DANIEL®
LIQUID TURBINE METER
TECHNICAL GUIDE

Flow Meter Systems

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TURBINE METER THEORY

The basic theory behind Daniel liquid turbine meters is relatively simple. Fluid flow through the meter impinges upon the turbine blades which are free to rotate about an axis along the center line of the turbine housing. The angular (rotational) velocity of the turbine rotor is directly proportional to the fluid velocity through the turbine. These features make the turbine meter an ideal device for measuring flow rate.

The output of the meter is taken by an electrical pickoff(s) mounted on the meter body. The pickoff's output frequency is proportional to the flow rate. In addition to its excellent rangeability, a major advantage of the turbine meter is that each electrical pulse is also proportional to a small incremental volume of flow. This incremental output is digital in form, and as such, can be totalized with a maximum error of one pulse regardless of the volume measured.

The turbine meter and associated digital electronics form the basis of any liquid metering system. An expanding blade hanger assembly holds the turbine rotor in alignment with the fluid flow. The angle of the turbine blades to the stream governs the angular velocity and the output frequency of the meter. A sharper blade angle provides a higher frequency output. In general, the blade angle is held between 20º and 40º to the flow. Lower angles cause too low of an angular velocity and loss of repeatability, while larger angles cause excessive end thrust.

Flow Rate is proportional to Angular Velocity

Figure 1 is a cross section of the internals of a Daniel Series 1500 turbine meter. Flow through the turbine meter is from left to right. The forward and rear suspension act as flow guides, ensuring fluid motion through the meter is parallel to the meter's centerline. Flow impinging upon the angular blade causes the rotor to spin at an angular velocity proportional to flow rate.

Figure 1: Liquid Turbine Flow Meter Cross Section
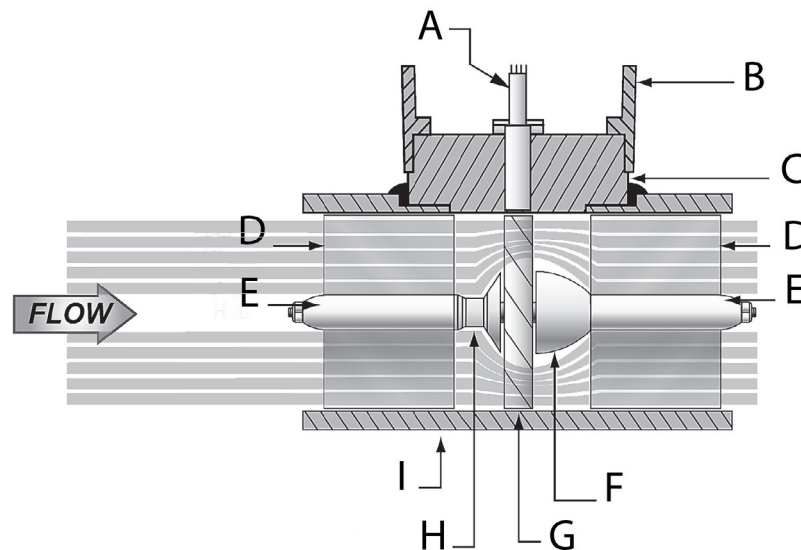
A. Pick-off coil

B. Local Mounted Enclosure (LME)

C. LME mounting pad

D. Hanger blade

E. Hanger hub

F. Downstream cone

G. Rotor assembly

H. Upstream cone

I. Meter body

TURBINE METER PARAMETERS

The following terms are the most widely discussed parameters of turbine meter applications.

Linearity

Linearity is the measure of variation in signal output across the nominal flow range of the meter. Turbine meters have a nominal K-factor which is the number of pulses output for a given volume measured. This value varies across the meter's flow range with linearity being a measure of the variance of actual output from the average K-factor. Advanced technology allows linearization of the meter registration within a flow computer, enabling further improvements in measurement accuracy.

Repeatibility

Repeatability is the ability of a meter to indicate the same reading each time the same flow conditions exist. Turbine meters exhibit excellent repeatability which is the most important parameter to be considered for many applications.

Accuracy

Accuracy is a measure of how closely the instrument indicates actual flow and is generally expressed as a percent of true volume for a specific flow range. Accuracy at a particular flow rate may be an order of magnitude better than "rated flow range accuracy."

Resolution

Resolution is a measure of the smallest increment of total flow that can be individually recognized, normally defined by a single pulse. Turbine meters have inherently high resolution.

Range

Range is the ratio of maximum flow to minimum flow over which the specified linearity will be maintained. Normal range or turndown is given as 10:1 which is often exceeded depending on meter size and required linearity.

Figure 2: Flow Ranges
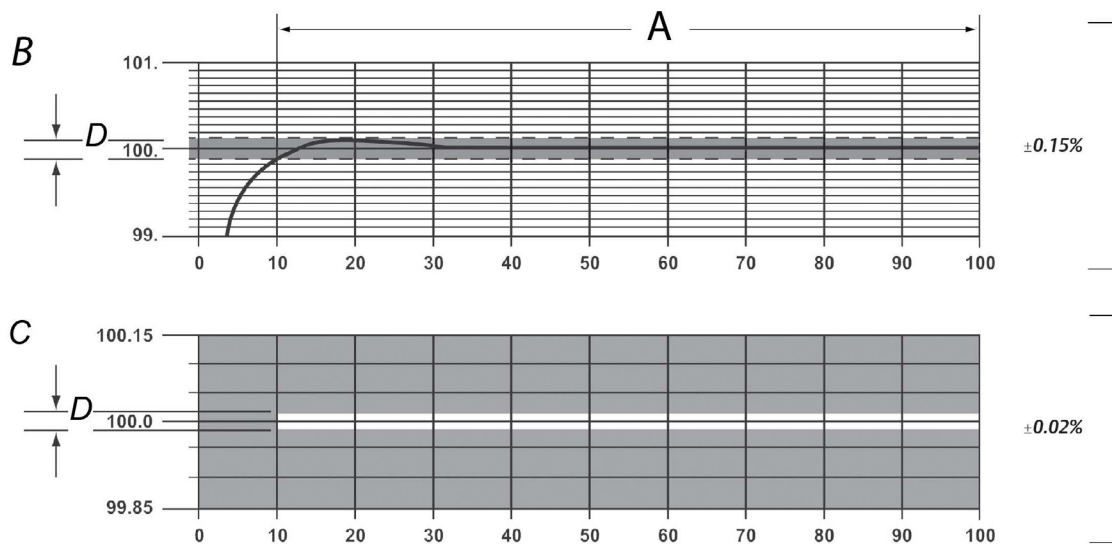
A. Meter range at the indicated linearity

B. Indicated linearity

C. Repeatability envelope

D. Percent registration

DANIEL LIQUID TURBINE FLOW METER SYSTEMS

Daniel Series 1200 and 1500 Liquid Turbine Flow Meter Systems combine turbine meters and electronic instrumentation to measure volumetric total flow and/or flow rate. Each Daniel turbine meter is comprised of a cylindrical housing that contains a precise turbine rotor assembly. One or two magnetic pickoffs are mounted in a boss on the meter body. As fluid passes smoothly through the flow meter, it causes the rotor to rotate with an angular velocity proportional to flow. The rotor blades or rim buttons passing through the magnetic field of the pickoff generate a pulsing voltage in the coil of the pickoff assembly. Each voltage pulse represents a discrete volume. The total number of pulses collected over a period of time represents the total volume metered.

