Introduction
Based on field experience, this guide is intended to help commission the ABB CoriolisMaster flowmeter.

Additional Information
Additional documentation on CoriolisMaster FCB100, FCB400 is available for download free of charge at www.abb.com/flow

Alternatively simply scan this code:
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1 Requirements

Recommended meter sizing

The following points should be observed when sizing the Coriolis meter for proving applications:

- At flow velocities of 3 to 55 ft/s (1 to 17 m/s), the optimum flow signal stability for proving is achieved. Over wider turndowns, it may be necessary to utilize a different meter factor for lower rates.
- Minimum flow rates with 0.8 specific gravity fluid are recommended as shown below.

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Minimum flowrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN 15 (1/2 in)</td>
<td>4 bbl/h (168 ugal/h)</td>
</tr>
<tr>
<td>DN 25 (1 in)</td>
<td>15 bbl/h (630 ugal/h)</td>
</tr>
<tr>
<td>DN 50 (2 in)</td>
<td>45 bbl/h (1890 ugal/h)</td>
</tr>
<tr>
<td>DN 80 (3 in)</td>
<td>115 bbl/h (4830 ugal/h)</td>
</tr>
<tr>
<td>DN 100 (4 in)</td>
<td>220 bbl/h (9240 ugal/h)</td>
</tr>
<tr>
<td>DN 150 (6 in)</td>
<td>270 bbl/h (11340 ugal/h)</td>
</tr>
</tbody>
</table>

- The proving measurement time should be sufficient to get a stable flow, and provide enough pulses to the counter.
- The flowing velocity of 55 ft/s (17 m/s) through the meter should not be exceeded.
- Cavitation or void fraction in the fluid should be avoided.
- Noise or vibration at frequencies that affect the sensor should be eliminated.
- Flow and density instability should be avoided.

Device type and software requirements

The following settings are valid for these device types:

- CoriolisMaster FCB130 / FCB150 all firmware versions
- CoriolisMaster FCB430 / FCB450 all firmware versions
2 Standard CoriolisMaster configuration

For proving ease, configure the meter to operate in its fast response and high repeatability mode, utilizing the following configuration settings.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Transmitter</th>
<th>Concentration</th>
<th>Field Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX Location TAG</td>
<td>Oil Field 001</td>
<td>TX TAG</td>
<td>Room 012</td>
</tr>
</tbody>
</table>

| Units | | | |
|-------|----------------|----------------|
| Massflow Qm | lb/h | | |
| Mass Totalizer | lb | | |
| Volumeflow Qv | bbl/h | | |
| Volume Totalizer | bbl | | |
| Density | lb/ft³ | | |
| Temperature | °F | | |
| Concentration | Variable Matrix | | |

| Damping Configuration | | | |
|-----------------------|----------------|----------------|
| Damping Mass | 0.10 sec | | |
| Damping Density | 0.10 sec | | |

| Density | Density Mode | Density Measured | |
|---------|--------------|-------------------|

<table>
<thead>
<tr>
<th>Cut Offs</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Flow Cut Off</td>
<td>0.50 %</td>
<td></td>
</tr>
<tr>
<td>Low Flow Hysteresis</td>
<td>20.00 %</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Transmitter</th>
<th>Concentration</th>
<th>Field Optimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range mode Config</td>
<td>Disabled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qm Max DN</td>
<td>198416.00 lb/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qm Max</td>
<td>198416.00 lb/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qv Max DN</td>
<td>1132.17 bbl/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qv Max</td>
<td>300.00 bbl/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor Location Tag</td>
<td>Allocation 0800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density Min</td>
<td>31.21 lb/ft³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp. Min</td>
<td>-58.00 °F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density at Tref Min</td>
<td>31.21 lb/ft³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conc. Min</td>
<td>0.00 Variable Matrix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net Qm Max</td>
<td>198416.00 lb/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qv at Tref Max</td>
<td>1132.17 bbl/h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Damping Mass**: 0.1 s
- **Damping Density**: 0.1 s
- **Volumeflow Qv**: set to your required volume flow unit e.g. bbl/d
- **Volume Totalizer**: set to your required volume flow unit e.g. bbl
- **QvMax**: set to your required maximum flow for your application e.g. 5000 bbl/d

*Figure 1: General settings often usable for proving and normal operations*
3 Frequency output configuration

Please make sure that there are always sufficient pulses per proving cycle. Ideally there should be 10,000 or more pulses per proving cycle.

