



# BCS 3.0 Working Paper

## Analysis of ISO 13443 Implementation

A Working Paper describing and explaining the principles behind calculation variations when using ISO 13443 within SAP Oil, Gas, & Energy systems.

## Notes

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The latest version of this documentation can be found in the QuantityWare [Knowledge Base](#). All documentation is kept current for the combinations of latest BCS release with the latest supported SAP Oil, Gas, & Energy release. For all currently supported combinations see [Note #000086 "Support and Release \(Lifecycle\) details" page 2, "Release Lifecycle"](#).

Your release level can be determined via:

`"/o/QTYW/COCKPIT" -> "Cockpit" -> "Support Package Level" or`

`"/o/QTYW/COCKPIT_GAS" -> "Cockpit" -> "Support Package Level"`

## Version History

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Version	Date	Description
00	2016-09-02	First published
01	2017-08-02	Editorially revised and confirmed
02	2021-06-18	Modern QW document style applied
03	2023-11-30	Editorially revised and confirmed

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## 1. Question

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ISO 13443(1996) – last reviewed and confirmed in 2020 - specifies:

*The ISO standard reference condition (standard reference conditions / base reference conditions) for combustion and metering temperature  $T_1$  and  $T_2$  is 15 °C = 288.15 K, the ISO standard reference condition for combustion and metering pressure  $p_1$  and  $p_2$  is 101.325 kPa.*

In the normative Annex A of ISO 13443 conversion factors with four decimals between natural gas physical properties at various alternative reference conditions (0 °C, 15 °C, 20 °C, 25 °C for  $T_1$ ,  $T_2$  and 101.325 kPa for  $p_1$ ,  $p_2$ ) are defined.

In the informative Annex B, conversion formulas (B.1 to B.21) are given for conditions not covered in Annex A, e.g., a temperature base of 60 °F.

ISO 13443 (1996) eq. B.8/ B.10/ B.12/ B.14 [Conversion of a molar-basis or mass-basis ideal or real superior calorific value  $H(\text{ISO})$  to a mass-basis ideal or real superior calorific value  $H(T_1, p_1)$ ] is given as:

$$HS(\text{ISO}) = HS(T_1, p_1) \times [1 + 0.00010 \times (T_1 - 288.15)]$$

If a conversion factor from 60 °F to 15 °C is calculated using this formula (which may also be utilized to convert energy quantity values), the calculation result is:

1.000 055 56, which rounded to 5 decimals equals 1.000 06.

With  $T_1 = 60 \text{ °F} = 288.7056 \text{ K}$  and setting  $HS(T_1, p_1) = 1$

The SAP ERP system with QuantityWare BCS installed calculates: **1.000 055 555 5<sup>-3</sup>**.

How can this be explained?

## 2. Answer

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The difference is due to in the rounding of the conversion result from °F to K (Kelvin) for the absolute temperature  $T_1$ . The formula to convert a °F value to a K value is given e.g., in [NIST SP811](#), page 66:

$$T / K = (t / ^\circ F + 459.67) / 1.8 \quad (1)$$

If you enter 60 °F, the result is 288.705 555 555 555 555 555 555 555 56 K when using the widely available MS Desktop Calculator, although the “truly” accurate result is:  $288.70\bar{5}^1$

In the calculation described in the question, the Kelvin value for 60 °F is rounded to 4 decimals, i.e., 288.7056 K. Then, the exact ISO 13443 factor is, as calculated, 1.000 055 560 - using 288.706 K would result in a factor of 1.000 055 600; using 288.70556 K one calculates 1.000 055 556 and so on).

Since ISO 13443 does not explicitly specify the number of decimals for the absolute temperatures  $T_1$  and  $T_2$ , (although the numbers in the informative Annex D examples use 3 decimals and final values, e.g., heating values, are rounded therein to 4 or 5 significant digits), the QuantityWare implementation uses the unrounded floating-point number for the ISO 13443 calculations. This is the “weak spot” of ISO 13443; it does not contain a state-of-the-art implementation guideline for software implementations (e.g., as ASTM D1250-04 does).

Having said this, one would expect a value of  $1.000\ 0\bar{5}$  as the “most accurate” ISO 13443 value, and not  $1.000\ 055\ 5\bar{5}^3$  as in the SAP system. Why is this not the case?

The reason for this deviation is that the SAP UoM conversion between temperatures (centrally defined via SAP transaction CUNI) calculates for formula (1) a value of  $288.70555\ 5\bar{3}$  K- an insignificant inconsistency (for a non-scientific system) of the SAP UoM conversion factor definition and underlying conversion calculation for **temperatures (other quantities are not affected)**.

