



**Cox**

Turbine Flow Meters

# Turbine Flow Meters

Exact Dual Rotor



*Model CDL*



**Badger Meter**

TRB-UM-00478-EN-02 (May 2019)

# User Manual

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## SCOPE OF THIS MANUAL

This manual is intended as an installation and operation guide for the Cox Exact Dual Rotor turbine flow meter. Please consult the factory or our website for any questions or concerns regarding any of the equipment or installation. The electronic version of this manual is available on our website at [www.badgermeter.com](http://www.badgermeter.com).

### IMPORTANT

*Read this manual carefully before attempting operation. Keep the manual in an accessible location for future reference.*

## Unpacking and Inspection

Upon opening the shipping container, visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts, or any other sign of damage that might have occurred during shipment.

**NOTE:** If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carrier. A claim for equipment damage in transit is the sole responsibility of the purchaser.

Inspect all packing material carefully to prevent the loss of meter parts or auxiliary components, which may have been packed with the shipment. Refer to the packing list/invoice for a detailed list of items included in the shipment.

## SAFETY CONSIDERATIONS

### Terminology and Symbols



Indicates a hazardous situation, which, if not avoided, is estimated to be capable of causing death or serious personal injury.



Indicates a hazardous situation, which, if not avoided, could result in severe personal injury or death.



Indicates a hazardous situation, which, if not avoided, is estimated to be capable of causing minor or moderate personal injury or damage to property.

## DESCRIPTION

The Exact Dual Rotor turbine flow meter uses a unique rotor design that reduces swirl effects. These flow meters are designed and manufactured to the highest quality standards to provide the best possible performance for flow measurement requirements.

### Traditional Operating Principle

A turbine flow meter, in its base form, measures fluid velocity. As a fluid passes through the meter, the velocity of the fluid presses rotational energy on the internal rotor assembly. The rotor blades generate pulses proportional to flow as they pass through a radio frequency field created by a pickup. Each pulse is transmitted to the meter electronics, where it amplifies the pulse output and provides a volumetric flow rate.

### Dual Rotor Advantages

The dual rotor design eliminates many of the problems associated with traditional single rotor designs. The hydraulic coupling of the two rotors reduces the fall-off of the output frequency at low flow rates, extending the usable range, or turndown ratio. Additionally, swirl at the meter inlet, which causes a significant inaccuracy in a single rotor meter, is largely canceled by summing the counter-rotating rotor signals.

### Performance

The performance of any turbine flow meter is affected by three forces, which can cause the output signal to become non-linear: bearing friction, viscous drag, and magnetic drag (from magnetic type pickups). Bearing friction is minimized by using exceptionally high quality ball bearings. Viscous drag, which is a function of the metered fluid, cannot be eliminated. Magnetic drag is eliminated by the use of modulated carrier (RF) pickup coils.

Bearing friction and viscous drag are accounted for by calibrating the flow meter on a primary standard positive displacement liquid flow meter calibrator.

## MATERIALS

<b>Body</b>	316 stainless steel
<b>Shafts</b>	316 stainless steel
<b>Rotors</b>	17-4 PH stainless steel
<b>Bearing</b>	Ceramic ball, with hybrid corrosion resistant raceways
<b>Nuts</b>	ASTM A286
<b>Spacers</b>	303 stainless steel
<b>Supports</b>	303 stainless steel
<b>Transitions</b>	302 stainless steel

