CH 4001 Manual

Proven Performance
for Over 50 Years

AN SERIES TURBINE FLOWMETERS
(Also Known as Series 20 Turbine Flowmeters)

INSTALLATION, OPERATION &
SERVICE INSTRUCTIONS

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DESCRIPTION AND USE

The Series 20 Cox Turbine Flowmeter is a precisely manufactured and calibrated instrument used in accurate rate of flow and total flow measurement of all types of fluids, whether liquid or gas. It also has many applications as a sensor in process flow control.

The flowmeter mounts directly in the flow line and consists of a cylindrically bored housing, a flow straightener and turbine assembly, and magnetic pickoff(s) as shows in Figure 1.

On Lo Flow, Gas, Flange and AN Series Flowmeters, the magnetic pickoff is located directly above the turbine, near the downstream end of the flow straightener. The flow straightener and turbine assembly is retained in the housing by a snap ring and is easily removed for cleaning and further disassembly.

(Note: Refer To Page 5 For Reassembly Instructions.)

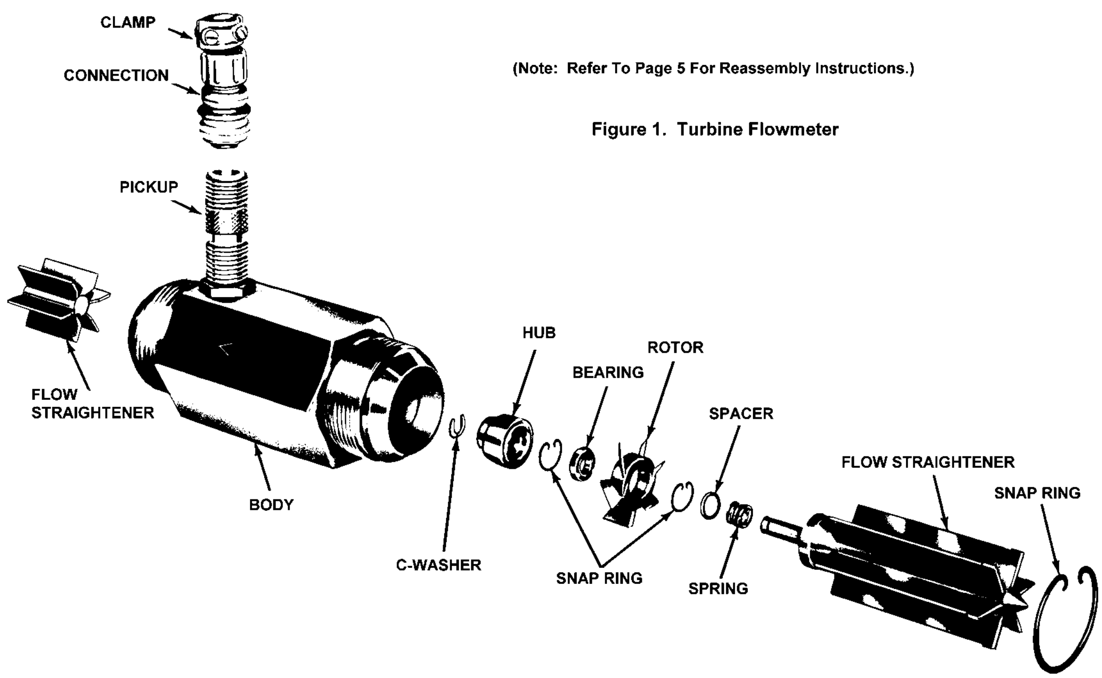


Figure 1. Turbine Flowmeter

AN Series Flowmeters are provided with an additional flow straightener at the downstream end. This flow straightener diminishes any turbulence created by the turbine. Other physical differences are illustrated in exploded views. (see Figures 5 and 6).

Fluid passing through the turbine causes it to revolve at a speed directly proportional to fluid velocity. As each rotor blade (Lo Flo, Gas, Flange and AN Series Flowmeters) passes the pickoff, it varies the pickoff's reluctance, producing an AC 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.

The Cox modulated carrier (MC) is an electrical turbine meter pickup designed to improve meter performance. Elimination of magnetic drag on the rotor results in linear flow ranges up to 100:1 and repeatable operating flow ranges up to 150:1. The Cox modulated carrier consists of a turbine meter, MC pickup and MC signal conditioner.

A high level signal offers the advantage of high output signal to noise ratio over the entire range of the flowmeter and permits long distance signal transmission.

All Cox Turbine Flowmeters 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 flowmeters to be connected in series to one indicating instrument. Data concerning extended ranges, specific output voltage and other frequency ranges is available from Cox Instrument Sales Department. As with any precision instrument, the full capabilities of the Cox Turbine Flowmeter can be realized only through close adherence to the installation and maintenance instructions discussed in this manual.