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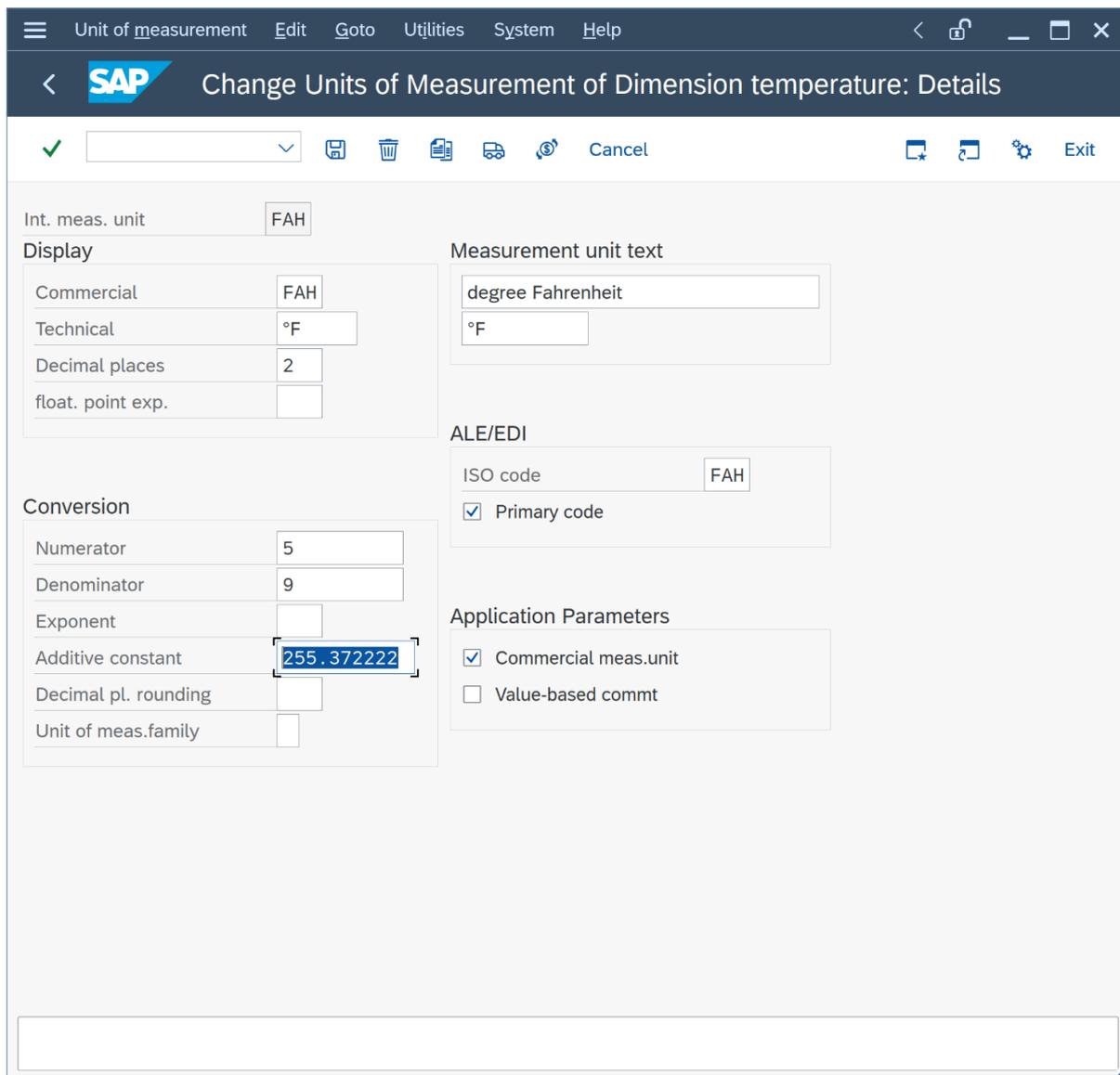
<sup>1</sup> Repeating Decimals notation is not internationally standardized. QuantityWare uses the U.S. “vinculum” notation to denote the repetend e.g.,  $0.\bar{3}$  to represent 0.3333... or  $0.\bar{54}$  to represent 0.54545454... etc.

