QuantityWare Working Paper

LPG Vapor Space Calculations

Advanced LPG stock and product transfer control using QuantityWare BCP & BCG conversion groups with QuantityWare Working Paper Tank Management.

Version History

Version	Date	Description
00	2009-12-21	Initial Version
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1. Introduction

Liquefied petroleum gas (LPG) is a major global energy source. Products such as commercial propane, commercial butane and varying mixtures of propane, butane, propylene, butylene etc. are traded all over the world to support the energy needs of industrial and private consumers.

QuantityWare BCP and BCG are the only commercial solutions which provide quantity conversions for all LPG products with the QuantityWare Working Paper solution. One important aspect of LPG quantity calculations is that LPG products show a high vapor pressure at room temperature. Thus, LPG products need to be stored in closed containers (closed (spherical) tanks, trucks, pipelines, cylinders, etc.) to avoid rapid and massive evaporation losses.

Commonly, storage vapor pressures range between approx. 100 to 1 000 kPa (15 to 150 lbf/in^2), depending on the vapor and liquid temperature and LPG composition. Within a closed container, LPG is therefore present as liquid to a certain filling level, while the remaining space in the tank is filled with LPG vapor.

In this working paper, we briefly describe the calculation steps required to calculate the total product mass of an LPG product (contained in the vapor and liquid LPG phase).

Based on such calculations, stock control measurements as well as opening and closing tank dips in large LPG tanks can be made, allowing a precise determination of product quantities (e.g., transfer quantities).

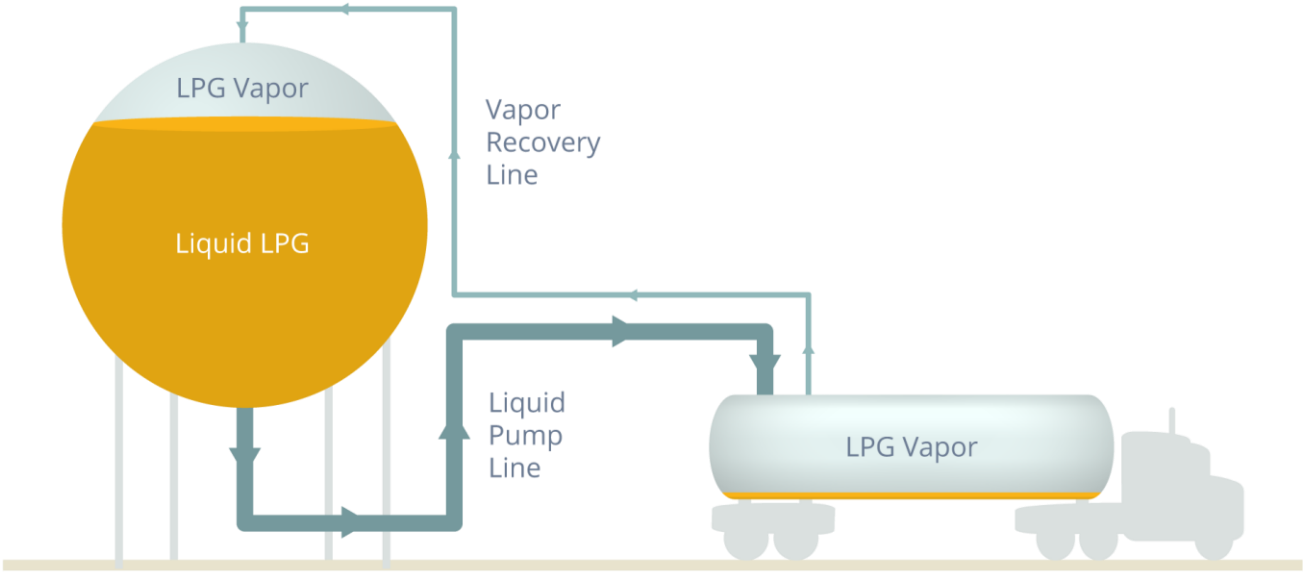
We also show how QuantityWare BCP, and QuantityWare BCG conversion groups can be configured to calculate all required data which is required e.g. within QuantityWare Working Paper tank management processes.

