Starling Associates GOFW2008

User's Manual

GOFW2008 License Agreement

The license agreement given below is the normal license agreement for GOFW2008. It can be noted according to condition number 11 that "This agreement constitutes the sole understanding between the parties concerning GOFW2008 and may only be modified in writing agreed to by all parties." If your company has agreed to a modified license agreement, a record of this modified license agreement should reside in your company's records.

This Agreement is by and between:

Starling Associates, Inc. 1324 Brookside Drive, Norman OK 73072, U.S.A. (hereinafter referred to as "DEVELOPER") and Licensee (hereinafter referred to as "USER") for the use of a certain proprietary computer software product known as GOFW2008 and its related documentation (herein referred to as "MANUALS") which together have been developed by DEVELOPER.

DEVELOPER grants to USER a non-exclusive license to use GOFW2008 solely by USER or USER company personnel and solely using USER or USER company owned Windows-based personal computers. Use of GOFW2008 by any person other than USER or USER company personnel is prohibited. Installation of software using GOFW2008 on any computer not owned by the USER or USER company is prohibited. Installation of software using GOFW2008 on any intranet or internet server is prohibited. The following conditions also apply.

1. License Fee. USER must pay the current license fee.

2. Activation. USER must activate the software only on the number of computers for which the license fee has been paid (Windows based personal computers). For each installed computer, USER must supply a file containing GOFW2008 security information, so DEVELOPER can supply a GOFW2008 license file for each installed computer. Any change in this activation process must be agreed between USER and DEVELOPER.

3. Support Service. DEVELOPER will provide one instance per installed computer, up to a maximum of ten instances per licensee, of reactivation or e-mail support service during the first year of this license agreement. Additional support will be billed at then current rates. Support service involving issues specific to computer operating systems (e.g., Microsoft Windows 7) and/or Microsoft Office software (e.g., Excel 2007) and/or other software or systems which affect the use of GOFW2008 will be billed at current rates at the time of service.

4. Copyright. USER will abide by the Copyright laws with respect to GOFW2008. USER may copy MANUALS for use by USER and/or USER company employees. Selling or distributing this software or executable programs (including intranet or internet applications) using this software without written permission from Starling Associates, Inc. is prohibited.

5. Disclaimer. GOFW2008 and the information contained therein are provided "as is." DEVELOPER and any agent , representative, publisher, or distributor of GOFW2008, or any of their respective directors, officers, employees, agents, representatives or members make no guarantee or warranty of any kind, either express or implied, including, but not limited to warranties

of merchantability or fitness for any particular use or any other warranties implied by law and USER specifically releases all such Developer and all such person from any such warranties and representations.

6. INDEMNIFICATION
Starling Associates, and any agent, representative, publisher or distributor of GOFW2008, or any of their respective directors, officers, employees, agents, representatives or members (the "Indemnified Parties") shall have no liability for, and User shall defend, indemnify and hold each of the Indemnified Parties harmless from and against any judgment, liability, loss, cost or damage (including any settlement amount, litigation costs, reasonable attorneys' fees, and other legal expenses) incurred as a result of any suit, action, or claim arising out of, pertaining to, or resulting in any way from, the use or possession of, or information contained in GOFW2008 by User and/or any of its users directors, officers, employees, representatives, agents or contractors.

7. LIMITATIONS OF LIABILITY

A. User acknowledges that each of the Indemnified Parties' obligations and liabilities with respect to GOFW2008 are exhaustively defined in this Agreement. NONE OF THE INDEMNIFIED PARTIES NOR ANY OF ITS DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, REPRESENTATIVES, OR MEMBERS SHALL BE LIABLE TO USER, WHETHER UNDER CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE, FOR ANY LOSS OF PROFITS, LOSS OF BUSINESS, INTERRUPTION OF BUSINESS OR INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND RESULTING FROM ANY BREACH OF ITS AGREEMENT OR FROM ANY USE OF GOFW2008, EVEN IF THE DAMAGED PARTY HAS ADVISED THE OTHER PARTY OF THE POSSIBILITY OF SUCH LOSS. WITHOUT LIMITING THE FOREGOING, THE INDEMNIFIED PARTIES' AGGREGATE LIABILITY TO USER SHALL BE LIMITED TO THE AMOUNT RECEIVED BY DISTRIBUTOR FROM USER HEREUNDER.

B. If at any time an allegation of infringement of any rights of any third party is made, or in the Indemnified Parties' opinion is likely to be made, with respect to GOFW2008, Distributor may, at its option and at its own expense (i) obtain for User the right to continue using GOFW2008, (ii) modify or replace GOFW2008 or any portion thereof so as to avoid any such claim of infringement, or (iii) refund to User the License Fee. The Indemnified Parties shall have no liability to User if any claim of infringement would have been avoided except for users refusal to use any modified or replacement GOFW2008 supplied or offered to be supplied pursuant to this Section 7(b) or to otherwise cease using GOFW2008.

C. Section 7(b) states the entire liability of the Indemnified Parties with respect to the infringement or alleged infringement of any third party rights of any kind whatsoever by any of GOFW2008.

8. Effective Date and Termination.

a. This Agreement shall become effective on the date of license fee purchase by USER.
b. For a three year license, the GOFW2008 license will continue from the date of purchase of license fee by the USER for three years.
c. For a longer-term license, the GOFW2008 license will continue from the date of purchase of license fee by the USER for the agreed period of the longer-term license.

9. GOVERNING LAW. This Agreement shall be governed and construed in accordance with the laws of the United States and with the laws of the state of Oklahoma applicable to contracts entered into and to be performed entirely therein without regard to any choice or law or conflict of law provisions.

10. DISPUTE RESOLUTION. In the event of a dispute arising from or relating to this Agreement, each Party shall appoint a senior management representative to negotiate a resolution. If such efforts are not successful within thirty (30) days or as otherwise agreed by the Parties, then the Parties may submit any dispute arising from or related to this Agreement to non-binding mediation in a neutral location mutually agreeable to the Parties. If the Parties cannot agree on a neutral location within thirty (30) days, then the mediation shall be in Norman,Oklahoma. If such mediation is not chosen or is not successful, then the Parties shall submit the dispute to arbitration by a single arbitrator in accordance with the Rules for Commercial Arbitration of the American Arbitration Association in a neutral location mutually agreeable to the parties. If the Parties cannot agree on a neutral location within thirty (30) days, then the arbitration shall be in Norman, Oklahoma. The arbitrator shall have the power to award damages, costs and attorneys' fees in his/her discretion and subject to the principles of equity.

11. Miscellaneous.
- This agreement constitutes the sole understanding between the parties concerning GOFW2008 and may only be modified in writing agreed to by all parties.
- Any obligations and duties which by their nature extend beyond the expiration or termination of this Agreement shall survive the expiration or termination of this Agreement.

Disclaimer, Copy and Copyright Notice

Nothing contained in this user's guide or the **GOFW2008** program is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent, nor as insuring anyone against liability for infringement of letters patent.

Every effort has been made to assure the accuracy and reliability of the data contained herein; however, Starling Associates, Inc. makes no representation, warranty, or guarantee in connection with this program and hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use; for any violation of any federal, state, or municipal regulation with which this program may conflict; or for the infringement of any patent resulting from its use.

The **GOFW2008** V1.0, Release 1.0 Manual
July 31, 2008
Visit our web site: www.starlingassoc.com

Acknowledgments

The technical information which provides the basis for the present computer program for natural gas orifice flow was developed through the cooperative efforts of many individuals and organizations including the Gas Research Institute, the American Gas Association (AGA), the American Petroleum Institute, the Gas Processors Association (GPA), the Chemical Manufacturers Association, the Canadian Gas Association, the International Standards Organization (ISO), the Gaz European Recherches Groupe, the European Community, Norway, Japan, and others.

The algorithms and equations in the present computer program are based on the 1992 AGA Reports Nos. 3 and 8, the 1985 AGA Reports Nos. 3 and 8, the 1962 NX-19 Standard and the GPA Standard 2172-86. The subroutines used for natural gas densities, compressibility factors and supercompressibility factors for the 1992 standard are given in AGA Report No. 8 (1992). These subroutines were developed under the sponsorship of the Gas Research Institute and are distributed on diskette by the American Gas Association. The algorithm for calculating flange tapped square edged orifice discharge coefficients is based on the algorithm in AGA Report No. 3 (1992). The AGA 7 - AGA 9 - Linear Meters calculations are based on AGA.7 - Measurement of Gas by Turbine Meters, Transmission Measurement Committee Report No. 7, Second Revision, April 1996 and AGA. 9 – Measurement of Gas by Multipath Ultrasonic Meters, Transmission Measurement Report No. 9, June 1998.

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GOFW2008 Product Support

Starling Associates Inc. is committed to providing the best possible technical support for **GOFW2008** and all our products. Please follow the procedure outlined below.

The Starling Associates web site is the fastest and most efficient way to locate information about our products including maintenance files and contact information. The web site is available 24 hours a day and allows you to send your questions, comments and suggestions by e-mail to sai@starlingassoc.com.

Technical Support

When requesting technical support, please provide the following information:

- Your name and the name of the registered user, if different.
- Address, phone and fax number, and email address, if available.
- System information of the computer you are using including the operating system, the amount of memory and system resources and any relevant devices or peripherals.
- A detailed description of the problem. Describe error messages exactly as they appear. List the steps and conditions that led to the problem.

Contacting Starling Associates, Inc

Starling Associates website	http://www.starlingassoc.com
E-mail	sai@starlingassoc.com

Activating the License for GOFW2008

Click the GOFW2008 License Manager in the Starling Associates GOFW2008 License Manager folder on the Start Menu and save the .c2v file on your PC with a name of your choice. Send this file to sai@starlingassoc.com. A file with the extension .v2c will be returned to you; you can check it in using the GOFW2008 License Manager and your 3 year license will be activated.

Chapter 1

Introduction

*Congratulations on licensing **GOFW2008**. Discover how easy it is to perform flow calculations and to evaluate the economic impact of using different standards to measure natural gas flow.*

ICON KEY
Valuable information
Steps
Contents

Installation

System Requirements

Please check that the system on which you will be installing **GOFW2008** meets these requirements:

- IBM compatible PC with a 486 or higher microprocessor
- Minimum 8 MB RAM
- Microsoft Windows Version 2000, XP or Vista.
- Hard disk space requirement: 60 MB (+ 24 MB for Acrobat reader).

Installing GOFW2008

If your installation is from a setup executable program, merely follow the instructions provided. If your installation is from a CD-ROM follow the instructions below.
Start Windows and close all open applications

- Insert the supplied diskettes/CD-ROM
- Click the Start button on the Windows taskbar.
- Point to Settings and click on Control Panel. In the Control Panel window, click on the Add/Remove Programs icon.
- Follow the instructions on the screen.

Check List

After installation you should have the following items installed in C:\Starling Associates GOFW2008\.

- GOFW2008 program files
- GOFW2008 MANUAL.PDF
- Example-As Found.CS1
- GOFW2008.INI
- LICENSE
- GOFW2008 License Manager

Manual File

The file GOFW2008 MANUAL.PDF is a copy of the GOFW2008 User Manual. It is installed during GOFW2008 installation. If the Adobe Acrobat reader is installed on the user computer, the manual may be viewed by clicking "GOFW2008 Manual" in the GOFW2008 folder on the Start taskbar. The Adobe Acrobat reader software also is available on the Internet. Note that the "Find" option in the "Edit" menu available with Adobe Acrobat provides the user with an effective tool for searching the **GOFW2008 Manual** for specific topics of interest. Also, viewing the index of the **GOFW2008 Manual** can be helpful in locating numerous topics.

Running GOFW2008

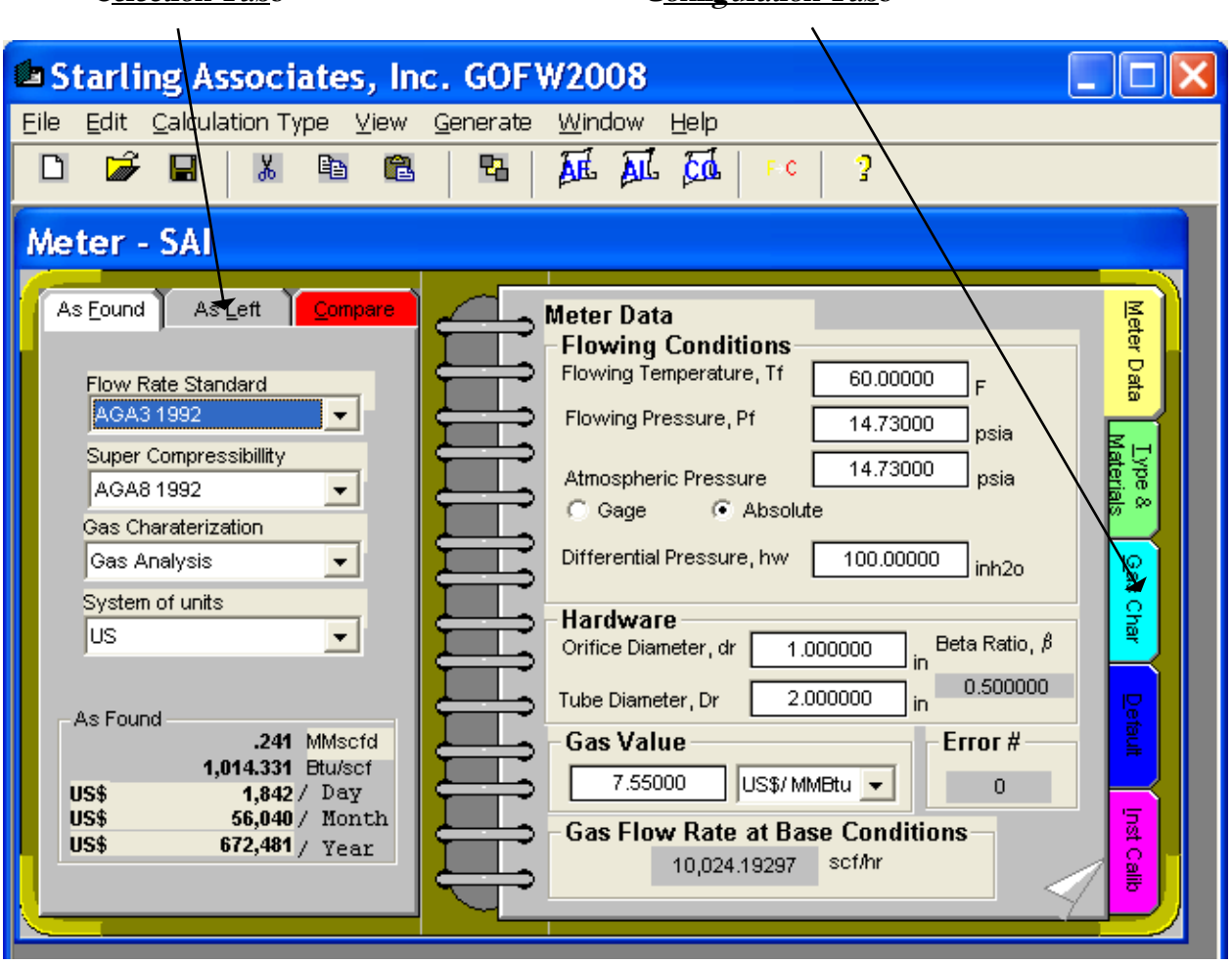
- In Windows, click on the Start button and choose All Programs. Select **Starling Associates GOFW2008** and click on the **GOFW2008** icon.
- The **GOFW2008** welcome screen appears while program initialization is taking place.
- You have successfully launched **GOFW2008.**

User Interface

Although many terms in this manual are familiar to Windows users, two terms relate specifically to the format of the **GOFW2008** program. These are the **GOFW2008** Notebook and the **GOFW2008** Tabs.