In detail, the SAP transaction CUNI requires the implementation of formula (1) as:

$$T / K = t / ^\circ F / 1.8 + 459.67 / 1.8 \quad (2) \quad \Leftrightarrow$$

$$T / K = t / ^\circ F / 1.8 + 255.37^{-2} \quad (3)$$

With  $1.8 = 9 / 5$ , one can maintain the repeating decimal value  $255.37^{-2}$  with a maximum of six decimals in transaction CUNI:



The screenshot shows the SAP transaction CUNI 'Change Units of Measurement of Dimension temperature: Details'. The interface includes a menu bar (Unit of measurement, Edit, Goto, Utilities, System, Help) and a toolbar with icons for save, delete, print, and exit. The main area is divided into several sections:

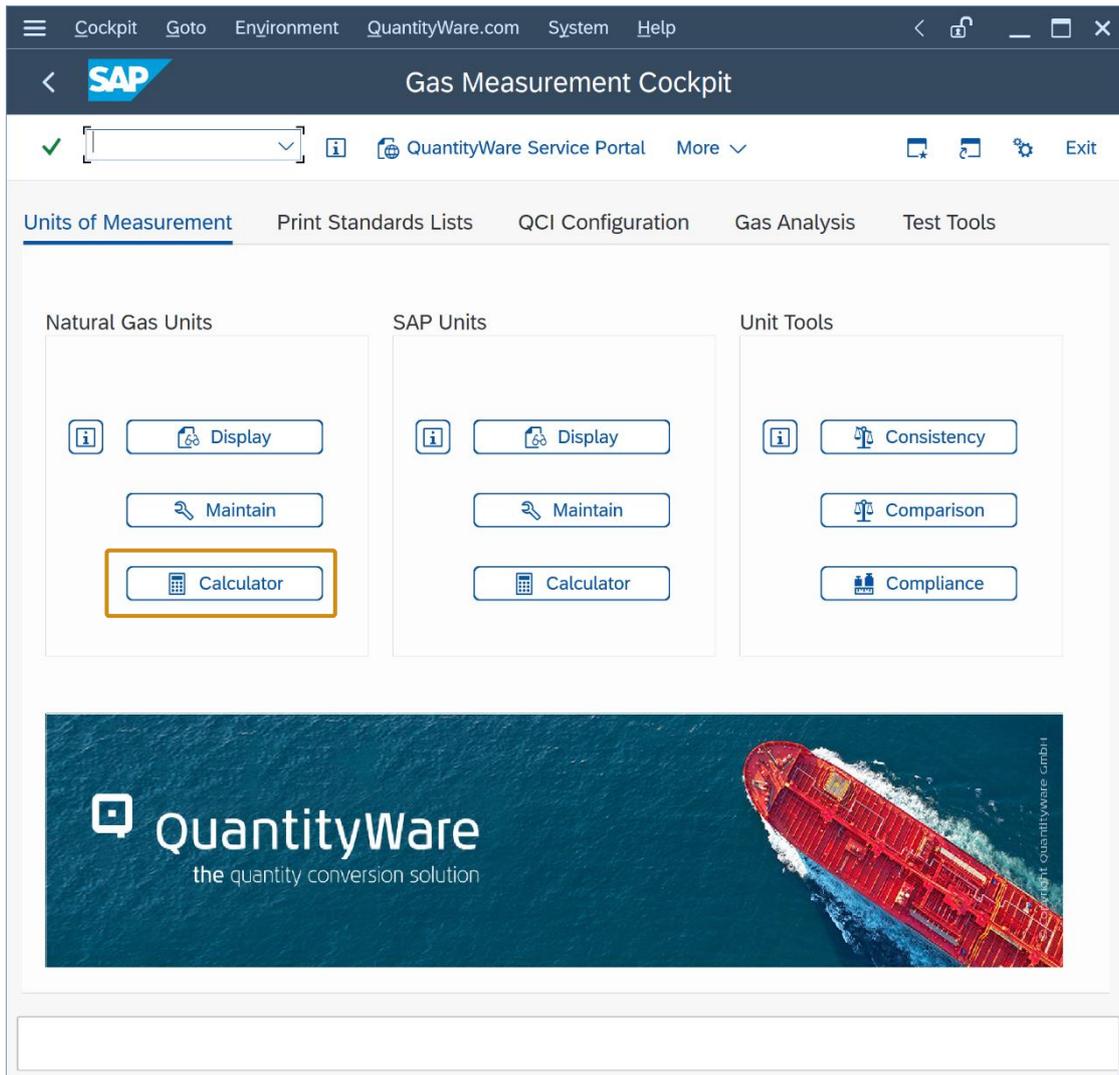
- Int. meas. unit:** FAH
- Display:**
  - Commercial: FAH
  - Technical: °F
  - Decimal places: 2
  - float. point exp.: [ ]
- Measurement unit text:**
  - degree Fahrenheit
  - °F
- Conversion:**
  - Numerator: 5
  - Denominator: 9
  - Exponent: [ ]
  - Additive constant: 255.372222
  - Decimal pl. rounding: [ ]
  - Unit of meas.family: [ ]
- ALE/EDI:**
  - ISO code: FAH
  - Primary code
- Application Parameters:**
  - Commercial meas.unit
  - Value-based commt