**Note**
Care should be taken when selecting the values to ensure that the following two conditions are satisfied.
When measuring medium is flowing through the flowmeter at maximum operational flow rate – the frequency output by the flowmeter should neither exceed 90 % of its rates maximum nor 90 % of the maximum rated input frequency of the tertiary devices receiving the signal.

**Upper frequency calculation example**
The upper frequency should be calculated in the following way:

\[ \text{Upper frequency} = \left( Q_{v\text{max}} / T \right) \times N \]

<table>
<thead>
<tr>
<th>Legend</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_{v\text{max}} )</td>
<td>Maximum flow in your application</td>
</tr>
<tr>
<td>( T )</td>
<td>Factor to calculate the chosen ( Q_{v\text{max}} ) unit down to a unit per second</td>
</tr>
<tr>
<td>( N )</td>
<td>Number of pulses per flow unit as configured in the receiving device (flow computer or prover counter)</td>
</tr>
</tbody>
</table>

**Example bbl/day:**
\[
\text{Upper frequency} = \left( \frac{5000 \text{ bbl/day}}{86400 \text{ s/day}} \right) \times 10000 \text{ pulses/bbl} = \left( \frac{5000}{86400} \right) \times 10000 / \text{s} = 579 \text{ Hz}
\]

**Example bbl/hr:**
\[
\text{Upper frequency} = \left( \frac{300 \text{ bbl/hr}}{3600 \text{ s/hr}} \right) \times 20000 \text{ pulses/bbl} = \left( \frac{300}{3600} \right) \times 20000 / \text{s} = 1666.67 \text{ Hz}
\]

**Note**
Ensure that the resulting ‘upper frequency’ factor is within reasonable limits.
- If it is less than 10 Hz, choose more pulses per unit ‘N’.
- If it is greater than 10000 Hz, choose less pulses per unit ‘N’.

Other digital output configuration (e.g. pulse output) are shown in **Appendix – Pulse output configuration** on page 12.
4 Electrical connections

Flow computer

In order to power the passive pulse output and condition the signals individually, it is necessary to add resistors.

1. When using a flow computer, the resistors can be integrated into the control cabinet of the flow computer. The cable between the Coriolis sensor and the flow computer needs to be connected as shown below.

For proving the additional cable can be connected in parallel to this cable: in the flow computer cabinet or in the Coriolis sensor connection box.

2. In all other cases the resistors can be integrated in the connection area of the Coriolis sensor connection box. This is the case if the sensor needs to be disassembled out of the pipe for proving.

<table>
<thead>
<tr>
<th>Input channel for flowmeter pulses</th>
<th>Jumper wire (between GND and input pulses ~)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 1 kΩ / 0,5 W (between GND and input pulses +)</td>
<td>R1 1 kΩ / 0,5 W (between GND and input pulses +)</td>
</tr>
<tr>
<td>R2 2 kΩ / 0,5 W (between 24 V DC and input pulses +)</td>
<td>R2 2 kΩ / 0,5 W (between 24 V DC and input pulses +)</td>
</tr>
</tbody>
</table>

Threshold flow computer should be 3,5 V ±0,5 V

Figure 3: Flow computer terminals – without internal ground connection

If there is still an internal ground connection between the power supply and the pulse channel input the jumper wire isn’t needed.

Figure 4: Flow computer terminals – with internal ground connection
**CoriolisMaster FCB100**

In-Situ proving with a flow computer

![Figure 5: CoriolisMaster FCB100](image)

**Precondition:**
- The resistor network is installed inside the flow computer as shown under Flow computer on page 6.

Connect the proving cable in parallel to the existing cable to the flow computer. The cable to the flow computer should be connected to the terminals 41 and 42 / 52.

