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FPP METERS Technical Manual

- How to select correct model size
  - Low Temperature issues
  - High Temperature issues
  - High Viscosity issues
- Registration & Communication options
- Accessories
- Air Elimination
- Installation in piping system
- Model Assembly Nos.
- Hydraulic reference tables



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This manual is intended to provide FPP Meter distributors with the basic information required to select a suitable flow meter for most applications. It addresses selection of:

- The basic flow meter model size
- Suitable registration & communications components
- Suitable/required accessories for the intended service

Tuthill Transfer Systems (TTS) cannot be responsible for model selections made in contradiction of the information & recommendations contained in this manual. If in any doubt about:

- ***Appropriate model selection for specific operating conditions.***
- ***Register or Accessory capability/functionality.***
- ***Communications signal compatibility.***

Please consult with Customer Care or your Regional Manager.

The information in this manual is provided in a chapter format. Each chapter is available as a separate document, for use as supporting documentation for quotations, or to educate end users, legislators and others who might be interested in this information. This manual will be updated from time to time; we recommend that you check the web site for new editions from time to time.

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FPP METERS

Flow Meter definitions

- **Types of Measurement**
- **Turndown Ratio**
- **Linearity vs Repeatability**
- **FPP Terminology**



Definitions, 2006-1

Types of Measurement

There are 3 basic approaches to measurement:

- Volume Allows calculation of velocity & mass.
- Velocity Allows calculation of volume & mass.
- Mass Allows calculation of volume & velocity.

There are flow meter principles based on all three values. Each type has strengths and weaknesses, so no single metering principle can be proclaimed universally better than all others. When comparing different flow meters against each other, consider:

- ◊ Liquid characteristics vs. operating principle
- ◊ Operating conditions (flow rate & viscosity)
- ◊ Model 'Accuracy' (see below)
- ◊ System design
- ◊ Operational practices
- ◊ Space & weight constraints
- ◊ Local codes & approvals
- ◊ Purchase & Installation costs
- ◊ Long term operating costs, covering:
  - ∗ Service costs (ease, frequency & parts consumption)
  - ∗ Low Delta P value (= lower lifetime energy costs)

Turn-Down, or Turn-Down Ratio

This term identifies the ***operating range*** of a flow meter. This value is calculated by dividing maximum capacity with minimum flow rate. Thus, if **manufacturer model rating** is:

Minimum	Maximum		
6 GPM	40 GPM	=	7:1 Turn-Down
76 LPM	380 LPM	=	5:1 Turn-Down
20 GPM	200 GPM	=	10:1 Turn-Down

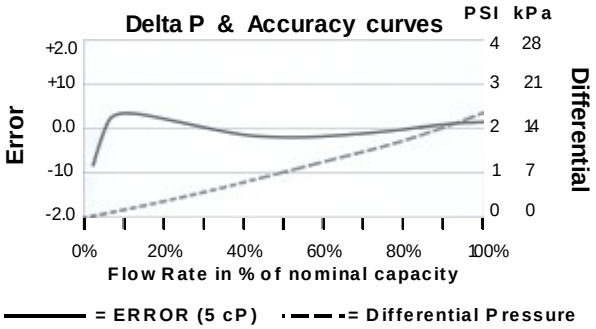
In general, the broader the turn-down ratio, the poorer flow meter 'accuracy' will be, since flow meter error is always greater at the low end of the operating range.

Flow Meter 'Accuracy'

This is a misnomer in more ways than one. First of all, the value discussed is actually **flow meter error**. Secondly, there are two distinctly different values, each of which can be clearly defined:

- **Flow Meter LINEARITY**
  Evaluating a flow meter over the **nominal operating range** (= ***flow rate varies, all other values remain constant***), we are talking about **linearity**.

For example:



From the curve shown above we can extract error values:

At	5%	-0.35%	5:1 Turn-Down (20-100%) covers
At	10%	+0.30%	+0.15%/-0.10% = ±0.125% linearity
At	20%	+0.15%	
At	40%	-0.10%	**or**
At	60%	-0.08%	
At	80%	-0.03%	10:1 Turn-Down (10-100%) covers
At	100%	+0.05%	+0.30%/-0.10% = ±0.20% linearity

Alternatively, if we wish to consider service from 5-100% = 20:1 Turn-Down Ratio, we find +0.30%/-0.35% = ±0.325%

- **Flow Meter REPEATABILITY**
  When multiple tests are performed under identical test conditions, we can establish **flow meter repeatability**. This is an expression of maximum deviation (error), and is usually a much smaller value. This type of testing requires:

  - Same liquid
  - Identical flow rate, pressure, temperature & viscosity
  - Same system, controls & identical test volume

  6 tests showing results ranging from +0.05% to -0.02% against the prover tank = ±0.035% **flow meter repeatability**. Thus, if someone proclaims +/-0.05% 'accuracy', you can be certain that they are talking about flow meter repeatability.

FPP Meter Terminology

In this manual, and in other documents, we use two terms:

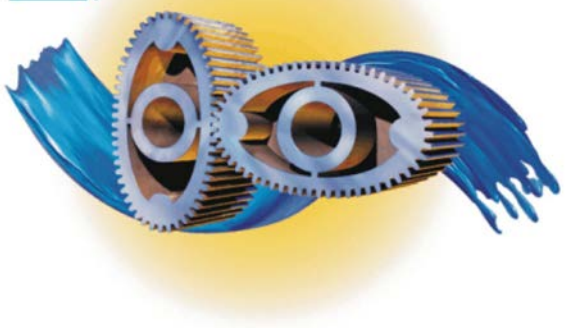
Flow Meter = Assembly including a display (register).

Flow Sensor = Assembly without display (might include a signal conditioner).

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FPP METERS

PD Meters



- **Definition**
- **Advantages**
- **Oval Gear principle**
- **Nutating Disc principle**
- **Spur Gear principle**

Positive Displacement Meters

A Positive Displacement flow meter is a volumetric device (measures volume, not velocity or mass). The measuring chamber has a mechanical movement, which isolates flow meter inlet from the outlet. When liquid is pushed through the measuring chamber, it causes the rotors to move. It is this movement, which forms the basis for the measurement.

While no flow meter is ideal for all operating conditions, positive displacement (PD) meters have very broad application coverage, and offer many advantages over most other metering principles. Some are obvious, such as:

- No straight pipe requirements on flow meter inlet/outlet.
- Mechanical register = inherently explosion proof.
- Certified for Custody Transfer Service (W&M approved).
- Lower initial cost (than a mass flow meter).

Other advantages are less obvious, but nevertheless also important. For example, a PD meter selected correctly has very low Delta P (pressure loss) values compared with a mass flow meter. This leads to:

A. It takes less pump HP to push the liquid through a PD meter. It might be possible to use a centrifugal pump, where a system with a mass flow meter requires a PD pump with larger motor. In other words, ***lower initial system cost.***

B. With lower HP requirements to move the liquid through the system, long term ***operating costs*** will be substantially less. Over the life of the system, energy cost savings will be on a scale of thousands, if not tens of thousands of dollars.

Currently Tuthill Transfer Systems (TTS) manufactures PD flow meters based on three different operating principles:

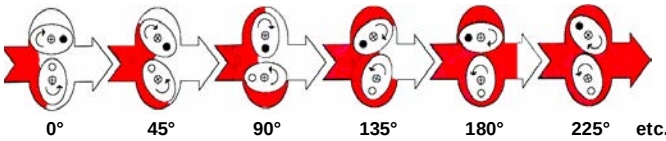
Oval gear operating principle.



The oval measuring chamber contains two oval gears. Each gear is centered on a horizontal post (shaft). The two gears have interlocking teeth, so the gears maintain the correct relative position to each other without the use of external timing gears.

As the gears turn, liquid volume being metered forms between the gear and the side of the measuring chamber, alternately in the lower and the upper half of the measuring chamber. Photo shows the upper half of the measuring chamber defined.

In a complete cycle (360° turn of rotors), 4 identical liquid volumes are transferred from the inlet side to the outlet side:



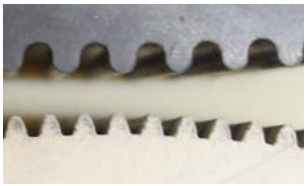
At 0-45° the lower half of the chamber fills, at 90° it is fully defined, and at 135° it releases to the outlet side. Etc.

The origin of the oval gear metering principles dates back to the 1930s. In the original design, the tooth profile has sharp edges, and tooth shape varies depending upon tooth location along the circumference of the oval gear.

In 2003 TTS was awarded a patent on a revolutionary new oval gear design, which we have named the **Waveform** gear. This design has a smooth tooth profile, and the teeth have the same shape along the entire circumference of the oval gear. This eliminates backlash, and reduces flow meter error.

Waveform tooth profile:

Old style tooth profile:



The Waveform gear design has been introduced in most model sizes as of 2006.

TS Series, 1", 1½", 2" & 3"

All models are NTEP certified for Custody Transfer service in the US (formerly known as NIST Certification). 1½", 2" & 3" models are certified in Canada, while 2" & 3" models are approved in the EEC/Australia under OIML R117.

Custody Transfer certifications are liquid specific, and may vary in terms of maximum flow rate approved. Lack of approval for a liquid caterogy does not mean that the flow meter cannot be used, it simpy has to undergo On Location approval under the supervision of the local authorities.

TS Series meters are based on a highly modular design, with many parts shared between multiple models. These meters are bi-directional, and can be serviced either from the front or from the rear, though service from the front is most practical.

Standard models are available in 3 versions:

- Mechanical flow meter with mechanical register (**V** assy.)
- Electronic flow sensor without register (**W** assy.)
- Electronic flow meter with electronic register (**F** assy.)

INDUSTRIAL DYNAMICS CO 800-940-0453

The electronic version of TS Series meters has an integral pulser, resulting in a true gland-less flow meter (with only static O-ring seals). Most seals in accessories are static O-ring type also, but a few are of other types.

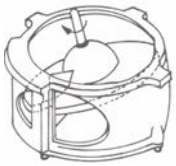
TM Series, ¼", ⅜", ½" & ¾"



These smaller oval gear meters are rated for ±0.5% linearity (±0.25% with electronic enhancement) as a group. The two larger models perform significantly better than this, and will usually achieve +/-0.25% linearity without electronic enhancement.

TM Series flow sensors are available with electronic signal conditioner and/or register, but not with mechanical register. Typical applications are additive injection, fuel consumption monitors and other low flow systems.

Nutating Disc Meters



This metering principle is based on a plate with a slot (straddling the membrane separating inlet from outlet), mounted on a center ball with a vertical drive shaft. The liquid alternately passes over and under the plate, causing the plate to 'wobble' around the center. The drive shaft moves in a circle, turning a coupling mounted on top of the measuring chamber.

TN Series, 1" & 1½"



This series of nutating disc meters date back to the founding of Fluid Power Products and beyond. This is a moderately priced flow meter with intermediate linearity & repeatability; it comes standard with 4 digit mechanical register.

TN Series meters are available with pressure rating to 1000 PSI (69 BAR), and can be calibrated for liquids with viscosity to 2500 cSt (12,000 SSU). This Series serves to span the gap between Fill-Rite meters (low pressure & low viscosity only), and flow meters with better linearity, higher capacity & pressure rating.

These meters perform well in service where the liquid viscosity remains constant, or where the viscosity is consistently above 125 cSt (600 SSU). In service where liquid viscosity fluctuates in 15-125 cSt (70-600 SSU) range, an oval gear type flow meter will perform better.

It is difficult to compare PD meters with different operating principles. We have interviewed a number of people, who have worked with PD meters of all types, and assembled their opinions in the following table:

	Metering Principle						
	Bi-Rotor	**Nutating Disc**	**Oscillating Piston**	**Oval Gear**	**Rotary Abutment** (block & dsplmt rotors)	**Sliding Vane**	**Spur Gear**
Cust. Trsfr accuracy	YES	NO	YES	YES	YES	YES	NO
Linearity (% error)	±0.2%	±1-2%	±0.2%	±0.2%	±0.2%	±0.2%	±0.5%
Recalibr. frequency	LOW	HIGH	MED.	LOW	LOW	LOW	MED.
Delta P at 100% cap.	MED.	VERY HIGH	HIGH	LOW	MED.	VERY LOW	EXTR. HIGH
Sensitive to visc.	LOW	HIGH	LOW	LOW	LOW	LOW	HIGH
Simple to calibrate	YES	YES	NO	YES	YES	YES	
Number of parts	LOW	LOW	LOW	LOW	HIGH	HIGH	LOW
Easy to service	YES	YES	NO	YES	NO	NO	YES
Product cost	HIGH	VERY LOW	LOW	LOW	MED.	HIGH	LOW

In this table, for **Linearity** we have shown ±0.2% for all metering principles, which have US NTEP certification for use in Custody Transfer service. It takes ±0.175% or better with 5:1 Turn-Down to achieve this certification. Some manufacturers claim better Linearity performance.

FPP Part Nos.

- **Flow Meter Model**
- **Registration/Controller**
- **Communication**
- **Accessories**

Every flow meter assembly consists of at least 2, and in many cases up to 5-6 components from the 4 product groups defined here:

1. Basic Flow Meter (measuring element)
- Model size matched to operating conditions.
- Case material matched to liquid requirements.
- Internals may vary with:
  - Liquid characteristics.
  - Actual operating conditions.

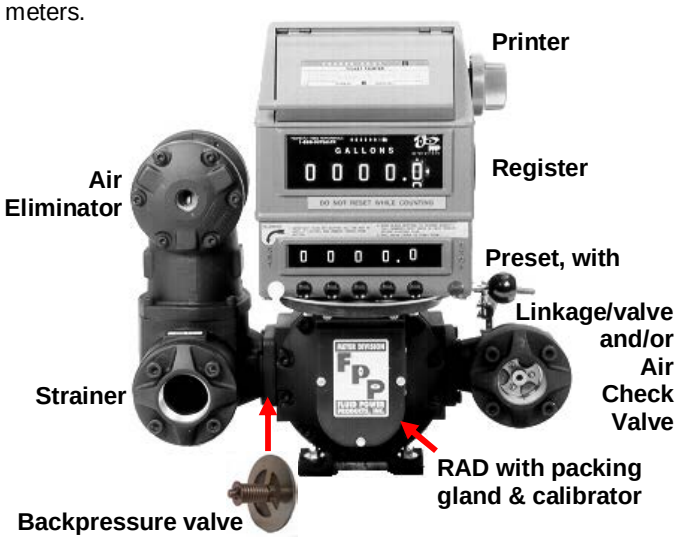
2. Accessories
Common accessories required for normal operation are:
- Strainer to protect flow meter against foreign particles.
  - Optional thermowell for temperature probe.
- Air eliminator to prevent measuring air as liquid.
  - Optional backpressure valve or air check valve.
- Control valve for:
  - Preset/batching service (mechanical or solenoid).
  - System security (on/off).
  - Rate of Flow control in systems, where one pump supplies multiple flow meters, to protect individual flow meters against full pump capacity.

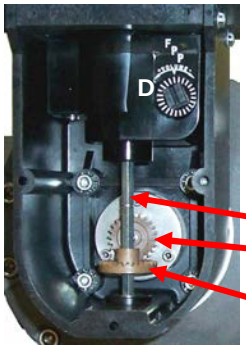
3. Register or Controller, mechanical or electronic
Depending upon user operational requirements, these can include:
- Register (simple volume display)
- 2-stage Preset Counter/Batch Controller
- Printer
- Rate Display (volume/time), electronic only

In Custody Transfer service (retail sale of liquids), local W&M regulations may dictate what components should be included in the flow meter assembly.

4. Communications
Many flow meters operate as a stand-alone piece of equipment. However, communications with other equipment, such as card readers, key-locks, printers or a local PC are rapidly becoming more common. In industrial installations PLCs and other instrumentation may be part of the system. See page 7.3 for signal types available.

For correct flow meter supply, it is necessary to define all the variables in each group. For flow meters with **mechanical register**, we can usually define all the variables in a single Part No., which can be as short as 10 positions if flow meter internals are standard. If non-standard rotors, seals or a pulser are selected, the P/No. is extended accordingly. See page 3.3 for break-down of **TS Series** P/No. structure for mechanical flow meters.





The mechanical version of the flow meter has a packing gland with a pinion (A), drive shaft (B) with face gear (C) & mechanical calibrator (D), all enclosed within the sealable RAD (Right Angle Drive adaptor) mounted on flow meter front cover.

B

A 12 or 24 tooth, depending upon model and unit of calibration

C always 24 tooth

Some secondary details cannot be defined in the Part No., but must specified in the text in the purchase order:

- Direction of flow (if different from Left-to-Right).
- Strainer inlet position (if not from the front).
- Valve outlet position (if not towards the front).
- If Ticket Printer should be accumulative type.

For flow meters with **electronic register** there are more variables, not only in terms of **register model** (TS Series meters are designed to work with all the major electronic registers), but also:

- Electrical specifications (AC or DC & voltage)
- Electrical classification (water proof, Intrinsically Safe or Explosion Proof).
- Optional solenoid valve, electronic printer and possible wireless communications.

2003-2009 Production with Disc Magnet/Pulser

Production through 2009 has the electronic register mounted on the RAD. In this version, the rotors drive a magnet wheel with 4, 6 or 12 poles, and a sensor (pulser) is used in place of the mechanical packing gland. With this design we have to define the individual components for electronic flow meter/ register assemblies, as per the list below (with items in **red** being the minimum required):

- **Electronic flow meter with pulser/basic accessories.**
- Signal conditioner, if required
- **Flange kit**
- **Electronic register**, which can be several items if it is the EMR³ register system:
  - Register
  - IB box
  - Cable kit
  - Opt. keypad kit
  - Opt. temperature probe
  - Protection kits for solenoid application
  - Opt. system security valve (LPG service)
  - Opt. wireless communications
- Opt. solenoid valve
- Opt. electronic printer



TS20A**E93** (LPG service) with **EMR³** register

Since the summer of 2007, the new Wave Form pulser has been available, which:

- Provides significantly **higher pulse resolution** (see page 7.3)
- **Minimizes the number of internal parts.**
- Allows service of flow meter **without removal of register**.
- **It is also significantly smaller,** which is best illustrated with two profile photos:



TS20AE06
2000-2007 production



TS20AF66A
available summer/fall 2007

With introduction of the Wave Form pulser, and Veeder-Root 2010 revisions to the EMR³ register, flow meter & register can be ordered under a single Part Number, where only non-attached components (some cables) are specified separately.

When the flow meter has standard internals & accessories, the Part No. can be as short as:

- ELNC register 11 positions
- EMR³ register 13 positions

If the flow meter has non-standard options, such as a 100 mesh strainer basket or a thermo well for temperature compensation, or is supplied with a Tuthill solenoid valve, the P/No. can extend out to 17 positions.

TS20A**F63**AA2UE +
EL846000-???? cable kit

2" flow meter
with strainer,
air eliminator,
electronic preset valve &
temperature compensated
EMR³ register



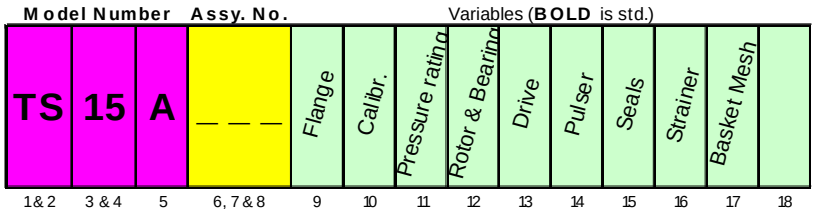
Charts on the next 3 pages define the basic Part No. structure for FPP Meter products for **TS** & **TS** Series meters, as it applies to 2010 production.

