Micro Motion 7835
Explosion Proof Liquid Density Meters

Standard Electronics
# Contents

## Chapter 1 Introduction
- 1.1 Safety guidelines ...................................................... 1
- 1.2 Product overview ....................................................... 1
- 1.3 Product range ............................................................ 2
- 1.4 Electronics product range ............................................. 2
- 1.5 2004/22/EC (MID) applications ....................................... 3

## Chapter 2 Installation Procedure
- 2.1 General ................................................................. 5
- 2.2 Safety Information ...................................................... 5
  - 2.2.1 General information applicable to the complete system .... 5
  - 2.2.2 Pressure bearing parts .......................................... 6
- 2.3 Installation planning .................................................. 7
- 2.4 Meter mounting and pipework ....................................... 7
- 2.5 Pressure drop in the meter .......................................... 11
- 2.6 Calculation of pressure drop in the meter ......................... 11
- 2.7 Post-installation checks ............................................. 11
- 2.8 Installation drawings ................................................. 12

## Chapter 3 Electrical Connections (Standard)
- 3.1 General ................................................................. 13
- 3.2 MID (2004/22/EC) Requirements .................................. 13
  - 3.2.1 Securing the meter for MID .................................... 13
- 3.3 Ground connections ................................................... 14
- 3.4 Use with Micro Motion signal converters ......................... 14
  - 3.4.1 System connections (Safe Area only) ....................... 14
- 3.5 Use with customer’s own equipment ............................... 15
  - 3.5.1 System connections (Safe Area only) ....................... 15
- 3.6 Post-installation checks ............................................. 17

## Chapter 4 Calibration and Performance
- 4.1 General ................................................................. 19
- 4.2 Interpretation of calibration certificate ............................ 19
  - 4.2.1 General density equation ..................................... 19
  - 4.2.2 Temperature correction ....................................... 20
  - 4.2.3 Pressure correction ............................................ 20
  - 4.2.4 Velocity of sound correction .................................. 22
- 4.3 Calibration ............................................................ 24
  - 4.3.1 Factory calibration .............................................. 24
  - 4.3.2 Calibration of transfer standards ............................. 24
  - 4.3.3 Instrument calibration certificate ............................ 24
  - 4.3.4 Pressure test .................................................... 25
  - 4.3.5 Insulation test .................................................. 25
  - 4.3.6 Calibration check methods .................................... 25
4.4 Performance .................................................. 27

Chapter 5 General Maintenance .................................. 29
5.1 General .......................................................... 29
5.2 Fault analysis .................................................... 29
5.3 General maintenance procedure .............................. 29
5.4 Physical checks. .................................................. 29
  5.4.1 Check calibration .......................................... 30
  5.4.2 Remedial servicing ........................................ 30

Appendix A 7835 Explosion Proof (Exd) Specifications ............ 33
A.1 Density performance .......................................... 33
A.2 Temperature specifications .................................... 33
A.3 Pressure ratings ............................................... 34
A.4 Hazardous area classifications ................................. 34
A.5 OIML R117-1 classifications .................................. 34
A.6 Electromagnetic compatibility ................................. 34
A.7 Materials of construction ...................................... 35
A.8 Weight .......................................................... 35
A.9 Electrical ....................................................... 35
A.10 Safety approval ............................................... 35

Appendix B Electronics Specifications .............................. 37
B.1 Standard Electronics .......................................... 37
  B.1.1 Meter Power Supply ...................................... 37
  B.1.2 Output Signals ............................................. 37
B.2 Environmental Performance .................................. 37
  B.2.1 Temperature ................................................. 37
  B.2.2 IP rating ...................................................... 37

Appendix C Calibration Certificates .................................. 39
C.1 Example calibration certificates ................................ 39

Appendix D Return Policy ............................................. 45
D.1 General guidelines ............................................ 45
D.2 New and unused equipment ................................... 45
D.3 Used equipment ............................................... 45
Chapter 1
Introduction

1.1 Safety guidelines

Handle the 7835 Explosion Proof Liquid Density meter with great care.

- Do not drop the meter or subject it to severe mechanical shock.
- Do not expose the meter to excessive vibration.
- Ensure axial loading from pipework does not exceed 1/2 tonne.
- Ensure all electrical safety requirements are applied.
- Ensure the meter and associated pipework have been pressure tested to 1-1/2 times the maximum operating pressure.
- Do not use liquids incompatible with the construction.
- Do not operate the meter above its rated pressure.
- Do not expose the meter to excessive vibration (> 0.5 g continuous).
- Ensure meter is not transported when it contains hazardous substances. This includes fluids that may have leaked into, and are still contained, within the case.
- To return a meter, refer to Appendix D for more information on the Micro Motion return policy.

Safety messages are provided throughout this manual to protect personnel and equipment. Read each safety message carefully before proceeding to the next step.

1.2 Product overview

This meter will provide a continuous on-line measurement of density and temperature of the process fluid being measured. The construction of the meter is to explosion proof standards, allowing installation in hazardous areas. Operational parameters can be found in the product specification.
Introduction

![Sideways view of the 7835 Explosion Proof Liquid Density meter](image)

Liquid density is determined from the resonant frequency of a vibrating tube containing the liquid, and liquid temperature is determined from a 100 $\Omega$ RTD.

1.3 Product range

The product range is summarized in Table 1-1. The meters are identical mechanically, except for the material used in the wetted parts, and the flanges/couplings. A fully welded design is utilized to ensure maximum reliability in the most severe environments. In the unlikely event of a leak occurring in the center tube assembly, the outer casing will withstand a line pressure rating of up to 100 bar (1450 psi).

Table 1-1. 7835 Explosion Proof Liquid Density meter range

<table>
<thead>
<tr>
<th>Meter</th>
<th>Tube material</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>7835</td>
<td>Ni-Span-C\textsuperscript{o}</td>
<td>Low temperature coefficient and long term stability, appropriate for fiscal applications.</td>
</tr>
</tbody>
</table>

1.4 Electronics product range

The 7835 Explosion Proof Liquid Density meter has the following electronics.

Table 1-2. Standard electronics board

<table>
<thead>
<tr>
<th>Standard Electronics</th>
<th>Density version</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Basic amplifier circuit providing a frequency signal (indicating liquid density) and RTD resistance (indicating liquid temperature).</td>
<td></td>
</tr>
<tr>
<td>• Interfaces with a Micro Motion\textsuperscript{®} Signal Converter or Flow Computer.</td>
<td></td>
</tr>
<tr>
<td>• Features 6 screw-terminals for power in, and outputs.</td>
<td></td>
</tr>
</tbody>
</table>
1.5 **2004/22/EC (MID) applications**

Mobrey Limited, a division of Emerson Process Management, has evaluated the 7835 and 7845 liquid density meters against OIML R117-1:2007 and WELMEC guide 8.8 for use in measuring systems for the continuous and dynamic measurement of quantities of liquids other than water. This evaluation was in compliance with the European Measuring Instrument directive (2004/22/EC) annex MI-005. You may use the evaluation certificate for the 7835 liquid density meter, with written permission of Mobrey Limited to assist in obtaining an EC-type examination certificate for the complete measuring system.
Introduction
Chapter 2
Installation Procedure

2.1 General

This chapter describes the mechanical installation of the 7835 Explosion Proof Liquid Density meter.