2. LPG Tank Measurements – Stock Control

As an example, let's look at a situation in a refinery that distributes LPG via trucks to its customers.

LPG is stored in closed spherical tanks. For a certain tank, a movement is planned of 10 000 gallons of LPG (e.g., commercial propane) into an LPG truck.

Before the movement starts, the situation is described in the picture down below:



Closed LPG tank with pump, liquid and vapor phase

LPG Truck

The closed LPG tank contains liquid commercial propane to a certain filling level (indicated by the horizontal line) and the remaining tank volume is filled with LPG vapor. The LPG truck contains a few gallons of liquid LPG, and the remaining tank volume is filled with LPG vapor.

The loading process is started, and the truck is filled via a liquid pump line, LPG vapor is recovered from the truck and flows back into the LPG tank (not necessarily via a separate line - modern terminal loading systems do not require such a line).

Before the loading starts, the following parameters are measured:

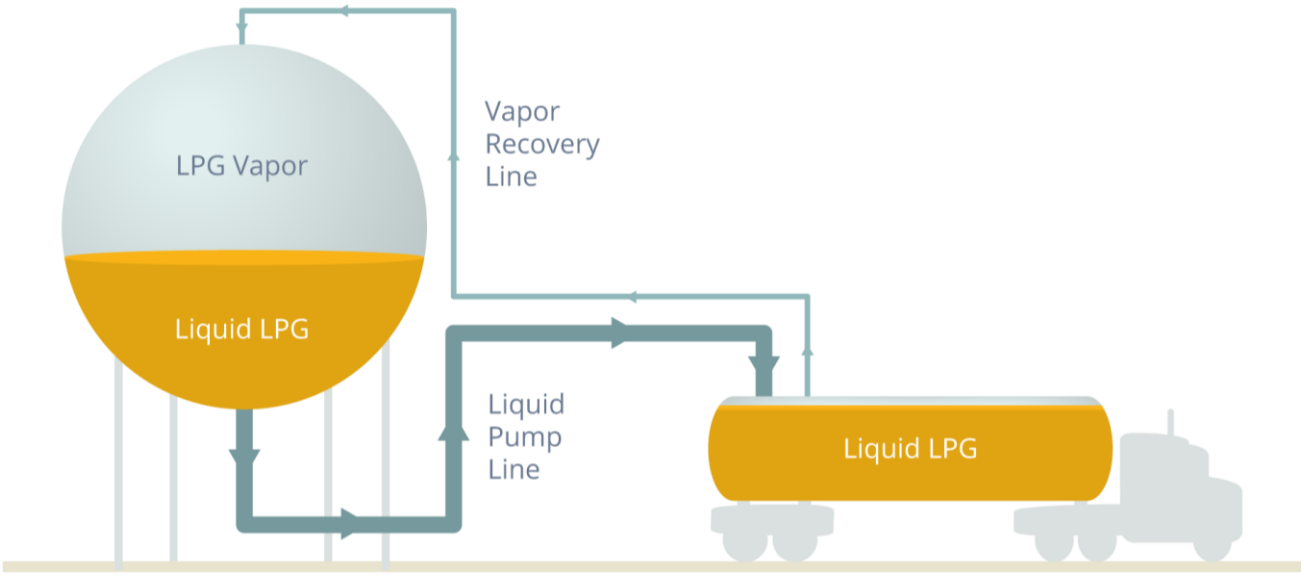
- The liquid tank levels
- The observed liquid LPG temperature
- The vapor pressure and vapor temperature of LPG gas within the tank.

An LPG sample has been analyzed by a laboratory to determine the LPG composition, density, and molar mass.

The tank capacity is also known.

With this data, an opening dip measurement can be taken and calculation of the liquid volume at observed and standard reference temperature (e.g., 60 °F), as well as the total mass of the vapor and liquid can be made. The vapor calculation basically utilizes the ideal gas equation and is described in detail in various LPG measurement standards, e.g., DIN 51650 or ISO 6578, which are the basis for BCP and BCG implementations.

