GUIDANT

Electronic Preset Delivery System

# *Smith Meter® microLoad.net™*

## Calculations

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Bulletin TP06005

microLoad.net

### *Caution*

The default or operating values used in this manual and in the program of the microLoad.net are for factory testing only and should not be construed as default or operating values for your metering system. Each metering system is unique and each program parameter must be reviewed and programmed for that specific metering system application.

### *Disclaimer*

Guidant hereby disclaims any and all responsibility for damages, including but not limited to consequential damages, arising out of or related to the inputting of incorrect or improper program or default values entered in connection with the microLoad.net.

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## *Volume Calculations*

### *Volume Calculations for Indicated Volume*

$$\text{Indicated Volume} = \frac{\text{Input Pulses}}{\text{K Factor}}$$

### *Volume Calculations for Gross*

$$\text{Gross Volume} = \frac{\text{Meter Factor} \times \text{Input Pulses}}{\text{K Factor}}$$

### *Volume Calculations for Gross @ Standard Temperature (GST)*

$$\text{GST Volume} = \frac{\text{CTL} \times \text{Meter Factor} \times \text{Input Pulses}}{\text{K Factor}}$$

### *Volume Calculations for Gross Standard Volume (GSV)*

$$\text{GSV Volume} = \frac{\text{CTPL} \times \text{Meter Factor} \times \text{Input Pulses}}{\text{K Factor}}$$

## *Mass Calculations*

A.

$$\text{Mass} = \text{Gross Volume} \times \text{Observed Density}$$

or

$$\text{Mass} = \text{GSV} \times \text{Reference Density}$$

B. Mass calculation using reference density

1. Program entry conditions

    a. A non-zero reference density entry.

    b. Valid density units select entry.

    c. Valid entries for GST compensation.

    d. Mass units

2. Hardware conditions

    a. A temperature probe installed. *(**Note:** Maintenance temperature may be used instead of a temperature probe.)*

3. Definition

    With this method the reference density and GST volume are used to calculate the mass. Therefore, the reference density program code must contain a non-zero entry, temperature must be installed, and GST compensation must be available.

4. Calculation method

$$\text{Mass} = \text{GST Volume} \times \text{Reference Density}$$

C. Mass calculation using a Densitometer

1. Program entry conditions

    a. Valid density units select entry.

    b. Valid densitometer configuration entries.

    c. Mass units.

2. Hardware conditions

   a. A densitometer installed.

3. Definition

   This method uses the densitometer input as the line density for calculating mass totals.

4. Calculation method

$$\text{Mass} = \text{Gross Volume} \times \text{Observed Density}$$

***Density Calculation***

The density values derived from the API calculations are “in vacuo” values. If live density is used, the reference density calculated is “in vacuo.” Also, if a reference density for a fluid is entered into the AccuLoad (even tables), it should be an “in vacuo” value. If mass is calculated by the AccuLoad using the reference density and volume, the mass would also be “in vacuo.”

According to API ASTM D 1250-04, pure fluid densities used in the calibration of densitometers are based on “weight in vacuo” and the readings obtained from such calibrations are also “in vacuo” values. The standard also states that all densities used in the API standard are “in vacuo” values.

***Meter Factor Linearization Calculations***

The non-linearity of the meter calibration curve for each product can be approximated through use of a linearization method by entering meter factors at up to four different flow rates.

The meter factors used will be determined from a straight line interpolation of the meter factor and its associated flow rate.

Graphically, the linearization method used can be represented as a point slope function between points:

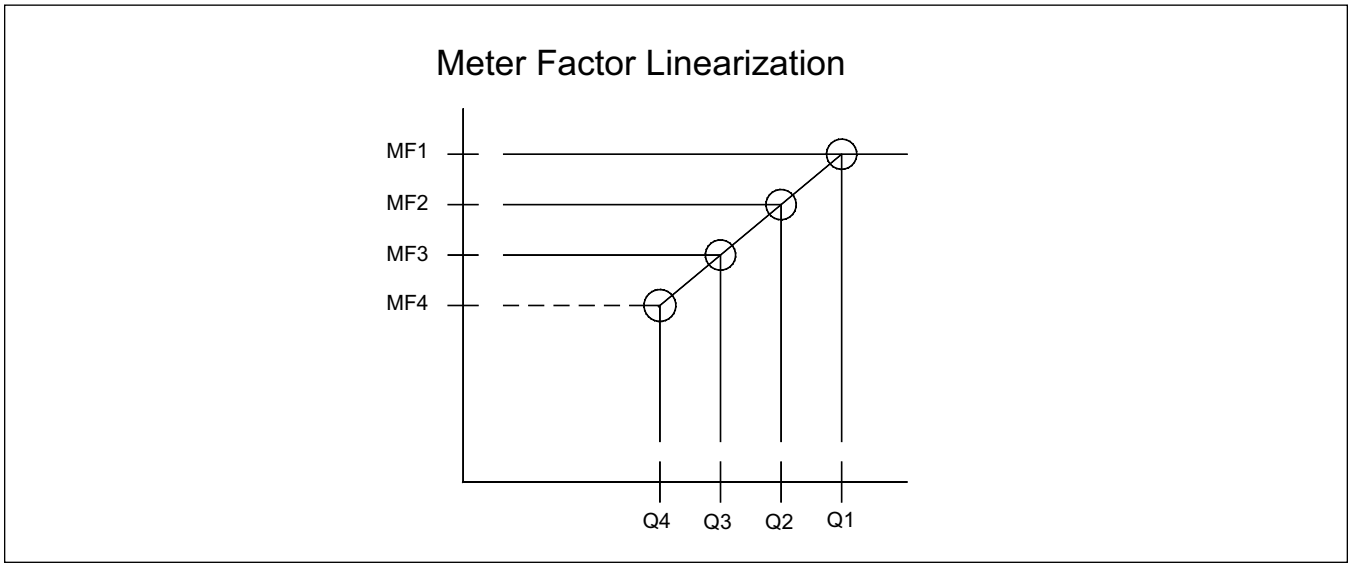


**Figure 1. Meter Factor vs. Flow Rate**

where: MF1, MF2, MF3, MF4 = meter factors 1, 2, 3, and 4
Q1, Q2, Q3, Q4 = associated flow rates 1, 2, 3, and 4

The number of factors used is determined by the programming. Up to four factors are available at corresponding flow rates. (See the meter factors and flow rate program codes.)

The input meter pulses may also be monitored by the unit to verify the integrity of the meters and/or transmitters. This is accomplished through pulse comparator circuitry. The pulse comparator verifies the integrity of the meter and the voltage sense verifies the integrity of the transmitter. The type and resolution of the pulse input stream to the unit is also programmable.

The input resolution, pulse and transmitter integrity, meter factors and their controls and adjustments may be defined through use of program parameters.

# Section III – Meter Factor Linearization Calculations

A. Calculations for meter factors between the flow points:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

where:

$m$ = slope (to be calculated)

$y_2$ = Meter factor at the lower flow rate

$y_1$ = Meter factor at the higher flow rate

$x_1$ = Flow rate for the meter factor of $y_1$

$x_2$ = Flow rate for the meter factor of $y_2$

B. After calculating $m$, calculate the straight line equation:

$$y - y_1 = m(x - x_1)$$

so

$$y = m(x - x_1) + y_1$$

where:

$x$ = the present flow rate
$y$ = the unknown meter factor.

C. Meter Factor calculating methods

1. The four-point linearization method uses four sets of the flow rate and associated meter factor program codes.

   Method:

   1. From zero to factor 4 flow, factor 4 will be used.
   2. Linearize from factor 4 flow to factor 3 flow.
   3. Linearize from factor 3 flow to factor 2 flow.
   4. Linearize from factor 2 flow to factor 1 flow.
   5. From factor 1 flow up, factor 1 will be used.

2. The three-point linearization method uses three sets of the flow rate and associated meter factor program codes.

   Method:

   1. From zero to factor 3 flow, factor 3 will be used.
   2. Linearize from factor 3 flow to factor 2 flow.
   3. Linearize from factor 2 flow to factor 1 flow.
   4. From factor 1 flow up, factor 1 will be used.

3. The two-point linearization method uses two sets of the flow rate and associated meter factor program codes.

   Method:

   1. From zero to factor 2 flow, factor 2 will be used.
   2. Linearize from factor 2 flow to factor 1 flow.
   3. From factor 1 flow up, factor 1 will be used.