The Help information specifies only 2 decimals:

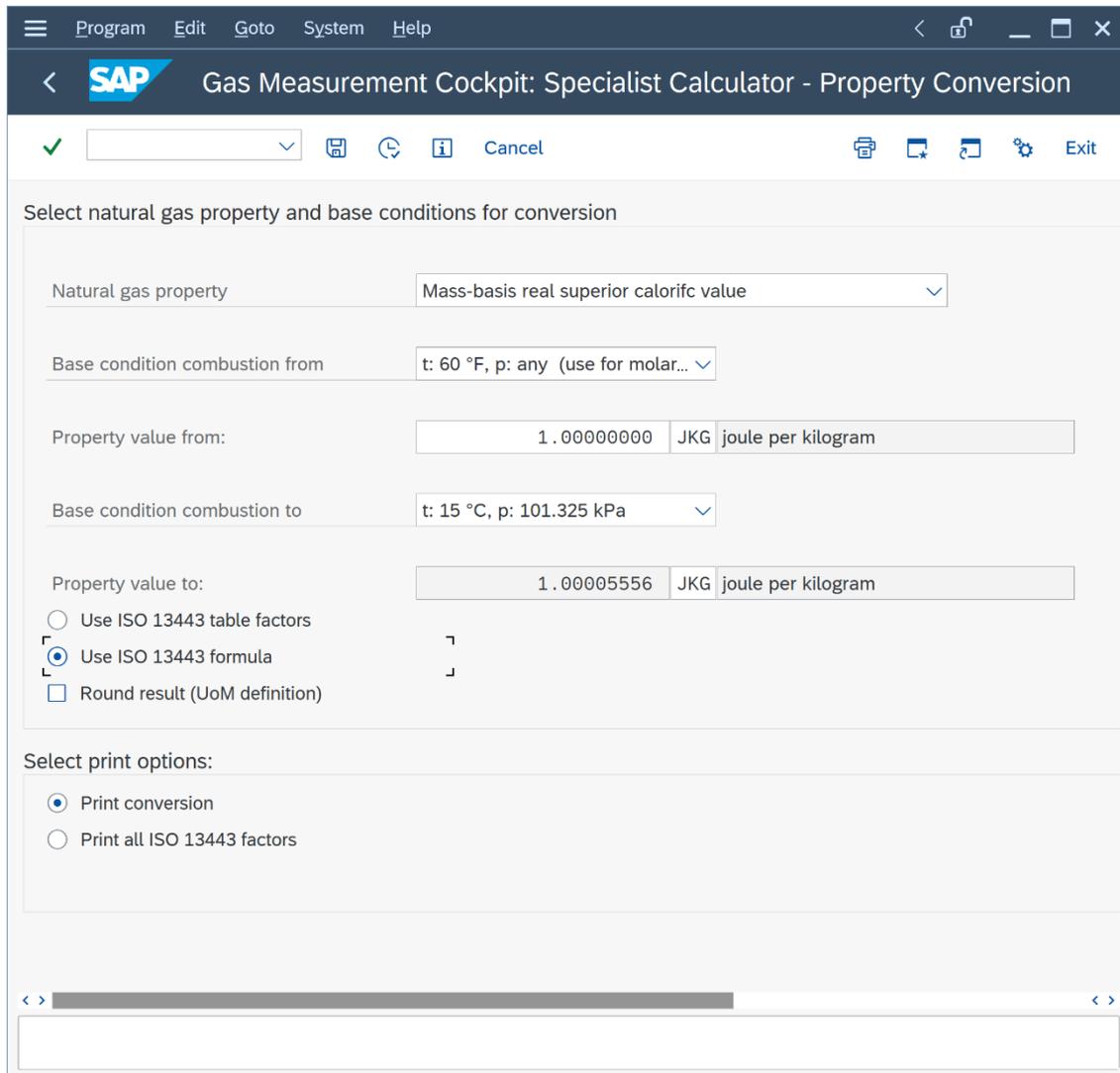


## Appendix A. QuantityWare Calculation Transparency

In the Gas Measurement Cockpit, you access the ISO 13443 Calculator via push button “Calculator” in the “Units of Measurement -> Natural Gas Units” tab strip:



The conversion of a theoretical mass-basis real superior calorific value of 1.0 Joule per kilogram leads to a result of 1.000 055 560 Joule per kilogram (rounded to 8 display decimals).