After truck loading is complete, we observe the following situation:



Closed LPG tank with pump, liquid and vapor phase

LPG Truck

Within the tank, the liquid level has dropped, and the truck has been loaded (within allowed maximum loading limits) with LPG.

A second measurement (closing dip), determining again the data described above, is made.

Determination of the total LPG product that has been transferred is now relatively simple.

Subtract the opening and closing quantity results to obtain the transferred mass and liquid volume. Here, we assume that the filling and recovery line status before and after loading is the same.

A second parallel measurement can also be made - the truck can be weighed on a weigh bridge before the start of loading and after loading completion, to obtain an independent measurement of the LPG mass transferred.

It is important to note that for closed LPG containers, the air buoyancy of an empty container tare measurement and the filled container gross measurement is almost identical, thus the air buoyancy correction can be neglected.

Vapor space calculations do update the mass and energy values (in any UoM), but **not the volume** quantities, which always represent the liquid part of the product (ISO 6578 definition, business practice) - Thus, for your LPG products, you must use a mass or energy UoM in the SAP material master if vapor space calculations are relevant, such that valuation calculations within SAP ERP processes consider the total product quantity. Read the LPG Volume Vapor FAQ for additional details.

Vapor space calculations are defined within dedicated vapor space calculation models. Thus, all LPG/NGL CTPL standards (e.g., GPA Standard 8217 or ISO 6578) may be combined with an LPG vapor space calculation model. The BCP and BCG template contains examples for various combinations.

3. BCP & BCG Conversion Group Calculations

SAP Tank Management supports the capture of several tank dip types. Opening and closing dips can be captured in the ERP system within the Tank Management transactions.

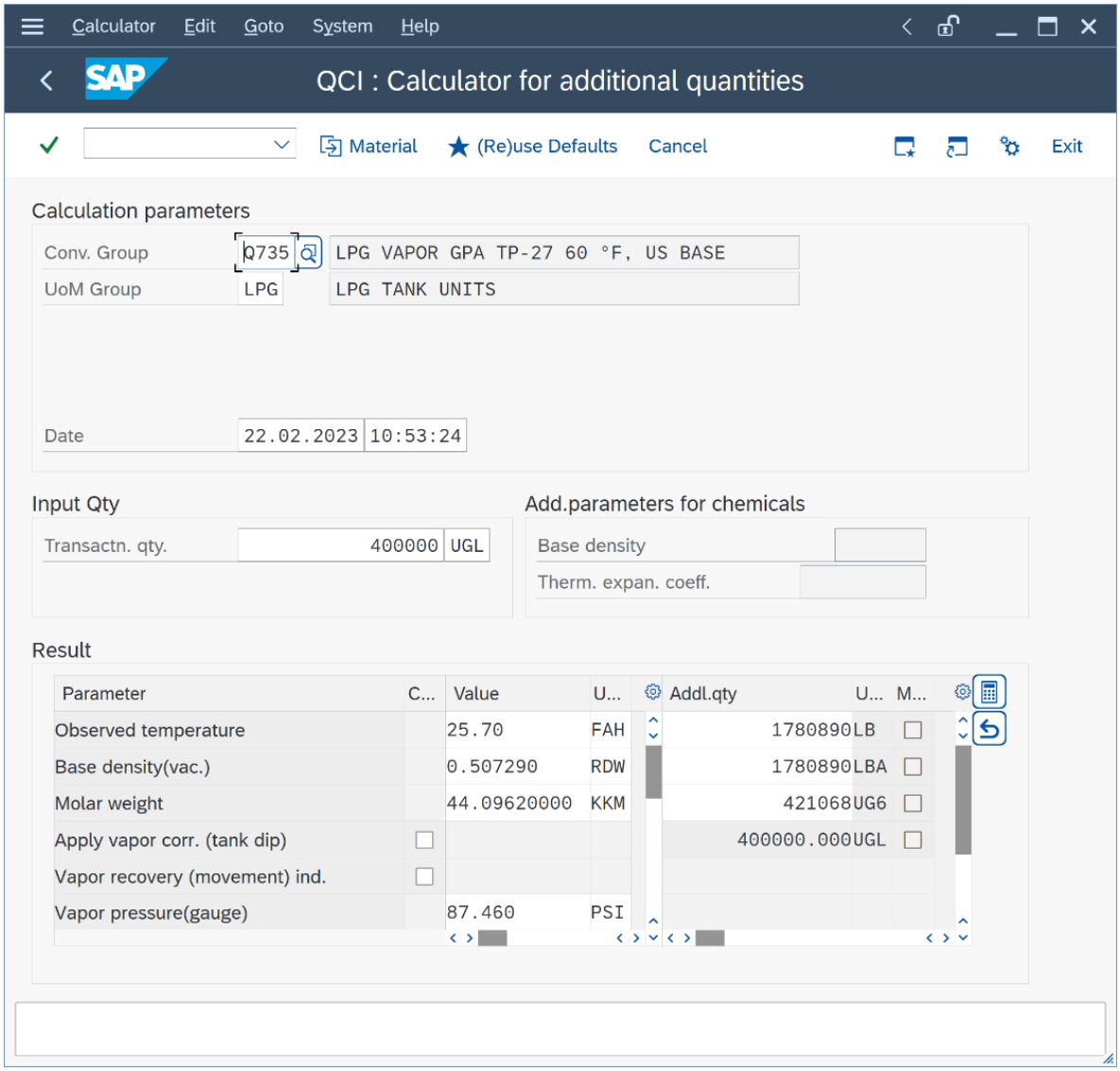
To directly post goods movements for a transfer posting, customers must build their own logic within an SAP Tank Management Business Add In (BAdI).