2.2 Safety Information

2.2.1 General information applicable to the complete system

- These safety instructions are to be used whenever handling or operating this product. Suitably trained personnel shall carry out the installation both mechanical and electrical in accordance with the applicable local and national regulations and codes of practice for each discipline.
- Safe working practices for the media and process concerned must be followed during the installation and maintenance of the equipment. Depressurize and isolate the system before starting to loosen or remove any connection.
- If the equipment is likely to come into contact with aggressive substances, it is the responsibility of the user to take suitable precautions that prevent it from being adversely affected.
- It is the responsibility of the installer/user of this equipment to ensure:
  - This product is not used as a support for other equipment or personnel.
  - This product is protected from impact.
- It is important that this sensor is handled with care due to its weight and sensitivity to impact; ensure lifting straps are fitted around flanged ends.
2.2.2 **Pressure bearing parts**

- It is the responsibility of the installer/user of this equipment to ensure:
  - The materials of construction are suitable for the application.
  - All piping connections conform to the local and national regulations and codes of practice.
  - The pressure and temperature limits for this equipment are not exceeded, if necessary by the use of suitable safety accessories. See Table 2-1.

- Correct gaskets/seals are fitted and are compatible with the media and process.
- The installed sensor is adequately supported for weight and vibration effects.
- Personnel are protected from hot burns by guards, thermal lagging or limited access. Allow time to cool prior to carrying out maintenance operations. It is recommended that “HOT” notices are fitted in the vicinity of the equipment where applicable.
- Regular inspection for corrosion and wear are carried out, both internal and external.
- The sensor must not be fitted until all installation work and final pre commissioning checks are carried out. Do not remove blanking plugs until the sensor is fitted.
- The sensor must be installed in compliance with this manual, to ensure correct fitting. This applies to all variants.
- The user should not repair this equipment, but general maintenance can be applied as described within this manual.

### Table 2-1 Pressure ratings: 316/316L dual-rated stainless steel

<table>
<thead>
<tr>
<th>Flange fitting</th>
<th>Pressure Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°C</td>
</tr>
<tr>
<td>Class 600</td>
<td>1440.2 psi (99.3 bar)</td>
</tr>
<tr>
<td>PN40</td>
<td>580.2 psi (40.0 bar)</td>
</tr>
<tr>
<td>PN100</td>
<td>1450.4 psi (100.0 bar)</td>
</tr>
</tbody>
</table>
2.3 Installation planning

When planning the installation of a meter, it is important to consider the following factors:

Table 2-2. Installation considerations

| Safety                  | When installing in a process line, it is important that the construction material of the wetted parts (tube) is matched to the non-corrosive performance of the liquid passing through the instrument. Failure to observe this requirement can cause deterioration of the central tube (the bellows) and loss in measurement accuracy, or even a failure if leaking occurs. For advice on which meter in the range is appropriate, please contact Micro Motion.
|                        | The Ni-SPAN-C material of the central tube is not rated for 'sour' service as defined in NACE specification MR0103-2005. For advice in this application, please contact Micro Motion.

| Serviceability         | Installing the meter in a by-pass configuration allows it to be removed for servicing or calibration without affecting the main pipeline. Possible by-pass configurations are shown in Figure 2-3.

| Performance            | Axial load should not exceed ½ tonne, so pipe-work should have a degree of flexibility. Excessive pipe vibration should be avoided. Figure 2-2 for preferable mounting positions.
| Pipe stresses and vibration | The presence of gas bubbles can seriously affect the meter performance and so the following points should be considered:
  |                        | • The liquid must always be at a pressure substantially above its vapor pressure.
  |                        | • All pipe-work couplings and joints must be airtight.
  |                        | • No vortex should be present at the inlet to the meter.
  |                        | • Cavitations, caused by pumping, should not generate bubbles from dissolved gases.
  |                        | • If a pump is used it should 'push' rather than 'pull' the product through the meter.

| Meter orientation      | • For low flow rates, for example 750 liters/hour (2.7 gal/min.), the meter should preferably be mounted vertically or at an incline, with the flow in an upwards direction.
  |                        | • If the liquid contains solid particles, the direction of flow should be upwards unless the particles are large enough not to be carried with the flow, in which case the direction of flow should be reversed.
  |                        | • The meter should be mounted with the electric cable running downwards thereby minimizing the ingress of water should a cable gland become defective.

| Flow rate              | A fast flow rate, for example 3000 liters/hour (11 gal/min.), will help to achieve good temperature equilibrium and have a self-cleaning action.
  |                        | A low flow rate, for example 1000 liters/hour (3.7 gal/min.), is recommended if the product contains particles which may cause erosion.
  |                        | The meters exhibit a small flow dependent density reading. For flow rates up to 15000 liters/hour (55 gal/min) and assuming no consequent line pressure or product changes, the maximum density offset will be less than 0.2 kg/m³.

| Temperature stability  | Thermally lag the meter and the inlet and slipstream/bypass-loop pipework to ensure good temperature stabilisation.

2.4 Meter mounting and pipework

This section considers in more detail the mounting of the meters and the design of the associated pipework, including the calculation of pressure drop in the meter.

The preferred methods of supporting the meter are shown in Figure 2-1.
For continuously high flow rates, the mounting position can be selected to simplify the associated pipework and help minimize the pressure and temperature losses (see Figure 2-2).
Installation Procedure

Figure 2-2  Preferred methods of mounting meter (angles)

1st
Electric Cable

Direction of flow should be reversed for slurries.

90°

2nd
Electric Cable

Direction of flow should be reversed for slurries.

>60°

3rd
Flow rate should be kept high to prevent gas bubbles & sediment from forming on the resonant tube.
Installation Procedure

Figure 2-3 Typical bypass pipeline configurations

'S' Bend Method

Pressure Bend Method

Laminar Flow Method

Pitot Tube Method

Orifice Plate Method

Pump Method

Direction of Flow

Integral Cleaning System
Installation Procedure

2.5 Pressure drop in the meter

The pressure drop in the meter depends on:

- Flow rate \( V \), and
- Kinematic viscosity \( \nu \)

2.6 Calculation of pressure drop in the meter

The meter should be considered as a straight pipe of 23.6 mm (0.929”) internal diameter and 1.03 m (40.551”) in length. The following formula has been proven to apply to the meter by measurements at 12000 liters/hour (44 gal/min).

\[
h = \frac{200 \times f \times L \times V^2 \times \rho}{g \times D}
\]

Where:

- \( h \) = Pressure drop (bars)
- \( f \) = Friction coefficient
- \( L \) = Pipe length (m) = 1.03 mm
- \( D \) = Internal pipe diameter (mm) = 23.6 mm
- \( V \) = Mean fluid velocity (m/s)
- \( \rho \) = Fluid density (g/cc)
- \( g = 9.81 \) (m/s²)

For viscous or laminar flow (Reynolds Number \( R_e \) less than 2000):

- Frictional Coefficient \( f \) = \( 16 \div R_e \)

For turbulent flow (\( R_e \) greater than 2500):

- Frictional Coefficient \( f \) = \( 0.064 \div R_e^{0.23} \)

Where, pipe \( R_e = 1000 \times V \times D \div \nu \) \( [\nu = \text{kinematic viscosity (cS)}] \)

In addition to the pressure drop caused by the liquid flow through the instrument, it will be necessary to calculate the pressure drop in any associated sample pipework before concluding the system design requirements.

