Cox Turbine Flow Meters

Precision Meters

Turbine Flow Meters

Badger Meter

TUR-UM-00477-EN-01 (May 2014)

User Manual

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DESCRIPTION AND USE

Cox Precision Turbine Flow Meters are a precisely manufactured and calibrated instruments used in accurate rate-of-flow and total-flow measurement of all types of fluids, whether liquid or gas.

They also have many applications as sensors in process flow control.

The flow meter mounts directly in the flow line and consists of a cylindrically bored housing, a flow straightener and turbine assembly, and magnetic or carrier frequency pickoffs, as shown in *Figure 1*.

On all Precision Flow Meters, the magnetic or carrier frequency pickoff is located directly above the turbine, near the downstream end of the flow meter. The flow straightener and turbine assembly is retained in the housing by a snap ring and can be easily removed for cleaning and further disassembly.

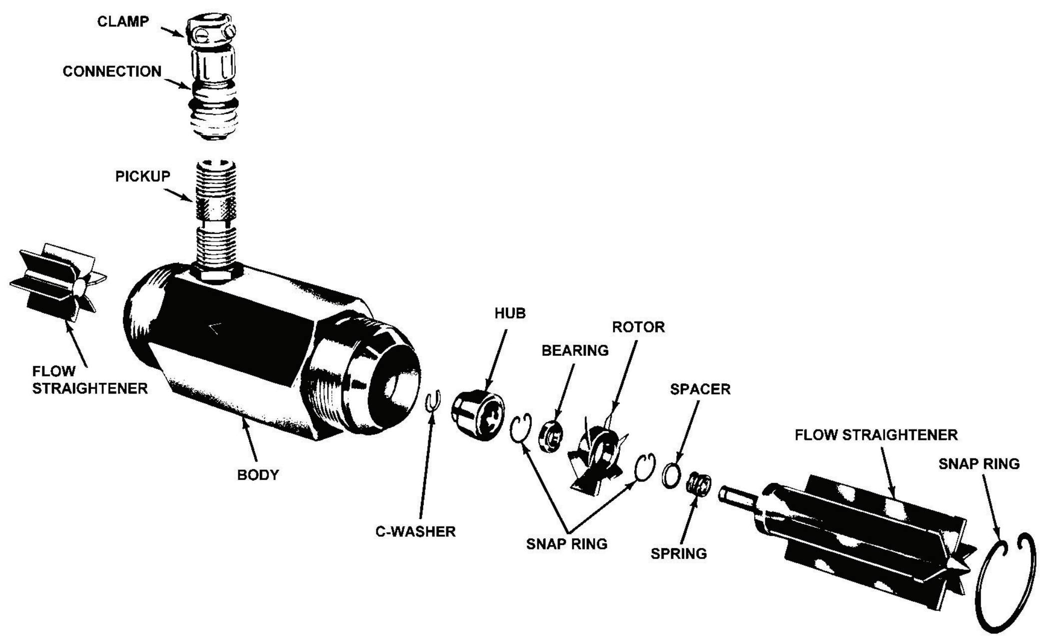


Figure 1: Turbine flow meter

Cox Precision Turbine Flow Meters are provided with flow straighteners at the downstream and upstream ends. The flow straighteners diminish any turbulence created by the turbine. Other physical differences are illustrated in exploded views. See *Figure 2* and *Figure 3*.

Fluid passing through the meter causes the rotor and bearing to revolve at a speed directly proportional to fluid velocity. As each rotor blade passes the pickoff, it varies the pickoff's reluctance, producing an output signal. Since turbine speed is directly proportional to fluid velocity, signal frequency is similarly proportional to the volumetric rate-of-flow. The output signal can be fed into various types of instruments to indicate the rate-of-flow, such as indicators, frequency converters, counters, recorders and controllers.

Cox uses two pickoff technologies, magnetic and carrier frequency (RF). The magnetic pickoff has a self-generating mV frequency output. The RF carrier pickoff senses eddy current losses as the rotor blade passes the pickoff. It does not use an internal permanent magnet and therefore eliminates magnetic drag on the rotor. This results in linear flow ranges up to 100:1 and repeatable operating flow ranges up to 150:1. The RF carrier pickoff requires a signal conditioner to generate an output. A high level signal offers the advantage of high output signal to noise ratio over the entire range of the flow meter and permits long distance signal transmission.

All Cox Precision Turbine Flow Meters are designed to provide a high frequency output voltage at the maximum of their flow range. This high frequency signal improves resolution and standardized output permits several overlapping range flow meters to be connected in series to one indicating instrument. Data concerning extended ranges, specific output voltage and other frequency ranges is available from the Badger Meter Sales Department. As with any precision instrument, the full capabilities of the Cox Precision Turbine Flow Meter can be realized only through close adherence to the installation and maintenance instructions discussed in this manual.

SAFETY INFORMATION

The installation of the Cox Precision Turbine Flow Meters must comply with all applicable federal, state, and local rules, regulations, and codes.

Failures to read and follow these instructions can lead to misapplication or misuse of the Cox Precision Turbine Flow Meters, resulting in personal injury and damage to equipment.

Safety Symbol Explanations

DANGER

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED IS ESTIMATED TO BE CAPABLE OF CAUSING DEATH OR SERIOUS PERSONAL INJURY.

WARNING

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED COULD RESULT IN SEVERE PERSONAL INJURY OR DEATH.

CAUTION

INDICATES A HAZARDOUS SITUATION, WHICH, IF NOT AVOIDED IS ESTIMATED TO BE CAPABLE OF CAUSING MINOR OR MODERATE PERSONAL INJURY OR DAMAGE TO PROPERTY.

UNPACKING & 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 may have occurred during shipment.

NOTE: If damage is found, request an inspection by the carrier's agent withing 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.

INSTALLATION

Meter Orientation

Cox Precision Turbine Flow Meters may be installed in any position without affecting performance. Be sure direction of flow is in the direction of the arrow engraved on the flow meter body. **Exception**: Position gas service meters as calibrated.

Piping

Recommended layout for Cox Precision Turbine Flow Meters specifies a straight section of pipe or tube in the same size as the flow meter and equal in length to 10 diameters on the upstream side, and a similar section equal in length to 5 diameters in order to retard the formation of swirls in the liquid, which can cause incorrect flow meter output. If space prohibits the use of these straight sections, use extreme care in arranging the piping to produce as straight and smooth a flow as possible. Available Cox Flow Straighteners are listed in the *Cox Flow Straighteners Product Data Sheet*. Go to *www.badgermeter.com.*

Use of Pipe Compound

The 37-degree flared tube connections of Cox Precision Turbine Flow Meters DO NOT require any sealing compound or Teflon tape, and none should be used. The use of these on adjacent piping should be held to a minimum in order to avoid coating the bearings and rotor blades with compound, causing premature rotor failure and erratic performance.

NOTE: Copper conical seals or crush rings may be used, if necessary.

⚠CAUTION

BLEED ALL AIR AND VAPOR FROM THE LIQUID AFTER INSTALLING OR REINSTALLING A FLOW METER.

START FLOW SLOWLY TO AVOID SENDING A "SLUG" OF HIGH VELOCITY AIR OR VAPOR THROUGH THE FLOW METER AND CAUSING IT TO OVERSPEED. START REQUIRED FLOW AFTER FLOW METER IS FULL OF LIQUID. AERATED LIQUIDS FLOWING THROUGH A FLOW METER WILL RESULT IN INCORRECT FLOW RATES.

DISASSEMBLY

Cox Precision Ball Bearing Type

1. Firmly hold flow meter and, using tweezers, carefully remove internal snap ring from the upstream end.
2. Use long nose pliers and grasp one vane of flow straightener and gently pull flow straightener and rotor assembly from the body. Use slight twisting motion. Snug fit at transition.
3. Press down on the hub to relieve spring pressure on C-washer and remove with tweezers or thin nosed pliers. Remove hub, spring and spacer.
4. Carefully remove rotor from shaft.
5. Remove a snap ring from side of bearing and push bearing out of rotor.

NOTE: Models CLFA6 and CLFB6 must be returned to factory for bearing change.

CLEANING

Immerse all parts, except pickoff, in a clean, filtered solvent suitable for removing residue from the liquid the flow meter has been used with. If necessary, use a soft bristle brush.