**Note**
Don’t use the terminals A / B (Modbus®) for proving.

In the case that the flow computer panel provide a connector for the prover.

![Figure 6: Connection for proving](image)

**Proving connection when the meter has been removed for the line**

![Figure 7: Connection for proving](image)

<table>
<thead>
<tr>
<th>Description</th>
<th>Resistance</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clamping connection</td>
<td>1 kΩ / 0,5 W (between terminal 2− and 41)</td>
<td></td>
</tr>
<tr>
<td>Cable gland for prover connection</td>
<td>2 kΩ / 0,5 W (between terminal 1+ and 41)</td>
<td></td>
</tr>
<tr>
<td>Jumper wire: between 2− and 42 / 52</td>
<td>jumper wire</td>
<td></td>
</tr>
</tbody>
</table>

Threshold at prover and flow computer should be 3,5 V ±0,5 V

**Note**
Don’t use the terminals A / B (Modbus®) for proving.

Add the resistor for proving:
Install the two resistors as shown.
Alternatively, the resistors can also be connected to the Prover:
- R1: 1kΩ / 0,5 W (between GND and Pulse input +)
- R2: 2kΩ / 0,5 W (between plus 24 V and Pulse input +)
- Jumper wire: (between GND and Pulse input −)

**Note**
Don’t use the terminals A / B (Modbus®) for proving.
... 4 Electrical connections

CoriolisMaster FCB400

In-Situ proving with a flow computer

Precondition:
- The resistor network is installed inside the flow computer as shown under Flow computer on page 6.

In the case that flow computer panel provide a connector for the prover.

Proving connection when the meter has been removed from the line

Note
For this configuration the “power mode” of the current out 31/32/Uco should be enabled. Parameter in Menu “Input/Output / ...Cur. Out 31/32/Uco / Loop Current Mode ⇒ set to Power Mode”.

Add the resistor for proving:
Install the two resistors as shown. Alternatively, the resistors can also be connected to the Prover:
- R1: 1 kΩ / 0,5 W (between terminal 32 and 41)
- R2: 2 kΩ / 0,5 W (between plus 24 V and Pulse input +)
- Jumper wire: (between terminal 32 and 42 / 52)

Threshold at prover should be 3,5 V ±0,5 V
CoriolisMaster FCB100 or FCB400 – How to connect to a flow computer and to a prover by using two outputs

- R1: 1 kΩ / 0.5 W (between GND and input pulses +)
- R2: 2 kΩ / 0.5 W (between 24 V DC and input pulses +)
- Jumper wire (between GND and input pulses −)

Figure 13: Connect to a flow computer and to a prover
5 Site and equipment considerations

Proving

The proving can be influenced by many factors, so it is important to consider the following:

1. Verification of calibrations on all references should be done; i.e. pressure, temperature, density, and volume.
2. The repeatability can easily affected by the flow pulsation of positive displacement pumps.
3. If a valve leakage occurs in the system this can lead to an incorrect meter zero or allow flow to bypass the prover. To ensure tightness, double block and bleed isolation valves are recommended.
4. The same conditions for the normally expected operation should be used for proving the meter.
5. The flow conditions have to be steady during the proving run in order to guarantee repeatable results. The following flow conditions must be at a stable level from the input of the meter under test to the outlet of the prover:
   - Pressure
   - Temperature
   - Density
   - Flow rate
6. For mass proving, an error in the density measurement on the prover leads to a meter factor error. The density meter factor should be checked using a pycnometer or hydrometer. For this purpose the following tolerances should be maintained:
   - The permissible temperature difference should not exceed 0.2°F
   - Pressure difference should not exceed 1 psi
   - The repeatability of the density meter factor (DMF) should be 0.05% or better between two pycnometer measurements in series.
7. Of course, a check of the detector switches of the prover and the certified measuring section for integrity and functionality must be done.
8. The run time can be shortened by a higher flow rate; thus, a larger small volume prover (SVP) may be needed for the CoriolisMaster. For estimation purposes, 33 % can be deducted from the maximum flow rate of a small volume prover sizing chart (Estimated value).
9. Flashing can be avoided by ensuring that there is sufficient back pressure on the testing meter and the flow prover.
10. In applications where the pressure fluctuates, the missing Coriolis pressure compensation can lead to repeatability and reproducibility problems.