<u>REPLACEMENT PARTS – COX SERIES TURBINE FLOWMETER</u>

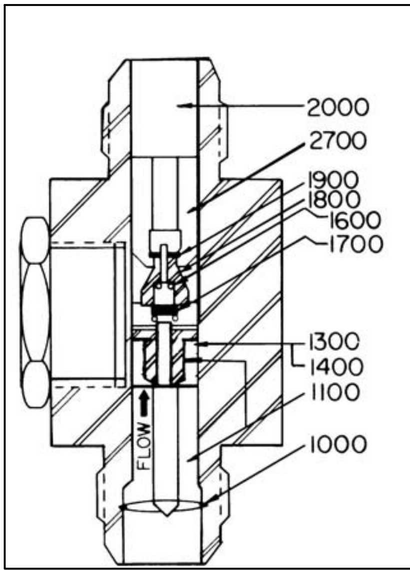


Figure 2

Model
LF-6-000

<u>Characteristics</u>

1100
Flow is through .03
1300
Rotor is angled blade
1400
Bearing is staked into rotor. (Factory replace)

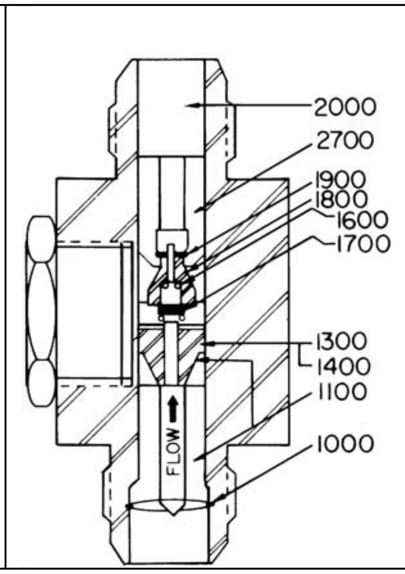


Figure 3

Model
LF-6-00

<u>Characteristics</u>

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)

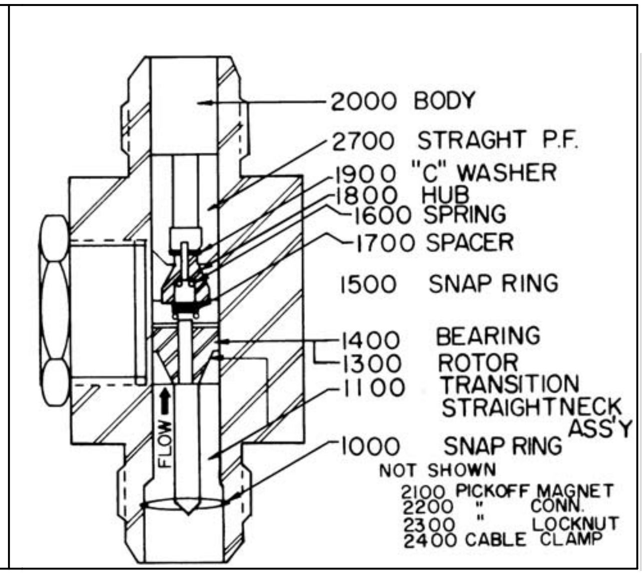


Figure 4

Model
LF-6-0 to 6-3

<u>Characteristics</u>

1100
Flow is through swirl slots. No tube over slots.
1300
Rotor has straight blades.
1400
Bearing is held with snap rings. (Field replace)

<u>INSTALLATION</u>

<u>Attitude</u>. Cox Turbine Flowmeters may be installed in any position without affecting performance. Be sure direction of flow is in the direction of the arrow engraved on the flowmeter body. Exception: Position gas service meters as calibrated.

Piping. Recommended layout for Cox Turbine Flowmeters specifies a straight section of pipe or tube in the same size as the flowmeter and equal in length to ten (10) diameters on upstream side, and a similar section equal in length to five (5) diameters on the downstream side. Gas service should be smooth and with a minimum radius equal to two (2) diameters in order to retard the formation of swirls in the liquid, which can cause incorrect flowmeter 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 is possible. Cox Flow Straighteners available are listed in the Cox Sales Bulletin 44-F.

Electrical. Use 2-wire shielded cable. Ground shield, avoid ground loops.

Use of Pipe Compound. The 37-degree flared tube connections of Cox Turbine Flowmeters 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.

CAUTION: Bleed all air and vapor from the liquid after installing or reinstalling a flowmeter. Start flow slowly to avoid sending a "slug" of high velocity air or vapor through the flowmeter and causing it to overspeed. Start required flow after flowmeter is full of liquid. Aerated liquids flowing through a flowmeter will result in incorrect flow rates.

DISASSEMBLY

1. LF, AN, ANC and F Series Ball Bearing Type.

   a) Firmly hold flowmeter and, using tweezers, carefully remove internal snap ring from the upstream end.

   b) 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.

   c) 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.

   d) Carefully remove rotor from shaft.

   e) Remove a snap ring from side of bearing and push bearing out of rotor.

NOTE: Models LF6-000 and LF6-00 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 flowmeter 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 ten (10) minutes and then dry with filtered compressed air. Do not use excessive air pressure. Do not sonic clean bearings!!!!

NOTE: 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.

While it is not recommended to use a ball bearing for water service, or even calibrate a ball bearing turbine meter in water, if it is done, then this procedure shall be followed:

1. remove meter from line and allow all excess water to drip out
2. fill the meter with alcohol (at least 50%, Isopropyl, Ethyl or Methyl) and let stand for 5 min.
3. dischard alcohol and allow meter to dry for 2 min.
4. fill meter with MIL-C-7024 Type 2 calibration fluid (or similar solvent) and let stand 1 min.
5. discard calibration fluid and flush meter with an approved fluorocarbon solvent such as “Isotron”.

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.