The **GOFW2008** interface is presented in an easy-to-use format referred to as the **GOFW2008** Notebook (shown below). Accessing various parts of **GOFW2008** requires a simple click on a Tab of the Notebook. Chapters 4 though 8 contain detailed descriptions of the **GOFW2008** Configuration Tabs found on the right side of the Notebook. The **GOFW2008** Selection Tabs (found on the left side of the Notebook) are used to specify the As Found and As Left conditions. The Compare Selection Tab shows a comparison of those conditions.

GOFW2008 Notebook



The other parts of the **GOFW2008** screen follow the familiar Windows format. They are explained below.

The Titlebar

The titlebar shows the software name, **Starling Associates, Inc. GOFW2008**.

The Meter Titlebar

The Meter Titlebar displays the meter's name.

The Menu Bar

The **GOFW2008** Menu Bar is always visible within **GOFW2008**. It contains the following drop-down menus:

- The **File** menu contains New Meter, Open, Save As, Save, Close, Print Setup and Exit
- The **Edit** menu contains Cut, Copy, Paste, Delete, AF-AL/AL-AF

- The **Calculation Type** menu contains Volume Flow Rate, Mass Flow Rate, Differential Pressure, Orifice Size
- The **View** menu contains As Found, As Left, Comparison, Meter Properties, Toolbar, Statusbar
- The **Generate** menu contains As Found Report, As Left Report and Comparison Report
- The **Window** menu contains Unit Converter and all active windows in **GOFW2008**
- The **Help** menu contains Help Topics and About **GOFW2008**

The Toolbar

Many essential **GOFW2008** Tools are included on the toolbar located at the top of the **GOFW2008** Notebook.

- The toolbar can be toggled on and off on the View menu

Button	Name	Function
	New meter	Opens a New Meter for a new calculation, comparison, etc.
	Open	Opens an existing **GOFW2008** file
	Save	Saves your **GOFW2008** file under its current name and location with the default .CS1 extension
	Cut	Cuts the selected text and places it on the clipboard
	Copy	Copies the selected text and places it on the clipboard
	Paste	Pastes the text from the clipboard at the point where the cursor is located
	AF-AL/ AL-AF	If the As Found Selection Tab is selected when this tool button is clicked, the configuration in the As Found Tab is copied to the As Left Tab. If the As Left Tab is selected when this tool button is clicked, the configuration in the As Left Tab is copied to the As Found Tab (note that this operation also occurs with the AF-AL/AL-AF selection on the Edit drop-down menu on the **GOFW2008** Menu Bar.
	AF	Opens the As Found report
	AL	Opens the As Left report
	CO	Opens the Comparison report

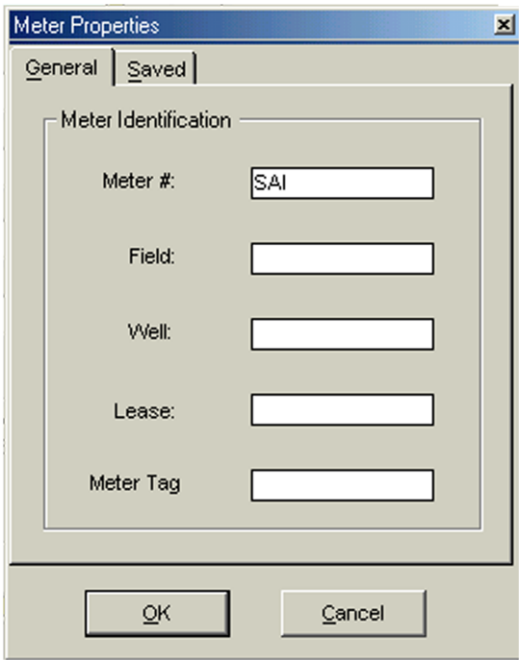
F→C F→C Opens the Units Converter

Meter Properties

Meter Properties is the first **GOFW2008** screen encountered after program initialization. Meter Properties also can be accessed from the drop-down menu under **View** on the **GOFW2008** menu bar. Meter Properties allows the user to record information pertinent to the meter. There are two Tabs in Meter Properties which are used to identify the meter:

General

In the General Tab, the user identifies the meter for which a calculation is being performed.



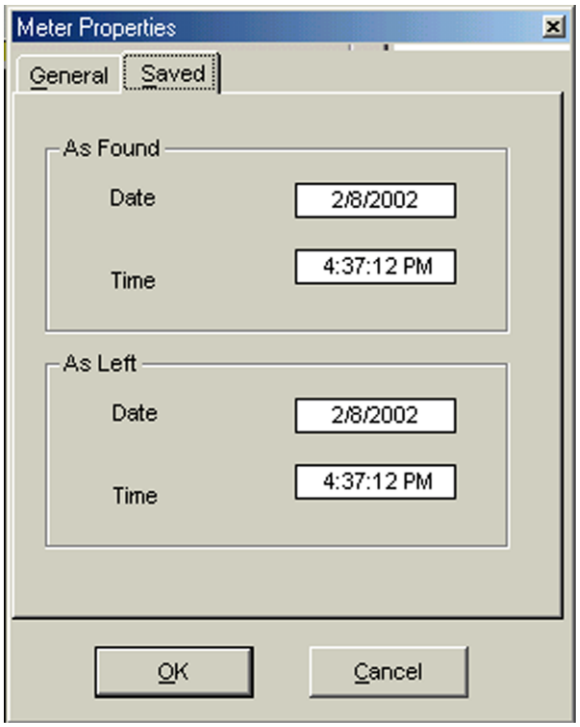
Identification fields on the General Tab are:

- Meter #.
- Field.
- Well.
- Lease.
- Meter Tag

Only Meter # must be specified in order to continue. The other fields are optional identifiers. When the OK button is clicked, the entry in the Meter # field will be shown at the top of the **GOFW2008** Notebook.

Saved

The Saved Tab shows the time at which the configurations for the meter As Found and As Left came into effect. The default for the Date and Time for both the As Found and As Left conditions is the time at which the new **GOFW2008** file was opened. The user may change those times for proper reporting and record.



GOFW2008 Help

GOFW2008 features a full-function online reference.

Information in **GOFW2008** can be easily located with any of the following methods:

- Clicking on highlighted text in the Contents window displays a discussion about the item of interest.
- Clicking the Search button located on the toolbar displays an alphabetical list of **GOFW2008** topic titles. You can select a topic from the list or search for an entry by entering a word in the search field.
- Within Help, you can access any topic highlighted in green by clicking on the text including:
- The location of **GOFW2008** variables in the reference standards and their use in **GOFW2008**. These can be accessed from the first screen in Help (Variables Description).
- A description of error and warning messages used in **GOFW2008**. These are available by placing the cursor on the Error Indicator field of the Meter Data Configuration Tab and pressing F1.

📖 The list of outputs generated by **GOFW2008**. These can be accessed from the opening Help screen by choosing Variables Description, then Output Variables, then Outputs.

Unit Converter

The unit converter is a useful feature for conversions of many different types of units. The results can be copied and pasted into the **GOFW2008** Notebook. To access Unit Converter, choose Unit Converter on the Window menu of the **GOFW2008** menu bar.

To perform a conversion, follow these steps:

✎ Click within the Conversion Type box to choose the unit conversion desired

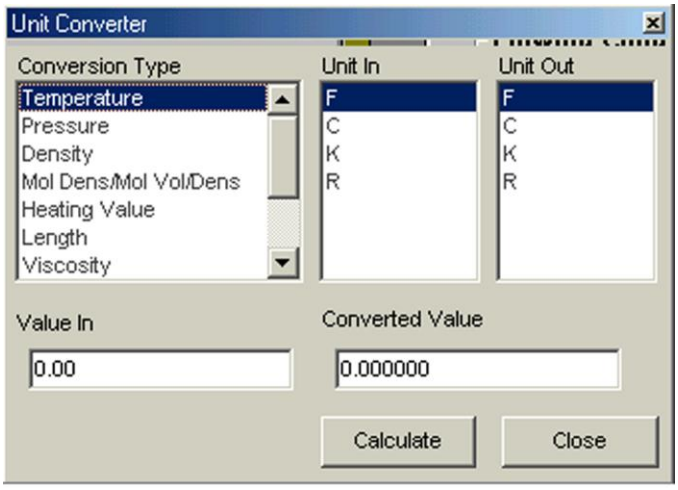
✎ Click within the Unit In box to choose the unit of the quantity to be converted

✎ Click within the Unit Out box to choose the desired units of the quantity being converted.

✎ Enter the quantity to be converted in the Value In box and click the Calculate button.

A conversion is made each time you choose a Unit In or a Unit Out. However, if the Value In changes and the Unit In and Unit Out remain the same, you must use the Calculate button to obtain the desired conversion.

➢ After highlighting the Converted Value, a click on the right mouse button opens a menu allowing cut/paste, copy/paste, and delete operations on the fly. Note that the Edit menu on the **GOFW2008** Menu Bar also can be used for delete, cut/paste, and copy/paste operations.



Generating a Report

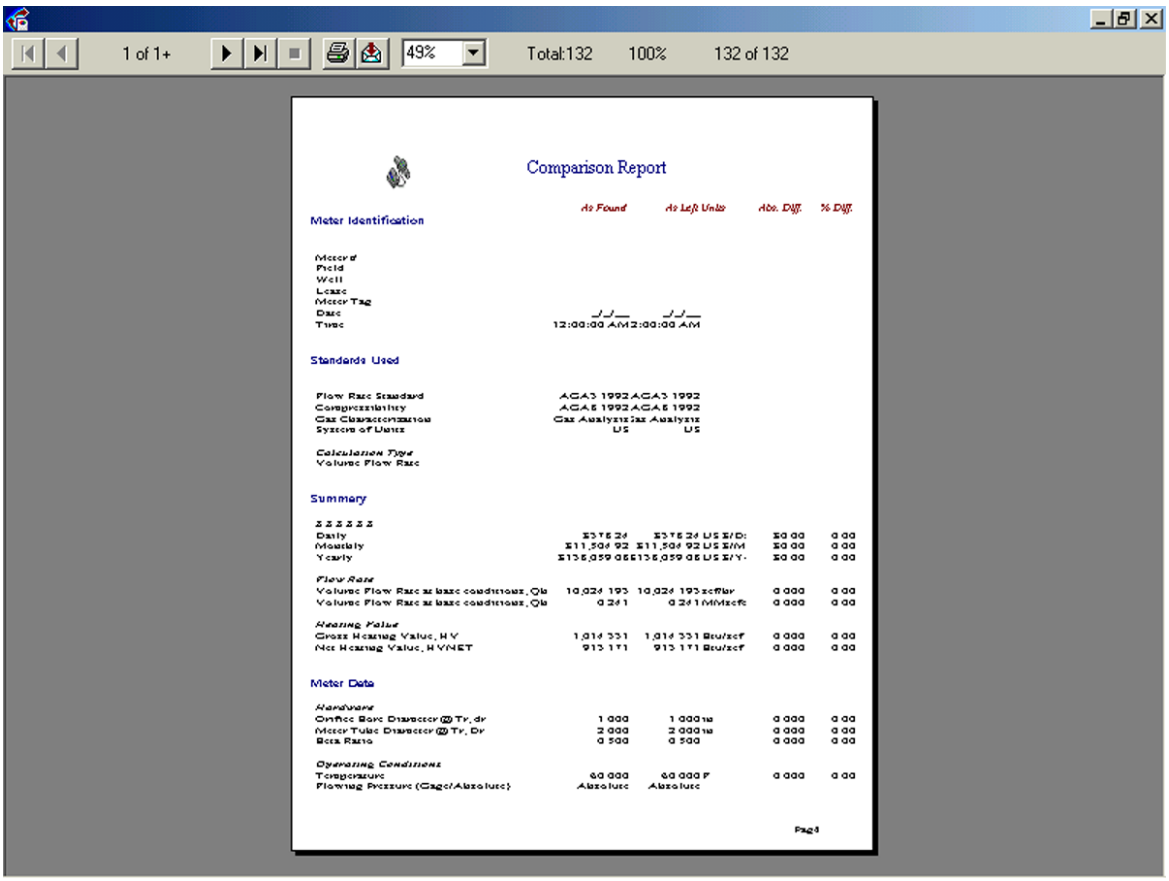
Three reports can be generated with **GOFW2008**:

🗁 An As Found Report

- An As Left Report
- A Comparison Report

The Comparison Report contains the information in the As Found Report and the As Left Report plus additional information about the absolute and percent differences between the As Found and As Left Conditions (As Left-As Found). **GOFW2008** uses Crystal Reports technology to generate reports. Information in the reports is written into a database that is replaced each time a report is generated. These reports are not attached to **GOFW2008** executable. They are independent files which can be customized if the user owns the Crystal Reports 7.0 software. For information about Crystal Reports, contact Seagate Software at 732-321-6500. The reports included allow the user to perform the following functions:

- Choose among three different screen displays.
- Export the report to most popular formats and save it to a disk or mail it via MAPI.
- Print the report.



