# 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

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

| 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 |

# Contents

1. Question .......... 4

2. Answer .......... 5

Appendix A. QuantityWare Calculation Transparency .......... 8

# 1. Question

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(ISO) to a mass-basis ideal or real superior calorific value H ($T_1$, $p_1$)] is given as:

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

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 °F "=" 288.7056 K and setting HS ($T_1$, $p_1$) = 1

The SAP ERP system with QuantityWare BCS installed calculates: **1.000 055 555 5̄3.**

How can this be explained?

# 2. Answer

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 / °F + **459.67**) / **1.8** **(1)**

If you enter 60 °F, the result is 288.705 555 555 555 555 555 555 555 555 56 K when using the widely available MS Desktop Calculator, although the "truly" accurate result is: $288.70\overline{5}$[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 $1.000\ 0\overline{5}$ as the "most accurate" ISO 13443 value, and not $1.000\ 055\ 555\ 5\overline{3}$ 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 $288.70555\ 5\overline{3}$ 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)**.

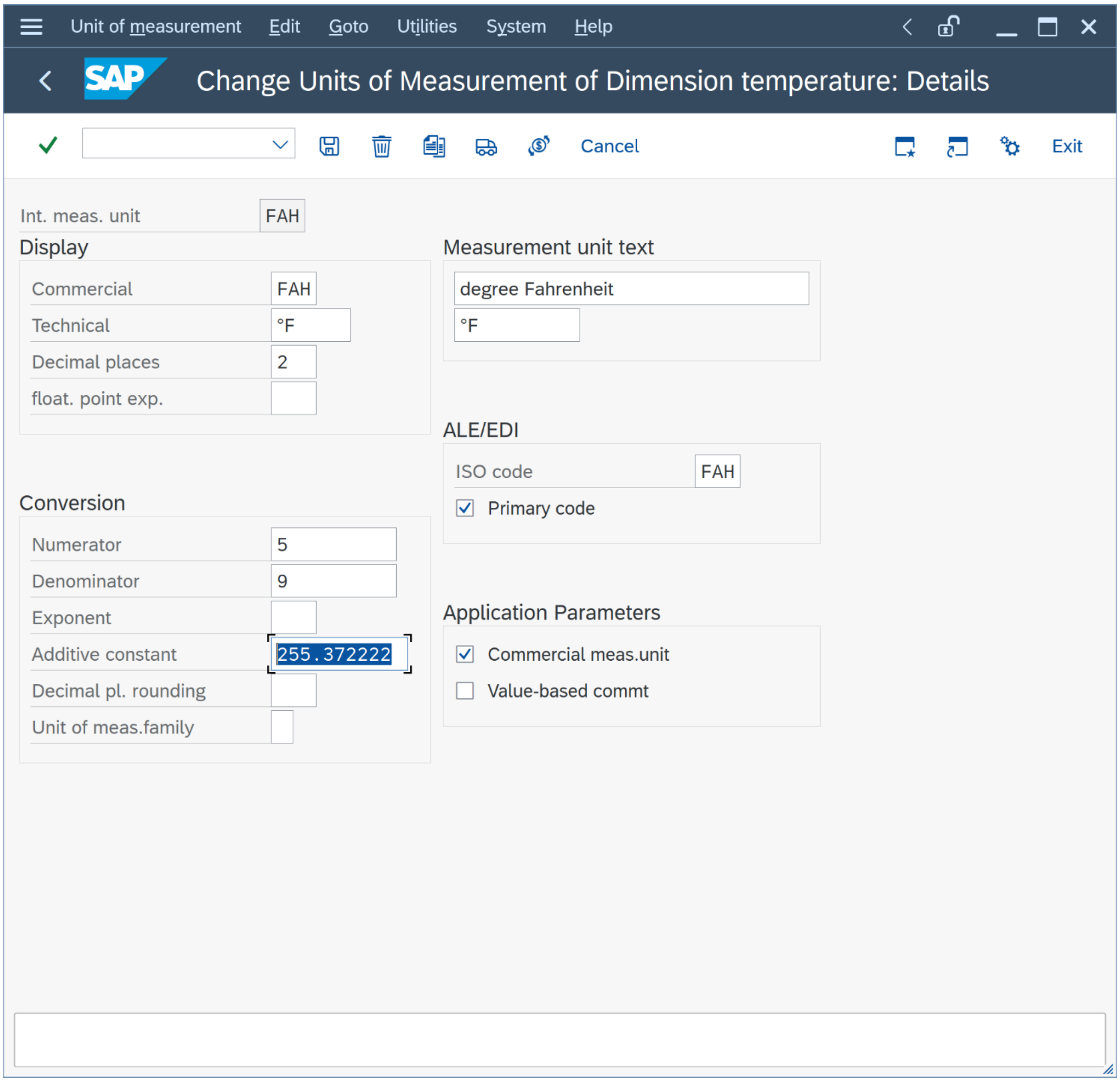
[1] Repeating Decimals notation is not internationally standardized. QuantityWare uses the U.S. "vinculum" notation to denote the repetend e.g., $0.\overline{3}$ to represent 0.3333... or $0.\overline{54}$ to represent 0.54545454... etc.