2.7 Post-installation checks

After installation, the meter should be pressure tested to 1.5 times the maximum working pressure of the system but not to a value exceeding the meter test figure shown on the meter label.

⚠️ If the pressure test figure is exceeded, the meter may be irrevocably damaged.

---

Table 2-3. Pressure drop at various flow rates

<table>
<thead>
<tr>
<th>Flow Rate (liters/hour)</th>
<th>Flow Velocity (V m/s)</th>
<th>( \nu = 2 ) cS</th>
<th>( \nu = 10 ) cS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.6</td>
<td>0.003</td>
<td>0.004(1)</td>
</tr>
<tr>
<td>4000</td>
<td>2.5</td>
<td>0.033</td>
<td>0.048</td>
</tr>
<tr>
<td>12000</td>
<td>7.6</td>
<td>0.238</td>
<td>0.345</td>
</tr>
</tbody>
</table>

(1) Indicates laminar flow (fluid density 1.0 g/cc)
2.8 Installation drawings

Figure 2-4. Installation drawing for 7835 with standard electronics
Chapter 3
Electrical Connections (Standard)

3.1 General
This chapter describes the electrical installation of the 7835 Explosion Proof Liquid Density meters with Standard Electronics fitted.

3.2 MID (2004/22/EC) Requirements
To comply with the MID (2004/22/EC) directive:

- Unused cable ports must be sealed with suitably rated blanking plugs.
- After commissioning or maintenance of the meter, you must seal the enclosure cover to secure legally relevant parameters from unauthorized modification.

See Section 3.2.1 for more information on securing the meter from unauthorized access to the meter controls.

3.2.1 Securing the meter for MID
To seal the meter from unauthorized access after commissioning or maintenance, Micro Motion has provided additional holes on the electronics housing cover to attach a locking wire to the transmitter cover. The securing component must bear the mark as laid down by the national inspection authority. Figure 3-1 illustrates the suggested method for sealing the meter.

Note: When installing the meter in a MID measuring system, you must consider the method in which the system will be verified to meet MID requirements. This method may impact the design of the measurement system, and we recommend you involve the national inspection authority early in the design process.
### Electrical Connections (Standard)

3.3 **Ground connections**

There are two earth-bonding points for the meter. One bonding point is located inside the aluminium enclosure for the maintaining amplifier housing. The second bonding point is located on the end plate of the meter body.

The 0 volt power supply lead should be earthed at the supply end.

3.4 **Use with Micro Motion signal converters**

When operated in conjunction with a flow computer or signal converter, only the meter can be operated in the hazardous area. The flow computer (or signal converter) must be sited in a safe area only.

3.4.1 **System connections (Safe Area only)**

The density system connections are illustrated in Figure 3-2.
3.5 Use with customer’s own equipment

3.5.1 System connections (Safe Area only)

- Power supply to density meter: 15.5 V to 33 V dc, 25 mA minimum
- Power supply to RTD: 5 mA maximum

The frequency at which the meter is operating can be detected by using a series resistor in the +VE power line. The value of resistance to be used for a given supply voltage must not exceed the value obtained from the LOAD NOMOGRAM (Figure 3-4). The electrical connections to be made are shown in Figure 3-3.
Electrical Connections (Standard)

Figure 3-3  Electrical connection diagram to customer's own equipment

![Electrical Connection Diagram](image)

Note: See Load Nomogram (Figure 3.3) to determine R value.

Figure 3-4  Load resistance

![Load Resistance Nomogram](image)

Note: It is recommended that the actual load resistor should be 50 ohms less than that given by the Nomogram.
3.6 Post-installation checks

After installation, the following procedure will indicate to a high degree of confidence that the meter is operating correctly.

Measure the current consumption and the supply voltage at the meter amplifier. This should be within the limits:

- 15.5 V to 30 Vdc, 17 mA ±1 mA

With the meter empty, clean and dry, measure the periodic time of the output signal and check that it is as specified on the meter calibration certificate (air check), to within the limits given in the table below.

<table>
<thead>
<tr>
<th>Meter type</th>
<th>Air check limit at 20°C</th>
<th>Added temperature effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>7835</td>
<td>±60 ns</td>
<td>±10 ns/°C</td>
</tr>
</tbody>
</table>
Electrical Connections (Standard)
Chapter 4
Calibration and Performance

4.1 General

The 7835 Explosion Proof Liquid Density meter is calibrated at the factory and is supplied with its own test and calibration certificate (see Appendix C for examples). This certificate specifies the various calibration constants that allow the user to convert the output periodic time signal from the meter into a density value.

4.2 Interpretation of calibration certificate

4.2.1 General density equation

The basic meter constants, $K_0$, $K_1$, and $K_2$ are computed from the factory calibration on three fluids. Using these constants and the general density equation, the density of the liquid within the meter can be calculated.

The general density equation is:

$$D = K_0 + K_1 \tau + K_2 \tau^2$$

Where:

- $D$ = The uncorrected density (kg/m$^3$) of liquid
- $\tau$ = Periodic time (μs) of vibration
- $\tau = 1/f$ where ‘f’ is the frequency of vibration
- $K_0, K_1 & K_2$ = Constants from the Calibration Certificate

It is stated on the calibration certificate that the basic constants are determined from a calibration at a temperature of 20 °C (68 °F) and at a pressure of 1 bar (14.5 psi). If the operating conditions of the meter differ from that of the calibration conditions, a correction to the density calculated using the general equation is required.
4.2.2 Temperature correction

If the meter operates at temperatures other than 20 °C (68 °F), a correction to the density calculated using equation (1) must be made using the temperature coefficient data given on the calibration certificate.

The equation used for this correction is:

\[
D_t = D[1 + K18(t - 20)] + K19(t - 20)
\]

Where: 
- \( D_t \) = Temperature corrected density (kg/m³)
- \( D \) = Density calculated using equation 1
- \( t \) = Temperature (degrees C)
- \( K18 \) and \( K19 \) = Constants from the Calibration Certificate

4.2.3 Pressure correction

The meter design has a unique facility to reduce the influence of the line pressure on the density measurement but there is a residual effect for which correction may be required. This residual pressure effect before a pressure correction is illustrated for the 7835 Exd meter in the following figures.

Figure 4-1 Pressure effect on the 7835 Exd meter before pressure correction (at 20°C)
Calibration and Performance

During the calibration of the meter, which is normally performed at a pressure of 1 bar (14.5 psi), the pressure influence is also measured. This data is also shown on the calibration certificate (see Appendix C).