NOTE: ORDER PARTS BY NAME AND BASIC NUMBER SHOWN, FOLLOWED BY FLOWMETER SIZE DESIGNATION. E.G., ORDER A BEARING FOR AN LF6-3 FLOWMETER AS BEARING #1400-63 FLOWMETER SERIAL NUMBER MUST BE PROVIDED WHEN ORDERING PARTS.

* REPLACEABLE AT FACTORY LEVEL ONLY.
† WHEN CLEANING FLOWMETERS KEEP BODY, SLEEVE, AND PICKOFF TOGETHER. SLEEVE IS FITTED TO BODY AND PICKOFF HAS PROTRUDING PIN. REPLACEMENT PICKOFFS ARE SUPPLIED WITH A NUT AND HAVE NO PROTRUDING PIN.

LF-6-0, LF-6-1, LF-6-2, LF-6-3

* 1. Body
2. "C" Washer
* 3. Hub
* 4. Spring
5. Spacer
* 6. Bearing Retainer Ring
7. Bearing
* 8. Rotor
* 9. Straightener Ass.
10. Body Retaining Ring

LF-6-00 and LF-6-000

* 1. Body
2. "C" Washer
* 3. Hub
* 4. Spring
5. Spacer
* 8. Rotor
* 9. Straightener Ass.
10. Body Retaining Ring