CHAPTER 2

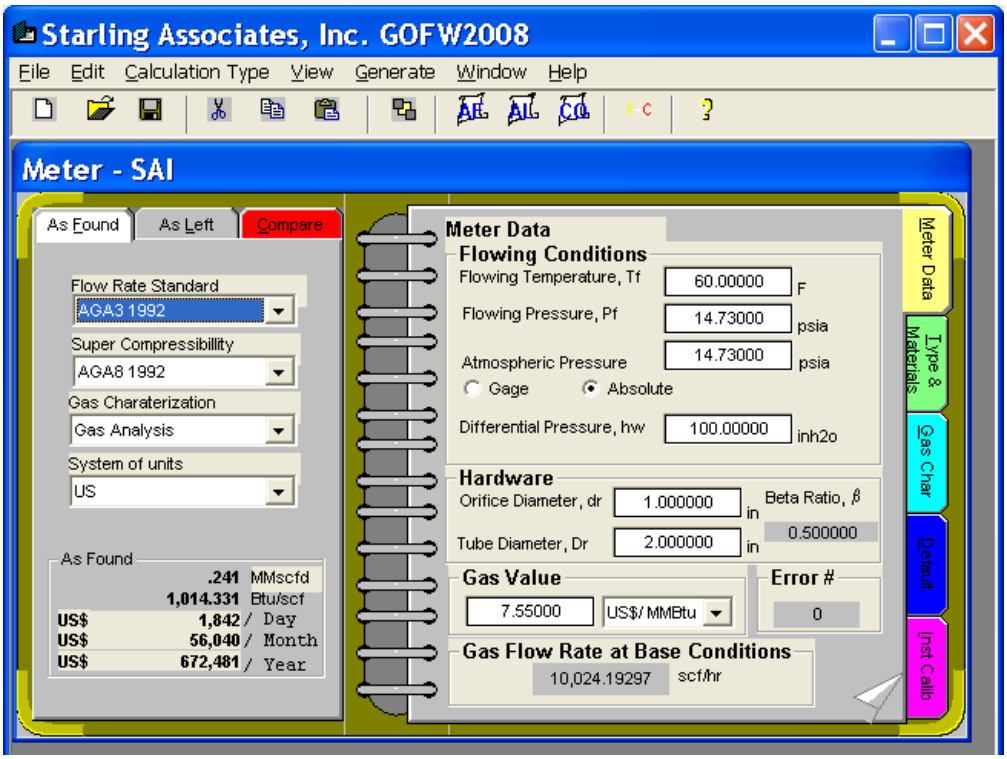
A Quick Tutorial

The **GOFW2008** program allows the user to compare the volumetric flow rate in the As Left condition with the As Found condition as, for example, following meter calibration. In this tutorial, we will use **GOFW2008** to find the difference in flow rate after a calibration of the differential pressure gage. The technician equipped with a laptop and the **GOFW2008** software will be able to immediately calculate the difference in flow rate (and other quantities) and print or email a detailed report reflecting the calibration.

The tutorial in this chapter was designed to familiarize users with the major features of **GOFW2008**. Follow along with steps below:

- Launch **GOFW2008** by clicking on the Windows Start button and selecting All Programs. Select **Starling Associates GOFW2008** and click on the **GOFW2008** icon.

- Click the OK button on the Meter Properties screen. The **GOFW2008** Notebook opens with the default configuration (see Chapter 7 for information on changing the default configuration).

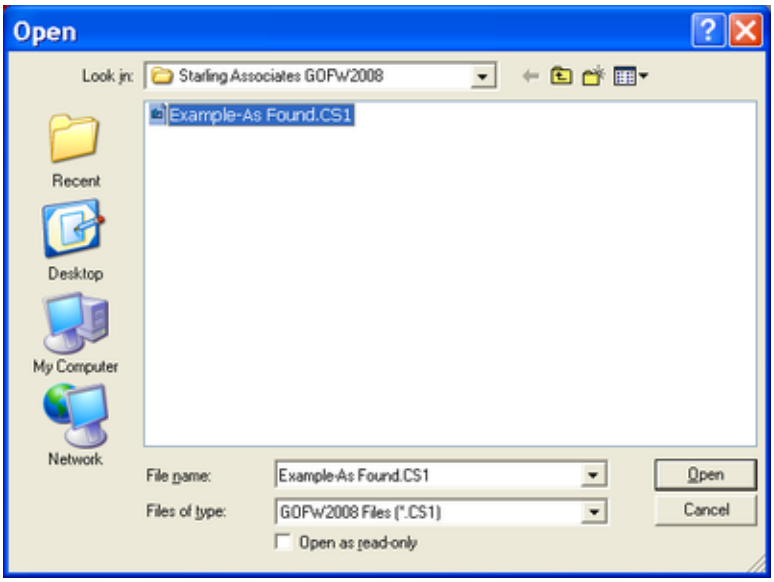


The As Found and As Left Conditions are the same. The default configuration is:

- Flow Rate Standard: AGA3 1992
- Super Compressibility: AGA8 1992
- Gas Characterization: Gas Analysis
- System of Units: US

Next, open the following file provided with **GOFW2008**: Example-As Found.CS1

- Click on the Open button and select the file Example-As Found.CS1 from the Open screen.



The **GOFW2008** Notebook will display the Meter Properties screen, with the entries CALIBRATION, GULF COAST GAS, COMPOSITION, AGA 8 1992, PAGE 74 (note that the calculated compressibility factor can be verified by comparison with the AGA8 1992 standard for this composition).

- Click the OK button on the Meter Properties screen. The **GOFW2008** Notebook will display the input values for the meter in Example-As Found.CS1, in the As Found condition (before calibration).

- Click on the Configuration Tabs to view the As Found input values. The As Found conditions in Example-As Found.CS1 correspond to the meter conditions "as found" before meter calibration was performed. The As Found conditions have been copied into the As Left conditions in Example-As Found.CS1 so that this tutorial can correspond to an example of calibration of a meter.

- Click on the As Left tab to see that Example-As Found.CS1 initially has the same meter conditions for As Left and for As Found.

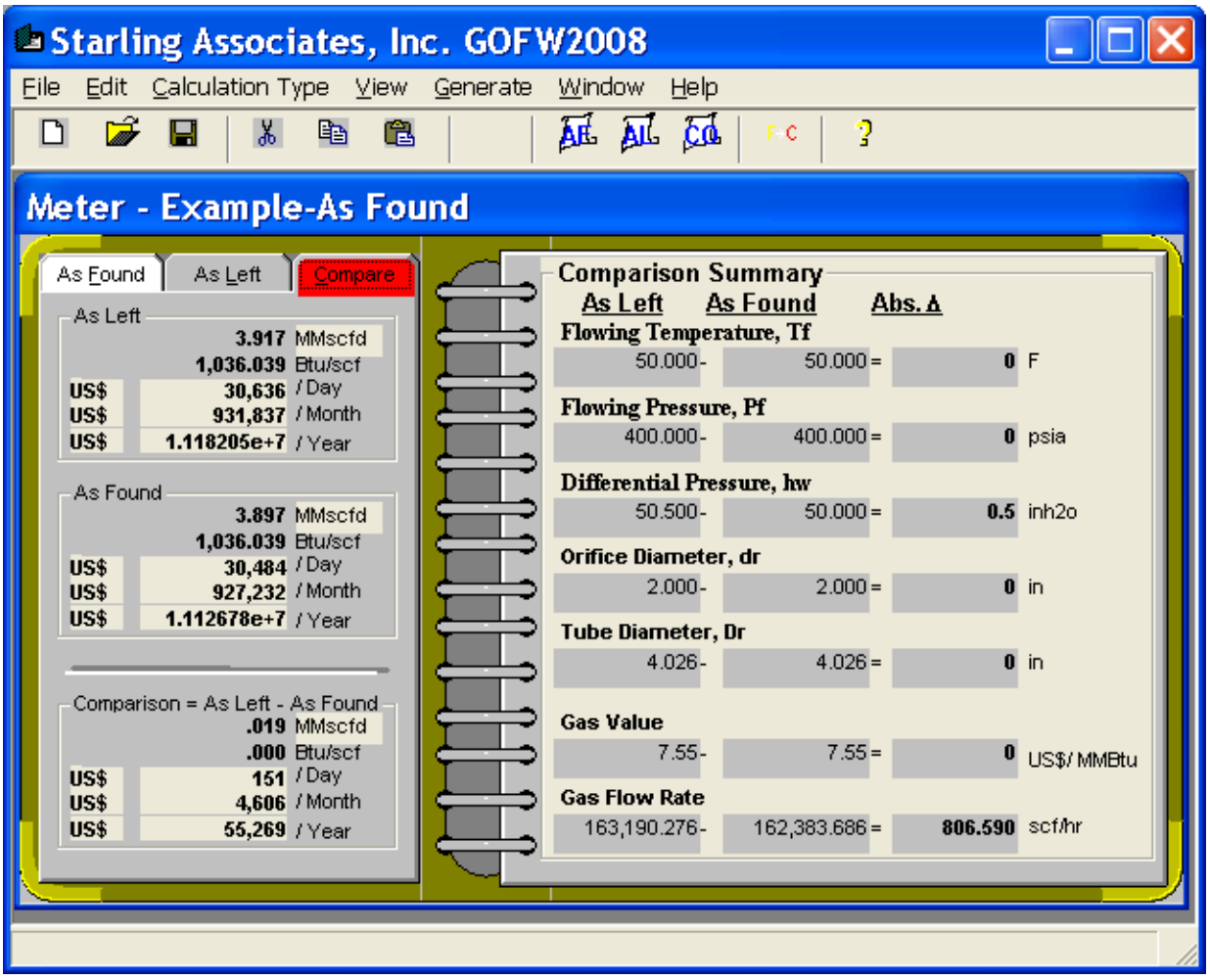
The Compare tab shows a comparison of the As Left and As Found values for certain quantities, including Meter Data, Hardware and Gas Flow Rate.

✎ Click on the Compare tab to see this comparison (the differences between As Left and As Found initially are zero).

After meter calibration, the meter may be left in a configuration which results in a calculated gas flow rate (As Left) which differs from values calculated before the calibration (As Found). Consider an example for which the calibration of the differential pressure gage results in h_w (As Left) = 50.5 inches of water, compared to h_w (As Found) = 50.0 inches of water.

Change the Differential Pressure, h_w for the As Left condition from 50.0 to 50.5.

✎ Click on the Compare tab to view the effect of this calibration of the differential pressure gage.

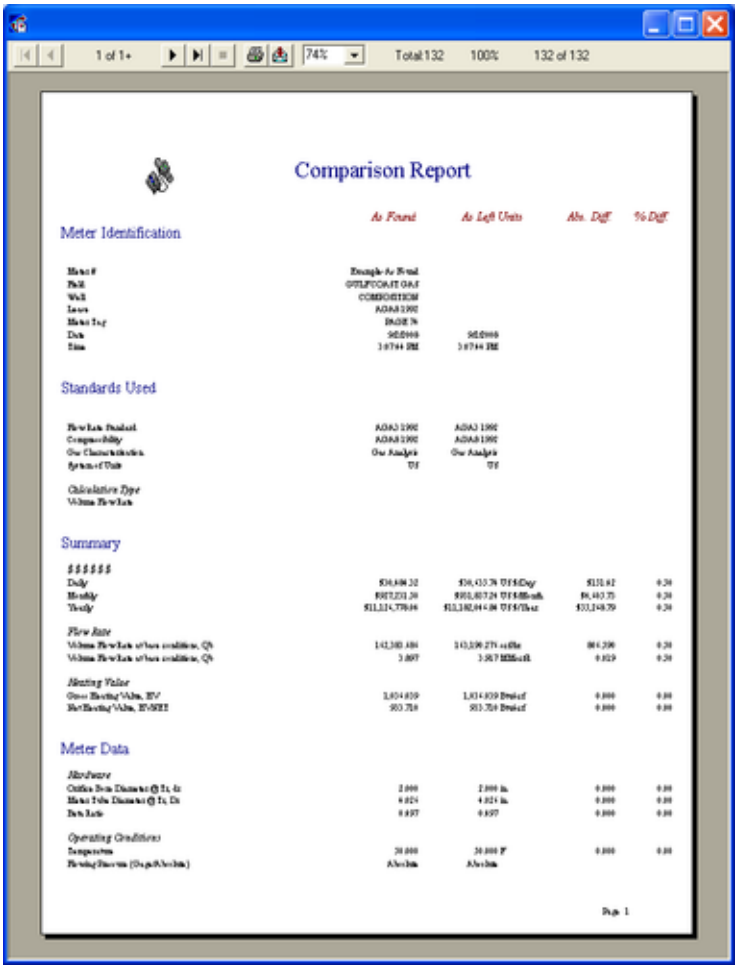


Notice on the Compare screen that the increase in Differential Pressure h_w from 50.0 to 50.5 inches of water yields an increase in the calculated Gas Flow Rate from 3.897 to 3.917 MMscfd. The Gas Analysis used (viewed by clicking the Gas Char tab) yields a calculated Gross HV = 1036.04 Btu/scf (viewed by clicking the meter Data tab then clicking the "dog ear" on that page to reveal the second

page of the Meter Data section of the Notebook). On the Compare report a Gas Value of 7.55 US$/MMBtu has been used resulting in a gas value increase from $30,484 to $30,636 per Day.

The Compare Tab shows only a summary of the differences between the As Left and As Found conditions. **GOFW2008** also prepares reports with detailed information on inputs and calculated outputs. Click on Generate on the **GOFW2008** menu bar to view the drop-down menu which allows the report options As Found Report, As Left Report and Comparison Report (the Toolbar options AF, AL and CO also provide these report options).

- Next, generate a Comparison Report. Simply choose Comparison Report from the Generate menu (or click on the CO button on the toolbar).



- Click on the Maximize button to have a full screen for the report window

- Click on the Print button  to print the report

- Click on the Export button  to export the report in numerous different ways, including as a Crystal Reports file, an Excel file, a Microsoft Word document, and a file for email via MAPI.

- Return now to the computer monitor display and perform the following steps to save the As Left configuration in a GOFW2008 file named Example-As Left.CS1. First, click the As Left tab. Next, access the drop-down menu under Edit on the GOFW2008 menu bar and click on AF-AL/AL-AF. This step moves all of the As Left input variable values into the As Found input text boxes, causing the As Found information to be the same as the As Left information. Next, access the drop-down menu under View on the GOFW2008 menu bar and click on Meter Properties. In the Meter# textbox, type Example-As Left and click the OK button. Then, access the drop-down menu under File on the GOFW2008 menu bar and click on Save As. In the File name dialog box type Example-As Left, then click the Save button, which saves the GOFW2008 file named Example-As Left.CS1.