## CONSTRUCTION

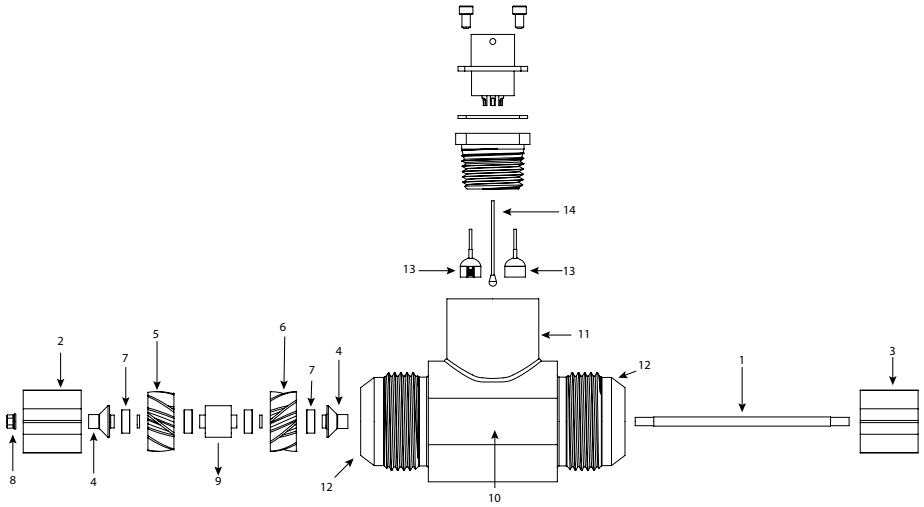


Figure 1: Cox Exact Meter sectional view

Item	Description	Item	Description
1	Shaft	8	Lock Nut
2	Upstream Support	9	Spacer
3	Downstream Support	10	Housing
4	Transition	11	Hub
5	Upstream Rotor	12	End Connections
6	Downstream Rotor	13	Embedded Pickup Coil
7	Bearings	14	Thermistor

Table 1: Cox Exact Meter sectional view data

The Cox Exact design uses a tie-bolt concept, where the rotors are suspended in the housing on a common stem. The stem is threaded into the downstream support, except for the 1/4 in. (84) and 3/8 in. (86) sizes where it is captured on both ends with a nut. Stem nuts are held in place with high temperature locking compound. The Cox Exact turbine flow meter does not contain snap rings or retaining rings that can be dislodged by shock or vibration.

Cox Exact flow meters use an embedded, radio frequency pickup coil that is not field-replaceable. The low profile design of these meters requires a specialized potted pickup that must be returned to Badger Meter, if it requires service or replacement. This type of embedded pickup is vibration resistant and allows for a compact, overall meter size.

## **INSTALLATION**

### **Placement**

Use the flow direction arrow on the meter housing to align the flow meter. Install the meter with the correct orientation to get the most accurate and reliable operation. When flow is expected to be intermittent, do not mount the meter at a low point in the piping system. Solids that settle or congeal in the meter can affect meter bearing performance. To achieve optimum electrical signal output from the flow meter, consider its isolation from ambient electrical interference such as nearby motors, transformers and solenoids.

### **Filtration**

Turbine flow meters have miniature ball bearings upon which the rotor turns. These bearings have extremely precise tolerances and are sensitive to contamination. It is recommended that 10 micron filtration be installed upstream of the flow meter and routinely serviced as part of the preventative maintenance schedule for the metering installation. A strainer should be located ahead of the flow meter, or ahead of the flow straightener if flow straighteners are used.

### **Notes on the Swirl Effect**

The Cox Exact Dual Rotor uses two closely coupled rotors, turning in opposite directions. The flow exiting from the first rotor greatly affects the inlet incidence angle on the rear rotor. The two rotors now become hydraulically coupled. Swirl conditions on the first rotor will have an opposite effect on the second rotor. This means that if the front rotor slows down due to swirl effect, the rear rotor will speed up by the same percentage. The inverse is also true. If the front rotor speeds up, the rear rotor will slow down. The sum (or average) of the two rotors is constant, regardless of swirl effects on rotor RPM. Therefore, flow straighteners are not required in most applications, making it possible to install the flow meter in tight spaces where the added length of piping cannot be tolerated.

### **Valves and Piping**

Blocking or isolation valves and a bypass loop should be installed at each end of the flow meter in order to perform preventive maintenance without shutting down the system completely. If installation conditions will not permit a bypass loop, a 'dummy' flow meter housing or spool should be purchased to replace the flow meter during maintenance and periodic recalibration.