Program Edit Goto System Help

SAP Gas Measurement Cockpit: Specialist Calculator - Property Conversion

✓ [dropdown] [save] [refresh] [info] Cancel [print] [copy] [paste] [gear] Exit

Select natural gas property and base conditions for conversion

Natural gas property: Mass-basis real superior calorific value

Base condition combustion from: t: 60 °F, p: any (use for molar...)

Property value from: 1.00000000 JKG joule per kilogram

Base condition combustion to: t: 15 °C, p: 101.325 kPa

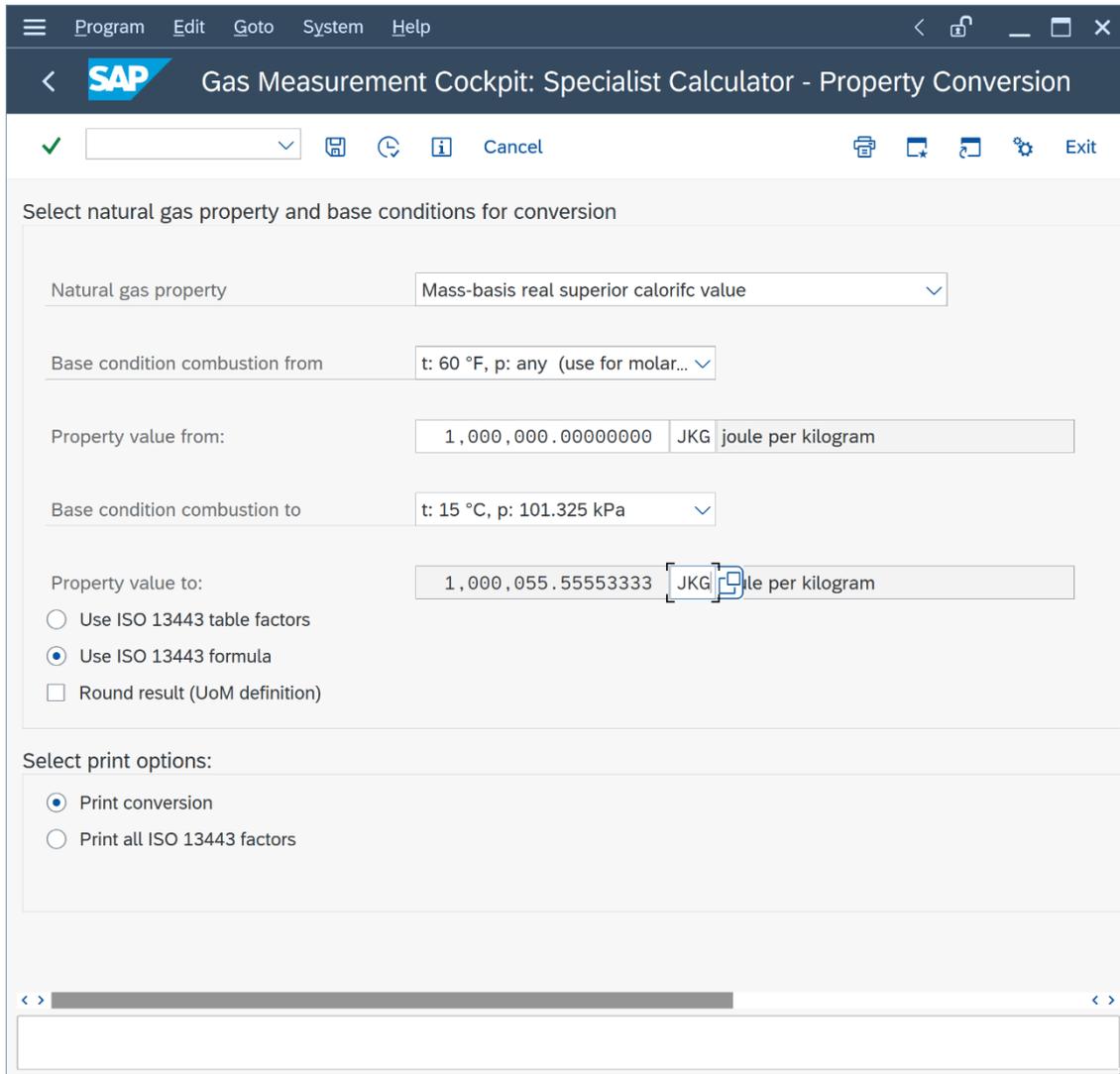
Property value to: 1.00005556 JKG joule per kilogram

Use ISO 13443 table factors  
 Use ISO 13443 formula  
 Round result (UoM definition)