- Note that the As Found information still is in the original GOFW2008 file named Example-As Found.CS1 and the As Left information is in the newly created GOFW2008 file named Example-As Left.CS1. The next section provides a more general discussion GOFW2008 file handling.

Creating, Saving and Reopening GOFW2008 Input Files

When GOFW2008 is started, a set of default values appear on the GOFW2008 window. GOFW2008 uses the file GOFW2008.ini for this initial default configuration. The file GOFW2008.ini is placed in the subdirectory in which the GOFW2008 software is installed.

The first screen which appears when GOFW2008 is started up has a form on the left hand side titled Meter Properties. The Meter# box is already filled in with "SAI", which comes from the initialization file GOFW2008.ini. Clicking OK in the Meter Properties form places "Meter – SAI" on the banner of the next window which appears.

A new input file can be created by modifying the entries in the boxes in the GOFW2008 windows. Accessing the drop-down menu under View on the GOFW2008 menu bar and clicking on Meter Properties allows changing the Meter# from "SAI" to a Meter# corresponding to the newly created calculation. Then accessing the drop-down menu under File on the GOFW2008 menu bar and clicking on Save As allows entering a file name for the newly created input file.

Similarly, another input file can be created by modifying the entries in the boxes in the GOFW2008 windows, changing the Meter# and saving the input file with an appropriate name. Then to reopen an input file which was created earlier, access the drop-down menu under File on the GOFW2008 menu bar and click on Open. You will be asked if you wish to save the information for the current meter before opening a new meter. It is best if you have saved the current information previously so you can click No. If you click No, you will immediately be allowed to reopen any previously saved GOFW2008 input file. When this meter reopens, be sure to click OK on the Meter Properties screen to preserve the Meter# associated with the meter calculation.

To insure that you know whether a GOFW2008 .CS1 file contains As Found information or As Left information, it is recommended that the As Left information be moved into the As Found input

textboxes and that the file be saved using an easily identified file name. The procedure is (1) click the As Left tab, (2) access the drop-down menu under Edit on the GOFW2008 menu bar and click on AF-AL/AL-AF, (3) access the drop-down menu under View on the GOFW2008 menu bar and click on Meter Properties, (4) in the Meter# textbox, type text identifying the meter information as being in the As Left description and click the OK button, (5) access the drop-down menu under File on the GOFW2008 menu bar and click on Save As, (6) in the File name dialog box type the desired file name, then click the Save button, which saves the GOFW2008 file with extension .CS1. An easy way to be reminded of what the configuration is for a GOFW2008 input (.CS1) file is to use the same file name as the Meter# textbox entry (as was done in the previous section for Example-As Found.CS1 and Example-As Left.CS1).

CHAPTER 3

GOFW2008 Standards and Calculation Types

GOFW2008 is a powerful analysis and calculation tool. It allows the user to compare the volumetric flow rate in the As Left condition with the As Found condition following meter calibration. In a similar manner, it can be used to compare the use of different measurement standards. In addition to the volumetric flow rate, **GOFW2008** can be used to calculate mass flow rates, to size an orifice plate or to estimate the pressure drop for a particular system. This chapter will discuss the standards and calculations available in **GOFW2008**.

Standards Covered

The flow rate standard used in a **GOFW2008** calculation is selected on the left side of the Notebook. The choices for Flow Rate Standard (📖) and associated Super Compressibility (Z) include:

- 📖 AGA 3 1992 (default)
  - Z AGA 8 1992 (default)
  - Z User Input
- 📖 AGA 3 1985
  - Z AGA 8 1985
  - Z AGA 8 1995 (Alternate Method)
  - Z NX19 1962
  - Z User Input
- 📖 AGA 7 - AGA 9 - Linear Meters AGA 8 1992
  - Z AGA 8 1992/GPA 2172-96
  - Z AGA 8 1985
  - Z AGA 8 1995 (Alternate Method)

- NX19 1962
- User Input

Technical documentation for calculations using default Flow Rate Standard **AGA3 1992** and Supercompressibility **AGA8 1992** in the **GOFW2008** computer program appears in the most recent versions of AGA Reports No. 3 (1992) Orifice Metering of Natural Gas and Other Related Hydrocarbon Gases and No. 8 (1994 Reprint) Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases and Chapter 14 of the American Petroleum Institute (API) Manual of Petroleum Measurement Standards. It should be noted that Section 2 of Chapter 14 of API MPMS is equivalent to AGA Report No. 8. It should also be noted that the following are equivalent documents: (1) Section 3 of Chapter 14 of API MPMS, (2) AGA Report No. 3, (3) GPA 8185, (4) API 2530 and (5) ANSI/API 2530. Note that although AGA Report No. 8 is referred to as AGA8 1992 in GOFW2008, all calculations are performed according to the most recent version (1994 reprint).

For the other possible standards in **GOFW2008** the technical documentation appears in the 1985 version of AGA. Report No. 3, the 1985 version of AGA. Report No. 8, the 1962 version of the NX-19 Report, the 1986 version of GPA. 2172, the Measurement of Gas by Turbine Meters, Transmission Measurement Committee Report No. 7, Second Revision, April 1996, and Measurement of Gas by Multipath Ultrasonic Meters, Transmission Measurement Report No. 9, June 1998.

The combinations of standards supported by **GOFW2008** are illustrated in the table below:

Flow Rate Standard	**Super Compressibility**	**Gas Characterization (GOFW2008 Syntax)**	**Standard Name**
AGA3 1992, AGA7, AGA9, LINEAR METERS	AGA8 1992	Gas Analysis	*Detail Method*
		HV-GR-CO2	*Gross Characterization Method 1*
		GR-CO2-N2	*Gross Characterization Method 2*
	AGA8 1992/ GPA2172 96	Gas Analysis	*Detail Method*
	User Input	User Input –Densities User Input - Zs	
AGA3 1985, AGA7, AGA9, LINEAR METERS	AGA8 1985	HV-GR-CO2	*The Gravity, Heating Value, Carbon Dioxide Method*
		GR-CO2-N2	*The Gravity, Carbon Dioxide, Nitrogen Method*
		Gas Analysis	*Primary, Compositional Analysis Method*
		HV-GR-CO2-N2	*The Gravity, Heating Value, Carbon Dioxide, Nitrogen Method*
		HV-CO2-N2	*The Heating Value, Carbon Dioxide, Nitrogen Method*
		GR-CH4-CO2-N2	*The Gravity, Methane, Carbon Dioxide, Nitrogen Method*
	AGA8 1985 (Alternate Method)	HV-GR-CO2	*The Gravity, Heating Value, Carbon Dioxide Method*
		GR-CO2-N2	*The Gravity, Carbon Dioxide, Nitrogen Method*
		Gas Analysis	*Primary, Compositional Analysis Method*
		HV-GR-CO2-N2	*The Gravity, Heating Value, Carbon Dioxide, Nitrogen Method*
		HV-CO2-N2	*The Heating Value, Carbon Dioxide, Nitrogen Method*
		GR-CH4-CO2-N2	*The Gravity, Methane, Carbon Dioxide, Nitrogen Method*

NX19 1962	GR-CO2-N2	*Standard Method*
	Gas Analysis	*Analysis Method*
	HV-CO2-N2	*Heating Value Method*
	GR-CH4-CO2-N2	*Methane – Gravity Method*
User Input	User Input – Densities	
	User Input - Zs	

- Among the choices for Super Compressibility for flow rate standard AGA3 1985, the user will notice the choice of AGA 8 1985 Alt Meth. The Alternate Method is a non-standard choice. The Gross Methods available for gas characterization in AGA Report No. 8 utilize gravity, heating value and diluent content to form a pseudo gas composition. This composition is then used to generate the properties of the gas using an equation of state. The Alternate Method makes a check to verify that the pseudo composition generated gives back the gravity input and adjusts the pseudo composition of the gas to return the input gravity.

Units

The US system of units is the initial default units for **GOFW2008** and a number of calculation types, such as orifice sizing, can be performed only in US units. For volume flow rate and mass flow rate calculations, the System of Units menu includes SI, Metric and IP units in addition to US units.

Calculation Types

GOFW2008 supports four different orifice meter calculation types. They are found under Calculation Type on the menu bar. The four Calculation Types (discussed below) are:

🗁 Volume Flow Rate

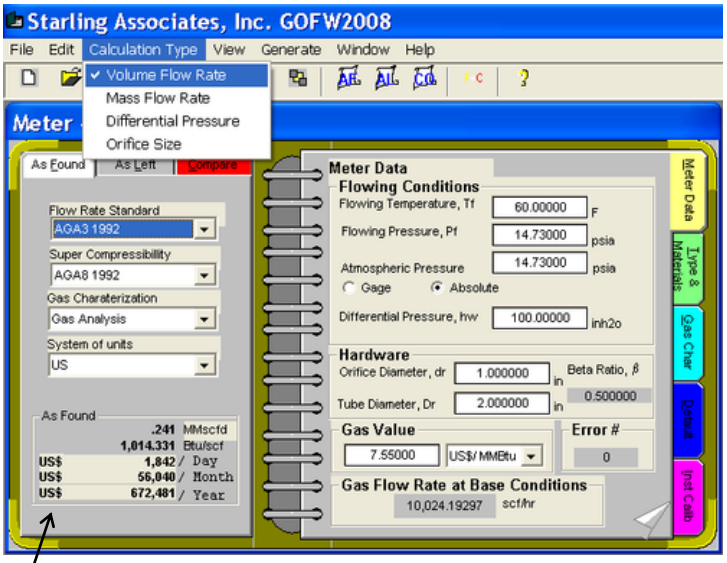
🗁 Mass Flow Rate

🗁 Differential Pressure

🗁 Orifice Size

Volume Flow Rate

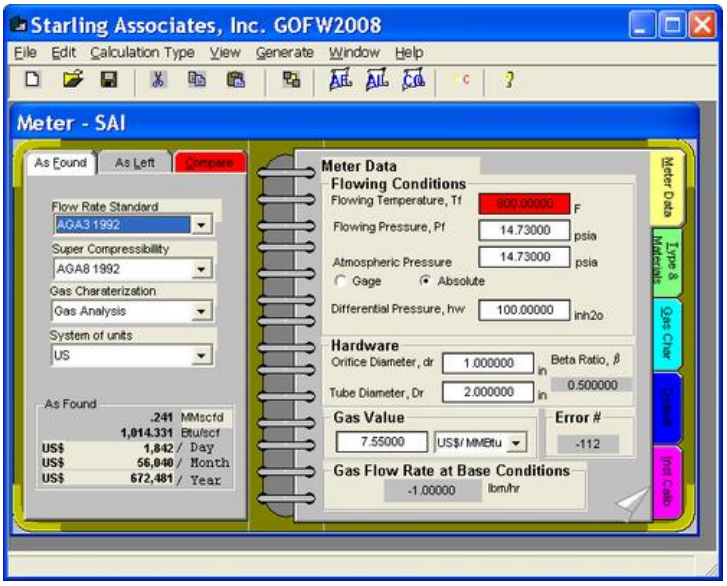
The default orifice meter calculation for **GOFW2008** is volumetric flow rate. When this calculation is selected, a check mark appears next to Volume Flow Rate on the Calculation Type menu.



Summary section

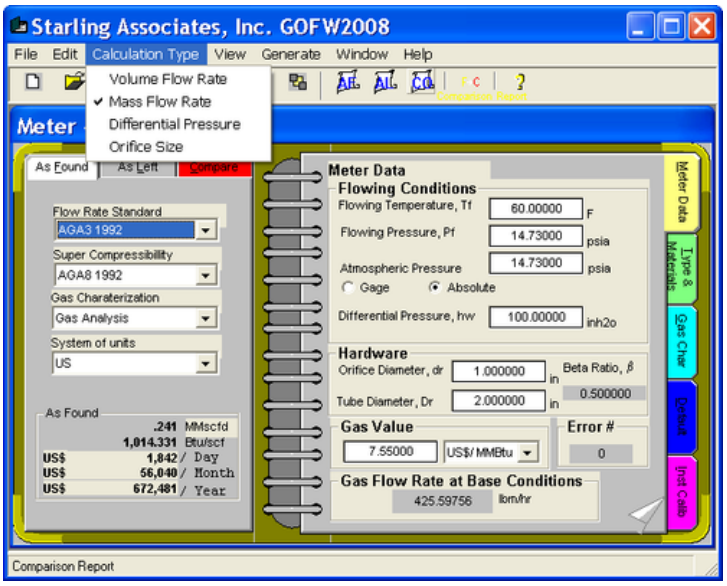
GOFW2008 ships with default conditions that generate an orifice meter volumetric flow rate calculation. A new calculation is made every time an entry changes. The volume flow rate is returned in the Gas Flow Rate field on the Meter Data Tab in standard cubic feet per hour for the default US units. It is also displayed in million standard cubic feet per day on the summary section of the As Found and As Left Tabs.

When a value of -1 is returned in the Gas Flow Rate field, an input variable has been entered which is out of range or in error. **GOFW2008** indicates the error by highlighting that field in red and returning the value of -1 as the Gas Flow Rate. The input must be corrected for the calculation to proceed. When an input variable is outside the normal range but within the calculation limit range, **GOFW2008** indicates the warning by highlighting that field in yellow (see Appendix A for a complete discussion of **GOFW2008** warnings and errors). In the figure below, a temperature of 800°F has been entered (maximum temperature in the normal range is 143°F). In the **GOFW2008** program, the temperature field is red. Note the value of -1 in the Gas Flow Rate field.



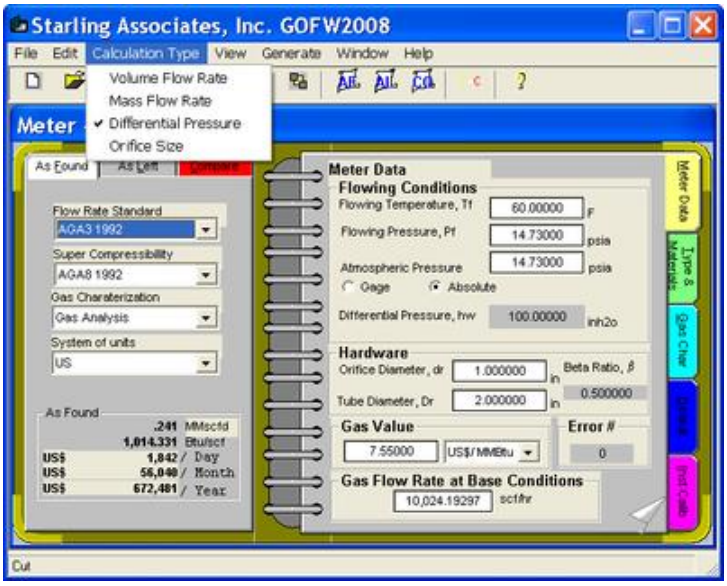
Mass Flow Rate

To determine mass flow rate, select Mass Flow Rate under the Calculation Type menu. The units in the Gas Flow Rate field will change to reflect mass flow rate. The As Found, As Left and Comparison Reports will reflect the choice of a mass flow rate calculation.