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

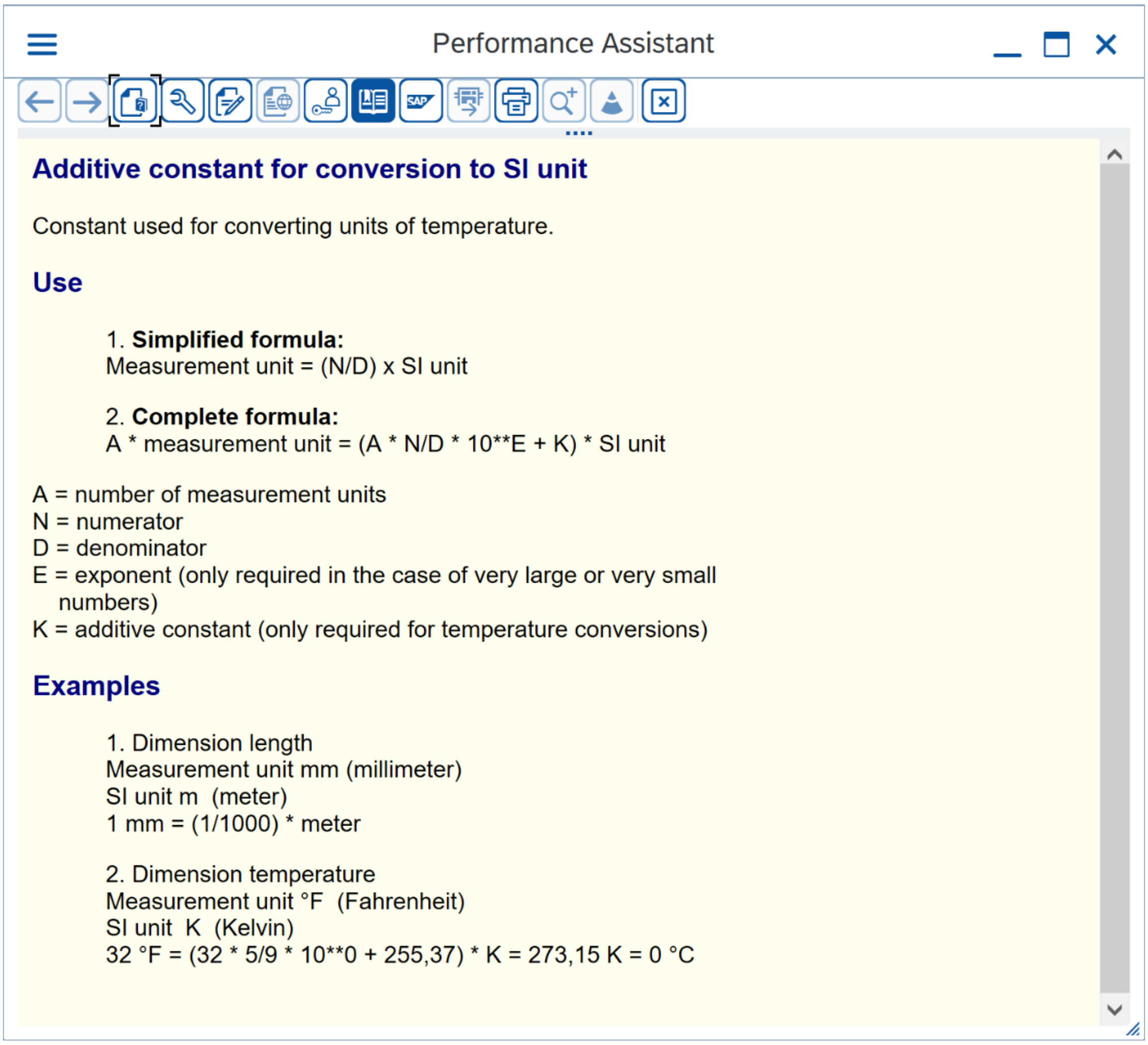
$$T / K = t / °F / \mathbf{1.8} \quad \mathbf{+ 459.67 / 1.8} \qquad \mathbf{(2)} \qquad \Leftrightarrow$$