Select print options:

Print conversion  
 Print all ISO 13443 factors

The conversion of a theoretical mass-basis real superior calorific value of 1 000 000.0 Joule per kilogram leads to a result of 1,000,055.55553333 Joule per kilogram (rounded to 8 display decimals), revealing the exact floating-point result of  $1.000\ 055\ 555\ 5\bar{3}$

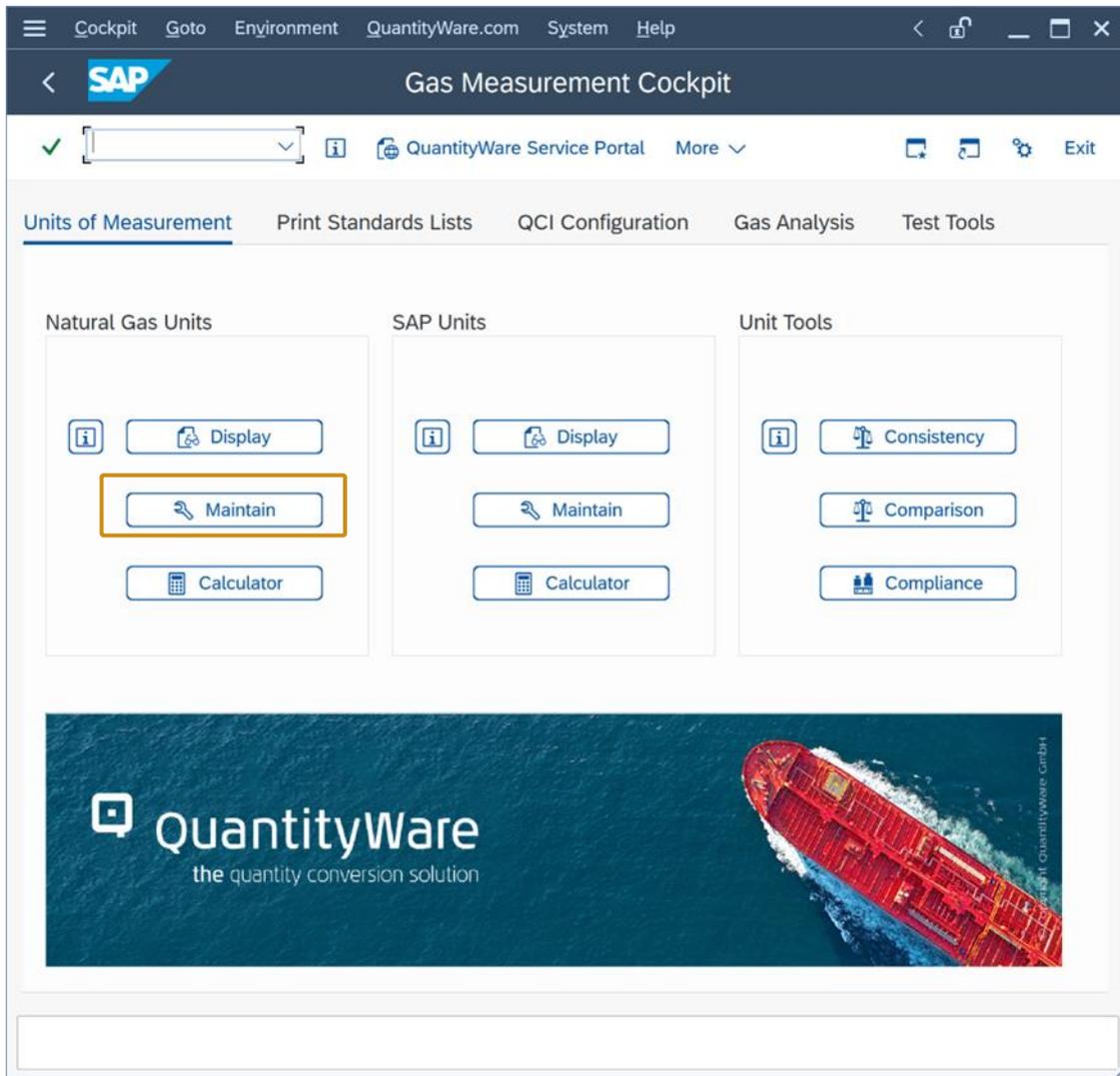


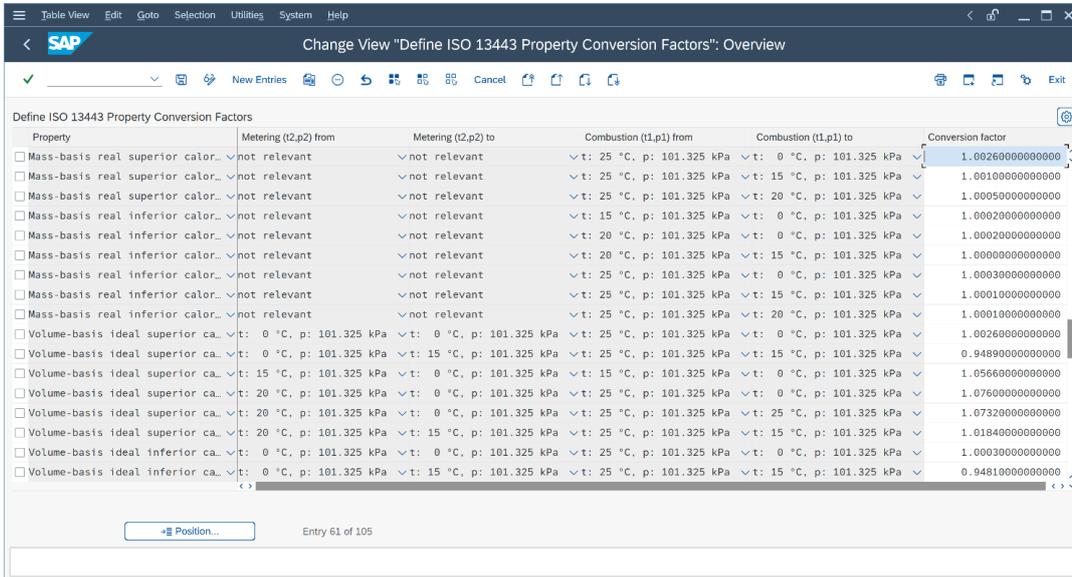
The screenshot shows the SAP 'Gas Measurement Cockpit: Specialist Calculator - Property Conversion' dialog box. The interface includes a menu bar (Program, Edit, Goto, System, Help) and standard window controls. The main area is titled 'Select natural gas property and base conditions for conversion'. It contains several input fields and options:

- Natural gas property:** A dropdown menu set to 'Mass-basis real superior calorific value'.
- Base condition combustion from:** A dropdown menu set to 't: 60 °F, p: any (use for molar...)'.