4. The single-point method uses one meter factor program code.

   Method:

   1. Factor 1 will be used at all flow rates.

## *Measurement Standards Applied in microLoad.net Firmware Revisions*

| microLoad Revision | Tables 5, 6, 23, 24, 53, 54 (A,B,C,D) | Tables 59, 60 (A,B,C,D) |
|---|---|---|
| 0.0 – 0.06 | API Chapter 11.1 – 1980 | |
| 0.07 and up | API Chapter 11.1 – 2004 | |
| 0.05 – 0.12 | | ISO 91 – 2 |
| 0.13 and up | | API Chapter 11.1 – 2004 |

***Note:*** *Actual calculations cannot be included since the API standard requires "no reproduction permitted without license." The standards should be procured from API.*

## *Volume Correction for Temperature (CTL) Calculation*

1. Volume correction factor terms, formulas and constants:
   a) Definition of terms

   $\Delta t$ = Actual Temperature - Reference Temperature

   $k_0$, $k_1$ and $k_2$ = API product range constants

   $\rho_t$ = density @ actual temperature

   $\rho_{60}$ = density @ reference temperature

   $\alpha$ = coefficient of expansion

   b) Formulas used (simplified, see API chapter 11.1:2004 for complete formulas)

   1. $\alpha$ calculation

      a. Using $k_0$, $k_1$ and $k_2$ constants

$$\alpha = \frac{k_0}{\rho_{60}^2} + \frac{k_1}{\rho_{60}} + k_2$$

   2. CTL calculation

$$\frac{\rho_t}{\rho_{60}} = e^{(-\alpha \times \Delta t\,(1+0.8\alpha \times \Delta t))}$$

   3. $\rho$t calculation

$$\rho_t = \rho_{60} \times e^{(-\alpha \times \Delta t\,(1+0.8\alpha \times \Delta t))}$$

   4. API to density calculation

$$\rho_{60} = \frac{141.5 \times \text{weight of water at ref conditions}}{131.5 + \text{API}}$$

5. Relative density to density calculation

$$\rho_{60} = \text{Relative Density} \times \text{Weight of water at reference conditions}$$

c) Constants used

1. Weight of water at reference conditions

| Weight | Temperature |
|---|---|
| 999.102 Kg/M$^3$ | 15°C |
| 62.367 Lbs/Ft$^3$ | 60°F |

2. $k_0$ and $k_1$ constants for different API products (API Chapter 11.1:2004)

| API Table | Range@60°F | $k_0$@60°F | $k_1$@60°F |
|---|---|---|---|
| 5A, 6A, 23A, 24A, 53A, 54A, 59A and 60A Crude Oils | API -10 to 100<br>RD 0.6112 to 1.1646<br>DEN 38.12 to 72.63 LB/F$^3$<br>DEN 610.6 to 1163.5 KG/M$^3$ | 341.0957 | 0.0 |
| 5B, 6B, 23B, 24B, 53B, 54B, 59B and 60B Diesel, Heating and Fuel Oils | API -10 to 37.1<br>RD 0.8391 to 1.1646<br>DEN 52.33 to 72.63 LB/F$^3$<br>DEN 838.3 to 1163.5 KG/M$^3$ | 103.8720 | 0.2701 |
| 5B, 6B, 23B, 24B 53B, 54B, 59B and 60B Jet Fuels and Kerosene | API 37.1 to 48.0<br>RD 0.7883 to 0.8391<br>DEN 49.16 to 52.33 LB/F$^3$<br>DEN 787.5 to 838.3 KG/M$^3$ | 330.3010 | 0.0 |
| 5B, 6B, 23B, 24B, 53B, 54B, 59B and 60B Gasolines and Napthanes | API 52.0 TO 100<br>RD 0.6112 to 0.7711<br>DEN 38.12 to 48.09 LB/F$^3$<br>DEN 610.6 to 770.3 KG/M$^3$ | 192.4571 | 0.2438 |
| 5D, 6D, 23D, 24D 53D, 54D, 59D and 60D Lube Oils | API -10 to 45<br>RD 0.80168 to 1.1646<br>DEN 50.00 TO 72.63 LB/F$^3$<br>DEN 800.9 TO 1163.5 KG/M$^3$ | 0.0 | 0.34878 |
| BR1P and BR2P (API tables for Brazil) | RD 0.498 to 0.9693 @20°C | N/A | N/A |

