pull down menu under **Edit** has the following :

- Cut** - To remove selected (highlighted) data from the spreadsheet to the Windows clipboard.
- Copy** - To copy selected (highlighted) data from the spreadsheet to the Windows clipboard.
- Paste** - To paste the data from Windows clipboard to the current cursor location in the spreadsheet.
- Clear** - To clear the cell in the spreadsheet
- Format cells** - To format the cells in the spreadsheet.

Accelerator keys, such as Ctrl-X for **Cut** and Ctrl-V for **Paste** are available for several menu items.

## Running the Program

The pull down menu under **Options** has the following :

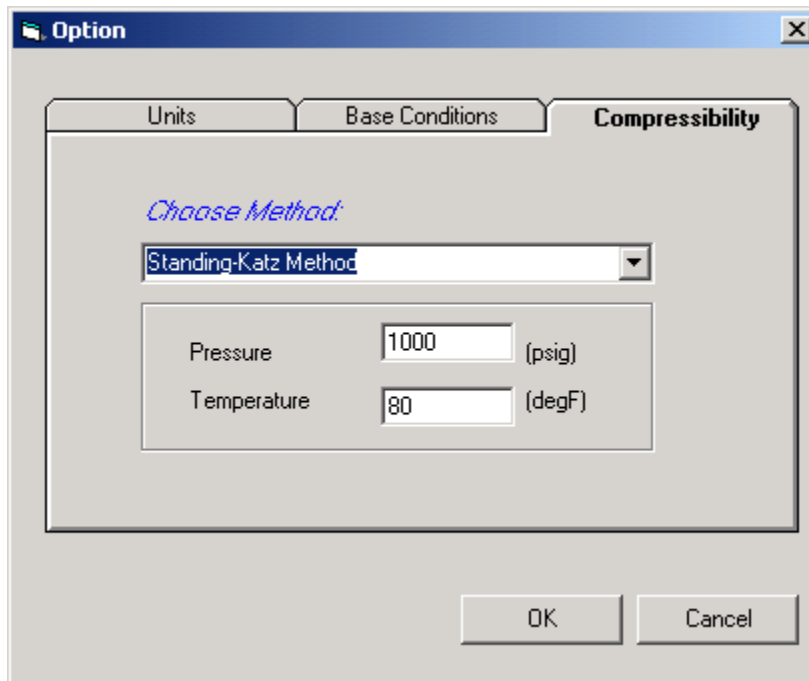


- Units** - For selecting English or Metric units of calculation.
- Base Conditions** - For inputting the base pressure and temperature of calculations.
- Compressibility** - For choosing the method of calculation for gas compressibility factor and the temperature and pressure at which it is to be calculated.

## Running the Program

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On choosing **Compressibility** the following screen opens up. Here you choose one of the three methods provided namely, Standing-Katz, CNGA and AGA. You also enter the pressure in psig and temperature in deg.F at which the compressibility factor is to be calculated.



The image shows a software dialog box titled "Option" with a close button (X) in the top right corner. The dialog has three tabs: "Units", "Base Conditions", and "Compressibility". The "Compressibility" tab is active. Inside this tab, there is a section titled "Choose Method:" with a dropdown menu currently set to "Standing-Katz Method". Below this, there are two input fields: "Pressure" with the value "1000" and the unit "(psig)", and "Temperature" with the value "80" and the unit "(degF)". At the bottom of the dialog, there are two buttons: "OK" and "Cancel".

## Running the Program

Clicking on **Database** displays the following screen, which shows the default gas properties such as, molecular weight, heating value, viscosity, specific heat, critical temperature etc. for the commonly used natural gas components. This spreadsheet is not editable, in the current version of GASPROP.