Install thermowells downstream of the flow meter for temperature sensing.

## ⚠ WARNING

**MAKE SURE TO PURGE ALL FLOW LINES OF FOREIGN OBJECTS AND DEBRIS PRIOR TO INSTALLING A FLOW METER TO AVOID BEARING CONTAMINATION OR ROTOR DAMAGE. DO NOT PURGE LINES WITH THE FLOW METER INSTALLED OR IRREPARABLE DAMAGE IS HIGHLY LIKELY TO OCCUR.**

It is critical to avoid over-spinning the meter (operating at greater than the maximum flow rate). Always select a meter sized appropriately for your application. Entrained vapor or gaseous state product in the metered fluid piping can also cause the rotor to over-spin resulting in bearing damage. Necessary precautions must be made by the end user to address these two situations.

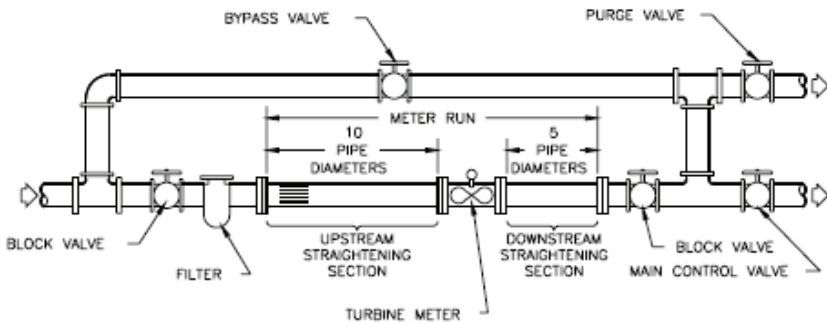


Figure 2: Recommended flow meter installation for bearing diagnostics

Flow meters with threaded end connection (NPT or AN) should not be over tightened when installed into the flow line. This can deform the end connection of the flow meter resulting in sealing issues and problems in performing routine maintenance. Stainless steel is relatively soft and can be damaged if not handled with care. Liquid pipe thread sealant is recommended for pipe thread applications as Teflon® tape often is pulled into the flow stream, thereby contaminating the rotor bearings. Copper conical seals (crush washers) are recommended for use in AN style connections to protect the sealing surface, but are not mandatory to attain a seal.

The flow meter housing is stainless steel, so if the mating part (for example, a flow straightener) is also stainless steel use anti-seize thread lubricant to prevent galling.

To obtain accurate flow measurement, sufficient downstream pressure is required to prevent flashing and/or cavitation. The minimum downstream pressure is calculated using the following equation:

$$\text{Pressure}_{\text{Minimum}} = (\text{Fluid Vapor Pressure} \times 1.25) + (\text{Pressure Drop} \times 2)$$

Adjust downstream pressure using a control valve located downstream of the metering assembly.

## Calibration

Flow meter calibrations should always be performed on a primary standard calibrator. Turbine flow meters are viscosity sensitive devices and should always be calibrated for the specific application viscosity range using the correct calibration fluid.

A flow measurement application with a variable viscosity should always use a Universal Viscosity Curve (UVC) flow meter calibration. The UVC uses data from two or more different viscosity calibrations to provide a blended data curve across the application viscosity range. This UVC data, including fluid properties, are then programmed into a flow computer. The flow computer can then compensate for the viscosity shift due to temperature changes encountered and provide an accurate linearized output.

### CAUTION

***MAKE SURE THE CALIBRATION OF THE FLOW METER MATCHES THE APPLICATION FLUID CONDITIONS IN ORDER TO ACHIEVE ACCURACY, UNCERTAINTY AND REPEATABILITY METRICS.***

All original calibrations of Cox Exact meters are performed by Badger Meter Flow Dynamics, an NVLAP accredited calibration lab. It is highly recommended that the flow meter be returned to Flow Dynamics for subsequent recalibrations in order to maintain performance standards. This will also eliminate any bias between calibration labs that might appear as a calibration shift.

