Technical Bulletin, Calculation of Natural Gas Net Volume and Energy: Using Gas Chromatograph, Product Overrides or Live 4-20mA Analyzer Inputs of Specific Gravity and Heating Value

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NOTE: User Manual Reference - This Technical Bulletin complements the information contained in Volume3, applicable to Revision 23/27 and replaces original TB-970804 (52-0000-0007).

Natural Gas Net Volume and Energy Calculation – Natural gas net volume and energy calculations apply to all gas flow computers. These calculations are considered using a gas chromatograph, product overrides, or live 4-20 mA analyzer inputs of specific gravity (SG) and heating value (HV).

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Scope

Firmware Revisions 23/27 of OMNI 6000/3000 Flow Computers have the feature of Natural Gas Net Volume and Energy Calculation. This feature applies to Orifice/Turbine Gas Flow Metering Systems. This bulletin covers natural gas net volume, energy calculations using a gas chromatograph, product override or live 420 mA analyzer inputs of specific gravity (SG) and heating value (HV).

Abstract

Gas compositional data needed by the flow computer to calculate flowing density, mass flow and energy flow of natural gas can be obtained from various sources. The following describes how the flow computer should be configured for each possible scenario.

NOTE: Heating Value Calculation – The flow computer always calculates Heating Value using one of the mentioned standards even it is instructed not to use it. These calculated values are stored in the data base and can be used to compare against the values obtained from the GC or calorimeter.

7629=Mtr #1 calculated HV
7630=Mtr #2 calculated HV
7631=Mtr #3 calculated HV
7632=Mtr #4 calculated HV

Additional Modbus address:

7142=Mtr #1 AGA8 HV
7242=Mtr #2 AGA8 HV
7342=Mtr #3 AGA8 HV
7442=Mtr #4 AGA8 HV

Heating Value in Use

8568=Mtr #1 HV in use
8668=Mtr #2 HV in use
8768=Mtr #3 HV in use
8868=Mtr #4 HV in use

Product Data heating Value in Btu/Ft3 or MJ/m3

17253=Prd #1 HV
17283=Prd #2 HV
17313=Prd #3 HV
17343=Prd #4 HV

Basic Calculations

Net Volume = Mass Flow / Density @ Base Conditions (1)

Energy = Net Volume x Heating Value (2)

(GC Relative Density) x (Density of Air @ Base Conditions) (3)

(Override Relative Density) x (Density of Air @ Base Conditions) (4)

(Live 4-20mA Relative Density) x (Density of Air @ Base Conditions)

Calculated using Detailed Method of AGA-8 (5)

Heating Value is obtained using one of the following methods:

- GC Analysis Heating Value (6)
- Manual Override Heating Value (7)
- Live 4-20mA Heating Value (8)
- Calculated using AGA-5, GPA 2172 or ISO 6976

(component analysis required)

Component Analysis Data is obtained from one of the following sources:

- Online Danalyzer or Applied Automation Gas Chromatograph (10)
- Manual Overrides in the 'Fluid Data Analysis' menu (11)
- Serial Communication Link (12)
- Live 4-20mA SG, HV, N2 and CO2
  (AGA-8 gross calculation methods only) (13)

Critical Configuration Entries Which Affect the Calculation of Net Volume and Energy

Density of Air at Base Conditions

This entry is in the 'Factor Setup' menu. Setting this entry to zero (0) ensures that 'gas density at base conditions' is calculated using AGA-8 (method (6)). Entering the 'density of air at base conditions' assuming a valid 'gas relative density (SG)' is available will override the AGA-8 calculation of 'gas density at base conditions'. In this case 'gas density at base conditions' is calculated using either method three (3), four (4) or five (5).

Gas Relative Density (SG)

This entry is located in the 'Fluid Analysis Data' menu. One (1) entry per active product is required. It is mandatory that this field contain a valid value of 'SG' for all AGA-8 'gross' calculation methods except for 1985 method #4. The data in this field can be manually entered or, automatically overwritten by a live 4-20mA input of 'SG' if it exists. This entry also serves as the GC 'SG' override if a GC is providing 'gas relative density (SG)' and a GC failure occurs.