The sinusoidal signal from each pickoff has low amplitude and may not normally be relied upon for transmission distances over 20 feet (6 meters). The signal must, therefore, be amplified which is achieved with a preamplifier mounted on the turbine meter. These pulse signals are typically transmitted to control room instrumentation such as flow computers, and may also be required as input to prover computers which calculate, display, transmit, control or record the flow sensed by the rotor. The results may be displayed as pulse counts or standard engineering units, such as gallons, barrels, cubic meters, etc.

All Series 1200 and 1500 Liquid Turbine Flow Meters have, as standard, the Local Mounted Enclosure (LME) which may be fitted with one or two pickoffs and a dual channel preamplifier. The pickoff mountings are oriented with the pickups 90º electrically out of phase. The Daniel Series 1500 Liquid Turbine Flow Meter may be supplied with two LMEs, offering up to four pulse outputs. Alternate pairs across the two LMEs are also 90º electrically out of phase.

Series 1200 and 1500 Liquid Turbine Flow Meters can be fabricated with adjacent tube sections. Each meter is precisely calibrated before shipment.

The meter systems are used to provide measurement information in fluid transport, petroleum and chemical processing, custody transfer of liquids, blending systems, and in-product batching in field or plant operations. The repeatability of the system ensures quality measurement of fluids over a wide range of flow rates, temperatures, compositions and viscosities.

Figure 3: Liquid Turbine Flow Meter System
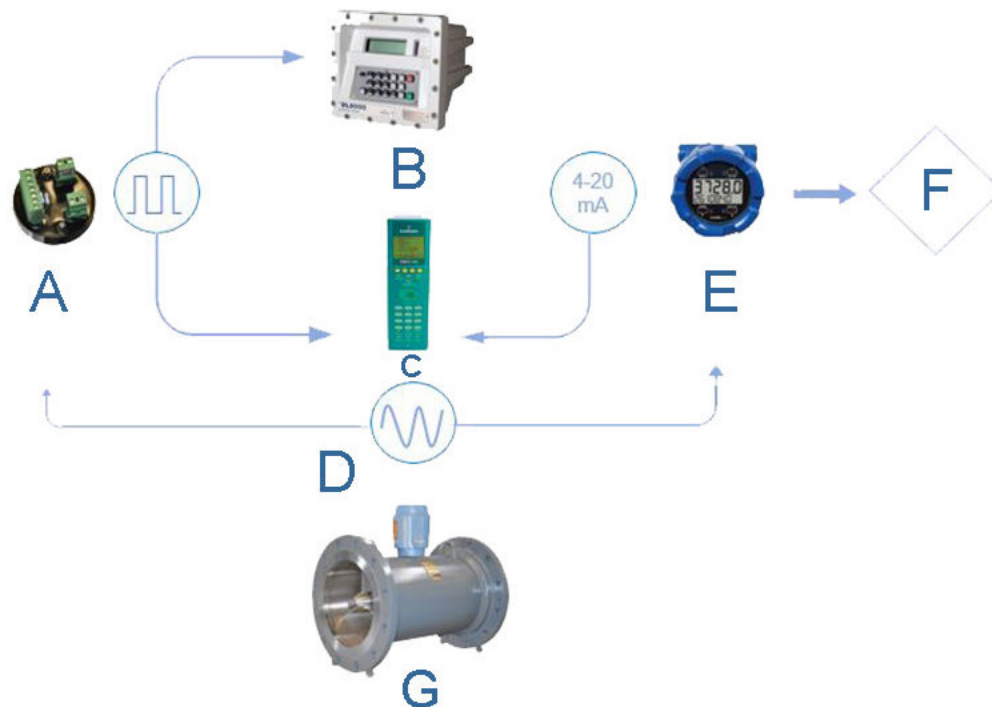
A. Preamplifier: conditions and amplifies pulse

B. Electronic preset

C. Flow computer

D. Pulse signal

E. DRT-899: converts to 4-20 mA

F. Rate total

G. Liquid turbine meter

Innovative Floating Rotor Design

Flowing fluid enters the turbine through the forward suspension. When it encounters the sharp angle of the upstream cone, the stream is deflected outward, increasing in velocity and causing a slight static pressure drop. As the fluid leaves the blade area, flow has redistributed. Velocity is reduced slightly and static pressure has increased proportionally.

The difference between the two velocity pressures causes the rotor to move upstream into the fluid flow. A slight offset ensures this upstream force will not cause the rotor to strike the forward thrust bearing.

The cross sectional area of the cone is slightly smaller than that of the rotor hub with some flow impinging directly upon the rotor hub, generating a downstream thrust. As a result, the rotor floats in balance between upstream and downstream cones, pushed forward by the pressure difference across the blades and pushed backward by the flow impingement. The only bearing surface other than the measured fluid is the cemented carbide sleeve bearing insert (see Figure 4).

In bi-directional meters, a second upstream cone replaces the downstream cone and rangeability is reduced in reverse flow.

Figure 4: Rotor Assembly Cross Section
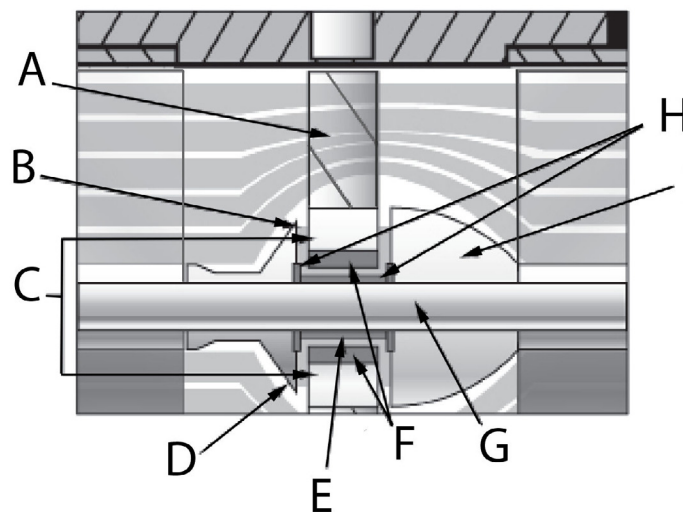
A. Rotor blade

B. Fluid

C. Rotor hub

D. Upstream cone

E. Journal

F. Bearing

G. Shaft

H. Thrust washer

I. Downstream cone

Magnetic Pickoff of Rotor Velocity

The angular velocity of the turbine rotor is taken through the turbine meter wall by means of a magnetic pickoff. Turbine blades made of a paramagnetic material (i.e. properties cause it to be attracted by a magnet) rotate past the pickoff coil, generating irregular shaped voltage pulses. The frequency of these pulses is linearly proportional to the angular velocity of the rotor and thus to the flow rate. Additionally, each pulse is incrementally proportional to a small unit of volume. The amplitude of the pulses will vary in proportion to blade velocity but is not considered in the measurement process. Flow rate and total flow information is transmitted by frequency and by counting (totalizing) the pulses.

