EM6

Calibration Manual

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1. Overview of Calibration

Calibrating any instrument essentially means ensuring that the quantity measured and displayed by the instrument is in fact correct. This is achieved by measuring the quantity (in this case volume) with 2 instruments, one of which has been proven to be correct, and the other the instrument to be calibrated.

In the Petrochemical Industry, the instrument that is used to compare to is typically an open test measure, master meter, loop prover or piston prover. Irrespective of which instrument is used, it will be certified as being accurate, typically by a National Standards organization.

The typical process of calibration would consist of measuring a known quantity with both instruments and comparing the values obtain. If the value shown by the instrument under test is incorrect, adjustments are made and the process is repeated. The adjustments are typically made to what is referred to as the K factor or calibration factor. Once the readings obtained on the Instrument under test are consistently the same as those of the certified instrument, the instrument under test is deemed to be calibrated, i.e. accurate to within applicable tolerances.

2. Multiple Calibration Factors

If an instrument is linear across the full range of measurement, a single calibration factor would be required. Flow meters used in the Petrochemical industry are normally linear when new, but as the mechanical components wear with time, the tendency is for the meter to become non-linear. With this is mind, the EM6 has been designed with 3 calibration factors per product. The various calibration factors are used at different flow rates. This multiple calibration factor feature allows the user of a mechanical meter to use the meter for a much longer period of time before refurbishment or replacement is required.

3. Weights and Measures Software Version

The weights and measures portion of the EM6 electronic calculator is stored in a separate location to the application software therefore the two sections have independent checksums.
The checksum for the weights and measures is listed in section 5 under the SYSTEM SETUP DIRECTORY.

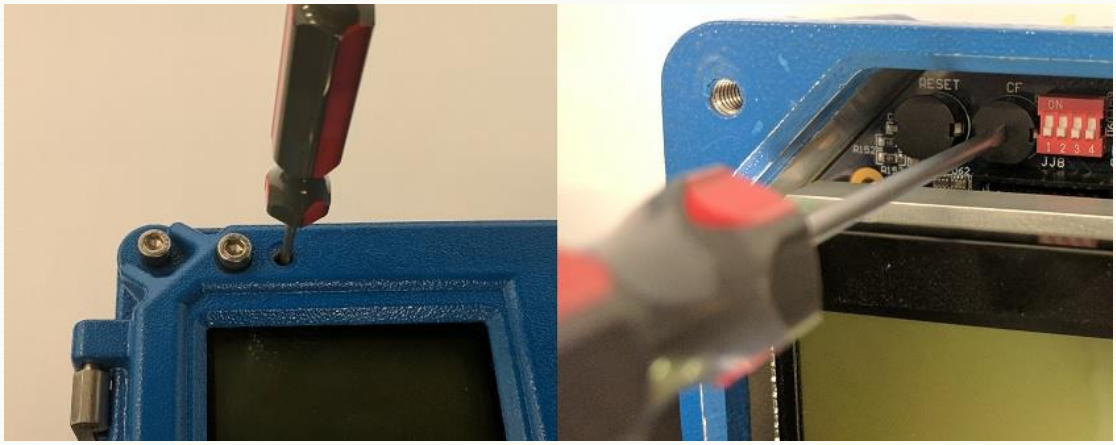
4. Weights and Measures Event Storage

Modification of any weights and measures parameters is recorded in a reserved section of memory. These recorded events are located under the W & M events. Under the W & M events the following information is recorded:

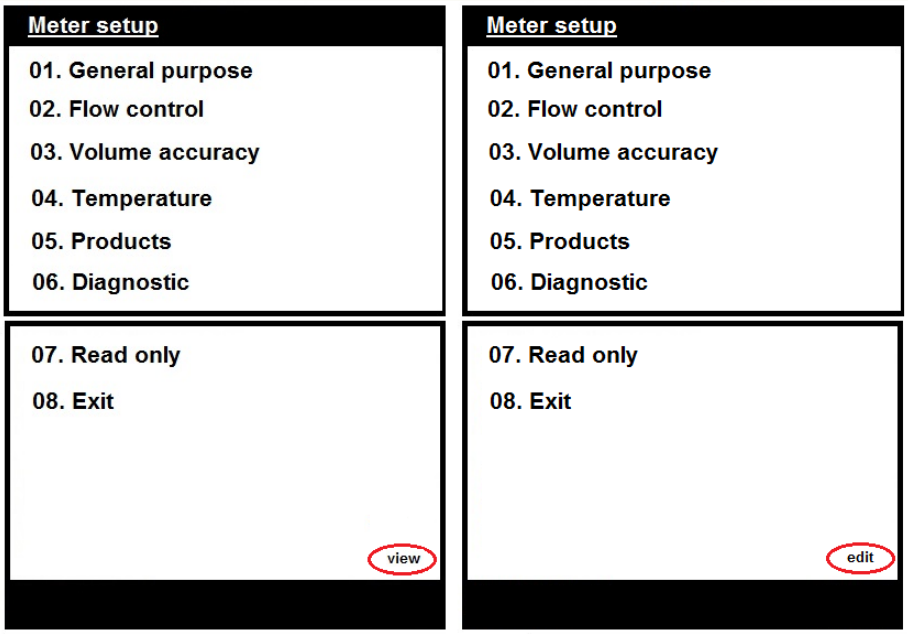
- Date
- Time
- Ticket number
- Verification officer ID
- Calibration 1 & 2 counter
- Details of parameter changed

5. Navigating through the Setup Menu's

To enter setup mode, the 'Enter' key needs to be pressed twice in quick succession. The EM6 will prompt for a verification officer number and PIN. The technical PIN needs to be entered in order to be able to change calibration factors (This cannot be done under the Managers PIN). Once the correct PIN has been entered, the CF (Calibration Factor) switch needs to be pressed. This switch is located at the top left of the unit, and is protected with a M6 cap screw which should be sealed for Trade Metrological purposes. There are two M6 caps screws in the top left corner above the displays, the left screw is for the RESET button and the right screw is for the CF switch.



Pressing the CF button will modify the menu status in the bottom right corner of the setup menu screen from "view" to "edit"



In the setup menu, use the following keys to navigate through the menu:

'Enter' or '→' : Selects the item. (Moves up one level in the menu-tree)
'CLR' or '← : Exit the current menu. (Move down one level in the menu-tree)
'↑' : Move cursor up
'↓' : Move cursor down

Each field that is described in this manual has three mandatory descriptions:

a) Access: Level-w
b) Hidden: Reason for the menu item to be hidden
c) Default: x units
d) Range: yyy – zzz / Options: yyy

a) Access is the level of access required to edit the field.
   There are two levels of access:
   1) Level-1 requires that the menu was entered via the Manager-PIN or Technical-PIN
   2) Level-2 requires that the menu was entered via the Technical-PIN and the CF-button must also be pressed. When this happens, 'Edit' will appear in the bottom right screen of the menu. In order to press the CF-button, the seal must be broken.

   If the user enters the menu via a level-1 access code, all the level 2 fields and Menu items will be hidden.
b) If the menu does not appear, the 'Hidden' description describes the parameter that causes the menu to be hidden.
c) Default is the default value that is set when the parameters are reset. The units are also displayed here (where applicable).
d) Range is the data range that is allowed for this field (where applicable).
   If the field is numeric, the range will be numeric
   If the field is an option, the range will indicate the options available.
   If the field is alphanumeric, the range will be the number of characters that is allowed for the field.

In addition to the fields, some menu items also have the 'Access' and 'Hidden' attribute.

5.1. Menu Structure

The high level menu tree looks as follows, the menu items relevant to the weights and measures and the calibration are highlighted in bold. Sub menus are not all shown in the structure below.