The equation used to apply pressure correction is:

\[ D_p = D_t \left[ 1 + K20(P - 1) \right] + K21(P - 1) \]

Where:
- \( D_p \) = Temperature and pressure corrected density (kg/m³)
- \( D_t \) = Temperature corrected density (kg/m³)
- \( P \) = Pressure in bar absolute
- \( K20 = K20A + K20B(P - 1) \)
- \( K21 = K21A + K21B(P - 1) \)

Note: \( K20A, K20B, K21A, \) and \( K21B \) are the pressure coefficient constants on the calibration certificate.

Note: The pressure correction is further enhanced on units that operate above 41 bar (595 psi) by having sets of pressure coefficient constants covering subsets of the full operating pressure range. Only one set of pressure coefficient constants is selected from your calibration certificate according to your operating pressure range. If your operating pressure range falls within the range of two sets of pressure coefficient constants, contact Micro Motion for a new calibration certificate. See Appendix C for an example calibration certificate.

Note: If it is required to apply temperature and pressure corrections, the temperature correction is applied first.

Figure 4-2 shows the typical residual error curves after pressure corrections for 7835 (100Bar) units using three sets of pressure coefficient constants. Each set covers a sub-set of the 100Bar range. The uncertainty specification for a 7835 is indicated by the upper and lower limit lines. The uncertainty for the 7835 pressure coefficients is ±0.003 kg/m³. This is in addition to the instrument calibration uncertainty of ±0.15 kg/m³.

Note: Only one set of pressure coefficient constants is selected from your calibration certificate according to your operating pressure range. For specimen calibration certificates, see Appendix C.
Optimization for pressure-temperature coupling effect (7835 meters only)

For the calibration of 7835 meters, a new generic constant is being applied to calculate the K21A pressure coefficient that is valid for use over a limited operating temperature and pressure range. The revised K21A pressure coefficient is selected from a table in a new format calibration certificate and is unique to the 7835 meter. The application of this K21A coefficient does not change the density calibration coefficient format or the density calibration equations previously used in the flow computer software.

*Note: This constant can only be applied to 7835 meters that have been calibrated at the factory beginning in January 2011. Additionally, it is not possible to recalculate a revised K21A for units that have been recertified at external calibration facilities.*

The new constant is being applied as an intermediary measure to meet the requirements of the United Kingdom Department of Energy and Climate Change (DECC) directive regarding the calibration of liquid density meters. The DECC directive recommended that by July 2011 all density meters be calibrated at the anticipated operating conditions (such as simultaneously at temperature and pressure). Micro Motion is in process of redesigning the calibration stands so that they can operate at a combined elevated temperature and pressure. These stands are planned to be completed and operational by July 2011.

For an example of the calibration certificate that includes the new K21A pressure coefficients, see Appendix C.

### 4.2.4 Velocity of sound correction

The Velocity of Sound (VOS) in the process liquid may have an effect on the accuracy of the indicated density. The calibration of the 7835 meter has been optimized to a density/VOS relationship as indicated in Figure 4-3. If the VOS of the process fluid deviates substantially from the relationship in Figure 4-3, it may be desirable to apply a correction. This may be achieved by the simple introduction of a calibration offset using the data in Figure 4-3. Adjustment of the value $K_0$ in the basic equation will achieve this.
Alternatively, the following equations may be used:

\[
D_{VOS} = D_p \left[ 1 + \frac{1.4E06}{D_p + 1400} \times \left( \frac{1}{V_C^2} - \frac{1}{V_A^2} \right) \right]
\]

Where: 
- \( D_{VOS} \) = Velocity of sound and temperature corrected density (kg/m³)
- \( D_p \) = Temperature and pressure corrected density (kg/m³)
- \( V_C \) = Calibration VOS (m/s)
- \( V_A \) = Liquid VOS (m/s)

\( V_C \) can be obtained direct from Figure 5.2 or may be calculated as follows:

\[
V_C = 100 + 1455D_p \quad \text{for a } D_p \text{ of 300kg/m}^3 \text{ to 1100kg/m}^3
\]

\[
V_C = 2690 - 0.9D_p \quad \text{for a } D_p \text{ of 1100kg/m}^3 \text{ to 1600kg/m}^3
\]

Figure 4-3  Optimized velocity of sound relationship for the 7835 Exd meter

Values shown are the required corrections
True density = Indicated density + Corrections
4.3 Calibration

4.3.1 Factory calibration

The 7835 Explosion Proof Liquid Density meters are calibrated prior to leaving the factory against Transfer Standard instruments, traceable to National Standards. Three fluids are used in the calibration – ambient air whose density is derived from look-up tables, hydrocarbon oil of about 815 kg/m³ density and a high-density fluid in the range 1400 to 1500 kg/m³ density. Several of the instruments-under-test are connected in parallel between two Transfer Standard Instruments on the Micro Motion special flow rig. During a calibration, and as the liquid flows through the instruments, readings are only taken when the indicated densities on the two Transfer Standard Instruments agree. In this way, a high integrity of calibration is achieved.

Measurements are also made under conditions of changing temperature and pressure to establish the magnitude of these effects on the instrument. From all this data, a calibration certificate is generated for each instrument.

Samples of the instruments are further tested by the Micro Motion Quality Assurance Department to verify the calibration.

4.3.2 Calibration of transfer standards

The Transfer Standard instruments used in the calibration are selected instruments that are calibrated and certified by the ISO/IEC17025-certified calibration laboratory.

Transfer Standard calibration uses a number of ‘density certified’ liquids. The densities of these certified liquids are obtained using the Primary measurement system, whereby glass sinkers of defined volumes are weighed in samples of the liquids.

Calibration is performed by pumping each certified liquid through the Transfer Standard in a closely controlled manner and recording the output signal in each case. A calibration certificate is issued for each Transfer Standard.

Calibrations are repeated, typically every six months, producing a well-documented density standard.

4.3.3 Instrument calibration certificate

Each instrument is issued with its own calibration certificate (see Appendix C for samples), containing four important pieces of data:

- The instrument serial number.
- The output signal/density relationship. This is based on three calibration points – air, medium density and high-density fluids. The air and high density fluid points are offset to achieve the product velocity of sound/density profile described earlier. However, the signal value at Air Density is also given for check purposes.
- Temperature coefficient data, describing the correction which should be applied to achieve the best accuracy if the instrument is operating at product temperatures other than 20 °C (68 °F).
- Pressure coefficient data, describing the correction that should be applied to achieve the best accuracy if the instrument is operating at elevated pressures.

A second page of the calibration certificate is retained by Micro Motion and contains all the calibration measurements.
4.3.4 Pressure test
A hydrostatic pressure test is carried out to a pressure value specified on the instrument label and on
the instrument calibration certificate. This test loads the instrument structure to a pressure that
exceeds the maximum permitted operating pressure of the instrument.

*Note: During manufacture, the welded structure is pressure tested to conform to the requirements of
EN50018:1997. The outer case is able to withstand 100 bar of internal pressure in the event of
tube/bellows failure.*

4.3.5 Insulation test
To comply with Intrinsic Safety requirements, a 500 Vac insulation test is carried out between the
electrical terminals and the instrument case.