Entering a minus value in this field will force the flow computer to calculate 'gas density at base conditions' using AGA-8. (method (6)). Entering the 'gas relative density (SG)' assuming a non zero 'Density of Air @ Base Conditions' is entered will override the AGA-8 calculation of 'gas density at base conditions'. In this case 'gas density at base conditions' is calculated using either method three (3), four (4) or five (5).

When an AGA-8 detailed method is selected and a GC is used to provide 'gas relative density (SG)', this entry field is ignored unless a GC failure occurs and the 'GC Fail Code' entry is set to 'Use Override on GC Failure'.

Gas Heating Value (HV)

This entry is located in the 'Fluid Analysis Data' menu. One (1) entry per active product is required. It is mandatory that this field contain a valid value of 'HV' for AGA-8 'gross' calculation method #1 and also AGA-8 1985 methods #2 and #4. The data in this field can be manually entered or, automatically overwritten by a live 4-20mA input of 'HV' if it exists. This entry also serves as the GC 'HV' override if a GC is providing 'gas heating value (HV)' and a GC failure occurs. Entering a minus value in this field will force the flow computer to use a 'calculated gas heating value (HV)' calculated using AGA-5, GPA 2172 or ISO 6976 (method (10)).

Entering a positive value into the 'gas heating value (HV)' entry will override the AGA-5, GPA 2172 or ISO 6976 calculation of 'gas heating value (HV)'. When an AGA-8 detailed method is selected and a GC is used to provide 'gas heating value (HV)', this entry field is ignored unless a GC failure occurs and the 'GC Fail Code' entry is set to 'Use Override on GC Failure'.

Heating Value calculations in the Flow Computer always provide the Superior Heating Value, meaning if there is an H2O effect it accounts for it.

Heating Value Calculations for AGA-5

Calculate the gas energy Btu per cubic foot, at 14.73 psi, and 60 deg F. (fixed values) using the following equation: (wet or dry depending on the contents of water of the gas analysis).

- Ev = Vg –(Vcd + Vn + Vo + Vhe + Vcm + Vhs + Vw-Vhy)
- Vg = (1571.5 x specific Gravity) +144

The result will be converted to Metric units for Revision 27.

Heating Value Calculation for GPA2172

Calculates the gross heating value at base temperature and pressure! (Wet or dry depending on the contents of water of the gas analysis)

To match the examples on GPA2172-96 @ 60 Deg F and 14.696 psia, the pre-calculated tables of constants will be used as shown in the examples with rounding and resolution effects when base temperature 60F and pressure 14.696 psia are entered into a Flow Computer. The pre-calculated tables are on dry basis.

The Flow Computer does not use the so-called four (4) lookup tables, it uses the algorithm. The so-called four (4) lookup tables are not actually tables, they are “example” and although all of the examples shown in the standard use 14.696 psia, you can use whatever reference pressure and reference temperature you like.

Heating Value Calculation for ISO 6976

Calculates the real superior calorific value at 15 Deg C and 1.01325 bar (wet or dry depending on the contents of water of the gas analysis)

Selections available for the user under Heating Value are:

2 = ISO6976 15/15 Deg C

3 = ISO6976 0/0 Deg C

4 = ISO6976 15/0 Deg C

5 = ISO6976 25/0 Deg C

6 = ISO6976 20/20 Deg C

7 = ISO6976 25/20 Deg C

ISO 5167 Selection

0 = ISO5167 1991 (E)

1 = ISO5167 1998 (E)

2 = ISO5167 2003 (E)

Neo-Pentane Component

If GPA 2172-96 or an ISO 6976-95 method is selected, the user may select whether to disregard the neo-Pentane component, Flow Computer to add the neo-Pentane component to the iso-Pentane component, or Flow Computer to add the neo-Pentane component to the n-Pentane component before feeding into the HV calculation.

