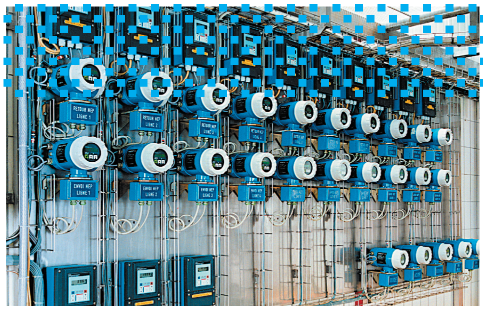
Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

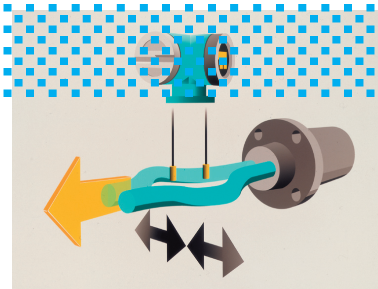
Entrained Air and Coriolis Mass Flow Meters

Recommended practices for handling applications susceptible to entrained air or gas to optimize performance



Multiple filling station

Promass 83 F



Mass meter operation

Product Information

Coriolis mass flow meters are being applied in more challenging applications. Some of these applications pose unique influences on meter performance. Batch operations with empty to full conditions, line purging, tank changeover, or slug flow conditions can be easily overcome.

Two phase fluids (gas/liquid) pose initial design, process, and installation considerations to optimize measurement accuracy and repeatability.

Understanding the effects on Coriolis meters and the advancements in microprocessor based technology can provide dramatic improvements in measurement performance.

Patents submitted by Endress+Hauser in the area of entrained gas in liquids have been shown to improve measurement accuracy and repeatability when implemented.

Customer Profile

Three typical customer applications with entrained air or gas in their fluid illustrate typical solutions with Endress+Hauser Promass Coriolis.

Application #1: A manufacturer of margarine products uses a food grade vegetable oil in their product emulsion. An existing air manifold was used to blow back unused product in the long product supply line back to the storage tank.

The process was found to have air block valves with worn seating surfaces. An Endress+Hauser Promass 83M25 was analyzed during operation with the Endress+Hauser FieldTool software. The no-flow condition caused erroneous flow spikes and batch errors.

Application #2: A manufacturer of home health care products (liquid soap) used an Endress+Hauser Promass 83F50 Coriolis meter.

The customer had long batch runs of product which demonstrate the effects entrained gas had on the measurement of fluid volume and corresponding effect on the measured density.

Application #3: A manufacturer of soup uses a dilute form of tomato paste with >18% entrained solids. The paste is mixed in a holding tank prior to being added to a ribbon blender and combined with other ingredients. An Endress+Hauser Promass 83F40 Coriolis meter was used.

During periods of no-flow, the meter was generating erroneous flow spikes which compromised batch measurement accuracy.

Application description

Coriolis mass flow meters utilize a vibrating conduit or tube(s). The conduit is designed to operate at an amplitude of oscillation controlled by a variable gain drive circuit. When entrained gas is present in a fluid flowing through this sensing element, the amplitude of oscillation damps the tube movement, causing an increase in the drive gain voltage or excitation current to move the conduit.

Coriolis mass flow meters have a limited current or voltage range of operation. Sustained operation at the voltage or current limit can generate a fault condition or produce measurement error.

Two phase conditions (liquid/gas) produce a mass and density measurement error.

Unfortunately, most applications do not have consistent amounts of gas entrained in fluids.

Endress+Hauser
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Application challenges

During flowing conditions, the gas present in a liquid is compressible. However, during periods of no-flow, the gas can migrate through the sensing conduit causing erroneous flow spikes.

Identifying the range of "good" and "poor" operation help to define limit values for the control. Fluctuating excitation current or unstable flow outputs is a direct indication of entrained gas in a liquid.

Coriolis meter density measurement is usually too slow (350 mS update time) to provide a direct means to control an application.

Consideration of the fluid properties in the design stage is paramount. Fluids which have entrained solids or have higher viscosities (>500 cPs) characteristically trap gas.

System limits may prevent adding line pressure and back pressure in a process system. Shear effects on fluids may restrict the amount of pressure drop from a back-pressure element or supply pressure which can be used in a system.

Vertical meter mounting would reduce the effects of trapped gas in the measurement sensor - allowing the air to migrate to the highest point in the system. Not all applications could use this orientation.

Instrument used

Promass 83 with Advanced Diagnostics F-Chip for all sensors

Measurement results

Each Endress+Hauser Promass 83 series meter was optimized by the addition of a special function chip incorporating Advanced Diagnostics.