4.3.6 Calibration check methods
There are two methods employed in calibration checks:

- Air checkpoint, which is simple and convenient and highlights long term drift, corrosion and
deposition.
- Liquid calibration verification comprising two choices:
  - Drawing off a sample of the liquid being measured and obtaining its density, using a
    hydrometer (for stable liquids) or pyknometer (for unstable liquids).
  - Using a second density meter.

Ambient air check

1. Isolate, drain and if necessary, disconnect the meter from the pipeline.
2. Clean and dry the wetted parts of the meter and leave them open to the ambient air.
3. Apply power to the instrument and check that the time period of the output signal agrees with
   the 'Air Check' figure shown in the calibration certificate, to within acceptable limits.
   Some variation between the two figures is to be expected due to changes in ambient air
   conditions. The density indication if using the K0, K1 and K2 factors will be about –0.9 kg/m^3
   because the basic density equation has been optimized for best performance over the normal
   operating density range.
   This test will indicate whether there has been a calibration offsets due to corrosion, deposition
   or long term drift.

<table>
<thead>
<tr>
<th>Meter</th>
<th>Temperature correction</th>
<th>Air check limit at 20 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>7835</td>
<td>±10 ns/°C</td>
<td>±60 ns</td>
</tr>
</tbody>
</table>

4. Reconnect the meter to the pipeline if serviceable, or remove it for further servicing.

Liquid density check – sample method

If it is necessary to verify the calibration using liquid at operating conditions, then the following
sample methods are recommended:

For Stable Liquids:
1. Draw off a sample of the liquid into a suitable container, at the same time noting the indicated
density, temperature and pressure of the liquid.
2. Measure the density of the sample under defined laboratory conditions, using a hydrometer or
other suitable instrument.
3. Refer the density measurement under laboratory conditions to that under the line operating
conditions of temperature and pressure.
4. Compare the referred density figure with that indicated by the density meter.

Note: It is essential that a good understanding of the physical properties (temperature coefficient,
etc.) of the liquid is acquired when using this method.

For Unstable Liquids:
1. Couple a pressure pyknometer and its associated pipework to the pipeline so that a sample of
the liquid flows through it.
2. When equilibrium conditions are reached, the meter density reading is noted as the
pyknometer is isolated from the sample flow.
3. Remove the pyknometer for weighing to establish the product density.
4. Compare the pyknometer registered density with that obtained from the meter.

Sampling Techniques
Sampling should comply with the international sampling standards (ISO 3171, ASTM D 4177, API
8.2 and IP 6.2).

For further details of these procedures, reference should be made to:

Part VII Section 1 – Method IP 160 (Hydrometer Method)
(BS2000–160, ISO3675, ASTM 1298)

Part VII Section 2 – Continuous Density Measurement

Chapter 14 – Natural Gas Fluids – Section 6:

Installing and proving density meters used to measure
hydrocarbon liquid with densities between 0.3 and 0.7 g/cc at
15.56 °C (60 °F) and saturation vapor pressure, 1991.

Liquid density check – second density meter
It is often the practice, especially in fiscal metering applications, to use two or more density meters in
a continuous measurement mode as a means of improving the integrity of the measurement system.
Any unacceptable discrepancies between the measurements can immediately raise the necessary
alarm signals.

1. Connect the second density meter to the pipeline adjacent to meter being checked so that it
receives the same sample of fluid under the same conditions of temperature and pressure as the
meter under test.
2. Connect the second meter to its readout equipment, switch on and allow both systems to reach
equilibrium conditions.
3. Compare the two readings, making any necessary corrections.
This method of automatic checking has proved to be a very successful technique and where there is a facility for two instruments, the practice of exchanging one for a newly calibrated instrument is proving successful. This is sometimes referred to as the "Substitution Method".

It is very important when using one instrument to verify the performance of a second and similar instrument, to ensure there are no unaccounted for systematic errors which would are not highlighted.

4.4 Performance

Micro Motion meters are generally calibrated using specified fluids at 20 °C and 1 bar absolute. When operating at other conditions, it is necessary to increase the uncertainty of measurement by the magnitude of the offsets if no corrections are applied or by a fraction of the offsets if corrections are applied.

The following table lists the sources and magnitudes of the offsets affecting the meters covered in this manual (including an example below).
For total operational accuracy, the square root of the sum of the squares of each error source (C to G) is recommended, such as:

\[
\text{Effective Total} = \sqrt{C^2 + D^2 + E^2 + F^2 + G^2}
\]

For example, if we consider instruments operating at 50 °C (122 °F) and 50 bar, six months after calibration and with no VOS offset, the total operational accuracy after corrections have been applied is derived as follows:

**Table 4-2. Total operational accuracy for example quoted**

<table>
<thead>
<tr>
<th>Error Source</th>
<th>7835</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.15</td>
</tr>
<tr>
<td>D</td>
<td>0.15</td>
</tr>
<tr>
<td>E</td>
<td>0.15</td>
</tr>
<tr>
<td>F</td>
<td>–</td>
</tr>
<tr>
<td>G</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Effective Total</strong></td>
<td><strong>0.27</strong></td>
</tr>
</tbody>
</table>

For better accuracy, it would be necessary to carry out an on-line calibration at the operating conditions. Higher accuracy can be obtained, by request, for all instruments by the use of water calibration or by UKAS certified laboratory calibration of selected fluids.

*Note: The tables above relate to the effect of uncertainties on the time period output of the meter, and do not take into account any uncertainty in the measurement of the time period itself.*
Chapter 5
General Maintenance

5.1 General
The 7835 Explosion Proof Liquid Density meters have no moving parts, which reduces the maintenance requirement to simple visual checks for leaks and physical damage.

Check calibrations should be carried out at specified intervals in order to highlight any malfunction or deterioration in meter performance. If a fault or a drop in meter performance is discovered, further tests are required to identify the cause of the fault. Remedial action is limited to cleaning the tube, making good any poor connections and replacing the maintaining amplifier or, in extreme cases, the entire instrument.

⚠ Extreme care is required in the handling of the meter during transit, its installation into the pipeline and its removal from the pipeline.

5.2 Fault analysis
Faults generally fall into two main categories: erratic readings or readings outside limits.

- **Erratic Readings**
  Normally caused by the presence of gas bubbles in the flowing liquid. Severe electrical interference or severe pipeline vibrations can also cause this effect.

- **Readings Outside Limits**
  Normally caused by deposition and/or corrosion on the resonating tube.

Since an electrical fault could also cause either of the two faults, and since examination for deposition or corrosion requires the removal off-line of the meter, it is recommended that the electrical system be checked first.

5.3 General maintenance procedure
This procedure is recommended for any periodic maintenance carried out on the system and forms the basis of any faultfinding task.

5.4 Physical checks
Physical checks are as follows:

- Examine the meter and its mounting bracket, pipe couplings and electrical cables for signs of damage and corrosion.
- Check the meter for signs of fluid leakage and the state of the rupture plate.
General Maintenance

Notes:

- Any physical damage to the meter case or mounting brackets may have adverse effects on the meter performance and a full calibration would be advisable to verify its accuracy.
- Any oil leakage can generally be remedied by servicing.