If there is foreign matter in the ball bearings, allow them to soak in the solvent for approximately 10 minutes and then dry with filtered compressed air. Do not use excessive air pressure.

NOTE: Do not sonic clean bearings!

⚠CAUTION

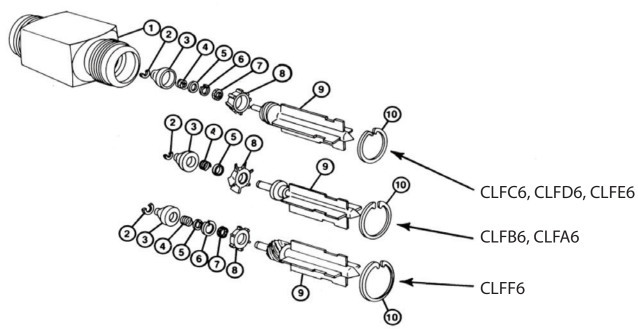
EXERCISE EXTREME CARE DURING THE CLEANING PROCESS SO THAT NONE OF THE PARTS ARE DROPPED, SCRATCHED OR DAMAGED IN ANY WAY. NO ATTEMPT SHOULD BE MADE TO FURTHER POLISH ANY OF THE PARTS, ESPECIALLY THE ROTOR.

Procedure for Cleaning a Turbine Meter after Water Calibration and/or Service

NOTE: When cleaning flow meters, keep the body, sleeve and pickoff together. Sleeve is fitted to body and pickoff has a protruding pin. Replacement pickoffs are supplied with a nut and have no protruding pin.

1. Remove the meter from the line and let all excess water drip out.
2. Fill the meter with alcohol (at least 50% Isopropyl, Ethyl or Methyl) and let it stand for 5 minutes.
3. Discard the alcohol and let the meter dry for 2 minutes.
4. Fill the meter with MIL-C-7024 Type 2 calibration fluid (or similar solvent) and let it stand for 1 minute.
5. Discard the calibration fluid and flush the meter with an approved fluorocarbon solvent, such as Isotron.

NOTE: If this procedure is not possible, the turbine meter should always remain filled with water when not in use, to prevent internal wetted parts from being exposed to air.



CLFC6, CLFD6, CLFE6, CLFF6

1. Body *
2. C-washer
3. Hub *
4. Spring *
5. Spacer
6. Bearing retainer ring *
7. Bearing
8. Rotor *
9. Straightener assembly *
10. Body retaining ring

CLFB6, CLFA6

1. Body *
2. C-washer
3. Hub *
4. Spring *
5. Spacer
8. Rotor *
9. Straightener assembly *
10. Body retaining ring

* Replaceable at factory level only.

NOTE: Order parts by name and basic number shown, followed by flow meter size designation. For example, order a bearing for a CLFF6 flow meter as bearing #1400-63. Flow meter serial number must be provided when ordering parts.

Figure 2: Cox Precision LoFlo turbine flow meter

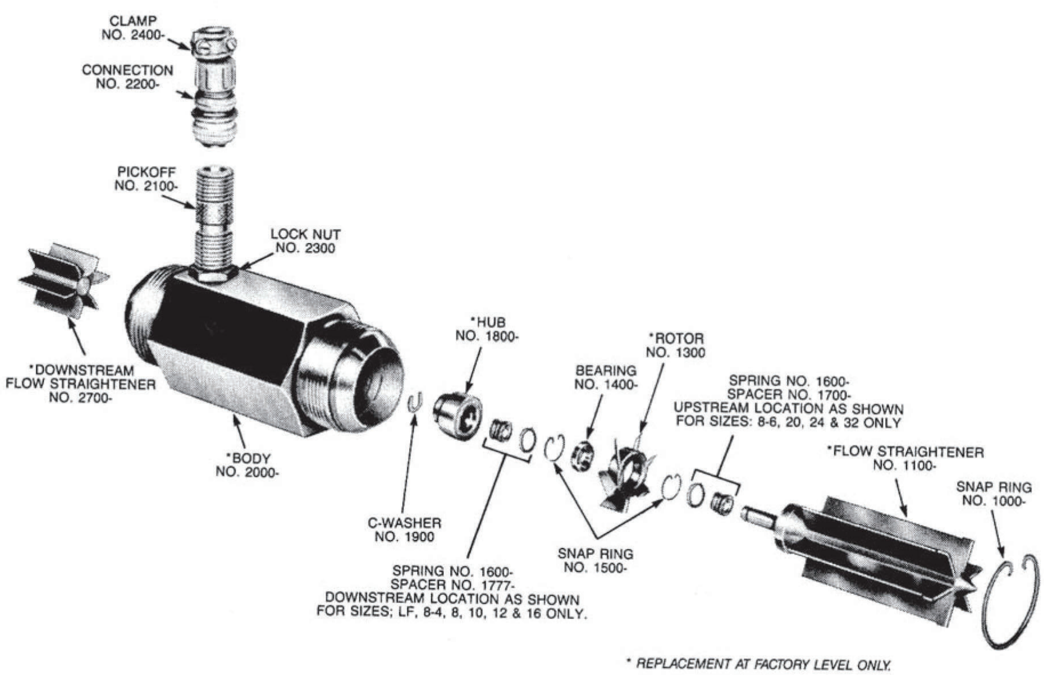


Figure 3: Cox precision turbine flow meter

CAUTION

DO NOT INTERCHANGE FLOW METER PARTS OTHER THAN BEARINGS AND RETAINING RINGS. THIS PRECAUTION IS NECESSARY TO PRESERVE LINEARITY AND REPEATABILITY.

REASSEMBLY

Reassembly is the reverse of disassembly except for the following:

- On Precision Turbine Flow Meters where shaft bearings are provided with a retainer, always install with the retainer flange facing upstream.
- Inspect rotor for markings as shown in *Figure 4* to indicate flow direction before assembly.
- Flow meters having broached slots in the body for flow straightener vanes should be carefully assembled.
- Align straightener vanes with the slots and push gently until the assembly is seated.

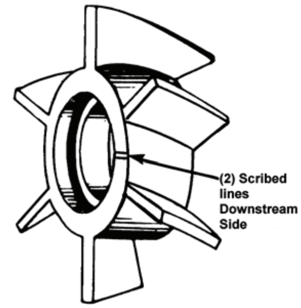


Figure 4: Scribed lines

TROUBLESHOOTING

Issue	Possible Cause	Remedy
Meter indicates higher flow than actual.	Cavitation.	Increase back pressure.
Meter indicates high flow.	Dirt blocking flow area rotor.	Clean meter; add filter.
Meter indicates low flow.	Dirt dragging rotor.	Clean meter; add filter.
Meter indicates low flow.	Worn bearing.	Replace bearing; recalibrate when required.
Meter indicates low flow.	Viscosity higher than calibrated.	Change temperature; change fluid; recalibrate meter.
Erratic system indication; meter alone works well.	Ground loop is shielding.	Ground shield one place only. Watch for internal electronic instrument grounds.
Indicator shows flow when shut off. Mechanical vibration causes rotor to oscillate without turning.	Mechanical vibration.	Isolate meter; use potted pickoff.
No flow indication. Full flow of fluid opened into dry meter. Impact of fluid on rotor causes bearing separation.	Fluid shock. New bearing failed.	Move meter to position where it is full of fluid at start-up.
Erratic indication at low flow; good indication at high flow.	Low instrument sensitivity. 10 mV rms turbine signal is being lowered by loading of electronics or instrumentation cannot sense low level signals.	Amplify signal.
No flow indication.	Faulty pickoff.	Replace pickoff; recalibrate as necessary.
System works perfectly, except indicates lower flow over entire range.	Bypass flow, leak.	Eliminate bypass valves, leak. Faulty solenoid valves.
Meter indicating high flow. Upstream piping at meter smaller than meter.	Fluid jet impingement on rotor. Critical in gas.	Change piping.
Opposite effects as above.	Viscosity lower than calibrated.	Change temperature; change fluid; recalibrate meter.
Mass flow indication wrong. Turbine meter is volumetric; density correction is electronic; must change with temperature.	Wrong fluid density. Critical in gas.	Check fluid, electronics.
Erratic or wrong indication of flow.	Loose pickoff.	Tighten pickoff.
Indicates high flow two hours after installing new bearing.	Bearing wear-in; small meters critical.	Recalibrate. 20…30 min. run-in is required to stabilize friction.
Cannot reach maximum flow rate; meter selection was with Delta-P at 0.75 sp. gr., now using on 1.0 sp. gr. Delta-P is proportional to specific gravity.	High pressure drop.	Install larger meter.
Does not repeat at low flows. Repeats at high flows.	System resolution readability.	Increase resolution, for example: 1 out of 100 = 1% 1 out of 1000 = 0.1%

Table 1: Troubleshooting

TECHNICAL TERMS

Several terms, such as K-Factor and linearity, are used to indicate turbine flow meter performance.

