



Precision Flow Measurement Configuring High Performance Systems



About Us

Flow measurement and control you can count on.

Badger Meter Flow Instrumentation understands that companies cannot manage what they cannot measure—and leverages more than a century of flow measurement expertise and a technology-rich portfolio to optimize customer applications worldwide.

An industry leader in both mechanical and electrical flow metering technologies, Badger Meter offers one of the broadest flow control and measurement portfolios in the industry—a portfolio that includes eight out of the ten major flow meter technologies.

Simply put, Badger Meter Flow Instrumentation provides technology to measure and control whatever moves through a pipe or pipeline—including water, air, steam, oil, other liquids and gases. And we apply our expertise to further enhance our products' ease-of-use, accuracy and effectiveness.

Customers can rely on Badger Meter Flow Instrumentation for application-specific solutions that deliver accurate, timely and dependable flow data and control essential for product quality, cost control, safer operations, and regulatory compliance.

Cox precision metering products by Badger Meter provide flow measurement solutions for the test and measurement market and precision industrial applications, such as:

- Automotive testing
- Heavy hydraulic equipment
- U.S. defense and aircraft fuel metering
- Aircraft flight testing
- Aircraft hydraulics
- Aircraft component testing
- Equipment testing and verification

Credentials

Cox Flow Measurement is certified compliant to AS9100D and ISO 9001 and accredited to ISO/IEC 17025 by NVLAP (Lab Code 200668-0).



*NVLAP accreditation applies only to the Badger Meter Flow Dynamics calibration Lab, located in Racine WI.



Precision Calibrations

A flow meter's performance is dependent on the quality of its calibration. Badger Meter delivers precision primary standard liquid and gas calibrations of the highest standard as a NVLAP accredited (Lab Code 200668-0) calibration facility.

Note: NVLAP accreditation applies only to the Badger Meter Flow Dynamics calibration Lab, located in Racine, WI.

The calibration criteria are based on ISO/IEC 17025 International Standard, used to evaluate the competence of calibration laboratories throughout the world. This specifically assesses factors relevant to the ability to produce precise and accurate calibration data including:

- Correct equipment – properly calibrated and maintained
- Adequate quality assurance procedures
- Proper correlation practices
- Appropriate testing methods
- Traceability of measurements to NIST
- Accurate recording and reporting procedures
- Suitable testing facilities
- Technical competence of staff



- Bi-annual NVLAP accreditation audits ensure competency.
- Calibration uncertainty statements are posted on the NIST government website.

Product Configuration Step-By-Step

Flow meter systems are configured to achieve the best solution to measure the most difficult flow applications. Cox flow meters are available with an assortment of pickoffs to meet temperature requirements and signal transmission distance, which is complemented by an assortment of electronic processors and indicators. Installation is accomplished by selecting from several standard end connections along with custom designs. The following guidelines will make system configuration simple, while presenting alternatives to maximize accuracy and minimize cost.

Steps to Specify the Flow Meter System for the Application

The following criteria must be determined to develop the correct flow meter configuration for any given test and measurement application.

- Step 1 – Define Fluid Parameters
- Step 2 – Determine Meter Type
- Step 3 – Consider Flow Meter Ranges
- Step 4 – Specify Pickoffs
- Step 5 – Define Pickoff Temperature Ranges
- Step 6 – Select End Connections
- Step 7 – Determine Need for Flow Straighteners
- Step 8 – Select Calibration Option
- Step 9a – Select Preamplifier
- Step 9b – Select Flow Processor
- Step 9c – Select Field Indication Display
- Step 9d – Select Panel Mount Flow Processor

Badger Meter provides a knowledgeable technical sales staff to assist in specifying the correct flow meter and calibration for the application. Their experience and attention to details will guide you into the proper electronics to meet an array of power and output configurations.