If you utilize a QuantityWare BCP or BCG LPG vapor space conversion group, you simply take the relevant opening and closing dips and calculate the difference quantities for goods movement posting, which you then pass to the standard SAP function module (e.g., BAPI “GoodsMovementOil”).

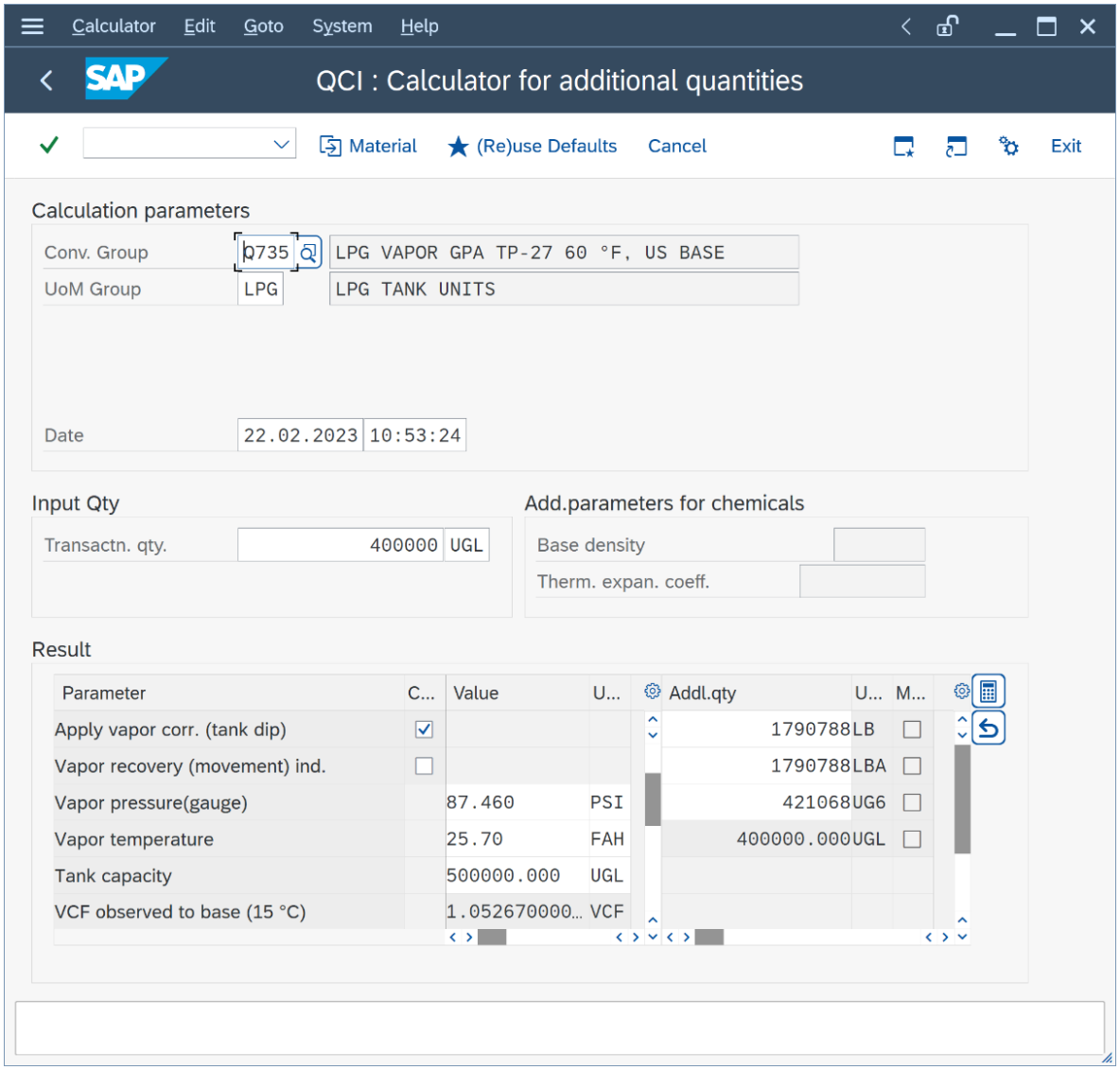
Read the SAP Tank Management FAQ for additional details.

