

Hoffer Engineering Guide for Liquids



Accurate, Versatile, Economical...

www.hofferflow.com

Principle of Operation:

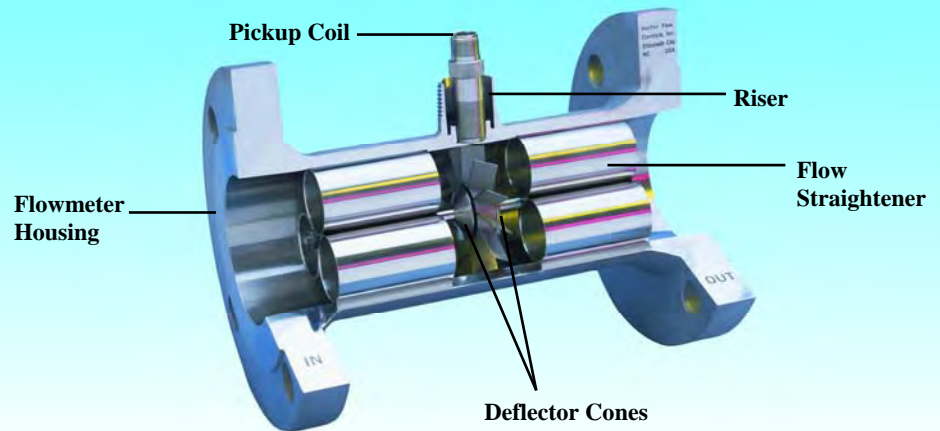
Hoffer inline turbine flowmeters are velocity measuring devices, which is to say they measure the average velocity of a fluid flowing through the body of the meter. See **Illustration 1** for details on the construction of the Hoffer inline turbine flowmeter. Mounted within the body of a Hoffer liquid turbine flowmeter is a vaned rotor. The rotor is centered on a shaft and allowed to rotate by means of bearings. The shaft is supported in the housing by tube bundles that also provide a measure of flow conditioning for the fluid stream.

The rotor is made from a ferromagnetic material or contains a magnet within the hub of the rotor. Liquid flowing through the meter body engages the rotor forcing it to rotate. The rotational velocity of the rotor is proportional to the average linear velocity of the liquid flow stream. This rotational velocity is transformed into an electrical frequency signal by means of a non-intrusive sensor or coil threaded partially into the body of the meter aligned with the rotational circumference of the rotor. Being in close proximity to the ferromagnetic or magnetic rotor creates an electromagnetic coupling with the coil. The output frequency of the coil then is directly proportional to the rotational velocity of the rotor. This frequency can then be converted to a flow rate indication or scaled signal by dividing the frequency by the meter's scaling or K-factor (e.g. pulses per gallon or pulses/liter). The K-factor is established by factory calibration of the flowmeter at the time of manufacture.

Performance Characteristics:

The general performance characteristics of a Hoffer turbine flowmeter are illustrated in **Figure 1**. For liquids with a viscosity in the range of approximately 0.8 to 2 centistokes (cstks.), the turbine meter will produce an output signal that is typically linear to within $\pm 0.5\%$ of reading or better over

Illustration 1 • Turbine Flowmeter Cutaway



a turndown range of 10:1. The meter will produce an output signal that is typically repeatable to within $\pm 0.1\%$ of reading over a turndown range of 20:1 to as wide as 100:1 depending on the coil used and the type bearing used. Accuracy and flow range specifications are given for each size and coil type combination are given in the individual meter series datasheets.

Sizing:

When selecting a specific size Hoffer inline turbine flowmeter, **Table 1** may be used as a general guide for the linear and repeatable (extended) flow ranges for the type coil to be used. These ranges shown are applicable for viscosities of typically 0.8 to 2.0 cstks. Consult the specific meter series product data sheets to confirm applicable flow ranges. For higher viscosities it is generally recommended that only the linear flow ranges of the flowmeters be used in selecting a specific meter size. If using a turbine flowmeter over its repeatable flow range it is necessary to linearize the flow signal over the calibrated repeatable flow range by using a signal transmitter, flow display or flow computer with the ability to perform the linearization.