Product Configuration

Step 1 – Define Fluid Parameters

Fluid properties vary from one application to another and must be defined in order to properly develop the correct meter configuration and calibration specification. Fluid parameters include:

Fluid Type

- Affects the wetted parts
- Defines filtration
- Determines water, solvent or oil blending calibration
- Provides fluid density, required for inferred mass flow

Operating Fluid Temperature (minimum and maximum)

- Defines fluid viscosity range
- Identifies the amount of calibrations required to develop a UVC calibration
- Is required to select pickoff type (cryogenic to high temperature applications)
- Determines if remote electronics are required

Static Line Pressure

- Over 1000 psig — changes viscosity and density properties (requires a flow processor)

Flow Range

- Determines the best operating range in combination with the pressure drop and UVC capability

Once this fluid information is defined, the flow meter can be specified to meet the application demands.



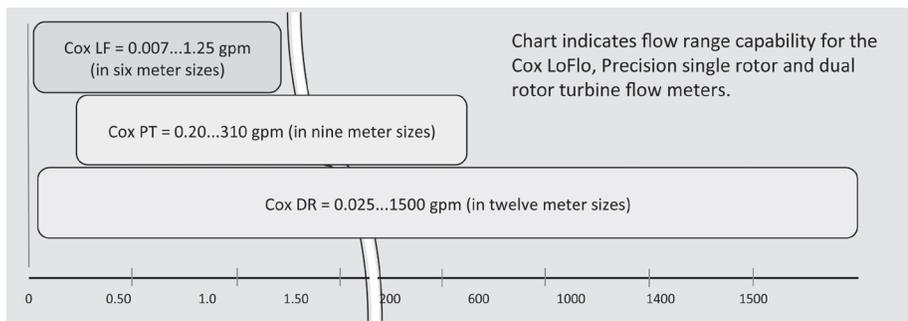
Product Configuration

Step 2 – Determine Meter Type

Badger Meter offers numerous meter configurations made up of essentially three types of meters, depending on the application.

- Precision LoFlo axial turbine meter
- Precision single rotor turbine meter
- Exact dual rotor turbine meter

The following will guide you to select the correct meter, based on range and features.



Features	Precision LoFlo Axial Single Rotor	Precision Single Rotor	Exact Dual Rotor
Flow Straighteners	Recommended	Recommended	Not Required
Ceramic Ball Bearings Water & Hydrocarbon Service	Standard	Standard	Standard
Repeatability	± 0.25%	± 0.02%	± 0.02%
Extended Linearity (NOTE: Repeatability added to linearity)	Inherently non-linear ± 0.35% with electronic linearizer	Superior ± 0.05% Mechanically linear over a wide extended range (± 0.12% with electronic linearizer)	± 0.12% with electronic linearizer over a wide extended range up to 500:1
Turndown Flow Ranges	12.5:1 smallest meter increasing to 20:1 on the largest meter	60:1 smallest meter increasing to 150:1 on 1 in. and larger	120:1 smallest meter increasing to 500:1 on larger meters
UVC Turndown Flow Range	Standard 10:1	Standard 10:1	Extended from 30:1 on the smallest meter and increasing up to 60:1 on 1 in. or larger meters
High Shock Design	N/A	N/A	Standard
Bearing Diagnostics	N/A	N/A	Rotor ratio technique