For **TS Series** the **Assembly No.** (pos. 6-8) defines the basic accessories included; see page 3.4 for mechanical meters, and pages 3.5 & 3.6 for electronic meters.

Every combination of these variables is not available, as some simply do not work together. Please refer to price lists for full details on the variables allowed, or consult with Customer Care or your Area Manager.

TS = Oval Gear, 1" & up

V●● Assy. No. = Mechanical, usually complete with Register.



Assembly No. See page 3.4

Material

A = Anodized aluminum, Viton std., Teflon opt.
C = 316 Stainless Steel, Teflon seals standard

Size/Nominal Capacity			GPM	GPH	lpm	m³/h	Calibr.
10 =	1"	25 mm	40	2,400	150	9	1-2, opt. 6
15 =	1½"	40 mm	60	3,600	230	14	1-5, opt. 6
20 =	2"	50 mm	150	9,000	570	35	1-5, opt. 3-6
30 =	3"	80 mm	200	12,000	760	46	4-5, opt. 3-7

Pos. 9 **Flange Type**

Companion Flanges	
A =	**NPT**
B =	BSP
C =	150# ANSI adaptors
F =	Aluminum slip-weld
H =	Steel slip-weld
S =	Stainless slip-weld

Pos. 10 **Register Calibration**

Mechanical Register			
T =	1/10	US gallons	(1)
U =	1/10	IMP gallons	(6)
G =	1/1	US gallons	(4)
I =	1/1	IMP gallons	(7)
Y =	1/10	liter	(2)
L =	1/1	liter	(5)
D =	1/1	dekaliter	(3)

Pos. 11 **Pressure Rating** **C =** 150 PSI 10 BAR

Pos. 12 **Rotor type & Bearing Material**

CODE	TYPE	Mat'l	Bearing
B =	**LV**	**PPS**	**Carbon**
L =	HT	PPS	Carbon
I =	HV	PPS	Carbon
C =	LV	PPS	Teflon
M =	HT	PPS	Teflon
J =	HV	PPS	Teflon

Pos. 13 **Drive** **M =** Mechanical

Pos. 14 **Pulser**
X = none
D = 10:1 dry reed
S = 100:1 solid state

Pos. 15 **Seals**
A = Viton™ (std. in Anod. Alum. models)
B = Teflon™ (std. in SS, opt. in AA)

Pos. 16 **Strainer type**
S = Tuthill 90° strainer
H = Tuthill High Capacity strainer
A = ANSI flanged strainer (SS only)

Pos. 17 **Basket Mesh**
4 = 40 mesh basket (**std with LV & HT rotors**)
2 = 20 mesh basket (**std with HV rotors**)
8 = optional 80 mesh basket (TS30A only)
0 = optional 100 mesh basket (TS15A & TS20A)

Pos. 18 **not in use**

Assy Nos. / Mechanical Meters

	WITHOUT preset valve/linkage	 METER	 + STRAINER	 + AIR ELIMINATOR	+ BACKPRESSURE VALVE — OR — + AIR CHECK VALVE	Issued August, 2009
CAL	With calibrator & RAD adaptor for register, but no ratio gear plate or register (distributor to add)	V03	V21	V22	V27 BPV V23 ACV	*Without register*
VR1	With Calibrator, RAD Adaptor, Ratio Gear Plate & Register	V04	V05	V06	V28 BPV V25 ACV	7887
VR2	Same + Zero Start Ticket Printer,	V07	V08	V09	V29 BPV V26 ACV	7887 & 7888
VR3	Same + Preset Counter/Micro Switch assy	V35	V36	V37	V31 BPV V38 ACV	7887, 7889 & 7856
VR4	Same + Zero Start Ticket Printer, Preset Counter/Micro Switch assy	V39	V40	V41	V32 BPV V42 ACV	7887, 7888, 7889 & 7856

with mechanical preset valve/linkage

if LV rotors, LV valve (1-50 cSt)
if HT rotors, LV valve (1-50 cSt)
if HV rotors, LV valve (50-300 cSt)

If liquid viscosity is in 50-300 cSt range, either the distributor or the installer must remove set screw from valve piston prior to start-up.

VR3	With Calibrator, RAD adaptor, Ratio Gear Plate, 2-stg Preset Counter & Register	V11	V12	V13	V43 BPV V30 ACV	7887 & 7889
	Same **+** **Micro Switch kit on preset counter**	V51	V52	V53	V44 BPV V54 ACV	7887, 7889 & 7856
VR4	With Calibrator, RAD adaptor, Ratio Gear Plate, 2-stg Preset Counter, Register & Zero Start Ticket Printer	V15	V16	V17	V45 BPV V34 ACV	7887, 7888 & 7889
	Same **+** **Micro Switch kit on preset counter**	V55	V56	V57	V46 BPV V58 ACV	7887, 7888, 7889 & 7856

TS Oval Gear, 1" & up, with register flange

Model Number			Assy. No.			Variables (**BOLD** is std.)											
TS	15	A	F	—	—	Flange	Rotors & Seals	Components	UL/cUL or ATEX	Language	Misc. options	Basket Mesh	1 or 2 stg valve	Valve rtg/voltage			
Same codes as mechanical																	
1&2	3&4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		

Position in Part No.

Pos. 7 Register

1 =	No register
6 =	EMR³, -404
7 =	SCL + ELNC

Pos. 8 Accessories

without sol valve	with sol valve	
4 =	**1 =**	Flow meter only
5 =	**2 =**	+ Strainer
6 =	**3 =**	+ Strainer & Air Elim.
7 =	**9 =**	+ Strainer, A/E & BPV
8 =	**0 =**	+ Strainer, A/E & ACV

Pos. 9 Flange Type

Companion Flanges

A =	**NPT**
B =	BSP
C =	150# ANSI adaptors
F =	Aluminum slip-weld
H =	Steel slip-weld
S =	Stainless slip-weld

Pos. 10 Rotors & Seals

CODE	TYPE	Bearing	Seals
A =	**LV**	Carbon	Viton
T =	**HT**	Carbon	Viton
V =	**HV**	Carbon	Viton
B =	**LV**	Carbon	Teflon
C =	**HT**	Carbon	Teflon
D =	**HV**	Carbon	Teflon
F =	**LV**	Teflon*	Viton
R =	**HT**	Teflon*	Viton
S =	**HV**	Teflon*	Viton
E =	**LV**	Teflon*	Teflon
P =	**HT**	Teflon*	Teflon
H =	**HV**	Teflon*	Teflon

** = subject to Tuthill approval.*

Pos. 11 Components

EMR³ register

4 =	EMR³, IB & roll printer
3 =	EMR³, IB & slip printer
2 =	EMR³ & IB
1 =	EMR³
T =	TBB (term block boar
G =	100 PPG SCL
L =	100 PPL SCL
A =	TBB/Amplifier
F =	TBB/Filter

ELNC register

1 =	DC, base
2 =	DC, BL/pulse
3 =	AC, base
4 =	AC, BL/pulse
5 =	IS, with ELPS
6 =	IS, ELPS & BL/puls
7 =	IS without ELPS

Pos. 12 Certification & Cable

U =	UL, with 100' cable
P =	UL, Temp Prb & 6' printer cb
A =	ATEX, with 100' cable
T =	ATEX, Temp Prb & 6' printer
X =	not applicable

Pos. 13 Language on EMR³ register front panel

E =	English
S =	Spanish
F =	French
Q =	Quebec
X =	not applicable

Pos. 14 Misc. options

Variables

S =	Tuthill 90° strainer
T =	+ Thermo Well
H =	Tuthill High Capacity strainer
W =	+ Thermo Well
A =	ANSI strainer (SS only)
3 =	LPG 3-way Solenoid valve
X =	not applicable

Pos. 15 Basket Mesh

4 =	40 mesh basket (**std with LV & HT rotors**)
2 =	20 mesh basket (**std with HV rotors**)
8 =	optional 80 mesh basket (TS30A only)
0 =	optional 100 mesh basket (TS15A & TS20A)

Pos. 16 & 17

Pos. 16 = Valve type

1 =	1-stage shut-off
2 =	2-stage shut-off

Pos. 17: Voltage & Rating

1 =	12VDC, water proof	**6 =**	12VDC, explosion proof
2 =	24 VDC, water proof	**7 =**	24VDC, explosion proof
3 =	110VAC, water proof	**8 =**	110VAC, explosion proof
4 =	220VAC, water proof	**9 =**	220VAC, explosion proof

Pos. 18 not in use

INDUSTRIAL DYNAMICS CO 800-940-0453

TS Oval Gear, 1" & up, without register flange

Model Number			Assy. No.			Variables (**BOLD** is std.)									
TS	15	A	W	_	_	Flange	Rotors & Seals	Components	UL/cUL or ATEX	Language	Misc. options	Basket Mesh	1 or 2 stg valve	Valve rtg/voltage	
Same codes as mechanical															
1&2	3 & 4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Position in Part No.

Pos. 7 — **Non-W&M register**

0 =	**Flow Sensor**
1 =	**1 x PIA-300**
2 =	**2 x PIA-300**
3 =	**PC58**
4 =	**PC58 + PIA-300**
5 =	**PC58/4-20**
6 =	**PC58/4-20/10 pt/Calibr**
7 =	**PC58/4-20/PIA-300**

Accessories

without sol valve	with sol valve	
4 =	**1 =**	Flow meter only
5 =	**2 =**	+ Strainer
6 =	**3 =**	+ Strainer & Air Elim.
7 =	**9 =**	+ Strainer, A/E & BPV
8 =	**0 =**	+ Strainer, A/E & ACV

Companion Flanges

A =	**NPT**
B =	BSP
C =	150# ANSI adaptors
F =	Aluminum slip-weld
H =	Steel slip-weld
S =	Stainless slip-weld

Pos. 8

Pos. 9 — **Flange Type**

Pos. 10 — **Rotors & Seals**

CODE	TYPE	Bearing	Seals
A =	**LV**	Carbon	Viton
T =	**HT**	Carbon	Viton
V =	**HV**	Carbon	Viton
B =	**LV**	Carbon	Teflon
C =	**HT**	Carbon	Teflon
D =	**HV**	Carbon	Teflon
F =	**LV**	Teflon*	Viton
R =	**HT**	Teflon*	Viton
S =	**HV**	Teflon*	Viton
E =	**LV**	Teflon*	Teflon
P =	**HT**	Teflon*	Teflon
H =	**HV**	Teflon*	Teflon

** = subject to Tuthill approval.*

Pos. 11 — **Signal Conditioner**

Internal Signal Cond.

T =	Terminal Block Board
G =	100 PPG SCL
L =	100 PPL SCL
A =	TBB/Amplifier
F =	TBB/Filter

Pos. 12 — **Certifications**

UL, ATEX, etc.

U =	UL/cUL listed
A =	ATEX listed
X =	not applicable

Pos. 13 — **Register enclosure rating**

Enclosure

X =	not applicable
4 =	NEMA 4X
7 =	NEMA 7/4X

Pos. 14 — **Misc. options**

Variables

S =	Tuthill 90° strainer
T =	+ Thermo Well
H =	Tuthill High Capacity strainer
W =	+ Thermo Well
A =	ANSI strainer (SS only)
3 =	LPG 3-way Solenoid valve
X =	not applicable

Pos. 15 — **Basket Mesh**

4 =	40 mesh basket (**std with LV & HT rotors**
2 =	20 mesh basket (**std with HV rotors**)
8 =	optional 80 mesh basket (TS30A only)
0 =	optional 100 mesh basket (TS15A & TS20A)

Pos. 16 & 17

Pos. 16 = Valve type

1 =	1-stage shut-off
2 =	2-stage shut-off

Pos. 17: Voltage & Rating

1 =	12VDC, water proof	**6 =**	12VDC, explosion proof
2 =	24 VDC, water proof	**7 =**	24VDC, explosion proof
3 =	110VAC, water proof	**8 =**	110VAC, explosion proof
4 =	220VAC, water proof	**9 =**	220VAC, explosion proof

Pos. 18 — **not in use**

INDUSTRIAL DYNAMICS CO 800-940-0453

Tuthill

FPP METERS

Model Number			Assy. No.	Variables (**BOLD** is std.)								Defined where applicable			
TM	03	A	_ _ _	A	X	F	A	2	H	A	A	A	A		
1&2	3&4	5	6, 7&8	9	10	11	12	13	14	15	16	17	18		

TM Series = Oval gear < 1"

Position in Part No.

Y-type Strainer
S4 = SS strainer, 40 mesh
S0 = SS strainer, 100 mesh

Seals **A =** Viton™ (std. in Anod. Alum. models)
B = Teflon™ (std. in Stainless Steel models, optional in AA models)

Pulser **H = Hall Effect pulser in case**
B = Reed Switch pulser in case (for battery powered registers).
Q = simulated Quadrature Hall Effect pulse signal **via SCL**

Rotor output **4 = Standard pulse resolution in SHE, 4 magnets in gears**
1 = Low pulse resoltuion (**std. in SRS**), 1 magnet in gears

Rotor (oval gear & bearing material) selection

Mdl	CODE	TYPE	Mat'l	Bearing
02	E =	Std./H.T.	SS	Teflon
03	A =	Standard	PPS	none
	K =	HT/MV	PPS	none
	E =	Std./H.T.	SS	Teflon
04	A =	Standard	PPS	none
	K =	HT/MV	PPS	none
06	A =	Standard	PPS	none
	K =	HT/MV	PPS	none

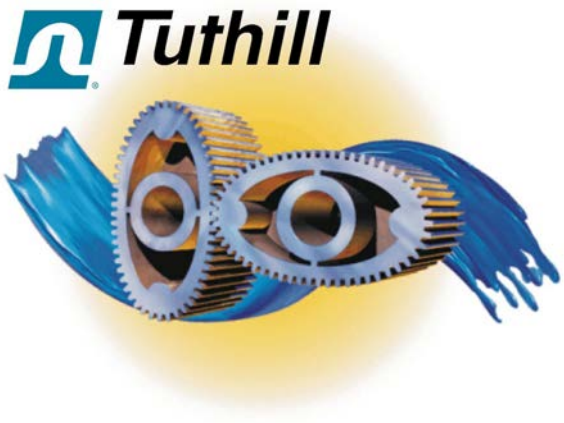
Pressure Rating **K = 1500 PSI 103 BAR**
L = 2500 PSI 172 BAR

Connection Type **A = NPT ports**
B = BSP ports

Assembly No.
SHE = Flow sensor with Hall Effect pulser
SHE = Flow sensor with Reed Switch pulser
SHQ = Flow sensow with simulated quadrature pulse signal (via SCL)
SC = **SCL** 100 PPG scaler, 5V and 6-12V DC & **HE**
T0 = **PIA-300** for use with **HE**
C0 = **CC56** battery powered & **RS**
C1 = **CC56 + PIA-300** (non-scaled signal) & **HE**
PD = **PC58** for external DC power & **HE**
PP = **PC58 + PIA-300** (***see manual!***) & **HE**
PK = **PC58** with **4-20 mA** & **HE**
PM = **PC58** with **4-20 mA + 4 point calibration** & **HE**
PL = **PC58** with **4-20 mA + PIA-300** (***see manual!***) & **HE**
C = NEMA 4X encl., installed
D = NEMA 4X encl., remote
E = NEMA 7/4X encl., installed
F = NEMA 7/4X encl., remote

Case Material **A =** Anodized aluminum
D = 316 Stainless Steel

Model Size & Nominal Capacity			GPM	GPH	lpm	lph
02	1/4"	6 mm	0.3	18	1.1	68
03	3/8"	10 mm	3	180	11.4	680
04	1/2"	13 mm	10	600	38	2250
06	3/4"	20 mm	20	1200	76	4500



Material Selection & FPP Meter Models

- **Material Recommendations**
- **FPP Model range**

Materials & Models, 2006-1

Oval gear meters were traditionally manufactured in all stainless steel. While this provides good chemical resistance, it also results in an expensive product, which is heavy and offers only moderate linearity.

FPP Meters is breaking with traditions

The **big news** is an innovative modular design. In both TM Series (< 1") & TS Series (1" & up), this design allows us to use identical parts, components and accessories in up to 4 different meter models.

The **better news** is much broader application coverage, with competitive prices for all industries. We have achieved this through:

- Modern engineering of design and manufacturing methods, which allow us to produce flow meters with a minimal material inventory. For example, excepting only case, gears & shafts, the rest of the parts in 2" & 3" models are identical.
- The critical components of any flow meter are in the measuring chamber. By carefully selecting space age materials for the oval gears, we have not only improved on meter performance, but also removed a significant cost factor.

The **latest news** is a breakthrough in oval gear design. In August 2003 a patent was awarded on our new tooth profile (wave form replacing traditional sharp edged teeth). Wave form oval gears eliminate backlash, resulting in a more accurate flow meter with broader operating range.

Case Material

The chemical industry traditionally asks for stainless steel, while petroleum and aviation industries prefer lightweight and corrosion resistant aluminum. This latter material is actually more than adequate for many non-corrosive chemicals, including virtually all solvents, alcohols & glycols. Aluminum should be considered any time liquid pH values are within the acceptable range for this material.

To satisfy all industries, we manufacture oval gear meters in both materials:

Anodized Aluminum, for 5.5-8.0 pH

356 Aluminum (used in castings)

Silicon	6.5-7.5%
Iron	0.5%
Copper	0.2%
Manganese	0.1%
Magnesium	0.20-0.40%
Zinc	0.2%
Titanium	0.2%
Aluminum	remainder

6061 Aluminum (used in extrusion, TS20A & TS30A)

Silicon	0.6%
Copper	0.25%
Magnesium	1.0%
Chromium	0.2%
Aluminum	remainder

6262 Aluminum (used in extrusion, TS10A & TS15A)

Silicon	0.7%
Copper	0.25%
Magnesium	1.0%
Chromium	0.09%
Lead	0.5%
Bismuth	0.5%
Aluminum	remainder

Stainless Steel, for 1-14 pH

304 Stainless Steel (used in TM06C & TS10C)

Carbon	0.08%
Manganese	2.0%
Silicon	1.0%
Chromium	18.0-20.0%
Nickel	8.0-11.0%
Iron	remainder

316 Stainless Steel (used in posts & TM02D to TM06D)

Carbon	0.10% max.
Manganese	2.0% max.
Silicon	1.0% max.
Chromium	16.0-18.0%
Nickel	10.0-14.0%
Molybdenum	2.0-3.0%
Iron	remainder

CF8M Stainless Steel (TS10D & TS15C to TS30C)

Carbon	0.08%
Manganese	1.50%
Phosphorous	0.04%
Sulfur	0.04%
Silicon	1.50%
Chromium	18.0-21.0%
Nickel	9.0-12.0%
Molybdenum	2.0-3.0%
Iron	remainder

Oval Gear Material

In FPP Meters we use PPS (polyphenylene sulfide resin, glass filled), also known as Ryton, as rotor material in most models. Only in the ¼" (std.) & ⅜" (opt.) models do we use SS rotors.