Meter performance was mapped by Field Service using the Endress+Hauser FieldTool software to establish benchmarks for the application.

In all cases, the measurement accuracy was better than 1% under varying levels of entrained gas. Since all applications were for batching, meter repeatability was found to meet the customer product specifications.

Instrument description

PROline Promass 83 electronics version with any sensor can use the Advanced Function F-chip or this chip can be added in the field to an existing 83 series transmitter.

Measuring principle

Coriolis meters produce a measurement of mass flow based on the Coriolis effect. An independent measurement of product density is calculated from the resonant frequency of the sensing tube vibration. Monitoring tube excitation current and tube damping levels can provide a means for fine control of batching applications susceptible to entrained air or gas.

For more information contact:

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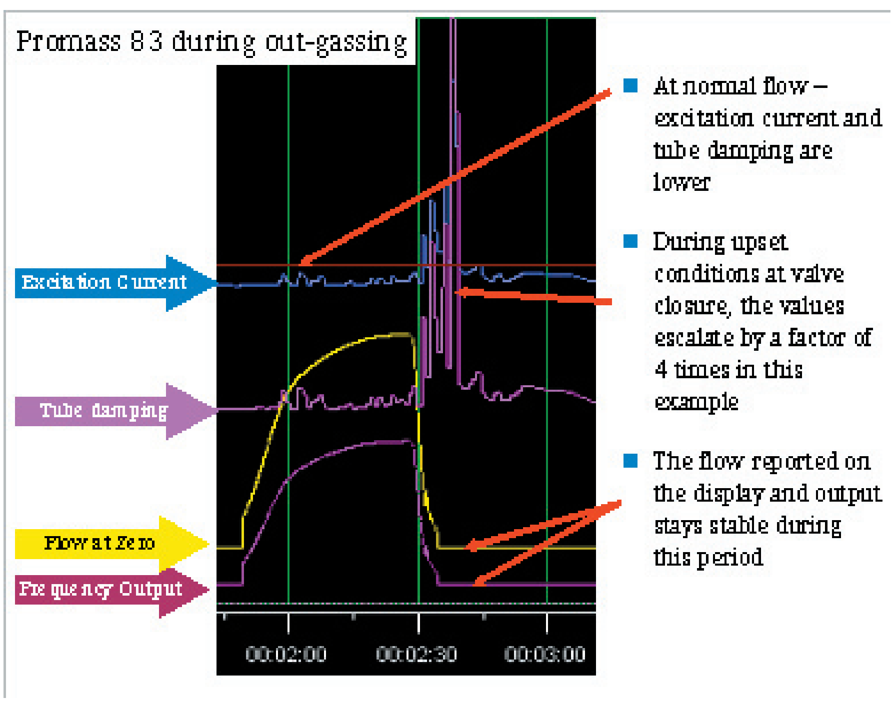
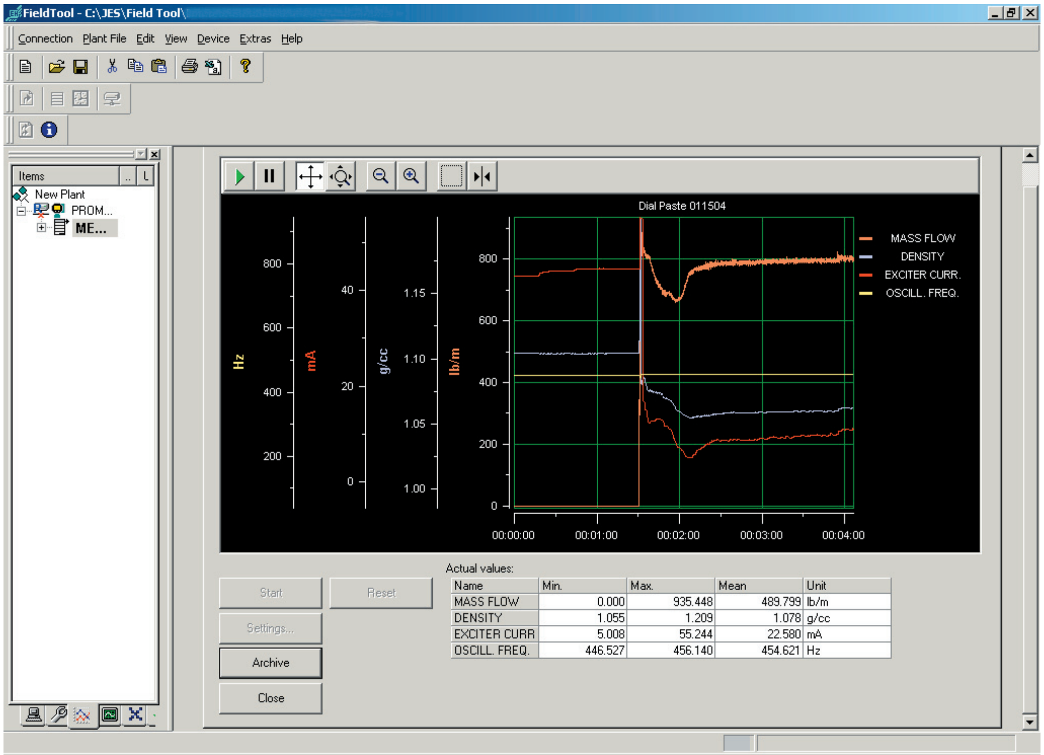
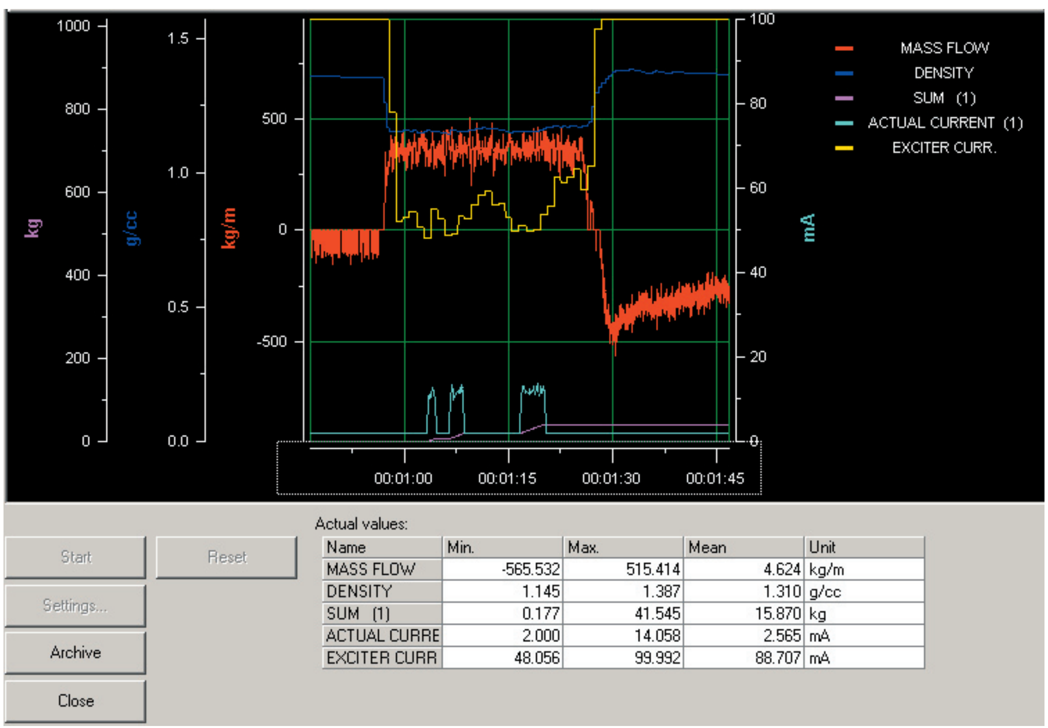