Precision LoFlo Axial Turbine



Precision Turbine Single Rotor

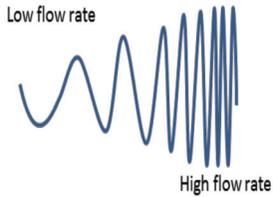


Exact Dual Rotor Turbine

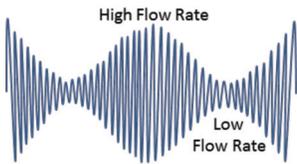
Product Configuration

Step 3 – Consider Flow Meter Ranges

Flow Range Effects for Magnetic & Carrier Pickoffs

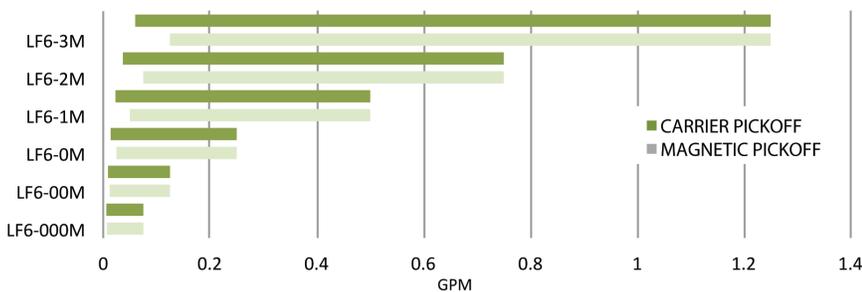


Magnetic pickoffs operate at a wider temperature range (-450...450° F) and they do not require power, however, they drop off at the low end due to magnetic drag.

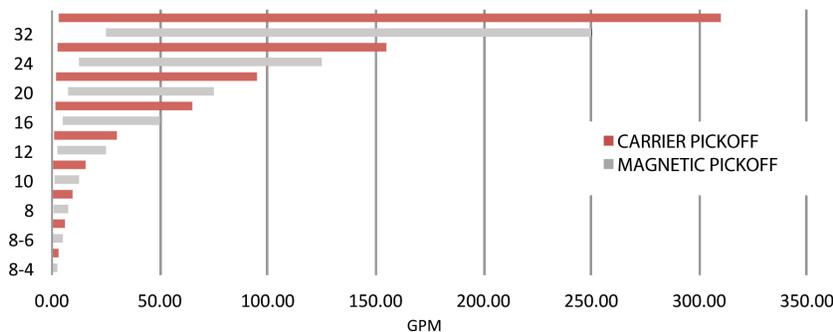


Carrier amplifier pickoffs require power and will transmit up to 100 feet. They eliminate magnetic drag, which extends the usable flow range.

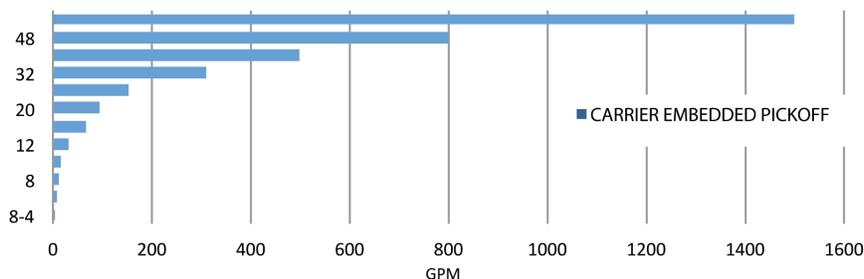
COX PRECISION LOW FLOW, MAGNETIC VS CARRIER PICKOFF FLOW RANGE



COX PRECISION, MAGNETIC VS CARRIER PICKOFF FLOW RANGE



COX EXACT DUAL ROTOR FLOW RANGE



Precision LoFlo Axial Turbine



Precision Turbine Single Rotor



Exact Dual Rotor Turbine

Product Configuration

Step 4 – Specify Pickoffs

Because application requirements vary so greatly, Badger Meter offers a variety of pickoff choices to meet specific needs. When specifying a pickoff, there are many factors to consider.

The following list outlines the consideration process:

Specifications:

- RF carrier pickoff (requires carrier amplifier)
- Magnetic pickoff (no power required)
- Pickoff fluid temperature ranges from $-450\text{...}450^{\circ}\text{F}$ ($-268\text{...}232^{\circ}\text{C}$)
- Embedded temperature sensor (RTD or thermistor)
- Transmission distance 100 feet (30.5 meters), when amplified

An RTD thermowell temperature probe can also be inserted into the flow straighteners to provide improved temperature monitoring, in place of an embedded pickoff temperature sensor.