SYSTEM SETUP DIRECTORY
- Preset
  - **Compensated mode**
- Temperature & density
  - **Show compensated**
  - **Print compensated**
- Communication
  - Printer
    - **Type**
    - **Auto print**
    - **Number of copies**
  - Port X setup
    - **Protocol**
    - **Baud rate**
    - **Parity**
- Read Only
  - **W & M checksum**
  - **W & M events**

METER SETUP DIRECTORY
- General Purpose

- Flow Control
  - **Minimum rate**
  - **Minimum time**

- Volume Accuracy
  - Pulsar type
  - **Pulses per Volume**
  - **Pulse Error Counter**
  - **Gravity switch 1**
  - **Gravity switch 2**
  - **Pump switch 1**
  - **Pump switch 2**

- Temperature
  - **Enable**
  - **Maximum**
  - **Table**
  - **Offset**

- Input

- Products
  - Number of products
  - Pulse rate
  - Product X
    - Select product
    - Product name
    - **Default density**
    - **Gravity calibration**
      - **Calculate factor 1**
      - **Calibration factor 1**
      - **Calculate factor 2**
      - **Calibration factor 2**
      - **Calculate factor 3**
      - **Calibration factor 3**
    - **Pump calibration**
      - **Calculate factor 1**
      - **Calibration factor 1**
      - **Calculate factor 2**
      - **Calibration factor 2**
      - **Calculate factor 3**
      - **Calibration factor 3**

Continued on following page

Price
Enable
Units
Currency
Modify price
Incl/excl tax
Tax

Diagnostics
Clear tickets, params
Clear tickets
Read Only

6. System legally relevant parameters definitions

6.1. Preset parameters

6.1.1 Compensated mode

Access: Level-2
Hidden: None
Default: Disable
Options: Enable
Disable

Enable or disable pre-set delivery to compensated volume. When compensated mode delivery is enabled, the EM6 will deliver according to the compensated volume and not the uncompensated volume.

6.2. Temperature and density

6.2.1 Show compensated

Access: Level-2
Hidden: None
Default: Disable
Options: Enable
Disable

Enable or disable display of compensated volumes.
Enable to allow the operator to view the compensated volume on the display. If the product controller's temperature setting is disabled or the product controller sends an invalid temperature reading, 'xxxxxx' will be displayed for the compensated volume and the relevant error will be displayed in the temperature field

Disable to prevent the operator the view the compensated volume on the display.

6.2.2 Print compensated

Access: Level-2
Hidden: None
Default: Disable
Options: Enable
Disable

Enable or disable Print-compensated volume.
Enable to allow the operator to view the compensated volume on the printouts. If the product controller's temperature setting is disabled or the product controller sends an invalid temperature reading, 'xxxxxx' will be printed for the compensated volume and the relevant error will be printed for the temperature

Disable to prevent the operator to view the compensated volume on the printouts.

6.3. Communication

6.3.1 Printer Type

Access: Level-2
Hidden: None
Default: None
Options: None
Datec-1000
Epson TM-U295
Blaster

Enter the printer type.

6.3.2 Auto Print

Access: Level-2
Hidden: If 'Printer Type' is set to none
Default: Disable
Options: Enable
Disable

Enable or disable 'Auto Print'
If enabled, the load will be printed automatically when a load is completed.
If 'Printer Type' is set to none, this options will be ignored.

6.3.3 Number of Copies

Access: Level-2
Hidden: If 'Printer Type' is set to none
Default: 1
Range: 1 – 10 (Copies)

Enter the number of copies to be printed.
This value only comes into effect when the load is printed automatically after the load is completed or the operator prints from the 'Load View Screen'. When individual tickets are printed from Manager mode, only one ticket is printed at a time.
If 'Printer Type' is set to none, the number of copies will be ignored.

6.4. Port X Setup

X represents either port 1 or port 2.

6.4.1 Protocol

Access: Level-2
Hidden: None
Default: Modbus
Options: Modbus
SLIP
Printer

Select the communication protocol for port X

6.4.2 Baud Rate

Access: Level-2
Hidden: None
Default: 9600 bps
Options: 2400
9600
19200

Select the baud rate for port X.

6.4.3 Parity

Access: Level-2
Hidden: None
Default: None bps
Options: None
Even

Select the parity for port X.