Installation:

Turbine flowmeters measure the average velocity of the flowing stream and this requires that the velocity profile of the fluid stream be symmetrical across the internal diameter of the flowmeter body when it engages the rotor. In order to assure that the flowing stream's velocity profile is symmetrical, it is necessary to provide straight runs of pipe into and out of the flowmeter. For most applications, a length equal to 10 diameters of the nominal turbine meter inlet size upstream and 5 diameters of the nominal turbine meter inlet size downstream of the meter are adequate to assure this condition. For flowmeters with nominal inlet piping sizes less than 1", 10" of upstream and 5" of downstream straight piping are recommended. For applications requiring the best accuracy, such as custody transfer or legal-

Figure 1 • Turbine Flowmeter Performance Characteristics

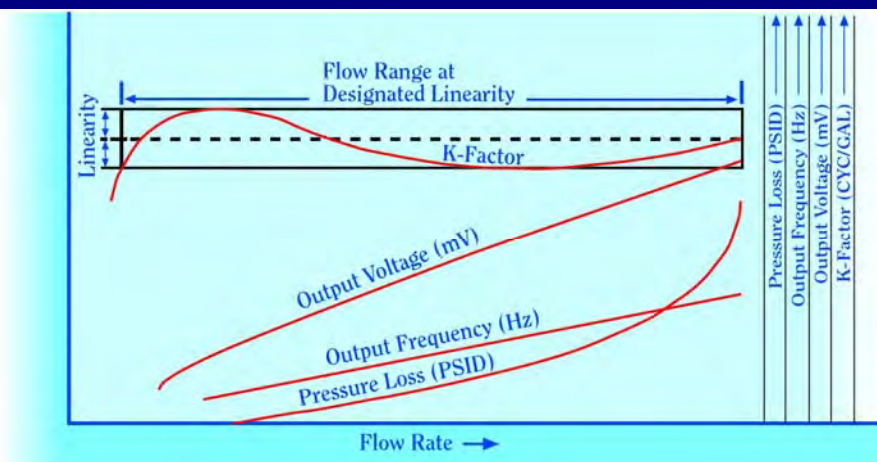


Table 1 •

Liquid Size Selector Chart for Standard HO Series Turbine Flowmeters

Flowmeter Size	MAGNETIC PICKUP COIL				MODULATED PICKUP COIL			
Diameter (inches)	Linear Range (US GPM)	Linear Range (LPM)	Repeatable Range (US GPM)	Repeatable Range (LPM)	Linear Range (US GPM)	Linear Range (LPM)	Repeatable Range (US GPM)	Repeatable Range (LPM)
1/4*	.35-3.5	1.3-13.2	.25-4.5	.95-17	.35-3.5	1.3-13.2	.0625-4.5	.24-17
3/8*	.75-7.5	2.8-28.4	.3-9	1.1-34	.75-7.5	2.8-28.4	.075-9	.28-34
1/2	1.25-9.5	4.7-36	.6-12	2.3-45	1.25-9.5	4.7-36	.12-12	.45-45
5/8	1.75-16	6.6-60.6	.9-20	3.4-75.7	1.75-16	6.6-60.6	.2-20	.75-75.7
3/4	2.5-29	9.5-110	1.5-35	5.7-132.5	2.5-29	9.5-110	.35-35	1.3-132.5
1	4-60	15-227	2-75	7.6-284	4-60	15-227	.75-75	2.8-284
1-1/4	6-93	23-352	3-115	11.4-435	6-93	23-352	1.15-115	4.35-435
1-1/2	8-130	30.3-492	5-175	19-662	8-130	30.3-492	1.75-175	6.6-662
2	15-225	56.8-852	11-275	42-1041	15-225	56.8-852	2.75-275	10.4-1041
2-1/2	25-400	95-1514	15-500	56.8-1893	25-400	95-1514	5-500	19-1893
3	40-650	151-2460	20-800	76-3028	40-650	151-2460	8-800	30.3-3028
4	75-1250	284-4731	50-1500	189-5678	MCP not recommended in 4" and larger sizes			
5	140-2000	530-7570	100-2500	379-9463				
6	200-2900	757-10977	125-3600	473-13626				
8	330-5200	1249-19682	270-6400	1022-24224				
10	650-8000	2460-30280	540-9800	2044-37093				
12	1400-12000	5299-45420	800-15000	3028-56775				