3. k coefficients, Refined Products, Transition Zone

| API Table | Range | $k_2$@60°F | $k_0$@60°F |
|---|---|---|---|
| 5B, 6B, 23B, 24B, 53B, 54B, 59B AND 60B Transition Zone | API 48 to 52<br>RD 0.7711 to 0.7883<br>DEN 48.09 to 49.16 LB/F$^3$<br>DEN 770.3 to 787.5 KG/M$^3$ | -0.00186840 | 1489.0670 |

4. Old Tables 6, 23, 24, 53 and 54

| API Table | Range |
|---|---|
| 6 | API -3 to 104<br>RD 0.6000 to 1.1000<br>DEN 37.42 to 68.60 LB/F$^3$ |
| 23 | API 89 to 205<br>RD 0.42 to 0.64<br>DEN 26.22 to 39.95 LB/F$^3$ |
| 24 | API -3 to 151<br>RD 0.5000 to 1.1000<br>DEN 31.18 to 68.60 LB/F$^3$ |
| 53 | API 89 to 205<br>RD 0.42 to 0.64<br>DEN 420.0 to 640.0 KG/M$^3$ |
| 54 | API -3 to 151<br>RD 0.5005 to 1.1011<br>DEN 500.0 to 1100.0 KG/M$^3$ |

***Note:*** *The American Petroleum Institute recommends that Tables 6, 24 and 54 may be used for asphalt in place of ASTM D4311.*

5. Tables 23E, 24E, 53E, 54E, 59E and 60E provide temperature correction for the volume of natural gas liquid (NGL) and liquefied petroleum gas (LPG) products. Calculations are performed per API Manual of Petroleum Measurement Standards Chapter 11.2.4 or GPA Technical Publication TP-27. The standard provides CTLs (correction for temperature on a liquid) calculated to 5 decimal digits (e.g. 0.xxxxx or 1.xxxxx).

   Example liquids: Ethane, propane, hexane, heptanes, ethylene and propane mixtures.

   The standard covers a temperature range of -50.8 to 199.4° F (-46 to 93°C). The allowable density ranges are shown below:

| Reference Temperature | Reference Density Range |
|---|---|
| 60°F | 0.3500 to 0.6880 Relative Density |
| 15°C | 351.7 to 687.8 KG/M$^3$ |
| 20°C | 331.7 to 683.6 KG/M$^3$ |

The API tables should be used as shown below:

| API Table | Reference Temperature | Density Input |
|---|---|---|
| 23E | 60°F | Observed |
| 24E | 60°F | Reference |
| 53E | 15°C | Observed |
| 54E | 15°C | Reference |
| 59E | All other temperatures | Observed |
| 60E | All other temperatures | Reference |

***Notes:*** *1. Observed density input – density @ line temperature (live density available)*
*2. Reference density input – density @ reference density is programmed into AccuLoad.*
*3. 59E and 60E are typically used with reference temperatures of 20°C and 30°C but can be used for any desired reference temperature.*

Rounding of input values are performed as follows:

| | |
|---|---|
| Temperature in F | 0.1 |
| Temperature in C | 0.05 |
| Relative Density | 0.0001 |
| Density | 0.1 KG/M$^3$ |

## *Volume Correction Factor Calculation Options*

A. Coefficient of expansion used (table 6C or 54C)
   1. Program entry conditions
      a. Correct entry in API table and product (Product Parameter 411)
      b. Valid entry in reference density (Product Parameter 412)
   2. Hardware conditions
      a. A temperature probe installed.
      *(**Note:** Maintenance temperature may be used instead of a temperature probe.)*
   3. Calculation method
      a. Input temperature units.
      b. Calculate delta t ($\Delta t$).
      c. Coefficient of expansion entry (Product Parameter 412) will be used as alpha.
      d. Calculate the CTL.