The permanent magnet produces a magnetic field which passes through the coil and is concentrated to a small point at the pickoffs. In **Figure 5** and **Figure 6** below, as a turbine blade (A) moves into close proximity to the pickoff point, its magnetic properties cause the magnetic field to deflect to accommodate its presence. This deflection causes a voltage to be generated in the coil. As the blade passes under the pickoff point (B), this voltage decays, only to build back in the opposite polarity as the leaving blade which is now in position (C). This result is caused by the magnetic field deflecting in the opposite direction. So as each blade passes the pickoff, it produces a separate and distinct voltage pulse. Since the fluid surrounding each blade represents a discrete unit of volume, each electrical pulse also represents a discrete unit of volume. Turbine meter output is rated in pulses per gallon, pulses per liter, or other standard engineering units.

Figure 5: Assembly of Local Mounted Enclosure with Dual pickoff configuration
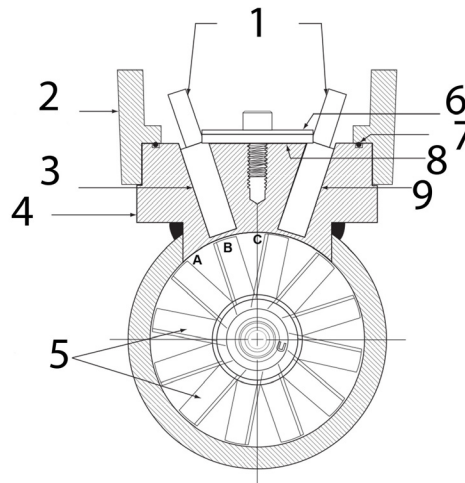
1. Magnetic sensors (pickoffs)
2. Local Mounted Enclosure (LME)
3. Pickoff #1
4. LME mounting box pad
5. Blades

6. Clamp
7. O-ring
8. Insulator
9. Pickoff #2

Figure 6: Voltage output, peak to peak
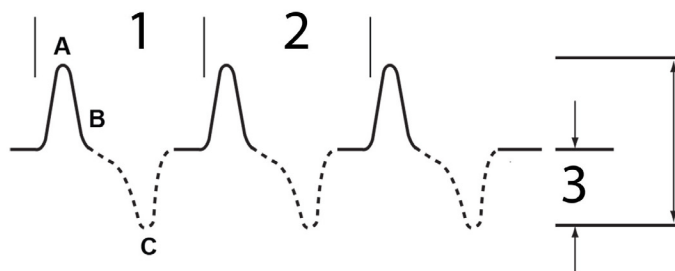
1. One pulse
2. One unit volume
3. This ½ pulse is not used by readouts

TURBINE METER ROTOR AND BEARING DESIGN

The primary differences in turbine meter technology are in the design of the rotor and bearings. The rotor is an assembly of up to 12 blades locked into a hub that rotates on a bearing(s). For light liquid applications that require viscosities of 5 cst or less and specific gravities of less than 0.70, the rotor does not normally need a rim or shroud. For measuring more viscous liquids and in larger size turbine meters (i.e. 200DN and above), a rim is fitted to ensure sufficient rigidity in the rotor. A rim also offers the advantage of higher pulse resolution. With a bladed rotor, the number of pulses per revolution is limited to the number of blades; in a rimmed rotor, the number of pulses per revolution corresponds to the number of buttons or slots in the rim.

For intermittent duties on light, clean hydrocarbons that may be found at tank truck terminals, ball bearings may be used for a rotor bearing. Proper design of rotors with ball bearings will use two ball races and a short axle upon which the rotor is fitted. Where space is constrained, ball races may be fitted directly into the rotor hub. This design is particularly suited to low and varying flow rate applications, and is utilized on the Series 1200 Liquid Turbine Flow Meter, designed primarily for distribution applications such as load racks. In these installations, liquids are typically light, refined products.

Pipeline applications often require continuous operation at fixed flow rates, requiring the turbine meter to offer sufficient longevity to minimize maintenance intervals. In these applications, tungsten carbide journal bearings are used. As tungsten carbide is extremely hard wearing, these bearings are often applied in more demanding measurement applications such as crude oil.

An important point is limitations on viscosity are related to the rangeability of the turbine flow meter. As the viscosity of the measured liquid increases, the K-factor variations at different flow rates increase. To maintain the linearity of the meter at the required level as the viscosity of the measured liquid increases, the turndown or rangeability of the meter must be reduced. For typical pipeline applications where the flow meter will operate at just one flow rate (or a very limited range of flow rates), a turbine meter may be used to measure flows of high viscosity liquids. The Series 1500 Liquid Turbine Flow Meter is designed for pipeline applications and is equipped with robust internals suited to continuous measurement of a wide range of liquids.

There may be a single hanger or hangers upstream and downstream of the rotor. In the Series 1200 Meter, there is a single upstream support for the rotor. In the Series 1500 Meter, there are both upstream and downstream hangers. Bearings may be either ball or tungsten carbide journal bearings. Ball bearings are used to provide improved performance at low flow rates and on clean product. These bearings are a reliable, cost-effective solution. The Series 1200 Meter deploys a cantilevered twin ball bearing design. The meter is designed with a rotating shaft on two ball bearing units and is available in DN25 to DN100 (1-inch to 4-inch) line sizes. For more demanding applications, a tungsten carbide journal bearing assembly is available as an option for DN80 and DN100 (3-inch and 4-inch) line sizes only.

Lightweight bladed rotors of this type mounted on ball bearings are particularly well suited to the intermittent duty cycles typical in loading rack applications. The design application is limited to clean refined products. In the event the turbine is used on slightly dirty products, use of tungsten carbide journal bearings is recommended. Tungsten carbide bearings are extremely hard wearing and used in turbine meters on a range of applications from LPGs to crude oils.

Rimmed Rotors for Higher Resolution

In the larger diameter Series 1500 Meter (normally above DN150 or 6-inch in line size), the resolution provided by a blade-type rotor may be improved by the use of a rimmed or shrouded rotor. This construction is standard for Daniel DN200 or 8-inch and larger meters. A lightweight stainless steel rim or shroud carries small paramagnetic buttons which provide greater resolution of flow by generating more pulses per unit volume.

Series 1200 and 1500 Meters are supplied with local mounted electronics (LME) as standard. The electronic enclosure is attached to a boss which, in turn, is attached to the meter body. This assembly may house two pickoffs in an orientation with their outputs 90°electrically out of phase.