NOTE: Performance enhancement techniques are routinely applied to produce larger linear and usable flow ranges. Consult with the applications group at Hoffer with your requirements.

for-trade, a flow straightening tube bundle in the upstream section is normally required to eliminate any rotation of the flow stream about its axis of flow. Hoffer offers a complete line of installation kits and flanged flow straightening sections that provide the required straight runs of piping in and out of the flowmeters as an option and meet API and AGA design criteria for custody transfer applications as well. Consult factory with your specific requirements.

A strainer is generally recommended for installation upstream of the straight run section in order to prevent debris from entering into or damaging the flowmeter. Specific maximum particle sizes and recommended strainer sizes for each size of turbine meter are given in **Table 2**. A typical installation schematic for a uni-directional turbine flowmeter is shown in **Figure 2**. The bypass flow loop shown in Figure 2 is optional but provides a convenient method for removing the meter from the line for servicing without the necessity of shutting down the flow. For liquid service, it is recommended that the turbine meter and straight run sections be installed in a horizontal plane

relative to ground level. They may also be installed in a vertical or slanted line with the flow direction being up through the flow meter. Vertical or slanted downflow installations are not recommended due to the difficulty in maintaining the line full of liquid and the probability of accelerating bearing wear. Turbine flowmeters should always be installed in positive pressure lines and will not perform well under vacuum flow conditions. Adequate back pressure is required downstream of the flowmeter in order to assure that the flowmeter will remain completely full of liquid during measurement operations and to prevent fluid cavitation. Normally a minimum back pressure of 5 to 10 PSIG is sufficient to prevent cavitation. For more volatile, low density liquids such as hydrocarbon based liquids, the minimum required back pressure can be calculated as follows:

$$P(b) = (2 \times \Delta P) + (1.25 \times P(e))$$

Where:

P(b) = minimum required back pressure in PSIG

ΔP = pressure drop through the turbine flow meter at the maximum flow rate for the liquid being measured in PSIG