- Property value from:** A text input field containing '1,000,000.00000000', a unit dropdown set to 'JKG', and a label 'joule per kilogram'.
- Base condition combustion to:** A dropdown menu set to 't: 15 °C, p: 101.325 kPa'.
- Property value to:** A text input field containing '1,000,055.55553333', a unit dropdown set to 'JKG', and a label 'joule per kilogram'. A red box highlights the unit dropdown and label.
- Options:** Three radio buttons: 'Use ISO 13443 table factors' (unselected), 'Use ISO 13443 formula' (selected), and 'Round result (UoM definition)' (unselected).
- Print options:** Two radio buttons: 'Print conversion' (selected) and 'Print all ISO 13443 factors' (unselected).

At the bottom, there is a scrollable area with a horizontal scrollbar and a large empty text box for output.

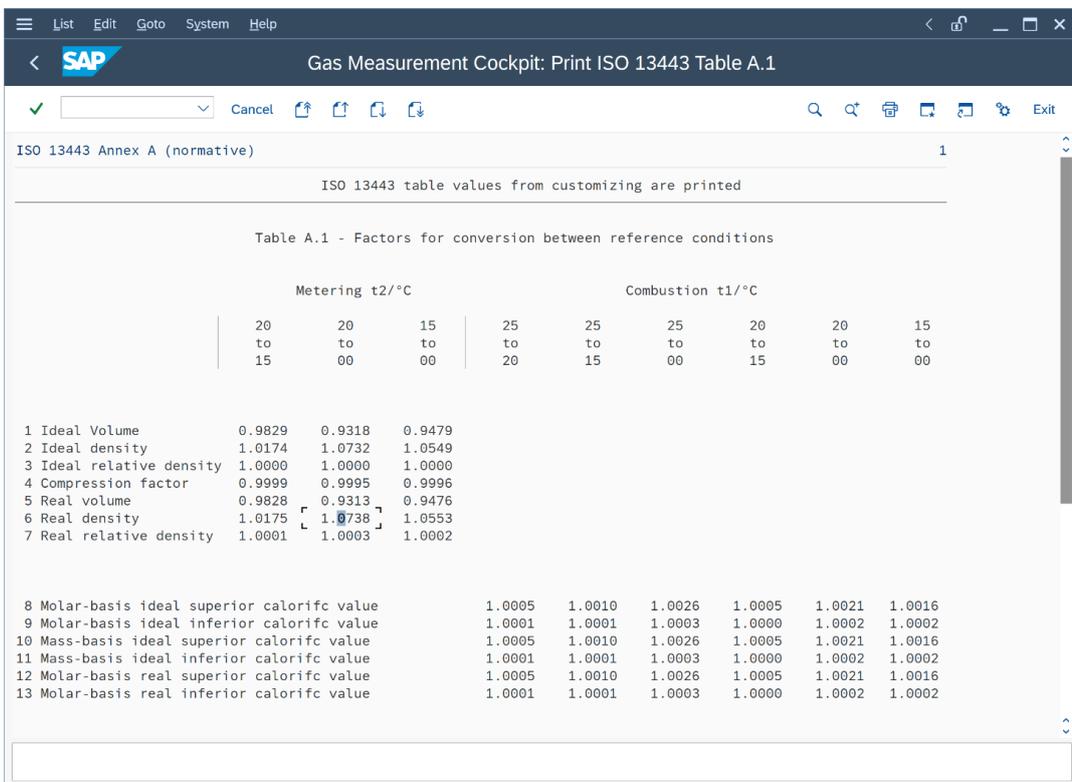
You access the ISO 13443 Annex A normative table factors via push button "Maintain" in the "Units of Measurement -> Natural Gas Units" tab strip:





Property	Metering (t2,p2) from	Metering (t2,p2) to	Combustion (t1,p1) from	Combustion (t1,p1) to	Conversion factor
<input type="checkbox"/> Mass-basis real superior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.00260000000000
<input type="checkbox"/> Mass-basis real superior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	1.00100000000000
<input type="checkbox"/> Mass-basis real superior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 20 °C, p: 101.325 kPa	1.00050000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 15 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.00020000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 20 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.00020000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 20 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	1.00000000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.00030000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	1.00010000000000
<input type="checkbox"/> Mass-basis real inferior calor...	not relevant	not relevant	t: 25 °C, p: 101.325 kPa	t: 20 °C, p: 101.325 kPa	1.00010000000000
<input type="checkbox"/> Volume-basis ideal superior ca...	t: 0 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	0.94890000000000
<input type="checkbox"/> Volume-basis ideal superior ca...	t: 15 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.05660000000000
<input type="checkbox"/> Volume-basis ideal superior ca...	t: 20 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.07600000000000
<input type="checkbox"/> Volume-basis ideal superior ca...	t: 20 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	1.07320000000000
<input type="checkbox"/> Volume-basis ideal superior ca...	t: 20 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	1.01840000000000
<input type="checkbox"/> Volume-basis ideal inferior ca...	t: 0 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 0 °C, p: 101.325 kPa	1.00030000000000
<input type="checkbox"/> Volume-basis ideal inferior ca...	t: 0 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	t: 25 °C, p: 101.325 kPa	t: 15 °C, p: 101.325 kPa	0.94810000000000

Printing of these factors is also available via the ISO 13443 calculator (Option "Print all ISO 13443 Factors -> F8"):



ISO 13443 Annex A (normative) 1

ISO 13443 table values from customizing are printed

Table A.1 - Factors for conversion between reference conditions

	Metering t2/°C			Combustion t1/°C					
	20 to 15	20 to 00	15 to 00	25 to 20	25 to 15	25 to 00	20 to 15	20 to 00	15 to 00
1 Ideal Volume	0.9829	0.9318	0.9479						
2 Ideal density	1.0174	1.0732	1.0549						
3 Ideal relative density	1.0000	1.0000	1.0000						
4 Compression factor	0.9999	0.9995	0.9996						
5 Real volume	0.9828	0.9313	0.9476						
6 Real density	1.0175	1.0738	1.0553						
7 Real relative density	1.0001	1.0003	1.0002						
8 Molar-basis ideal superior calorific value				1.0005	1.0010	1.0026	1.0005	1.0021	1.0016
9 Molar-basis ideal inferior calorific value				1.0001	1.0001	1.0003	1.0000	1.0002	1.0002
10 Mass-basis ideal superior calorific value				1.0005	1.0010	1.0026	1.0005	1.0021	1.0016
11 Mass-basis ideal inferior calorific value				1.0001	1.0001	1.0003	1.0000	1.0002	1.0002
12 Molar-basis real superior calorific value				1.0005	1.0010	1.0026	1.0005	1.0021	1.0016
13 Molar-basis real inferior calorific value				1.0001	1.0001	1.0003	1.0000	1.0002	1.0002

Thus, full transparency of the ISO 13443 conversion options and configurations is available via the Gas Measurement Cockpit.

## Legal Notices

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