The Daniel Series 1500 Liquid Turbine Flow Meter is offered with its standard paramagnetic H. Mu button Rim type rotor (Figure 7). A light shrouded rotor is available and is designed with slots in the rim in place of paramagnetic buttons. This light shrouded rotor provides a higher number of pulses per unit volume (Figure 8) than the standard rotor which enables proving with a smaller prover (Figure 9).
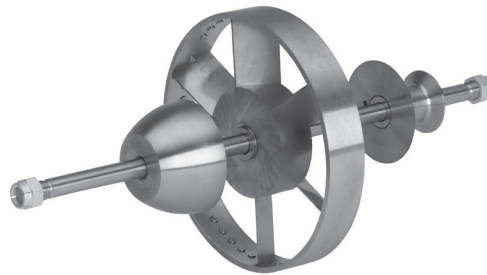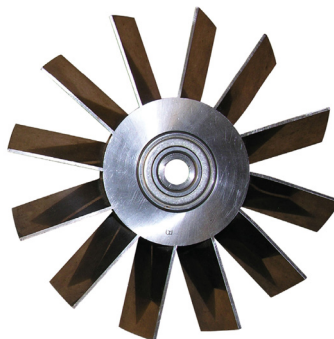
Figure 7: Rim rotor DN80 to DN600 (3-inch to 24-inch)

Figure 8: Optional Lite product Rim rotor DN80 to DN300 (3-inch to 12-inch)

Figure 9: Blade rotor DN25 to DN150 (1-inch to 6-inch)

DANIEL SERIES 1500 LIQUID TURBINE FLOW METER

The Series 1500 Meter is designed for applications requiring rugged dependability with high accuracy and throughput. Engineered for use on pipelines, marine loading and other demanding systems, the internals are well proven in the Daniel PT meter. The Series 1500 Meter utilizes these internals in a body designed to accept Locally Mounted Electronics (LME) and the latest pickoff and preamplifier technology.

Upstream and downstream self-centering hangers, a highly durable rotor assembly utilizing a tungsten carbide sleeve and journal bearings, and a floating rotor design make the Series 1500 Meter ideal for applications where downtime is not an option.

In such applications, dual-pulse transmission is normally used to allow the meter instrumentation (normally a flow computer) to check the fidelity of pulse transmission. The single LME housing contains one or two pickoffs and a dual channel preamplifier. When configured with two pickoffs, the square wave outputs are 90° electrically out of phase.

A second LME is an option on DN80 (3-inch) and larger meters. For meters DN80 (3-inch) and larger with a dual LME, four matched pulse outputs are possible. Corresponding pairs are then 90° electrically out of phase.

Series 1500 Meter utilizes only tungsten carbide journal bearings. In applications with fluids of adequate lubricity, a film of the measured fluid lubricates the journal, contributing to instrument longevity. These bearings are extremely hard (Rockwell A-94) and polished with diamond paste to a smoothness of 0.05 micron (a mirror finish).

The rotor may be blade-type or rimmed-type. Rimmed or shrouded rotors have the advantages of greater structural strength and the possibility of higher resolution, as a greater number of paramagnetic buttons than of blades may be used on the stainless steel rim. A bladed rotor is limited to one pulse per blade per revolution with the practical limit for the blades being 12. With a rim or shroud, there may be up to 64 pulses (buttons) per rotor revolution.

The rimmed design is optional on DN80 to DN150 (3-inch to 6-inch) turbines and is standard on DN200 (8-inch) and larger.

Regardless of the meter design and rotor configuration, the blades are locked and welded into the desired angular position, forming a solid, one piece rotor.

In the Series 1500 Meter, both upstream and downstream shaft supports are deployed. The expanding hanger principle is used to ensure positive self-centering of the internals. The shape of the internal cones results in a reverse differential pressure that counterbalances the downstream thrust on the rotor, allowing the rotor to float on a fluid cushion. This floating action ensures long life and minimal maintenance.

Local Mounted Enclosure (LME)

Configuration shown for temperature up to +140°F (+60°C)

Figure 10: Local Mounted Enclosure assembly

A. O-ring

B. Dual-channel preamplifier

C. Mounting bracket

D. Socket head screws

E. Grounding cap

F. Plug pipe hex socket
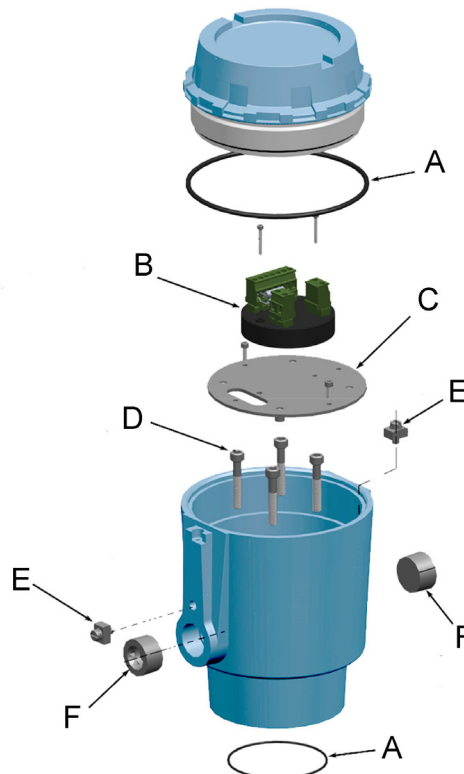
Rim Type Rotor

Available in DN80 to DN600 (3 to 24-in)

Figure 11: Rim type rotor assembly
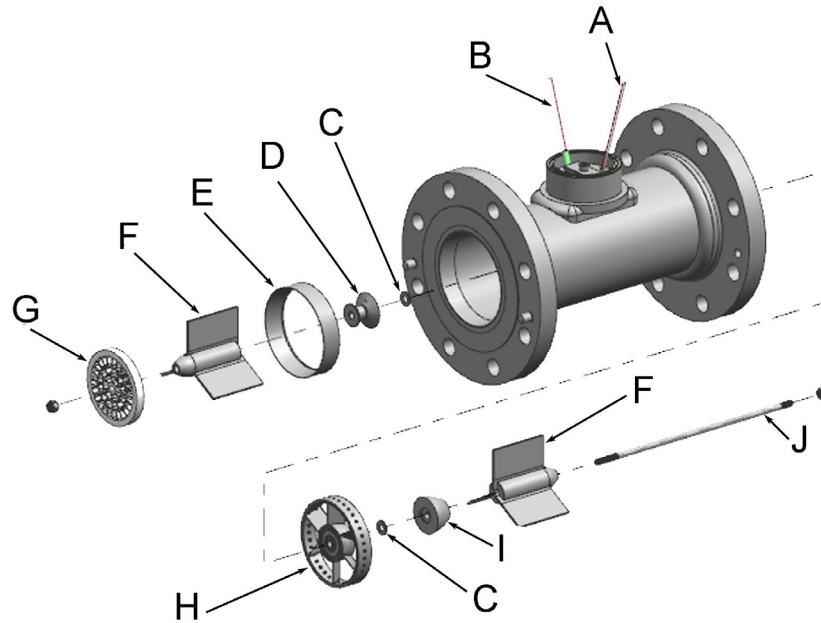
A. Pick A