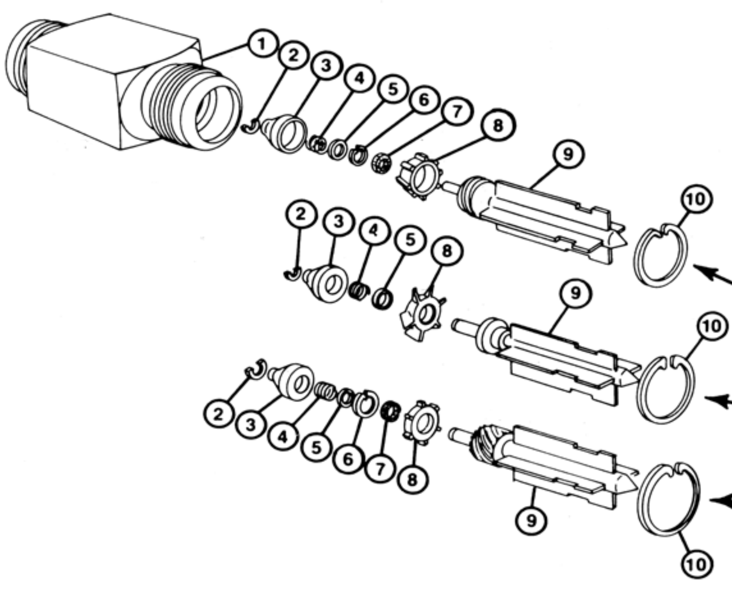


Figure 5. Lo Flo Series Ball Bearing Type Flowmeter

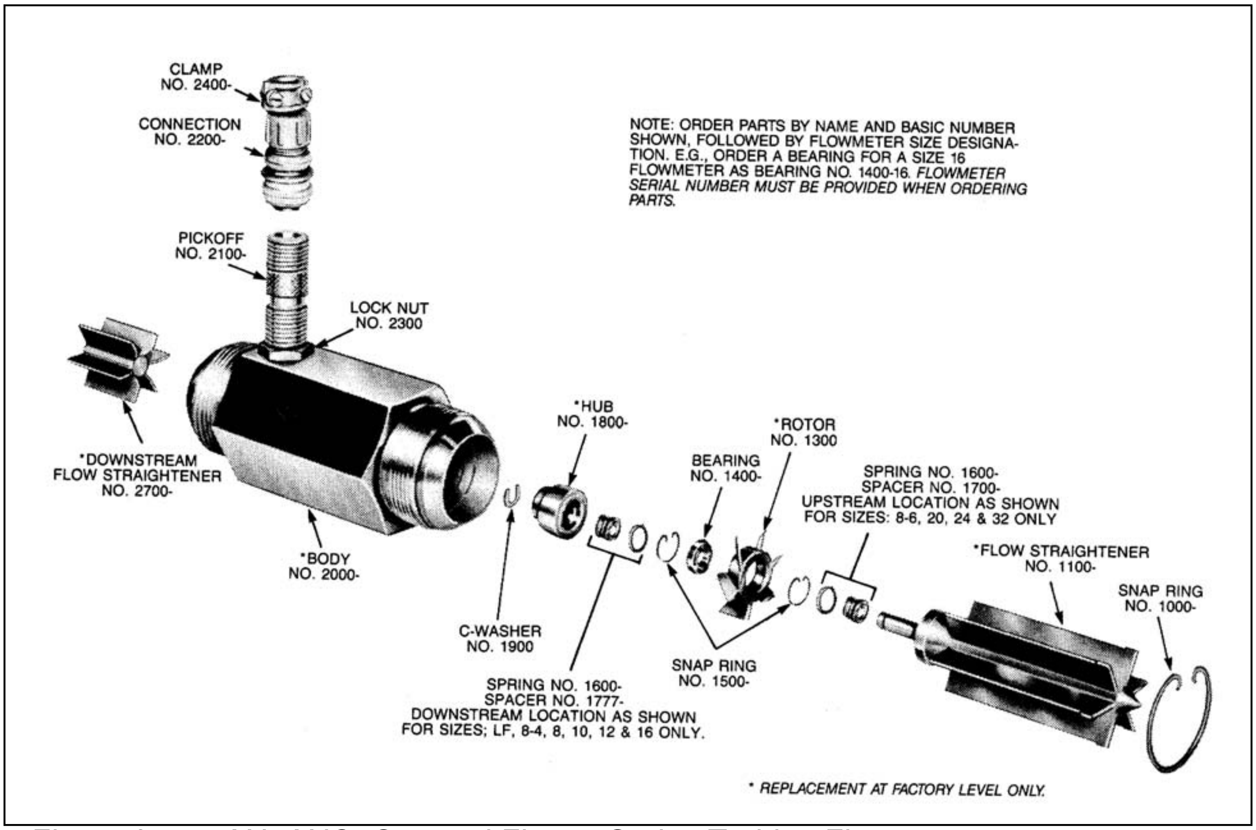


Figure 6. AN, ANC, Gas and Flange Series Turbine Flowmeter

CAUTION: Do not interchange flowmeter parts other than bearings and retaining rings. This precaution is necessary to preserve linearity and repeatability.

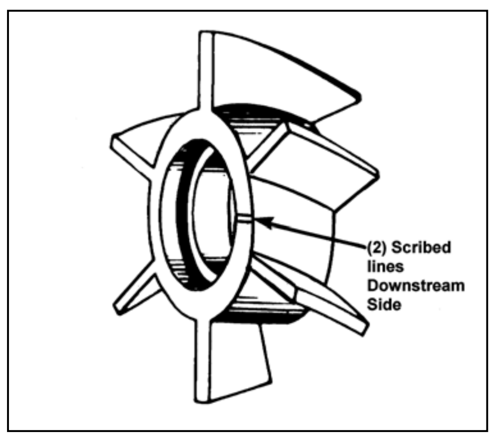
REASSEMBLY

Reassembly is the reverse of disassembly except for the following:

a) On Lo Flo, Gas, AN and Flange Series Flowmeters where shaft bearings are provided with a retainer, always install with the retainer flange facing upstream.

b) Inspect rotor for markings as shown in Figure 7, to indicate flow direction before assembly.

c) Flowmeters 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.



Part Number	6	12	18	6-000	6-00	6-0	6-1	6-2	6-3	Standard Material
1000	0	0	1	X	X	X	X	X	X	303-SS
1100	1	1	1	0^	0^	0^	0^	0^	0^	316-SS
1300	0	1	1	0^	0^	0^	0^	0^	0^	416-SS
1400	1	2	3	X^#	X^#	X^	X^	X	X	440-CSS
1500	1	1	1	———	———	X	X	X	X	303-SS
1600	1	1	1	X	X	X	X	X	X	302-SS
1700	1	2	2	X	X	X	X	X	X	303-SS
1800	0	0	1	0	0	X^	X^	X^	X^	303-SS
1900	1	2	2	X	X	X	X	X	X	302-SS
2000	0	0	0	X^#	X^#	X^#	X^#	X^#	X^#	316-SS
2100	1	1	1	X	X	X	X	X	X	304-SS
2200	0	0	1	X	X	X	X	X	X	Aluminum
2300	0	1	1	X	X	X	X	X	X	304-SS
2400	0	1	1	X	X	X	X	X	X	Aluminum

Table 2.

NOTES:

6 = 6 months spare parts

12 = 12 months spare parts Quantity/unit

18 = 18 months spare parts

0 = Non-interchangeability between standard liquid LF Models

X = Interchangeability parts between LF models

^ = These models must be recalibrated when this item is replaced

= Factory replacement

TROUBLESHOOTING

Trouble	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. 10mv 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 perfect, 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.

TROUBLESHOOTING

Trouble	Possible Cause	Remedy
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 flowrate; meter selection was with Delta-P at .75 sp. gr., now using on 1.0 sp. gr. Delta-P is proportional to specific gravity.	High pressure drop (also see leaks).	Install larger meter.
Does not repeat at low flows. Repeats at high flows.	System resolution readability.	Increase resolution, i.e.: 1 out of 100 = 1% 1 out of 1000 = .1%

TECHNICAL DATA

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

K-Factor. "K" is a letter used to denote the cycles per gallon factor of a flowmeter. This factor is a fixed value used in resolving or totalizing the pulse count output of a flowmeter. It results from:

$$\frac{\text{Cycles per second}}{\text{Gallons per second}} = \text{Cycles per gallon (k)}$$

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 Turbine Flowmeters are linear to +/- ½% over the range shown.

CALIBRATION DATA

K-Factor. The calibration data supplied with a Cox Turbinemeter is as shown in Figure 8.

Correct application of a Cox Turbine Flowmeter 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 bulletin. For special requirements concerning temperatures beyond the range of -300°F or plus 350°F, corrosive liquids, gases and other unusual conditions, consult Cox Instrument 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 graph). 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 Cox facility, a curve of ACFM vs. Hertz is supplied. When performed by CEESI, a computer printout of ACFM vs. Hertz is provided.

Pressure Rating

The standard Lo Flo and AN Series Flowmeter are rated from 2500 to 6000 psi operating pressure. They have a 4:1 pressure safety factor. Flange Series Flowmeters are rated for service pressure according to ASA ratings for the flanges used. Split ring flanges have the same rating as standard flanges.