K-Factor

"K" is a letter used to denote the cycles per gallon factor of a flow meter. This factor is a fixed value used in resolving or totalizing the pulse count output of a flow meter. It results from the equation:
Cycles per second/Gallons per second = Cycles per gallon (K)

Repeatability

The maximum deviation from the corresponding data points taken from repeated tests under identical conditions.

Linearity

This is defined as the deviation from the mean calibration factor (K) and is expressed as being within a certain tolerance. Cox Precision Turbine Flow Meters are linear to ± 0.5% over the range shown.

CALIBRATION DATA

K-Factor

The calibration data supplied with a Cox Precision Turbine Flow Meter is shown in *Figure 6*.
Correct application of a Cox Precision Turbine Flow Meter requires consideration of many important factors. Because of the wide variation of possible applications, detailed data for liquid flow models only is given in this manual. For special requirements—such as those outside the range of –300…350° F, those with extremely corrosive liquids, gases and other unusual conditions—consult the Badger Meter Sales Department.

20-Point Calibration

Calibration at twenty flow rates (10 up-scale and 10 down) between minimum and maximum flow range, is available for application where ± 0.25% accuracy or better is required. With this calibration complete data on signal output, pressure drop, K-Factor and deviation from linearity is supplied.

30-Point Calibration

This is the same as the 20-point, with 10 extra points to cover the longer range of the carrier type meters.

UVC-Universal Viscosity Curve

A 10-point calibration is made at each of four viscosities if curves of "K" versus Hertz were made. In between, viscosities cannot be determined (see right side of *Figure 5*). Replot as "K" versus Hertz divided by centistokes. A single curve is drawn through all data points. Other viscosity curves can now be determined. Use only over 10:1 range for viscosity effects.

Gas Calibrations

When performed at the Flow Dynamics facility, a curve of ACFM vs. Hertz is supplied.

Pressure Rating

The standard LoFlo and Precision Flow Meters are rated 2500…5000 psi operating pressure. They have a 4:1 pressure safety factor. Flange flow meters are rated for service pressure according to ANSI ratings for the flanges used.

Operation at temperatures above 200° F will decrease the connection rating because of lowered stress capabilities of the metal.

Liquid Formula

$$GPM = (Hertz \times 60) \div K$$

$$\frac{PPH = Hertz \times 3600 \times 8.328 \times S.G.}{K}$$

$$Time\ Base\ in\ Seconds = \frac{Engrg.Units\ GPM - PPH}{Hertz}$$

Gas Formula

$$\rho = \frac{144 \times PSIA}{R \times {}^{\circ}Rankine} = \#/ft^3$$

$$SCFM = ACFM \times \frac{\rho\ \text{Act}}{\rho\ \text{Std}}$$

$$PPM = ACFM \times \rho\ Act$$

Figure 5: Calculating flow rates in different units

Flow Dynamics®
Calibrators | Calibration Services

Certificate of Calibration

Badger Meter®

www.badgermeter.com

15555 North 79th Place • Scottsdale, AZ 85260 • Phone: (480) 948 -3789 • Fax: (480) 948 -3610 • sales@flow-dynamics.com

Customer Name:	HONG KONG EVERBLOOMING INTL CO LTD	**Report #**	CX35874 - X14892
Customer Address:	Sooner Air Freight Int'l Ltd Unit 7,Corp Square, 8 Lam Lok Street KLN BAY Hong Kong		
Customer PO #	13EB0205COX		
Model #	NRPC 12	**Cal Date:**	2/21/2013
Serial #	X14892	**Customer Re-Cal Date:**	
Signal:	PULSE (Collect Raw Data)	**Lab Temp:**	72.1 Deg F
Calibration Procedure:	FDP-002	**Lab Relative Humidity:**	27.3%
Calibration Tech:	Luis		
Fluid Specifications:	MIL-C-7024 T2	**Specific Gravity:**	0.76
Temperature (F):	80	**Viscosity (CSTKS):**	1.12
Notes, Adjustments & Repairs			

Calibration Results (Initial Calibration)

Test Point #	Frequency Hz	Flow Rate GPM	Roshko # Hz/cstk	Strouhal # pul/gal	Meter Temp Deg. F	Viscosity cStks	Density g/cc	Flow Rate LPM
1	10.5941	0.23290	10.1597	2729.48	72.223	1.0428	0.7662	0.88161
2	10.5995	0.23292	10.1649	2730.62	72.223	1.0428	0.7662	0.88169
3	16.4760	0.35749	15.8004	2765.43	72.224	1.0428	0.7666	1.35326
4	16.4773	0.35751	15.8017	2765.55	72.224	1.0428	0.7666	1.35331
5	23.0864	0.49779	22.1398	2782.83	72.229	1.0428	0.7665	1.88435
6	23.0878	0.49790	22.1411	2782.42	72.229	1.0428	0.7665	1.88474
7	31.8261	0.68334	30.5241	2794.65	72.239	1.0427	0.7665	2.58671
8	31.8233	0.68336	30.5214	2794.30	72.244	1.0427	0.7665	2.58681
9	45.9753	0.98154	44.0817	2810.58	72.207	1.0430	0.7665	3.71553
10	45.9764	0.98158	44.0913	2810.53	72.224	1.0428	0.7665	3.71569
11	65.0253	1.38527	62.2155	2816.58	71.909	1.0452	0.7665	5.24383
12	65.0929	1.38719	62.2802	2815.61	71.909	1.0452	0.7665	5.25109
13	92.3185	1.97035	88.2532	2811.37	71.782	1.0461	0.7665	7.4586
14	92.7150	1.97801	88.7088	2812.52	71.909	1.0452	0.7665	7.4876
15	126.727	2.71355	121.228	2802.25	71.876	1.0454	0.7665	10.2719
16	126.986	2.71960	121.429	2801.72	71.829	1.0458	0.7665	10.2948
17	172.915	3.72060	165.032	2788.63	71.567	1.0478	0.7668	14.084
18	173.020	3.72232	165.100	2789.03	71.539	1.0480	0.7668	14.0905
19	249.704	5.39233	238.001	2778.54	71.382	1.0492	0.7668	20.4122
20	250.070	5.39867	238.304	2779.35	71.347	1.0494	0.7668	20.4362
21	353.158	7.64305	335.772	2772.47	71.032	1.0518	0.7669	28.9321
22	353.580	7.65082	336.141	2772.96	71.016	1.0519	0.7669	28.9615
23	487.881	10.5643	462.716	2770.99	70.694	1.0544	0.7669	39.9901
24	488.960	10.5857	464.180	2771.49	70.824	1.0534	0.7669	40.0714
25	724.643	15.6740	686.287	2773.97	70.499	1.0559	0.7669	59.3325
26	725.055	15.6826	685.830	2774.01	70.321	1.0572	0.7669	59.3651
27	986.019	21.3207	976.576	2775.36	76.755	1.0098	0.7669	80.7077
28	993.053	21.4722	982.275	2775.43	76.571	1.0111	0.7668	81.281
29	1406.85	30.3943	1390.06	2777.71	76.414	1.0122	0.7668	115.055
30	1412.22	30.5055	1393.71	2778.13	76.245	1.0134	0.7668	115.476

Standards Used in Calibration

Standard #	Description	Serial #	ReCal Date
FDI-180	30 GPM Liquid Prover	NA	8/12/2013

The instrument referenced above was calibrated using standards traceable to the National Institute of Standards and Technology. Calibration reports for references maintained by Badger Meter, Inc. are available upon request to the customer of this calibration report. The volumetric flow rates reported are within a best uncertainty of +/- .037% of reading (Represents an expanded uncertainty using a coverage factor, k = 2, at an approximate level of confidence of 95%) and applies to calibration equipment only and does not apply to the UUT (Unit Under Test).
Badger Meter, Inc. Flow Dynamics calibration services are accredited by NVLAP (Lab Code 200668-0) to ISO/IEC 17025:2005 (NIST Handbook 150) and are compliant to ANSI/NCSLZ540-1-1994; Part 1. This certificate is not an endorsement by NVLAP, NIST or an agency of the federal government.
The results reported relate only to the item(s) calibrated as described above. This report may not be reproduced, except in full, without the written approval of Badger Meter, Inc.