Badger Meter's Flow Dynamics is a primary standard flow calibration laboratory, supplying both manufacturers and end users with dependable calibration results. Throughout the global metrology industry, they are recognized as the calibration-lab-of-choice for customers demanding high-accuracy flow meter calibrations traceable to the most rigorous international standards.



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## MAINTENANCE

### Bearing Replacement

Bearings should be periodically replaced due to normal, in-service wear. Failure to periodically service the bearings will result in inaccurate readings. Generally, replacing the bearing will return the meter to its original calibration. However, new bearings can be defective and rotor blade wear will also shift the calibration. Therefore, turbine flow meters should never be returned to service after a bearing change until they have been calibrated using a primary standard flow meter calibrator.

It is highly recommended to have bearing replacement performed by the factory. Bearing changes are technically simple but can become very costly and time-consuming if performed incorrectly. Additionally, bearing changes mandate recalibration in order to maintain accuracy due to variances in bearing performance. By returning the meter to the factory, you guarantee receiving the fastest, most economical service combined with the correct and current calibration for your application.

### Visual Inspection

Simple visual inspection is the only other preventive maintenance to be performed. Periodically inspect the flow meter housing for signs of damage, wear or fatigue failure (stress cracking, specifically on flanged series). Leaks from fluid connections are important to catch in order to maintain accuracy and to prevent contamination of the environment. Regard the flow meter as both pipe work and instrumentation when defining the preventive maintenance schedule.

The signal output system should be periodically checked while inspecting for environmental deterioration. Allowing the connectors and cabling to degrade can adversely affect the quality of the output signal, which may cause data acquisition system issues.

The frequency of inspection and maintenance is application-specific. As the environment and application get harsher or dirtier, the frequency of inspection should be increased.

### Recommended Spare and Replacement Parts

Due to the calibrated nature of this instrument, it is not beneficial to maintain a stock of spare or replacement parts. If the application is critical and must not be offline for maintenance or periodic recalibration, it is highly recommended to stock a spare calibrated flow meter assembly.

## TROUBLESHOOTING

The typical failure mode for a turbine flow meter is failure to provide an output indication of flow. Troubleshooting this condition can be divided into two major sections: mechanical and electrical.

### Mechanical Issues

Mechanical items to check when there is a failure-to-indicate condition:

- **Is there flow present to the instrument?**

Confirm all isolation and/or bypass valves are in the correct orientation to provide a moving fluid stream to the unit. Spectacle blinds and other blocking devices must be removed in order to allow fluid to enter the meter and turn the rotor. Flange gaskets can also slip out of place during installation and block the flow stream.

- **Is there foreign material blocking the rotor?**

Debris or solids allowed to enter the flow meter can easily stop the rotation of the rotor. Purging lines for construction debris should be performed with the instrument removed from the line. Remove the meter and remove all foreign bodies. Typical debris is Teflon thread tape, flux, rags and slug from the bottom of tanks. Anytime upstream pipe maintenance is performed, there is a potential of bearing contamination or blockage.

- **Is there damage to the internal assembly?**

Allowing solids to enter the meter or shocking the system with extreme pressurization variations can damage the internal assembly such that the rotor will no longer rotate. Remove the meter and gently blow air through the meter. Verify that the rotor can freely move. Do not use high pressure air or further damage can result. If the rotor does not rotate freely under minimal input, contact the factory for repair.

### Electrical Issues

Electrical items to check when there is a failure-to-indicate condition:

- **Is the pickup or flow computer connected?**

The pickup or flow computer must be connected to the data acquisition system for signal to be received. Often, a break is encountered in the cable run rather than at the connector.

- **Is power supplied to the pickup or flow computer?**

Several models of pickup and all flow computers require supply power to operate. Consult the applicable wiring diagram for your model and verify that supply voltage is present on the correct conductors at the correct pins.