Example:

Our LPG tank has a total capacity of 500 000 gallons. We take an opening dip and measure 400 000 gallons of liquid, as well as the observed temperature, vapor temperature and pressure:



Without the vapor corr. (tank dip) indicator, we calculate a total mass of 1 780 890 pounds (rounded). We need to set the indicator to include the vapor mass:


Calculator Edit Goto System Help
QCI : Calculator for additional quantities
Material
(Re)use Defaults
Cancel
Exit
Calculation parameters
Conv. Group
Q735
LPG VAPOR GPA TP-27 60 °F, US BASE
UoM Group
LPG
LPG TANK UNITS
Date
22.02.2023
10:53:24
Input Qty
Transactn. qty.
400000
UGL
Add.parameters for chemicals
Base density
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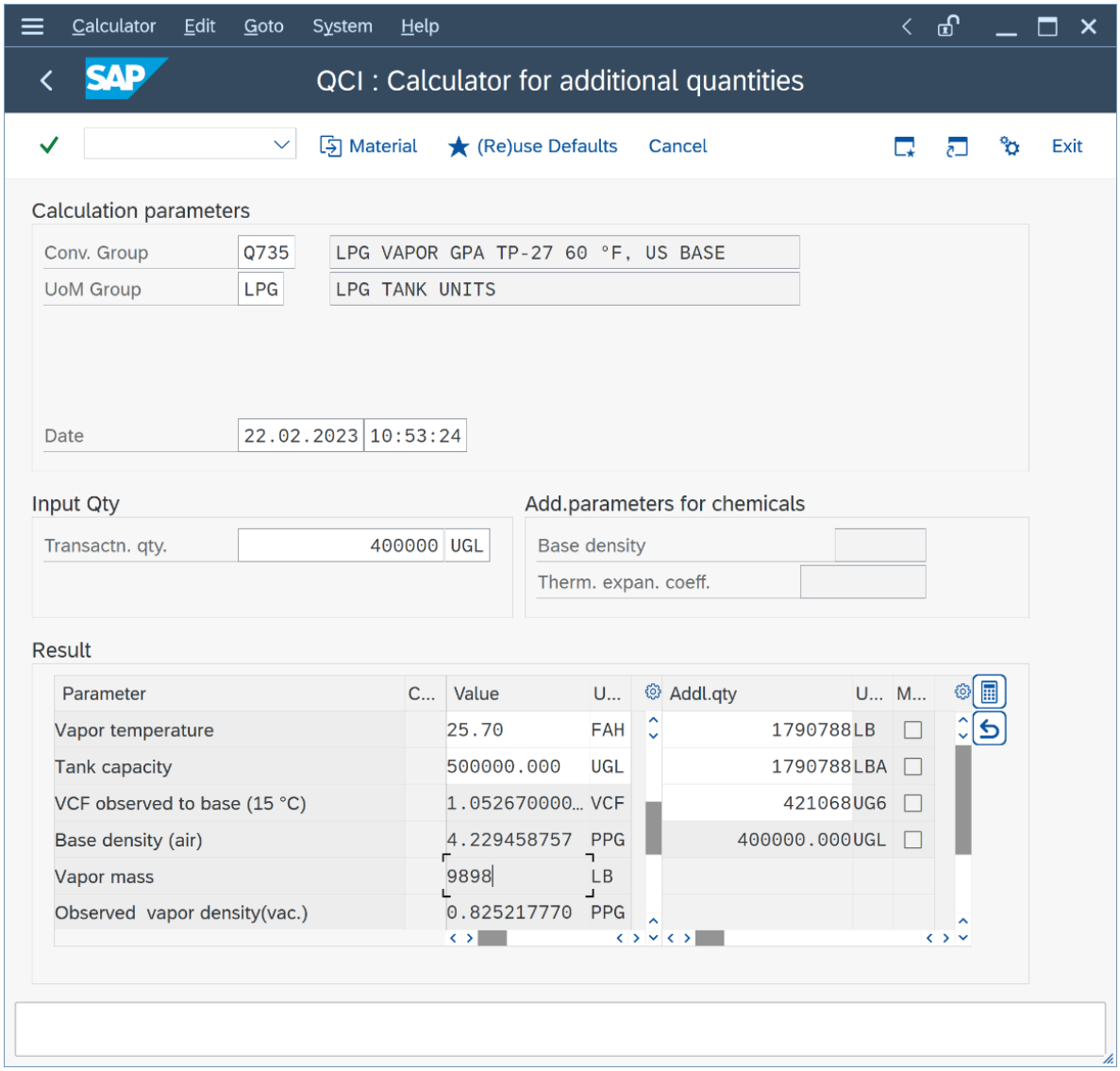
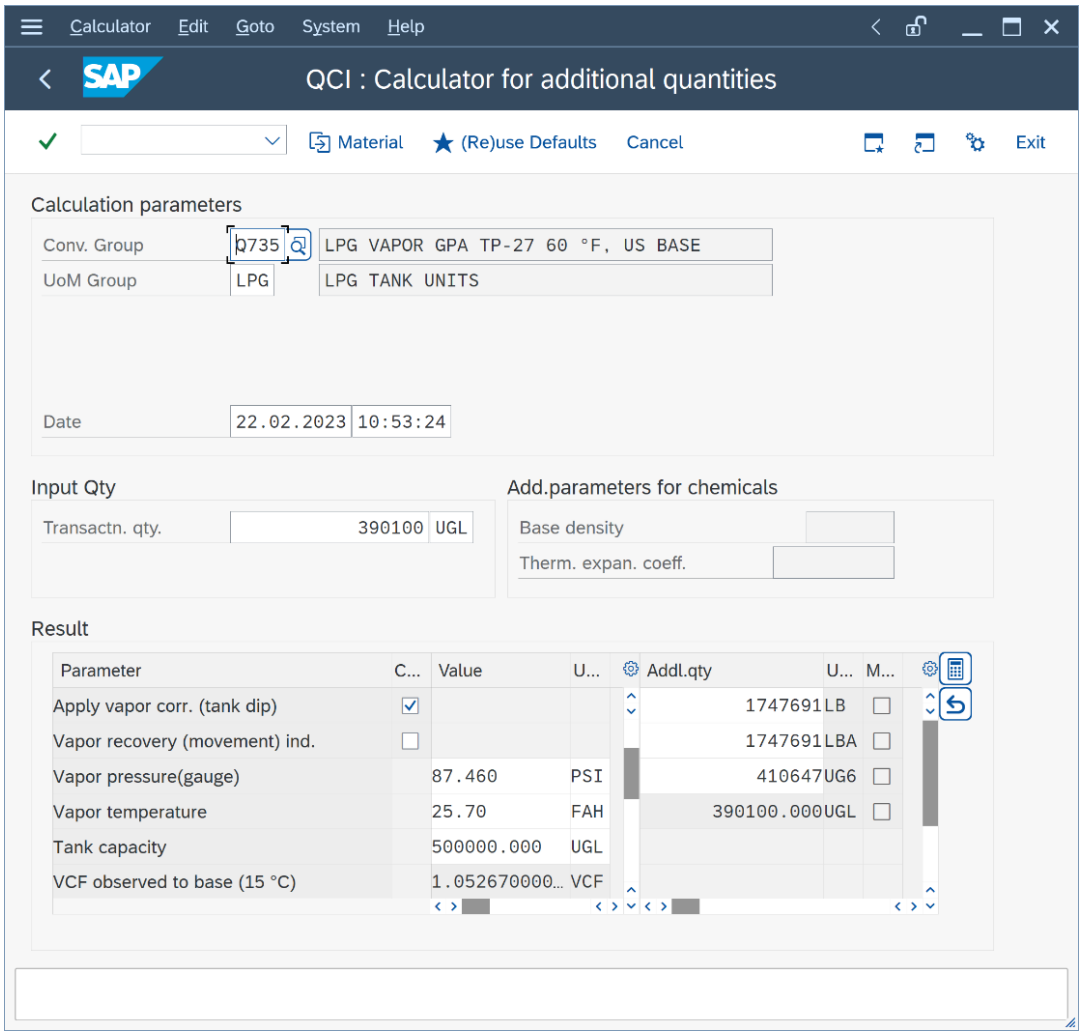
Result
Parameter
C...
Value
U...
Addl.qty
U...
M...
Apply vapor corr. (tank dip)
1790788
LB
Vapor recovery (movement) ind.
1790788
LBA
Vapor pressure(gauge)
87.460
PSI
421068
UG6
Vapor temperature
25.70
FAH
400000.000
UGL
Tank capacity
500000.000
UGL
VCF observed to base (15 °C)
1.052670000...
VCF