B. Pick B

C. Thrust washer

D. Upstream cone

E. Deflector ring

F. Hanger blades

G. Flow conditioning plate (optional DN80 - DN 150 only)

H. Rim type rotor assembly

I. Downstream cone

J. Shaft

Blade Type Rotor

Available in DN25 to DN150 (1 to 6-in)

Figure 12: Blade type rotor assembly
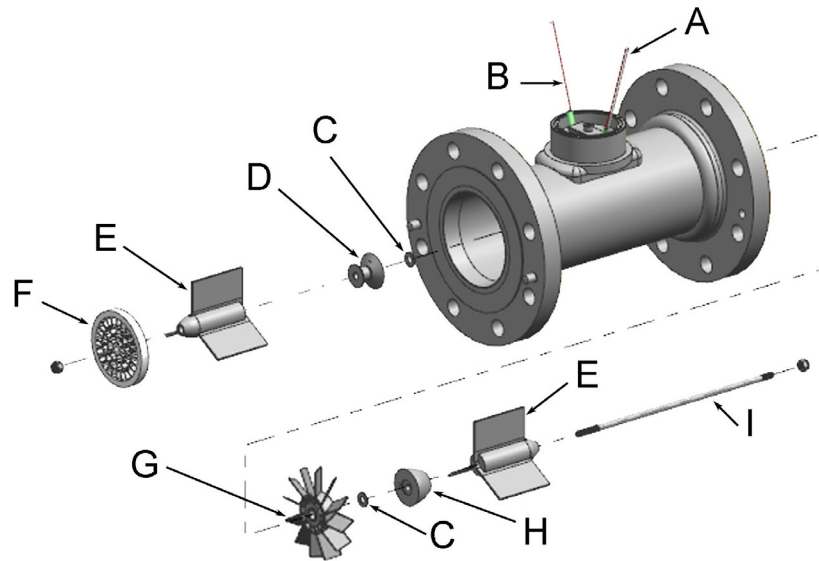
A. Pickoff A

B. Pickoff B

C. Thrust washer

D. Upstream cone

E. Hanger blade

F. Flow conditioning plate (Optional DN80 - DN 150 only)

G. Blade type rotor assembly

H. Downstream cone

I. Shaft

(4) Grease sticks must be tordered separately. Consult with an Daniel technical specialist to confirm the correct type of grease for the application.

Daniel Series 1500 Meter Design Features

The linearity specification is dependent on the characteristics of the calibration fluid. For DN25 to 200 (1-inch to 8-inch) meters, SG is 0.78 and KinVisc (cSt) is 2.1. For DN250 to 600 (10-inch to 24-inch) meters, SG is 1.0 and KinVisc (cSt) is 1.0.

Table 1: Linear Flow Range[1]										
Nominal Size		BBL/HR			M³/HR			USGPM		
DN	Inches	Standard Flow Range		Extended Max Flow Rate[2]	Standard Flow Range		Extended Max Flow Rate[2]	Extended Min Flow Rate Linearity 0.75% (1"-2.5") 0.50% (3"-24")	Standard Flow Range		Extended Max Flow Rate
		Min	Max		Min	Max			Min	Max	
25	1	10	100	115	1.6	16	18	5.6	7	70	81
40	1.5	21	214	246	3.4	34	39	12	15	150	173
50	2	43	429	493	6.8	68	78	24	30	300	345
65	2.5	57	571	657	9.1	91	105	32	40	400	460
80	3	100	1,000	1,150	15.9	159	183	56	70	700	805
100	4	185	1,850	2,128	29.4	294	338	104	130	1,295	1,489
150	6	420	4,000	4,830	66.8	668	768	235	294	2,940	3,381
200	8	850	8,500	9,775	135	1,351	1,554	476	595	5,950	6,843
250	10	1,200	12,000	13,800	191	1,908	2,194	672	840	8,400	9,660
300	12	1,800	18,000	20,700	286	2,862	3,291	1,008	1,260	12,600	14,490
400	16	2,800	28,000	32,200	445	4,452	5,120	1,568	1,960	19,600	22,540
450	18	4,000	40,000	46,000	636	6,359	7,313	2,240	2,800	28,000	32,200
500	20	4,800	48,000	55,200	763	7,631	8,776	2,688	3,360	33,600	38,640
600	24	6,000	60,000	69,000	954	9,539	10,970	3,360	4,200	42,000	48,300

(1) Bi-directional meters have a standard linear flow range as stated above. The minimum flow rate in the reverse direction is 20% of its maximum extended flow rate.

(2) Extended flow rate with 20% duty cycle not to exceed 2 hours per day.

Table 2: Nominal K-Factor[1]							
Nominal Size		Pulses/BBL		Pulses/M³		Pulses/US Gal	
DN	Inches	Blade	Rim	Blade	Rim	Blade	Rim
25	1	21,000	N/A	132,086	N/A	500	N/A
40	1.5	9,660	N/A	60,760	N/A	230	N/A
50	2	5,460	N/A	34,342	N/A	130	N/A
65	2.5	2,730	N/A	17,171	N/A	65	N/A
80	3	2,100	4,620	13,209	29,059	50	110
100	4	1,00	2,940	6,287	18,462	24	70
150	6	245	1,050	1,532	6,604	5.8	25
200	8	N/A	550	N/A	3,461	N/A	13
250	10	N/A	250	N/A	1,585	N/A	6.0
300	12	N/A	200	N/A	1,268	N/A	4.8
400	16	N/A	100	N/A	634	N/A	2.4
450	18	N/A	100	N/A	634	N/A	2.4
500	20	N/A	100	N/A	634	N/A	2.4
600	24	N/A	100	N/A	634	N/A	2.4

(1) K-Factors for individual rotors vary. An acceptable rotor can be nominal ±15%.

Rangeability

The flow ranges indicated in the previous tables show a nominal flow range with a turndown of 10:1. The turbine meter will report measurement repeatable to the indicated specification based on the measurement of clean liquids such as water (specific gravity 1, viscosity 1 cSt) and mineral spirits (specific gravity 0.78, viscosity 2.1 cSt).

When liquids with properties outside of the range described by these liquids are to be measured, the meter flow range will be affected.

Extended flow rates on intermittent duty cycles are permitted and shown in **Table 1**. It should also be noted that the use of the meter in the extended flow range should be limited to a 20% duty cycle.

Performance Based on Specific Gravities

Liquid turbine meters are affected by changes in liquid density. When measuring liquids with specific gravities of 0.7 or less, the meter's minimum flow rate must be increased to maintain the meter's linearity within the required limits. In this application, the maximum flow rate may be increased to allow for greater rangeability.