Gas Properties Database

Component	Mol.Wt	HeatVal(Btu/cu.ft)	Visc(cpoise)	Sp.Heat-Cp(Btu/lb/F)	Sp.Heat-Cv(Btu/lb/F)	Crit.Temp(degF)
Methane	16.043	1010.0	0.0107	0.52676	0.4021	-116.66
Ethane	30.07	1769.6	0.0089	0.40789	0.3414	90.07
Propane	44.097	2516.1	0.0075	0.38847	0.3431	205.93
i-Butane	58.123	3251.9	0.0071	0.38669	0.3523	274.40
n-Butane	58.123	3262.3	0.0073	0.39500	0.3606	305.52
i-Pentane	72.15	4000.9	0.0066	0.38448	0.3568	368.96
n-Pentane	72.15	4008.9	0.0066	0.38831	0.3606	385.7
Hexane	86.177	4755.9	0.0063	0.38631	0.3631	453.8
Heptane	100.204	5502.5	0.0059	0.38449	0.3645	512.8
Octane	114.231	6248.9	0.0050	0.38334	0.3658	564.15
Nonane	128.258	6996.5	0.0048	0.38248	0.3669	610.72
Decane	142.285	7742.9	0.0045	0.38181	0.3678	652.1
Ethylene	28.054	1599.8	0.0098	0.35789	0.2866	48.54
Carbon Monoxide	28.01	320.5	0.0184	0.24847	0.1771	-220.51
Carbon Dioxide	44.01	0	0.0147	0.19909	0.1536	87.73
Hydrogen Sulphide	34.082	637.1	0.0122	0.23838	0.1797	212.40
Sulfur Dioxide	64.065	0		0.14802	0.1168	315.7
Air	28.9625	0	0.0178	0.23980	0.1707	-221.29
Hydrogen	2.0159	324.2		3.4066	2.4145	-400.3
Oxygen	31.9988	0		0.21897	0.1565	-181.4
Nitrogen	28.0134	0	0.0173	0.24833	0.1769	-232.48
Chlorine	70.9054			0.11375	0.0855	290.69
Water	18.0153			0.44469	0.3337	705.1
Helium	4.0026		0.0193	1.2404	0.7407	-450.31
Hydrogen Chloride	36.4606			0.19086	0.1360	124.75

Save      Close

## Running the Program

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The pull down menu under **Calculate** has the following :

- Output Format** - For entering date, project title, case number, and output file name.
- Go !** - This initiates calculation after confirming the basis of calculations, and allowing the option to save the data file.

Clicking on **Output format** displays the screen for specifying the format of the calculated results.

The project title may be a maximum of four lines. The calculated results are stored in an output file same as the input file name, except with a file extension of .OUT. For example, if the input data file is named Sample1.SS3 as in the example above, the output file will be automatically named Sample.OUT

The menu bar item on the extreme right titled **Help** provides information about the program, such as version number, licensed user information and general help on the program.

# 4. Tutorial

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This section leads you through the program, using illustrative examples. See the **Reference** section for an explanation of the symbols and formulas used.

## Sample Problem 1:

Determine the compressibility factor  $Z$  at 130 deg.F and 800 psia for the following gas composition:

<b>Component</b>	<b>Mole %</b>
Methane	85.00
Ethane	9.00
Propane	4.00
<i>n</i> -Butane	2.00
	-----
	100.00

### **Sample Problem 2:**

Determine the specific gravity and the compressibility factor of a natural gas mixture at 1200 psig and 120 degF. The gas has the following molecular composition:

<b>Component</b>	<b>Mole %</b>
Methane	88.00
Ethane	5.00
Propane	4.00
<i>i</i> -Butane	2.0
<i>n</i> -Butane	0.4
<i>i</i> -Pentane	0.3
<i>n</i> -Pentane	0.2
<i>n</i> -Hexane	0.1
	-----
	100.00

### Sample Problem 3:

A sample of the Gulf Coast gas is described below. Calculate critical temperatures, pressures and the compressibility factor at 100 degF and 1200 psia pressure.

<b>Component</b>	<b>Mole %</b>
Methane	96.5222
Ethane	1.8186
Propane	0.4596
<i>i</i> -Butane	0.0977
<i>n</i> -Butane	0.1007
<i>i</i> -Pentane	0.0473
<i>n</i> -Pentane	0.0324
<i>n</i> -Hexane	0.0664
Nitrogen	0.2595
Carbon Dioxide	0.5956
	-----
	100.00

### Sample Problem 4:

Calculate the critical properties, molecular weight, specific gravity, heating value and compressibility factor for the following gas composition:

Component	Mole percent
Methane	83.1900
Ethane	8.4800
Propane	4.3700
i-Butane	0.7600
n-Butane	1.6800
i-Pentane	0.5700
n-Pentane	0.3200
Hexane	0.6300

## Solution

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After setting up the software as described in the **Getting Started** section, start **GASPROP** by double clicking on its icon.