(Available with firmware versions: 23.74.20; 27.74.20 and up)

Base Conditions: (available with firmware v27.74.19 and up)

Base Temperature: Enter the contract base temperature in degrees C. If an ISO 6976 selection is made for Heating Value Method, the base temperature value is automatically set to the metering reference temperature.

Base Pressure: Enter the contract base pressure in absolute units.

AGA-10 Calculation Option

Additional thermodynamic properties such as velocity of sound in the fluid (VOS), isentropic exponent (k) and dZ/dT at constant density are calculated when the (Enabling of AGA-10 Calculation is "checked"). This option is only functional when 'AGA-8 1994 Detailed' method is selected. The calculated VOS of the fluid is a function of the component analysis, temperature and pressure of the fluid. If a serial connection is connected to a supported ultrasonic flowmeter (UFM) the VOS measured and transmitted by the UFM can be compared to the VOS value calculated by AGA-10 in the flow computer. This comparison is done real-time and serves as a good indication as to the validity of the GC's component analysis versus the UFM measured VOS.

The calculated isentropic exponent 'k' is available for use in the selected ISO-5167 orifice meter calculation.

Calculated dZ/dT has some value in metric gas flow applications, where ISO-5167(2003) recommends the use of the **Joule-Thomson coefficient** to apply an isenthalpic correction from downstream temperature to temperature upstream of the orifice.

Rev 27.74 + - ISO 5167 (2003) Joule - Thomson Coefficient

There are two (2) methods available to calculate the Joule Thomson coefficient. For transmission quality natural gas the user can select "Use simplified Joule-Thomson Calculation' developed by Reader-Harris of NEL-TUV in the UK. Alternatively, the user can manually enter terms dZ/dT and Cmp. These selections are found in the 'Physical Meter Run – Orifice' property sheet of OMNICOM. The Joule-Thomson equation included in ISO-5167(2003) requires dZ/dT at 'constant pressure', whereas AGA-10 calculates dZ/dT at constant density. Entering a minus value for dZ/dT will cause the flow computer to use the AGA-10 'constant density' dZ/dT value. However, OMNI Flow Computers cannot guarantee the accuracy of the calculated Joule-Thomson coefficient in this case. It is believed that while the two (2) values of dZ/dT are different, they should closely track each other because density is closely related to pressure. With non-transmission quality gasses, there may be some advantage to using the AGA-10 dZ/dT.

AGA-8 Density Calculation - neo-Pentane Component

1) If any AGA-8 Detailed density method is selected, the user may select whether to disregard the neo-Pentane component,
2) Flow Computer to add the neo-Pentane component to the iso-Pentane component, or
3) Flow Computer to add the neo-Pentane component to the n-Pentane component before feeding into the density calculation.

   (Available with firmware versions 23.74.20 and 27.74.20 and up)

ISO 6976 Reference Density Calculation

If any of the AGA-8 Detailed density methods are selected, the user may check the box so that the Flow Computer uses ISO 6976 to calculate the reference density. If the box is checked, the user also selects a reference temperature from the list.

NOTE: If the user has selected an ISO 6976 Heating Value Method and the temperature selected there does not match the temperature selected for reference density, a warning message is displayed.

(Available with firmware versions 27.74.20 and up)

Redlich-Kwong

Enter the following entries for the Redlich-Kwong equation of state:

- **critical temperature**, Tc,
- **critical pressure**, Pc,

- The **Soave-Redlich-Kwong** (SRK) EOS is available with application firmware v27.74.21+. (Refer to the help for Density Method for more information.) If the Soave-Redlich-Kwong method is selected, the user is asked for an Accentric Factor. The default is zero (0).

Ideal Gas Calculation Override Z

Enter the value used for Z in the following ideal gas equation:

- Density = Pf/Pb * Tb/Tf * 1/Z * Density @ Ref. Condition.
- Density @ Ref. Condition = SG * Density of Air.