Pickoff Choices:

- High or low temperature
- Amplified output
- Embedded RTD
- Bayonet or MS connectors
- NPT wire leads



Amplified Output
Square Wave Pulse
0...5 or 0...10V DC



Embedded RTD or Thermistor



RTD Thermowell
inserted in Flow Straightener



Bayonet Connector



MS Connector



NPT Wire Leads

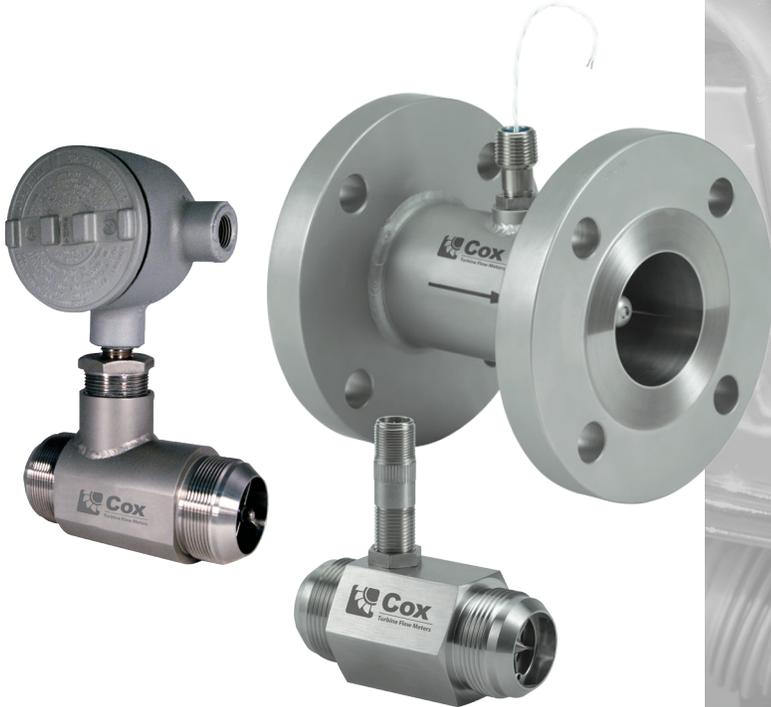
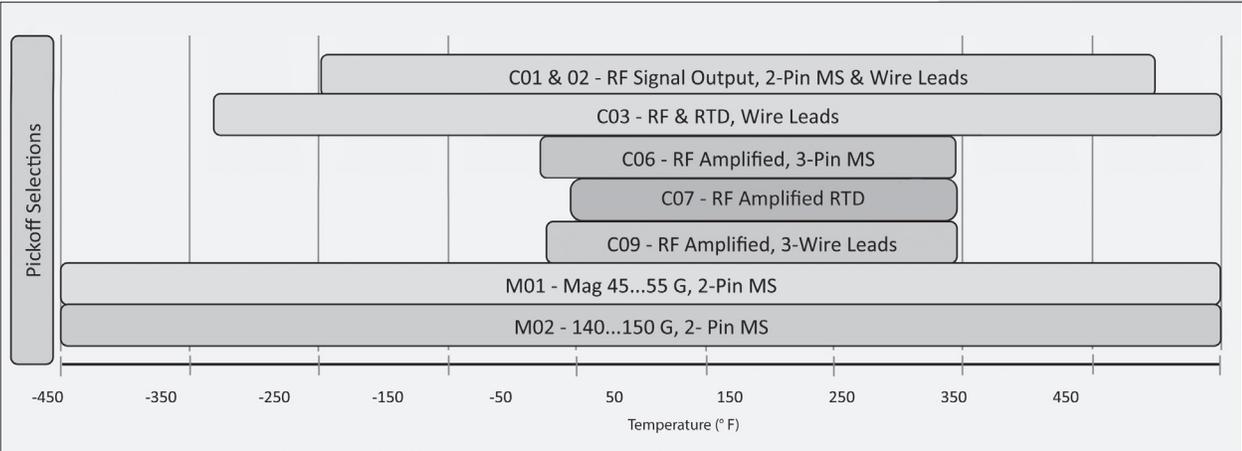


Embedded RF Coil
(high vibration)

Product Configuration

Step 5 – Define Pickoff Temperature Ranges

Defining the fluid temperature range for an application will help determine which pickoffs are compatible with the given parameters.