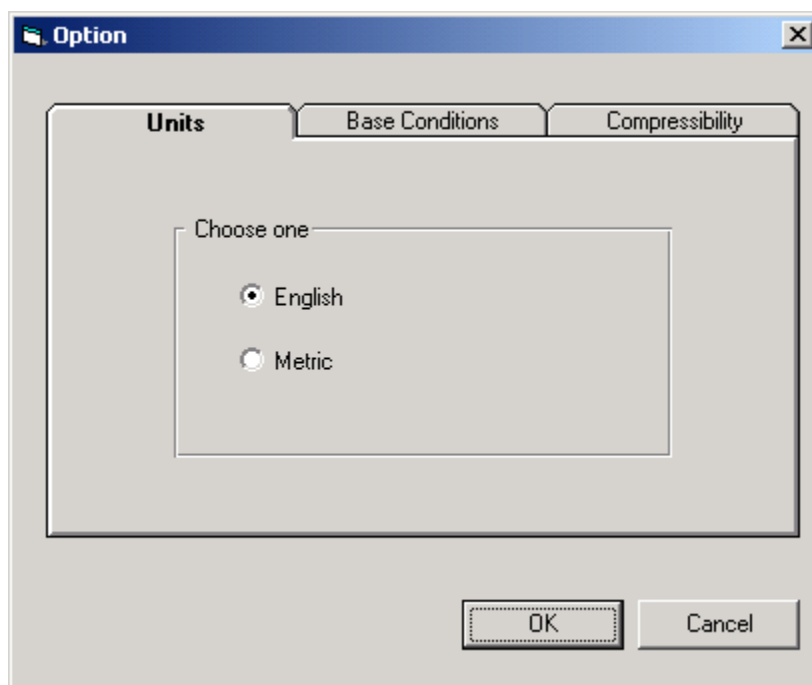
In the main program window, choose **File** from the pull down menu by using the mouse or pressing the Alt together with the underlined letter **F**. Choose **New to create a new data file**. To open an existing data file, you will choose **Open** from the File menu.

For the sample problem enter the gas composition in the blank spreadsheet presented. After entering data save the file by choosing **SaveAs** from the file Menu. Data files are stored in a proprietary spreadsheet format with a file name extension of **.SS3**. For example, a composition data file may be Sample.SS3.

## Solution

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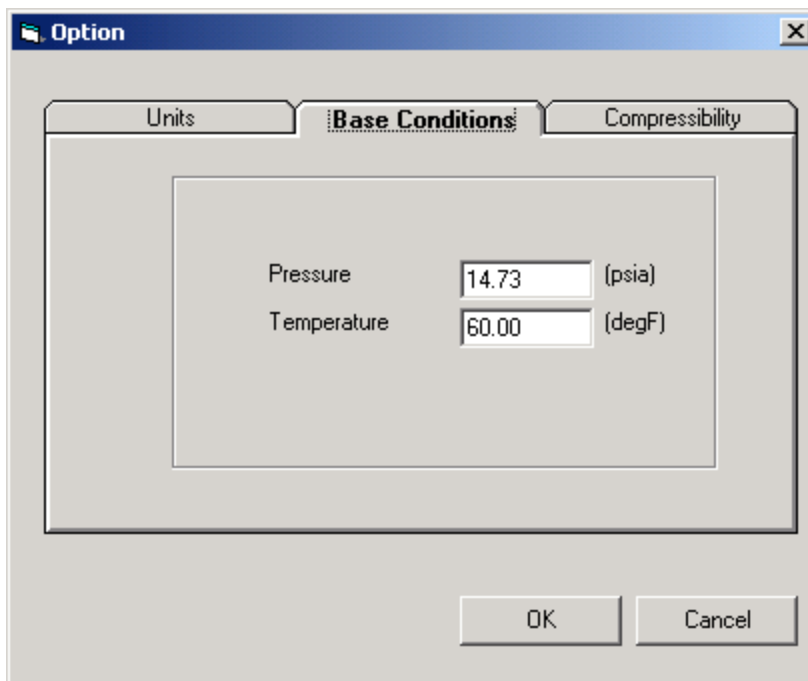
To proceed with the sample problem, choose the pull down menu item **Options** followed by **Units** and the following window opens up:



This screen is used to choose English or Metric units of calculation. Selection is made by clicking the mouse or using the cursor key to select the appropriate button.

Choose English units of calculations for the sample problem.

