

## **BCG 1.0A**

Standard

Implementation

AGA Report No.3

Orifice Metering Of Natural Gas  
and Other Related  
Hydrocarbon Fluids

## Notes:

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## Introduction

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This solution is an implementation of the standard:

*“Orifice Metering of natural gas and other related hydrocarbon fluids”, AGA report no. 3, adjunct to API MPMS 14.3 & GPA 8185-90.*

It is part of the product Bulk Calculations Gas Version 1.0A (BCG 10A).

The solution runs only in an SAP ABAP environment in which IS-Oil has been implemented.

This solution can be accessed by the SAP Quantity Conversion Interface (QCI) or the QuantityWare MQCI.

## 1. Installation

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The technical implementation is provided as a part of a CSP package for BCG 10A.

Please follow the standard SAP instructions for importing service packages into your system via transaction SPAM, or the implementation on installation packages via transaction SAINT.

SAP Oil and Gas must be installed

QuantityWare BCG 10A must be installed.

Customizing settings, which are needed in every client in which this standard will be used, are included in the delivery package.

On releases based upon SAP 4.72 and below, the related customizing transport must be imported into all necessary clients, or distributed to them from client 000.

On releases based upon SAP ERP 2005 (ECC 6.00) or newer, BC Set /QTYW/BCG\_10A must be activated in the relevant clients.

Please refer to the QuantityWare BCG 10A Installation Guide for more information.

**▲ WARNING:** *If you import the customizing template into a pre-existing client, any pre-existing entries listed within the template (transport or BC-Set) will be **OVERWRITTEN!***

## 2. Basic definitions of natural gas quantities and behaviour

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Besides serving as basic feedstock for the chemical industry, natural gas is predominantly used for heat production as a fuel in large industry sites and millions of households worldwide.

In order to define a trading value for natural gas and to ensure natural gas interchangeability, certain quantities that characterize natural gas must be defined and recorded in business transactions for various processes e.g. inventory management, quality assurance, pricing and excise duty payments. For a comprehensive list of such quantities we recommend ISO standard ISO 6976 as a reference.

With BCG 1.0A QuantityWare delivers conversion groups that are designed for all globally known standard reference conditions for natural gas in the gas phase (high and low pressure regime (CNG), as well as conversion groups for NGL (Natural Gas Liquids). With the release of BCG 1.0A, LNG (Liquefied Natural Gas) support is also provided.

Pipeline transmission of natural gas requires metering devices that calculate the total volume (or mass) flow rate of natural gas for a given time period, based on e.g. pressure and temperature conditions at specific metering points.

In order to aid the comprehension of this documentation, we cite the most important definitions from standard ISO 6976 & ISO 6578 & AGA report no. 3.

### Common definitions:

Superior calorific value:

The amount of heat which would be released by the complete combustion in air of a specified quantity of gas, in such a way that the pressure  $p_1$  at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature  $t_1$  as that of the reactants, all of these products being in the gaseous state except for water formed by combustion, which is condensed to the liquid state at  $t_1$ .

▲ A synonym for calorific value is the term **heating value**. Calorific values can be specified on a molar or mass basis. Then the calorific value depends on the combustion reference conditions  $t_1$  and  $p_1$ . More commonly, calorific values are determined based upon a volumetric basis ;in this instance, the calorific value needs to be specified with the combustion reference conditions  $t_1$  and  $p_1$  as well as the volumetric reference conditions  $t_2$  and  $p_2$ .

#### Inferior calorific value:

The amount of heat which would be released by the complete combustion in air of a specified quantity of gas, in such a way that the pressure  $p_1$  at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature  $t_1$  as that of the reactants, all of these products being in the gaseous state.

#### Density:

The density is the mass of a gas sample divided by its volume at specified conditions of pressure and temperature.

#### Relative density:

The density of a gas divided by the density of dry air of standard composition (see Annex B ISO 6976:1995 for a definition of dry air) at the same specified conditions of pressure and temperature.

#### Wobbe index:

The superior calorific value on a volumetric basis at specified reference conditions, divided by the square root of the relative density at the same specified metering reference conditions.

- ▲ *The Wobbe index is an important quality designation for natural gas, which is commonly used to determine trade prices and the interchangeability of natural gas.*
- ▲ *The SAP QCI does not calculate the Wobbe index for natural gas. BCG contains functions to perform these calculations within the delivered global templates.*

#### Gas interchangeability:

An important business requirement when trading natural gas is that natural gas combustion is kept at a defined quality levels that are e.g. required by burners. The Wobbe index (sometimes also referred to as Wobbe number) can serve as one important quality number to ensure interchangeability of natural gas batches with e.g. an apparent different composition.