FPP has used PPS as a manufacturing material for more than 20 years, and so have many others. According to Phillips Chemical Company (supplier of PPS), this material is used for engine components by Chrysler, Ford & BMW amongst many others.

The two rotors (oval gears) have traditionally been made in stainless steel by other oval gear meter manufacturers, since this material is universally accepted by the chemical process industry. However, the mechanical properties of stainless steel make it a less than satisfactory material for use in rotating equipment, such as pumps and flow meters.

- **Mechanical Properties**
  Moving parts in stainless steel are subject to galling (the moving parts tear chunks of material out of each other). To avoid galling, most manufacturers increase the internal clearances. In flow meters, this leads directly to a **less accurate flow meter!**
- **Accuracy**
  It is due to the increased clearances, that our competitors rate their stainless steel meters with 0.35% or 0.5% accuracy over operating range. In comparison, FPP TS Series with non-metallic rotors have US, Canadian, Australian & EEC approval for Custody Transfer service. To obtain US NTEP listing, the meter must satisfy:
  ±0.175% over 5:1 turn-down
- **Pumping Cost**
  PPS rotors are lighter than SS, requiring **less energy** to start their motion. Weight is also a critical factor for flow meters installed on tank trucks and in portable metering systems. PPS rotors significantly reduce the overall flow meter weight.
- **Repair Cost**
  SS is an expensive raw material. With longer machining time and a higher percentage of scrap, SS rotors would cost 6-10 times more than FPP Meters standard non-metallic rotors.

For those not familiar with this engineered plastic, PPS:

- can be molded with 0.0010" (0.025 mm) precision.
- has no known solvent under 240°C (464°F).
- was found to be compatible with 90% of the liquids in a chemical listing with 200+ entries. For SS the number was 68%.
- has excellent temperature characteristics, being rated for use to 240°C (464°F) in continuous duty service.
- is lightweight, weighing less than 10% of an equivalent rotor manufactured in SS.
- has lower manufacturing cost compared with metallic rotors in aluminum, steel or stainless steel.

FPP Meter Product Range

Current production consists of following models:

TS Series for Custody Transfer service,
available as a flow sensor, or as a flow meter with either mechanical or electronic register. Manufactured in both Anodized Aluminum (TSxx**A**) & Stainless Steel (TSxx**C**).

	Nominal Model Capacity	
TS10	40 GPM	150 lpm
TS15	60 GPM	230 lpm
TS20	150 GPM	570 lpm
TS30	200 GPM	760 lpm***

*** Certified to 200 GPM (760 lpm), but electronic version may be used to 250-300 GPM, subject to TTS approval of the application.

In both case materials rotor options are:

	Visc < 300 cSt	Visc > 300 cSt	Temp > 120°F (50°C)
	LV	**HV**	**HT**
PPS with carbon bearings	Std.	Opt.	Opt.
PPS with Teflon bearings*	Opt.	Opt.	Opt.

* Teflon bearings should not be used unless specifically required (please refer to the application recommendations on page 4.3).

TM Series for low flow applications
Fuel consumption systems & other low flow applications. Available as flow sensors or with electronic register mounted on the pulser. Case materials & rotor options (letters refer to the code used in flow meter Part No. in position 12, **bold** = standard) are:

			Rotor options		
Aluminum	**Nominal Capacity**		**LV**	**HT**	**SS**
TM03A	3 GPM	11 lpm	**A**	K	E
TM04A	10 GPM	38 lpm	**A**	K	
TM06A	20 GPM	76 lpm	**A**	K	
Stainless	**Nominal Capacity**		**LV**	**HT**	**SS**
TM02D	0.3 GPM	1.1 lpm			**E**
TM03D	3 GPM	11 lpm	**A**	K	E
TM04D	10 GPM	38 lpm	**A**	K	
TM06D	20 GPM	76 lpm	**A**	K	

TN Series for inventory control service on liquids with consistently low or high viscosity:

Aluminum	Viscosity	Nominal Capacity		Pressure
TN740A	> 125 cSt	10 GPM	38 lpm	1000 PSI
TN760A	> 125 cSt	15 GPM	57 lpm	400 PSI
TN860A	< 25 cSt	60 GPM	230 lpm	150 PSI

Page 4.3 provides guidance on case material, seal material and rotor type for many common liquid groups for oval gear meters (TS & TM Series). Where Anodized Aluminum can be used, TN Series meters are usually also suitable, unless the viscosity fluctuates in 15-125 cSt (70-600 SSU) range.

For applications not covered on page 4.3, some guidance can be found in chemical compatibility lists. However, chemical compatibility is not the only issue*, so please consult with Customer Care.

* = for example:

Sulfuric acid (H_2SO_4) over 90% concentration is compatible with 316SS. However, strong acids are usually so contaminated with foreign particles, that PD meters are not suitable. Mag meters are a better choice for this type of liquids.

Model Selection

- Select a meter to operate in 50-85% range of model nominal capacity for optimum accuracy & life.
- Intermittent service to 100% is acceptable on low viscosity liquids in most cases.
- Intermittent service over 100% depends upon model configuration, liquid and type of service (intermittent vs. continuous duty). Please consult with Customer Care if operation over 100% of nominal capacity is being considered.
- On medium/high viscosity liquids limits on differential pressure across the flow meter might restrict permissible flow rate.

Case, Rotor (Oval Gear) & Bearing material selections

- **High Viscosity** (HV) rotors are required, when the viscosity can exceed 300 cSt (1500 SSU). In high viscosity applications, limits on maximum differential pressure across the flow meter apply. Using HV rotors on liquids where viscosity is below 300 cSt part of the time, will not affect meter linearity (accuracy).
- **High Temperature** (HT) rotors are required, if operating temperature can exceed 50°C (120°F).
- Do not operate over 80% of nominal capacity on non-lubricating liquids, if rotors have Teflon™ bearings.

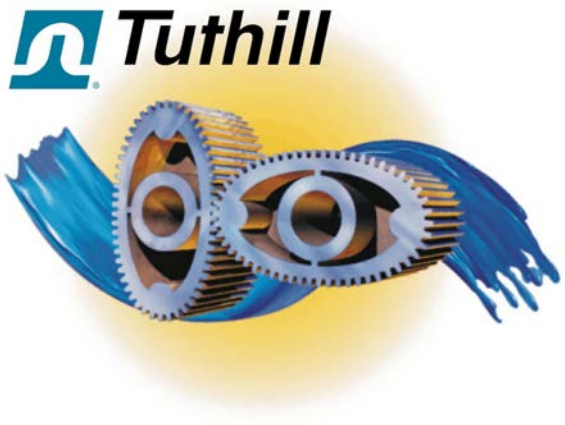
Liquid Category	Examples	Case Mat'l		Rotor Type	TS Series bearing material	Rotor Code in meter Part No.		SEALS	Meter max. rating with this combination
		AA	SS			TM	TS		
Alcohols	Ethanol, Iso-propanol, Methanol, etc.	●	●	**LV**	carbon	A	B	B	100%
Aldehydes	Benaldehyde, Formaldehyde, etc.	●	●	**LV**	carbon	A	B	B	100%
Automotive fluids	Transmisstion fluid, hydraulic oil, glycol & water	●	●	**LV**	carbon	A	B	A	Subj. to visc. limits!
Caustics	Potassium Hydroxide & Sodium Hydroxide < 50%		●	**LV**	carbon	A	B	B	100%
	Potassium Hydroxide & Sodium Hydroxide > 50%		●	**LV**	Teflon™	K	C	B	80%
Esters & Ethers	Amyl Acetate, Butyl Acetate, Dibutyl Phtalate, etc	●	●	**LV**	carbon	A	B	B	100%
Fertilizer	Clear nitrogen solutions	●	●	**HV**	Teflon™	K	J	A	80%
Glycols	Ethylene, Diethylene, Triethylene & Propylene	●	●	**LV**	carbon	A	B	A	100%
Halogenated solvents	Hydrocarbon solvents with Fluorine, Chlorine, Bromine, Iodine & Astatine (Perchlorethylene)		●	**LV**	carbon	A	B	B	100%
Herbicides	Atrazine, Lasso™, Round-Up™, etc.	●	●	**HV**	Teflon™	K	J		80%
Ketones	Acetone, Cyclohexanone, MEK, MIBK, etc.	●	●	**LV**	carbon	A	B	B	100%
LPG	Butane, Propane, Pentane & mixtures	●	●	**LV**	carbon	n/a	B	-	100%
Lube oil	Automotive lubricants, gear oil & grease	●	●	**HV**	carbon	K	I	A	Subj. to visc. limits!
Organic acids	Acetic acid, Formic acid, Lactic acid, Vinegar	●	●	**LV**	Teflon™	A	C	B	80%
Refined Petroleum Products	Avition fuels (Avgas & Jet Fuel), gasoine, diesel fuel, Gasohol, Kerosene & Light fuel oil	●	●	**LV**	carbon	A	B	A	100%
	Fuel Sentry meters on diesel & fuel oil	●	●	**HT**	carbon	K	L	A	100%
	Medium & Heavy Fuel Oils, Automotive lubricants	●	●	**HV**	carbon	K	I	A	Subj. to visc. limits!
Solvents	Benzene, Mineral Spirits, Toluene, Xylene, etc.	●	●	**LV**	carbon	A	B	B	100%
Syrups	Corn Syrup, Sugar Syrup, liquid sugar	●	●	**HV**	Teflon™	K	I	A	Subj. to visc. limits! usually < 25%
Shear sensitive liquids	Adhesives, glue, somy glycols, many resins, etc.	Depends upon pH		**HV**	Teflon™	K	J	B	Subj. to visc. limits! usually < 50%
Vegetable oils[1]	Corn, Cotton, Olive, Peanut, Soya, etc.	●	●	**LV**	carbon	A	B	A	100%
Water	Drinking & process water	●	●	**LV**	carbon	A	B	A	< 50°C/120°F 100%
						K		A	> 50°C/120°F 50%
							L	A	> 50°C/120°F 75%
	Distilled, deionized or otherwise treated water	●	●	**LV**	Teflon™	A	C	A	< 50°C/120°F 75%
						K	M	A	> 50°C/120°F 50%

LV = Low Viscosity rotors
HT = High Temperature rotors
HV = High Viscosity rotors

A = Viton™
B = Teflon™

NOTE: 1. Carbon bearings are commonly used, but some users prefer Teflon™ bearings (to avoid contamination from bearing wear). When Teflon™ bearings are used, lower limits apply to maximum differential pressure allowed across the flow meter.

2. *If the liquid to be metered (and operating conditions) are not shown in the purchase order, TTS can take no responsibility for suitability of the product for the intended service. In such cases,* ***warranty is limited to material defects and workmanship of product supplied.***



Model Selection

Information Required

- **Liquid to be metered**
- **Flow Rate**
- **Operating Pressure**
- **Operating Temperature**
- **Liquid Viscosity**

Model Selection, 2006-1

There are several considerations to made when selecting a positive displacement flow meter. Unless you have the 5 key values indicated above, it is not possible to make a sound model selection.

Liquid To Be Metered

This is the most important piece of information. Without clear identification of the liquid, it can be impossible to select correct case material, rotor type, bearing material & seals.

A guide for common liquid categories is found on page 2 of the Comprehensive price list & page 4.3 in this manual. For liquids not included in that list, please refer to the Liquid Compatibility List and/or consult with Customer Care.

- Generic descriptions are not satisfactory. 'Additive' can cover liquids with pH values from 1-14.
- Check whether the user is planning to flush the system with a liquid different from the liquid being metered. This is not an ideal practice when using a PD meter; but if they do, the flow meter must be compatible with both liquids.

Flow Rate & Viscosity

It is critical to obtain the **actual** flow rate, which the customer will operate at. If the flow rate in the system fluctuates, you need to obtain minimum, normal & maximum values for full evaluation and model selection.

If they report all 'round' numbers (such as 100 GPM, 150 PSI & 180°F), then the data is clearly coming from a product spec sheet. ***That information is useless***, you need to obtain ***actual operating conditions.***

All manufacturers publish a nominal capacity for each model. This is typically the maximum flow rate allowed in intermittent duty on an unidentified low viscosity liquid. Depending upon actual liquid characteristics and other operating conditions, ***higher*** ***or*** ***lower*** values might apply (more on this on page 5.2).

The table shown at right provides a quick guide to limits on model capacity, based on maximum actual flow rate and maximum liquid viscosity. Multiply model nominal capacity with the factor shown for maximum liquid viscosity.

In certain applications non-standard Teflon bearings are necessary. Since this material has lower differential pressure limit, meters with this bearing material are subject to greater reductions than the standard version (with carbon bearings).

Rotor identifiers refer to type of oval gear used:

LV = Low Viscosity (standard)
HT = High Temperature, used on heated liquids.
HV = High Viscosity, used if visc can exceed 300 cSt

Liquid Viscosity	Meter Coefficient							
	TM Series		TS Series with					
			Carbon brgs.			Teflon brgs.		
ROTOR	LV	HT	LV	HT	HV	LV	HT	HV
cSt 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
200	1.00	1.00	1.00	1.00	1.00	0.90	0.90	1.00
300	0.86	0.86	0.86	0.86	1.00	0.73	0.73	0.98
400	0.77	0.77	0.77	0.77	1.00	0.62	0.62	0.96
500	0.71	0.71	0.71	0.71	1.00	0.57	0.57	0.94
600	0.66	0.66	0.66	0.66	1.00	0.53	0.53	0.92
700	0.63	0.63	0.63	0.63	1.00	0.50	0.50	0.90
800	0.60	0.60	0.60	0.60	1.00		0.48	0.85
900	0.56	0.56	0.56	0.56	1.00		0.45	0.80
1,000	0.54	0.54	0.54	0.54	1.00		0.43	0.75
2,000	0.35	0.35		0.35	0.77		0.28	0.65
3,000	0.28	0.28		0.28	0.65		0.22	0.55
4,000	0.24	0.24		0.24	0.58			0.46
5,000	0.19	0.19		0.19	0.53			0.42
6,000	0.16	0.16		0.16	0.49			0.39
7,000	0.14	0.14		0.14	0.47			0.37
8,000	0.12	0.12		0.12	0.44			0.35
9,000	0.10	0.10		0.10	0.42			0.34
10,000		0.09			0.41			0.32
20,000		0.07			0.30			0.24
30,000		0.06			0.24			0.19
40,000		0.05			0.20			0.16
50,000		0.04			0.18			0.14
60,000		0.04			0.17			0.13
70,000		0.03			0.14			0.11
80,000		0.03			0.13			0.10
90,000		0.02			0.12			0.10
100,000		0.02			0.11			0.09
200,000		0.02			0.08			0.06
300,000		0.01			0.07			0.05
400,000					0.06			0.05
500,000					0.06			0.04
600,000					0.06			0.04
700,000					0.05			0.04
800,000					0.05			0.04
900,000					0.05			0.04
1,000,000					0.05			0.04

- On low viscosity refined petroleum products, optimum flow meter performance (accuracy & life) is achieved when the flow meter is operating between 50% and 80-85% of nominal capacity. Intermittent flow in 100-125% range does not damage the flow meter, ***but it will accelerate the wear factor***.
- On low viscosity liquids **with lubricity**, such as diesel fuel, kerosene & aviation fuels, higher flow rates are often acceptable, depending upon torque requirements from the register stack. Please consult for approval in each case.
- On **high viscosity liquids** the capacity with standard rotors is reduced. When liquid viscosity can exceed 300 cSt (1500 SSU), use:
  - TM03, TM04 & TM06 models: Code **K**, = HT rotors
  - All TS Series models : **HV** rotors
- On ***shear sensitive*** liquids, such as adhesives, resins & many polymers:
  - Use **HV** rotors with **Teflon bearings**
  - Meter should not operate at more than 35-50% of nominal capacity, but Delta P restrictions usually limits operating speed to less on these high viscosity liquids.

Operating Pressure

The value shown on the spec sheet applies at a base temperature of 100°F (38°C). At higher operating temperatures, flow meter pressure rating is reduced:

		Anodized Aluminum	CS ANSI Adapt.		Stainless Steel	SS ANSI Adapt.
100 °F	**38 °C**	**100 %**	**290 PSI**		**100 %**	**275 PSI**
150	**66**	89 %	94 %		91 %	89 %
200	**93**	79 %	90 %		83 %	82 %
225	**107**	75 %	88 %		79 %	80 %
250	**121**	71 %	84 %		74 %	78 %
275	**135**	62 %	81 %		70 %	76 %
300	**150**	43 %	79 %		67 %	74 %

Legend for these tables:

GREEN Nominal rating for anodized aluminum is 150, 400, 1000 or 1500 PSI (10, 28, 69 or 103 BAR)

BLUE Nominal rating for stainless steel is 150, 400, 1500 or 2500 PSI (10, 28, 103 or 172 BAR)

YELLOW All applications with operating temperature higher than +250°F (+120°C) are subject to individual approval by TTS (*Wave Form pulser is limited to* +125°C = +257°F).

Operating Temperature

Operating temperature range impacts on flow meter pressure rating as outlined above. It impacts on model & accessory selections in several other areas:

- **Low Ambient and/or Liquid Temperature**
  - Mechanical meters are rated to -40°F (-40°C).
    - Mechanical meters are NOT suitable for cryogenic service (low liquid temperature/normal ambient), as condensation ice interferes with calibrator drive shaft.
  - Electronic flow sensors are rated to -40°F (-40°C). Ratings for signal conditioners & electronic registers vary; some LCDs work to -13°F (-25°C), but many have significantly higher minimum temperature rating. For operation to -40°F (-40°C) an internal heater or a heated enclosure is required.
    - Electronic flow sensors might be OK in cryogenic service, since the register can be mounted remote from the flow meter.
- **High Ambient and/or Liquid Temperature**
  - When liquid temperature exceeds +120°F (+50°C), use **HT rotors** in oval gear meters (not necessary if meter has been fitted with **HV rotors**).
  - Rating for electronic signal conditioners & registers vary (refer to spec sheet for individual models), for many models max. temperature is +158°F (+70°C). If higher liquid temperatures can be encountered, move the electronic register away from the flow meter to a location with lower temperature.
  - Maximum operating temperature for mechanical register (both TS & TN Series) is +180°F (+80°C). For higher operating temperatures, use a remote electronic register.
- **Hot Water Service**
  - In hot water service (over +120°F = +50°C), meters are derated 20-30%.
  - When temperature exceeds +170°F (+75°C) use stainless steel, as hot water is aggressive against aluminum.
  - Maximum allowable temperature in water service is +194°F (+90°C).

Liquid Viscosity & Differential Pressure (ΔP) Values

Viscosity has been called ***the liquids resistance to flow***. Using that 'definition' makes it is obvious, that the higher the resistance, the greater the ΔP across the flow meter. And in turn, ***the greater the wear factor on the flow meter***.