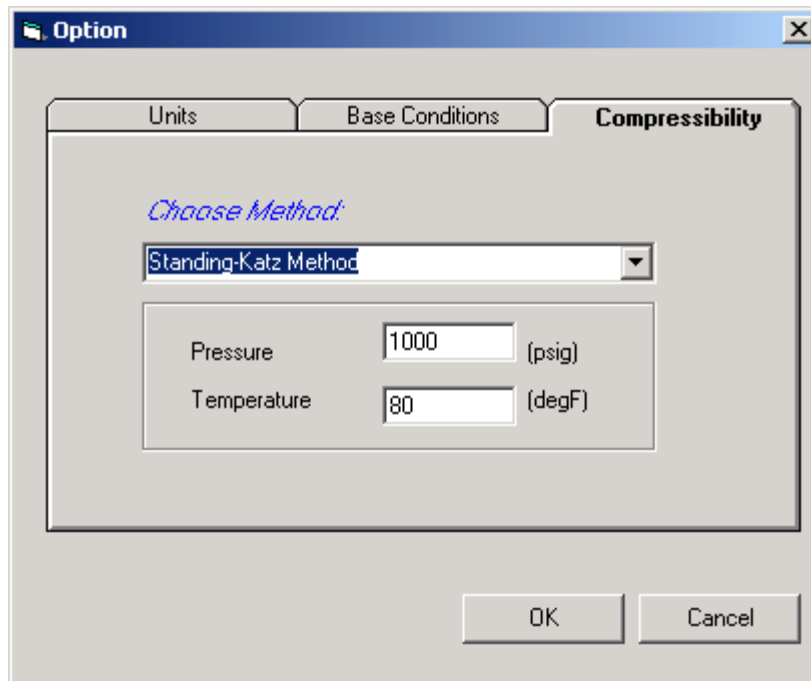
Next, choose **Options** followed by **Base Conditions** on the menu bar and the following window opens up:



This screen is used to input the pressure and temperature for the gas mixture. You are provided with default values for the sample problem in most cases.

## Solution

Next, choose **Options** followed by **Compressibility** on the menu bar and the following window opens up:



Choose the default method (Standing-Katz) and press OK.

Read the explanation of the compressibility factor calculation methods in the **Reference** section of this manual.

Other input data such as pressure and temperature are also input here. Default values are provided for the above input data fields, which in most cases will match the sample problem.

## Solution

---

Next, from the pull-down menu **Calculate**, choose **Output format**. In the resulting dialog box, enter the date, project title, case number, etc.

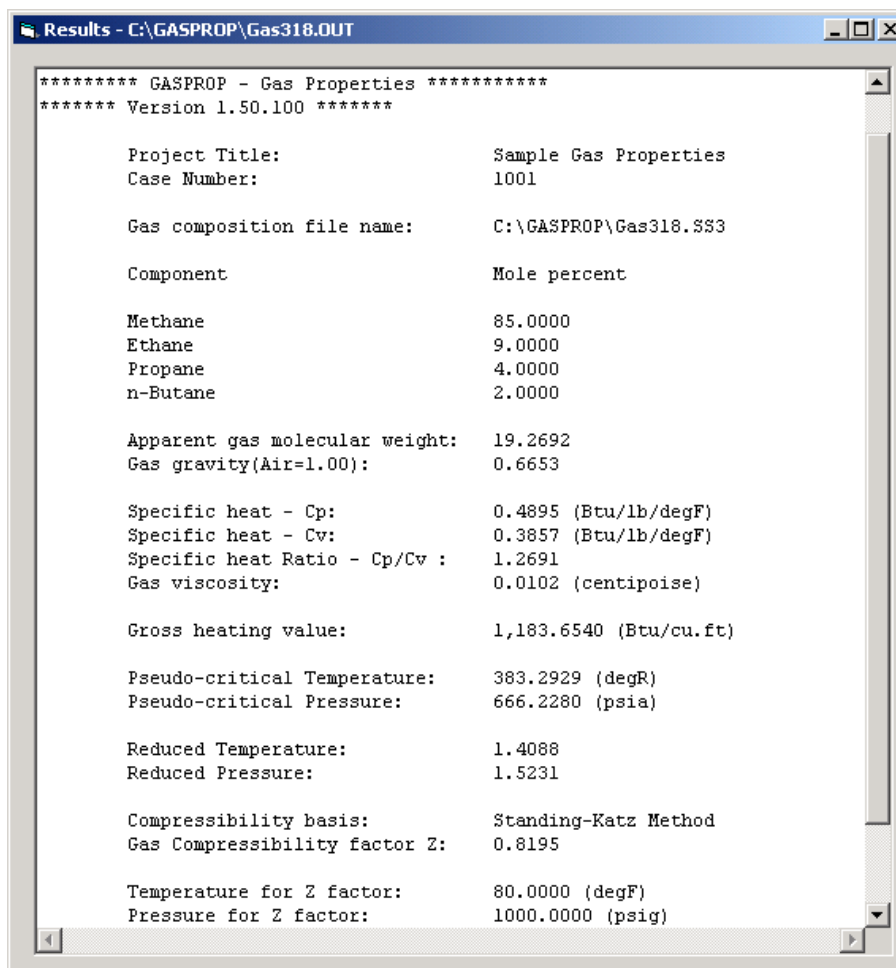
The project title may be a maximum of 4 lines. Press the Tab key to move from each line to the next to enter the additional lines for the project title. Notice that the data file name is shown as Sample1.SS3. The calculated output will be stored in a file named Sample1.OUT. Similarly, if the input data file for gas composition were XYZ.SS3, the corresponding output file will be XYZ.OUT.