Now the mass is 1 790 788 pounds, which includes the vapor mass. The vapor mass is displayed as well as the observed vapor density, so that terminal operators can always reproduce the result:



After truck loading, the closing dip measurement is taken; for the sake of simplicity, we assume that the vapor temperature and pressure temperature did not change and thus enter the same final vapor pressure and vapor temperature values:



These results are posted with the tank dips, if such a conversion group is assigned to the tank and product. By simply observing the difference for the gallon at 60 °F and pound values, we know how much LPG product we have loaded onto the truck and can post this data for the goods movement ticket.

If a customer does not use SAP Tank Management, it is still possible to post movement data which includes vapor corrections. For this scenario, as defined in standard ISO 6578, you enter the total liquid volume that has been transferred, the flowing liquid density and the closing dip vapor data. By setting the vapor recovery (movement) indicator instead of the tank dip vapor indicator, the QuantityWare MQCI then adjusts the mass as defined in ISO 6578, basically reducing the total mass by the mass that is contained in the displaced vapor volume of the liquid.

4. Conclusion

With QuantityWare BCP and BCG, vapor space calculations for LPG products can be easily integrated into your QuantityWare Working Paper logistics transactions. The LPG calculations that we described briefly in this working paper are available with QuantityWare BCS, also for LNG calculations.

Energy calculations for LPG based on ISO 6578 are also included in QuantityWare BCS.

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