Figure 2 • Typical Flowmeter Installation

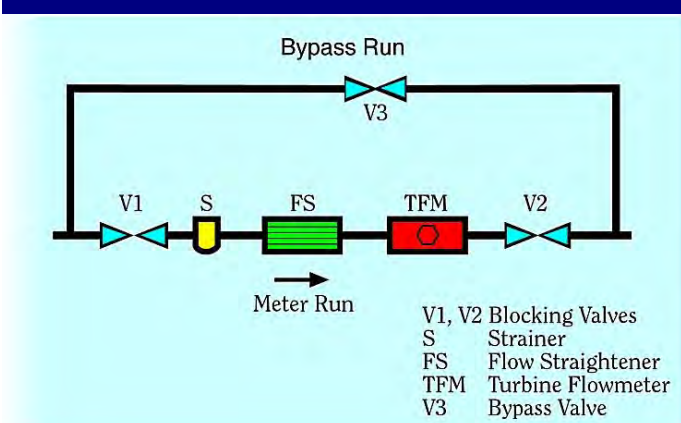
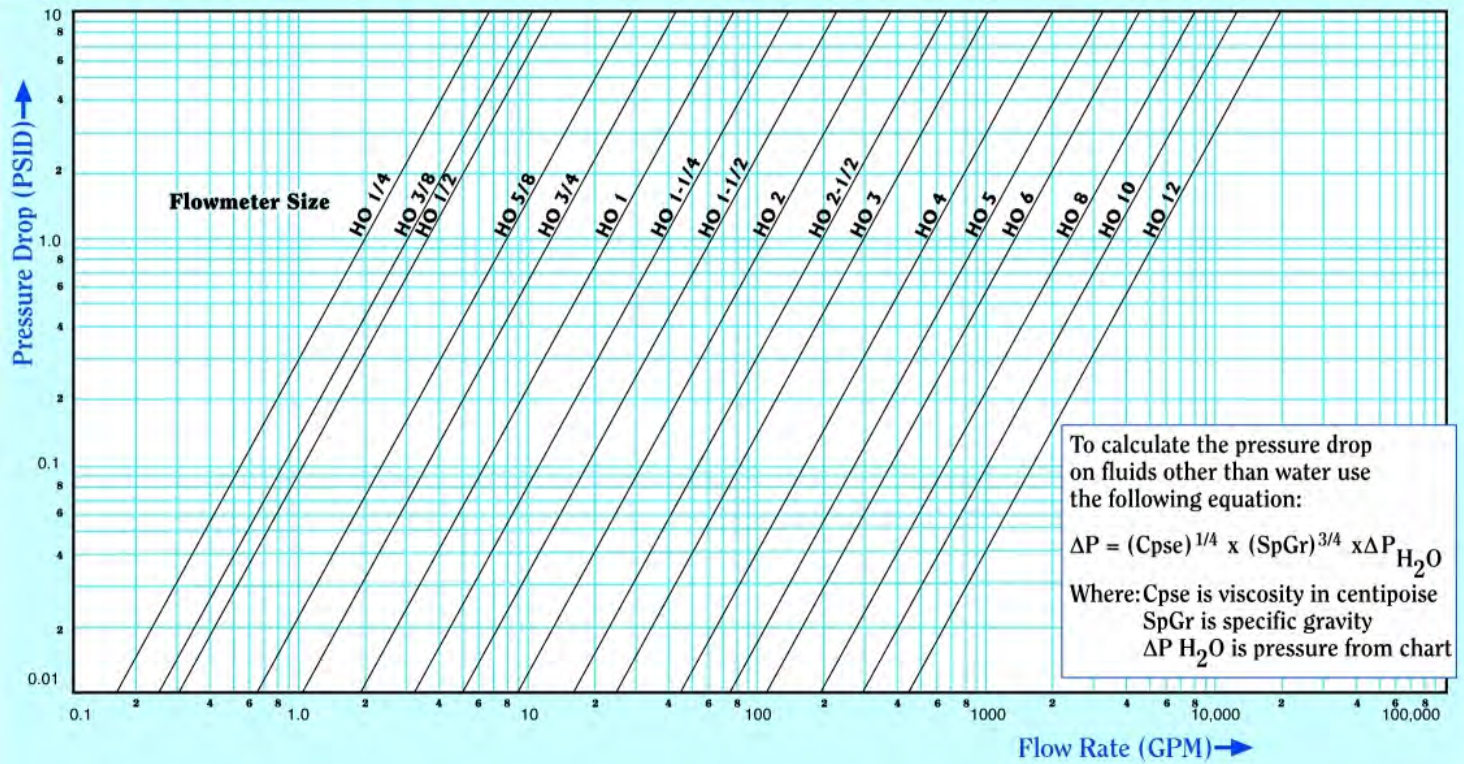


Table 2 • Recommended Strainer Sizes

Meter Size	Mesh Size	Particle Size Maximum (inches)
Mini-Flow Series	100	.0055
1/4" to 1/2"	100	.0055
5/8" to 1-1/4	80	.007
1-1/2 to 3"	40	.015
4 " to 12"	20	.031

Figure 3 • Pressure Drop Characteristics for HO Series on Liquid Service



P(e) = equilibrium vapor pressure of the liquid at the operating temperature in PSIA

Pressure Drop:

See **Figure 3** for pressure drop across the meters and the side-bar note for calculating pressure drop at viscosities other than 1 cstk.