At this point, if you want to change the method of calculation of the compressibility factor, you may choose a different option here. Click the **OK** button after entering all data.

Finally, choose **Go!** from the **Calculate** menu or click on the **Calculate** icon.

## Solution

After a pause, varying from a few seconds to several minutes depending on the computer, the results of the calculation are displayed in a scrollable window similar to the following:



```
***** GASPROP - Gas Properties *****
***** Version 1.50.100 *****

Project Title:           Sample Gas Properties
Case Number:            1001

Gas composition file name:  C:\GASPROP\Gas318.SS3

Component              Mole percent

Methane                85.0000
Ethane                 9.0000
Propane                4.0000
n-Butane               2.0000

Apparent gas molecular weight: 19.2692
Gas gravity(Air=1.00):  0.6653

Specific heat - Cp:    0.4895 (Btu/lb/degF)
Specific heat - Cv:    0.3857 (Btu/lb/degF)
Specific heat Ratio - Cp/Cv : 1.2691
Gas viscosity:         0.0102 (centipoise)

Gross heating value:   1,183.6540 (Btu/cu.ft)

Pseudo-critical Temperature: 383.2929 (degR)
Pseudo-critical Pressure:  666.2280 (psia)

Reduced Temperature:   1.4088
Reduced Pressure:      1.5231

Compressibility basis: Standing-Katz Method
Gas Compressibility factor Z: 0.8195

Temperature for Z factor: 80.0000 (degF)
Pressure for Z factor:   1000.0000 (psig)
```

The calculated results are also saved on disk. As mentioned earlier, if the input data file is Sample1.SS3 the corresponding output file will be saved under the name Sample1.OUT. After viewing the results of the calculations on screen, click the **Print** button to print the results on the printer. The calculated results are included in this User Manual under the heading **Sample Output**.

## 5. Sample Output

## Sample Problem -1

Project Title: Sample Gas Properties Sample1

Case Number: 1001

Gas composition file name: D:\GASPROP\Sample1.SS3

Component	Mole percent
Methane	85.0000
Ethane	9.0000
Propane	4.0000
n-Butane	2.0000
Apparent gas molecular weight:	19.2692
Gas gravity(Air=1.00):	0.6653
Specific heat - Cp:	0.5079
Specific heat - Cv:	0.3934
Specific heat Ratio - Cp/Cv :	1.2909
Gas viscosity:	0.0212 (centipoise)
Gross heating value:	1,183.6540 (Btu/cu.ft)
Pseudo-critical Temperature:	383.2929 degR
Pseudo-critical Pressure:	666.2280 psia
Reduced Temperature:	1.5393
Reduced Pressure:	1.2008
Compressibility basis:	Standing-Katz Method
Gas Compressibility factor Z:	0.8943
Temperature for Z factor:	130.0000 degF
Pressure for Z factor:	785.3000 psig
Base pressure:	14.7300 psig
Base temperature:	60.0000 degF