Ideal gas and real gas:

An ideal gas is one that obeys the ideal gas law:

$$p \cdot V_m = R \cdot T \quad \dots(1)$$

where

$p$  is the absolute pressure

$T$  is the thermodynamic temperature

$V_m$  is the volume per mole of gas

$R$  is the molar gas constant, in coherent units.

No real gas obeys this law. For real gases, equation (1) must be rewritten as

$$p \cdot V_m = Z(T,p) \cdot R \cdot T \quad \dots(2)$$

where  $Z(T,p)$  is a variable often close to unity, and is known as the compression factor.

Compression factor:

The actual (real) volume of a given mass of a gas at specified pressure and temperature divided by its volume, under the same conditions, as calculated by the ideal gas law.

Combustion reference conditions:

The specified temperature  $t_1$  and pressure  $p_1$ . These are the conditions at which the fuel (natural gas) is notionally burned.

Metering reference conditions:

The specified temperature  $t_2$  and pressure  $p_2$ . These are the conditions at which the amount of the fuel to be burned is notionally determined; there is no a priori reason for these to be the same as the combustion reference conditions.

▲ *A range of reference conditions is in use throughout the world. In order to ensure ease of trade, exact conversions of natural gas quantities between different sets of reference conditions is required, based on international standards. This range of different reference conditions is also one of the main reasons why natural gas quantity conversions are complex, even in the low pressure regime.*

Standard reference conditions of selected countries:

Country	$t_1$	$p_1$	$t_2$	$p_2$
Argentina	-	101,325 kPa	15 °C	101,325 kPa
Australia	15 °C	101,325 kPa	0 °C	101,325 kPa
Austria	25 °C	101,325 kPa	0 °C	101,325 kPa
Belgium	25 °C	101,325 kPa	0 °C	101,325 kPa
Brazil	-	101,325 kPa	0 °C	101,325 kPa
Canada	15 °C	101,325 kPa	15 °C	101,325 kPa
China	20 °C	101,325 kPa	20 °C	101,325 kPa
Czechoslovakia	25 °C	101,325 kPa	20 °C and 0 °C	101,325 kPa
Denmark	25 °C	101,325 kPa	0 °C	101,325 kPa
Egypt	-	101,325 kPa	15 °C	101,325 kPa
Finland	-	101,325 kPa	15 °C	101,325 kPa
France	0 °C	101,325 kPa	0 °C	101,325 kPa
Germany	25 °C	101,325 kPa	0 °C	101,325 kPa
Hong Kong	-	101,325 kPa	15 °C	101,325 kPa
Hungary	-	101,325 kPa	0 °C	101,325 kPa
India	-	101,325 kPa	0 °C	101,325 kPa
Indonesia	-	101,325 kPa	0 °C	101,325 kPa
Iran	-	101,325 kPa	15 °C	101,325 kPa
Ireland	15 °C	101,325 kPa	15 °C	101,325 kPa
Italy	25 °C	101,325 kPa	0 °C	101,325 kPa
Japan	0 °C	101,325 kPa	0 °C	101,325 kPa
Netherlands	25 °C	101,325 kPa	0 °C	101,325 kPa
New Zealand	-	101,325 kPa	15 °C	101,325 kPa
Norway	-	101,325 kPa	15 °C	101,325 kPa
Pakistan	-	101,325 kPa	15 °C	101,325 kPa
Romania	25 °C	101,325 kPa	15 °C and 0 °C	101,325 kPa
Russia	25 °C	101,325 kPa	20 °C and 0 °C	101,325 kPa
Spain	0 °C	101,325 kPa	0 °C	101,325 kPa
Sweden	-	101,325 kPa	0 °C	101,325 kPa
United Kingdom	15 °C	101,325 kPa	15 °C	101,325 kPa
USA	15 °C	101,325 kPa	15 °C	101,325 kPa
Yugoslavia	0 °C	101,325 kPa	0 °C	101,325 kPa

Source: ISO 13443 and ISO 12213.

On the other hand, ISO 6976 specifies six sets of reference conditions for heating values on a volumetric basis (Table 5 therein), which can be extracted from the above table, and one additional set (25/15) is apparently in usage in some countries. QuantityWare thus defines a global template for the SI system based on seven sets of combustion and metering reference conditions, plus an additional three sets of U.S. customary conditions.