Materials of Construction:

The materials of construction selection for a turbine meter usually are based upon chemical compatibility between the flowing liquid and wetted components of the meter. In the case of Hoffer turbine flowmeters, the wetted components include the meter body and the internals of the meter (internal flow straighteners, shaft, lock nuts or clips, rotor and bearings). For flanged flow meters, Hoffer employs a special manufacturing technique that prevents the flanges from coming into direct contact with the flowing liquid. Material selection for the flanges is at the discretion of the customer and/or compatibility with any external atmosphere or environmental conditions. The normal materials of construction for the meter bodies, flanges and internals are summarized in **Table 3**. Hoffer also offers custom materials of construction to meet specific requirements. For special material requirements, consult factory.

Table 3 • Materials of Construction for Hoffer Turbine Flowmeters

Component:	All Inline Turbine Meter Series Except Teflon®	Teflon® Series
Body:	316/316L Dual Rated Standard	316/316L Dual Rated, Non-Wetted Shell with PTFE Liner
Flanges:	Carbon Steel , 316/316L Dual Rated	316/316L Dual Rated with PTFE Flange Faces
Internals (Except bearings & Rotors)	316/316L Standard	PTFE. Shaft is a PTFE/PEEK (Poly-Ether-Ether-Ketone) Blend. For liquids not compatible with PEEK, consult factory.
Rotors:	17.4-PH (Standard), Nickel 200, 430 SS	PTFE
Bearings:	Hybrid Ceramic, Self-Lubricated Ball Bearing Type with 440C Races & Shields, Hard Carbon Composite Sleeve & Journal Type or Tungsten Sleeve & Journal Type	PTFE/PEEK (Poly-Ether-Ether-Ketone) Blend. For liquids not compatible with PEEK, consult factory

Table 4 • Bearing Selection

	Hybrid Ceramic Ball Bearing	Hard Carbon Composite Sleeve	Tungsten Carbide Sleeve
Temperature Range:	-400°F to +350°F (-240°C to +177°C)	-50°F to +500°F (-45°C to +260°C)	-450°F to +850°F (-268°C to +454°C)
Requires Lubricating Liquid?	No	No	Recommended*
Use in "3A" Sanitary Series?	No	Yes	Yes
Use in Dirty/Abrasive Service?	No	Moderate	Best
Use in Viscous Service?	Yes	No	Only if Abrasive
General Corrosion Resistance:	Good	Best	Poor
Extended Flow Range Service?	Best	Fair-Lubricity Dependent	Fair-Lubricity Dependent

Note: Temperature range of meter will also be limited by coil temperature range. See Table 8 on page 6.

Bearing Selection:

A specific bearing type is selected first on chemical compatibility with the flowing liquid. Other considerations include lubricity of the liquid, operating temperature of the liquid, presence of any solids in the liquid, whether the meter will be sitting stagnant or drained with a potentially corrosive liquid or atmosphere in the meter, viscosity and desired operating flow range. The Hoffer factory will confirm any bearing selection for a specific application. Refer to **Table 4** as a guideline for bearing options excluding the standard Teflon® bearing used with the Teflon® Series meter.

*Tungsten carbide sleeve bearings are used on non-lubricated applications primarily for oilfield service applications such as sand and cement slurries.

End

Connections:

**Table 5 •
Pressure Rating for the NPT Series**

Meter Size	End Fitting Size	Face/Face Length		Working Pressure	
		inches	cm	PSIG	BARG
1/4"	1/2"	2.45	6.22	6000	413.7
3/8"	1/2"	2.45	6.22	6000	413.7
1/2"	1/2"	2.45	6.22	6000	413.7
5/8"	3/4"	2.75	6.99	6000	413.7
3/4"	3/4"	3.25	8.26	4400	303.38
1"	1"	3.50	8.89	3850	265.45
1 1/4"	1 1/4"	3.875	9.84	3850	265.45
1 1/2"	1 1/2"	4.375	11.11	3500	241.32
2"	2"	4.75	12.06	3000	206.85
2 1/2"	2 1/2"	6.062	15.40	1100	75.84
3"	3"	7.50	19.05	1500	103.42
4"	4"	10.00	25.4	1500	103.42