5.4.1 Check calibration

Checking the calibration is as follows:

- Carry out a check calibration using methods detailed in Chapter 4.
- Compare the results obtained with the current calibration certificate figures to identify any substantial deterioration in the meter’s performance or any malfunction.

Notes:

- A substantial drop in meter performance is likely due to a build-up of deposition on the vibrating tube, which can be removed by the application of a suitable solvent. See Section 5.4.2 below.
- Malfunctions may be the result of electrical/electronic faults in either the meter circuit or the readout equipment. The readout equipment should be proved before attention is directed to the meter as detailed under Section 5.4.2.

5.4.2 Remedial servicing

The required servicing falls into two categories – electrical and mechanical.

Electrical servicing

1. Follow the steps below.
   a. Carry out power supply and current consumption tests at the meter terminals. These should give: 17 mA ± 1 mA at 15.5 V to 30 V.
   b. Remove the power supply to the meter. If current consumption is suspect, replace the meter amplifier.
   c. Identify the drive coils (terminals 7 and 8) and disconnect the drive coil wires from the amplifier. Measure the resistance of the drive coils. This should be: 95 ± 5 ohms at 20 °C (68 °F).
   d. Reconnect the drive coil wires to the amplifier.
2. Identify the pick-up coils (terminals 9 and 10) and disconnect the pick-up coil wires from the amplifier. Measure the resistance of the pick-up coils. This should be: 95 ± 5 ohms at 20 °C (68 °F).
   Reconnect the pick-up coil wires to the amplifier.
3. Follow the steps below.
   a. Check the 100 Ω RTD element across the terminals 11 and 12 (ensure terminals 3 to 6 are disconnected). The value of the element resistance is temperature dependent. For this data, see the product specifications appendix.
   b. Check for continuity between terminals 11 and 3, and terminals 11 and 4, also from terminals 12 to 5 and 12 to 6.
4. Carry out an insulation test by removing all the input connections to the amplifier terminals (1 to 7 inclusive) and short-circuit the terminals together. Test their insulation resistance to the metal case using a 500 V dc insulation tester (current limited to 5 mA maximum). This resistance must be greater than $2 \, \text{M} \Omega$.

Remove the short-circuit, and reconnect the input leads if required.

**Mechanical servicing**

Mechanical servicing comprises mainly of keeping the inner surface of the vibrating tube clear of deposition and corrosion. Deposition may be removed by the use of a suitable solvent. Alternatively, the instrument can be removed from the pipeline and cleaned mechanically. Care is required to prevent damage to the inner surface of the tube during the cleaning.

⚠️ **Great care is essential in handling the meter during transit, installation into the pipeline and removal from the pipeline.**

Ensure that the meter is not transported when it contains hazardous fluids. This includes fluids which may have leaked into, and are still contained, within the case.
## Appendix A

### 7835 Explosion Proof (Exd) Specifications

#### A.1 Density performance

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>±0.0001 g/cc</th>
<th>±0.00015 g/cc</th>
<th>±0.1 kg/m³</th>
<th>±0.15 kg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Enhanced calibration)</td>
<td></td>
<td></td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(Standard calibration)</td>
<td></td>
<td></td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>Operating Range</td>
<td>Up to 3 g/cc</td>
<td>Up to 3000 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repeatability</td>
<td>±0.00002 g/cc</td>
<td>±0.02 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stability</td>
<td>±0.00015 g/cc</td>
<td>0.15 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Temperature Effect</td>
<td>±0.000005 g/cc</td>
<td>±0.005 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Corrected) (3)</td>
<td>±0.00278 g/cc</td>
<td>±0.278 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Pressure Effect</td>
<td>±0.000003 g/cc</td>
<td>±0.003 kg/m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Corrected) (4)</td>
<td>±0.000021 g/cc</td>
<td>±0.021 kg/m³</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Accuracy is dependent upon the calibration option chosen. Density range for which this accuracy applies depends on the calibration option chosen.

(2) Stated accuracy is for operating density range of 0.3 to 1.1 g/cc (300 - 1100 kg/m³).

(3) Temperature effect is the maximum measurement offset due to process fluid temperature changing away from the density calibration temperature.

(4) Pressure effect is defined as the change in sensor density sensitivity due to process pressure changing away from the calibration pressure. To determine factory calibration pressure, refer to calibration document shipped with the 7835. If data is unavailable, contact the factory.

#### A.2 Temperature specifications

| Operating Range | –50 °C to +110 °C (–58 °F to +230 °F) |

Integral temperature sensor:

<table>
<thead>
<tr>
<th>Technology</th>
<th>100 Ohms RTD (4 wire)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>BS 1904 Class, DIN 43760 Class A</td>
</tr>
</tbody>
</table>
A.3  Pressure ratings

<table>
<thead>
<tr>
<th><strong>Maximum operating pressure</strong></th>
<th>Explosion proof (Exd)</th>
<th>1450 psi (100 bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test pressure</strong></td>
<td>Tested to 1.5 times the maximum operating pressure</td>
<td></td>
</tr>
<tr>
<td><strong>PED compliance</strong></td>
<td>Complies with European directive 97/23/EC on Pressure Equipment.</td>
<td></td>
</tr>
</tbody>
</table>

A.4  Hazardous area classifications

### ATEX Explosion Proof

ATEX-approved Exd 7835: Certification for use in Europe

| 7835 (Frequency Output): | (7835****AK****) | ATEX II2G EEx d IIC T6 (Ta –40 °C...+70 °C) |

### CSA Explosion Proof

CSA-approved Exd 7835: Certification for use in Canada and USA

| 7835 (Frequency Output): | (7835****AM****) | Class I, Division 1 Groups C & D, T3C |

A.5  OIML R117-1 classifications


<table>
<thead>
<tr>
<th><strong>Viscosity range</strong></th>
<th>0.75 cP to 50 cP (0.75 mPa·s to 50 mPa·s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density range</strong></td>
<td>0.7 g/cc to 1.2 g/cc (700 kg/m³ to 1200 kg/m³)</td>
</tr>
<tr>
<td><strong>Temperature range ambient</strong></td>
<td>−40 °F to +158 °F (−40 °C to +70 °C)</td>
</tr>
<tr>
<td><strong>Environmental class</strong></td>
<td>Mechanical: M2</td>
</tr>
<tr>
<td></td>
<td>Electromagnetic: E2</td>
</tr>
<tr>
<td><strong>Maximum pressure</strong></td>
<td>Fluid temperature range</td>
</tr>
<tr>
<td>928.2 psi (64 bar)</td>
<td>+23 °F to +131 °F (−5 °C to +55 °C)</td>
</tr>
<tr>
<td>1450.4 psi (100 bar)</td>
<td>+32 °F to +104 °F (0 °C to 40 °C)</td>
</tr>
<tr>
<td>1450.4 psi (100 bar)</td>
<td>+23 °F to +131 °F (−5 °C to +55 °C)</td>
</tr>
</tbody>
</table>