Differential Pressure

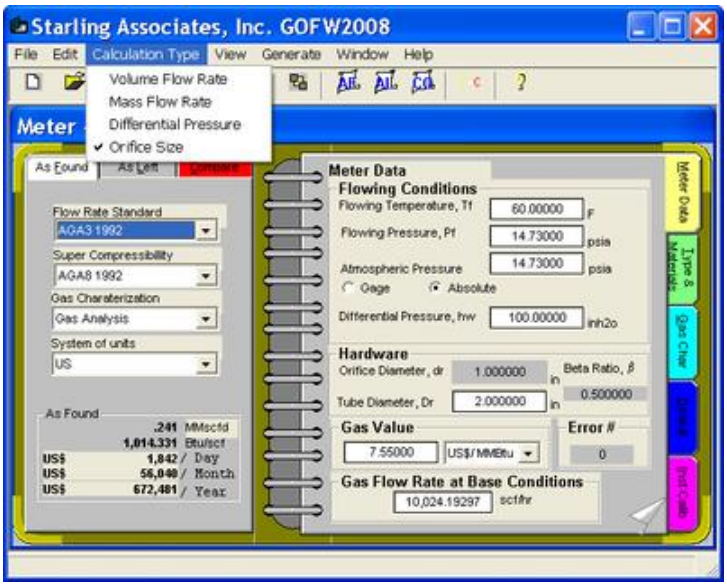
To determine the pressure drop across the orifice plate for a given pipeline configuration and volumetric flow rate, under the Calculation Type menu, first Volume Flow Rate and then select Differential Pressure. The Gas Flow Rate field becomes an input (enabled) and the Differential Pressure field becomes an output (disabled). A new differential pressure calculation is performed each time a field entry changes. The As Found, As Left and Comparison Reports will reflect a differential pressure calculation.



- **GOFW2008** will only perform Differential Pressure calculations in US units. Additionally "User Input" Super Compressibility may not be used for Differential Pressure calculations.

Orifice Size

To determine the appropriate orifice size given a volumetric flow rate and assigned differential pressure, under the Calculation Type menu, first Volume Flow Rate and then select Orifice Size. The Gas Flow Rate field becomes an input (enabled) and the Differential Pressure field becomes an output (disabled). An orifice size calculation is made each time a field entry changes. The As Found, As Left and Comparison Reports will reflect an orifice size calculation.



- **GOFW2008** will only perform Orifice Size calculations in US units. Additionally "User Input" Super Compressibility may not be used for Orifice Size calculations.

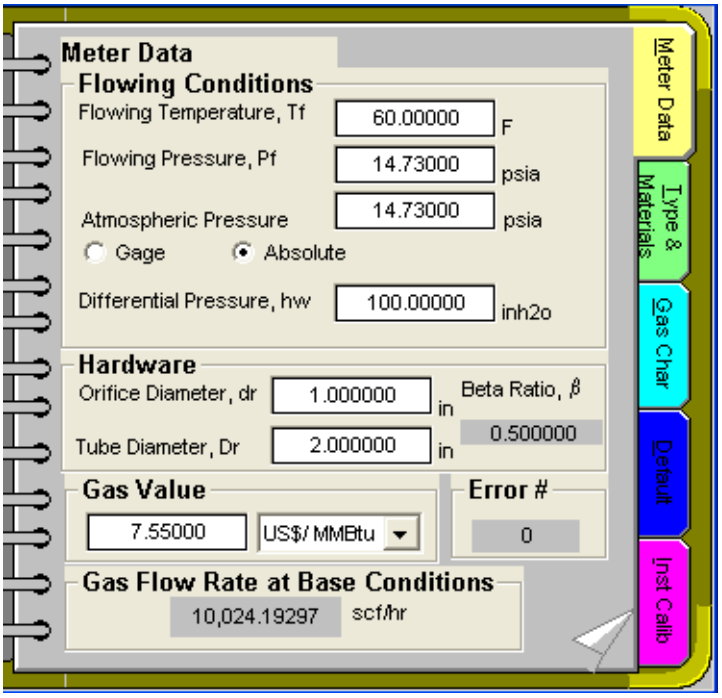
CHAPTER 4

Meter Data Tab

The Meter Data Tab contains basic meter information necessary to perform a calculation. Additionally, it contains gas value information and a calculation error indicator.

Meter Data

The Meter Data Tab appears when the **GOFW2008** Notebook is opened. There are two pages in the Meter Data Tab. The page can be changed by clicking on the "dog ear" on the current page. Most of the information in this tab is self explanatory so only a brief description of the fields is given below.



Flowing Conditions

The flowing conditions for an orifice plate calculation are Flowing Temperature, Tf, Flowing Pressure, Pf and Differential Pressure, hw. The ranges of applicability of the flowing conditions vary depending on the standard chosen. A click on the field of entry displays the range of applicability for the flowing condition in the statusbar at the bottom of the screen.

GOFW2008 allows the use of either absolute pressure or gage pressure for the input flowing pressure (GOFW2002 required that the input flowing pressure be given in absolute pressure units, not gage pressure).

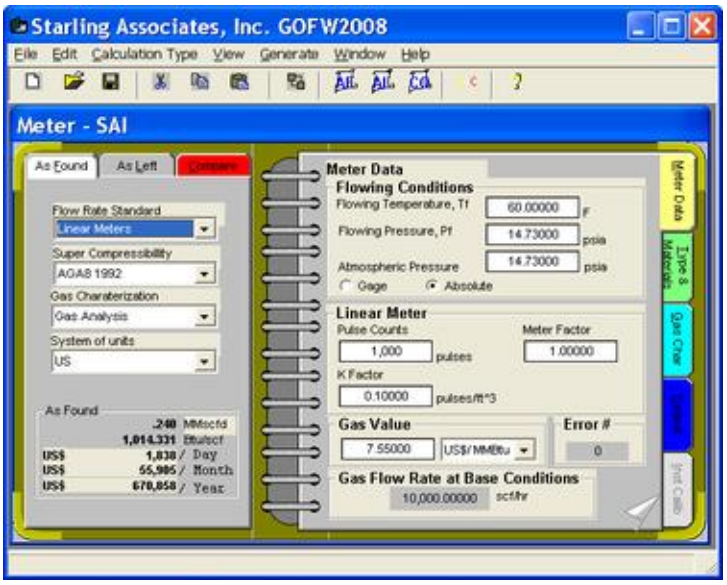
Linear Meters

The Linear Meter Frame appears when AGA7, AGA9 or LINEAR METER is indicated under the "flow rate standard" combo box and disappears otherwise.

Specify the pulse counts, meter factor and k factor.

The volume through the meter at flowing conditions is calculated with the simple relation:

Volume at flowing conditions = pulse counts * meter factor / k factor.



The volume at flowing conditions is converted to base conditions using the supercompressibility method specified.

Hardware

The Hardware section of the Meter Data Tab is used to specify orifice and tube diameter. It outputs the ratio of the orifice plate diameter to the tube diameter (commonly known as Beta Ratio). Since it is possible for both diameters to be within the range of the applicable standard, while their ratio is not, the Beta Ratio field follows the color formats used to display warnings and errors.

Gas Value

The Gas Value is used to indicate the monetary value of the energy unit which is driven by the market. Depending on the System of Units used, the Gas Value may be expressed in different units.

Gas Flow Rate

The Gas Flow Rate shows the volume in scf/hr flowing through a pipeline. If an error occurs in the calculation, the Gas Flow Rate shown is -1.

Error Indicator

When an error or warning occurs in the calculation, a number corresponding to an error or warning description will be displayed in the error indicator field (zero indicates no error or warning). The meaning of the error indicator can be obtained by positioning the cursor on the error indicator field. The error/warning short description will appear in the statusbar.

Useful Outputs

The second page of the Meter Data Tab is titled Useful Outputs. These outputs include the Gas Relative Density, the Gross Heating Value, the Net Heating Value, the Molecular Weight (Molar Mass), the Critical Temperature and Critical Pressure (calculated by the Kay's rules method) and the Reduced Temperature and Reduced Pressure.

Heating Value

The Heating Value of the gas is needed to evaluate the economic value of a gas stream. When the full composition of the gas is specified, the Heating Value is automatically calculated and displayed in the Heating Value field. When a Gross Method or User Input gas characterization is used, **GOFW2008** outputs -1 for the Heating Value of the gas indicating that the Heating Value has not been calculated. The -1 output as well as any other gross heating value output from **GOFW2008** can be overwritten if the actual gross heating value of the gas is known. Simply check the HV Overwrite check box and input the desired value which will then be used for the economic evaluation performed by **GOFW2008** for As Found and/or As Left (but not for the comparison screen or Comparison Report.

CHAPTER 5

Type and Materials Tab

The Type and Materials Tab is used to specify the configuration of the orifice meter and the materials used in pipeline and orifice plate manufacture.

Type and Materials

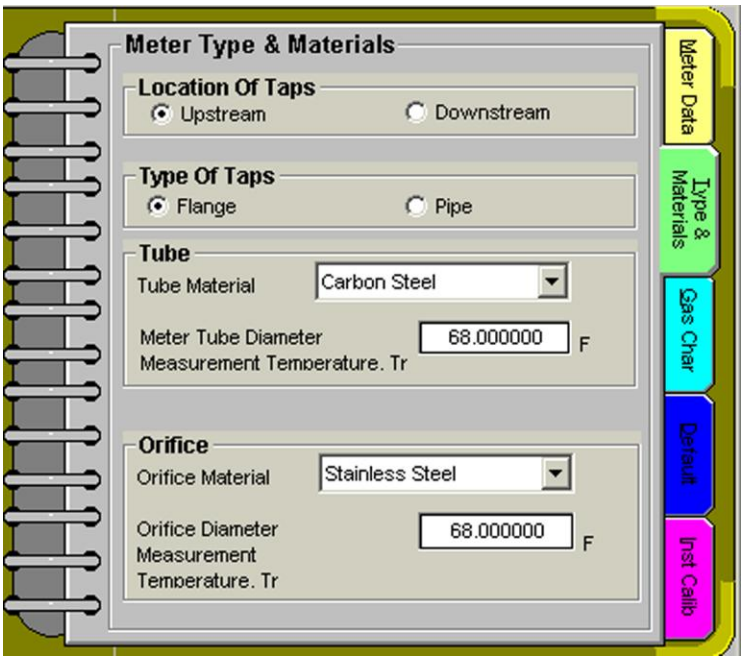
Type and Materials can be accessed by clicking on the Type and Materials Tab of the **GOFW2008** Notebook.

Type of Taps

There are two types of taps supported in AGA Report No. 3, flange and pipe taps. Cases of mixed taps are not supported by **GOFW2008**. Select calculations for Flange or Pipe Taps by clicking on the option button desired.

Location of Tap for Measurement of Flowing Pressure

Specify whether the flowing pressure tap is located before the orifice plate (upstream) or after the orifice plate (downstream).



Tube Material

Tube material must be specified to account for thermal expansion of the tube at different temperatures since metals have different thermal expansion coefficients. Three materials are specified in AGA Report No. 3 (1985 and 1992).

- Carbon Steel
- Monel
- Stainless Steel

Carbon steel is the default tube material since it is most commonly used in orifice meter installations.

Meter Tube Diameter Measurement Temperature, Tr

The Meter Tube Diameter Measurement Temperature refers to the tube temperature when the tube diameter was measured. When a tube diameter is given, a temperature must accompany it since the diameter is sensitive to temperature changes. A default temperature of 68°F is given.

Orifice Material

Orifice material must be specified to account for thermal expansion of the orifice at different temperatures since metals have different thermal expansion coefficients. Three materials are specified in AGA 3 (1992) and two in AGA 3 (1985).

- Stainless Steel
- Monel
- Carbon Steel *

* Carbon Steel as orifice material is not supported in AGA Report No.3, 1985. If the user selects Carbon Steel with AGA3 1985 as the flow rate standard, the program will issue a warning and change the selection to Stainless Steel. If Carbon Steel has been selected and the user changes the flow rate standard to AGA 3 1985, **GOFW2008** will change the Carbon Steel selection to Stainless Steel without issuing a warning.

Stainless steel is the default orifice material since it is most commonly used for orifice plates.

Orifice Diameter Measurement Temperature, Tr

The Orifice Diameter Measurement Temperature refers to the orifice temperature when the orifice diameter was measured. When an orifice diameter is given, a temperature must accompany it since the diameter is sensitive to temperature changes. A default temperature of 68°F is given.

CHAPTER 6

Gas Characterization Tab

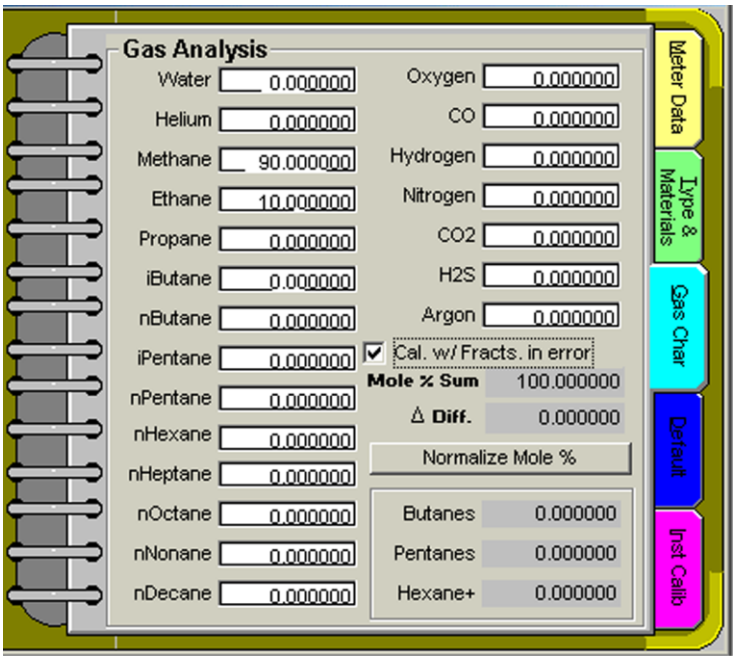
The Gas Characterization Tab is used to specify the composition of the gas or the means to characterize its physical properties.