**Table 6 •
Pressure Rating for the MS Flared Series**

Meter Size	MS(37°) Flared End Fittings	Face/Face Length		Working Pressure	
		inches	cm	PSIG	BARG
1/4"	MS33656-8	2.45	6.22	5000	344.75
3/8"	MS33656-8	2.45	6.22	5000	344.75
1/2"	MS33656-8	2.45	6.22	5000	344.75
5/8"	MS33656-10	2.75	6.99	5000	344.75
3/4"	MS33656-12	3.25	8.26	4400	303.38
1"	MS33656-16	3.50	8.89	4300	296.48
1 1/4"	MS33656-20	3.88	9.84	3600	248.22
1 1/2"	MS33656-24	4.38	11.11	3600	248.22
2"	MS33656-32	4.75	12.06	1800	124.11

Table 7 •
Flanged Series Maximum Allowable Working Pressure Ratings

Meter Size	Flange Size	Maximum ANSI Class Flange (See Note 2)	Max. Allowable Working Pressure (See Note 2)	
			PSIG	BARG
1/4", 3/8", 1/2"	1/2"	Up to 2500#	6170	419
5/8", 3/4"	3/4"	Up to 2500#	6170	419
1", 1¼"	See Note 1	Up to 2500#	5000	340
1½", 2"	See Note 1	Up to 1500#	3700	251
2½", 3", 4"	See Note 1	Up to 900#	2200	149
5"	5"	Up to 600#	1200	82
6"	6"	Up to 600#	1480	100
8"	8"	Up to 600#	1480	100
10"	10"	Up to 400#	990	67
12"	12"	Up to 400#	800	54

Note 1: Flange size must match meter size.

Note 2: Maximum allowable flange class & pressure rating are specific to the flange material selected. Consult factory for details.

The most popular threaded type end connections for Hoffer inline turbine flowmeters are the male NPT type and the male 37° flared MS type. Hoffer can readily supply other thread forms including BSP, JIS, SAE and metric to name a few. The most popular flange connection type is the ANSI raised face flange in various pressure classes. For the "3A" recognized sanitary series, the Triclamp flange fitting is typically supplied. Again, Hoffer routinely supplies other type flange end connections including DIN, API, ANSI ring joint, ANSI flat faced and a variety of proprietary flange and clamp end connections especially for high pressure services. Consult factory for any specific requirement.

Pressure Ratings:

For meters supplied with NPT, 37° flared or flanged connections, see **Tables 5, 6 and 7** for pressure ratings for each size meter. "3A" series Sanitary meters supplied with Tri-clamps are rated to 300 PSIG for temperatures to 100°F. For the Victaulic Grooved End Series and the Wing Nut High Pressure Series meters, consult the specific data sheet for ratings. For higher pressure ratings, custom designs are available. Consult factory with specific higher pressure requirements.

Coil Selection:

There are essentially two types of sensor coils used with Hoffer turbine flowmeters, the magnetic type and RF type. Magnetic coils either contain a magnet or, in the case of the Teflon® Series detect the presence of a magnet in the turbine meter rotor. The magnetic field generated is modulated by the rotation of the rotor to generate a voltage frequency signal that is directly proportional to the rotor's velocity and thus the velocity of the fluid stream. An RF coil produces a low-level radio frequency field that encompasses the rotor. As the rotor passes through the field, the frequency and amplitude of the field are modulated in direct proportion to the rotational velocity of the rotor and thus the velocity of the fluid stream. There are a number of factors that go into the selection of a specific coil for a given application. The most important difference between the two coils for the majority of applications is the fact that the magnetic coil imposes a magnetic drag or retarding action on the turbine rotor whereas the RF type coil does not. This has a direct influence on the extended or repeatable flow range of turbine meters in nominal sizes 3" and below. Other factors affecting the selection include operating temperature range, viscosity of the flowing stream, un-amplified signal transmission distance required, power availability, desired electronics interface and outputs and the area classification for the application.