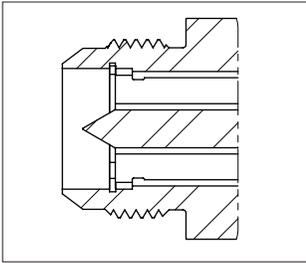


Product Configuration

Step 6 – Select End Connections

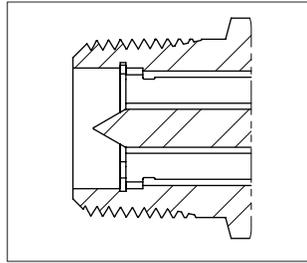
End connections are determined by the pipeline pressure, pipe size, ease of removal, and custom requirements. Adjoining pipe and end connection pressure rating also must be considered. Note that high temperature will reduce the pressure rating on all fittings.

Standard End Fittings



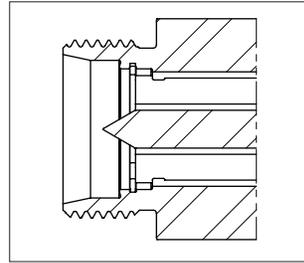
AN 37° Flare

- Pressure rating
- 1760...7000 psig (121...483 Bar)
- Size dependent



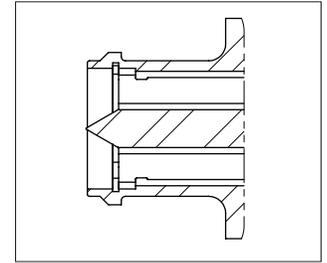
NPT Pipe, Male

- Pressure rating
- 3760...7614 psig (259...525 Bar)
- Size dependent



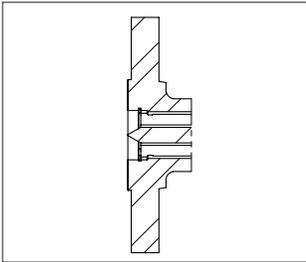
High Pressure

- Pressure rating
- Continuous 5000 psig (345 Bar)
- Burst 25,000 psig (1724 Bar)



Hose Barb

- Low pressure <300 psig (21 Bar)
- Clamp dependent



ANSI 150, 300 and 600 Flanges

- Raised face and ring joint
- 275...6000 psig (19...414 Bar)
- Class dependent

Product Configuration

Step 7 – Determine Need for Flow Straighteners

Flow straighteners are recommended on single rotor turbine meters to negate swirl from influencing the accuracy of the meter. Cox flow straighteners have a six-bladed insert to prevent swirl and minimize pressure drop. In addition, they offer pressure and temperature taps.

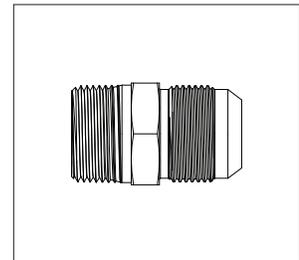
When flow straighteners are impractical due to space, a flow meter can be calibrated before installation using the same piping found in the application environment to compensate for fluid swirl. The Cox Exact dual rotor meter cancels out fluid swirl and can be used without flow straighteners. Flow straighteners are required with the Cox Exact dual rotor meter when implementing bearing diagnostics, which monitors the ratio of both rotor frequency outputs. Flow straighteners are also required when the dual rotor meter is used as a master meter or a calibration check standard.

Technical Tip

When using NPT threads, consider using flared (37° AN) fittings on the flow meter and flow straighteners. Use an AN to NPT adapter on the pipe connection ends. This will avoid a step in the internal dimension of the piping close to the turbine meter and will facilitate removal of the turbine meter for calibration.