It is vital that proper back pressure be maintained (refer to Back Pressure for the formula for determining required back pressure). Failure to do so may result in flashing and cavitation, which will cause over ranging of, and damage to, the meter.

Liquids with low specific gravities generally have high vapor pressures and high coefficients of thermal expansion. When measuring these liquids, it is extremely important that proper installation, measurement and proving practice be followed to provide stable temperatures and to negate the potential for poor measurement and possible system damage.

The data on the following page is for the Series 1500 Meter. Similar effects will be observed in all turbine meter designs.

Figure 13: Daniel Series 1500 Liquid Turbine Flow Meter

Series 1500 Meter Flow Range Adjustment

The tables below represent the effect of specific gravity on the linear flow range.

Table 3: Specific Gravity = 0.7 to 1 (Blade and Rim Type Internals)							
Nominal Size		Minimum Linear Flow Rate			Maximum Linear Flow Rate		
DN	Inches	BBL/HR	M³/HR	USGPM	BBL/HR	M³/HR	USGPM
25	1	10	1.6	7	100	15.9	70
40	1.5	21	3.4	15	214	34.1	150
50	2	43	6.8	30	429	68.1	300
65	2.5	57	9.1	40	571	90.9	400
80	3	100	15.9	70	1,000	159	700
100	4	186	29.5	130	1,850	294	1,295
150	6	420	66.8	294	4,200	668	2,940

Table 4: Specific Gravity = 0.6 (Blade Type Internals Only)							
Nominal Size		Minimum Linear Flow Rate			Maximum Linear Flow Rate		
DN	Inches	BBL/HR	M³/HR	USGPM	BBL/HR	M³/HR	USGPM
25	1	17	2.7	12	116	18.4	81
40	1.5	36	5.7	25	247	39.3	173
50	2	71	11.4	50	493	78.4	345
65	2.5	96	15.2	67	657	105	460
80	3	167	26.6	117	1,150	183	805
100	4	309	49.1	216	2,129	338	1,490
150	6	701	112	491	4,830	768	3,381

Table 5: Specific Gravity = 0.5 (Blade Type Internals Only)							
Nominal Size		Minimum Linear Flow Rate			Maximum Linear Flow Rate		
DN	Inches	BBL/HR	M³/HR	USGPM	BBL/HR	M³/HR	USGPM
25	1	23	3.6	16	116	18.4	81
40	1.5	50	7.9	35	247	39.1	172
50	2	101	16.1	71	493	78.4	345
65	2.5	134	21.3	94	657	105	460
80	3	236	37.5	165	1,150	183	805
100	4	436	69.3	305	2,129	338	1,490
150	6	989	157	692	4,830	768	3,381

Table 6: Specific Gravity = 0.4 (Blade Type Internals Only)							
Nominal Size		Minimum Linear Flow Rate			Maximum Linear Flow Rate		
DN	Inches	BBL/HR	M³/HR	USGPM	BBL/HR	M³/HR	USGPM
25	1	23	4.5	20	116	18.4	81
40	1.5	60	9.5	42	246	39.1	172
50	2	120	19.1	84	493	78.4	345
65	2.5	160	25.4	112	657	105	460
80	3	280	44.5	196	1,150	183	805
100	4	517	82.2	362	2,129	338	1,490
150	6	1,173	187	821	4,830	768	3,381

Table 7: Specific Gravity = 0.3 (Blade Type Internals Only)							
Nominal Size		Minimum Linear Flow Rate			Maximum Linear Flow Rate		
DN	Inches	BBL/HR	M³/HR	USGPM	BBL/HR	M³/HR	USGPM
25	1	33	5.2	23	116	18.4	81
40	1.5	71	11.4	50	246	39.1	172
50	2	141	22.5	99	493	78.4	345
65	2.5	190	30.2	133	657	105	460
80	3	331	52.7	232	1,150	183	805
100	4	613	97.4	429	2,129	338	1,490
150	6	1,393	221	975	4,830	768	3,381

# DANIEL SERIES 1200 LIQUID TURBINE FLOW METER

Series 1200 Meter is designed specifically for load rack service where repeatability is vital. The meter deploys a lightweight rotor that is supported on self-cleaning, flow through ball bearings. As a result, the meter is versatile and is particularly suited to batch loading of light hydrocarbons. The meter has been used successfully on fluids with viscosities up to 6 centistokes. The meter can also be supplied with optional tungsten carbide bearings for more demanding applications.

The meter features an upstream expanding hanger which centers the internals in the body with cantilevered support of the rotor. It will operate in any plane and is frequently used in the vertical orientation with flow upward to save space on a load rack.

An integral flow conditioning plate (FCP) in Polyoxymethylene (POM) (standard) or aluminum (an option for DN80 and DN100, or 3-inch and 4-inch meters) allows operation without upstream flow straightening. This configuration is particularly valuable for vertical installation of the meter on load racks. The FCP is available on DN40 (1.5-inch) meters and larger.

Local Mounted Enclosure (LME)