$$T / K = t / °F / \mathbf{1.8} \quad \mathbf{+ 255.37\overline{2}} \qquad \mathbf{(3)}$$

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




The Help information specifies only 2 decimals:



Performance Assistant

**Additive constant for conversion to SI unit**

Constant used for converting units of temperature.

**Use**

1. **Simplified formula:**
Measurement unit = (N/D) x SI unit

2. **Complete formula:**
A * measurement unit = (A * N/D * 10**E + K) * SI unit

A = number of measurement units
N = numerator
D = denominator
E = exponent (only required in the case of very large or very small numbers)
K = additive constant (only required for temperature conversions)

**Examples**

1. Dimension length
Measurement unit mm (millimeter)
SI unit m (meter)
1 mm = (1/1000) * meter

2. Dimension temperature
Measurement unit °F (Fahrenheit)
SI unit K (Kelvin)
32 °F = (32 * 5/9 * 10**0 + 255,37) * K = 273,15 K = 0 °C

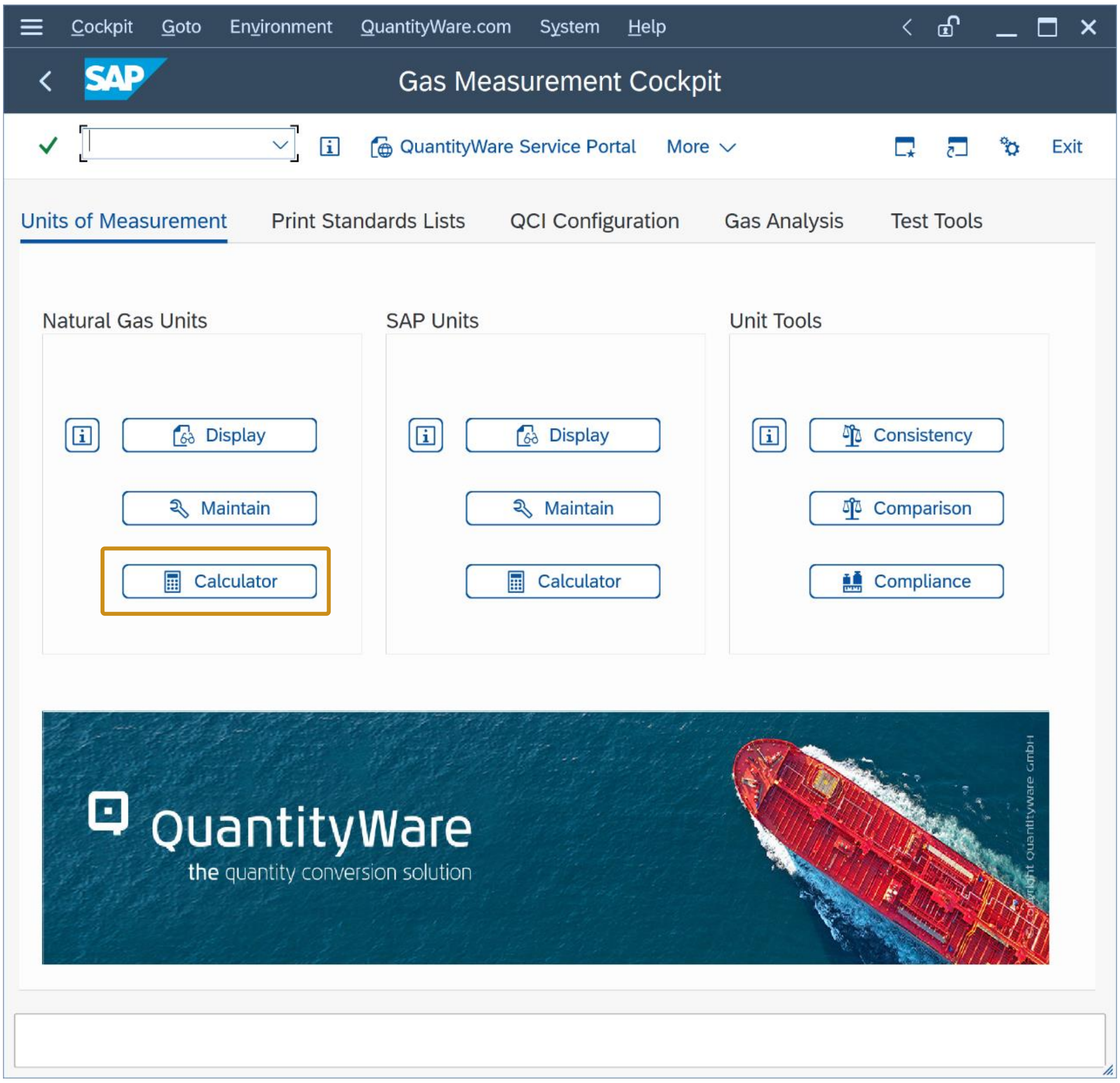
If one calculates the ratio of the “most accurate” ISO 13443 value 1.000 0¯5 and the “most accurate” SAP ISO 13443 value 1.000 055 555 5¯3, one obtains a ratio of 1,000 000 000 022 220 987 723 398 055 390 8 (MS Desktop Calculator) i.e., a deviation at the 11th decimal. Thus, quantity values exceeding 99 billion (in any UoM) would show a noticeable difference – however quantities exceeding 99 billion are not “sensible” in business process terms, so noticeable differences are usually never encountered in live business transactions.

On the other hand, the fact that business contracts typically specify a “rounded ISO 13443 factor” is of benefit in approaching a well-defined implementation guideline, which automatically overcomes the two weaknesses or inconsistencies, outlined above.