$$CTL = e^{(-\alpha \times \Delta t (1+0.8\alpha \times \Delta t)}$$

B. API tables with API product range A, B, or D (with reference density)
   1. Program entry conditions:
      a. A valid API table and product entry (Product Parameter 411).
      b. A valid reference density entry (Product Parameter 412).
      c. A valid density units entry (System Parameter 411).
      d. A valid temperature units entry (System Parameter 401).
      e. A valid reference temperature entry (System Parameter 402).
   2. Hardware conditions:
      a. A temperature probe installed.
      *(**Note:** Maintenance temperature may be used instead of a temperature probe.)*
   3. Definition:
      In this mode of operation, the microLoad.net software will calculate the CTL using the $k_0$ and $k_1$ constants of the API product range selected. (If API product range B is selected, it will use the $k_0$ and $k_1$ constants for the product range it is measuring.) All related entries shown above must correspond. If table 53 or 54 is used, the temperature units must be in Celsius.)
   4. Calculation method for reference density at 60°F
      a. Input temperature units.
      b. Calculate delta t ($\Delta t$).
      c. Calculate the alpha and the CTL using the reference density entered.
         1. Calculate alpha with the proper $k_0$ and $k_1$ constants for API product range selected.
         2. Calculate CTL.
      d. Calculate the CPL.
      e. Calculate the CTPL.
         $CTPL = CTL \times CPL$
   5. Calculation method for reference density at 15°C or 20°C.
      a. Calculate the correction factors ($CTL_{60}$) for the density at 60°F (p60) corresponding to the metric base density at the metric base temperature (15°C or 20°C) using the procedure defined in step C.4.
      b. Using the calculated base density at 60°F (p60), calculate the CTL* to correct the live density using the procedure defined in step B.4.
      c. Calculate the CTL to correct the volume to the metric base temperature.

$$CTL = CTL^* / CTL_{60}$$
$$CTPL = CTL \text{ X } CPL$$

*(**Note:** * indicates an intermediate CTL value used for the CTL calculation per API Chapter 11.1.)*

C. API tables with API product range A, B, or D (live density)

1. Program entry conditions:
   a. A valid API table and product entry (must be an odd-numbered table) (Product Parameter 411).
   b. A valid density units entry (System Parameter 411).
   c. A valid temperature units entry (System Parameter 401).
   d. A valid reference temperature entry (System Parameter 402).
2. Hardware conditions
   a. A temperature probe installed.

      *(**Note:** Maintenance temperature may be used instead of a temperature probe.)*

   b. A densitometer installed.
3. Definition:

   In this mode of operation, the microLoad.net software will calculate the CTL using the $k_0$ and $k_1$ constants of the API product range selected. (If API product range B is selected, it will use the $k_0$ and $k_1$ constants for the product range it is measuring.) All related entries shown above must correspond. If table 53 or 54 is used, the temperature units must be in Celsius. Density units selected must match the densitometer output.
4. Calculation method for live density at 60°F
   a. Input temperature units.
   b. Calculate delta t ($\Delta t$).
   c. Input density units.
   d. Calculate the density corrected to reference temperature using Newton's method, which will in turn calculate the required CTL and CTPL.
      1. Calculate alpha selecting proper $k_0$ and $k_1$ constants for API product range selected (Parameter 411).
      2. Calculate the CTL, CPL and CTPL.
      3. Calculate the corrected density.
      4. Check for convergence of the solution. (A converged solution is reached when a change in density is less than 0.05 kg/m$^3$ in two successive passes.)
      5. For API product range B only, check to see that the $k_0$ and $k_1$ constants used are in the range of the corrected density calculated. If not, repeat steps 1 through 4 with the correct constants.
5. Calculation method for live density at 15°C or 20°C.
   a. Calculate the correction factors (CTL*) for the density at 60°F (p60) corresponding to the observed density at observed temperature and pressure using the procedure defined in step C.4.
   b. Using the corresponding density at 60°F (p60), calculate the associated metric base density. Call the CTL associated with this step $CTL_{60}$ using the procedure defined in step B.4.
   c. Calculate the CTL to correct the volume to the metric base temperature.

$$CTL = CTL^* / CTL_{60}$$
$$CTPL = CTL \times CPL$$

*(**Note:** * indicates an intermediate CTL value used for the CTL calculation per API Chapter 11.1.)*

D. API (old) tables 24 and 54 with API range 100 to 150

1. Program entry conditions:
   a. A valid API table and product entry (Product Parameter 411).
   b. A valid reference density entry (Product Parameter 412).
   c. A valid density units entry (System Parameter 411).
   d. A valid temperature units entry (System Parameter 401).
   e. A valid reference temperature entry (System Parameter 402).