This is a critical factor when selecting both flow meters and pumps, yet most end users do not have this value. Generalities do not help us when it comes to viscosity, a numerical value is required to establish actual maximum Delta P (differential pressure) across the equipment. If user cannot obtain this value from their liquid supplier, ***it is distributor responsibility to research the liquid.***

Liquid viscosity is usually expressed in seconds; but there are many different tables in common use, so it is important to establish which table is being referred to. The most common viscosity units are:

SSU Seconds Saybolt Universal

cSt centiStoke = mm²/s (squaremillimeter-second)

cP centiPoise = mPa●s (millipascal-second)
(cP = cSt x specific gravity)

Other viscosity units exist. Conversion tables for SSU, cSt & several other units follow on page 5.6. Additional conversion charts are found in the Technical Data folder on the Distributor CD.

Viscosity reference tables for common liquids follow on pages 5.4 and 5.5, but be aware that these are values are not exact. This information has been assembled from a variety of sources, and appears to be representative of the liquids listed.

Some liquids (incl. all fuel oils) have 'loose' specifications. For example, the viscosity of Fuel Oil No. 6 is known to vary significantly from delivery to delivery. If a user asks for a flow meter for 'bunker oil' (marine fuel oil), it is important to obtain grade & viscosity data. We have seen Diesel Fuel No. 3 to products heavier than Fuel Oil No. 6 designated as bunker oil.

On higher viscosity liquids, **ΔP** (Delta P = pressure loss across the flow meter) values increase. This is an expression of a higher wear factor. Maximum values allowed depend upon bearing material in the oval gear, whether the meter will be used in continuous or intermittent duty (intermittent is defined as < 6 hours per day) and register torque requirements:

Bearing	Continuous Duty	Intermittent Duty	Where Used TM	TS
PPS	6.7 PSI 45 kPa	10 PSI 70 kPa	Std.	
Carbon	10.0 PSI 70 kPa	15 PSI 100 kPa		Std.
Teflon	3.5 PSI 24 kPa	5 PSI 35 kPa	TM02	Opt.

Under normal operating conditions, it is recommended that the Delta P value be somewhat less than the maximum allowed.

The table on page 5.1 provides a quick guide to a responsible model selection. If you need actual **ΔP** values to calculate pump HP requirements, please refer to:

FPP206 **TM Series** ΔP on water
FPP207 **TS Series** ΔP on water
FPP208 **TN Series** ΔP on water
& **FPP209** **Viscosity correction factors**

Multiply value for water with the appropriate correction factor for **maximum liquid viscosity**. If the corrected **ΔP** value exceeds bearing limits shown above, there are 3 options:

- Reduce the flow rate.
- Select a larger flow meter.
- Increase minimum temperature to reduce the viscosity.

The value calculated is for the flow meter only; for other components, add:

- Strainer — Similar to flow meter value.
- Air Eliminator — None (is not in liquid stream)
- Preset Valve — Similar to flow meter
- Backpressure Valve — 12 PSI
- Air Check Valve — Similar to flow meter + 10 PSI
- Solenoid Valve — Similar to flow meter + 20-40 PSI

System Design Evaluation based on Liquid Velocity
Here are 3 quick rules for evaluating system design:

- In terms of overall optimum design, covering initial cost, installation, equipment life, flow meter linearity, service/maintenance requirements & energy costs, the liquid velocity in low viscosity systems should be **5 feet/s (150 cm/s).**
- Considering only initial & installation cost (what a construction company considers), they will select equipment for low viscosity service based on a velocity closer to 10 feet/s (300 cm/s). PD meters will work fine here, but will be subject to a higher wear factor and operating costs.
- Oil companies want to work very fast, but must avoid product flashing to vapor when entering an internal enlargement (= meter measuring chamber). This limits liquid velocity to 16 feet/s (488 cm/s).

Line Size	5 feet/s GPM	5 feet/s lpm	10 feet/s GPM	10 feet/s lpm	16 feet/s GPM	16 feet/s lpm
1½"	32	120	63	240	102	384
2"	52	197	105	397	167	633
3"	115	435	230	871	369	1395
4"	198	751	397	1502	635	2403

In smaller lines 10 feet/s or less is usually the practical upper limit.

Viscosity Correction Factor

Viscosity SSU	Viscosity cSt	TM/TS Std	TM HT	TS HT	TS HV	TN	Series Rotors
500,000	105,000	n/a	Pls consult for higher viscosities	n/a	25.00	Pls consult for higher viscosities	
400,000	84,000	n/a		n/a	23.00		
300,000	63,000	n/a		n/a	21.00		
200,000	42,000	n/a		n/a	19.00		
150,000	31500	n/a		n/a	17.00		
100,000	21,000	n/a		n/a	15.00		
80,000	16,800	n/a		n/a	13.70		
60,000	12,600	n/a		n/a	12.25		
40,000	8,400	n/a		n/a	11.00		
30,000	6,300	n/a		n/a	10.00		
20,000	4,200	n/a		n/a	8.70		
15,000	3,150	n/a		n/a	7.70		
10,000	2,100	n/a	12.00	n/a	6.80	6.80	
9,000	1,890	n/a	10.75	n/a	6.50	6.50	
8,000	1,680	n/a	9.50	n/a	6.25	6.25	
7,000	1,470	n/a	8.75	n/a	6.05	6.05	
6,000	1,260	n/a	8.00	n/a	5.80	5.80	
5,000	1,050	n/a	6.90	6.90	5.30	5.30	
4,000	840	n/a	6.00	6.00	5.00	5.00	
3,000	630	n/a	5.30	5.30	4.50	4.50	
2,000	420	4.60	4.30	4.30	3.90	3.90	
1500	315	3.95	3.80	3.80	3.50	3.55	
1000	210	3.30	3.30	3.30	3.10	3.30	
900	189	3.15	3.15	3.15	n/a	3.15	
800	168	3.05	3.05	3.05	n/a	3.05	
700	147	2.90	2.90	2.90	n/a	2.90	
600	126	2.75	2.75	2.75	n/a	2.75	
500	105	2.55	n/a	n/a	n/a	2.55	
450	95	2.42	n/a	n/a	n/a	2.42	
400	85	2.30	n/a	n/a	n/a	2.30	
350	74	2.20	n/a	n/a	n/a	2.20	
300	63	2.10	n/a	n/a	n/a	2.10	
250	52	2.00	n/a	n/a	n/a	2.00	
200	42	1.90	n/a	n/a	n/a	1.90	
175	37	1.79	n/a	n/a	n/a	1.79	
150	32	1.70	n/a	n/a	n/a	1.70	
125	27	1.59	n/a	n/a	n/a	1.59	
100	22	1.50	n/a	n/a	n/a	1.50	
90	19	1.45	n/a	n/a	n/a	1.45	
80	17	1.40	n/a	n/a	n/a	1.40	
70	15	1.30	n/a	n/a	n/a	1.30	
60	10	1.20	n/a	n/a	n/a	1.20	
50	7	1.15	n/a	n/a	n/a	1.15	
40	4	1.08	n/a	n/a	n/a	1.08	
30	1	1.00	n/a	n/a	n/a	1.00	

	Viscosities in cSt										
	-30°F	-20°F	-10°F	0°F	15°F	30°F	45°F	60°F	100°F	130°F	210°F
	-34.4°C	-28.9°C	-23.3°C	-17.8°C	-9.4°C	-1.1°C	7.2°C	15.6°C	37.8°C	54.4°C	98.9°C
Diesel Fuel						30	19	15	5.5	3.8	
Fuel Oil No. 2											
Min. value	18	14	11	8.3	6.0	4.5	3.6	2.9	1.6		
Max. value	70	48	35	25	17	12	8.9	6.7	3.7	2.8	
No. 4											
Min. value	375	215	135	85	48	30	20	14	6	4	1.8
Max. value	18,500	7,000	3,000	1,650	650	295	150	80	26	13	4.0
No. 5, light											
Min. value	60,000	22,000	9,000	3,800	1,300	500	240	130	33	17	4.5
Max. value	135,000	50,000	21,000	9,000	3,000	1,200	550	285	70	31	7.8
No. 5, heavy											
Min. value	200,000	75,000	30,000	13,000	4,000	1,700	700	350	80	35	8.5
Max. value	?	700,000	180,000	60,000	18,000	6,000	2,200	950	165	68	13
No. 6											
Min. value	?	?	350,000	115,000	30,000	9,000	3,000	1,400	215	80	14
Max. value	?	?	?	?	?	300,000	85,000	30,000	2,000	500	46
Lube oil											
SAE 5W20	5,000	2,800	1,700	800	400	230	135	82	31	18	6.0
10W-30	10,000	6,500	3,300	2,000	1,000	550	300	175	61	33	11
10W	13,500	7,000	3,600	2,000	850	430	240	140	45	17	7
20W	68,000	30,000	12,500	6,000	2,400	1,050	500	280	75	35	9
20W-40	70,000	30,000	16,000	7,500	3,100	1,450	750	420	115	55	14
30	200,000	80,000	35,000	14,500	5,500	2,150	1,000	500	120	55	13
40	300,000	160,000	65,000	32,000	9,500	3,800	1,700	800	170	75	16
50	550,000	280,000	115,000	55,000	18,000	6,500	2,800	1,250	270	105	21

	Mobilgear® 600 Series, Viscosities in cSt										
for enclosed gear drives											
626			15,750		3,045	1,155	588	294	72		8.5
627			33,600		5,460	2,100	945	462	107		12
629			63,000		9,240	3,780	1,638	756	163		16
630			115,500		15,750	6,300	2,730	1,197	242		20
632			189,000		26,250	9,450	4,095	1,610	347		26
634			346,500		46,200	15,750	6,720	2,940	504		32
636			882,000		98,700	33,600	11,970	5,040	735		39

	Spirax A (Shell), Viscosities in cSt										
Axle oil											
80W						2,900		500	74		9
80W-90						7,800		1,150	154		16
85W-140						20,000		3,000	432		30
90						5,000		1,000	185		17
140						35,000		5,000	559		33

	(Shell), Viscosities in cSt										
Donax ATF TG						225		85	34		7
Tellus Hydr. Oil											
ISO 22						180		75	22		4
ISO 32						338		100	32		5
ISO 37						440		120	37		6
ISO 46						580		140	46		7
ISO 68						1,040		190	68		9
ISO 100						1,790		400	100		11

	Viscosities in cPs										
				0°F				77°F			
				-17.8°C				25.0°C			
Grease No. 0				96,000				67,200			
No. 1				592,000				161,600			
No. 2				1,328,000				368,000			

Liquid Name & Specifications		Sp.Gr. @ 60°F (15.5°C)	Viscosity in cSt.							
			30°F -1°C	60°F 15.6°C	80°F 26.7°C	100°F 37.8°C	130°F 54.4°C	170°F 76.7°C	210°F 98.9°C	250°F 121°C
Caustic Soda (sodium hydroxide)	20%	1.22 at 65°F		4 @65°F						
	30%	1.33 at 65°F		9 @65°F						
	40%	1.43 at 65°F		24 @65°F						
Glycerin	99% soluble		2,240	475	250	130	59	28	16	8.5
	100%	1.26 at 68°F	4,460	880	357	171	68	28	16	8.3
Glycol	Propylene	1.038 at 68°F		50 @70°F						
	Triethylene	1.125 at 68°F		39 @70°F						
	Diethylene	1.120		32 @70°F						
	Ethylene	1.125		19 @70°F						
Ink	newspaper		13,650	4,250	2,200	950	500	215	105	59
	printers	1.00 - 1.38		21,000	6,360	2,625	800	231	88	42
Molasses	A. Maximum	1.40 - 1.46	8,925	4,725	3,150	2,200	1,240			
	A. Minimum		1,950	755	440	273	150			
	B. Maximum	1.43 - 1.48				12,600	3,150			
	B. Minimum		14,700	4,620	2,290	1,400	630			
	C. Maximum	1.46 - 1.49				52,500	15,750			
	C. Minimum			18,900	7,350	3,570	1,300			
Oil	cocoanut	0.925	475	115	57	32	17	7		
	corn	0.924	452	155	87	52	30	17	8.5	
	cotton	0.88 - 0.925	334	110	62	37	22	11		
	gas	0.887	43	19	11	7	4			
	lard	0.912 - 0.925	294	117	71	46	29	17	8.5	
	olive	0.912 - 0.918	320	115	67	42	25	15	8.3	
	palm	0.924	376	134	75	46	29	17	8.4	
	peanut	0.920	278	108	63	41	24	15	8.3	
	rape seed	0.919	326	132	71	52	32	19	11	7
	rosin	0.980	7,435	1,595	670	320	130	49	25	16
	soy bean	0.927 - 0.98	277	99	56	35	21	10		
Syrup, corn	Karo			12,600	3,255	1,050	273	74	30	
	41° Baume	1.395		14,700	5,250	2,420	756	242	95	47
	42° Baume	1.409			11,340	4,250	1,300	347	130	59
	43° Baume	1.423				8,925	2,200	462	150	63
	44° Baume	1.437					4,725	830	220	81
	45° Baume	1.450					11,550	1,500	305	101
Syrup, sugar	60 Brix	1.290	347	73	34	19	8.5	4		
	62 Brix	1.300	545	101	45	23	11	5		
	64 Brix	1.310	925	154	63	32	15	5.5		
	66 Brix	1.326	1,555	242	89	41	18	7		
	68 Brix	1.338	2,520	347	134	58	29	9	5	
	70 Brix	1.350	5,880	650	220	85	32	12	5.5	
	72 Brix	1.360	9,450	1,010	330	134	46	18	8.3	
	74 Brix	1.376		2,420	640	242	71	29	10	5.5
	76 Brix	1.390		3,990	1,175	420	134	40	19	8.5

INDUSTRIAL DYNAMICS CO 800-940-0453

VISCOSITY CONVERSION TABLES

KINEMATIC viscosity

SAYBOLT		REDWOOD		ENGLER	CST
SSU	**SSF**	**No. 1**	**No. 2**		**100 cSt**
Seconds	Seconds	Standard	Admiralty		= 1Stoke
Universal	Furol	Seconds	Seconds	Seconds	mm2/s
100,000	10,000	91,300	9,130	144,000	21,000
90,000	9,000	82,100	8,210	130,000	18,900
80,000	8,000	73,000	7,300	120,000	16,800
70,000	7,000	64,000	6,400	100,000	14,700
60,000	6,000	54,900	5,490	86,500	12,600
50,000	5,000	45,700	4,570	72,000	10,500
45,000	4,500	41,100	4,110	64,500	9,450
40,000	4,000	36,500	3,650	60,000	8,500
35,000	3,500	32,000	3,200	50,000	7,350
30,000	3,000	27,400	2,740	45,000	6,300
25,000	2,500	22,800	2,280	36,000	5,250
20,000	2,000	18,400	1,840	3,000	4,250
15,000	1,500	13,700	1,370	21,500	3,150
10,000	1,000	9,000	900	15,000	2,200
9,000	900	8,000	800	13,000	1,950
8,000	800	7,100	710	12,000	1,700
7,000	700	6,200	620	10,500	1,500
6,000	600	5,400	540	9,000	1,300
5,000	500	4,300	430	7,500	1,050
4,000	400	3,600	360	5,500	850
3,000	300	2,600	260	4,500	630
2,000	200	1,800	180	3,000	420
1,000	100	900	90	1,500	220
900	90	800	80	1,300	195
800	80	710	71	1,200	170
700	70	620	62	1,050	150
600	60	540	54	900	130
500	50	430	43	750	105
400	40	340	34	550	85
300	33	260	26	450	63
200	24	195	20	300	42
100	15	90		150	22
90		80		130	19
80		70		120	17
70		62		100	15
60		54		90	10
50		43		75	7
40		36		55	4

DYNAMIC VISCOSITY

Based on liquid specific gravity =								
0.700	**0.775**	**0.850**	**0.925**	**1.000**	**1.075**	**1.150**	**1.225**	**1.300**
14,700	16,275	17,850	19,425	21,000	22,575	24,150	25,725	27,300
13,230	14,648	16,065	17,483	18,900	20,318	21,735	23,153	24,570
11,760	13,020	14,280	15,540	16,800	18,060	19,320	20,580	21,840
10,290	11,393	12,495	13,598	14,700	15,803	16,905	18,008	19,110
8,820	9,765	10,710	11,655	12,600	13,545	14,490	15,435	16,380
7,350	8,138	8,925	9,713	10,500	11,288	12,075	12,863	13,650
6,615	7,324	8,033	8,741	9,450	10,159	10,868	11,576	12,285
5,950	6,588	7,225	7,863	8,500	9,138	9,775	10,413	11,050
5,145	5,696	6,248	6,799	7,350	7,901	8,453	9,004	9,555
4,410	4,883	5,355	5,828	6,300	6,773	7,245	7,718	8,190
3,675	4,069	4,463	4,856	5,250	5,644	6,038	6,431	6,825
2,975	3,294	3,613	3,931	4,250	4,569	4,888	5,206	5,525
2,205	2,441	2,678	2,914	3,150	3,386	3,623	3,859	4,095
1,540	1,705	1,870	2,035	2,200	2,365	2,530	2,695	2,860
1,365	1,511	1,658	1,804	1,950	2,096	2,243	2,389	2,535
1,190	1,318	1,445	1,573	1,700	1,828	1,955	2,083	2,210
1,050	1,163	1,275	1,388	1,500	1,613	1,725	1,838	1,950
910	1,008	1,105	1,203	1,300	1,398	1,495	1,593	1,690
735	814	893	971	1,050	1,129	1,208	1,286	1,365
595	659	723	786	850	914	978	1,041	1,105
441	488	536	583	630	677	725	772	819
294	326	357	389	420	452	483	515	546
154	171	187	204	220	237	253	270	286
137	151	166	180	195	210	224	239	254
119	132	145	157	170	183	196	208	221
105	116	128	139	150	161	173	184	195
91	101	111	120	130	140	150	159	169
74	81	89	97	105	113	121	129	137
60	66	72	79	85	91	98	104	111
44	49	54	58	63	68	72	77	82
29	33	36	39	42	45	48	51	55
15	17	19	20	22	24	25	27	29
13	15	16	18	19	20	22	23	25
12	13	14	16	17	18	20	21	22
11	12	13	14	15	16	17	18	20
7	8	9	9	10	11	12	12	13
5	5	6	6	7	8	8	9	9
3	3	3	4	4	4	5	5	5