Gas Characterization

The Gas Characterization Tab changes according to the Gas Characterization option chosen on the left side of the Notebook.

Gas Analysis

The Gas Analysis screen is used when the full compositional analysis of the gas mixture is known. The Gas Analysis screen is displayed on the Gas Characterization Tab when the Gas Analysis option is chosen under Gas Characterization on the left side of the Notebook.



The Gas Analysis screen permits the user to enter values for 21 components. However, when the Gas Analysis Method under AGA8 1985 or NX19 1962 is used argon is excluded.

The Cal. w/Fracts. in error Checkbox

A check in the **Cal. w/Fracts. in error** (calculate with fractions in error) checkbox allows computations to be performed even if the mole percent of a gas component is outside the range recommended for some standards. For example, AGA Report No. 8 was developed and tested within certain limits. The accuracy of calculations made with components outside the tested range cannot be assured. If, however, a computation is required under these circumstances, the **Cal. w/Fracts. in error** checkbox prevents **GOFW2008** from checking fractions and allows the calculation to proceed. Since the numbers entered are outside the tested limit, an unexpected math error may occur. The user is cautioned that the use of this override is not in conformance with the limits of the standards and therefore this override is not recommended.

The Normalize Mole % Button

A useful feature of the Gas Analysis Method is the Normalize Mole % button. When the user input mole percentages are very close to 100% this button can be clicked to normalize all component percentages so that they equal 100.

Other Features

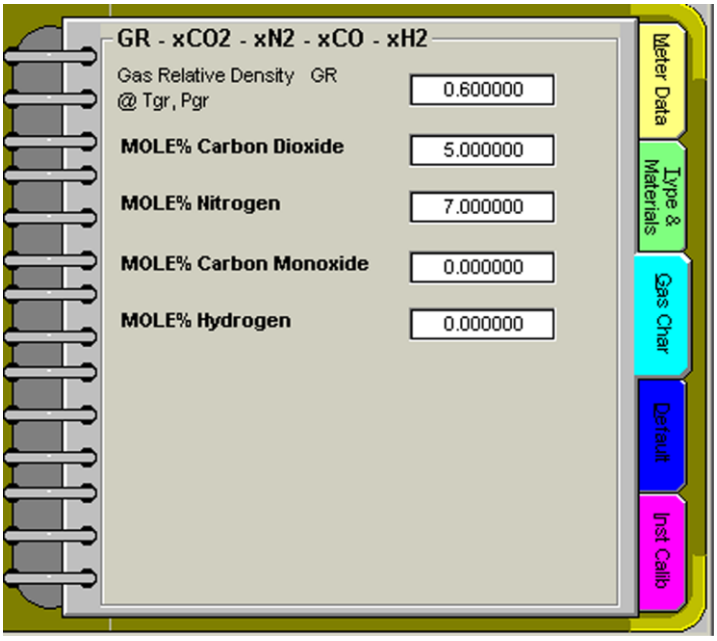
Other features of the Gas Analysis input screen include the Mole % Sum and the Δ Diff labels. They assist the user in assessing the deviation of the total of the input mole percentages from 100%.

The Gas Analysis input screen carries a summation of butanes, pentanes and hexane+ percentages. It is possible for individual percentages to be within the accepted range while their sum is not. For example, if AGA Report No. 8 is used to characterize a gas with 3.5% n-butane and 3.5% i-butane, the individual components are within the allowed range but their sum is not. **GOFW2008** indicates the error by displaying the Butanes summation label in red.

Gross Methods

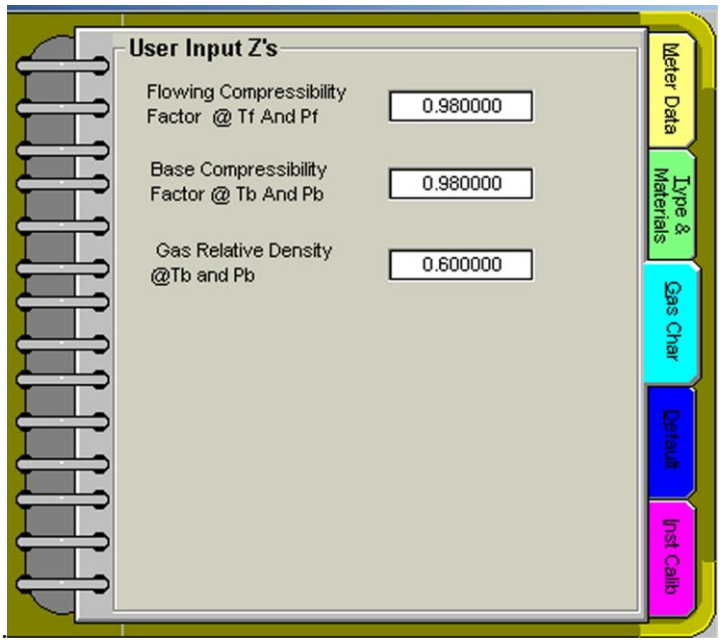
Gross Methods include all the characterization methods that use a combination of Specific Gravity, Heating Value, Mole Percent of Nitrogen, Carbon Dioxide, Methane, Hydrogen and Carbon Monoxide.

Gross Methods in **GOFW2008** are those which are characterized neither as Gas Analysis Methods nor as User Input Methods. An example of a Gross Method is the Gross Characterization Method 2 in AGA Report No. 8 (1992).



User Input Method

A gas can also be characterized directly in **GOFW2008** by specifying the gas densities at base and standard conditions or by specifying the compressibility factor of the gas at base and standard conditions and the gas relative density. These are equivalent since, if the temperature and pressure of the gas are known, having the density at base and flowing conditions allows one to calculate the compressibility factor at base and flowing conditions as well as the gas relative density at base conditions. Nevertheless, either screen may be used to input known properties.



CHAPTER 7

Default Tab

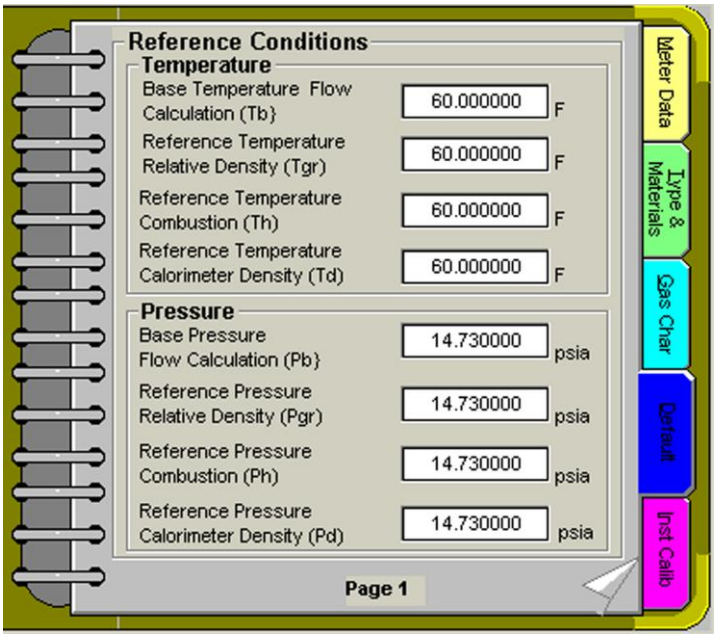
Default Quantities

The Default Configuration Tab in the **GOFW2008** Notebook has three pages. The user can change the page by clicking on the "dog ear" on the current page. Page 1 of the Default Tab is used to configure default temperatures and pressures.

Reference Conditions

The various reference temperatures and pressures include the following:

- The contract temperature and pressure or base conditions (T_b, P_b)
- The reference temperature and pressure for relative density (specific gravity) (T_{gr},P_{gr})
- The reference temperature and pressure for the mass (and molar) heating value, the reference temperature and pressure of gas combustion (T_h, P_h)
- The reference temperature and pressure for gas calorimetric density (T_d, P_d). T_d and P_d is used for conversion of mass (or molar) heating value to volumetric heating value, the gas density used for calorimeter/heating value calculations.



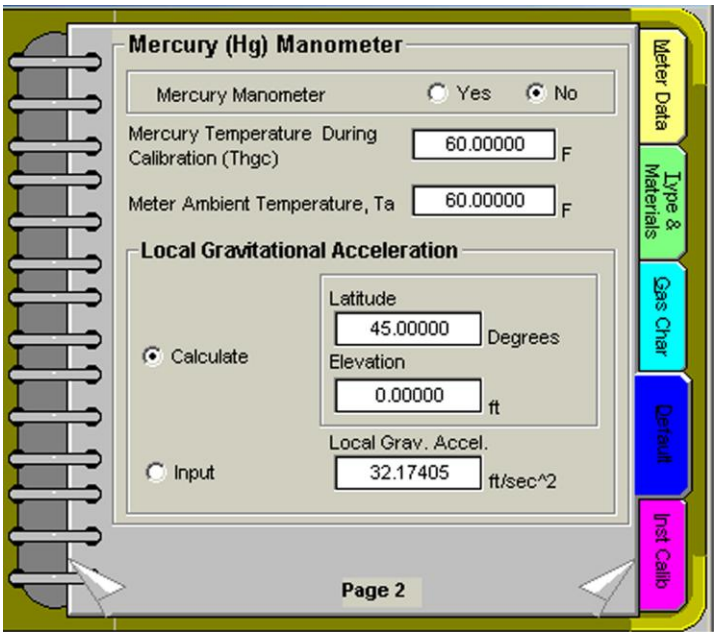
Appendix C of AGA Report No. 8 (1992) can be consulted for a detailed discussion of reference conditions. The default reference temperatures of 60°F and reference pressures of 14.73 psia are commonly used in the U.S. gas industry.

The contract pressure and temperature (P_b and T_b) are used for all standard options to calculate the gas volume flow rate at base conditions. However, all other reference pressures and temperatures are only used when AGA Report No. 3 (1992) is combined with AGA Report No. 8 (1992) and in other standards' combinations that include a full gas composition analysis.

Mercury (Hg) Manometer

Page 2 of the Default Tab, Mercury (Hg) Manometer, is needed only if a mercury manometer is used to measure the differential pressure. If a mercury manometer is used, then the calculation of the factors Fhgm, Fhgl and Fhgt require:

- The temperature of the mercury when the manometer was calibrated.
- The meter ambient temperature.
- The gravitational acceleration at the meter location.



The gravitational acceleration can be either input or calculated. If calculated, the required quantities are the meter latitude and the meter elevation above sea level (the elevation is negative below sea level). The default values are 60°F for the mercury temperature when the manometer was calibrated, 60°F for the meter ambient temperature, the input option (not the calculate option) for the gravitational acceleration at the meter location and 32.174 ft/sec^2 for the gravitational acceleration. If the calculate option is used for the gravitational acceleration at the meter location, the meter latitude and elevation can be revised from the default values 0.0 feet and 45 degrees.

The alternative values are the actual conditions.

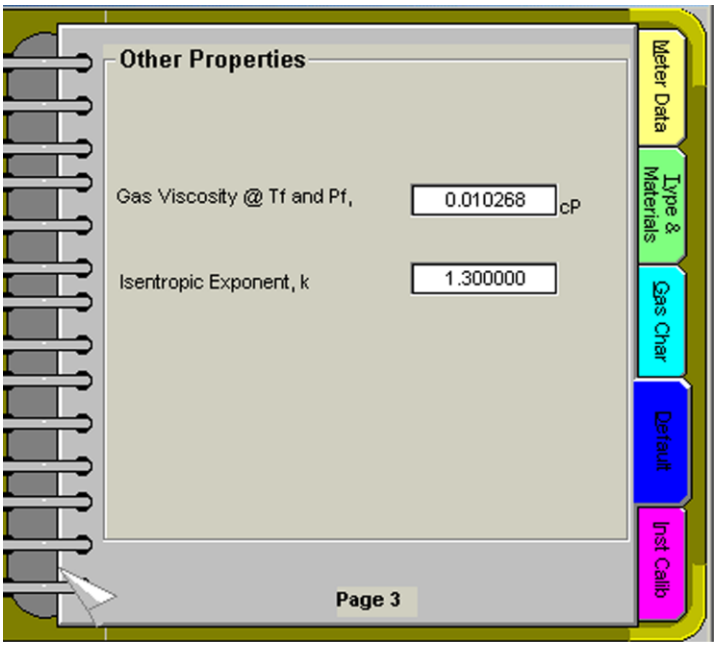
Other Properties

Page 3 of the Default Tab, Other Properties, is available when the flow rate standard is AGA Report No. 3 (1992). The defaults are the following conditions:

- A natural gas absolute viscosity at flowing conditions, Tf and Pf of 0.0102680 cP
- A natural gas isentropic exponent, k of 1.3.

Alternatives are the following conditions:

- The natural gas viscosity at flowing conditions
- The natural gas isentropic exponent.



Section 3.4.5 of AGA Report No. 3 (1992) notes that the default value for viscosity is an average value for natural gases with relative density from 0.55 to 0.75 in the temperature range from 30 to 90°F. For gases with viscosity outside the range 5.9E-6 to 7.9E-6 pounds mass per foot-second and/or flow outside the above ranges, particularly at low Reynolds numbers, the default value should be replaced by a more accurate gas viscosity input value.

Discussion in Section 3.4.6.1 of AGA Report No. 3 (1992) states that for many applications, the real compressible fluid isentropic exponent is nearly identical to the ideal gas isentropic exponent. This is nearly identical to the perfect gas isentropic exponent, and accepted practice for natural gas applications is to use 1.3 for the isentropic exponent. For gases with isentropic exponents significantly different from 1.3, the default should be replaced with a more accurate value.

How To Change the Default Configuration

GOFW2008 uses the file GOFW2008.ini for the default configuration. This file is placed in the subdirectory in which you install the software. The format of **GOFW2008**.ini is the same as the .CS1 files. If you prefer a different set of default values when you run **GOFW2008**, simply edit a **GOFW2008** file to the desired defaults and save it. Then, in Windows Explorer, rename the saved .CS1 file to **GOFW2008**.ini and replace the original **GOFW2008**.ini file.