I certify the accuracy of this Calibration Report:	Andrew Yee	Calibration Engineer	
	Name	Title	Signature

Doc Nbr: CRF-002 Rev: F
Report #:CX35874 - X14892 **Page 1 of 1**

NVLAP® Lab Code 200668-0

Figure 6: Calibration certification

Torque Rating

When using Precision Flow Meters with AN end fittings at high pressure, tighten the fittings to the torque values in *Table 2*.

Size	Minimum Torque (Dry)
All CLF Meters	270 in-lb
8-4, 8-6, 08	450 in-lb
10	650 in-lb
12	900 in-lb
16	1200 in-lb
20	1400 in-lb
24	1600 in-lb
32	1800 in-lb

Table 2: Torque values

Materials

Materials listed in *Table 3* are recommended and used for most turbine flow meter applications. For unusual requirements—such as those outside the range of –300…350° F or those with extremely corrosive liquids—consult the Badger Meter Sales Department.

Part	Type
Bearing	Hybrid ceramic
Body	316
C-Washer	302
Hub	303
Locknut	CRS (plated)
Pickoff	304
Spacer	303
Spring	302
Snap Ring	303
Straightener Assembly	316
Rotor	17-4 SS

Table 3: Materials per part

Dimensions

- See *"Dimensions (Liquid)" on page 14* for tube sizes and mounting dimensions of liquid Precision Turbine Flow Meters.
- See *"Dimensions (Gas)" on page 18* for tube sizes and mounting dimensions of gas Precision Turbine Flow Meters.

DIMENSIONS (LIQUID)

Dimension B specifies the most common pickoff type. Actual size may vary depending on pickoff choice. Consult factory for details.

AN End Fitting

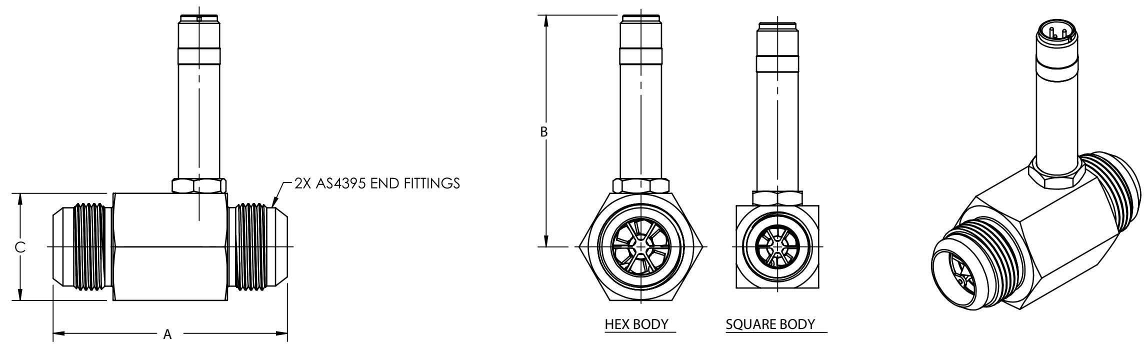


Figure 7: AN end fitting

Size	End Fitting in. (mm)	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C in. (mm)
8-4	0.50 (12.70)	2.45 (62.23)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square Body
8-6	0.50 (12.70)	2.45 (62.23)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square Body
8	0.50 (12.70)	2.45 (62.23)	3.30 (83.82)	2.80 (71.12)	1.12 (28.45) Square Body
10	0.625 (15.88)	2.72 (69.08)	3.30 (83.82)	2.80 (71.12)	1.25 (31.75) Square Body
12	0.75 (19.05)	3.25 (82.55)	3.40 (86.36)	2.90 (73.66)	1.25 (31.75) Square Body
16	1.00 (25.40)	3.56 (90.42)	3.50 (88.90)	3.00 (76.20)	1.63 (41.40) Hex Body
20	1.25 (31.75)	4.06 (103.1)	3.60 (91.44)	3.10 (78.74)	1.88 (47.75) Hex Body
24	1.50 (38.10)	4.59 (116.6)	3.80 (96.52)	3.30 (83.82)	2.25 (57.15) Hex Body
32	2.00 (50.80)	6.06 (153.9)	4.00 (101.6)	3.50 (88.90)	2.75 (69.85) Hex Body

Table 4: AN end fitting dimensions

NPT End Fitting

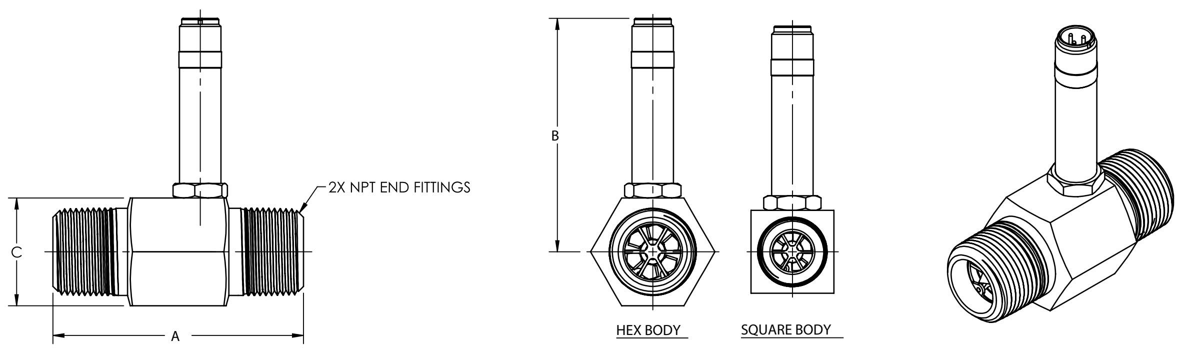


Figure 8: NPT end fitting

Size	End Fitting in. (mm)	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C in. (mm)
8-4	0.50 (12.70)	2.70 (68.58)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square Body
8-6	0.50 (12.70)	2.70 (68.58)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square Body
8	0.50 (12.70)	2.70 (68.58)	3.30 (83.82)	2.80 (71.12)	1.12 (28.45) Square Body
10	0.75 (19.05)	3.29 (83.57)	3.30 (83.82)	2.80 (71.12)	1.25 (31.75) Square Body
12	0.75 (19.05)	3.29 (83.57)	3.40 (86.36)	2.90 (73.66)	1.25 (31.75) Square Body
16	1.00 (25.40)	3.78 (96.01)	3.50 (88.90)	3.00 (76.20)	1.63 (41.40) Hex Body
20	1.25 (31.75)	4.23 (107.4)	3.60 (91.44)	3.10 (78.74)	1.88 (47.75) Hex Body
24	1.50 (38.10)	4.67 (118.6)	3.80 (96.52)	3.30 (83.82)	2.25 (57.15) Hex Body
32	2.00 (50.80)	5.89 (149.6)	4.00 (101.6)	3.50 (88.90)	2.75 (69.85) Hex Body