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

Formulae-Liquid

$$\text{GPM} = (\text{Hertz} \times 60) \div K$$

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

$$\text{Time Base In Secs.} = \frac{\text{Engrg. Units GPM-PPH}}{\text{Hertz}}$$

Gas

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

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

$$\text{PPM} = \text{ACFM} \times \rho\ \text{Act}$$

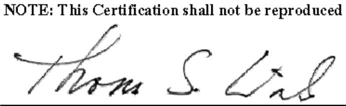
COX INSTRUMENT
A Division of Schutte and Koerting
2233 State Road Bensalem, PA 19020
Tel:215-639-0900 Fax:215-639-1597
Turbine Meter Flow Calibration Certification

Customer Name	ABC Company	File Number	12345
Customer Address	Street	Flowmeter Specifications	
	City, State Zip	Calibration Minimum (GPM)	2.5
P.O. Number	12345	Calibration Maximum (GPM)	60
Shop Order	CO 143880	Linear Minimum (GPM)	
Model Number	AN 16	Linear Maximum (GPM)	
Serial Number	12345	Linearity (+/- % OR)	
Pickoff Number	92279-02	Accuracy (+/- % OR)	0.50%
Calibration Date	30-Apr-03	Mid K-Factor (Counts/Gallon)	
Calibration Stand	1		
Operator's Initials	123	**NEXT CALIBRATION DUE DATE**	**29-Apr-04**
Fluid Specifications			
Type	Mil-L-23699	Specific Gravity	0.9480
Temperature (F)	195	Viscosity (CSTK)	5.8000

DATA PT.	Frequency	F/V	K-Factor Counts/Gal	Flow Rate GPM	Mass Flow Rate PPH
1	57.20	9.92	1502.12	2.285	1082.304
2	57.28	9.89	1502.93	2.287	1083.186
3	120.11	20.74	1510.36	4.771	2260.145
4	120.17	20.76	1509.12	4.778	2263.154
5	240.02	41.40	1495.03	9.633	4563.055
6	240.06	41.40	1495.33	9.632	4562.833
7	360.45	62.17	1483.48	14.578	6905.746
8	360.45	62.17	1483.09	14.583	6907.706
9	480.48	82.75	1472.66	19.576	9273.072
10	480.63	82.78	1471.92	19.592	9280.696
11	599.96	103.33	1469.46	24.497	11604.236
12	600.21	103.37	1468.87	24.517	11613.787
13	720.61	123.93	1463.46	29.544	13994.960
14	720.76	123.95	1463.75	29.544	13994.960
15	959.77	165.06	1458.36	39.487	18704.887
16	960.18	165.13	1458.06	39.512	18716.681
17	1200.19	206.40	1453.71	49.536	23465.139
18	1200.67	206.19	1454.07	49.544	23468.726
19	1460.36	250.42	1452.10	60.341	28583.384
20	1460.36	250.42	1452.39	60.329	28577.789

K-Factor = Cycles/Gallon **Frequency** = Counts/Time(sec) **F/V** = Freq/Visc. (Hz/cstk)
Flow(PPH)= [Wt(Lbs.)*3600/Time(sec)] **K-Factor**= [Counts*8.3278*SG/Wt] **Flow(GPM)**= [Freq*60/K-Factor]

This is to certify that the above flowmeter has been individually calibrated on a COX Primary Standard Flowmeter Calibrator, Traceable to the National Institute of Standards and Technology Document Number TN 254138 8361606, and is hereby certified to operate within the above stated accuracy when used withinabove fluid specifications.
PROCEDURE EDS-13 WAS USED AND MEETS ISO GUIDE 25, ISO 10012-1 AND ANSI/NCSL Z540-1
NOTE: This Certification shall not be reproduced except in full without the written approval of Schutte & Koerting



Thomas S. Wilson (Quality Assurance Mgr.)

Figure 8

Torque Rating. When using AN Flowmeters at high pressure, tighten the fittings to torque values given in Table 3.

Dimensions. Refer to Tables 4 and 5 for tube sizes and mounting dimensions of Series 20 Turbine Flowmeters.

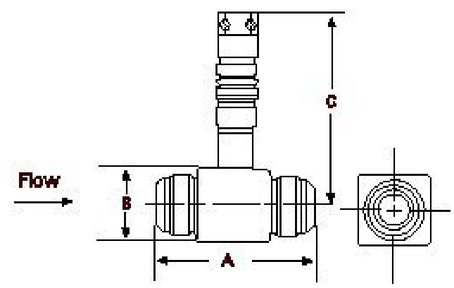
Materials. The use of materials given in Tables 6 and 7 are recommended and used for most turbine flowmeter applications. For unusual requirements such as beyond the range of minus 300°F or plus 350°F and extremely corrosive liquids, consult the Cox Instrument Sales Department.

SIZE	MINIMUM TORQUE (DRY)	SIZE	MINIMUM TORQUE (DRY)	SIZE	MINIMUM TORQUE (DRY)	SIZE	MINIMUM TORQUE (DRY)
6	270 in. lbs.	10	650 in. lbs.	16	1200 in. lbs.	24	1600 in lbs.
8	450 in. lbs.	12	900 in. lbs.	20	1400 in. lbs.	32	1800 in. lbs.