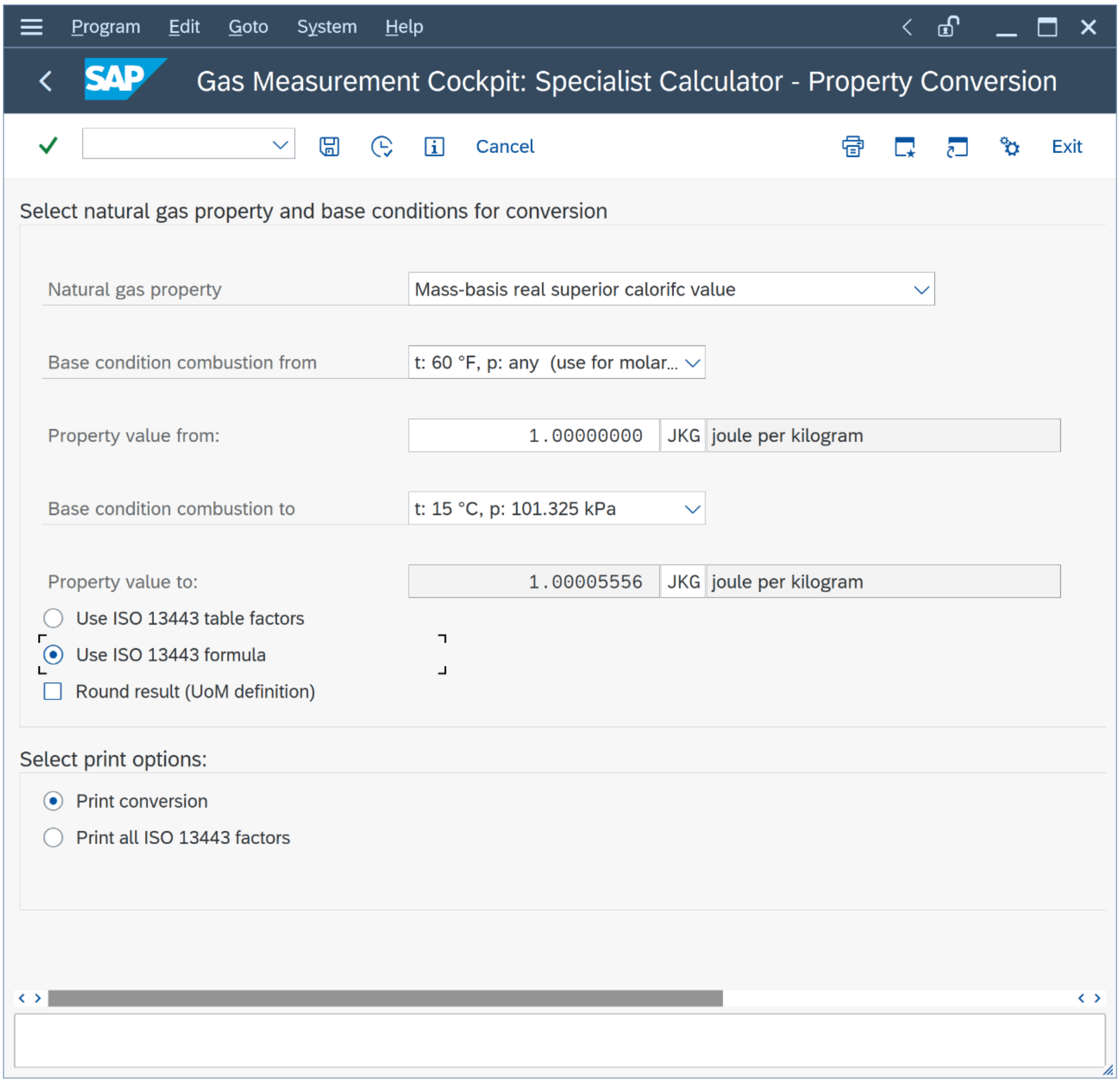
Alternatively, when using the ASTM D1250-04 (API MPMS Chapter 11.1 – 2004) for comparison, ISO could clearly specify the use of 64-bit floating point accuracy values for all intermediate calculations; this however would not eliminate the SAP ERP transaction CUNI “inconsistency”.