Table 5: NPT end fitting dimensions

Flange End Fitting

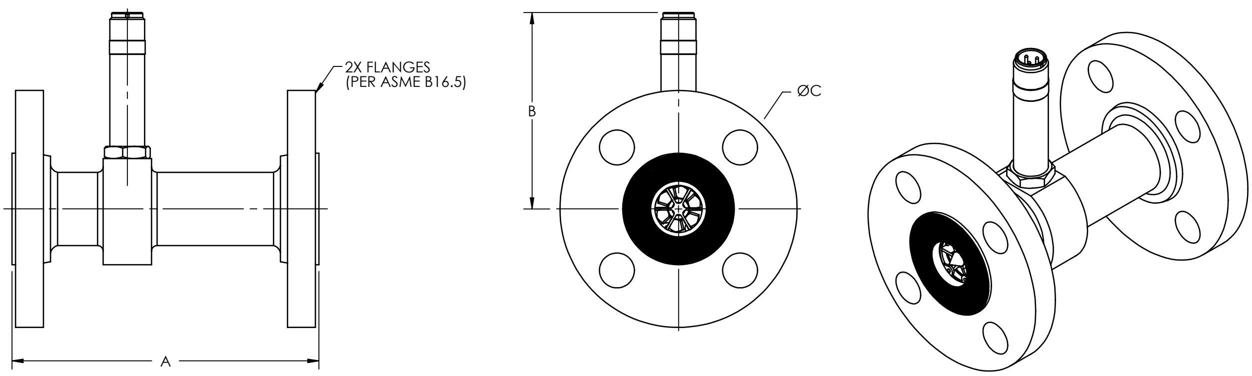


Figure 9: Flange end fitting

Size	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C—150# Flange in. (mm)	C—300# Flange in. (mm)	C—600# Flange in. (mm)
8-4	5.00 (127.0)	3.20 (81.28)	2.70 (68.58)	3.50 (89)	3.75 (95)	3.75 (95)
8-6	5.00 (127.0)	3.20 (81.28)	2.70 (68.58)	3.50 (89)	3.75 (95)	3.75 (95)
8	5.00 (127.0)	3.30 (83.82)	2.80 (71.12)	3.50 (89)	3.75 (95)	3.75 (95)
10	5.50 (139.7)	3.30 (83.82)	2.80 (71.12)	3.50 (89)	3.75 (95)	3.75 (95)
12	5.50 (139.7)	3.40 (86.36)	2.90 (73.66)	3.88 (99)	4.62 (117)	4.62 (117)
16	5.50 (139.7)	3.50 (88.90)	3.00 (76.20)	4.25 (108)	4.88 (124)	4.88 (124)
20	6.00 (152.4)	3.60 (91.44)	3.10 (78.74)	4.62 (117)	5.25 (133)	5.25 (133)
24	6.00 (152.4)	3.80 (96.52)	3.30 (83.82)	5.00 (127)	6.12 (155)	6.12 (155)
32	6.50 (165.1)	4.00 (101.6)	3.50 (88.90)	6.00 (152)	6.50 (165)	6.50 (165)

Table 6: Flange end fitting dimensions

Hose Barb End Fitting

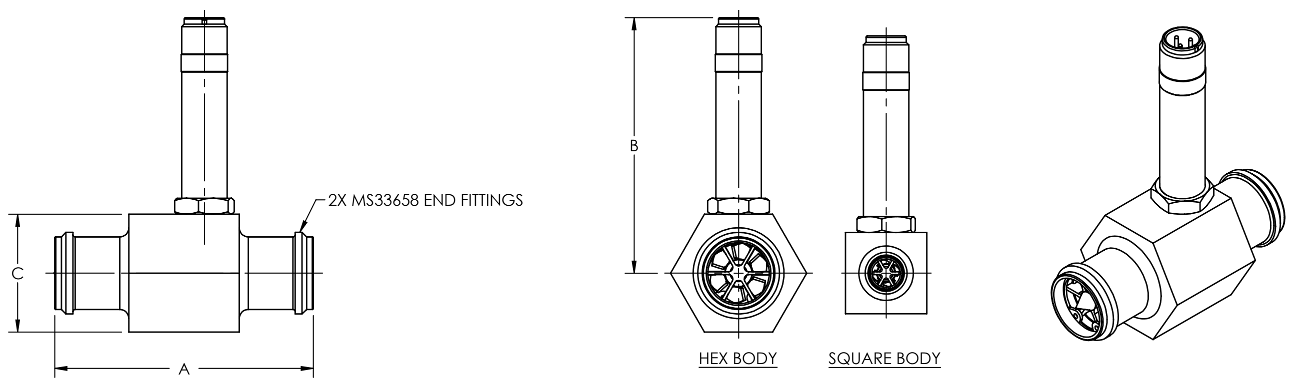


Figure 10: Hose barb end fitting

Size	End Fitting in. (mm)	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C in. (mm)
8-4	0.50 (12.70)	3.18 (80.77)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square body
8-6	0.50 (12.70)	3.18 (80.77)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square body
8	0.50 (12.70)	3.18 (80.77)	3.30 (83.82)	2.80 (71.12)	1.12 (28.45) Square body
10	0.625 (15.88)	3.24 (82.30)	3.30 (83.82)	2.80 (71.12)	1.25 (31.75) Hex body
12	0.75 (19.05)	3.25 (82.55)	3.40 (86.36)	2.90 (73.66)	1.25 (31.75) Hex body
16	1.00 (25.40)	3.56 (90.42)	3.50 (88.90)	3.00 (76.20)	1.63 (41.40) Hex body
20	1.25 (31.75)	4.50 (114.3)	3.60 (91.44)	3.10 (78.74)	1.88 (47.75) Hex body
24	1.50 (38.10)	5.00 (127.0)	3.80 (96.52)	3.30 (83.82)	2.25 (57.15) Hex body
32	2.00 (50.80)	6.50 (165.1)	4.00 (101.6)	3.50 (88.90)	2.75 (69.85) Hex body

Table 7: Hose barb end fitting dimensions

Tri-Clamp End Fitting

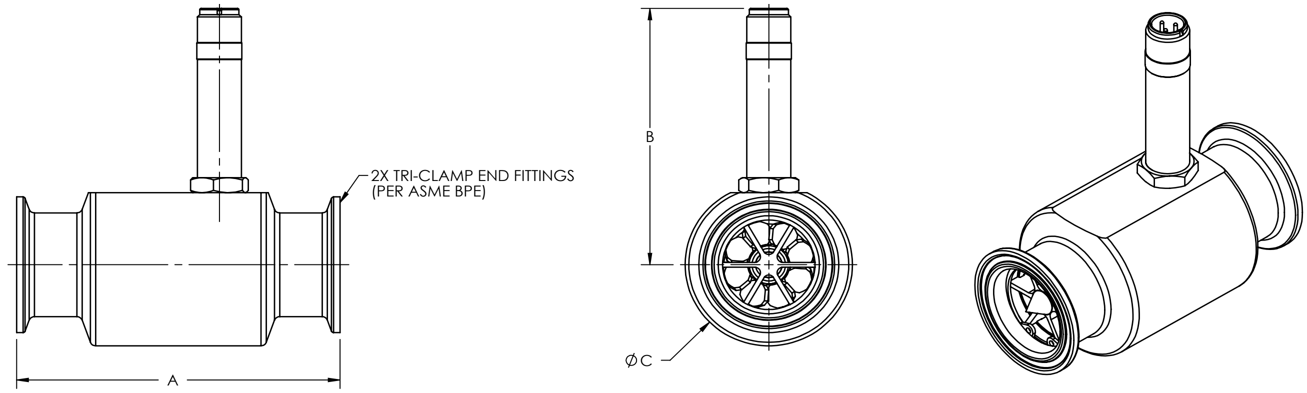


Figure 11: Tri-clamp end fitting

Size	End Fitting in. (mm)	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C in. (mm)	Clamp Size in. (mm)
8-4	0.50 (12.70)	3.56 (90.42)	3.20 (81.28)	2.70 (68.58)	1.50 (38.10)	0.75(19.05)
8-6	0.50 (12.70)	3.56 (90.42)	3.20 (81.28)	2.70 (68.58)	1.50 (38.10)	
8	0.50 (12.70)	3.56 (90.42)	3.30 (83.82)	2.80 (71.12)	1.50 (38.10)	
10	1.25 (31.75)	3.56 (90.42)	3.30 (83.82)	2.80 (71.12)	1.77 (44.96)	1.50 (38.10)
12	1.25 (31.75)	3.56 (90.42)	3.40 (86.36)	2.90 (73.66)	1.77 (44.96)	
16	1.50 (31.80)	3.56 (90.42)	3.50 (88.90)	3.00 (76.20)	1.99 (50.55)	
20	1.50 (31.80)	4.59 (116.6)	3.60 (91.44)	3.10 (78.74)	2.17 (55.12)	
24	1.50 (31.80)	4.59 (116.6)	3.80 (96.52)	3.30 (83.82)	2.38 (60.45)	
32	2.00 (50.80)	6.06 (153.9)	4.00 (101.6)	3.50 (88.90)	3.18 (80.77)	2.00 (50.80)