Table 3. Torque Values

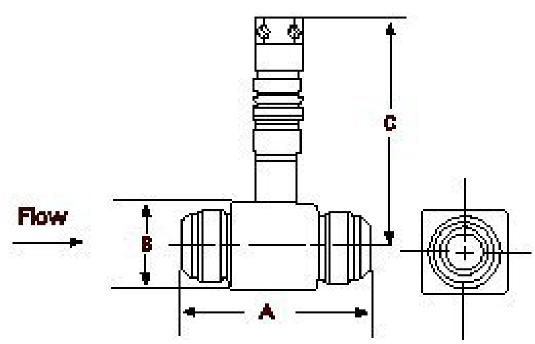
COX MODEL	A	B†	C	TUBE SIZE (Inches)
LF 6-00	2.219	1.000	4.250	3/8
LF 6-0	2.219	1.000	4.250	3/8
LF 6-1	2.219	1.000	4.250	3/8
LF 6-2	2.219	1.000	4.250	3/8
LF 6-3	2.219	1.000	4.250	3/8
†All Lo Flo Series have square bodies				

Table 4. Lo Flo Series



COX MODELS AN & ANC	A	B	C	TUBE SIZE (Inches)
8-4	2.45	1.12†	4.19	1/2
8-6	2.45	1.12†	4.22	1/2
8	2.45	1.12†	4.25	1/2
10	2.72	1.25†	4.34	5/8
12	3.25	1.25†	4.41	3/4
16	3.56	1.63*	4.53	1
20	4.06	1.88*	4.63	1-1/4
24	4.59	2.25*	4.75	1-1/2
32	6.06	2.75*	5.00	2
40	8.50	3.50	5.25	2-1/2
† Square Body			*Hex Body	

Table 5. AN and Gas Series



COX MODEL	A	B 150# FLG.	B 300# FLG.	B 600# FLG.	C	D
F-1/2	5.00	3.50	3.75	3.75	4.18	1.38
F-1/2	5.00	3.50	3.75	3.75	4.21	1.38
F-1/2	5.00	3.50	3.75	3.75	4.27	1.38
F-3/4	5.00	3.88	4.62	4.62	4.34	1.69
F-3/4	5.00	3.88	4.62	4.62	4.41	1.69
F-1	8.00	4.25	4.88	4.88	4.53	2.00
F-1-1/4	8.00	4.62	5.25	5.25	4.63	2.50
F-1-1/2	9.00	5.00	6.12	6.12	4.75	2.88
F-2	9.00	6.00	6.50	6.50	5.00	3.62
F-2-1/2	10.00	7.00	7.50	7.50	5.25	4.12
F-3	10.00	7.50	8.25	8.25	5.63	5.00
F-4	12.00	9.00	10.00	10.75	5.00	6.18
F-6	14.00	11.00	12.50	14.00	6.40	8.50
F-8	16.00	13.50	15.00	16.50	6.40	10.62
F-10	20.00	16.00	17.50	20.00	8.56	12.75
F-12	24.00	19.00	20.50	22.00	8.56	15.00

Table 6. Flange Series

PART	TYPE
Bearing………………………………………………………	440C
Body (Lo Flo, AN, ANC and Gas Series)……………..	316
Body (Flange Series)……………………………………	303
C-Washer…………………………………………………	302
Hub………………………………………………………..	303
Locknut……………………………………………………	CRS (plated)
Pickoff…………………………………………………….	304
Spacer……………………………………………………	303
Spring……………………………………………………	302
Snap Ring………………………………………………..	303
Straightener Assembly…………….…………………..	316
Rotor………………………………………………………	416

FACTORS AFFECTING LINEARITY

There are many factors affecting the linearity of turbine flowmeters. 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 Sales Catalog. 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 size larger meter to avoid overspeeding will result in the non-linear range at the lower flow rates.