6.5. Read Only

6.5.1 W & M Checksum

Access: Level-1
Hidden: None

Weights and measures checksum. Checksum calculated on the legally relevant weights and measures functions on the electronic calculator.

6.5.2 W & M Events

Access: Level-1
Hidden: None

All modifications made to the electronic calculator's settings are recorded and are available for viewing and printing.

7. Meter point legally relevant parameter definitions

7.1. Flow Control

7.1.1 Minimum Rate

Access: Level-2
Hidden: None
Default: 150 volume units per minute
Range: 1 – 9999

Set the minimum flow rate.

The Minimum-rate and Minimum-time work together to determine when the flow rate is too low.

If the flow rate of the product is below the minimum rate for a certain period of time (set by the minimum-time parameter), a Minimum-Flow error will occur and the transaction will terminate.

7.1.2 Minimum Time

Access: Level-2
Hidden: None
Default: 10 seconds
Range: 1 – 255

Set the minimum time.
See 'Minimum-Rate' parameter for a complete description.

7.2. Volume Accuracy

7.2.1 Pulsar type

Default: IS pulsar
Range: IS pulsar
EXD pulsar

Select which pulsar interface to use.

7.2.2 Pulses Per Volume

Default: 1
Range: 1 – 99999
Description: The value of this parameter is dependent on both the type of Flow meter used and the type of pulsar.

Example: If a pulse encoder has a resolution of 100 pulses per revolution and the meter has a volume of 4.55 litres per revolution then the pulses per volume would be 22 pulses per litre.

$$\frac{\textit{Encoder pulses per revolution}}{\textit{Meter litres per revolution}} = \textit{Pulses per litre}$$

7.2.3 Switch Point 1

Default: 100 litres per minute
Range: 0 – 999
Description: Enter the flow rate at which the Calibration Factor 2 value should be used.

7.2.4 Switch Point 2

Default: 300 litres per minute
Range: 0 – 999
Description: Enter the flow rate at which the Calibration Factor3 value should be used.

7.3. Temperature

7.3.1 Enable

Access: Level-2
Hidden: None
Default: Disable
Options: Enable
Disable

Enable or disable the temperature circuit.
Set the ‘System – Temperature, pressure – Display GST’ and / or ‘System – Temperature, pressure – Print GST’ to enable. This will allow the operator to view the temperature and GST volume.

7.3.2 Maximum

Access: Level-2
Hidden: If 'Temperature' is disabled
Default: 70°C
Range: 0 – 140

Set the maximum temperature allowed. If the instantaneous temperature exceeds the maximum temperature, a temperature alarm will occur and if a transaction is in progress, it will terminate.
Note: during a transaction, the average temperature is displayed but the instantaneous temperature must not rise above the maximum temperature.

7.3.3 Table

Access: Level-2
Hidden: If 'Temperature' is disabled
Default: Table 60B (20°C)
Options: Table 54A (15°C)
Table 54B (15°C)
Table 54C (15°C)
Table 54D (15°C)
Table 60A (20°C)
Table 60B (20°C)
Table 60C (20°C)
Table 60D (20°C)
GPL
Butane
Propane
LPG
None

Select the correct table to use.
Note: The option None is the same effect as using Table B (1963 revision). In this case, the expansion coefficient must be entered.

7.3.4 Offset

Access: Level-2
Hidden: If 'Temperature' is disabled
Default: 0 °C
Range: -9.9 – +9.9

Set the temperature offset to cater for offset in the temperature probe. See section on 'How to use the editor'.

7.3.5 Expansion Coefficient

Access: Level-2

Hidden: If 'Table' is not set to 'Table 54C, Table 60C or None'
Default: 0.000000
Range: 0.000648 – 0.001728

Set the temperature coefficient according to 'Table-G' in the 'Petroleum Measurement Tables' 1963 revision.

7.4. Product

7.4.1 Pump Calibration

Access: Level-2
Hidden: If the 'Pump Gravity' setting is set to gravity only

7.4.1.1 Automatically Calculate Calibration Factor 1

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 1.