Flow straightener set



AN to NPT adapter



RTD thermowell inserted in downstream flow straightener



Flow Straightener Specifications

Straightener Vanes	<ul style="list-style-type: none"> • 6 bladed
Length	<ul style="list-style-type: none"> • Upstream: 10 diameters • Downstream: 5 diameters
Materials of Construction	<ul style="list-style-type: none"> • 304 SST
Pressure Rating	<ul style="list-style-type: none"> • 3000 psi for AN 37° flare fittings • All others conform to the end fitting rating
End Fittings	<ul style="list-style-type: none"> • AN 37° flared, 150# flange, 300# flange and 600# flange, NPT adaptor and others, as required
Taps	<ul style="list-style-type: none"> • Upstream: 1 pressure tap standard • Downstream: 1 temperature tap standard or 2 taps (1 pressure and 1 temperature)

Product Configuration

Step 8 – Select Calibration Option

Turbine meters are viscosity sensitive and may need a calibration that accounts for temperature/viscosity effects on the output. This type of calibration is commonly accomplished by blending solvent and oil to simulate the kinematic viscosity of the fluid at a given temperature. Wide temperature variations might require multiple calibrations to develop a Universal Viscosity Curve (UVC). This UVC data is used by a flow processor to provide fully temperature-compensated precision flow output.

Most Common Calibrations for Turbine Meters

Single Fluid – Stable Temperature

If the meter is used in the linear range, the viscosity variance is minimized. Therefore, a single fluid viscosity calibration will produce accurate flow measurements.

Multiple Blend – Temperature Variance

Requires two or more blended fluids, with a kinematic viscosity differential contained within a 10:1 ratio, to cover the temperature/viscosity span. The results is a blended UVC, which compensates for temperature viscosity effects on the output.

Additional Calibration Options

Single Fluid Universal Viscosity Curve – Single Blend

Allows one viscosity to be used to determine temperature-induced kinematic viscosity shifts. By extending the calibration of a single fluid beyond the operating range, one fluid can be used to develop a UVC calibration, thereby reducing cost.

Multiple Single Fluid Calibrations – Stable Temperature

Used when different fluids are measured in the same piping or when the meter is relocated to piping using a different fluid.

Multiple Fluid UVC Calibrations– Multiple Blends

When using more than one fluid in a varying temperature environment, multiple UVC calibrations can be accomplished so that each fluid type blends into one single curve fit. The flow processor will need to know which fluid is being used in order to match the proper temperature/viscosity table.

Kinematic Viscosity

The ratio of a fluid's absolute viscosity to its density – or the absolute viscosity divided by the density.

Product Configuration

Step 9a – Select Preamplifier, if Necessary

A preamplifier may be required to transmit the signal output, up to 100 feet. Preamplifiers in explosion-proof enclosures contain a module with terminal screws. The Model SCA-242 (magnetic) and SCA-243 (carrier) are attached to the pickoff, using MS connectors, which makes for easy replacement or for repurposing with other flow meters. The SCA-244, -245, -250, and -252 all have pickoffs assembled into the explosion-proof housing.

The EC80 flow processor could also be integrally mounted, which will amplify the signal outputs for transmission (see flow processors, Step 9b).

Types of Pickoff Amplifiers



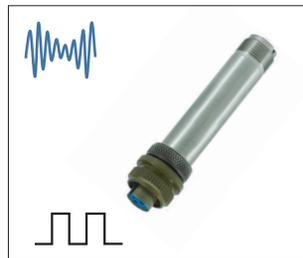
MS Connector, Magnetic

- Model No. SCA-242
- Attaches to pickoff
- MS connectors



Wire Terminal, Magnetic

- Model No. SCA-244-NP
- Explosion-proof Y1 housing, with pickoff
- Screw wire terminals