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CONVERSION TABLES

VOLUME

US GPM	US GPH	LPM	m³/h	Imp GPM	Imp GPH	BPD
0.02	1.0	0.076	0.0045	0.02	1.0	0.7
0.04	2.0	0.151	0.0091	0.03	2.0	1.4
0.06	4.0	0.227	0.0136	0.05	3.0	2.1
0.08	5.0	0.303	0.0182	0.07	4.0	2.7
0.10	6.0	0.379	0.023	0.08	5.0	3.4
0.15	9.0	0.568	0.034	0.12	7.0	5.1
0.2	12	0.757	0.045	0.17	10	6.9
0.4	24	1.51	0.091	0.33	20	14
0.6	36	2.27	0.136	0.50	30	21
0.8	48	3.03	0.182	0.67	40	27
1.0	60	3.79	0.227	0.83	50	34
2	120	7.57	0.45	1.7	100	69
4	240	15.1	0.91	3.3	200	137
6	360	22.7	1.36	5.0	300	206
8	480	30.3	1.82	6.7	400	274
10	600	38	2.27	8.3	500	343
15	900	57	3.41	12	749	514
20	1,200	76	4.54	17	999	686
25	1,500	95	5.7	21	1,249	857
30	1,800	114	6.8	25	1,499	1,029
40	2,400	151	9.1	33	1,998	1,371
50	3,000	189	11.4	42	2,498	1,714
60	3,600	227	13.6	50	2,998	2,057
80	4,800	303	18.2	67	3,997	2,743
90	5,400	341	20.4	75	4,497	3,086
100	6,000	379	23	83	4,996	3,429
110	6,600	416	25	92	5,496	3,771
120	7,200	454	27	100	5,995	4,114
130	7,800	492	30	108	6,495	4,457
140	8,400	530	32	117	6,995	4,800
150	9,000	568	34	125	7,494	5,143
160	9,600	606	36	133	7,994	5,486
180	10,800	681	41	150	8,993	6,171
190	11,400	719	43	158	9,493	6,514
200	12,000	757	45	167	9,992	6,857
210	12,600	795	48	175	10,492	7,200
220	13,200	833	50	183	10,991	7,543
230	13,800	871	52	192	11,491	7,886
240	14,400	908	55	200	11,991	8,229
250	15,000	946	57	208	12,490	8,571
260	15,600	984	59	216	12,990	8,914
270	16,200	1,022	61	225	13,490	9,257
280	16,800	1,060	64	233	13,989	9,600
290	17,400	1,098	66	241	14,489	9,943
300	18,000	1,136	68	250	14,988	10,286
325	19,500	1,230	74	271	16,237	11,143
350	21,000	1,325	79	291	17,486	12,000
375	22,500	1,420	85	312	18,735	12,857
400	24,000	1,514	91	333	19,985	13,714
425	25,500	1,609	97	354	21,234	14,571
450	27,000	1,703	102	375	22,483	15,429
US GPM	US GPH	LPM	m³/h	Imp GPM	Imp GPH	BPD

TEMPERATURE

°F	°C
-40	-40.0
-30	-34.4
-20	-28.9
-10	-23.3
0	-17.8
10	-12.2
20	-6.7
30	-1.1
40	4.4
50	10.0
60	15.6
70	21.1
80	26.7
90	32.2
100	37.8
110	43.3
120	48.9
130	54.4
140	60.0
150	65.6
160	71.1
170	76.7
180	82.2
190	87.8
200	93.3
210	98.9
220	104.4
230	110.0
240	115.6
250	121.1
260	126.7
270	132.2
280	137.8
290	143.3
300	148.9
°F	°C

PRESSURE

PSI	BAR	kg/cm	kPa	Mpa
5	0.3	0.4	34	0.03
10	0.7	0.7	69	0.07
15	1.0	1.1	103	0.10
20	1.4	1.4	138	0.14
25	1.7	1.8	172	0.17
30	2.1	2.1	207	0.21
35	2.4	2.5	241	0.24
40	2.8	2.8	276	0.28
45	3.1	3.2	310	0.31
50	3.4	3.5	345	0.35
55	3.8	3.9	379	0.38
60	4.1	4.2	414	0.41
65	4.5	4.6	448	0.45
70	4.8	4.9	483	0.48
75	5.2	5.3	517	0.52
80	5.5	5.6	552	0.55
85	5.9	6.0	586	0.59
90	6.2	6.3	621	0.62
95	6.6	6.7	655	0.66
100	6.9	7.0	690	0.69
125	8.6	8.8	862	0.86
150	10.3	10.5	1,034	1.03
175	12	12	1,207	1.21
200	14	14	1,379	1.38
225	16	16	1,551	1.55
250	17	18	1,724	1.72
275	19	19	1,896	1.90
300	21	21	2,069	2.07
325	22	23	2,241	2.24
350	24	25	2,413	2.41
375	26	26	2,586	2.59
400	28	28	2,758	2.76
500	34	35	3,448	3.45
600	41	42	4,137	4.14
700	48	49	4,827	4.83
800	55	56	5,516	5.52
900	62	63	6,206	6.21
1,000	69	70	6,895	6.90
1,100	76	77	7,585	7.59
1,200	83	84	8,274	8.27
1,300	90	91	8,964	8.96
1,400	97	98	9,653	9.65
1,500	103	105	10,343	10.34
2,500	172	176	17,238	17.24
5,000	345	352	34,475	34.48
PSI	BAR	kg/cm	kPa	Mpa



Accessories

- **Strainer**
- **Air Eliminator**
- **Control Valves**
- **Pump Control**

A complete hydraulic system usually includes components from several manufacturers. TTS provides the basic accessories for an accurate flow meter assembly, but not necessarily a complete hydraulic system.

Strainer

It is recommended that every positive displacement flow meter be protected against foreign particles (welding slag, rust, parts breaking off pumps or valves, etc.) with a strainer. Strainers offered by TTS do not have sufficient straining capacity to clean a contaminated fluid; they are strictly intended as insurance against the flow meter jamming on foreign particles. In some cases the strainer also serves as a place to mount an air eliminator.

Standard Strainer, Anodized Aluminum



This is a 90° strainer, which can be assembled with inlet from either the front (standard) or the rear (optional). The liquid stream turns 90° to enter the flow meter. Inlet flange & strainer basket cover have same bolt pattern, so inlet position can be changed in the field.

The strainer is supplied with a stainless steel mesh basket.

- 40 mesh Standard
- 20 mesh For high viscosity liquids
- 100 mesh For gasoline, alcohol & solvent service
- 200 mesh For LPG service

This strainer is manufactured in two sizes. 2" for use with models TS10A, TS15A & TS20A, and 3" for use with model TS30A. Strainer outlet flange bolts directly to meter body on models TS20A & TS30A, and mounts to TS10A & TS15A with an adaptor. Both strainers have an opening on top, where either a blind cover (shown above) or an air eliminator is installed.

Materials:

Strainer Body & Cover	:	Anodized aluminum
Flange & Basket Cover	:	Anodized aluminum
Strainer basket & mesh	:	Stainless Steel
All O-rings	:	Viton™ standard, Teflon™ opt.

Rating:
To 400 PSI (28 BAR) at 100°F (38°C)

High Capacity Strainer, Anodized Aluminum



On higher viscosity liquids such as diesel fuel, it takes more time for the air to rise out of the liquid, to the point where the air eliminator can capture and vent the air. On high speed tank truck systems, which must meet 'Split Compartment' testing standards, the holding capacity of the standard strainer is often inadequate on diesel fuel.

A high capacity strainer is available for these systems. This is also a 90° strainer, but with 3" strainer basket and a tank with significantly larger holding capacity. The liquid is directed around a baffle below the air eliminator, giving any air present maximum time to escape.

For more details, please refer to section on air elimination.

Materials:
Same as for standard strainer.
Rating:
To 150 PSI (15 BAR) at 100°F (38°C)

Strainer, Stainless Steel

For use with stainless steel meters, we offer two types of stainless steel strainers:

- When no air eliminator is required, a Y-type strainer is the most economical solution. We offer FNPT strainers in sizes from 1/4" through 2", all with mesh screen (choice of 20, 40, 80 & 100 mesh).



- When an air eliminator is required, a straight-through basket type strainer is used. We offer these in 1½" through 2" size with FNPT ports, and in 1½" through 3" size with 150# RF ANSI flanges. Baskets are mesh lined, with choice of 20, 40, 80 & 100 mesh.

  1" FNPT strainer is available, but it is too small to support an air eliminator. Similarly, ANSI flanged strainers are available in ¾" & 1" sizes, but these sizes do not support an air eliminator.

Materials:

Strainer Body & Cover	:	316SS (CF8M-A351)
Strainer basket & mesh	:	304SS
Cover O-rings	:	Spiral wound SS (non Asbestos)

Rating:
To 275 PSI (19 BAR) at 100°F (38°C)

Air Eliminator

PD meters cannot distinguish between liquid and air/vapors. To avoid recording air/vapors as liquid, in systems where air or vapors might occur in the lines, an air eliminator should be installed immediately before the flow meter.

An air eliminator is mandatory in systems subject to Custody Transfer regulations, unless fuel is supplied by a submersible pump in an underground storage tank. For more details, please refer to page 8.1.

Air eliminators operate on a gravity principle, so this device must be installed in a horizontal position.

Anodized Aluminum



The air eliminator is common for all anodized aluminum meters. The operating mechanism consists of a float riding on a center shaft.

When air is present the float drops, peeling two valve reeds away from the vent ports (1" FNPT). Vent ports should be piped to storage or a collection tank, as a few drops of liquid might exit when the air eliminator vents.

While the air eliminator housing can hold static pressure to 400 PSI (28 BAR), the venting mechanism is restricted to 150 PSI (10 BAR) differential. Air eliminator base bolt pattern is square, so the air eliminator can be turned in 90° increments on the strainer. This permits piping of vent lines in the most convenient pattern to the individual installation. The air eliminator is available in two versions:

- Standard — For flow meters without air check valve
- Limited Bleed — For flow meters with air check valve, which requires tubing from one AE vent port to the connection on the ACV. When the AE vents, it activates the ACV. The ACV stops the flow as long as AE remains open.

Materials:

Air Eliminator Body/Cover	:	Anodized aluminum
Float, Guide & Valve reeds	:	Stainless Steel
Baffle below the float	:	PPS
All O-rings	:	Viton™ standard, Teflon™ opt.

Rating:

To 150 PSI (15 BAR) at 100°F (38°C) if venting to atmosphere
To 350 PSI (24 BAR) at 100°F (38°C) in LPG systems

Stainless Steel



The SS air eliminator also works on a gravity principle, but is a slightly different construction. In this model the float is mounted on a guided lever, which in turn opens/closes the air vent. It is a permanently welded unit, with no seals or gaskets.

The SS air eliminator can be mounted on basket strainers for use with models TS15C, TS20C & TS30C. 1" strainers are too small to accept this device, so for TS10D model the air eliminator must be mounted on an inverted 'Tee' with 3/4" MNPT vertical leg, installed between strainer & flow meter.

Materials:

Air Eliminator Body/Cap	:	Stainless Steel 304-L
Valve & Seat	:	440
Lever Systems & Float	:	303/304 Stainless Steel

Rating:

To 600 PSI (41 BAR) at 100°F (38°C),
but restricted to 150 PSI (10 BAR) if venting to atmosphere.

Backpressure Valve

The air eliminator requires some backpressure for maximum efficiency. In systems with little backpressure from other components, it might be necessary to add a backpressure valve between the strainer and the flow meter. This component is commonly required on tank trucks.

This flat wafer type valve fits between strainer flange and flow meter inlet. This usually eliminates the need for the alternative air check valve.



Materials

Valve Poppet & Stem:		Anodized aluminum
Valve Stem & Spring	:	Stainless Steel
Seal ring	:	Viton™

Air Check Valve

In some regions there is a tradition for, or regulations requiring, use of an air check valve in conjunction with the **limited bleed** version of the Air Eliminator. This valve is mounted on flow meter outlet, and requires a connection to one of the air eliminator vent ports (not provided by TTS). Port on the valve is 1/2" FNPT; use 3/8" or 1/2" tubing to establish the connection.

The air check valve has a spring loaded piston (12-15 PSI), which ordinarily is held open by system pressure. When the air eliminator opens, system pressure is directed to the backside of the piston. With pressure equalized, the piston now closes the valve to stop the flow. When the air eliminator closes, system pressure is bled off piston backside, so the valve opens and flow resumes. Connection between air eliminator vent port and air check valve must be provided in the field (pipe, tubing or hose).

This valve utilizes the same body as the preset valve, with the same materials, pressure rating & installation options.

Preset Valve

When the flow meter has a Preset Counter, or an electronic register with preset function, a control valve is required to stop the flow at the end of the selected volume. A valve with dual shut-off is required if flow rate exceeds 20 GPM (75 lpm). On the first trip (signal), the valve closes partially to slow down the flow, and the second trip (signal) causes the valve to close fully. 2-stage shut-off allows accurate close at the end of the delivery, and prevents hydraulic shock ('water hammer') in the system.

Mechanical Preset Valve



This is a 90° valve used in conjunction with a mechanical Preset Counter. The mechanical piston valve has a linkage, which connects to the trip ring in the Preset Counter. The operator enters volume to be delivered on the Preset Counter, and opens the valve by pulling the handle on the linkage.

Standard installation of a mechanical preset valve is with the outlet pointing out from the flow meter. It can also be installed with the outlet pointing up, down or towards the rear. Changing valve position in the field is difficult (a different linkage is required in some cases), so it is important to specify correct installation position initially.

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The preset valve comes in two versions:

- Low Viscosity: to 50 cSt (about 200 SSU)
- High Viscosity: 50-1000 cSt (about 5000 SSU)

For higher viscosity liquids, other types of valves should be utilized (ball or butterfly valve with 1-stg or 2-stg actuator).

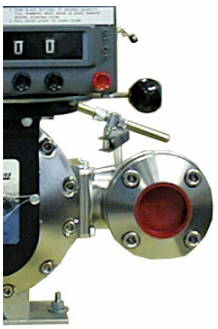
Anodized Aluminum valves are manufactured in two sizes. 2" for use with models TS10A, TS15A & TS20A and 3" for use with TS30A. Valve inlet flange bolts directly to meter body on models TS20A & TS30A, and mounts to TS10A & TS15A with an adaptor.

Materials:

Valve Body/Piston/Flanges	:	Anodized aluminum
Valve Stem & Spring	:	Stainless Steel
All seal rings	:	Viton™ standard, Teflon™ opt.

Rating:
To 150 PSI (15 BAR) at 100°F (38°C)

The mechanical preset valve is also manufactured in all stainless steel for use with models TS15C & TS20C. It bolts directly to the outlet of TS20C, and attaches to TS15C via an adaptor. It does not fit the TS10D model, but 1" SS solenoid valves are readily available from ASCO and other valve manufacturers.



Materials:

Metallic parts	:	316SS
All seal rings	:	Teflon™

Rating:
To 150 PSI (15 BAR) at 100°F (38°C)

Solenoid Preset Valve

The anodized aluminum preset valve is available as a solenoid operated valve for use with electronic preset & industrial batch controllers. This version of the valve is restricted to liquids with viscosity under 150 cSt (700 SSU), and compatible with Viton seals.



Using copper tubing & brass solenoids, this valve is available in 2 sizes. 2" for use with models TS10A, TS15A & TS20A and 3" for use with TS30A. Valve inlet flange bolts directly to meter body on models TS20A & TS30A, and mounts to TS10A & TS15A with an adaptor.

This valve has relatively high Delta P values (30-40 PSI to open fully), and may be a restriction if a centrifugal or submersible pump is used.

Solenoid valves are available with choice of:

- Watertight or Explosion Proof solenoids
- DC or AC powered solenoids

Micro Switch Kit for 7889 Preset Counter

VR7856 = an explosion proof micro switch kit (4 SPDT). This option is available for installation on the mechanical Preset Counter. This permits control of:

- Pump on/off signal
- Solenoid valve in place of mechanical valve

Control Valves for Loading Racks

In loading racks, there is often a need for control valves with additional control functions. In systems where a single pump supplies multiple flow meters, Rate-of-Flow control is required to protect individual flow meters against excessive flow rates. Valves can also be used to either sustain or reduce operating pressure, prevent reverse flow, etc.

Instead of installing additional valves for each function, solenoid valves with 2-stage preset control can be augmented with pilots for additional control functions. While we do not manufacture these multi-function valves, we can provide these valves from one of the premier valve manufacturers in the US.



These valves are limited to liquid viscosity = max. 800 SSU (175 cSt). Valves are available in:

- Ductile Iron, 125# FF, epoxy coated
- Carbon Steel, 150# RF, epoxy coated
- Stainless Steel, 150# RF

Please consult with Customer Care for pricing when this type of valves are required.

Tuthill

FPP METERS

Registration, Data & Communications

- **Mechanical vs. Electronic**
- **Values to be Shown/Captured**
- **Pulse, Analog or Serial Port**

Traditionally positive displacement flow meters have been supplied with mechanical register, and possibly a preset counter (which could have micro switches for pump or solenoid valve control) and/or a ticket printer. The register might have an electro-mechanical pulse generator, to communicate with other instruments. All of this adds up to:

- High maintenance with many mechanical components.
- High torque impacts negatively on flow meter accuracy.
- Register is damaged if reset while operating.
- Large & heavy assembly.
- Packing gland in the meter (medium term replacement item).
- Calibrator in the meter (long term replacement item).
- Manual data collection.



Since the 1990s, many electronic registers have reached the market. Each register system has different levels of functionality and cost. Most are getting close to the price level of equivalent mechanical registration, and all are offering significant advantages over the mechanical version.

- Low maintenance.
- Minimal torque = improved flow meter accuracy.
- Register cannot be reset while operating, and is not damaged if reset is attempted.
- Weighs 25 lbs (11 kg) less.
- Gland-less meter.
- No calibrator to wear out.
- Automated data collection.



= Lower Cost of Ownership!

FPP Meters support all the major electronic register systems. Please consult with Customer Care if you are ordering meters for use with out-sourced electronic registers, to ensure that FPP pulse signal is compatible with the receiving instrument.

Values & Functions

Many different values & functions can be provided. However, they need to be clearly defined for selection of the correct register and/or signal conditioner. In some cases it might be necessary to combine two or more components to generate all the values/functions desired by the end user.

Volume Display

Mechanical registers are installed on a right-angle drive (RAD) adaptor mounted on the front cover of the flow meter. This adaptor contains the drive shaft from the flow meter, and the mechanical calibrator assembly.

The standard register (VR7887) has 5 digit reset and an 8 digit accumulative totalizer. A version with 6 digit reset is available (VR7886), but the extra capacity is rarely required.

For example, if 9,999.9 gallon total is insufficient, a larger model calibrated in whole gallons would be more practical. At 100 GPM it takes 100 minutes for a 2" model to reach 9,999 gallons, while a 3" model can deliver the same volume in 50 minutes or less, and can continue up to 99,999 gallons total.

Standard register calibration by model (see page 7.6 for ratio gear plate P/Nos. & pattern):

	US	Metric
TS10	1/10 gallon	1/10 liter
TS15	1/10 gallon	Whole liter
TS20	1/10 gallon	Whole liter
TS30	Whole gallon	Whole liter (dekaliter optional)



Electronic registers have 5 or 6 digit reset total, and generally also an 8 digit accumulative totalizer. Electronic registers can be calibrated in any engineering unit supported by flow meter pulse resolution (preferably minimum 10+ pulses per unit, or 100+ if one decimal is to be shown).

Preset Function

VR7889 mechanical preset allows the operator to enter volume to be delivered, after activating the preset via the white **SET** button. After the desired volume has been entered by pressing buttons below the numerals, flow is started by opening the valve via the handle on the linkage. If a hazardous condition should occur, the red **EMERGENCY STOP** button allows the operator to stop the delivery instantly.



The preset counts down, and at the end of the delivery the control valve closes in 2 steps. This enables the controller to stop exactly at the end of the delivery, and also minimizes the risk of a hydraulic shock when the valve closes.

2-stage valve closure is mandatory when the flow rate exceeds 20 GPM (75 lpm), and always required when batching water directly from municipal water supply, regardless of flow rate.

The mechanical preset is not suitable for very small batches (less than 30-40 sec delivery).