- **Is the electrical installation correct?**

Many factors affect electrical installation including power and signal cable proximity, shielding from adjacent electrical noise sources, proper grounding, amplifier gain settings, length of cabling runs, impedance matching of pickup and amplifier or readout, shielding from excessive heat sources, and more. Each installation is unique and may require several iterations of troubleshooting to correct electrical issues. Badger Meter can assist in solving any issues that may arise. Contact Technical Support.

## FLOW RANGE SPECIFICATIONS

### Sizing and Range

Size (in.)	Pipe ID	Flow Ranges at 1 cSt S.G. – 1			
		gpm	lb/hr	lpm	kg/hr
1/4	8-4	0.025...3.00	9.53...1143	0.095...11.40	4.32...518.46
3/8	8-6	0.035...6.00	13.34...2286	0.132...22.71	6.05...1036.91
1/2	8	0.040...10.0	15.24...3810	0.151...37.85	6.91...1728.19
5/8	10	0.045...16.0	17.15...6096	0.170...60.56	7.78...2765.10
3/4	12	0.080...30.0	30.48...11,430	0.303...113.5	13.82...5184.56
1	16	0.150...65.0	57.15...24,765	0.568...246.0	25.92...11,233.21
1-1/4	20	0.250...95.0	95.25...36,195	0.946...359.6	43.20...16,417.78
1-1/2	24	0.350...155	133.35...59,055	1.324...586.7	60.49...26,786.90
2	32	0.600...310	228.60...118,110	2.27...1173.5	103.69...53,573.79
2-1/2	40	1.000...500	381.00...190,500	3.78...1892.7	172.82...86,409.35
3	48	2.000...800	762.00...304,800	7.57...3028	345.64...138,254
4	64	5.000...1500	1905.00...571,500	18.90...5678	864.09...259,228

Size (in.)	Pipe ID	Repeatable Range 1 cSt	UVC Down Range	Typical K-Factor (pulses/gallon)	
		Ratio	Ratio	Rotor "A"	Rotor "B"
1/4	8-4	120:1	30:1	30,000	33,000
3/8	8-6	171:1	35:1	15,000	16,500
1/2	8	250:1	40:1	9480	10,440
5/8	10	355:1	45:1	6000	6375
3/4	12	375:1	50:1	3640	4000
1	16	433:1	60:1	1680	1846
1-1/4	20	380:1	60:1	1149	1263
1-1/2	24	443:1	60:1	705	774
2	32	517:1	60:1	242	266
2-1/2	40	500:1	60:1	132	145
3	48	400:1	60:1	45	50
4	64	300:1	60:1	20	22

Table 2: Sizing and range

### Dual Frequency Outputs

See the EC80 Flow Processor data sheet for output selections, available at [www.badgermeter.com](http://www.badgermeter.com).