NIST14 Analysis Basis

Enter the basis in which the components are analyzed for the NIST14 equations. The choices are Mole Percent, Mole Fraction, Mass Percent, and Mass Fraction**.**

NIST14 Density Calculation -Add neo-Pentane to iso-Pentane

If any of the AGA-8 Detailed density methods are selected, the user may select whether to:

- disregard the neo-Pentane component,
- Flow Computer to add the neo-Pentane component to the iso-Pentane component, or
- Flow Computer to add the neo-Pentane component to the n-Pentane component before feeding into the density calculation.

(Available with firmware versions 23.74.20 and 27.74.20 and up)

Compressibility Z: This value is calculated by the flow computer and can be viewed via the front panel by pressing “Pressure”, “Factor”, “Enter” keys

Key Analyzer Setup Menu Entries Needed

The following discusses only those key entries that must be made to ensure that the right values for component analysis are used in the calculation of Net Volume and Energy Flow:

- **No Gas Chromatograph Used - Manual Overrides Required**

  Select ‘Always Use Fluid Data Overrides’ for ‘GC Fail Code’ in the ‘Analyzer Setup’ menu. No other entries are needed.

- **Component Analysis Data Obtained From a Gas Chromatograph**

  In the Analyzer setup menu the GC Fail code should be set to either:

  1) Never Use Fluid Data Overrides, or
  2) On Fail Use Fluid Data Overrides to ensure that the GC data will be used in place of the ‘Fluid Data & Analysis Data’ overrides’.

- **Using the ‘GC’ Heating Value and Relative Density**

  To ensure that the heating value and relative density calculated by ‘GC’ are used in the calculations, make sure that component numbers are assigned for the ‘Heating Value’ and ‘Specific Gravity’ entries in the ‘Analyzer Setup’ menu. The number entered is not critical; simply use the next consecutive numbers after all the other components are numbered.

- **Ignoring the ‘GC’ Heating Value and Relative Density**

  Entering ‘0’ for the component number for ‘Heating Value’ and ‘Specific Gravity’ entries in the ‘Analyzer Setup’ menu causes the flow computer to ignore the heating value and relative density sent by the GC and to use the override values entered in the ‘Fluid Data & Analysis Data’ menu.

Using Manual Overrides for Component Analysis Data

Activate the ‘Fluid Data & Analysis’ entries by selecting ‘Always Use Fluid Data Overrides’ for ‘GC Fail Code’ in the ‘Analyzer Setup’ menu. No other entries are needed in the ‘Analyzer Setup’ menu.

Enter the compositional analysis data values into the appropriate fields in the ‘Fluid Data & Analysis’ menu.

Component Analysis Data Obtained via a Serial Data Link

In the Analyzer setup menu the GC Fail code should be set to the ‘Always Use Fluid Data Overrides’. No other entries are needed in the ‘Analyzer Setup’ menu.

Compositional analysis data values should be written into the appropriate Modbus points 17230 thru 17256 normally containing the manual overrides in the ‘Fluid Data & Analysis’ menu.

Using Live Inputs for Heating Value, Specific Gravity, Nitrogen or Carbon Dioxide

In the Analyzer setup menu the GC Fail code should be set to ‘Always Use Fluid Data Overrides’. No other entries are needed in the ‘Analyzer Setup’ menu.

In the ‘Station Configure’ menu, assign valid I/O points where 4-20mA and/or Solartron 3096 gravitometer signals will be connected. Input valid scaling factors in the ‘Station N2 / SG Setup’ menu.

NOTE: That override data fields in ‘Product #1’ entries of the ‘Fluid Data & Analysis Data’ menu are overwritten by live data values when 4-20mA inputs are used for HV, SG, N2 or CO2

DOCUMENT REVISION HISTORY

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A	21-May-2003	Maintained on the Web - Initial release
B	08-August-2005	Maintained on the Web
C	23-February-2009	DCR 090048