7.4.1.2 Calibration Factor 1

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the Pump Calibration Factor 1 for the product selected in the product menu.

7.4.1.3 Automatically Calculate Calibration Factor 2

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 2

7.4.1.4 Calibration Factor 2

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the Pump Calibration Factor 2 for the product selected in the product menu.

7.4.1.5 Automatically Calculate Calibration Factor 3

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 3

7.4.1.6 Calibration Factor 3

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the Pump Calibration Factor 3 for the product selected in the product menu.

7.4.2 Gravity Calibration

Access: Level-2
Hidden: If the 'Pump Gravity' setting is set to pump only

7.4.2.1 Automatically Calculate Calibration Factor 1

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 1

7.4.2.2 Calibration Factor 1

Access: Level-2
Hidden: If the 'Pump Gravity' is set to pump only
Default: 1
Range: 0 – 9.9999

Enter the Gravity Calibration Factor 1 for the product selected in the product menu.

7.4.2.3 Automatically Calculate Calibration Factor 2

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 2

7.4.2.4 Calibration Factor 2

Access: Level-2
Hidden: If the 'Pump Gravity' is set to pump only
Default: 1
Range: 0 – 9.9999

Enter the Gravity Calibration Factor 2 for the product selected in the product menu.

7.4.2.5 Automatically Calculate Calibration Factor 3

Access: Level-2
Hidden: If the 'Pump Gravity' is set to gravity only
Default: 1
Range: 0 – 9.9999

Enter the EM6 indicated volume and the test vessel actual volume and the EM6 will calculate the new calibration factor 3

7.4.2.6 Calibration Factor 3

Access: Level-2
Hidden: If the 'Pump Gravity' is set to pump only
Default: 1
Range: 0 – 9.9999

Enter the Gravity Calibration Factor 3 for the product selected in the product menu.

7.4.3 Price

Access: Level-2

7.4.3.1 Enable

Access: Level-2
Hidden: None
Default: Disable
Range: Disable
Enable

Allow operator to use pricing as part of the electronic calculators preset operation

7.4.3.2 Units

Access: Level-2
Hidden: If price disabled
Default: Per 1L
Range: Per 1L
Per 100L
Per 1000L

Pricing can be applied on a per 1L, per 100L or per 1000L as application demands. The price calculation works as follows:

$$\frac{Volume\ delivered\ x\ cost\ per\ unit}{units}$$

7.4.3.3 Currency

Access: Level-2
Hidden: If price disabled
Default: EUR

Currency can be made up of three symbols or alphanumeric characters.

7.4.3.4 Modify Price

Access: Level-2
Hidden: If price disabled
Default: Disable
Range: Disable
Enable

Enabled allows operator to modify price during preset operation.
Disabled denies operator ability to modify pricing during preset operation

7.4.3.5 Price

Access: Level-2
Hidden: If price disabled
Default: 1.00
Range: 0.00 - 9999.99

Enabled allows operator to modify price during preset operation.
Disabled denies operator ability to modify pricing during preset operation

7.4.3.6 Incl/excl Tax

Access: Level-2
Hidden: If price disabled
Default: Including tax
Range: Including tax
Excluding tax

Price per unit including of excluding tax

7.4.3.7 Tax

Access: Level-2
Hidden: If price disabled
Default: 14.0%
Range: 0.1% - 99.9%

Tax amount to be used in price calculations

7.5. Diagnostics

7.5.1 Clear Parameters, Tickets

Access: Level-2
Hidden: None
Default: Not applicable
Range: Not applicable

Select ‘Proceed’ to Clear the memory and reset the parameters to default value.

7.5.2 Clear Tickets

Access: Level-2
Hidden: None
Default: Not applicable
Range: Not applicable

Select ‘Proceed’ to Clear the Transaction history.

8. Calibration procedure

A generic calibration procedure is listed below, care must be taken to ensure compliance with local authorities. This calibration procedure is a guideline and not legally relevant.