### Sample Problem -3

Project Title: Sample Gas Properties Sample-3

Case Number: 1003

Gas composition file name: D:\GASPROP\sample3.SS3

Component	Mole percent
Methane	96.5222
Ethane	1.8186
Propane	0.4596
i-Butane	0.0977
n-Butane	0.1007
i-Pentane	0.0473
n-Pentane	0.0324
Hexane	0.0664
Carbon Dioxide	0.5956
Nitrogen	0.2595
Apparent gas molecular weight:	16.7994
Gas gravity(Air=1.00):	0.5800
Specific heat - Cp:	0.5208
Specific heat - Cv:	0.3985
Specific heat Ratio - Cp/Cv :	1.3069
Gas viscosity:	0.0216 (centipoise)
Gross heating value:	1,031.4316 (Btu/cu.ft)
Pseudo-critical Temperature:	351.0775 degR
Pseudo-critical Pressure:	668.9020 psia
Reduced Temperature:	1.5951
Reduced Pressure:	1.7940
Compressibility basis:	Standing-Katz Method
Gas Compressibility factor Z:	0.8696
Temperature for Z factor:	100.0000 degF
Pressure for Z factor:	1185.3000 psig
Base pressure:	14.7300 psig
Base temperature:	60.0000 degF

## Sample Problem -4

Gas composition file name: D:\GASPROP\sample1.SS3

Component	Mole percent
Methane	83.1900
Ethane	8.4800
Propane	4.3700
i-Butane	0.7600
n-Butane	1.6800
i-Pentane	0.5700
n-Pentane	0.3200
Hexane	0.6300
Apparent gas molecular weight:	20.4264
Gas gravity(Air=1.00):	0.7053
Specific heat - Cp:	0.5052
Specific heat - Cv:	0.3927
Specific heat Ratio - Cp/Cv :	1.2867
Gas viscosity:	0.0212 (centipoise)
Gross heating value:	1,245.3515 (Btu/cu.ft)
Pseudo-critical Temperature:	393.0021 degR
Pseudo-critical Pressure:	662.1158 psia
Reduced Temperature:	1.3740
Reduced Pressure:	1.5326
Compressibility basis:	Standing-Katz Method
Gas Compressibility factor Z:	0.7998
Temperature for Z factor:	80.0000 degF
Pressure for Z factor:	1000.0000 psig
Base pressure:	14.7300 psig
Base temperature:	60.0000 degF

# 6. Reference

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This section provides an explanation of formulas and variable names used.

## Formulas

### 1. Molecular Weight

From Gas composition, determine apparent molecular weight of gas mixture:

$$\text{Molecular weight} \quad M_g = \sum M_i * Y_i$$

where

$M_i$  - molecular weight of component  $i$

$Y_i$  - Mole percent of component  $i$

### 2. Specific Gravity

Specific gravity of gas mixture is obtained from:

$$\text{Specific gravity} \quad \text{Density of gas mixture} / \text{Density of Air}$$

$$G = M_g / M_{\text{air}} = M_g / 28.9625$$

### 3. Compressibility Factor

Compressibility Factor  $Z$  is the ratio of the volume occupied by a gas to the volume the gas would occupy as an ideal gas at the same temperature and pressure.

$$Z = V_{\text{actual}} / V_{\text{ideal}}$$

The compressibility factor varies with the Gas composition of temperature and pressure. GASPROP calculates the compressibility factor using one of the following three methods:

1. Standing-Katz Method
2. CNGA Method
3. AGA Method

The Standing-Katz Method is based on charts published in the Transactions of AIME, 146, 144 in January 1941.

CNGA Method is based on the following equation:

$$Z = 1/(1+C_z*P*10^{1.785}*G/T^{3.825})$$

where  $C_z =$  a constant,  $3.444*10^5$  for English Units  
and  $5.172*10^5$  for Metric units.

$G =$  Specific gravity of gas (Air = 1.00)

$P =$  Gas pressure, psig

$T =$  Absolute gas temperature, degree Rankin.

AGA method uses the approach outlined in AGA-IGT, Report No. 10. This correlation is valid for temperatures between 30 deg.F and 120 deg.F and for pressures up to 1380 psig. It produces an error of less than 0.03 percent in this range of temperatures and pressures. Beyond this range the discrepancy can be up to 0.07 percent.

For details of other methods of compressibility calculations refer to American Gas Association publication Report No. 8, Second Edition, November 1992.

#### 4. Specific Heat

Specific Heat capacity is the ability of a gas to store heat. It is referred to under conditions of constant pressure and constant volume. The specific heat at constant pressure is designated as  $C_p$  and the corresponding value at constant volume is designated as  $C_v$ .

In English units both are measured in BTU/lb-degF. Specific heat based on molecular weight of gas is simply the product of  $C_p$  or  $C_v$  and the gas molecular weight. The ratio of the two specific heats,  $C_p / C_v$  is referred to as specific heat ratio or K factor.