Table 8: Tri-clamp end fitting dimensions

High Pressure End Fitting

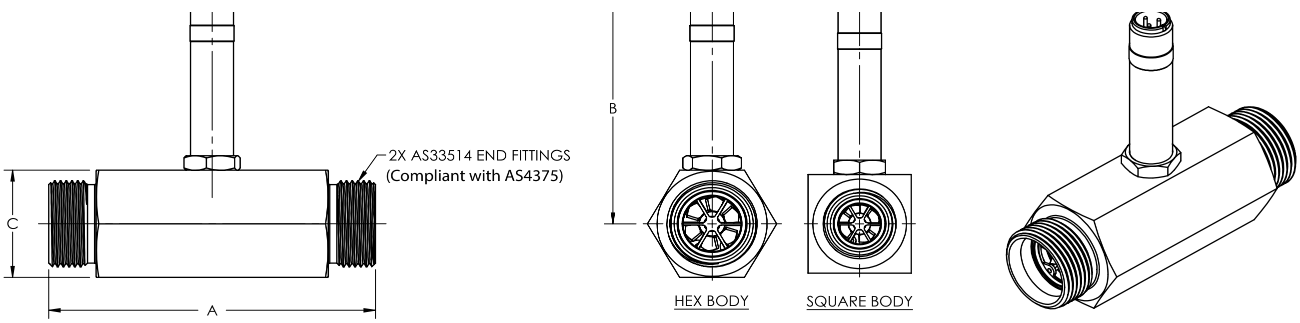


Figure 12: High pressure end fitting

Size	End Fitting in. (mm)	A in. (mm)	B (RF) in. (mm)	B (MAG) in. (mm)	C in. (mm)
8-4	0.50 (12.70)	3.25 (82.55)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square body
8-6	0.50 (12.70)	3.25 (82.55)	3.20 (81.28)	2.70 (68.58)	1.12 (28.45) Square body
8	0.50 (12.70)	3.50 (88.90)	3.30 (83.82)	2.80 (71.12)	1.12 (28.45) Square body
10	0.625(15.88)	4.00 (101.6)	3.30 (83.82)	2.80 (71.12)	1.25 (31.75) Square body
12	0.75 (19.05)	4.50 (114.3)	3.40 (86.36)	2.90 (73.66)	1.50 (38.10) Square body
16	1.00 (25.40)	4.75 (120.7)	3.50 (88.90)	3.00 (76.20)	1.63 (41.40) Hex body
20	1.25 (31.75)	5.50 (139.7)	3.60 (91.44)	3.10 (78.74)	1.88 (47.75) Hex body
24	1.50 (38.10)	6.00 (152.4)	3.80 (96.52)	3.30 (83.82)	2.25 (57.15) Hex body
32	2.00 (50.80)	7.00 (177.8)	4.00 (101.6)	3.50 (88.90)	2.75 (69.85) Hex body

Table 9: High pressure end fitting dimensions.

LoFlo

The dimension from the center of bore to top of pickoff represents the most common pickoff types. Length may vary depending on pickoff choice. Consult factory for details.

NOTE: Dimensions below are shown in inches.

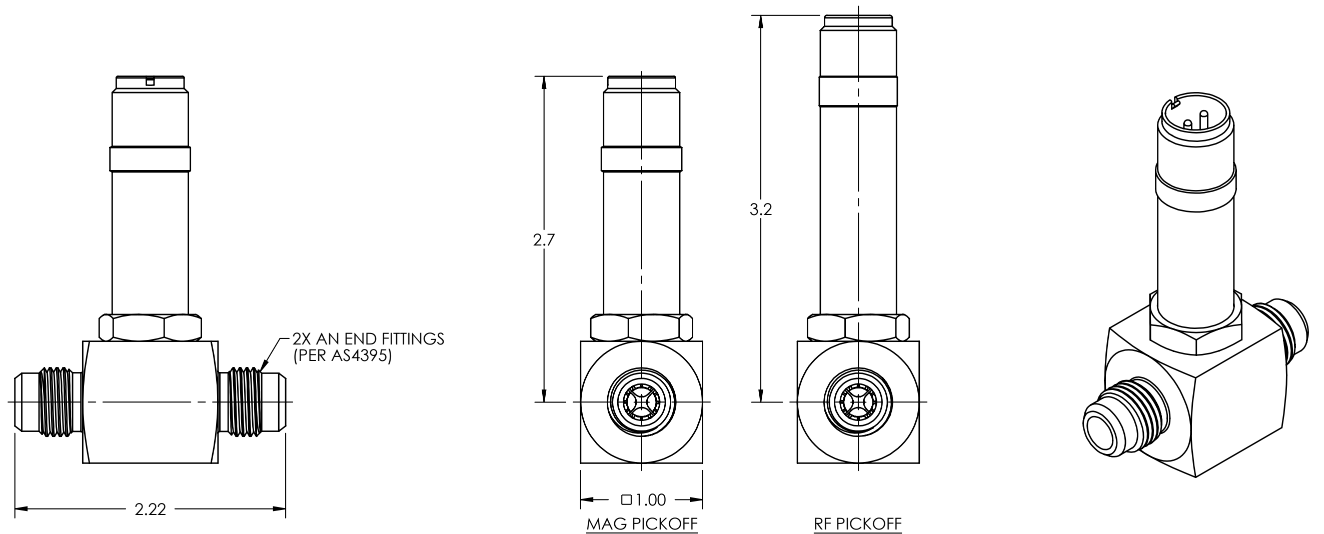


Figure 13: LoFlo meter dimensions

DIMENSIONS (GAS)

Dimension B specifies the most common pickoff type. Actual size may vary depending on pickoff choice. Consult factory for details.

AN End Fitting

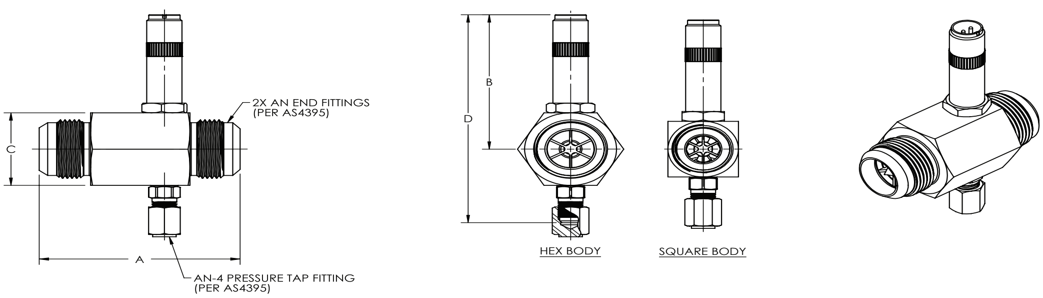


Figure 14: AN end fitting

Size	End Fitting in. (mm)	A in. (mm)	B in. (mm)	C in. (mm)	D in. (mm)
8-4	0.50 (12.70)	2.45 (62.23)	2.80 (71.12)	1.12 (28.44) Square Body	4.20 (106.7)
8-6	0.50 (12.70)	2.45 (62.23)	2.80 (71.12)	1.12 (28.44) Square Body	4.20 (106.7)
8	0.50 (12.70)	2.45 (62.23)	2.80 (71.12)	1.12 (28.44) Square Body	4.20 (106.7)
10	0.625 (15.88)	2.72 (69.08)	2.80 (72.12)	1.25 (31.75) Square Body	4.30 (109.2)
12	0.75 (19.05)	3.25 (82.55)	2.90 (73.66)	1.25 (31.75) Square Body	4.40 (111.8)
16	1.00 (25.40)	3.56 (90.42)	3.00 (76.20)	1.63 (41.40) Hex Body	4.70 (119.4)
20	1.25 (31.75)	4.06 (103.1)	3.10 (78.74)	1.88 (47.75) Hex Body	4.90 (124.5)
24	1.50 (38.10)	4.59 (116.6)	3.30 (83.82)	2.25 (57.15) Hex Body	5.20 (132.1)
32	2.00 (50.80)	6.06 (153.9)	3.50 (88.90)	2.75 (69.85) Hex Body	5.70 (144.8)