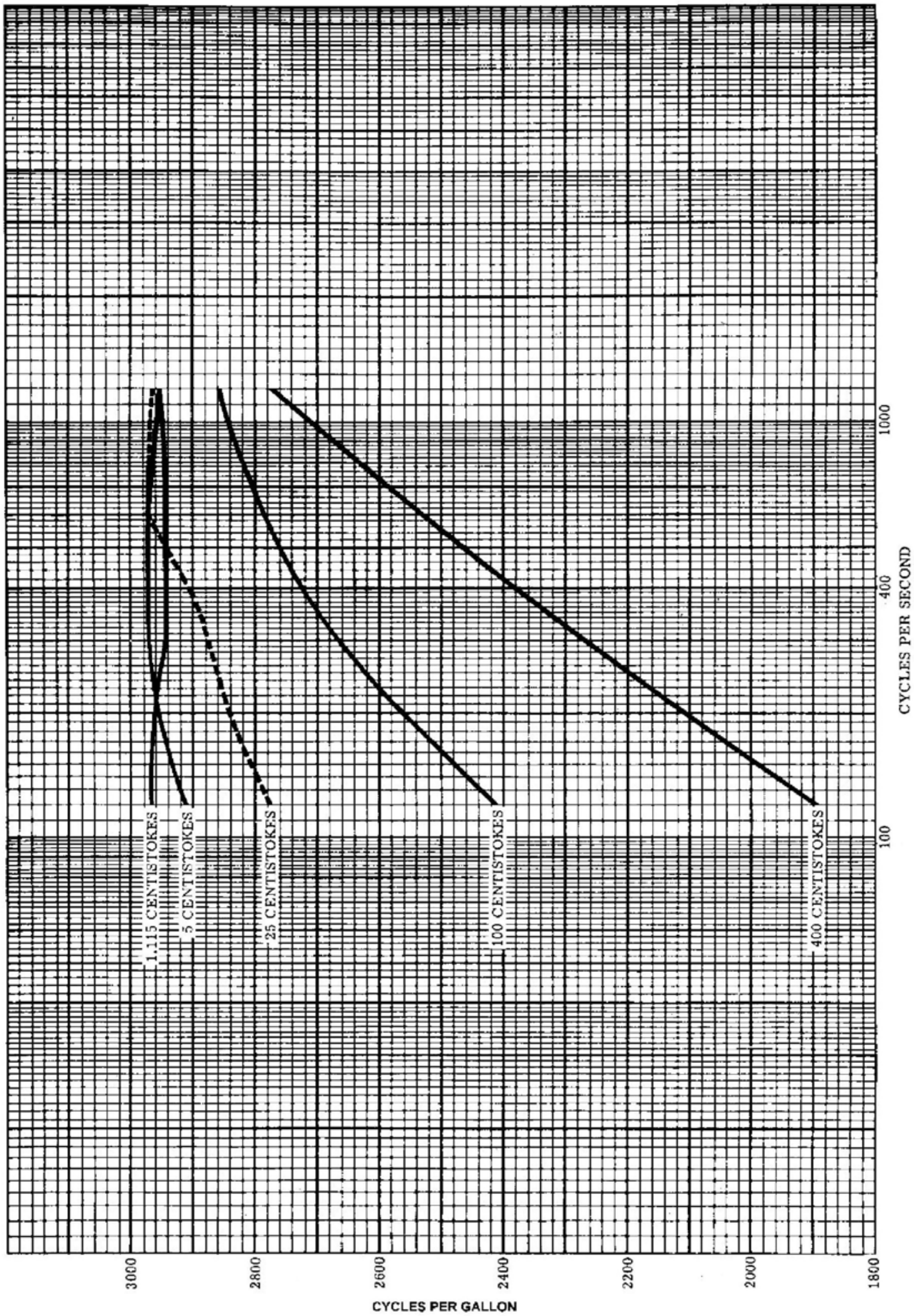


Figure 1. Typical Calibration Curve for a size 12 Flowmeter

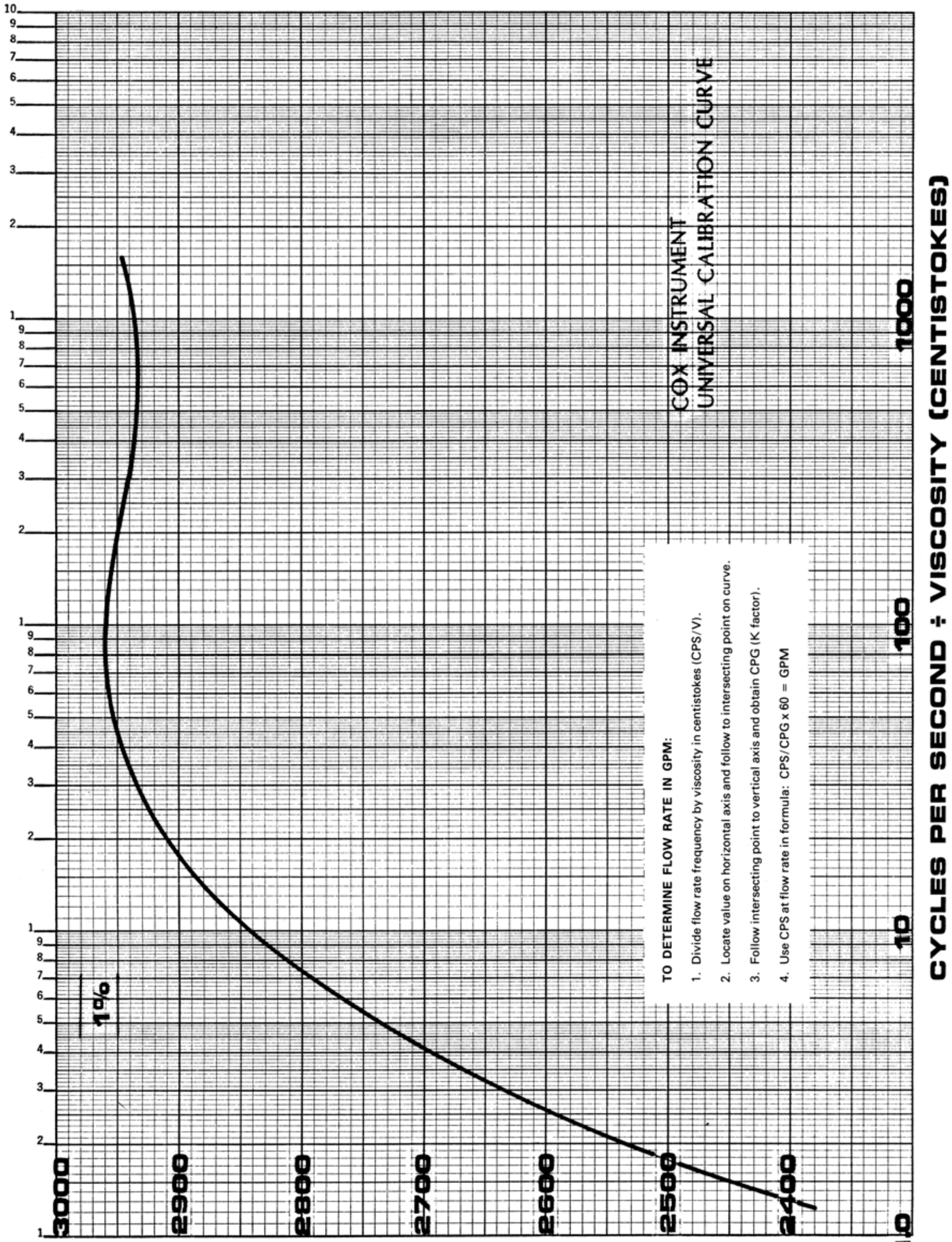

COX INSTRUMENT
UNIVERSAL CALIBRATION CURVE
TO DETERMINE FLOW RATE IN GPM:
1. Divide flow rate frequency by viscosity in centistokes (CPS/V).
2. Locate value on horizontal axis and follow to intersecting point on curve.
3. Follow intersecting point to vertical axis and obtain CPG (K factor).
4. Use CPS at flow rate in formula: CPS/CPG x 60 = GPM
1%
3000
2900
2800
2700
2600
2500
2400
1.0
10
100
1000
CYCLES PER SECOND ÷ VISCOSITY (CENTISTOKES)
"K" FACTOR (CYCLES PER GALLON)

Figure 10

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. Pickoffs do 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, it is obvious 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 i.e., liquids, there are three factors which 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 flowmeters 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 design bearing life. The maximum frequency can be approximately calculated as shown by the following example:

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

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 sufficiently low Reynolds number, the boundary layer is completely laminar. At 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 flowmeters, the viscosity effect may be of such an order that the entire flow range will be in the laminar flow region.

<u>Mounting for Calibration.</u> At Cox Instrument, turbine flowmeters are calibrated with the axis horizontal and the pickoff on top. Flowmeters with ball bearings may be mounted in any attitude with nil affect on the linearity range or calibration. Meters with bushing or sleeve type bearings should be mounted in the same attitude as calibrated. Pipe configuration such as valves, tees, elbows immediately preceding the meter, can produce swirl in the fluid with erroneous results. A minimum of ten (10) diameters of tubing of the same size as the meter, is recommended. For maximum precision external flow straighteners are available for all size meters.

<u>Pressure Drop.</u> Pressure drop across turbine flowmeters 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.

<u>Specific Gravity.</u> Changes in specific gravity of a liquid in a linear shift in gravimetric calibration that 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 flowmeter.

<u>Pressure.</u> Pressure changes have no measurable effect on volumetric flow rates.

<u>Temperature.</u> Large temperature changes cause an area change within the flowmeter. 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 flowmeter. Turbine flowmeters calibrated at one temperature and operated at another, require correction of their K-Factor. Cox Turbine Flowmeters can operate from -350˚F to +500˚F, and up to 800˚F utilizing a special high temperature pickoff.