## DIMENSIONS

### AN End Connection

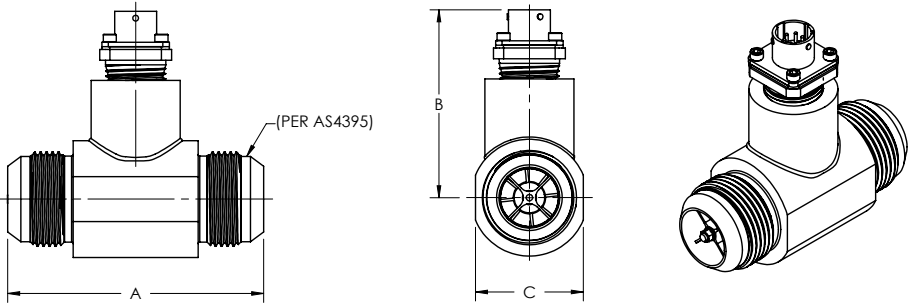


Figure 3: AN end connection

Size	Pipe ID	End Connection in. (mm)	A in. (mm)	B (DL Model) in. (mm) ± 0.13 (3.30)	C in. (mm)
1/4	8-4	0.50 (12.70)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
3/8	8-6	0.50 (12.70)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
1/2	8	0.50 (12.70)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
5/8	10	0.625 (15.88)	2.92 (74.17)	2.42 (61.47)	1.00 (25.40)
3/4	12	0.75 (19.05)	3.25 (82.55)	2.53 (64.26)	1.37 (34.80)
1	16	1.00 (25.40)	3.56 (90.42)	2.61 (66.29)	1.50 (38.10)
1-1/4	20	1.25 (31.75)	4.06 (103.1)	2.80 (71.12)	1.72 (43.69)
1-1/2	24	1.50 (38.10)	4.59 (116.6)	2.93 (74.42)	2.00 (50.80)
2	32	2.00 (50.80)	6.06 (153.9)	4.26 (108.2)	2.63 (66.80)

Table 3: AN end connection dimensions

## NPT End Connection

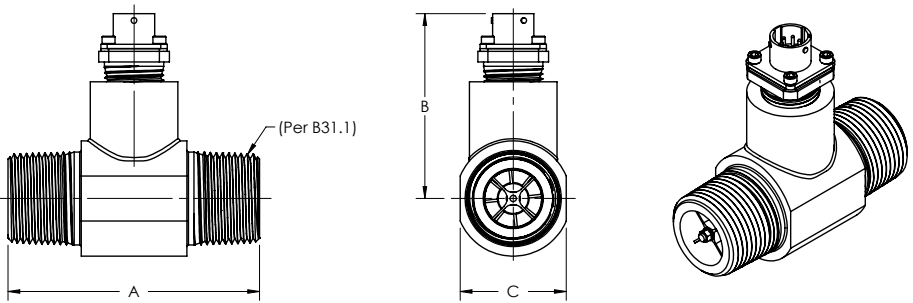


Figure 4: NPT end connection

Size	Pipe ID	End Connection in. (mm)	A in. (mm)	B (DL Model) in. (mm) ± 0.13 (3.30)	C in. (mm)
1/4	8-4	0.25 (6.35)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
3/8	8-6	0.375 (9.53)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
1/2	8	0.50 (12.70)	2.75 (69.85)	2.42 (61.47)	0.87 (22.10)
5/8	10	0.75 (19.05)	2.92 (74.17)	2.42 (61.47)	1.00 (25.40)
3/4	12	0.75 (19.05)	3.25 (82.55)	2.53 (64.26)	1.37 (34.80)
1	16	1.00 (25.40)	3.56 (90.42)	2.61 (66.29)	1.50 (38.10)
1-1/4	20	1.25 (31.75)	4.06 (103.1)	2.80 (71.12)	1.72 (43.69)
1-1/2	24	1.50 (38.10)	4.59 (116.6)	2.93 (74.42)	2.00 (50.80)
2	32	2.00 (50.80)	6.06 (153.9)	4.26 (108.2)	2.63 (66.80)