2. Hardware conditions:
   a. A temperature probe is installed.
   *(**Note:** Maintenance temperature may be used instead of the temperature probe.)*
3. Definition:
   In this mode of operation, the microLoad.net software will use the reference density and the current temperature to retrieve the CTL from the selected table. (If table 24 is selected, temperature units must be Fahrenheit. If table 54 is selected, temperature units must be Celsius.)
4. Calculation method
   a. Input temperature units.
   b. Using the temperature and reference density, go to the proper table (24 or 54) and select the proper CTL.

## *RTD Temperature Input Conversion*

The resistance temperature detector (RTD) supplies resistance from which temperature may be calculated. The Callendar-Van Dusen equation is used to approximate the RTD curve.

$$T = \frac{-A + \sqrt{A^2 - 4B\left(1 - \frac{R}{R(0)}\right)}}{2B}$$

**Where:**

T = temperature in °Celsius
R = resistance at temperature T
R(0) = resistance at 0°C
A = 3.9083 e-3
B = -5.775 e-7

## *Volume Correction for Pressure (CPL) Calculation*

1. Definition of terms
   - P = pressure
   - $P_e$ = equilibrium pressure (vapor pressure @ temperature)
   - F = compressibility factor (API Chapters 11.2.1 or 11.2.2)
   - CPL = correction for pressure on a liquid

2. Formula used

   a.

$$CPL = \frac{1}{1-(P-P_e) \times F}$$

   b.

$$^{\circ}API = \frac{141.5 \times \rho_{60}\, H_2O}{\rho_{60}\, Product} - 131.5$$

   c. For -10 to 90 °API (-10 to 100 per API Chapter 11.1)

$$F = e^{A + (B \times T) + \frac{C}{\rho^2} + (D \times \frac{T}{\rho^2})}$$

***Note:*** *this calculation is used for densities from -10 to 100 °API for products included in API Chapter 11.1 (5A, 5B, 5D, 6A, 6B, 6C, 6D, 23A, 23B, 23D, 24A, 24B, 24D, 53A, 53B, 53D, 54A, 54B, 54C, 54D). Otherwise this calculation is used for densities from -10 to 90 °API.*

where:

A, B, C and D = constants
T = temperature (°F or °C dependent)
$\rho$ = grams/cm$^3$ @ 60°F or grams/cm$^3$ @ 15°C

| | A | B | C | D |
|---|---|---|---|---|
| °F | -1.99470 | 0.00013427 | 0.79392 | 0.0023260 |
| °C | -1.62080 | 0.00021592 | 0.87096 | 0.0042092 |

Note that F is scaled before usage in the CPL formula above. If temperature is in degrees Fahrenheit, F is multiplied by 0.00001. If temperature is in degrees Celsius, F is multiplied by 0.000001.

d. For 91 to 220 °API (101 to 220 per API Chapter 11.1)

$$F = \frac{1}{A+(D_p \times B)}$$

where:

A and B = Calculated variables based on temperature & density

$D_p$ = Pressure above equilibrium in (PSI or Kpa dependent) (i.e., Pressure – Vapor Pressure)

$$A*10^{-5} = A_1* TR^2 + A_2* G^2 + A_3 * TR^2 * G^4 + A_4 * TR^3 * G^6 + A_5 + A_6 * TR^3 * G^2 + A_7 * TR^3 * G^4 + A_8 * TR * G^2 + A_9 * TR * G + A_{10} * TR + A_{11}* G^6$$

If temperature units are degrees Celsius, then A = A * 6.894757E0

$$B*10^{-5} = B_1* TR^2 + B_2* TR * G^2 + B_3 * G + B_4* G^2$$

where:

TR = Temperature, in degrees Rankine

G = Relative density

$A_1$ = -2.1465891E-6

$A_2$ = +1.5774390E-5

$A_3$ = -1.0502139E-5

$A_4$ = +2.8324481E-7

$A_5$ = -0.95495939E0

$A_6$ = +7.2900662E-8

$A_7$ = -2.7769343E-7

$A_8$ = +0.036458380

$A_9$ = -0.05110158E0

$A_{10}$ = +0.00795529E0

$A_{11}$ = +9.13114910E0

$B_1$ = -6.0357667E-10

$B_2$ = +2.2112678E-6

$B_3$ = +0.00088384E0

$B_4$ = -0.00204016E0

## *Vapor Pressure Calculations*

A. Linearization method: Calculate the slope of a line between two points :

1. Calculate *m*.

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

where:

$m$ = Slope (to be calculated)
$y_2$ = Vapor pressure @ $x_2$ in PSI, Bars or Kg/cm$^2$.
$y_1$ = Vapor pressure @ $x_1$ in PSI, Bars or Kg/cm$^2$.
$x_1$ = Temperature for vapor pressure of $y_1$
$x_2$ = Temperature for vapor pressure of $y_2$

*(**Note:** Temperature may be in degrees C or F.)*

2. After calculating *m*, calculate the straight line equation:

$$y - y_1 = m(x - x_1)$$

so

$$y = m(x - x_1) + y_1$$

where:

$x$ = the present temperature
$y$ = the unknown vapor pressure

B. GPA TP-15 Method: Calculate vapor pressure through the use of the following formula as outlined in the GPA TP 15.

$$\text{Vapor Pressure} = e^{A_0 + A_1 \text{ relative density} + \frac{B_0 + B_1 \times \text{relative density}}{\text{temperature } °F = 443}}$$

Where $A_0$, $A_1$, $B_0$, and $B_1$ are constants dependent on the range of the density.

Note that this method requires GST compensation installed as the relative density is used in the calculation.

## *Load Average Values*

The load average temperature, pressure, density, and meter factor will be accumulated in a volume-weighted method (see below). At the start of any batch, a reading of each load average parameter installed will be taken. This will be the value used for the initial average. Thereafter, another sample will be taken along with the accumulated volume to determine the load average value. Samples will be taken only when flow is in progress. The following formula will be used to calculate the load average value.

Load Average Value (LAV) Formula:

$$LAV = \frac{\Sigma\ (\Delta \text{Volume} \times \text{Current parameter reading})}{\text{Total Volume}}$$

Load average temperature, pressure and density values will only be calculated when correct entries have been made in the temperature, pressure or density program codes. If a probe or transducer alarm occurs, the corresponding current reading will stop being used in the calculation of the load average value. The current load average value for the failed probe or transducer stands until flow goes to zero. At this point the alarm must be cleared and the problem corrected for normal load average calculations to resume.

## *Auto Prove Meter Factor Calculations*

The following equations are used by the microLoad.net to calculate the new meter factor.

***CTSP (Correction for Temperature on Steel of a Prover)***

$$CTSP = 1 + ((T - t_{ref}) * y)$$

where

T = temperature of the prover

y = coefficient of cubical expansion, a constant, 0.0000186 for mild steel

t ref = reference temperature (System Parameter 402)

***CTLP (Correction for Temperature on Liquid in a Prover)***

$$CTLP = e^{(\alpha \bullet \Delta t (1 + 0.8\alpha \bullet \Delta t))}$$

where

e = the exponential constant

$\Delta t = \Delta$ temperature = actual temperature of the prover - reference temperature (System Parameter 402)

$\alpha = k_0/(\rho_{60})^2 + (k_1/\rho_{60})$

where

$k_0$ and $k_1$ are constants determined based on the product group

$\rho_{60}$ = (141.5 * weight of $H_2O$)/(131.5 + API)

OR

$\alpha = A + (B/(\rho_{60})^2)$

where

A and B are constants for a special range of API gravities

$\rho_{60}$ = (141.5 * weight of $H_2O$)/(131.5 + API)

***Combined Correction Factor (CCF) For a Prover***

$$CCFP = CTSP * CTLP$$

where

CTSP and CTLP are as shown above

***Corrected Prover Volume***

$$\text{Corrected Prover Volume} = \text{Base Prover Volume} * CCFP$$

where

Base Prover Volume is as determined by a waterdraw

CCFP is as shown above

***Corrected Meter Volume***

Corrected Meter Volume = CTPLM * Raw Meter Volume

where
CTPLM is as shown earlier

***Meter Factor***

Meter Factor = Corrected Prover Volume/Corrected Meter Volume

where
Corrected Prover Volume and Corrected Meter Volume are as shown above

***Average Meter Factor***

Average Meter Factor = Sum of Meter Factors/Number of Meter Factors

Note that the buffer of meter factors saved for calculating an average meter factor is cleared whenever a meter factor is saved or a new flow rate is selected for proving.

Revision included in TP06005 Issue/Rev. 0.2 (3/11):

Page 10: Addition of Tables 23E, 24E, 53E, 54E, 59E and 60E to Temperature Calculations

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