<u>Associated Equipment.</u> Electrical leads from the flowmeter to remote associated equipment, should be carefully chosen to be compatible with the flowmeter output and the impedance values of the components used. Distance between flowmeter 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 flowmeter since neither pin of the standard pickoff is grounded. Ground at some other point to eliminate ground loops in the associated equipment.

<u>Filtration.</u> Filtration is recommended as follows:

1. Lo Flo, AN 8-4 through AN 8, and flange size ½ inch flowmeters should have filters with a rating between 25 and 40 microns.

2. AN 10 through AN 32 and flange sizes ¾ through 3 inch flowmeters should have filters with a rating between 40 and 75 microns.

3. Turbine meters, sizes 4 inches and up, should have filters rated at approximately 75-150 microns or strainers of 140 mesh.

RECALIBRATION

1. Recalibration is not necessary following a cleaning operation or the replacement of bearings, snap rings, springs, or spacers.

2. Recalibrate the flowmeter if the rotor hub, or rotor and flow straightener assembly is replaced.

3. Flowmeters may be recalibrated by the User if the facilities are available, or they may be returned to the factory. Yearly calibration is recommended.

4. When the flowmeter is set up for recalibration, allow the fluid to circulate for five (5) minutes before beginning the calibrating runs.

Warranty

Schutte & Koerting warrants Cox Instrument products to perform according to specifications and to be free of defects in workmanship and material for a period of ninety days from date of shipment. Defective material or improper workmanship will be corrected without cost to the purchaser when returned to the factory within the twelve months or 1 year warranty period.

The warranty is voided on any product that has been subjected to misuse, tampering, or negligence.

PROCEDURE FOR RETURNING MATERIALS TO FACTORY

1. Advise your Cox Instrument representative of problems encountered.

2. Upon approval by him or the service department of Cox Instrument, return the material in question to the plant, transportation charges prepaid.

3. Upon receipt at the factory, a complete inspection will be performed and a service report prepared, indicating our findings.

4. Where failure is determined to be poor workmanship or defective material, the product will be repaired and returned at no cost. Where failure results from misuse, tampering, or negligence, the unit will be repaired and a service charge made.