Table 10: AN end fitting dimensions

NPT End Fitting

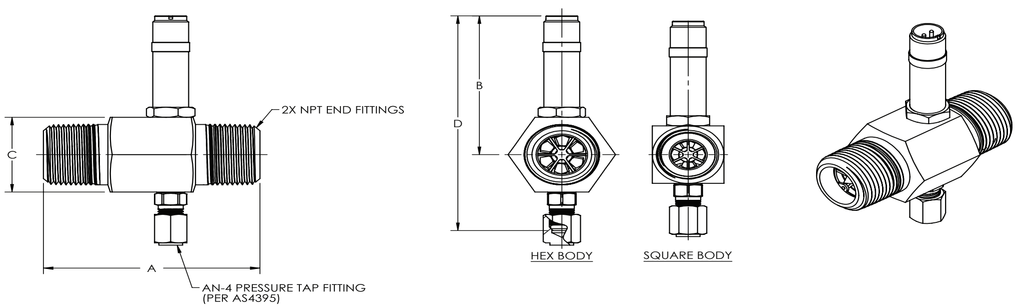


Figure 15: NPT end fitting

Size	End Fitting in. (mm)	A in. (mm)	B in. (mm)	C in. (mm)	D in. (mm)
8-4	0.50 (12.70)	2.70 (68.58)	2.80 (71.82)	1.12 (28.44) Square Body	4.20 (106.7)
8-6	0.50 (12.70)	2.70 (68.58)	2.80 (71.82)	1.12 (28.44) Square Body	4.20 (106.7)
8	0.50 (12.70)	2.70 (68.58)	2.80 (71.82)	1.12 (28.44) Square Body	4.20 (106.7)
10	0.75 (19.05)	3.29 (83.57)	2.80 (71.82)	1.25 (31.75) Square Body	4.30 (109.2)
12	0.75 (19.05)	3.29 (83.57)	2.90 (73.66)	1.25 (31.75) Square Body	4.40 (111.8)
16	1.00 (25.40)	3.78 (96.01)	3.00 (76.20)	1.63 (41.40) Hex Body	4.70 (119.4)
20	1.25 (31.75)	4.23 (107.4)	3.10 (78.74)	1.88 (47.75) Hex Body	4.90 (124.5)
24	1.50 (38.10)	4.67 (118.6)	3.30 (83.82)	2.25 (57.15) Hex Body	5.20 (132.1)
32	2.00 (50.80)	5.89 (149.6)	3.50 (88.90)	2.75 (69.85) Hex Body	5.70 (144.8)

Table 11: NPT end fitting dimensions

Flange End Fitting

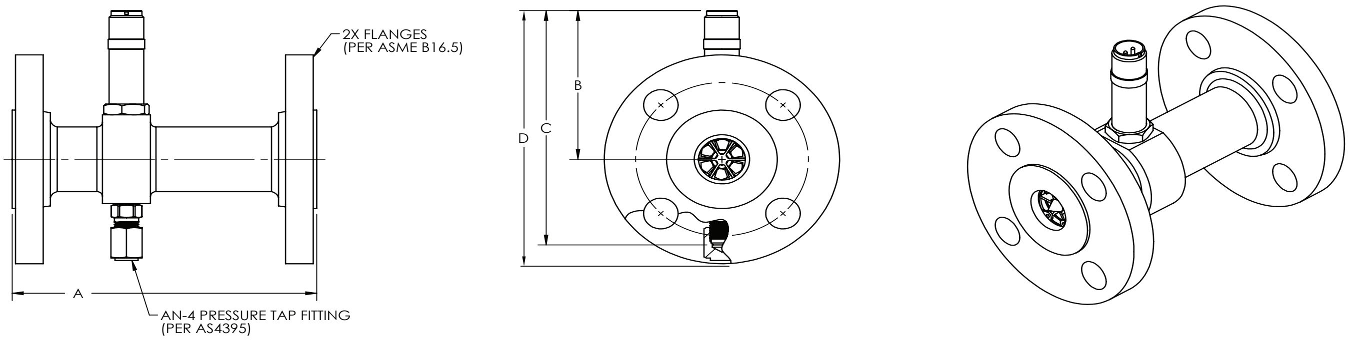


Figure 16: Flange and fitting

Size	A in. (mm)	B# in. (mm)	C# in. (mm)	D 150# Flange in. (mm)	D 300# Flange in. (mm)	D 600# Flange in. (mm)
8-4	5.00 (127.0)	2.80 (71.12)	4.10 (104.1)	3.50 (89)	3.75 (95)	3.75 (95)
8-6	5.00 (127.0)	2.80 (71.12)	4.10 (104.1)	3.50 (89)	3.75 (95)	3.75 (95)
8	5.00 (127.0)	2.80 (71.12)	4.30 (109.2)	3.50 (89)	3.75 (95)	3.75 (95)
10	5.50 (139.7)	2.80 (72.12)	4.40 (111.8)	3.50 (89)	3.75 (95)	3.75 (95)
12	5.50 (139.7)	2.90 (73.66)	4.50 (114.3)	3.88 (99)	4.62 (117)	4.62 (117)
16	5.50 (139.7)	3.00 (76.20)	4.80 (121.9)	4.25 (108)	4.88 (124)	4.88 (124)
20	6.00 (152.4)	3.10 (78.74)	5.00 (127.0)	4.62 (117)	5.25 (133)	5.25 (133)
24	6.00 (152.4)	3.30 (83.82)	5.20 (132.1)	5.00 (127)	6.12 (155)	6.12 (155)
32	6.50 (165.1)	3.50 (88.90)	5.70 (144.8)	6.00 (152)	6.50 (165)	6.50 (165)

Table 12: Flange end fitting dimensions

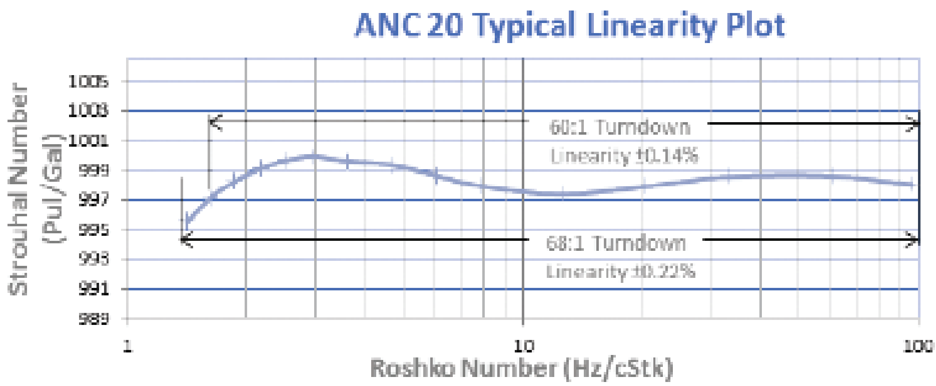


Figure 17: Typical linearity curve for a size 20 flow meter

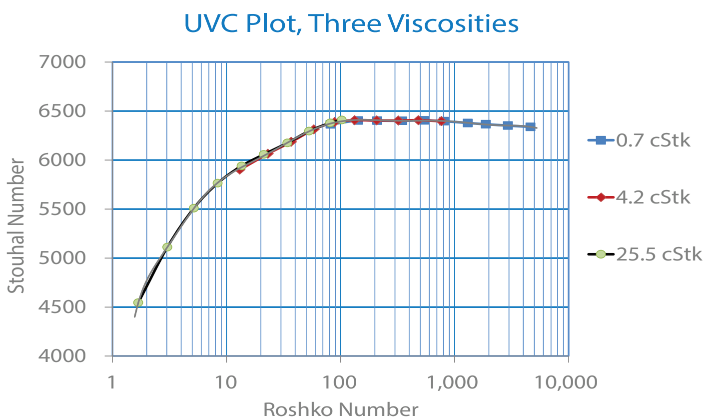


Figure 18: UVC plot

FACTORS AFFECTING LINEARITY

There are many factors affecting the linearity of turbine flow meters. The following enumerates some of these factors and their effect.