The RF and magnetic coils are also available in the Redi-Pulse coil series. The Redi-Pulse coils are all powered by DC current and produce a conditioned pulse output whose frequency is equal to that produced by the rotating turbine. A variety of pulse types are available with the Redi-Pulse option. Consult the Redi-Pulse product data sheets for complete specifications.

The Hoffer factory will confirm any coil selection for a specific application. The following general guidelines in **Table 8** may be used for specification purposes.

Bi-Directional/Quadrature Flow & Pulse Security:

The symmetrical design of most Hoffer inline turbine meter series allows for their use in bi-directional flow applications. When used for bi-directional flow measurement, the meter is typically supplied with two sensing coils. The coils are positioned at 90-electrical degrees of separation from each one another around the perimeter of the flowmeter body. The resulting pair of output signals are staggered electrically by 90-degrees. By

Table 8 • Coil Selection

	Standard Magnetic Coil	Standard RF Coil	Redi-Pulse Coil Magnetic or RF
Temperature Range:	-450°F to +450°F (-268°C to +232°C) Std. -450°F to +850°F (-268°C to +454°C) Optional	-250°F to +400°F (-157°C to +204°C) Std. -450°F to +450°F (-268°C to +232°C) Optional	-40°F to +185°F (-40°C to +85°C)
Max. Un-amplified Signal: Transmission Distance	200 FT.	10 FT.	5,000 FT.
Use with Viscous Liquids?	Not Recommended	Yes	RF Version Recommended
Intrinsically Safe Option?	Yes	No	Yes
Power Required?	No	Yes-For Preamplifier	Yes

Table 9 • Viscosity Recommendation

Nominal Meter Size	Max. Recommended Viscosity
1/4" - 12"	300 Cstks. *

* Subject to operating pressure and pressure drop across the meter.

use of a flow computer with a quadrature discriminator circuit it is then possible to determine direction of flow. A dual coil arrangement may also be specified for applications requiring pulse security; a technique common to certain custody transfer and legal-for-trade flow measurement applications. A third coil may also be added for use as a spare coil or for ease of connection to a flow meter proving system. Consult factory with specific requirements.

Viscosity Effects:

Hoffer inline turbine flowmeters may be used for measuring relatively viscous fluids. The exception is the Teflon® Series which is only recommended for use on viscosities of 3 csts. and below. The maximum viscosity that can be successfully addressed will depend on the available operating pressure and pressure drop across the meter or allowable pressure drop. The usual maximum recommended viscosity for the inline turbine meters is summarized in **Table 9**.

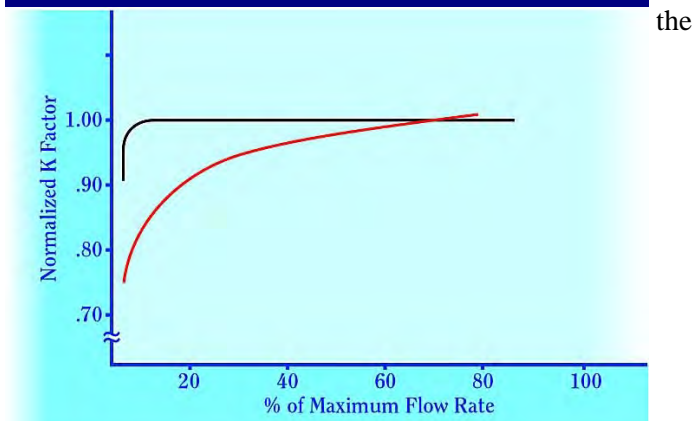
Ball bearings are usually preferred for viscous applications when a choice is available. It is also usually recommended that the meter be calibrated on a viscosity equal to or similar to the operating viscosity. Finally, signal linearization is often required for such applications. This effect is illustrated in **Figure 4**.