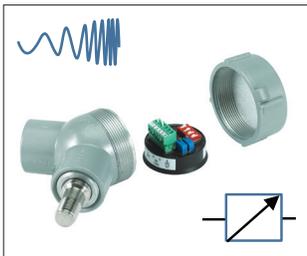
MS Connector, Carrier

- Model No. SCA-243
- Attaches to pickoff
- MS connectors



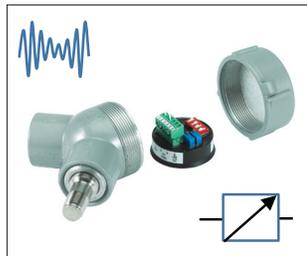
Wire Terminal, Carrier

- Model No. SCA-245-NP
- Explosion-proof Y1 housing, with pickoff
- Screw wire terminals



Digital to Analog, Magnetic

- Model No. DAC-250-NP
- Output 0...50 mA or 0...20 mA
- Current mode, 2-wire analog
- Supply Voltage: 11...30V DC
- Screw wire terminals



Digital to Analog, Carrier

- Model No. SCA-252-NP
- Output 10...50 mA or 4...20 mA
- Current mode, 3-wire analog
- Supply Voltage: 11...38V DC
- Screw wire terminals



Programmable Scaler

- Model No. B220-873 or B220-874
- Programmable Scaler takes the raw frequency flow meter output and scales it to the desired K Factor for 5V DC pulse (B220-874) or 4...20 mA output (B220-873)

- Input: Magnetic pickoff
- Output: Amplified pulse square wave 30V DC max.
- Power: 8.5...30V DC
- Temperature: -22...158° F (-30...70° C)
- Screw wire terminals

Specifications Common to Both Digital to Analog Convertors

Response Time: Full scale change to 95% is 180 ms. Zero and span adjustments (no interaction). All outputs are jumper selectable.

Temperature: -20...160° F (-0...7° C)

Product Configuration

Step 9b – Select Flow Processor

The EC80 and IFC15BBA are a powerful field-mounted flow processor, which extends the measuring capability of the flow meter by providing:

- Flow meter output to be linearized within 0.1% of reading
- Temperature compensation, EC80 with RTD input, IFC15 with thermistor
- Configurable outputs comprised of two frequency, one analog output with IFC15 or two analog output with EC80
- UVC temperature/viscosity tables
- Rotor blade running average, to enhance low flow resolution
- Dual rotor input
- Improved measurement accuracy with Strouhal-Roshko correlation
- Configurable interface software for fluid selection, configuration of outputs and scaling
- Dynamic response (100 μ s latency)

Packaging allows for integral mounting or remote mounting. Remote mounting provides a solution when space is limited or when environmental temperatures are excessive. OEM meters are typically designed with an embedded flow processor, allowing for 100 percent interchangeability of the meter system. The flow processor requires 24V DC nominal, 3 watts maximum.



Typical system, with remote mounted EC80 flow processor.
Cables ordered separately.



Remote mount



Integral mount



Explosion-proof housing
mounted directly on the
flow meter.

Product Configuration

Step 9c – Select Field Indication Display

The CUB 5 is a basic scalable indicator and will display either rate or total, using the toggle select button. Units can be mounted in a panel or NEMA 4 enclosure. Flow meter raw frequency or amplified square wave input is scaled internally.

Step 9d – Select Panel Mount Flow Processor

Panel-mounted flow processors display rate and total, and provide additional functions such as:

- Linearizing flow meter output
- Fluid temperature compensation
- Batching capabilities

FC-5000 Panel-mounted Liquid Flow Processor

- Total and rate display
- Linearizer
- Selectable engineering units
- Output alarms
- Pulse and analog outputs
- Modbus RTU communication
- Power input 10...40V DC

FC30 Panel-mounted Liquid and Gas Flow Processor

- Total and rate display
- Linearizer
- Batcher
- Selectable engineering units
- Output alarms
- Pulse and analog outputs
- NEMA 4 housing, panel-mounted
- Power input 110 or 220V AC
- 12 and 24V DC



CUB 5 rate & total display



FC-5000 Flow Computer



FC30 Flow Processor



Control. Manage. Optimize.

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