**Figure 14: Part Identification for Local Mounted Enclosure (LME)**
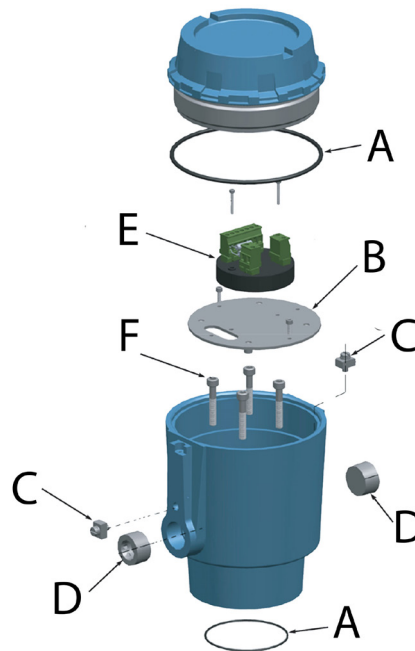
A. O-ring

B. Mounting bracket

C. Grounding cap

D. Plug pipe hex socket

E. Dual-channel preamplifier

F. Socket head screws

Stainless Steel Bearing Internals

**Figure 15: Part Identification for a NPS 3 through 4 Meter**

A. Flow conditioning plate

B. Fins

C. Diffuser

D. Stainless steel ball bearing

E. Retaining rings

F. Roll pin

G. Shaft

H. Rotor assembly
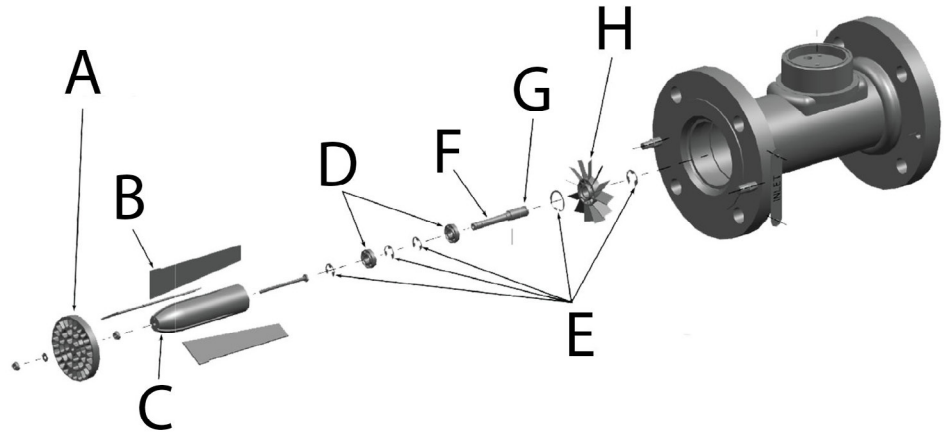
Tungsten Carbide Bearing Internals

Figure 16: Part Identification for a NPS 3 through 4 Meter

A. Flow conditioning plate

B. Fins

C. Diffuser

D. Rotor assembly

E. Cotter pin

F. Thrust washers

G. Outlet diffuser cap
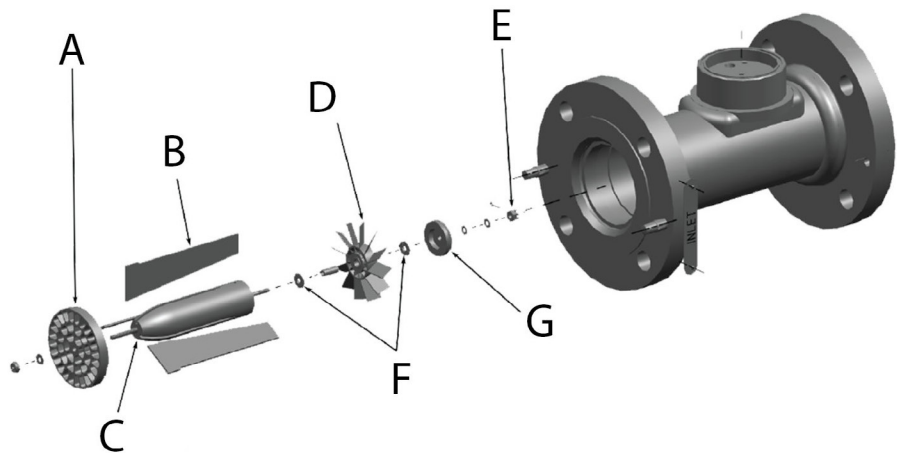
Series 1200 Meter Design Features

The following data is applicable for Daniel Series 1200 Liquid Turbine Flow Meter calibrated on mineral spirits.

Table 8: Flow Rate									
Nominal Size		BBL/HR			M³/HR			USGPM	
DN	Inches	Standard Flow Range		Extended Maximum Flow Rate[1]	Standard Flow Range		Extended Maximum Flow Rate[1]	Standard Flow Range		Extended Maximum Flow Rate[1]
		Min	Max		Min	Max		Min	Max	
25	1	8.6	86	99	1.4	14	16	6	60	69
40	1.5	19	186	214	3.0	30	34	13	130	150
50	2	31	314	361	5.0	50	58	22	220	253
80	3	93	929	1,068	15	148	170	65	650	748
100	4	143	1,429	1,785	23	227	284	100	1,000	1,250

(1) *Extended maximum flow range with 20% duty cycle not to exceed 2 hours per day*

Table 9: Nominal K-Factor				
Nominal Size		K-Factor[1]		
DN	Inches	Pulses/BBL	Pulses/M³	Pulses/USG
25	1	33,600	211,338	800
40	1.5	16,800	105,669	400
50	2	7,560	47,551	180
80	3	2,184	13,737	52
100	4	966	6,076	23

(1) *K-Factors for individual rotors vary. An acceptable rotor can be nominal ±15%.*

Figure 17: Daniel Series 1200 Liquid Turbine Flow Meter

FLOW CONDITIONING

For a turbine meter to perform without increased uncertainty and in a repeatable and accurate manner, the flowing stream must be free of rotational components. The internal assembly supports of a turbine meter offer a slight straightening effect but additional flow straightening is normally required.

Generally, upstream flow straightening is achieved by installing adequate upstream straightening sections that often comprise a set of straightening vanes or a tube bundle. Guidance on this subject is offered in the API Manual of Petroleum Measurement Standards, Chapter 5, Section 3. A properly sized strainer (40 mesh) is always recommended in close proximity of the upstream meter tube.

For DN50 (2-inch) or smaller meters, straightening vanes are not normally used. For most installations, 20D of upstream pipe should be provided for adequate flow straightening (see Figure 18).

For line sizes DN50 (2-inch) and larger, upstream flow straightening sections are normally supplied with straightening vanes. With this construction, the upstream straightening section need only be 10D in length.

Upstream and downstream flow straightening sections can be supplied in either carbon steel or stainless steel, as required by the application. The standard design offered is the two-section tube, with a single upstream and single downstream straightening section. The upstream section contains the tube bundle which is securely located within the pipe section (see Figure 19).

Flow straightening sections may in fact be supplied in any configuration with any line connection and to any specified length. In some installations, a three-section flow straightening configuration is required. By using this configuration, ready access to the straightening vanes is afforded (see Figure 20).

In some circumstances, the use of a Flow Conditioning Plate (FCP) is possible. The FCP is available from DN80 to DN200 (3-inch to 8-inch) for the Series 1500 Meter and is standard on the Series 1200 Meter (with the exception of the DN25 or 1-inch meter). When supplied, the FCP is an integral part of the turbine meter and serves to reduce swirl in the same way as flow straightening sections. It is of particular significance where piping installations do not permit long upstream sections, such as in load racks where space is at a premium.

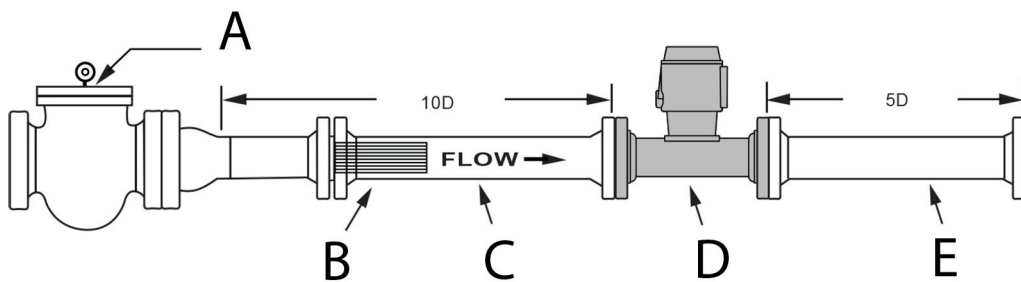**Figure 18: Small diameter meter tube**
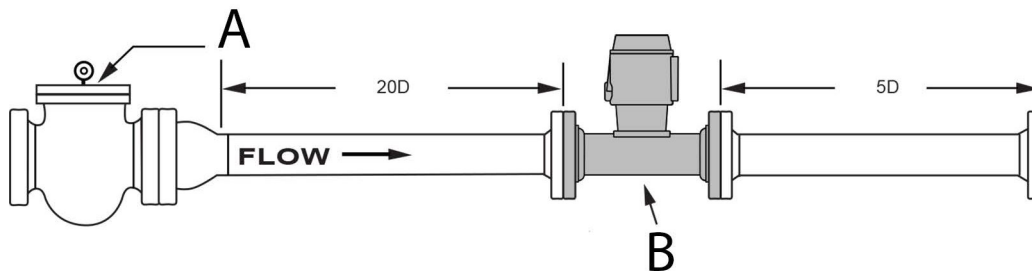
A. Strainer