Dwell setting (2nd stage trip) can be adjusted in the preset counter, please refer to the operation manual for the preset counter. Standard factory settings are:

	Min Batch Size	2nd Stage Trip Setting	
TS10 model	10 gallon	3 gallon	10 liter
TS15 model	12 gallon	3 gallon	10 liter
TS20 model	20 gallon	8 gallon	20 liter
TS30 model	40 gallon	20 gallon	30 liter

Since the preset mounts below the register, it requires a modified ratio gear plate for the register. This gear plate has a longer drive shaft (extending through the preset), and then an Up/Down drive shaft driving both register & preset.

The preset can be expanded with a micro switch kit (4 SPDT poles) in an explosion proof enclosure. This allows pump on/off control, or use of a solenoid valve in place of the mechanical control valve.

The preset function is available in most electronic register systems. It is also available in industrial batch controllers, which also can function as the register in non-Custody Transfer service.

Printer (written record)

VR 7888 mechanical ticket printer is available in two versions:



- **Zero Start** prints 0 at the start of the delivery, and total volume delivered at the end of the delivery.
- **Accumulative** prints starting and ending totalizer readings.

Both install on top of the mechanical register. The reset knob is then moved from the register to the printer. Zero Start is supplied as standard, unless the order specifies Accumulative.

The ticket printer uses a standard form, which is available from commercial printers in every country. The printer accepts some variation in ticket dimensions, please refer to **Mech Register, Preset, Printer & Pulsers** on the distributor CD (in ***Pulsers, Registers & Signal Conditioners*** folder).

A variety of printers are available with electronic register systems. The EMR^3 register utilizes an EPSON tabletop printer. Many other systems use the same printer, but some might rely on different models.

Pulse Signal from Mechanical Register

An electro-mechanical pulser can be installed on the mechanical register. This is identified in position 14 of the P/No., using:



D = Dry reed (10:1)
S = Solid state (100:1), 10-15 VDC

NOTE:	10:1 Pulser	100:1 Pulser
1/10 unit register	= 10 PPU	= 100 PPU
Whole unit register	= 1 PPU	= 10 PPU

Mechanical Register Combinations

Mechanical flow meters can be supplied with the following combinations:

- Without register (meter with RAD adaptor & calibrator only)
- With Register (1)
- With Register & Ticket Printer (1)
- With Register & Preset Counter (1) (2)
- With Register, Preset Counter & Ticket Printer (1) (2)

(1) Opt. electro-mechanical pulser
(2) Opt. linkage/mechanical valve and/or micro switch kit

Together with strainer, air eliminator and the optional air check valve, all these combinations can be defined in flow meter **Assy No.** (= pos. 6-8 in the P/No.). Please refer to chart on page 7.6.

Rate Display (Volume/Time unit)

Rate display is not offered on flow meters with mechanical register, since the cost of such a component is excessive. This function is readily available in most electronic registers.

The main consideration is what ***time values*** the individual register can display. Rate per minute is standard, but some industrial registers allow display in volume per **hour** or **day**. If the flow rate is very low, a longer time unit is preferable, since it makes changes more visible. For example:

Base Value	0.5%	1%	3%	5%	10%	change
1.80 GPM	1.79	1.78	1.75	1.71	1.62	
108.0 GPH	107.5	106.9	104.8	102.6	97.2	
2592 GPD	2579	2566	2514	2462	2333	

Temperature/Volume Compensation

TTS does not offer a mechanical compensator, since mechanical compensation is no longer legal in most world markets. Mechanical compensators are limited in range, react very slowly to temperature changes (30-90 seconds), can not be repaired in the field and last, but not least, are extremely expensive.

When temperature/volume compensation is desired, or required under local regulations, it is available as an option in both the EMR^3 register and in several industrial controllers. Electronic compensators react instantly, and can be programmed for wide operating ranges.

Electronic Registers

FPP meters can be supplied ready for use with electronic registers manufactured by TTS, Veeder-Root, MIDCOM, Liquid Controls Corp., Pegasus & others. *Please consult with Customer Care, when ordering flow meters for use with electronic registers supplied by others.*

FPP Meters are available with two different electronic Custody Transfer service registers factory installed:



- **ELNC** (W&M certified in the US); not for use on trucks. Optional with backlight display & 10:1 pulser.

  Reset total has full 1" (25 mm) numerals. Can be mounted directly on the register mounting pad, or installed remote from the flow meter on any flat surface.

  The processor works correctly to -40 °F (-40°C) ambient, but the LCD lags behind below -13°F (-25°C).



- **EMR^3** (W&M certified in the US, Canada & the EU). Preset function, Currency & Temperature Compensation functions are standard; add solenoid valve and/or thermo well to the flow meter utilize all functions. The Interconnect Box has RS232 & RS485 serial ports for PC/printer connections.

  Can be mounted directly on the register mounting flange, or installed remote from the flow meter on an installation kit (see page 7.5).

  The processor works correctly to -40 °F (-40°C) ambient, but the LCD lags behind below -13°F (-25°C).

When considering a flow meter with electronic register and possible data collection, it is necessary to address a number of options, which are either impractical, expensive or do not exist for mechanical registers:

Should Any Component be Remote?

Whether for operational, security, temperature or practical considerations, an electronic register does not have to be mounted on the flow meter. For example:

In loading racks with top loading, it is practical to have the flow meter on the ground, but the register on the platform with the operator.

End user might want a system, that can be operated either from the flow meter location, or from a control room.

When considering a remote installation, always establish **distances between the components**. Depending upon model selected & distances to be covered, there can be 3-6 components involved:

- Flow meter with pulser
- Possible amplifier
- Possible signal conditioner
- Optional solenoid valve
- Remote register
- IB box with serial port connections to printer, PC, etc.

Of these, the first 5 can be installed in the hazardous zone, but the IB box must be indoors in a non-hazardous zone.

Type of Signal

There are several possible communication methods:

- **Pulse Signal**

  This is a simple electrical on/off signal (digital value), but it is restricted in terms of transmission distances. In gland-less electronic flow meters, we offer different pulsers for different purposes. Depending upon type of pulser & distances involved, an amplifier might be required.

  From a **flow sensor,** the K Factor (= number of pulses per unit of volume) varies by model size and pulser type. When standard Hall Effect pulser is used, in some models there is a choice between standard and high pulse resolution. High pulse resolution is normally required if the pulse signal is used to drive an analog signal converter.

TM Series Meters

- **Hall Effect** pulser is standard. For use with ELNC register, most industrial registers and also in flow sensors without register. This pulser provides a SINKING output; when SOURCING is required, add a PIA-300 signal conditioner.
- **Quadrature Hall Effect** pulser is used for the EMR^3 and other registers capable of detecting reverse flow.
- **Reed Switch** pulser is used with FPP battery powered registers (ELNC, CC56 & other industrial registers), when no external power source is available.

Caution: When an FPP flow sensor (meter without register) is used with non-FPP electronics, a PIA-300 signal conditioner is almost always required.

Pulser type (1)	Hall Effect		Reed Switch		Over
	Standard		Optional		100 cSt
Model	PPG	ppl	PPG	ppl	viscosity
TM02D	7700	2034	3850	1017	+ 4-5%
TM03A & D	2800	740	700	185	+ 3-4%
TM04A & D	805	213	201	53	+ 2-4%
TM06A & D	405	107	101	27	+ 2-4%

(1) Hall Effect pulser should be used whenever external DC power is available, *even if used with a battery powered register.*
(2) Value shown is rounded to nearest 100 PPG. Individual meters can vary by +/-1%. K Factor decreases with increased liquid viscosity.

TS Series Meters

Electronic meters have been produced in 3 generations:

1st With 2 or 4 magnets inside the oval gears. *Obsoleted in 2003*.

2nd With multi-pole (4, 6 or 12) magnet wheel in flow meter the front cover. *Phased out in 2009/2010.*

3rd Wave Form = single magnet in vertical plane on rotor coupling. This higher pulse resolution design has been phased in gradually since 2007.

In the 2nd generation it was recognized that the Reed Switch pulser would wear out quickly, unless the pulse resolution was reduced. Thus, the number of magnets were reduced in meters with that pulser only.

The 2007 change to ***Wave Form pulser*** represents a breakthrough in flow meter design:

- Only 2 moving parts = less wear & maintenance.
- Flow meter can be serviced without removing the register.
  - Field rebuild a flow meter in-line in 20 minutes.
  - No risk of swapping registers with other flow meters.
- The flow meter is 5" smaller front to back than the previous version, which was as large as the competitors.

In the Wave Form version, only Hall Effect & Quadrature Hall Effect signal options are available.

Pulser type (1) (2)	3rd gen.		2nd gen.		1st gen.	
Magnet:	Wave Form		Disc		In Gears	
Model	PPG	ppl	PPG	ppl	PPG	ppl
TS10A, OS	2176	575	136	36	136	36
TS10A, NS	1728	456				
TS10C	2176	575	136	36	136	36
TS15A, OS			108	28	68	18
TS15A, NS	1013	268	188	50		
TS15C	1152	304	108	28	68	18
TS20A, OS			101	27	34	9
TS20A, NS	395	104	72	19	24	6
TS20C, OS			101	27	34	9
TS20C, NS	395	104	72	19		
TS30A & C	275	73	51	13		

(1) Hall Effect pulser should be used whenever external DC power is available, *even if used with a battery powered register.*
(2) Waveform pulser offers Hall Effect or Quadrature Hall Effect out put. When pulse resolution exceeds capacity of receiving instrument, or when exactly 10 or 100 PPG is required, a scaler can be added.
(3) Value shown is rounded to nearest 1 PPG. Individual meters can vary by +/-1%. K Factor decreases with increased liquid viscosity.

From an **electronic flow meter/register** there are several variables, which need to be considered to ensure that meter pulse signal is compatible with the receiving instrument. ***It is the responsibility of the system engineer or designer to verify that the pulse signal is compatible.***

- Voltage requirements for pulser & instruments.
- Type of pulse signal accepted by the receiving instrument.
  - Sinking or Sourcing signal?
  - Standard, Complementary or Quadrature signal?
- Minimum & Maximum pulse frequency accepted.
- Pulse width (on/off time) requirements.
- Voltage = ON and OFF values.

While we are familiar with signal requirements for the major register systems common in the petroleum industry, there are many industrial systems/models, which are unknown to us. For use with industrial instrumentation, ***it is distributor responsibility to verify signal compatibility.***

- **Analog Signal**

This signal is commonly used in industrial systems. It is an attractive signal, since it can be used over much greater distances. It is commonly 4-20 mA (4 mA = no flow & 20 mA = maximum flow rate), but it also exists in 0-20 mA, 0-5VDC, 0-10VDC and other variations.

Note that the analog signal is an expression of **flow rate** (volume/time unit). When calculated back to volume, there will be a difference between totalizer reading on the flow meter, and totalizer reading on the receiving instrument.

- To generate a reliable analog signal, minimum pulse frequencies are required (usually between 4.5 & 10 Hz). Check signal converter spec sheet, and verify that the frequency at minimum system flow rate will suffice.
- When converting pulse signal to analog signal, there is a degree of error (usually around ±0.15%). Thus, a totalizer based on an analog signal will never match a totalizer on the flow meter.

- **Serial Port communications**

For direct cable connection to a printer or a PC; usually limited to about 50' (17 m). When this requirement comes up, you must determine:

1. What data do they wish to capture?
This determines which electronic register or controller we can use. For example, if totalizer reading must be referenced to time & date, those functions must be available in the register.

2. Where should this part of the system be installed?
Since we cannot use Serial Port connections in a hazardous environment, this portion of the system must be in a non-hazardous zone. We need to know how far away this will be from each flow meter in the system.

3. What type of Serial Port?
- RS232
- RS422
- RS485

4. What Protocol?
Not all instruments use the same protocol. Some systems (such as EMR^3) have an open protocol, others use a proprietary protocol, and the user might need to have special software written to be able to extract data.

- **Electrical Classification**

It is necessary to establish electrical classification requirements for each portion of the system. While diesel fuel can be metered safely with electronic components in NEMA 4X (equiv. IP67) enclosures, the site safety code might call for a higher level of protection.

The industry trend is to supply Intrinsically Safe equipment, rather than Explosion Proof enclosures with large, heavy and expensive metal enclosures.

- **Wireless Communications (for Trucks)**

The **EMR^3 register** is available with wireless communications for delivery trucks. With this option, the register will upload transaction data to a home base receiver, any time the truck is within line of sight, usually a distance of 3-4 miles (5-7 km).

This option requires purchase of:
- One home base receiver
- One transmitter for each register (specify whether register is with or without the keypad kit).

This option is also the economical solution when the distance between the EMR^3 register, and the IB exceed 500' (150 m).

Programming of Electronic Registers

TTS will do basic programming of electronic registers, so they are functional upon receipt, ***provided programming instructions are included in the purchase order.***

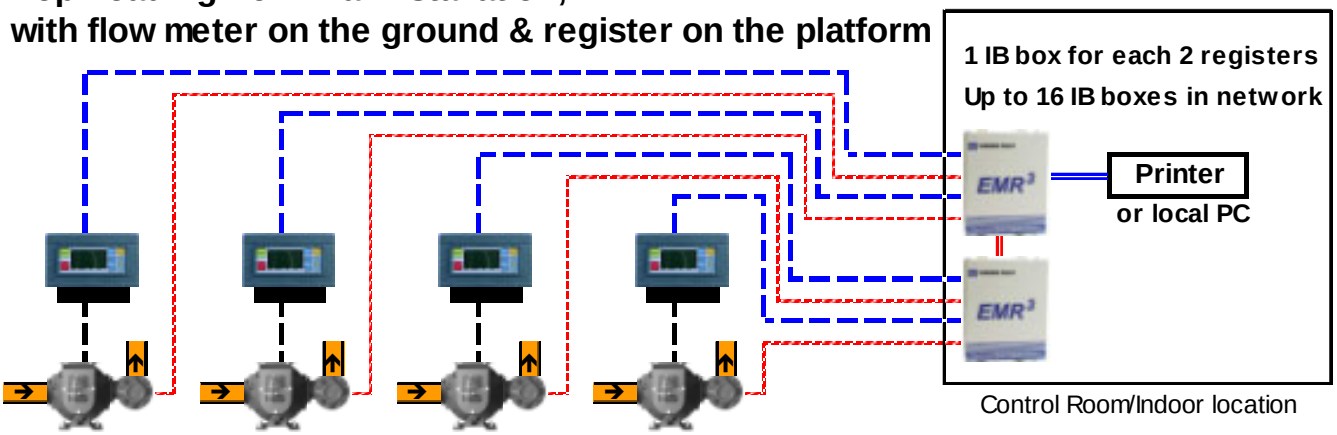
Meter calibration data should still be updated after the flow meter has been re-calibrated in place of operation.

If no programming instructions are included in the order, we will program to Factory Standard. Specifics of Factory Standard are shown in a file included on the Distributor CD (in Electronic Register.

Metering Systems & Flow Meter Networks with Electronic Register

When interviewing a customer about projects, it is important that layout of the complete site be considered, as well operating procedures. With electronic registers, there are many ways to improve on the metering systems. For example, you can replace 4 meters with individual mechanical register, preset & printer (and possible rigid extension) with:

Top Loading Terminal installation, with flow meter on the ground & register on the platform



There are numerous other variations. Common examples are:

A. Operational register mounted on the flow meter is the most basic version.

B. Same as A + remote display for a control room.

C. Operational register remote from the flow meter, which is now supplied without a register flange.

D. Same as C + local display for the operator to see.

E. Operational register local on the flow meter + operational register in remote location (*system can be operated from either location*).

In **C**, **D** & **E** an ***installation kit*** for the **remote EMR3 register** is required. This kit (P/No. AK4100) consists of two Veeder-Root flanges from the top of the RAD adaptor, one upside down mounted on the installation surface, and the other in standard position to hold the electronic register. The two flanges are then bolted together:



To quote these systems, it is important to define not only the operational procedures & requirements, but also ***the distances involved***. This is required to quote the special cable used between the register and the IB box, which must be mounted indoors (outside of the hazardous zone).

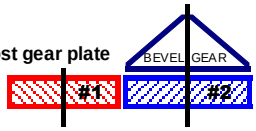
TS Series, Ratio Gear Plates for Mechanical Register

The calibrator assembly is uni-directional, so the ratio gear plate must have an even number of posts. Thus, all ratio gear plates for FPP Meters are either Pattern A, B or C, with 2, 4 & 6 gears respectively (the bevel gear is common to all gear plates, and does not count in this respect).

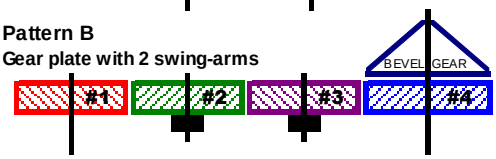
Part numbers for common ratio gear plates are listed below. Certain low frequency gear plates do not have a P/No. assigned, but are assembled from components when required.

Ratio gear plates can be assembled for units of mass (lbs or kg), but generally an electronic register is the more practical solution to measurement in units of mass. When temperature volume compensation is required, electronic registration & compensation is the only option available.

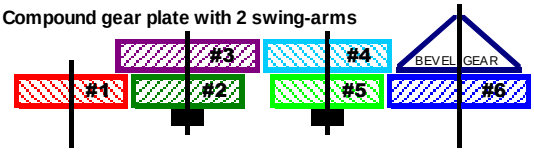
Pattern A
Standard 2 post gear plate



Pattern B
Gear plate with 2 swing-arms



Pattern C
Compound gear plate with 2 swing-arms



	Unit	Internal Reduction	Packing Gland	G/P Pattern	Gear # on Gear Plate #1	#2	#3	#4	#5	#6	SHORT (standard)	LONG (for preset)
TS10D & OS TS10A	1/10 gallons	12 : 1	2 : 1	A	47	70					GP560T2-1	
	liter	12 : 1	2 : 1	C	28	55	57	57	29	58	GP560L	GP560L-UD
	1/10 liter	12 : 1	1 : 1	A	66	52						
NS TS10A	1/10 gallons	12 : 1										
	liter	12 : 1										
	1/10 liter	12 : 1										
TS15C & OS TS15A	1/10 gallons	12 : 1	2 : 1	A	66	52					GP580T2-1	GP580T2-1-UD
	liter	12 : 1	2 : 1	B	28	57	57	58			GP580L2-1	GP580L2-1-UD
NS TS15A	1/10 gallons	12 : 1	1 : 1	A	50	68					GPTS15-70T1-1	GPTS15-70T1-1-UD
	liter	12 : 1	2 : 1	A	42	75					GPTS15-70L2-1	GPTS15-70L2-1-UD
OS TS20A OS TS20C (100 GPM)	1/10 gallons	12 : 1	1 : 1	A	67	50					GP590T1-1	GP590T1-1-UD
	whole gallons	12 : 1	2 : 1	C	28	52	57	57	30	60		
	liter	12 : 1	2 : 1	A	59	58					GP590L2-1	GP590L2-1-UD
	dekaliter	12 : 1	2 : 1	C								
NS TS20A NS TS20C (150 GPM)	1/10 gallons	12 : 1	1 : 1	A	77	41					GPTS2HT1-1	GPTS2HT1-1-UD
	whole gallons											
	liter	12 : 1	1 : 1	A	49	69					GPTS2HL1-1	GPTS20L-UD
	dekaliter	12 : 1	2 : 1	C	28	54	30	60	29	54		
TS30	1/10 gallons	12 : 1	1 : 1	C	64	39	57	57	64	39		
	whole gallons	12 : 1	2 : 1	A	41	76					GP5201G2-1	GP5201G2-1-UD
	liter	12 : 1	1 : 1	A	59	58					GP5201L2-1	GPTS30L-UD
	dekaliter	12 : 1	2 : 1	C	34	75	57	57	34	75		

Legend: Std. US unit of calibration | Std. Metric unit of calibration | Non-Std | Ext. Lead Time

1:1 P/G pinion + Face Gear = GS2002 for Stationary Service or GS2002 for Tank Truck Service

2:1 P/G pinion + Face Gear = GS2001



Air Elimination

- **General comments**
- **When not required**
- **Tank Truck Systems**
- **Metering product into storage**

PD meters cannot tell the difference between liquid and air or vapors. Thus, if air or vapor can occur in the lines, an air eliminator is required to avoid recording air/vapor as liquid. In some systems air will only occur very rarely, n such cases a simple air eliminator will usually suffice. In other systems air will appear on a regular basis, so high efficiency air elimination is called for.