### 5. Viscosity

Viscosity is a measure of the resistance to flow exerted by the gas. It is usually measured in the units of centipoises which is dimensionally gram mass/100sec-cm. Two types of viscosity are used – dynamic and kinematic. They are related as follows:

$$\text{Kinematic Viscosity} = \text{Dynamic viscosity/density}$$

When Dynamic viscosity is measured in centipoises, the kinematic viscosity is usually referred to in centistokes.

Viscosity of gases are generally calculated from curves developed for pure gases at various temperatures and pressures. For a mixture of gases the viscosity of the gas mixture is calculated from the individual viscosities and their respective mole percentages. The following equation is used to calculate the viscosity of a gas mixture when the gas composition is known

$$\text{Viscosity of mixture, } \mu = \frac{\sum \mu_i * Y_i * M_i^{1/2}}{(\sum Y_i * M_i^{1/2})}$$

Viscosity of common gases, such as Air, Nitrogen, Methane etc. at atmospheric pressure have been tabulated in Transactions of AIME, 201,269

For additional information on Viscosity refer to The Properties of Petroleum Fluids, William D. McCain, Jr., Petroleum Publishing Company, Tulsa, Oklahoma, 1973.

## Symbols

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$M_g$	-	Apparent molecular weight .
$T_{pc}$	-	Pseudocritical temperature, deg.F.
$P_{pc}$	-	Pseudocritical pressure, psia.
$T_r$	-	Reduced temperature,dimensionless
$P_r$	-	Reduced pressure,dimensionless
$\mu$	-	Dynamic viscosity, centipoise
$S$	-	Specific gravity of liquid at flowing temperature, dimensionless.
$\mu_g$	-	Dynamic viscosity of gas, centipoise
$Z$	-	Compressibility factor, dimensionless
$C_p$	-	Specific heat at constant pressure
$C_v$	-	Specific heat at constant volume
$K$	-	Specific heat ratio, $C_p/C_v$

## **Bibliography**

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1. The Properties of Petroleum Fluids, William D. McCain, Jr., Petroleum Publishing Company, Tulsa, Oklahoma, 1973.
2. American Gas Association publication Report No. 8, Second Edition, November 1992.
3. Transactions of AIME, 146,144 in January 1941

# 7. Troubleshooting

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**GASPROP** is a powerful gas properties program for various gas mixtures. Despite the complexity of the program it is very user friendly. Online HELP is available for most data entry screens and the program has extensive error checking features. However, there is always a possibility that some extraneous or invalid data was entered and the program may hang up. In such cases, try quitting the program by using the **File/Exit** menu item or click on the **Exit** icon on the toolbar. If this does not work, you have no choice but to perform a hard re-boot and re-start the **GASPROP** program.

If you cannot get **GASPROP** to run properly even after following the steps outlined in the *Getting Started* section of this manual, please email Technical Support. Have your program disk serial number and program version number handy to facilitate quick response.

## **Error Messages:**

Here are some errors that you may encounter while running **GASPROP**:

### **1. Divide by zero error**

This is generally due to some data input value that is zero. Check all input data for zero values.

### **2. Illegal Function call**

This is generally due to some illegal mathematical operation such as trying to extract the square root of a negative value. Ensure that there are no inadmissible negative values.

### **3. File not found**

A common error when a file specified cannot be located on the hard disk or does not exist. When specifying gas properties, make sure the file is present in the sub-directory or folder containing GASPROP. Otherwise, ensure that the file name is typed in correctly, including the full path.

If the above problems persist or you cannot successfully install the software on your hard disk, contact Technical Support.

# 8. Technical Support

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*Please read the Troubleshooting section of this manual before you call us for technical support.*

In order to facilitate quick response, please have your disk serial number and program version available when you call us.

## **How to contact us:**

In order to facilitate quick response, please have your disk serial number and program version available when you call us.

## **How to contact us:**

You may contact SYSTEK in any of the following ways:

Phone/Fax: +1 (928) 453-9587

E-mail: [support@systek.us](mailto:support@systek.us)

Web site: [www.systek.us](http://www.systek.us)

Free Technical Support is provided for registered users of this software for a period of sixty (60) days from the initial purchase date. After that period, Technical Support can be provided only if an annual Software Maintenance and Technical Support plan has been purchased. Call or write for details.