A.6  Electromagnetic compatibility

All versions conform to the latest international standards for EMC, and are compliant with EN 61326/IEC 61326.
7835 Explosion Proof (Exd) Specifications

A.7 Materials of construction

<table>
<thead>
<tr>
<th>Wetted parts</th>
<th>Ni-Span-C® and 316L Stainless steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case finish</td>
<td>316L Stainless steel</td>
</tr>
<tr>
<td>Flange</td>
<td>316L Stainless steel</td>
</tr>
</tbody>
</table>

A.8 Weight

<table>
<thead>
<tr>
<th>Weight</th>
<th>Explosion proof (Exd) 77 lb (35 kg)</th>
</tr>
</thead>
</table>

A.9 Electrical

<table>
<thead>
<tr>
<th>Power supply (Standard version)</th>
<th>16 to 28 VDC at 17 mA maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outputs (Standard version)</td>
<td>Current modulation on power supply line</td>
</tr>
</tbody>
</table>

A.10 Safety approval

See the ATEX or CSA Safety Instructions booklet for explosion proof liquid density meters for safety approval information. The booklet was shipped with the product or is available at www.micromotion.com.
Appendix B
Electronics Specifications

B.1 Standard Electronics

B.1.1 Meter Power Supply

<table>
<thead>
<tr>
<th>Safe Areas:</th>
<th>+16 V to +28 Vdc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Areas:</td>
<td>+24 V (nominal)</td>
</tr>
<tr>
<td>Minimum Input Voltage</td>
<td>&gt; 15.5 Vdc</td>
</tr>
</tbody>
</table>

B.1.2 Output Signals

<table>
<thead>
<tr>
<th>Output Signals:</th>
<th>2 wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 V across 180 Ω</td>
<td></td>
</tr>
<tr>
<td>4 V across 390 Ω</td>
<td></td>
</tr>
</tbody>
</table>

B.2 Environmental Performance

B.2.1 Temperature

<table>
<thead>
<tr>
<th>Standard Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating:</td>
</tr>
<tr>
<td>Storage:</td>
</tr>
</tbody>
</table>

B.2.2 IP rating

| Standard electronics enclosure: | IP66 |
Appendix C
Calibration Certificates

C.1  Example calibration certificates

The following certificates are examples of the calibration certificate for the liquid density meters. None of these are the calibration certificates for your product. The calibration certificate for your product is shipped with the unit.
Figure C-1  Example of a calibration certificate with pressure-temperature coupling optimization  
(page 1 of 2)

CALIBRATION CERTIFICATE  
Temperature-Pressure Coupling  
(Generic Constant)

7835B LIQUID DENSITY METER  
7835BAFAJTAAX  
Serial No : 356283  
Cal. Date : 30SEP10  
Pressure Test : 151 BarA

DENSITY CALIBRATION AT 20°C AND AT 1 BarA

<table>
<thead>
<tr>
<th>DENSITY [Kg/m³]</th>
<th>PERIODIC TIME [µS]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Air 1085.965</td>
<td>1086.354</td>
</tr>
<tr>
<td>300 1206.303</td>
<td>K0 = -1.13597E+03</td>
</tr>
<tr>
<td>600 1314.344</td>
<td>K1 = -2.62138E-01</td>
</tr>
<tr>
<td>800 1381.273</td>
<td>K2 = 1.20451E-03</td>
</tr>
<tr>
<td>900 1413.447</td>
<td></td>
</tr>
<tr>
<td>1000 1444.844</td>
<td></td>
</tr>
<tr>
<td>1100 1475.519</td>
<td>K0 = -1.13262E+03</td>
</tr>
<tr>
<td>1200 1505.519</td>
<td>K1 = -2.70949E-01</td>
</tr>
<tr>
<td>1600 1619.559</td>
<td>K2 = 1.20908E-03</td>
</tr>
</tbody>
</table>

TEMPERATURE COEFFICIENT DATA

K18 = -1.83580E-05  
K19 = 1.50424E-02

PRESSURE COEFFICIENT DATA

DP = Dt(1+K20(P-1))+K21(P-1)  
K20 = K20A + K20B(P-1)  
K21 = K21A + K21B(P-1)

RANGE ( <41 BarA)  
K20A = -1.93584E-04  
K20B = 8.48471E-07  
K21A = See page 2  
K21B = -4.14979E-03

RANGE (61-101 BarA)  
K20A = -1.39003E-04  
K20B = -2.29104E-07  
K21A = See page 2  
K21B = -2.30520E-03

K20A = -1.93584E-04  
K20B = 8.48471E-07  
K21A = See page 2  
K21B = -4.14979E-03

where  
D = Density (Uncorrected)  
Dt = Density (Temperature Corrected)  
DP = Density (Temperature-Pressure Corrected)  
T = Periodic Time (µS)  
t = Temperature (°C)  
P = Pressure (BarA)
**CALIBRATION CERTIFICATE**

**Temperature-Pressure Coupling**  
(Generic Constant)

---

### Temperature-Pressure Coupling Coefficient Data

#### Table 1: K21A(Coupled) at operation temperature

<table>
<thead>
<tr>
<th>Temp Range</th>
<th>K21A</th>
<th>Pressure Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>°C</td>
<td>&lt;41 BarA</td>
</tr>
<tr>
<td>LO</td>
<td>HI</td>
<td>40</td>
</tr>
<tr>
<td>-35</td>
<td>-30</td>
<td>3.14296E-01</td>
</tr>
<tr>
<td>-30</td>
<td>-25</td>
<td>3.13750E-01</td>
</tr>
<tr>
<td>-25</td>
<td>-20</td>
<td>3.13204E-01</td>
</tr>
<tr>
<td>-20</td>
<td>-15</td>
<td>3.12658E-01</td>
</tr>
<tr>
<td>-15</td>
<td>-10</td>
<td>3.12112E-01</td>
</tr>
<tr>
<td>-10</td>
<td>-5</td>
<td>3.11566E-01</td>
</tr>
<tr>
<td>-5</td>
<td>0</td>
<td>3.10820E-01</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
<td>3.09928E-01</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>3.08836E-01</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>3.07644E-01</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>3.06452E-01</td>
</tr>
<tr>
<td>20</td>
<td>25</td>
<td>3.05260E-01</td>
</tr>
<tr>
<td>25</td>
<td>30</td>
<td>3.03966E-01</td>
</tr>
<tr>
<td>30</td>
<td>35</td>
<td>3.02672E-01</td>
</tr>
<tr>
<td>35</td>
<td>40</td>
<td>3.01378E-01</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>3.00084E-01</td>
</tr>
<tr>
<td>45</td>
<td>50</td>
<td>3.00140E-01</td>
</tr>
<tr>
<td>50</td>
<td>55</td>
<td>3.00196E-01</td>
</tr>
<tr>
<td>55</td>
<td>60</td>
<td>3.00252E-01</td>
</tr>
<tr>
<td>60</td>
<td>65</td>
<td>3.00307E-01</td>
</tr>
<tr>
<td>65</td>
<td>70</td>
<td>3.00363E-01</td>
</tr>
<tr>
<td>70</td>
<td>75</td>
<td>3.00418E-01</td>
</tr>
<tr>
<td>75</td>
<td>80</td>
<td>3.00474E-01</td>
</tr>
<tr>
<td>80</td>
<td>85</td>
<td>3.00529E-01</td>
</tr>
<tr>
<td>85</td>
<td>90</td>
<td>3.00584E-01</td>
</tr>
<tr>
<td>90</td>
<td>95</td>
<td>3.00639E-01</td>
</tr>
<tr>
<td>95</td>
<td>100</td>
<td>3.00694E-01</td>
</tr>
<tr>
<td>100</td>
<td>105</td>
<td>3.00749E-01</td>
</tr>
</tbody>
</table>