1. Configure the EM6 with the correct pulses per litre corresponding to the pulse encoder and meter combination.

2. Correctly connect meter under test to the test vessel ensuring all valves are in their correct state to ensure correct loading of the vessel.

3. Preset the EM6 for the test vessel volume, this delivery is called **wetting the line** and is used to ensure that all the pipework and the air eliminator contain product.

4. Preset the EM6 for the volume of the test vessel and complete two deliveries to test repeatability. Ensure the repeatability of these two deliveries by checking the final delivered volumes are within 5% of each other. If the delivery volume is not repeatable please check the air eliminator and meter combination. After inspection and corrective action is performed and the test is still not repeatable then the meter has failed calibration.

5. Once the meter has shown repeatable results perform two deliveries at 100% flow rate and record the results. Ensuring the accuracy of the final delivered amount is within 0.25% of the volume displayed on the EM6. The value for calibration point 3 is calculated using the formula 1

6. Refill the test measure at 50% flow rate ensuring that the final delivered volume is within 0.5% of the EM6 displayed volume. Calibration factor 2 is calculated using formula 1.

7. Refill the test measure at 20% flow rate ensuring that the final delivered amount is within 0.5% of the EM6 displayed volume. Calibration factor 1 is calculated using formula 1.

8. Once complete calibrate the temperature probe and enter the offset value in the temperature setup under the meter point setup.

9. Using a hydrometer check the density of the various products and enter them in the product menu of the meter point setup.

10. Refill the test measure and check that both the gross and compensated volume are within the allowable tolerance.

Formula 1

New Calibration factor = Test Measure Reading x Previous Calibration-Factor
EM6 Reading

The verification certificate shown below is generic example and care should be taken to comply with local authorities.

Verification Certificate

Customer: _____
Bay No: 1
Product: Diesel 50
Test Measure Capacity: 2000 l
Date of calibration _____

Particulars of Measuring Instruments

Make & Model No:	Capacity / Flow Rate	Serial No:
Isoil BM 400	240 - 2400 l/m	4 - 2672

Totalised Readings

Before Start of test	After completion of test
26630481	26640531

OBSERVATIONS

ENVIRONMENTAL CONDITIONS	PRELIMINARY EXAMINATION
Good	Good

Particulars of Test

Test (L/min)	Error As Found	Tolerance	Error Found	Factor Before	Factors After
(100%) 1780	+4	5	+1	0,9877	0,9886
(100%) 1762		5	+1		
(50%) 1068		10	+1	0,9905	0,9866
(20%) 427		10	+1	1,0029	0,9942
(Other)	—	—	—	—	—

9. Automatic Calibration

The EM6 has built in functionality which is able to calculate the calibration factors by simply entering the indicated volume on the EM6 and the actual volume in the test measure.
This removes the chance of mathematical calculation errors allowing the technician to focus on the calibration process

10. Example

If values of 0.9987, 0.9995 and 1.0020 as entered for Calibration factors 1 to 3 respectively, and the Switch Point values are left at the default of 100 and 300 respectively, a calibration factor of 0.9987 will be used when loading starts. As soon as the flow rate reaches 100 lpm, the factor 0.9995 will be used, and when the flow rate exceeds 300 lpm, the calibration factor of 1.0020 will be used. The same principles will apply when the flow rate decreases.

With new flow meters, the possibility is high that they would be linear across the flow rate range. This would result in all 3 Calibration Factors being the same.

When doing a calibration run, the flow rate should be controlled and monitored to ensure that the correct Calibration factor is adjusted if required.

The formula shown below can be used to calculate the new calibration factor should adjustments be required:

$$\text{New Calibration Factor} = \frac{\text{Test Measure Reading}}{\text{EM6 Reading}} \times \text{Previous Calibration-Factor}$$

11. Sealing Method

The EM6 provides an easy and effective method of sealing and securing the EM6. Sealing can only be undertaken by a certified verification officer using sealing twine and lead seals. The verification officer is to seal the preset with his or her unique sealing pliers ensuring that the seal number is unambiguous. See below for an example of the ideal sealing method.