# Appendix A. QuantityWare Calculation Transparency

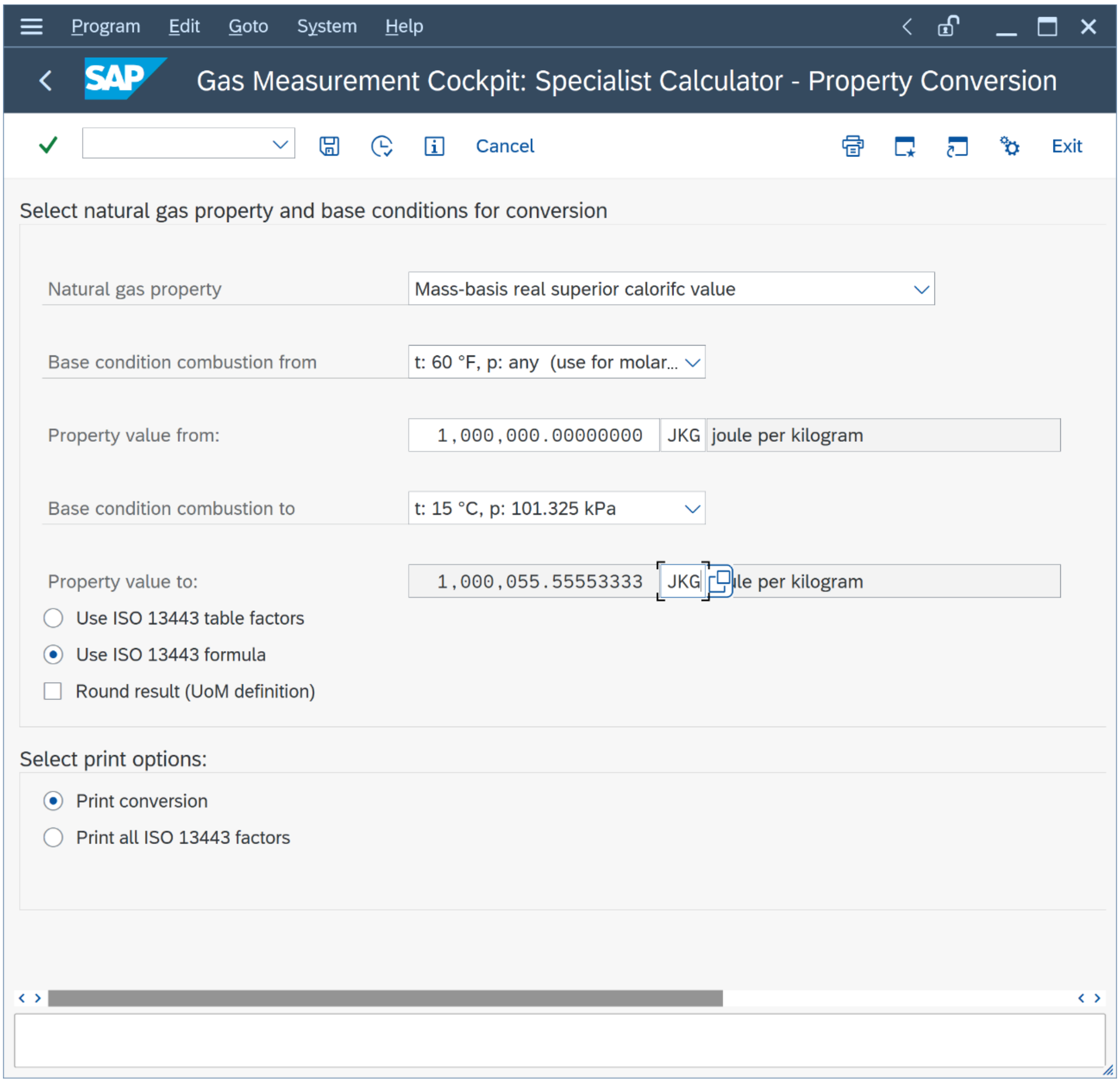
In the Gas Measurement Cockpit, you access the ISO 13443 Calculator via push button “Calculator” in the “Units of Measurement -> Natural Gas Units” tab strip:



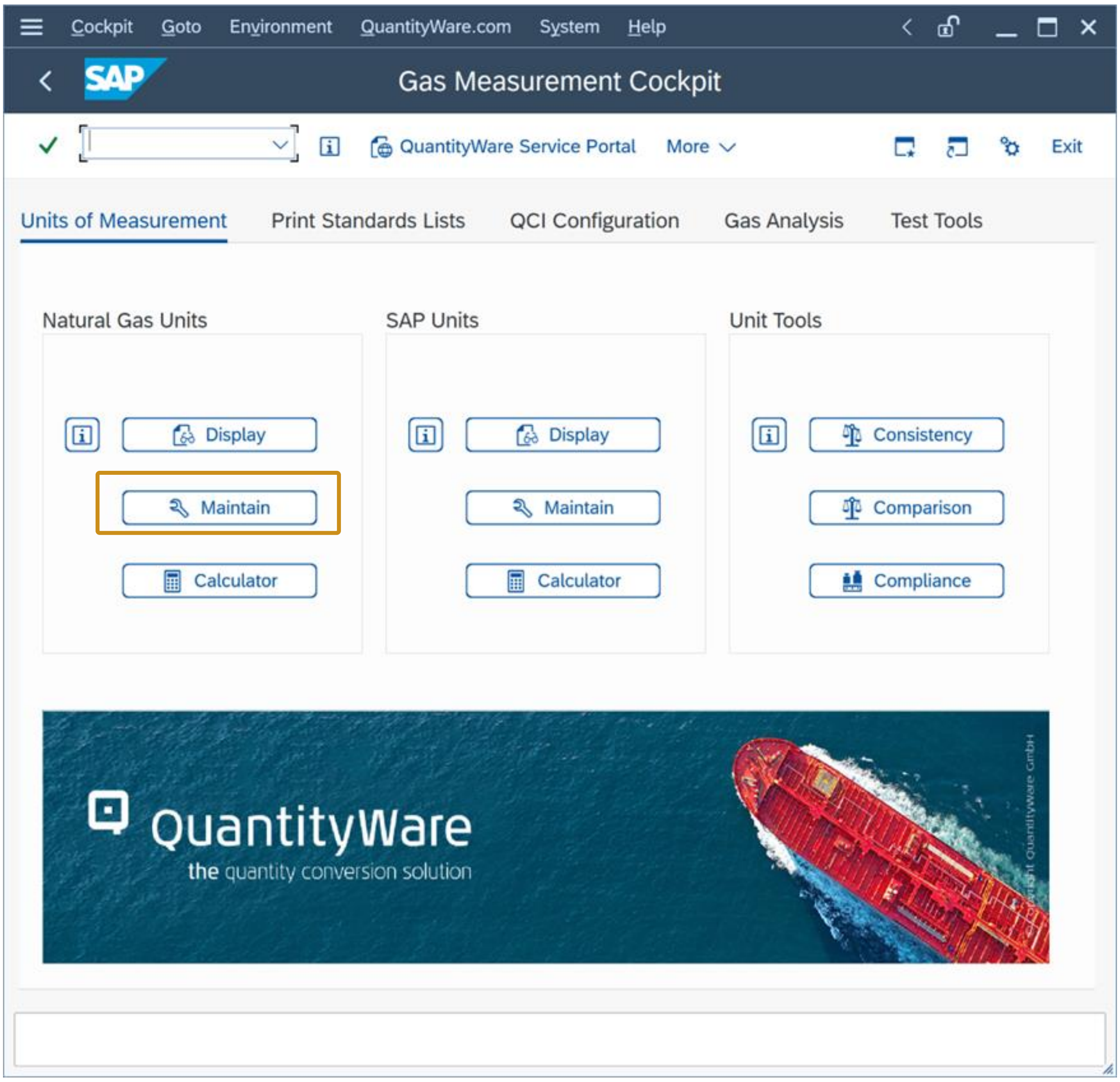
The conversion of a theoretical mass-basis real superior calorific value of 1.0 Joule per kilogram leads to a result of 1.000 055 560 Joule per kilogram (rounded to 8 display decimals).