CHAPTER 8

Instrument Calibration Correction Factors Tab

Instrument Calibration

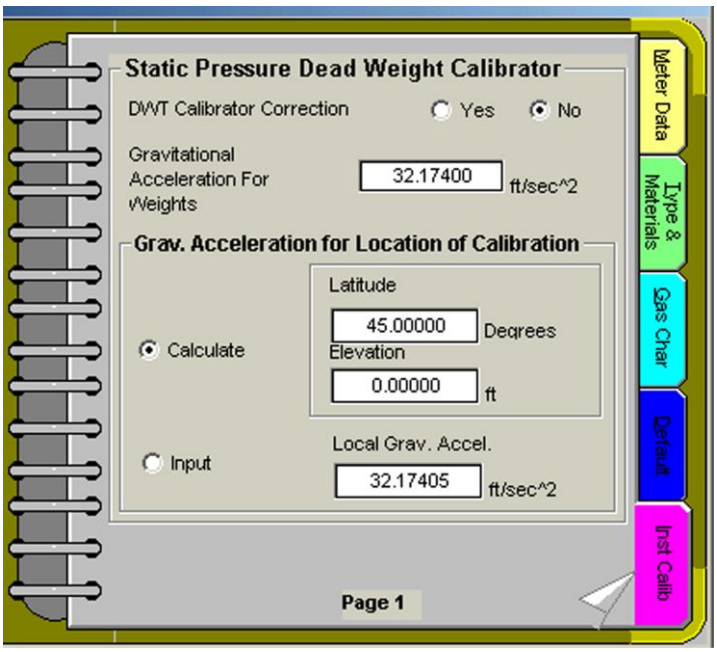
The Instrument Calibration Tab is used if instrument calibration is required. The default for **GOFW2008** is not to use instrument calibration corrections.

Four different instrument calibration options are provided

- Static pressure instrument calibration with a deadweight calibrator
- Differential pressure instrument calibration with a deadweight calibrator
- Differential pressure instrument calibration using a water manometer (with air in both manometer legs)
- User Input calibration factor (to allow for alternative calibration techniques). Calculations of factors are made using methods in the 1985 and 1992 AGA Reports No. 3.

Static Pressure Deadweight Calibrator

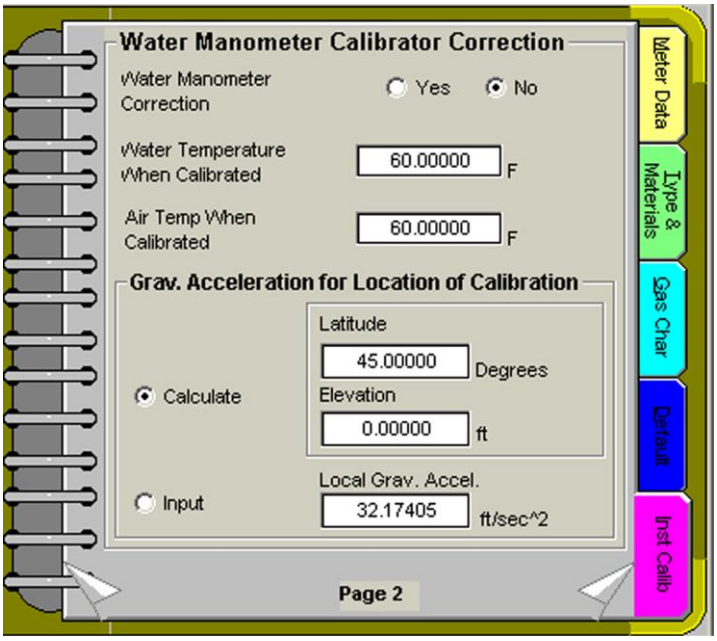
Page 1 of the Inst. Calib. Tab contains entries for the Static Pressure Dead Weight Calibrator.



Select Yes for the DWT (Dead Weight) Calibration Correction if static pressure instrument adjustment with a calibration factor is required and the static pressure sensor was calibrated with a deadweight calibrator. The weights used for most calibrators are based on the default value of the gravitational acceleration at 45 degrees latitude and sea level, that is the standard acceleration of gravity, 32.17405 ft/sec^2. If the weights are based on a gravitational acceleration different from 32.17405 ft/sec^2 it should be input. The option is provided to either input or calculate the gravitational acceleration at the location where the static pressure measurement was calibrated (usually the meter location). If the input option is used, the default will be replaced by the input value. If the calculate option is used, the location (latitude and elevation) where the static pressure measurement instrument was calibrated is required.

Water Manometer Calibration Correction

Page 2 of the Inst. Calib. Tab contains entries for the Water Manometer Calibrator.

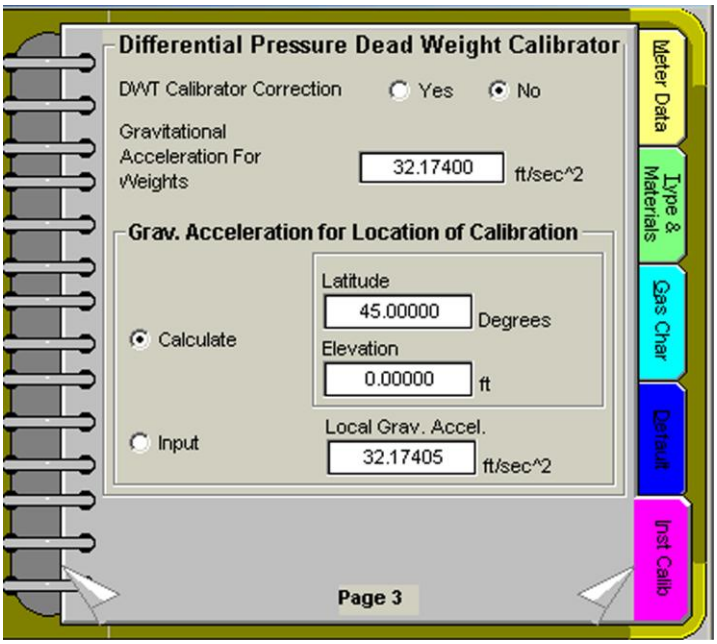


Select Yes for the Water Manometer Correction if differential pressure instrument adjustment with a water manometer is required and the differential pressure sensor was calibrated with a water manometer. Quantities required for the calculation of correction factors are the water temperature when calibrated, the air temperature when calibrated (using air in both legs of the water manometer), and the elevation and gravitational acceleration at the location of calibration of the differential pressure instrument.

The option is provided to input or to calculate the gravitational acceleration at the location of the calibration of the differential pressure instrument. If the input option is used, the default value will be replaced by the input value. If the calculated value is used, the location (latitude and elevation) where the differential pressure instrument was calibrated using the water manometer are required (the elevation is required in every case in which water manometer correction factors are used).

Differential Pressure Dead Weight Calibrator

Page 3 of the Inst. Calib. Tab contains entries for the Differential Pressure Dead Weight Calibrator.

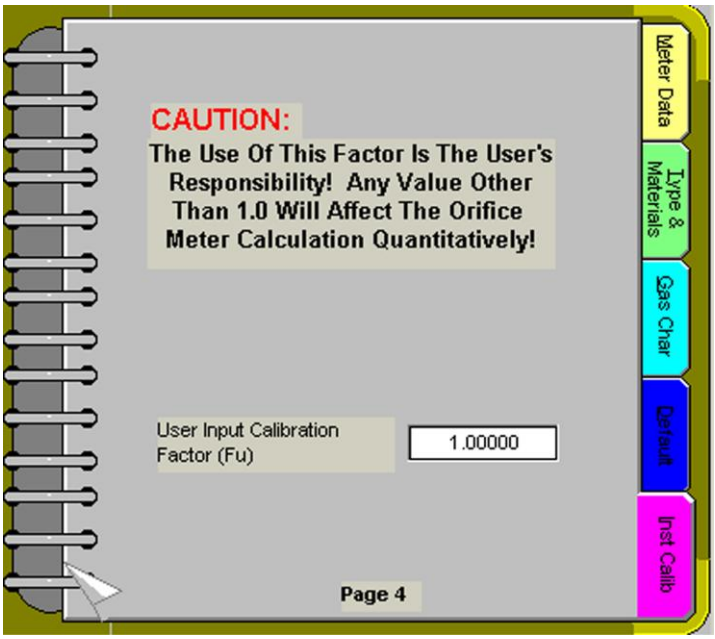


Select Yes for the DWT (Dead Weight) Calibration Correction if differential pressure instrument adjustment with a calibration factor is required and the differential pressure sensor was calibrated with a deadweight calibrator. The weights used for most calibrators are based on the default value of the gravitational acceleration at 45 degrees latitude and sea level, that is the standard acceleration of gravity, 32.17405 ft/sec^2. If the weights are based on a gravitational acceleration different from 32.17405 ft/sec^2 , it should be input. The option is provided to either input or calculate the gravitational acceleration at the location where the static pressure measurement was calibrated (usually the meter location). If the gravitational acceleration at the location of the calibration is input, the default will be replaced by the input value. If the calculate option is used for the gravitational acceleration, the location (latitude and elevation) where the differential pressure measurement instrument was calibrated is required.

User Input Calibration Factor

Page 4 of the Inst. Calib. Tab contains the User Input Calibration Factor.

The User Input calibration factor is needed only in unusual situations where a factor not provided by other options in **GOFW2008** is required. One example is the measurement of the differential pressure using a manometer other than a mercury manometer. Another example is the use of a prover to calibrate the orifice meter. In any case, the user is cautioned that any value other than the default value of 1.0 for the user input calibration factor will change the calculated meter flow rate proportional to the user input calibration factor.


CAUTION:
The Use Of This Factor Is The User's Responsibility! Any Value Other Than 1.0 Will Affect The Orifice Meter Calculation Quantitatively!
User Input Calibration Factor (Fu)
1.00000
Page 4
Meter Data
Type & Materials
Gas Char
Default
Inst Calib

Appendix A

Warnings and Errors

Introduction

This appendix discusses warnings and errors which can be encountered when running the **GOFW2008** program for orifice meter calculations. Each warning or error has a number (positive for warnings and negative for errors) and a one-line message associated with it. Numbers are shown in the error indicator field located in the Meter Data Tab and one-line messages are shown on the statusbar.

GOFW2008 displays input errors by highlighting the relevant field in red. The calculation cannot be made until the error is corrected. An error is encountered if (1) the user attempts to make an invalid program selection, (2) an input quantity is outside the calculation limit range of the selected calculation method or (3) the resultant calculation encounters an instance where the calculation is not valid.

GOFW2008 displays input warnings by highlighting the relevant field in yellow. If a warning is encountered, the calculation is allowed to continue.. A warning occurs when (1) an input quantity is outside the normal range but inside the calculation limit range or (2) the calculated value is outside the tested limits of the correlation used. For a more detailed discussion of the normal and calculation limit ranges, refer to the referenced technical documentation listed in the following sections.

GOFW2008 Program Selection Errors, Input Quantity Warnings and Errors and Calculation Warnings and Errors

GOFW2008 warnings and errors can be divided into two categories shown in Table A-1:

Table A-1

Warning and Error Categories

Number	Description
110-128	Input Quantity Warning or Error
129-138	Calculation Warning or Error

An input quantity error occurs when an input is outside the calculation limit range (outside the acceptable or tested limits for the selected method). An input quantity warning occurs when an input is outside the normal range. This occurs when the input quantity is outside the specified range as defined by AGA Report No. 8 (1992), where the compressibility factor is within a 0.1% average uncertainty, or outside the specified range of AGA Report No 8 (1985), or outside the specified range of the 1962

NX-19 Standard; (2) outside the specified range as defined by ISO/CD 12213, Part 3, 1994 Draft, where the calculated compressibility factor is within a 0.1% average uncertainty (for OPTION 1) or (3) outside the specified range of AGA Report No. 3, Part 3 (1992) standard or the AGA Report No 3.

A calculation warning occurs if during the calculation an abnormal situation is encountered in which the resultant calculated values are outside the tested limits of the method. A calculation error occurs if, during the calculation, an abnormal situation is encountered in which the resultant calculated values are known to be incorrect.

Numbers and one-line messages for warnings and errors are listed in Table A-2. Table A-3 provides a detailed description of the warnings and errors.

Table A-2

GOFW2008 Warnings and Errors

Warning or Error Number	One-Line Message
-109	Instrument Factor Input out of range
-110	User Input Calibration Factor out of range
+111	Flowing Pressure in expanded range
-111	Flowing Pressure out of range
+112	Flowing Temperature in expanded range
-112	Flowing Temperature out of range
+113	Heating Value in expanded range
-113	Heating Value out of range
+114	Relative Density in expanded range
-114	Relative Density out of range
+115	A Component Mole % in expanded range
-115	A Component Mole % out of range
+116	Sum of Comp. Mole %'s <99.99 or >100.01
-116	Sum of Component Mole %'s out of range
-117	User Input of Density out of range
-118	User Input of Z Factor out of range
-119	Reference Temperature out of range
-120	Reference Pressure out of range
+121	Meter Tube Diameter less than 2.0 inches
-121	Meter Tube Diameter out of range
+122	Orifice Diameter less than 0.45 inches
-122	Orifice Diameter out of range
+123	Diameter Measurement Temperature not 68 Deg.F
-123	Diameter Measurement Temperature out of range
+124	Beta Ratio < 0.1 or > 0.75

Warning or Error Number	One-Line Message
-124	Beta Ratio out of range
-125	Differential Pressure out of range
-126	Gas Viscosity out of range
-127	Isentropic Exponent out of range
-128	Gas Flowrate out of range
-129	Density Root out of range
-130	DGROSS iterations out of range
-131	VIRGS Calculation out of range
-132	Pressure Derivative out of range
+133	Density in BRAKET out of range
-134	No. of BRAKET iterations out of range
-135	No. of DDETAIL iterations out of range
+136	Reynolds Number out of range
-137	Gr, HV and CO2 not consistent
-138	VIRGS term out of range

Table A-3

Input Quantity Warnings and Errors

Reference Symbol	Actual Reference
8	AGA Report No. 8 (July 1994 Printing)
3	AGA Report No. 3, Part 3 (1992)
I	ISO/DIS 12213-3, 1994 Draft