#### Orifice definitions:

▲ *For natural gas flow rate measurements, the following definition (as defined in AGA report no. 3) has to be considered.*

Orifice meter:

An orifice meter is a fluid flow measuring device that produces a differential pressure to infer flow rate. The meter consists of the following elements:

- A thin, concentric, square-edged orifice plate.
- An orifice plate holder consisting of a set of orifice flanges (or orifice fitting) equipped with the appropriate differential pressure sensing taps.
- A meter tube consisting of the adjacent piping sections (with or without flow conditioners)

▲ *A detailed list of all orifice engineering and technical terms and their definitions can be found in AGA report no. 3, part 1: “General equations and uncertainty guidelines”.*

### 3. Components of the Installation

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Within this implementation, we provide formula implementations that allow the calculation of volume flow quantities from orifice metering data using methods defined in AGA report no. 3.

#### Customizing data:

All required customizing data is contained in BC set /QTYW/BCG\_10A; no specific data to utilize the orifice functions is required beyond this data.

#### Programs & Test Tools:

The following programs are provided:

- ➔ Test report: /QTYW/AGA3\_ORIFICE\_TEST
- ➔ Function Group: /QTYW/AGA83 – function /QTYW/AGA3\_ORIFICE

## 4. Formula and requirements

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### Implemented formula

This is an implementation of orifice metering functions, based on:

*“Orifice Metering of natural gas and other related hydrocarbon fluids”, AGA report no. 3, adjunct to API MPMS 14.3 & GPA 8185-90”.*