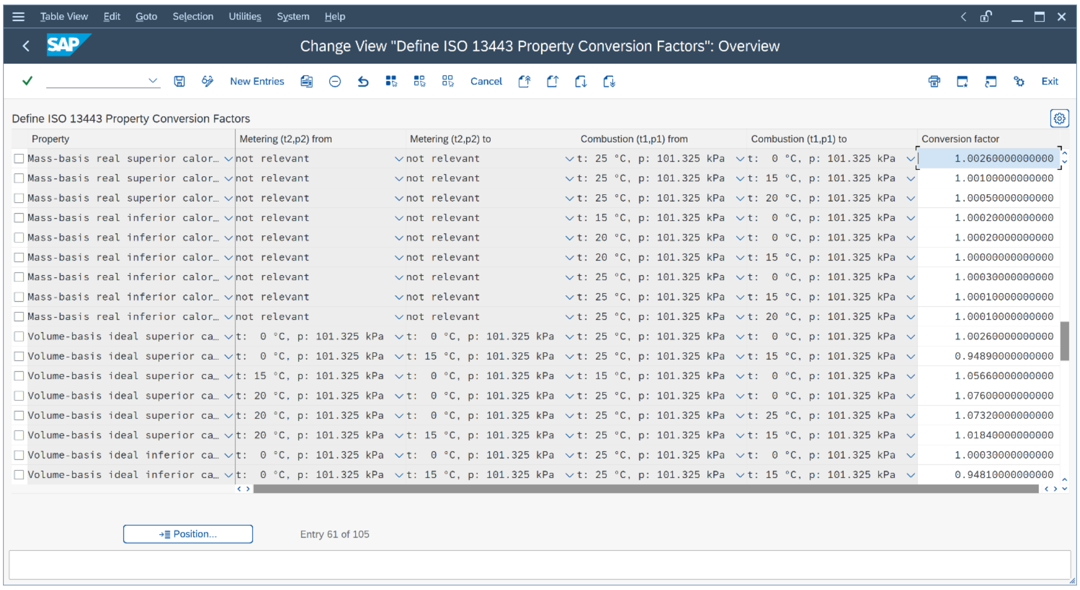


The conversion of a theoretical mass-basis real superior calorific value of 1 000 000.0 Joule per kilogram leads to a result of 1,000,055.55553333 Joule per kilogram (rounded to 8 display decimals), revealing the exact floating-point result of 1.000 055 555 5¯3

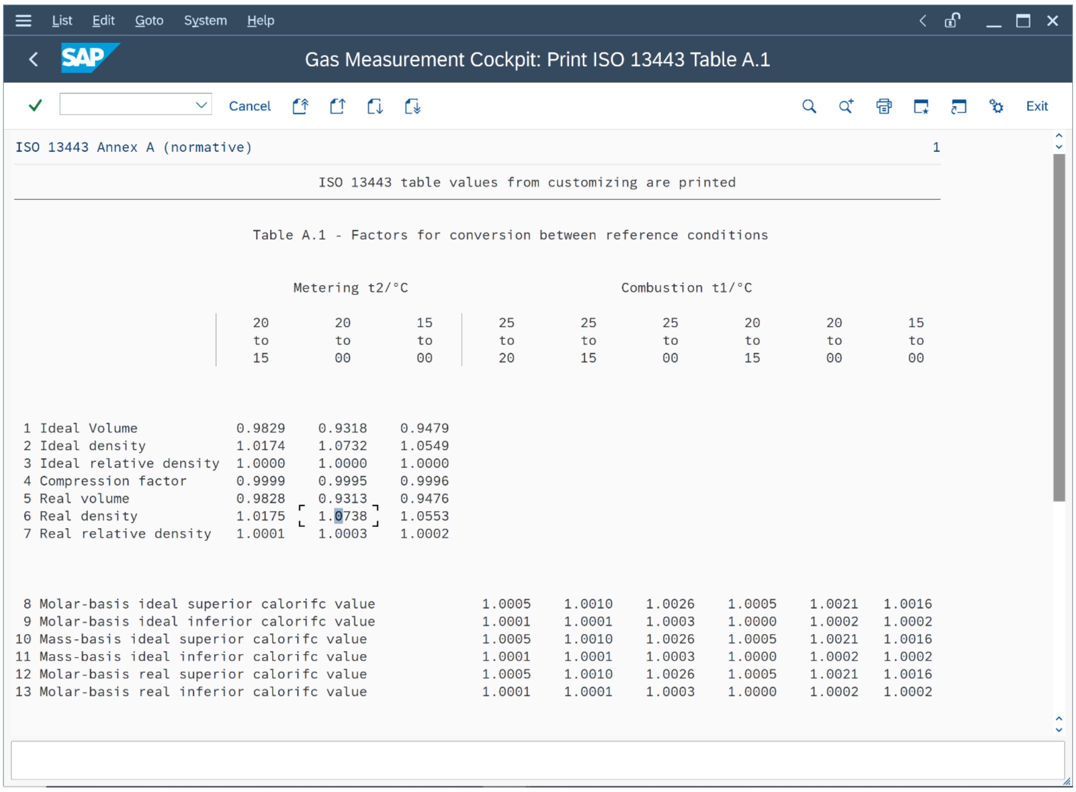


You access the ISO 13443 Annex A normative table factors via push button “Maintain” in the “Units of Measurement -> Natural Gas Units” tab strip:






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




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

# Legal Notices