Size

The size of the meter selected is determined by the flow range required and the fluid characteristics. Standard flow ranges are listed in the Product Data Sheet. Where range requirements fall between listed ranges, it may be necessary to use two meters or a meter can be ordered for the specific range required. Overspeeding to meet a required flow capacity results in lowered operating life. Going to a larger meter size to avoid overspeeding will result in the non-linear range at the lower flow rates.

Bearings

The rotor in a standard meter is mounted on ball bearings. The function of rolling friction in regard to linear operating range is nil and can be disregarded. Where ball bearings cannot be used because of fluid characteristics, a sleeve or bushing type bearing is available at the expense of a reduced linear range. Due to the inherent character of increased friction, the linear operating range may be sharply curtailed in the lower capacity meters.

Pickoffs

Magnetic pickoffs affect the linear range of a meter, due to magnetic drag on the rotor. Since the turning force available is a function of the total mass flow, the low capacity meters will be more affected at the minimum flow rate than the high capacity meters. Replacement pickoffs should have the same part number as original equipment, otherwise the linear range can be affected.

Fluids

There are two types of fluids: compressible and incompressible. Considering only the incompressible (liquids), there are three factors that affect the linear flow range. They are lubricity, density and viscosity.

Lubricity

This is not a measurable quantity. It is that property of a liquid which determines the friction within the bearing and affects the life of the bearing as well as the linear operating range. Lack of lubricity can cause erratic action, especially at the low end of the flow range.

Density

Turbine flow meters are designed to operate over the standard frequency range with liquids of 1.0 specific gravity (H_2O). If a liquid of 1.5 specific gravity is used, it will have a 50% increase in driving force available at a given frequency. Also, the differential pressure of the meter is increased a like amount. This increased differential pressure can reduce the life of the bearing. Reduction of maximum operating frequency to maintain design pressure drop will result in reduced bearing life. The maximum frequency can be approximately calculated as shown by the following example:

$$Maximum\ Frequency = 1200\sqrt{1.0/1.5} = 980\ cps$$

Figure 19: Calculating maximum frequency

Viscosity

In a turbine meter, the one factor that affects the linear range the greatest is viscosity. The skin friction (viscous affect of the boundary layers) on the blades of the rotor and adjacent surfaces, is known to be a function of the Reynolds number (a dimensionless parameter). At a sufficiently low Reynolds number, the boundary layer is completely laminar. At a high Reynolds number, the boundary layer is turbulent. In the transition region, there is a gradual change from laminar to turbulent flow. At low viscosities, the Reynolds number is high, so that at the minimum operating frequency the flow is still turbulent. As the viscosity is increased, the Reynolds number decreases and the meter (at the same minimum frequency) is operating in the transition region. At this point, the drag actually decreases and the K-Factor (cycles per gallon) increases. A further increase in viscosity and the Reynolds number decreases to a point where the flow is completely laminal and the K-Factor decreases. In effect, as the viscosity increases, the range in which the flow is turbulent decreases. In low capacity flow meters, the viscosity effect may be of such an order that the entire flow range will be in the laminar flow region.

Mounting for Calibration

Turbine flow meters are calibrated with the axis horizontal and the pickoff on top. Flow meters with ball bearings may be mounted in any attitude with nil affect on the linearity range or calibration. Pipe configuration, such as valves, tees and elbows immediately preceding the meter, can produce swirl in the fluid with erroneous results. A minimum of 10 diameters of tubing the same size as the meter is recommended. For maximum precision, external flow straighteners are available for all size meters.

Pressure Drop

Pressure drop across turbine flow meters is substantially constant for a given gravimetric flow rate, but varies in approximate proportion to the square of the volumetric flow rate. This variation is proportional to a liquid's density. The values shown under range characteristics are based on a liquid specific gravity of 0.760 and a viscosity of 1 centistoke.

Specific Gravity

Changes in the specific gravity of a liquid in a linear shift in gravimetric calibration can be plotted as a function of specific gravity. These changes have no measurable effect on the volumetric flow rate but will cause a shift in the pressure drop across the flow meter.

Pressure

Pressure changes have no measurable effect on volumetric flow rates.

Temperature

Large temperature changes cause an area change within the flow meter. Higher temperature will result in decreased fluid velocity while depressed temperature will result in increased fluid velocity. This change will cause a variation of the K-Factor that is supplied with the turbine flow meter. Turbine flow meters calibrated at one temperature and operated at another require correction of their K-Factor. Cox Precision Turbine Flow Meters can operate from –350…500° F, and up to 800° F using a special high temperature pickoff.

Associated Equipment

Electrical leads from the flow meter to remote associated equipment should be carefully chosen to be compatible with the flow meter output and the impedance values of the components used. Distance between flow meter and associated equipment is then a negligible factor. Use good quality coaxial cable or twisted pairs, with or without shielding, as required by environmental factors. If a shielded lead is required, it must not be grounded at the flow meter since neither pin of the standard pickoff is grounded. Ground at some other point to eliminate ground loops in the associated equipment.

Filtration

Filtration is recommended as follows:

- LoFlo meters, meter sizes 84 through 08, and flange sizes 84, 86, 8 and 10 flow meters should have filters with a rating of 25…40 microns.
- Size 10 through 32 and flange sizes 12 through 48 flow meters should have filters with a rating of 40…75 microns.

RECALIBRATION

- Recalibration is not necessary following a cleaning operation or the replacement of bearings, snap rings, springs or spacers.
- Recalibrate the flow meter if the rotor hub, or rotor and flow straightener assembly is replaced.
- Flow meters may be recalibrated by the user if the facilities are available, or they may be returned to the factory. Yearly calibration is recommended.
- When the flow meter is set up for recalibration, allow the fluid to circulate for 5 minutes before beginning the calibrating runs.

LOFLO REPLACEMENT PARTS

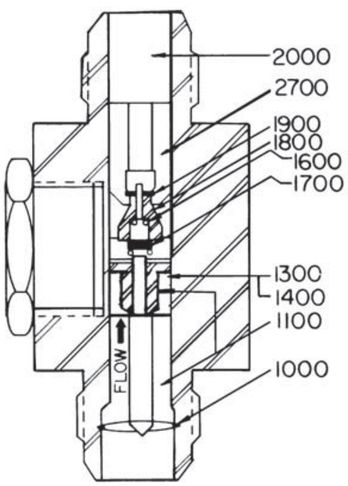


Figure 20: Model CLFA6

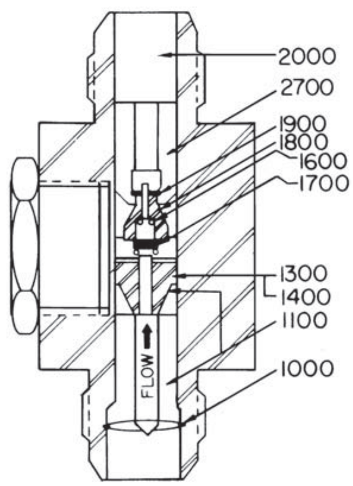


Figure 21: Model CLFB6

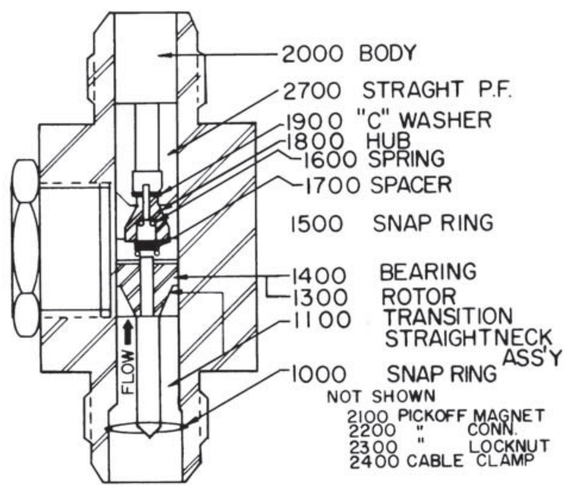


Figure 22: Models CLFC6…CLFF6

1100 – Flow is through 0.03

1300 – Rotor is angled blade

1400 – Bearing is staked into rotor. (Factory replace)

1100 – Flow is through swirl slot. Tube is press fit over slot.

1300 – Rotor has straight blades.

1400 – Bearing is staked into rotor. (Factory replace)

1100 – Flow is through swirl slots. No tube over slots.

1300 – Rotor has straight blades.

1400 – Bearing is held with snap rings. (Field replace)

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