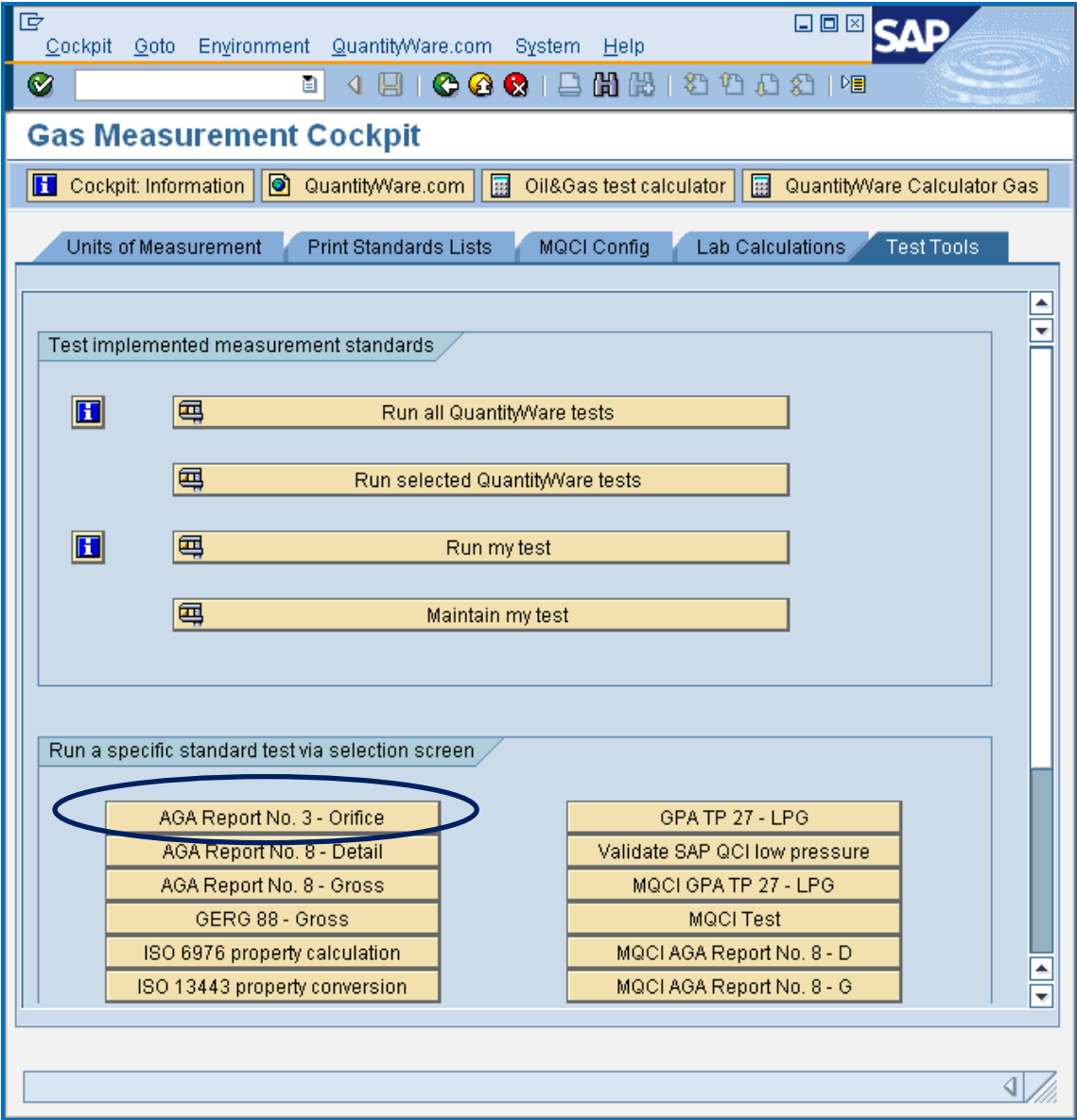
### Implementation requirements

None beyond the requirements defined above.

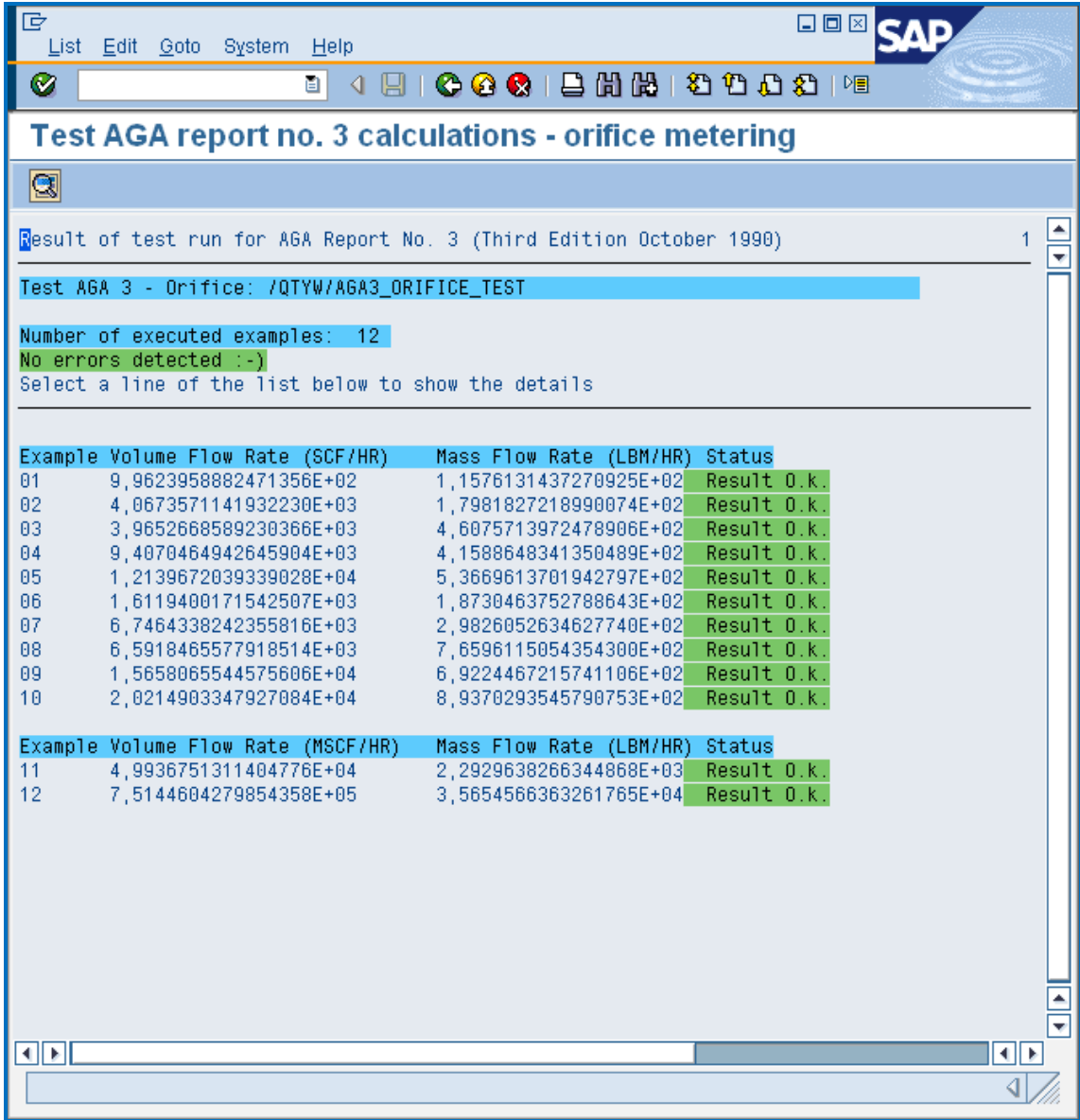
## 5. Installation Test

Included in the BCG 1.0A package are test & validation programs that can be used to test and also validate the installation for natural gas calculations based on AGA report no. 3:

Test report: /QTYW/AGA3\_ORIFICE (execute with transaction SA38) or directly from the QuantityWare Gas Measurement Cockpit (/QTYW/COCKPIT\_GAS):



After starting the report, the complete test will be executed (You do not need to select an option):



**Test AGA report no. 3 calculations - orifice metering**

Result of test run for AGA Report No. 3 (Third Edition October 1990) 1

Test AGA 3 - Orifice: /QTYW/AGA3\_ORIFICE\_TEST

Number of executed examples: 12  
 No errors detected :-)

Select a line of the list below to show the details

Example	Volume Flow Rate (SCF/HR)	Mass Flow Rate (LBM/HR)	Status
01	9,9623958882471356E+02	1,1576131437270925E+02	Result O.k.
02	4,0673571141932230E+03	1,7981827218990074E+02	Result O.k.
03	3,9652668589230366E+03	4,6075713972478906E+02	Result O.k.
04	9,4070464942645904E+03	4,1588648341350489E+02	Result O.k.
05	1,2139672039339028E+04	5,3669613701942797E+02	Result O.k.
06	1,6119400171542507E+03	1,8730463752788643E+02	Result O.k.
07	6,7464338242355816E+03	2,9826052634627740E+02	Result O.k.
08	6,5918465577918514E+03	7,6596115054354300E+02	Result O.k.
09	1,5658065544575606E+04	6,9224467215741106E+02	Result O.k.
10	2,0214903347927084E+04	8,9370293545790753E+02	Result O.k.
Example	Volume Flow Rate (MSCF/HR)	Mass Flow Rate (LBM/HR)	Status
11	4,9936751311404776E+04	2,2929638266344868E+03	Result O.k.
12	7,5144604279854358E+05	3,5654566363261765E+04	Result O.k.

All 12 examples defined in AGA report no.3 are executed and the results are displayed. By clicking on one result line, the details of the example are displayed:

List Edit Goto System Help
SAP

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**Test AGA report no. 3 calculations - orifice metering**

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Details of the calculation - Example no: 01  
Standard Temperature: 60 FAH, Standard Pressure: 14.73 PSI

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**Input:**

Type of Taps:	Flange
Static Pressure (PSI):	1,4696000000000000E+01
Flowing Temperature (FAH):	0,0000000000000000E+00
Orifice Material:	Stainless Steel
Orifice Diameter, temperature uncorr. (IN):	5,7811000000000001E-01
Orifice Diameter Temperature (FAH):	6,8000000000000000E+01
Pipe Material:	Carbon
Pipe Diameter, temperature uncorr. (IN):	2,9003899999999998E+00
Pipe Temperature (FAH):	6,8000000000000000E+01
Density Fluid @ Flowing Cond. (LBM/FT3):	1,3222999999999999E-01
Density Fluid @ Standard Cond. (LBM/FT3):	1,1619800000000000E-01
Differential Pressure (IN H2O):	2,0236000000000001E+01
Abs. Viscosity of Fluid @ Flowing Cond. (CentiPoise):	1,3070000000000000E-02
Isentropic Exponent:	1,3198000000000001E+00
Fluid Type:	Compressible
Location of Taps:	Upstream
Supercompressibility @ Standard Cond.:	1,0273000000000001E+00
Relative Density @ Standard Conditions:	6,2000000000000000E-01
All Calibration Factors:	1,0000000000000000E+00
Compressibility Factor of Air @ Standard Cond.:	9,9958400000000003E-01

**Output:**

	Calculated	Expe
Volume Flow Rate (SCF/HR):	9,9623958882471356E+02	9,96
Rounded values:	9,9620000000000005E+02	9,96
Mass Flow Rate @ Standard Cond. (LBM/HR):	1,1576131437270925E+02	1,15
Rounded values:	1,1576100000000000E+02	1,15

## **6. Integration into SAP – Traders & Schedulers Workbench (TSW)**

The orifice metering functions can easily be integrated into processes such as the SAP Trader's & Schedulers Workbench (TSW) ticketing transactions, utilizing one of the standard Ticketing sub-screens for metering processes.