A batching operation shows flow and no flow (by the yellow line). As the flow of liquid causes the entrained gas to be compressed, no observed flow spikes are evident.

When the flow ramps to zero, a series of spikes are observed in the excitation current (blue line) and tube damping (magenta line) – spikes which indicate the movement of gas through the tubes, during periods of out-gassing. As the gas movement occurs during no-flow, the output flow value could show spikes. In this example with the patented Endress+Hauser Air Entrainment solution used, no flow spikes or erroneous flow variables occur during the period of out-gassing. This batching operation was solved with Advanced Diagnostics control in the Promass 83.



A home health care product (soap) is shown in flowing conditions. The normal excitation current peaks to levels of 99 mA during no-flow and drops to 5 mA during flow. This is the effect of gas compressed by a flow liquid. The measurement of the fluid density changes from no-flow to flowing conditions – also a direct indicator of gas entrained in a fluid.



A system with a meat slurry and 48% entrained solids gas is shown in a condition without sufficient back pressure to produce reliable measurement. The meter has an actual current output (blue line) which missed measured flow during a bathing sequence until backpressure was applied in final tests. A change in the operating excitation current (yellow line) from no-flow (higher) to flowing conditions (lowest) is shown. This proves the gas compressibility effect in liquids and the error they can produce if not properly addressed.

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