- Standard air eliminators (AE) are installed on top of the strainer, and function based on a gravity principle. Thus, the strainer/AE assembly must always be installed in a **horizontal position** in the system.
  - When the air eliminator starts to vent, a few drops of product might exit through the vent port. The vents should be piped to storage or a collection tank, with lines sloping towards the tank.
- An AE performs best with some backpressure (8-10 PSI = 0.6+ BAR). This value is commonly reached between the flow meter, control valve and a hose reel/hose. In systems with lesser differential, this effect can be achieved by adding a backpressure valve (BPV) between strainer & flow meter.

  Some regions have a preference (regulatory demand) for an air check valve (ACV), which stops the flow when the air eliminator vents. When ACV is used, BPV is not necessary.
- The AE depends upon air/vapors separating from the liquid during passage of the strainer. The higher the viscosity, the slower any air/vapor bubbles present will rise out of the liquid, so flow rate and liquid viscosity are very important factors in evaluation of likely AE efficiency.

The general rules concerning air elimination are:

* Free air (ahead of the liquid) will always vent. The only exception to this is on extremely high viscosity liquids (molasses, asphalt, fuel oil No. 6, etc.), where the AE float might get hung up against AE case if coated with the liquid.
* Bubbles/entrained air will release freely from low viscosity liquids (alcohols, gasoline & solvents).
* From medium viscosity liquids (such as diesel fuel & fuel oils Nos. 2-4), bubbles/entrained air will release freely at low velocity (flow rate vs. line diameter), but will not have time to do so in a standard strainer at higher velocities. ***A high capacity strainer may be required.***
* On high viscosity liquids (> 150-170 cSt = 7-800 SSU for this purpose), bubbles/entrained air will not have time to release from the liquid, unless a very large size holding tank is placed under the AE.

In three types of systems, an AE is not necessary:

- When the liquid comes from an underground storage tank (UST), and is extracted with a submersible pump.
- When the liquid comes from an above ground storage tank (AGT), which is fitted with a low level knock-off switch. Yet, if the installation is subject to W&M regulations, an air eliminator might still be required to satisfy those regulations.
- Metering water directly from municipal supply, as lines are normally full of water.

Tank Truck Systems

Here we have to distinguish between two types of tank trucks:

A. Tank Truck with a Pump

B. Tank Truck unloading via gravity flow

A. Tank Truck with a Pump

Commonly used for retail delivery, these vehicles can have from 500-3,000 gallon (2,000-10,000 liter) tank capacity. While smaller vehicles might have a single compartment tank, most larger vehicles have multiple compartments.

In tank truck systems subject to W&M regulations, an AE is always required. If the system must satisfy socalled ***Split Compartment Testing***, vehicle design (tanks, manifold and pump) becomes a factor in the efficiency of the AE.

If the system is not designed to minimize the amount of air drawn into the pump, this increases the demands upon the AE supplied with the flow meter. On medium viscosity liquids such as diesel fuel & light fuel oils, a high capacity strainer might be required to give the air additional time to rise out of the liquid.

- On single compartment trucks, a standard AE will usually suffice. ***A backpressure valve (BPV) is recommended.***
- On gasoline and other low viscosity liquids, a standard AE will suffice. ***The BPV is recommended.***
- On diesel fuel/light fuel oils, ***the BPV is recommended***. If the velocity exceeds 6 feet/s (180 cm/s), the **high capacity strainer** is required to satisfy split compartment testing. This limit translates to:

  2" system 70 GPM (265 lpm)
  3" system 140 GPM (530 lpm)
- On high viscosity liquids (> 150-170 cSt = 7-800 SSU), effective air elimination is difficult/impossible. A high capacity strainer should perhaps be considered.

- In truck systems where air is introduced repeatedly, such as when pumping out of drums or totes, BPV or ACV is mandatory.

B. Tank Truck unloading via gravity flow

These tank trucks are much larger, and usually have 6 compartments. With bottom loading the piping system is 4", and gravity flow achieves flow rates around 250-350 GPM (900-1300 lpm).

This type of system requires a flow meter with minute Delta P values, as well as a special air eliminator + control valve to stop flow when air is a present. Currently TTS does not offer this type of flow meter/AE.

Metering Product into Storage

Here we need to distinguish between 3 possible combinations of delivery system (truck) and receiving tank:

C. Gravity truck into Underground Storage Tank

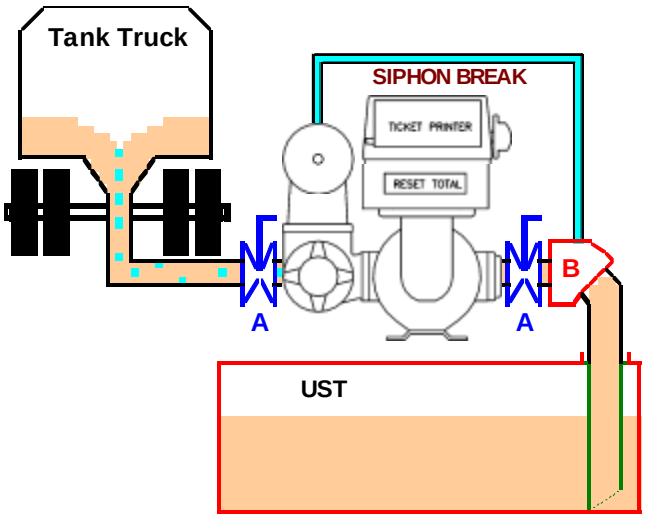
D. Truck with Pump into Underground Storage Tank

E. Truck with Pump into Above Ground Tank

C. Gravity truck into Underground Storage Tank

It is very difficult to avoid recording some air as liquid in this type of system. When the liquid level in the tank truck drops towards empty, a vortex forms above the drain, pulling air into the discharge line. With little backpressure, the AE is not as efficient as could be desired.

Further, since most USTs have a drop tube (to avoid splashing the product into the tank), a siphon effect is created, where liquid/air mixture is pulled through the flow meter. To minimize this effect, install a siphon break (connection) between the AE vent port, and piping just downstream of the flow meter.



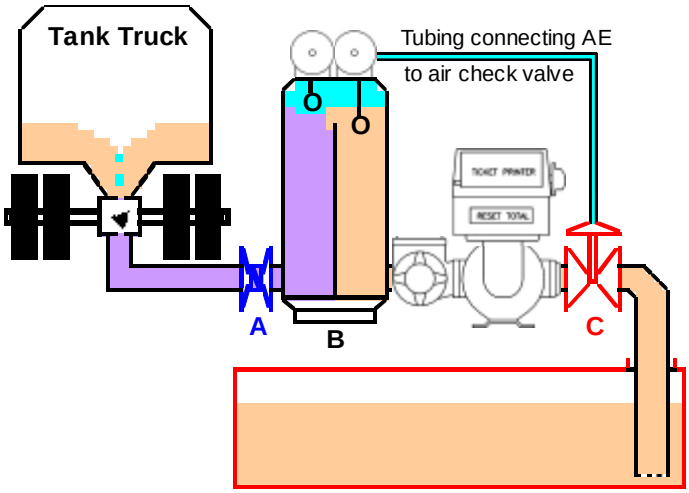
A = Manual butterfly valve (isolation valve)

If the flow meter is portable (brought out when deliveries arrive), a tilt flange (B) is recommended. This allows the flow meter to be drained of product at the end of the delivery. If the flow meter is installed permanently at the delivery point, this option is not necessary.

D. Truck with Pump into Underground Storage Tank

Here the situation becomes more complex. When air starts getting into the discharge line, the pump will mix the air into the liquid. In the case of diesel fuel & fuel oil, what arrives at the flow meter is more like a 'foam'. A standard AE cannot get rid of air in this state.

The ideal installation to deal with this situation requires some additional components (currently not available from TTS), as outlined in this diagram:



A = Swing check valve

B = Bulk Plant Air Eliminator (dual head)

C = Air Check Valve

Here the very large tank gives the 'foam' time to separate into air & liquid. The first AE (high float) can vent without activating the air check valve (ACV). Only when there is so much air present, that the second AE (low float) is activated, will the ACV stop the flow until all air has been vented.

E. Truck with Pump into Above Ground Tank

This variation requires components similar to type D system.

Tuthill

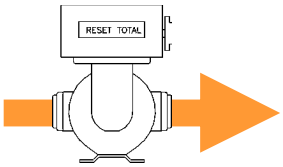
FPP METERS

Installation & Start-Up

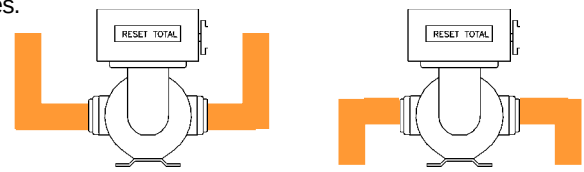
- System Design
- Installation recommendations
- Start-Up procedures
- Parts Orders/Meter Serial No.

System Design

- Flow meter must be installed on pressure side of pump. PD meters are not designed for service on suction/vacuum side.
- Flow meter repeatability suffers if delivering liquid directly to atmosphere (open tank). Valves, hose or other components to provide backpressure, and keep meter full of product, will improve on flow meter repeatability.



- Flow meters perform best if sudden jumps in flow rate or liquid temperature can be avoided.
- Design piping, so that the flow meter will be full of liquid at all times.



GOOD INSTALLATION **POOR INSTALLATION**

- Meters can be installed in vertical lines, **if the flow goes up**.
  - TS20 & TS30 with any register.
  - TS10 & TS15 only with remote electronic register.
- 1" & larger flow meters should be secured to a firm support (do NOT 'hang' meters on piping).
- Include:
  - Connections for calibration in place on operating liquid.
  - Isolation valves so meter can be serviced in place.
  - A bypass line in critical service installations, so flow can continue even while the flow meter is being serviced.
  - Thermal relief valves in pipe sections, which can be isolated between two closed valves.
  - A deadhand pressure gauge near the flow meter.
- Allow room for removal/cleaning of strainer basket.
- If an air eliminator is included in the assembly, provide for collection of any product that might exit when the AE vents.

Installation Recommendations

- Leave pipe protectors in flanges till ready to install.
- Install flow meter with firm support and without pipe strain.
- Slowly fill the system with liquid, to purge all air.
- Flush the system prior to installing the flow meter. If not possible, then temporarily remove rotors from the flow meter, so system debris can be flushed without damaging rotors.

Start-Up Procedures

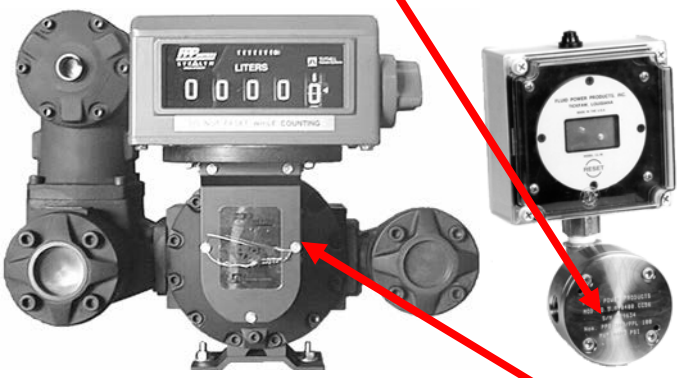
- ***Do not*** operate the flow meter on air.
- ***Slowly*** fill the flow meter with liquid, allowing time for liquid to fill meter end covers.
- ***Gradually*** increase the flow rate to full system flow.
- Calibrate the flow meter in place, on actual operating liquid.
- Establish a permanent file for each flow meter, tracking flow meter service/maintenance record and re-calibration data.

Failure to follow these instructions can result in serious damage to flow meter internals. That type of failure is not covered by product warranty.

Parts Orders/Meter Serial No.

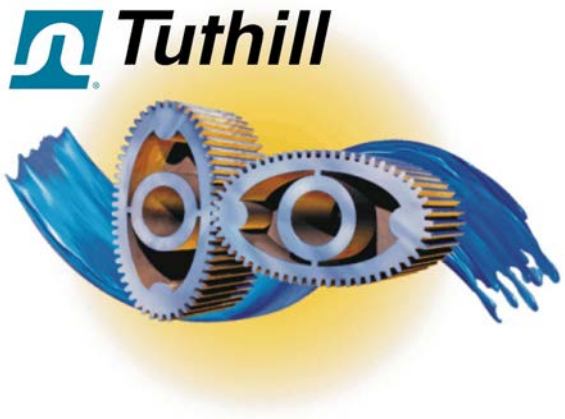
Over the years several models have undergone revisions in order to improve on the product. To ensure correct supply of spare parts, it is imperative that every inquiry & purchase order for spare parts include the Serial No. of the flow meter.

On **TM Series** flow meters the S/No. is engraved on flow meter cover plate.



On **TS Series** flow meters the S/No. is on the Spec Plate, which is attached on the side of the RAD register adaptor.

Electronic registers are also updated from time to time, so here the S/No. is even more important. Separate S/Nos. apply to the **ELNC** & **EMR³** electronic registers; please look at the register enclosure for the S/No. for these products.



Meter Calibration

- **Frequency**
- **Methods & Procedures**
- **Formula**
- **Calibration Connections**
- **Record Keeping**

Meter Cal, 2006-1

All FPP Meters flow meters are calibrated prior to shipment from the factory. However, test fluid in our flow lab is rarely the same liquid, as the one the flow meter will be used to measure in the field. To ensure accurate measurement, it is strongly recommended (mandatory), that every flow meter be recalibrated after installation in place of use, on the actual liquid of service.

Frequency

If the flow meter is used in Custody Transfer service (subject to Weights&Measures regulations), it must obviously be re-calibrated in accordance with local W&M regulations. In most cases these regulations call for annual re-calibration, though different time periods apply in some territories.

If the user is ISO9000 certified, user ISO standards will indicate frequency of re-calibration for instrumentation. Those rules should be observed.

If neither W&M regulations, nor internal standards apply, our recommendations are:

A. Calibrate immediately after installation.
B. Re-calibrate after 15-30 days.
C. Re-calibrate after 180 & 360 days.

After the run-in calibration (B) and follow-up calibrations (C), it is possible to evaluate degree of change under normal operating conditions. Based on values found, and total volume being metered under normal operating conditions, decide whether a 6, 12 or possibly 24 month schedule should be adopted.

Methods & Procedures

There are three common methods for re-calibration of flow meters:

- ♦ Against a certified prover tank.
- ♦ Against a Master Meter
- ♦ Against a Scale

Proper re-calibration requires tests of at least 60 seconds duration, to minimize the impact of greater meter error during start-up and shut-off.
All tests must be performed 3 times, to confirm that the flow meter repeats.

When testing is done against a prover tank (test measure), it is **not** acceptable to test TS Series meters with 40-250 GPM (150-950 lpm) capacity, against a typical 5 gallon (20 l) test measure used to calibrate retail service station dispensers. A meter with 100 GPM (380 lpm) capacity, operating at 82 GPM (310 lpm), should not be tested on volumes smaller than 82 gallons (310 liter).

Volumetric Prover Tank
This is the most accurate proving device, but it is very expensive and might be too large to transport to the place of operation. It is also a very slow method, as you repeatedly have to fill and drain the prover tank.

Scale
A common method, but the least accurate. Results depend not only upon accuracy of the scale, but also:

- Resolution of scale (many weigh bridges are calibrated in 10 or 25 lbs (5 or 10 kg) increments. This is not adequate to evaluate a 0.05% difference in 82 gallons of diesel fuel, since 0.041 gallon @ 0.85 sp.gr. = 0.29 lbs (132 g).
- Liquid evaporation or spills if the tank has to be transported over significant distances to get to the scale.
- If a tank truck is used for large liquid volumes, you have fuel consumed in driving to & from the scale.

Master Meter
Where allowed, this is the most practical approach to flow meter re-calibration. It is connected in series immediately after the operating flow meter (**OM**), and liquid used in testing can be circulated directly back to storage.

A Master Meter (**MM**) is a standard flow meter, which repeats well, and which has had meter error documented well through calibration at 5 or more points over the operating range. The MM must have a register and a Rate of Flow display, ***but no other accessories aside from isolation valves.***

The Rate of Flow display is necessary to determine flow rate during individual tests. Without this value, you would not know what MM error to include in the equation, when calculating correction for the OM.

Procedures
Correct re-calibration procedures are the same for all 3 methods. The first step is to wet down the test equipment:

Prover:	Fill the tank and let it drain.
Scale:	Fill the vessel and let it drain.
Master Meter:	Slowly fill the MM to purge air, then circulate liquid for 1-2 mins to equalize the temperature.

- In systems where the flow rate can vary, the OM must be tested at minimum, intermediate & maximum flow rates.
- In systems with a PD pump, where the flow rate is constant, testing can usually be limited to normal flow rate.

Run 3 tests at each flow rate. If one result differs significantly from the other two, an aberration is likely to have occurred. Run one more test to verify this.

* If test #4 agrees with the two earlier tests, discard the aberration, and use the average of the other 3 tests for calibration purposes.
* If test #4 varies as well, this meter is no longer repeating well.

  In a mechanical flow meter, this is an indication that the calibrator is worn out. If calibrator does not turn smoothly, replace.

Calculating OM Correction

With initial testing completed, calculate whether a correction is required as follows:

$$\frac{\text{(Vol in Prover) - (Vol on OM register)}}{\text{Volume in Prover x 0.01}} = \%\ \text{correction}$$

If using a MM, where MM error is documented with an accuracy curve, we have to include this in the equation:

$$\frac{\text{(MM Vol. +/- correction) - (Vol on OM register)}}{\text{(Volume on MM +/- correction) x 0.01}} = \%\ \text{correction}$$

Example:

Flow rate in test:	85 GPM
MM error at 85 GPM	+0.12%
MM register gross reading	91.63 gallons
OM register reading	91.33 gallons
MM **net reading** is 91.63 -0.12% =	91.52 gallons

$$\frac{91.52-91.33}{0.9152} = +0.21\%\ \text{correction}$$

With a **positive value**, we have to **increase the value on OM register**. This means:

- Mechanical meter with calibrator assembly:
  Turn the calibrator dial towards **negative**
  Each 'click' = approx. 0.03% change.
- Electronic meter without calibrator assembly:
  Program a smaller K Factor in the electronic register

Record Keeping

Maintain a written record for each flow meter, and document degree of change each time the flow meter is re-calibrated. As long at the change is small, the flow meter is exhibiting normal wear.