It is also possible that the viscosity of a particular fluid may vary with operating temperature. This will also create a non-linear output from the turbine flowmeter. A technique known as Universal Viscosity Curve (UVC) correction may be employed to compensate for this effect over the linear range of the turbine meter. Consult Hoffer Technical Note TN-21 for additional information on this option as well as Technical Note TN-47 for an expanded discussion on viscosity effects on turbine flowmeters.

Density Effects:

In general, liquid density is not a consideration or concern for most Hoffer inline turbine meter applications. The one notable exception pertains to the applicable flow ranges for the API Standard and Premium Series for use in measuring low density hydrocarbon products. See Hoffer Technical Note TN-46 for additional information on this subject. Applications where the measured liquid exhibits significant changes in density over the operating temperature range and where the desired measured units are in mass, it may be necessary to compensate for the temperature/density effect. This is done using a temperature sensor in conjunction with the turbine meter and a flow computer that accepts both signals and performs the required compensation calculations. For certain cryogenic fluid applications, where compressibility of the liquid under pressure can also change

Figure 4 • Viscosity Effects on 1" Flow-



specific volume of the fluid under the operating conditions, it may be necessary to compensate both for temperature and pressure in order to obtain accurate, inferred mass flow measurement readings.

Calibration Options:

With the exception of the STAR and LO-CO Series turbine flowmeters, all other Hoffer inline liquid turbine flowmeters are wet-calibrated and such calibrations are traceable to NIST. A permanent record of all new-build and repaired Hoffer turbine flowmeter calibrations are maintained by Hoffer in accordance with our ISO 9001 quality assurance system. The standard calibration, included in the base price of all wet-calibrated meters, is a 10-point, 1 cstk. calibration conducted over the specified range of flow rates with the first and last points repeated. A variety of additional options are available and include calibration at viscosities other than 1 cstk., calibration over more than 10-points, loop calibrations and multiple viscosity calibrations typically used for UVC applications. Third-party calibration services are also available for projects requiring that the Hoffer turbine flowmeters be calibrated by an independent calibration laboratory. Consult factory with any specific requirements.

Hazardous Area Applications:

Whether the requirement is for explosion-proof, flame-proof, non-sparking or intrinsically safe rated equipment to US, Canadian, Australian or European standards; Hoffer has the ability to supply its inline liquid turbine flowmeters and electronic accessories to meet most any hazardous area rating specification. Such applications are normally addressed with a combination of rated devices and/or enclosures to conform to the specific requirement. Consult factory with specific requirements.



Corporate History



Hoffer Flow Controls brings over 30 years of experience designing and manufacturing quality turbine flowmeters and related process measurement and control instrumentation. Our initial experience was in the field of cryogenic flow measurement. Today our reputation in this field is synonymous with quality.

Tens of thousands of Hoffer turbine flowmeters are on the job today throughout the world in applications ranging from oil well fracturing to food processing. Providing turbine flowmeters of varying configurations is our specialty. Our broad line of state-of the art electronics enable Hoffer to handle a variety of flow applications routinely. Totally new designs from Hoffer allow for near custom applications for a wide range of process operations which include indicating, blending, batching and flow control.

Ordering Information

Please supply the following basic information so that Hoffer Flow Controls can evaluate your application and correctly size the appropriate Hoffer turbine flowmeter.

- | | |
|---|-------------------------------|
| 1. Description of fluid or gas to be metered. | 5. Operating pressure range. |
| 2. Operating flow rates. | 6. Line Size. |
| 3. Viscosity (if applicable). | 7. End connection preference. |
| 4. Operating temperature range. | 8. Functional Description. |

A detailed application form to request a quotation is available on our web site at www.hofferflow.com.

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The specifications contained herein are subject to change without notice and any user of said specifications should verify from the manufacturer that the specifications are currently in effect. Otherwise, the manufacturer assumes no responsibility for the use of specifications which may have been changed and are no longer in effect.

The quality system covering the design, manufacture and testing of our products is certified to International Standard ISO 9001.