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
110	User Cal. Factor		All Standards	(-)	0 < Fu	
111	Pressure (psia)	3-5-(3-2)	AGA8'92 -AGA3'92 Gr-HV-CO2	(+)	0 < Pf <= 1200	8-7
			AGA8'92 Gr-N2-CO2	(-)	0 < Pf <= 1740	I-7
			AGA8'92 Full Gas Analysis	(+)	0 < Pf <= 1750	8-6
				(-)	0 < Pf <= 40000	8-3
			User Input	(-)	0 < Pf <= 40000	
			AGA3 '85 - NX19 '62 All Methods	(+)	0 < Pf <= 5014.7	
				(-)	0 < Pf	
			AGA3 '85 AGA8 '85 All Methods	(+)	0 < Pf <= 20000	
				(-)	0 < Pf	
112	Temperature (Deg F)	3-5-(3-2)	AGA8'92 -AGA3'92 Gr-HV-CO2	(+)	32 <= Tf <= 130	8-7
			AGA8'92 -AGA3'92 Gr-N2-CO2	(-)	14 <= Tf <= 149	I-7
			AGA8'92 -AGA3'92 Full Gas Analysis	(+)	17 <= Tf <= 143	8-6

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
				(-)	-200 <= Tf <= 760	8-3
			User Input	(-)	-200 <= Tf <= 760	
			AGA3 '85 - NX19 '62 All Methods	(+)	-40 <= Tf <= 240	
			AGA3 '85 AGA8 '85 All Methods	(+)	-200 <= Tf <= 400	
113	Heating Value (Btu/ft^3)	8-142-(C.5-1)	AGA8'92 -AGA3'92 Gr-HV-CO2	(+)	805 <= HV <= 1208	I-7
				(-)	477 <= HV <= 1211	8-3
			AGA3 '85 All Methods with HV	(-)	0 < HV <=1800	
114	Relative Density	8-132-(C.3-10)	AGA8'92 -AGA3'92Gr-HV-CO2	(+)	0.55 <= Gr <= 0.8	I-9
			AGA8'92 -AGA3'92Gr-N2-CO2	(-)	0.55 <= Gr <= 0.87	8-3
			User Input	(-)	0.07 <= Gr <= 1.52	8-3
			AGA3 '85 - NX19 '62 All Methods with Gr	(+)	Gr <=0.75	
			AGA3 '85 All Methods with Gr	(-)	0.07 <= Gr <=1.52	
115	Component Mole %	8-29-(25)	AGA8'92 -AGA3'92Gr-HV-CO2	(+)	0 <= CO2 <= 20.0	I-7
			AGA8'92 -AGA3'92Gr-N2-CO2	(-)	0 <= CO2 <= 30.0	8-3
				(+)	0 <= H2 <= 0	8-5
				(-)	0 <= H2 <= 10.0	I-7
				(+)	0 <= CO <= 0	8-3
				(-)	0 <= CO <= 3.0	8-3
			AGA8'92 -AGA3'92Gr-N2-CO2	(+)	0 <= N2 <= 20.0	I-8
				(-)	0 <= N2 <= 50.0	I-9
		8-17-(12)	AGA8'92 -AGA3'92Full	(+)	0 <= H2O <= 0.05	8-3

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
			Gas Analysis			
				(-)	0 <= H2O <= 10.0	
				(+)	0 <= He <= 0.2	8-3
				(-)	0 <= He <= 3.0	8-3
				(+)	45.0 <= Meth <= 100.0	8-3
				(-)	0 <= Meth <= 100.0	8-3
				(+)	0 <= Ethane <= 10.0	8-3
				(-)	0 <= Ethane <= 100.0	8-3
				(+)	0 <= Prop <= 4.0	8-3
				(-)	0 <= Prop <= 12.0	8-3
				(+)	0 <= Butanes <= 1.0	8-3
				(-)	0 <= Butanes <= 6.0	8-3
				(+)	0 <= Pentanes <= 0.3	8-3
				(-)	0 <= Pentanes <= 4.0	8-3
				(+)	0 <= Hexanes + <= 0.2	8-3
				(-)	0 <= Hexanes + <= 10.0	
				(+)	0 <= O2 <= 0.0	8-3
				(-)	0 <= O2 <= 21.0	8-3
				(+)	0 <= CO <= 3.0	8-3
				(-)	0 <= CO <= 3.0	8-3
				(+)	0 <= H2 <= 10.0	8-3
				(-)	0 <= H2 <= 100.0	8-3
				(+)	0 <= N2 <= 50.0	8-3
				(-)	0 <= N2 <= 100.0	8-3
				(+)	0 <= CO2 <= 30.0	8-3
				(-)	0 <= CO2 <= 100.0	8-3

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
				(+)	0 <= H2S <= 0.02	8-3
				(-)	0 <= H2S <= 100.0	8-3
				(+)	0 <= Argon <= 0.0	8-3
				(-)	0 <= Argon <= 1.0	8-3
			AGA3 '85 - NX19 '62 All Methods with CO2	(+)	0 <= CO2 <= 15.0	
				(-)	0 <= CO2 <= 100.0	
			AGA3 '85 - NX19 '62 All Methods with N2	(+)	0 <= N2 <= 15.0	
				(-)	0 <= N2 <= 100.0	
			AGA3 '85 - NX19 '62 Full Gas Analysis	(-)	0 <= Any Component <= 100.0	
			AGA3'85 -AGA8'85 All Methods with CO2	(+)	0 <= CO2 <= 50.0	
				(-)	0 <= CO2 <= 100.0	
			AGA3'85 -AGA8'85 All Methods with N2	(+)	0 <= N2 <= 50.0	
				(-)	0 <= N2 <= 100.0	
			AGA3'85 -AGA8'85 Full Gas Analysis	(+)	0 <= H2O <= 1.0	
				(+)	0 <= He <= 1.0	
				(+)	50.0 <= Meth <= 100.0	
				(+)	0 <= Ethane <= 20.0	

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
				(+)	0 <= Prop <= 5.0	
				(+)	0 <= Butanes <= 3.0	
				(+)	0 <= Pentanes <= 2.0	
				(+)	0 <= Hexanes + <= 1.0	
				(+)	0 <= O2 <= 0.0	
				(+)	0 <= CO <= 1.0	
				(+)	0 <= H2 <= 1.0	
				(+)	0 <= N2 <= 50.0	
				(+)	0 <= CO2 <= 50.0	
				(+)	0 <= H2S <= 1.0	
				(-)	0 <= Any Component <= 100.0	
116	Sum of Mole %'s		Full Gas Analysis	(+)	99.99 <= Sum <= 100.01	
				(-)	98.0 <= Sum <= 102.0	
117	Densities	3-5-(3-1)	User Input	(-)	0 < Rho @ Tf & Pf	
	(Lbm/Ft^3)	3-6-(3-4a)		(-)	0 < Rho @ Tb & Pb	
118	Z Factors	3-5-(3-2)	User Input	(-)	0 < Z @ Tf & Pf	
		3-7-(3-7)		(-)	0 < Z @ Tb & Pb	
119	Reference Temp.	8-11-(7)		(-)	32.0 <= Tb <= 77.0	8-143
	(Deg. F)	8-12-(9)		(-)	32.0 <= Tgr <= 77.0	8-143
		8-136-(C.4-5)		(-)	32.0 <= Th <= 77.0	8-143
		8-142-(C.5-1)		(-)	32.0 <= Td <= 77.0	8-143
120	Reference Press.	8-11-(7)		(-)	13.0 <= Pb <= 16.0	8-143
	(psia)	8-12-(9)		(-)	13.0 <= Pgr <= 16.0	8-143
		8-142-(C.5-1)		(-)	13.0 <= Pd <= 16.0	8-143
121	Pipe Diameter	3-8-(3-10)		(+)	2.0 <= Dr	3-9
	(inches)			(-)	0.0 < Dr < 100.0	

Warning or Error Number	Input Quantity	Input Quantity Reference Ref-Pg-Eq	Standard Option and Gas Analysis Method	Warning (+) or Error (-)	Input Quantity Acceptable Range	Input Quantity Range Reference Ref-Pg
122	Orifice Diameter	3-8-(3-9)		(+)	0.45 <= dr	3-9
	(inches)			(-)	0 < dr < 100.0	
123	Measurement Temp.	3-8-(3-10)		(+)	Tr not equal 68 Deg. F	
124	BETA Ratio	3-8-(3-8)		(+)	0.1 <= dr/Dr <= 0.75	3-9
				(-)	0 < dr/Dr < 1.0	
125	Differential Press. (inches H2O)	3-12-(3-30)		(-)	0 < hw	
126	Gas Viscosity	3-10-(3-23)	AGA3'92AGA8'92Gr-Hv/N2-CO2	(-)	0.01 <= Visc <= 0.1	
	(Centipoise)		AGA3'92AGA8'92Detail /User	(-)	0.005 <= Visc <= 0.5	
127	Isentropic Exp.	3-12-(3-32)	AGA3'92AGA8'92	(-)	1.0 < k < 2.0	

Table A-4

Calculation Warnings and Errors

Warning or Error Number	Description
-129	Density search failed. A default density might be used. The compressibility factor calculation cannot be made.
-130	No convergence in density search for gross methods. The compressibility factor calculation cannot be made.
-131	Gross Method Error: Attempt to take the square root of a negative number. The compressibility factor calculation cannot be made.
-132	Detail Method Error: Pressure has a negative density derivative. Default gas density used. One cause of this error is that the system may contain liquid.
133	Detail Method Warning: Density found exceeded maximum allowable density. Default procedure used.
-134	Detail Method Error: Maximum number of iterations in to find density exceeded. Default density used.
-135	Detail Method Error: Maximum number of iterations in Density Search exceeded.
136	Flowrate Calculation Warning: Reynolds number is less than 4000.
-137	Gross Method Error: Combined value of gas relative density (Gr), heating value (HV) and mole % CO2 are not consistent. This error is encountered when these three values entered are not consistent or realistic. The compressibility factor cannot be

Warning or Error Number	Description
	calculated.
-138	Gross Method Error: Invalid term. The compressibility factor cannot be calculated.

Appendix B

Methods for comparing GOFW2008 Calculations with GPA-2172, ISO 6976 and Other Standards

INTRODUCTION

This appendix provides information on how to compare **GOFW2008** calculations which use the gas composition analysis in the AGA Report No. 8 (1992) DETAIL CHARACTERIZATION METHOD with calculations using other standards. Relative density and heating value from natural gas composition calculated using GPA 2172 and ISO 6976 are particularly pertinent because of their wide use. The titles of these standards are GPA-2172, "Calculation of Gross Heating Value, Relative Density and Compressibility Factor for Natural Gas Mixtures from Compositional Analysis," and ISO 6976, "Natural Gas - Calculation of Calorific Value, Density, Relative Density and Wobbe Index Composition." The 1992 AGA Report No. 8 (1994 reprint) can be consulted as the basis for the equations below.

RELATIVE DENSITY

The molar density d of a natural gas is calculated from the natural gas composition using differing equations in AGA Report No. 8, GPA-2172 and ISO 6976. For this reason there are small differences in the calculated values of Z_{gr}, the compressibility factor at the relative density reference condition T_{gr} and P_{gr}. For equal values of reference temperature and pressure, the relationship of the relative density G_r^* for a given standard to the relative density G_r from AGA Report No. 8 is

$$G_r^* = (Z_{gr} / Z_{gr}^*) G_r$$

where Z_{gr} is the compressibility factor from AGA Report No. 8 and Z_{gr}^* is the compressibility factor from the given standard. For most dry natural gases, the ratio (Z_{gr}/Z_{gr}^*) usually differs from unity by less than 100 parts per million.

HEATING VALUE

The relationship of the volumetric gross heating value HV^* for a given standard to the volumetric gross heating value HV from AGA Report No. 8 is

$$HV^* = (Zd / Zd^*) (HN^*_{ideal} / HN_{ideal}) HV$$

In this equation Z_d is the compressibility factor at T_d, P_d , and HN_{ideal} is the molar ideal gas gross heating value at T_h, P_h. AGA Report No. 8, Appendix C can be consulted for discussion of the reference temperatures and pressures T_h, P_h, T_d and P_d. The molar ideal gas gross heating value HN_{ideal} is related to the volumetric gross heating value HV by the relation

$$HN_{ideal} = (Z_d R T_d / P_d) HV$$

where R is the universal gas constant.

FLOWRATE

The volume flowrate Q_b referenced to base conditions T_b, P_b is equal to the mass flowrate Q_m divided by the mass density r_b at the base conditions T_b, P_b. The mass density at base conditions r_b is

$$r_b = (P_b\, Mr / Z_b\, R\, T_b)$$

where M_r is the molar mass (molecular weight) of the gas and R is the universal gas constant. The relationship of Q_b to Q_m is therefore

$$Q_m = (P_b\, M_r / Z_b\, R\, T_b)\, Q_b$$

The relationship of the flowrate Q_b^* referenced to a given standard for which Z_b^* is the compressibility factor at T_b^*, P_b^* to the flowrate Q_b referenced to AGA Report No. 8 for which Z_b is the compressibility factor at T_b, P_b is

$$Q_b^* = Q_b\, (P_b / P_b^*)\, (T_b^* / T_b)\, (Z_b^* / Z_b)$$

If $T_b^* = T_b$ and $P_b^* = P_b$ then

$$Q_b^* = (Z_b^* / Z_b)\, Q_b$$

As an example of the use of this ratio, consider a case in which **GOFW2008** is to be used to check calculations from an electronic flow meter using the 1992 AGA Report No. 3 orifice meter calculations methods, the AGA Report No. 8 method for gas density at flowing conditions and the GPA-2172 methods for the relative density and the compressibility factor at base conditions. In this instance, the EFM calculation can be verified using **GOFW2008** by performing the flowrate calculation using the gas analysis as input to obtain $(Q_b)_{\mathbf{GOFW2008}}$. Then the following calculation can be made for Q_b^*

$$Q_b^* = (Q_b)_{\mathbf{GOFW2008}}\, (Z_b)_{\text{GPA-2172}} / (Z_b)_{\mathbf{GOFW2008}}$$

where $(Z_b)_{\mathbf{GOFW2008}}$ is the value of Z_b from **GOFW2008** and $(Z_b)_{\text{GPA-2172}}$ is the value of Z_b from GPA-2172 (both at the same base temperature and same base pressure). The value of Q_b^* then can be compared with the volume flowrate $(Q_b)_{\text{EFM}}$ calculated by the electronic flow meter. Agreement between $(Q_b)_{\text{EFM}}$ and Q_b^* should be achieved at a specified level for EFM verification purposes. Disagreement greater than 50 parts per million would not be expected if the electronic flow meter is correctly programmed.

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