Zero point adjustment

The perfect meter zero will produce a meter factor near 10000.

Devices in the CoriolisMaster series do not necessarily require zero point adjustment. Performing a zero point adjustment is only recommended in the following cases:

- For measurements in the lower flow range (below 10 % of Q_{max}DN).
- If particularly high accuracies are required (0.1 % or better).
- If the operating conditions (pressure and temperature) deviate greatly from the reference conditions (see data sheet).

At particularly small flow rates, the meter zero has a major influence on the meter factor.

1. A zero adjustment is recommended before the first use.
2. The zero adjustment result should be lower than 0.1 %.
3. A new proving meter factor should be determined, if a meter is re-zeroed.
6 Number of proving runs and repeatability

'Validity of the average meter factor to a random uncertainty of 0.00027', is the API requirement for proving.

The higher the number of runs in a proving, the lower the repeatability requirements.

The API MPMS 4.8 requirement is shown below:

Sets of runs can also be averaged for the repeatability calculation. One technique is the averaging of three sets of five proving runs. An example of this technique is as follows:

<table>
<thead>
<tr>
<th>Proving run</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>40009</td>
<td>39996</td>
<td>39995</td>
</tr>
<tr>
<td>Sample 2</td>
<td>40007</td>
<td>40002</td>
<td>40001</td>
</tr>
<tr>
<td>Sample 3</td>
<td>40005</td>
<td>40007</td>
<td>40008</td>
</tr>
<tr>
<td>Sample 4</td>
<td>40002</td>
<td>40004</td>
<td>39998</td>
</tr>
<tr>
<td>Sample 5</td>
<td>39998</td>
<td>39998</td>
<td>40004</td>
</tr>
<tr>
<td>Repeatability</td>
<td>0.028 %</td>
<td>0.028 %</td>
<td>0.033 %</td>
</tr>
<tr>
<td>Average</td>
<td>40004.2</td>
<td>40001.4</td>
<td>40001.2</td>
</tr>
<tr>
<td>Repeatability all</td>
<td>0.01 %</td>
<td>0.01 %</td>
<td>0.01 %</td>
</tr>
</tbody>
</table>

Averaging allows for more flow fluctuations during proving, the more data that is averaged, typically the better the repeatability.
7 Appendix – Pulse output configuration

In some applications, it is required to use a pulse output instead of a frequency output. The main difference is that the pulse output provides a constant pulse length. Each pulse has the same pulse length.

For unit ‘bbl’

Digital output 41/42 mode: Pulse
Digital output 51/52 mode: Impulse Phase Shift 90° to Dig. Out.
Output value: Volume flow
Pulse per unit: Set the required pulses per unit: e.g. 20000 pulse/bbl. For proving, please ensure that there are always sufficient pulses per proving cycle. Ideally, these are more than 10000 per proving cycle.
Make sure that the pulse per unit matches between the flowmeter and the flow computer.

Example:
(300 bbl/h / 3600 s/h) × 20000 pulse/bbl
= (300 / 3600) × 20000/s
Maximum output frequency = 1666.67 Hz

Note
The Totalizer should be set to ‘bbl’ or ‘ugal’ too.

For unit ‘ugal’

Digital output 41/42 mode: Pulse
Digital output 51/52 mode: Impulse Phase Shift 90° to Dig. Out.
Output value: Volume flow
Pulse per unit: 238,000 /ugal

Figure 14: Digital output configuration as pulse output

Note
Insure that the settings do not exceed the maximum input frequency of the prover counter or flow computer.
Trademarks

Modbus is a registered trademark of the Modbus Organization
Notes
Notes
Introduction

Based on field experience, this guide is intended to help commission the ABB CoriolisMaster flowmeter.

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