B. Turbine meter

Figure 19: Two-Section meter tube
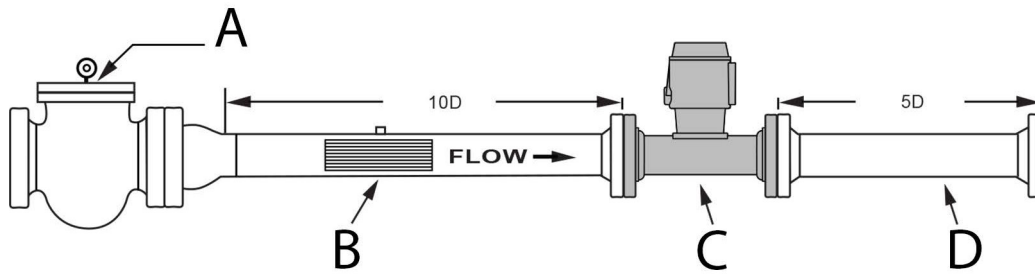
A. Strainer

B. Upstream section with straightening vane

C. Turbine meter

D. Downstream section

Figure 20: Three-Section meter tube

A. Strainer

B. Upstream section

C. Meter tube

D. Turbine meter

E. Downstream section

BACK PRESSURE

It is essential to maintain sufficient back pressure on the turbine meter to prevent flashing and cavitation. This back pressure is particularly important when measuring liquids with high vapor pressures, such as LPGs.

The necessary back pressure required is given by the equation:

BP = (meter ΔP X 2) + (VP X 1.25)

BP = Back pressure required

ΔP = Meter pressure drop at maximum flow

VP = Equilibrium vapor pressure of the liquid at the operating temperature, pounds per square inch absolute.

The pulses per unit volume / flow range curves below illustrate the effects of back pressure. Not only does insufficient back pressure lead to measurement inaccuracy, the resultant flashing and cavitation is extremely damaging to the flow meter and pipework.

Figure 21: Effects of Back Pressure
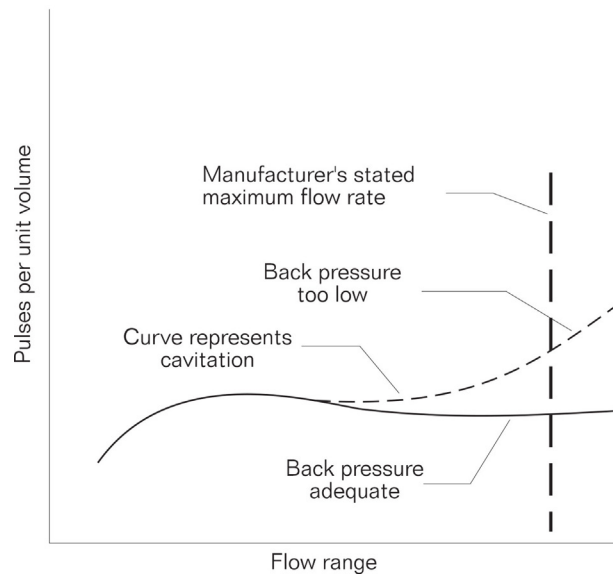
PREAMPLIFIER

The turbine pickoff coil has high impedance and only offers low voltage output. Transmission of flow signals requires low impedance and high voltage, requiring amplification of the pickoff signal.

Series 1200 and 1500 Meters are supplied with the LME and a dual channel preamplifier as standard. The preamplifier shapes and conditions the pickoff output signal, rendering it suitable for transmission over distances of up to 3,000 feet (914 meters) with the appropriate cabling.

The LME allows for either one or two pickoffs. The outputs from the two pickoffs are 90 electrically out of phase which facilitates proper dual-pulse fidelity checking.
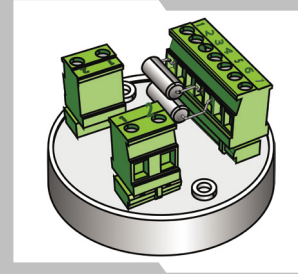
Standard

The Daniel Model 2818 Dual Channel Preamplifier is the standard offering for the Series 1200 and 1500 meters. The signals from two inductive pickoff coils, positioned 90° electrically out of phase, are strengthened and conditioned by a single preamplifier. Fully potted in Polyoxymethylene resin, the Model 2818 has three possible outputs: powered pulse, variable voltage and open collector.

Pickoff Specifications

• Type: 2-wire reluctance

• Resistance: 600-900 Ohms

• Inductance: 250 mH max

• Output: Sinusoidal 40mV p-p minimum @ minimum flow with preamplifier load

• Optional: 2 pickoff coils (singe or dual LME) or 4 pickoff coils (dual LME required)

Table 10: Standard Preamplifier Available	
DESCRIPTION	Dual channel
MODEL	2818
Daniel Part #	1-504-05-550
INPUTS	
# of Inputs (Pickoffs):	1 or 2
Supply Voltage:	10 to 30 VDC
Sensor Type:	Reluctance
Signal:	Sine Wave
Current:	10 to 30 VDC @ 40 mAp-p
Preamplifier Sensitivity:	40 mVpp
Frequency Response:	0 to 5 kHz
OUTPUTS (POWERED PULSE)	
Type:	Square Wave
Frequency Range:	≤ 0 to 5 kHz
Amplitude:	0 to 5 V
Impedance:	1000 Ohm, 20 mA max
CONSTRUCTION	Polyoxymethylene (POM) Housing Solid Epoxy Encapsulation
TEMPERATURE RANGE	-40°F to +185°F (-40°C to +85°C)
CUSTOMER CONNECTION	
Terminal Block 1 (TB1):	(1) +10 to 30 VDC (2) Common (3) Common (4) Channel A Output (5) Channel B Output (6) TTL Out A (7) TTL Out B
PICKOFFS	
Channel A (TB2):	(1) White (2) Red
Channel B (TB3):	(1) White (2) Red

With over 90 Years of experience, Daniel is the only manufacturer that has the knowledge and experience to engineer and offer superior products that are trusted to provide the most reliable and accurate measurements in the global oil and gas industry.

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