Table 4: NPT end connection dimensions

## Flange End Connection

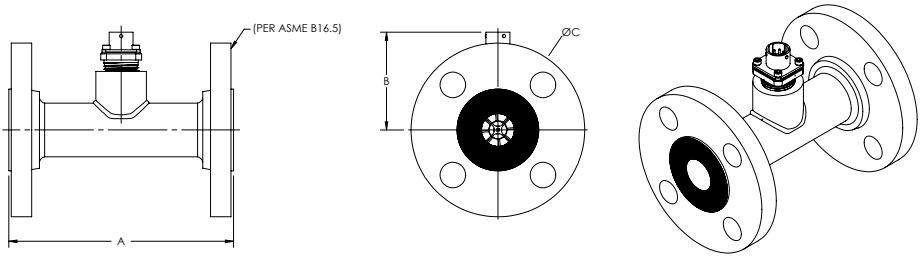


Figure 5: Flange end connection

Size	Pipe ID	End Con- nection in. (mm)	A in. (mm)	B (DL Model) in. (mm)	C – 150# Flange in. (mm)	C – 300# Flange in. (mm)	C – 600# Flange in. (mm)
1/4	8-4	Consult Badger Meter					
3/8	8-6						
1/2	8						
5/8	10						
3/4	12						
1	16	1.00 (25.40)	5.50 (139.7)	2.40 (60.96)	4.25 (107.9)	4.88 (123.9)	4.88 (123.9)
1-1/4	20	1.25 (31.75)	6.00 (152.4)	2.70 (68.58)	4.625 (117.5)	5.25 (133.3)	5.25 (133.3)
1-1/2	24	1.50 (38.10)	6.00 (152.4)	2.80 (71.12)	5.00 (127.0)	6.12 (155.4)	6.12 (155.4)
2	32	2.00 (50.80)	6.50 (165.1)	4.30 (109.2)	6.00 (152.4)	6.50 (165.1)	6.50 (165.1)
2-1/2	40	2.50 (63.50)	7.00 (177.8)	4.30 (109.2)	7.00 (177.8)	7.50 (190.5)	7.50 (190.5)
3	48	3.00 (76.20)	10.0 (254.0)	4.60 (116.8)	7.50 (190.5)	8.25 (209.5)	8.25 (209.5)
4	64	4.00 (101.6)	12.0 (304.8)	5.10 (129.5)	9.00 (228.6)	10.0 (254.0)	10.75 (273.1)

Table 5: Flange end connection dimensions

## Hose Barb End Connection

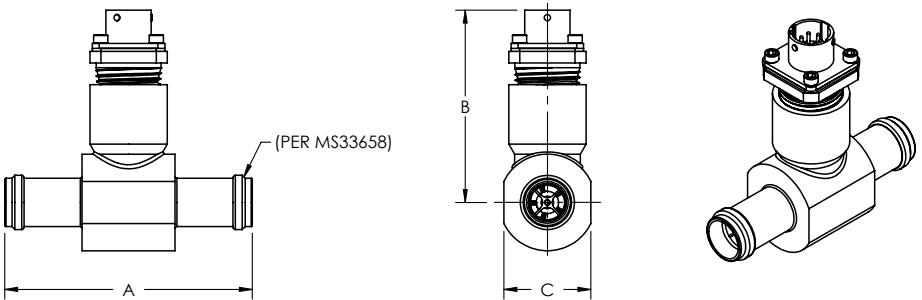
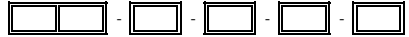


Figure 6: Hose barb end connection

**NOTE:** Hose barb fittings available for all ranges. Special end connection are developed to meet your application requirements.

# PART NUMBERING CONSTRUCTION

Cox Exact Turbine Flow Meters



**Model**

Dual Rotor, MS Connector; for use with remote mount electronics	CDL
Dual Rotor; for use with integral mount electronics	CDX

**Meter Size**

8-4 (1/2" End Fitting, 1/4" Bore)	84
8-6 (1/2" End Fitting, 3/8" Bore)	86
8 (1/2" End Fitting, 1/2" Bore)	08
10 (5/8" End Fitting)	10
12 (3/4" End Fitting)	12
16 (1" End Fitting)	16
20 (1-1/4" End Fitting)	20
24 (1-1/2" End Fitting)	24
32 (2" End Fitting)	32
40 (2-1/2") Available for flanges only.	40
48 (3") Available for flanges only.	48
64 (4") Available for flanges only.	64

**End Fitting Type**

37° MS Flare	AN
National Pipe Thread	NP
Hose Barb	HB
150# ANSI Raised Face Flange	F1
300# ANSI Raised Face Flange	F2
600# ANSI Raised Face Flange	F3

**Bearing**

Hybrid Ceramic Ball Bearing, Water/Hydrocarbon Service	C
--	---

**Pickoff**

RF Carrier	A
RF Carrier with Thermistor	B
RF Carrier with RTD	R

**Specials**

3-Digit Special Code (Leave blank for non-custom orders.)	XXX
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**NOTE:** Higher flange ratings and other end connection types can be provided. Consult the factory for pricing and delivery estimates.

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