---

**Final Test & Inspection**

Ref No: LD7835/V6.09T/FVB  
DATE: 30SEP10

---

Page 2 of 2
CALIBRATION CERTIFICATE

7835B LIQUID DENSITY METER                          Serial No : 356366
7835BAFAAJTAAA                          Cal. Date : 14MAR07
Pressure Test : 151 BARA

DENSITY CALIBRATION AT 20 DEG. C AND AT 1 BARA

<table>
<thead>
<tr>
<th>DENSITY PERIODIC TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>[KG/M3]</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>(Air)</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>600</td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>900</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>1100</td>
</tr>
<tr>
<td>1200</td>
</tr>
<tr>
<td>1600</td>
</tr>
</tbody>
</table>

**DENSITY = K0 + K1.T + K2.T**2**

K0 = -1.10786E+03 (300 - 1100 kg/m3)
K1 = -2.52754E-01
K2 = 1.17101E-03 (300 - 1100 kg/m3)
K0 = -1.10439E+03 (0 - 3000 Kg/m3)
K1 = -2.61778E-01
K2 = 1.17566E-03 (0 - 3000 Kg/m3)

TEMPERATURE COEFFICIENT DATA

Dt=D(1+K18(t-20))+K19(t-20)

K18 = -1.80459E-05
K19 = 1.51725E-02

PRESSURE COEFFICIENT DATA

DP=Dt(1+K20(P-1))+K21(P-1)

K20A = 1.02046E-05 (0 - 31 BARA)
K20B = -1.38764E-06 (0 - 31 BARA)
K21A = 1.70570E-1 (0 - 31 BARA)
K21B = -2.75303E-3 (0 - 31 BARA)
K20A = 5.64682E-06 (31 - 71 BARA)
K20B = -1.25741E-06 (31 - 71 BARA)
K21A = 1.55537E-01 (31 - 71 BARA)
K21B = -2.32351E-03 (31 - 71 BARA)

K20A = 1.02046E-05 (0 - 31 BARA)
K20B = -1.38764E-06 (0 - 31 BARA)
K21A = 1.70570E-1 (0 - 31 BARA)
K21B = -2.75303E-3 (0 - 31 BARA)

where:

D = Density (Uncorrected)
Dt = Density (Temp Corrected)
DP = Density (Pressure Corrected)
T = Periodic Time (uS)
t = Temperature (DEG.C)
P = Pressure (BarA)

-------------
| FINAL TEST | |
| INSPECTION | |
-------------

Ref No:- LD7835/V5.0/FVA DATE : 17MAR07
Figure C-4  Example of certificate with 3 sets of pressure coefficients (US Units)

CALIBRATION CERTIFICATE

7835B LIQUID DENSITY METER  Serial No : 356366
7835BAAFAJTAAA  Cal. Date : 14MAR07
Pressure Test : 2175 PSIG

DENSITY CALIBRATION AT 68 DEG. F AND AT 0 PSIG

<table>
<thead>
<tr>
<th>Density (g/cc)</th>
<th>Periodic Time (us)</th>
<th>DENSITY = K0 + K1.T + K2.T**2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>1086.919</td>
<td>(Air 1086.520)</td>
</tr>
<tr>
<td>0.300</td>
<td>1209.943</td>
<td>K0 = -1.10786E+00 \</td>
</tr>
<tr>
<td>0.600</td>
<td>1320.514</td>
<td>K1 = -2.52754E-04  \</td>
</tr>
<tr>
<td>0.800</td>
<td>1388.922</td>
<td>K2 =  1.17101E-06 /</td>
</tr>
<tr>
<td>0.900</td>
<td>1421.788</td>
<td></td>
</tr>
<tr>
<td>1.000</td>
<td>1453.850</td>
<td>K0 = -1.10439E+00 \</td>
</tr>
<tr>
<td>1.100</td>
<td>1485.163</td>
<td>K1 = -2.61778E-04  \</td>
</tr>
<tr>
<td>1.200</td>
<td>1515.779</td>
<td>K2 =  1.17566E-06 /</td>
</tr>
<tr>
<td>1.600</td>
<td>1632.089</td>
<td></td>
</tr>
</tbody>
</table>

TEMPERATURE COEFFICIENT DATA

Dt=D(1+K18(t-68))+K19(t-68) K18 = -1.00255E-05
K19 =  8.42918E-06

PRESSURE COEFFICIENT DATA

DP=Dt(1+K20(P))+K21(P) K20 = K20A + K20B(P)
K21 = K21A + K21B(P)

RANGE ( <580 PSIG)    RANGE (435-1015 PSIG)
K20A =  7.03762E-07   K20A =  3.89436E-07
K20B = -6.59993E-09   K20B = -5.98057E-09
K21A =  1.17635E-05   K21A =  1.07267E-05
K21B = -1.30941E-08   K21B = -1.10512E-08

RANGE (870-1450 PSIG)
K20A =  -2.47383E-07
K20B = -5.30490E-09
K21A =  8.62626E-06
K21B =  -8.82260E-09

where    D = Density ( Uncorrected )
Dt = Density ( Temp Corrected )
DP = Density ( Pressure Corrected )
T = Periodic Time ( us )
t = Temperature ( DEG.F )
P = Pressure (PSIG)

-----------------------
|  FINAL TEST & |
|  INSPECTION  |
|                |
|                |
|                |
-----------------------

Ref No:-  LD7835/V5.0/FVA  DATE : 17MAR07
Calibration Certificates
Appendix D
Return Policy

D.1 General guidelines
Micro Motion procedures must be followed when returning equipment. These procedures ensure legal compliance with government transportation agencies and help provide a safe working environment for Micro Motion employees. Failure to follow Micro Motion procedures will result in your equipment being refused delivery.

Information on return procedures and forms is available on our web support system at www.micromotion.com, or by phoning the Micro Motion Customer Service department.

D.2 New and unused equipment
Only equipment that has not been removed from the original shipping package will be considered new and unused. New and unused equipment requires a completed Return Materials Authorization form.

D.3 Used equipment
All equipment that is not classified as new and unused is considered used. This equipment must be completely decontaminated and cleaned before being returned.

Used equipment must be accompanied by a completed Return Materials Authorization form and a Decontamination Statement for all process fluids that have been in contact with the equipment. If a Decontamination Statement cannot be completed (for example, for food-grade process fluids), you must include a statement certifying decontamination and documenting all foreign substances that have come in contact with the equipment.
Return Policy