If there is a sudden increase in the degree of change, the flow meter should be re-built (with a new set of oval gears).

Recommended Piping & Calibration connections:

A.1 & A.2: Isolation valves (NO), so meter can be serviced.

B: NC valve on optional by-pass line, permitting flow to continue while flow meter is being serviced.

C.1 & C.2: NC valves on calibration connections.

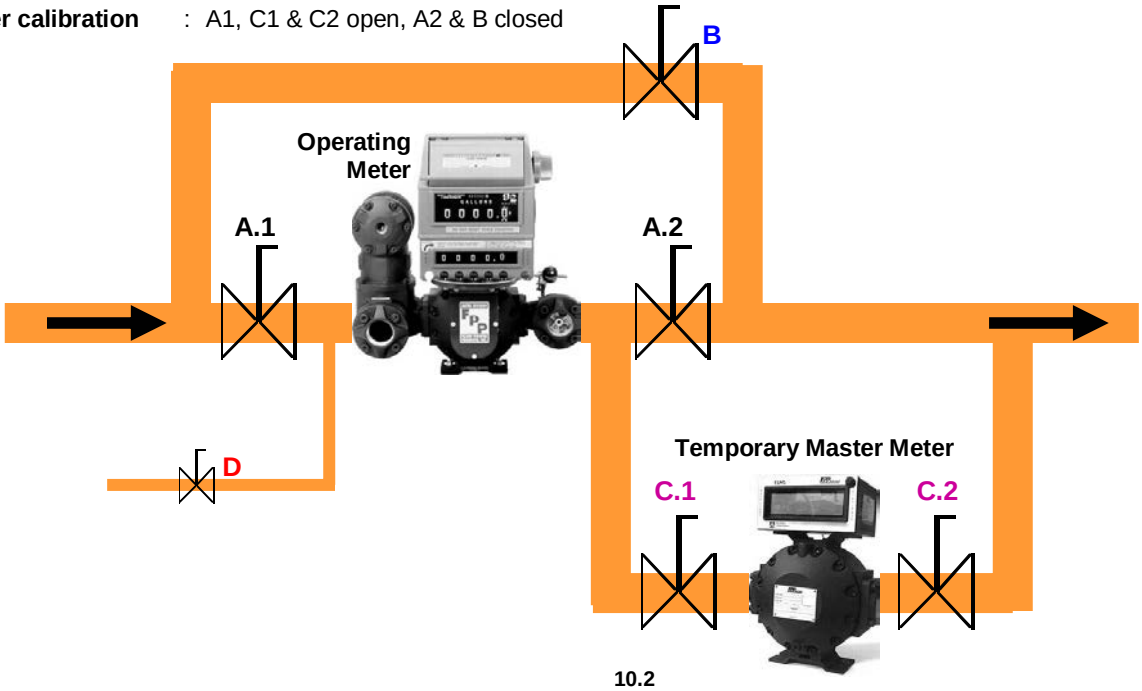
D: Thermal relief valve, in case A & C are closed.

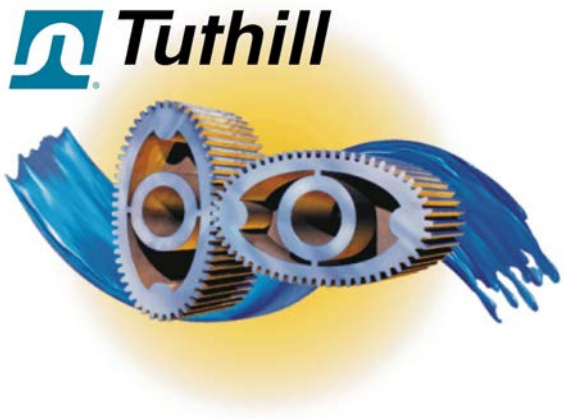
Normal operation : A open, B & C closed.

Flow meter service : A, B & C closed.

Service with by-pass: B open, A & C closed.

Meter calibration : A1, C1 & C2 open, A2 & B closed





Meter Calibration Report

- **TS Series flow meters**
- **TM Series flow meters**
- **TN Series flow meters**

Calibr Rpt, 2006-1

Tuthill Transfer Systems (TTS) calibrates all flow meters prior to shipment, on equipment and to standards as stated below. Test data is ordinarily not released to the field, since results on our test fluid rarely will apply to the liquid the flow meter will be used to measure in the field. Depending upon meter Series, differences in liquid viscosity can result in meter curve shifting anywhere from less than 0.1% to perhaps as much as 3-5%.

A **Certified Test Certificate** with actual test results is available at a fee (see current price list for prevailing rates), ***if requested in the purchase order.***

* **TM** & **TN Series** meters ordinarily undergo pass/fail testing, so a Certified Test Certificate cannot be issued for these models after the flow meter has shipped.
* For **TS Series** meters a Certified Test Certicate can be issued after shipment if requested, but additional fees apply.

TS Series meters for Custody Transfer service

- **Models TS10, TS15 & TS20**
  Calibrated with multiple runs at 3 flow rates against Master Meter with S/No. 2HA063276. Master Meter is calibrated periodically against Seraphin model J prover, S/No. 96-118.
  Fluid : Water
  Temperature : 60-85°F (15-30°C)
  Pressure : Static test to 150 PSI (10 BAR)
  * Meters shipping to Australia & EEC are tested to OIML R117 standards, requiring ±0.30% linearity over 10:1 turndown.
  * Meters shipping to other destinations are tested to NIST standards, requiring 0.175% linearity over 5:1 turndown.
- **Model TS30**
  Calibrated with multiple runs at 3 flow rates against Master Meter with Serial No. WF152013. Master Meter is calibrated periodically against a certified prover, tracable to NIST.
  Fluid : Stoddard solvent, viscosity 1.5-3 cSt.
  Temperature : 40-95°F (15-30°C)
  Pressure : Static test to 150 PSI (10 BAR)
  * Meters shipping to Australia & EEC are tested to OIML R117 standards, requiring ±0.30% linearity over 10:1 turndown.
  * Meters shipping to other destinations are tested to NIST standards, requiring 0.175% linearity over 5:1 turndown.

TM Series meters for Inventory/Process Control

- **Model TM02**
  Calibrated with multiple runs against Master Meter with S/No. 99510718. Master Meter is calibrated periodically against a certified prover (we have several low volume provers on hand).
  Fluid : Alcohol, viscosity 0.7-1.0 cSt
  Temperature : 60-85°F (15-30°C)
- **Models TM03, TM04 & TM06**
  Calibrated with multiple runs against Master Meter with S/No. PT11431. Master Meter is calibrated periodically against a certified prover, Seraphin model F, S/No. 41338 or model E, S/No. 02-12612-02.
  Fluid : Stoddard solvent, viscosity 1.5-3 cSt
  Temperature : 60-85°F (15-30°C)

To pass testing **TM Series** meters must satisfy:
Linearity : ±1.0%
Repeatability : ±0.25%

TN Series meters for Inventory/Process Control

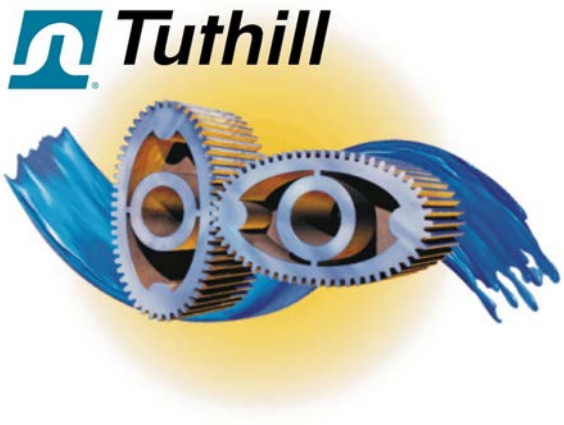
- **Models TN740, TN760, TN840 & TN860**
  Calibrated with multiple runs at 2 flow rates against Master Meter with S/No. B1063249. Master Meter is calibrated periodically against a certified prover, Seraphin model E, S/No. 97-4261.
  Fluid : Water
  Temperature : 60-85°F (15-30°C)
  Pressure : Static test to 300 PSI (20 BAR)

To pass testing **TN Series** meters must satisfy:
Linearity : ±2.0%
Repeatability : ±0.5%

Non-Standard Testing

- Testing to customer specifications (in terms of specific flow rate, additional test points or specific zero error point) is available at an additional fee. Please inquire for specifics.

Testing on specific liquids is not available from TTS. It might be available from outside test laboratories at additional cost. Please



Order Details

- **Operating Conditions**
- **Calibration Details**
- **Assembly Specifications**
- **Delivery Requirement**

Order Details, 2006-1

Even through both **FPP Meters** & **Fill-Rite Products** are Tuthill Transfer System brand names, the two products cannot be ordered in a single purchase order. The two products must be ordered separately, since they ship from different locations and are subject to different sales, discount & freight policies. For international distributors requiring a consolidated shipment, we will endeavor to coordinate the shipping dates from the two plants.

For FPP Meters products, there are a number of practical details, which should be included in every purchase order. To ensure that all details are included, we strongly recommend that you submit an ***Application Data Sheet*** with every purchase order. *Application Data Sheets* are found on the Distributor CD.

Operating Conditions

It is important that operating conditions be included in every purchase order. If operating conditions are not included, we have no opportunity to confirm that the flow meter assembly specified is suitable for the intended service. If meters are ordered for stock, simply state this and the expected service (such as: ***Stock - low viscosity petroleum products***). The details required varies with the model:

TS Series

- Liquid* & Operating Conditions*
- Direction of Flow
- Accessory inlet & outlet positions
- Strainer: Basket mesh size, if different from standard
- Printer : Zero start is standard, Accumulative is optional

TM Series

- Liquid* & Operating Conditions*
- Whether accessories (if any), are to be installed on the flow meter, or supplied separately for local installation. ***Fees apply to installation by TTS.***
- Strainer: Basket mesh size

TN Series

- Liquid** & Operating Conditions**.

* **Liquid name** (not generic, such as 'additive').
Minimum & Maximum **flow rate**.
Minimum & Maximum **operating temperature**.
Maximum operating **pressure.**
Product viscosity over operating temperature range.

** TN Series meters are calibrated to viscosity of the liquid using change gears between the measuring chamber and the register. Thus, it is imperative that liquid, operating temperature & viscosity over full operating temperature be included in orders for TN Series meters with mechanical register.

The calibration can be changed in the field, but gears are very difficult to align correctly, unless you have a special tool ('spider'). This tool holds the drive gear, while you align the swing-arm & transfer gear in the gear plate.

Mechanical Register, Calibration

There are practical limits on gear ratios in the drive train between the measuring chamber and the register. These limits dictate, which units of calibration are available for each model size.

The P/No. for flow meters with mechanical register, includes an identifier for the unit of calibration. For TS Series it is in pos. 9, and for TN Series it is in pos. 13.

Standard register calibration by model:

	US	Metric
TS10	1/10 gallon	1/10 liter
TS15	1/10 gallon	Whole liter
TS20	1/10 gallon	Whole liter
TS30	Whole gallon	Whole liter (dekaliter optional)
TN860A	Whole gallon	Whole liter

Electronic Register, Calibration

TTS will provide basic programming of electronic registers ordered on flow meters, ***provided that the purchase order specifies how the register should be programmed***. If programming is not specified, we will program as shown in ***FPP Standard Programming*** (see file on the Distributor CD). Changes or corrections to such standard programming are distributor responsibility.

Electronic registers can be field programmed. They have no mechanical restrictions on units of calibration, but they do have practical limits. Limits are based on pulse resolution available from the flow meter. Ideally the K Factor should be at least 10 for whole units & 100 for display with 1/10th unit. If smaller K Factors are entered, the degree of uncertainty for the smallest unit is simply higher. For example, model TM06 resolution is:

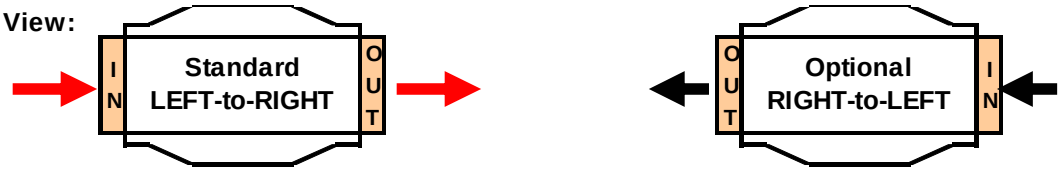
HE pulser, standard: 405 PPG (= 107 ppl)

RS pulser, standard: 101 PPG (= 27 ppl)

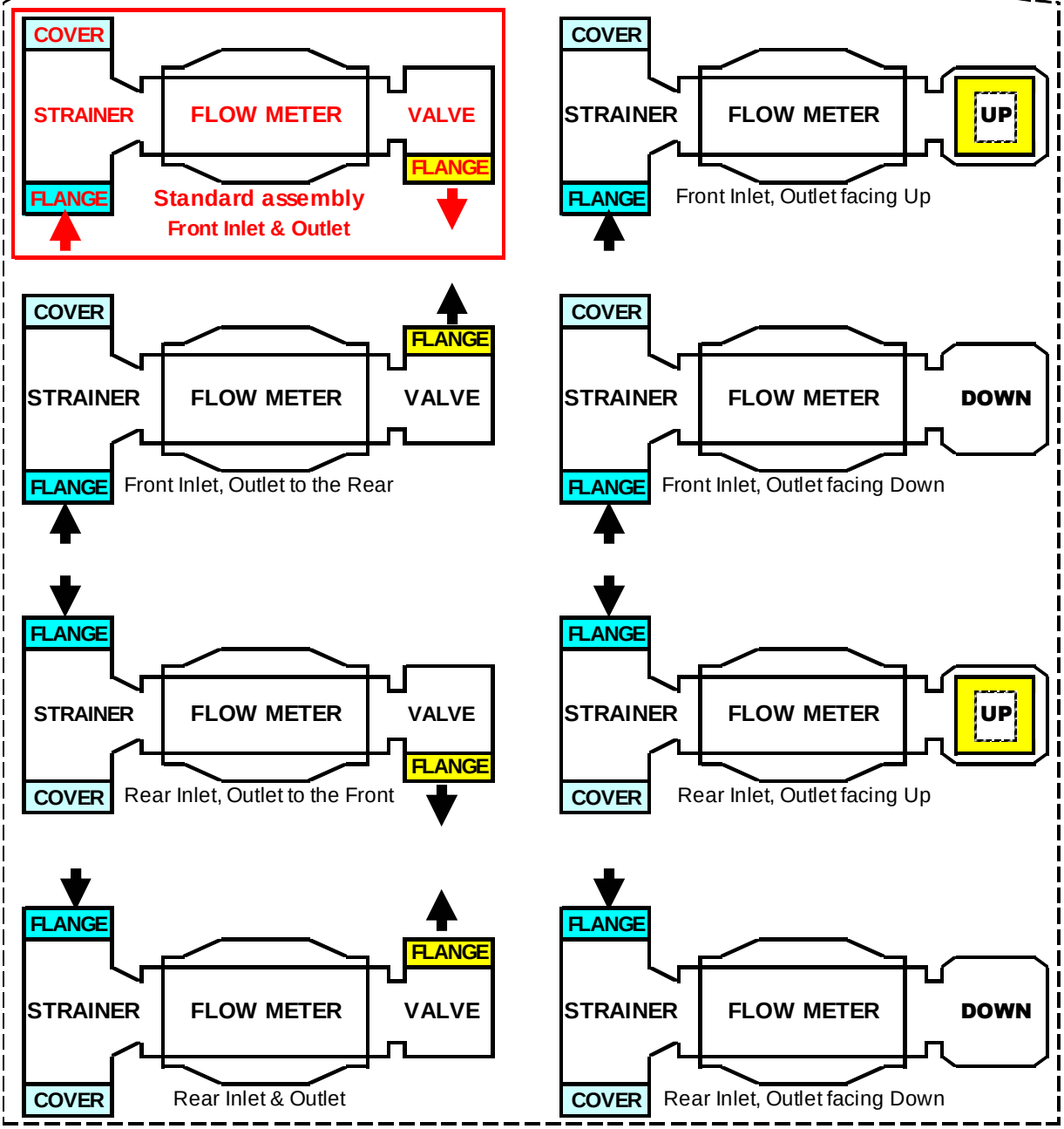
Both support gallons with 1 decimal, but only high resolution supports liter with 1 decimal. 2 decimals are not possible in either case.

To fit into the system as conveniently as possible, TS Series meters can be assembled in 16 different configurations, as outlined below. ***If the order does not specify assembly***, ***we will supply standard configuration (shown in red box).*** Most configurations can be field re-assembled. The only exception concerns models with mechanical preset valve. Some valve positions require a modified valve linkage.

Top View:



With mirror image of the 8 variations shown for Left-to-Right assembly



Product Availability

When quoting large quantities (10+ units), please consult with Customer Care or your Area Manager for product availability. For smaller quantities you can normally expect the following rules to apply.

Price lists for FPP Meters are coded with three symbols, indicating normal lead time for all models & options in reasonable quantities (1-5 pcs in anodized aluminum, 1-2 pcs in stainless steel):

● = Standard Product
Our goal is to ship these products in 2 weeks or less. In an emergency situation, we will try to accommodate urgent requirements for single units in 1-2 days.

▲ = Regular Product
This applies to modifications such as **HT** or **HV** rotors, and also flow meters with Teflon seals. Ordinarily these meters are available within 2-4 weeks.

■ = Non-Standard Product
This applies to product purchased or machined to order, including solenoids with non-US voltage and certifications. Ordinarily the lead time is 6-10 weeks, in rare cases extending out to 16-18 weeks (ASCO 24VDC & 240VAC solenoids with ATEX certification).

From time to time the level of demand can impact on above target lead times. Please consult with Customer Care for current situation.

TTS will make every effort to meet the requested delivery date shown in the purchase order. Thus, we ask you to indicate a realistic shipping date request, based on your actual local delivery and installation commitment. If a local deadline applies, we recommend that you consult with Customer Care when placing the order.

Our order confirmation indicates the expected shipping date, at the time the order is received. Under extraordinary circumstances delays might occur, but if so we will notify you as soon as possible.

TTS does not accept penalties for late delivery without prior consultation.

Product 'Translation'

In some cases quotation requests are based on a competitors model number. While it is possible to 'translate' into something similar from TTS, this is a dangerous practice, since:

- ***Model capacities do not match 100% between different manufacturers.***
- ***Operating conditions might have changed since the original model was selected.***
- ***Other manufacturers do not identify optional add-ons in their part numbers (such as a pulser on the mechanical register), so their model/part number might not tell the whole story!***
- ***There is no guarantee that whoever selected the competitive model knew what he was doing.***

If quoting on this basis, there is no warranty coverage for problems arising due to unsuitable service conditions.

Product Assistance

If you need assistance with model selection, please consult with Customer Care or your Area Manager. It is important that you include following details:

1. **Liquid to be metered**
   - 1.1 Minimum & Maximum **FLOW RATE**
     How many hours of operation per day?
   - 1.2 Minimum & Maximum operating **TEMPERATURE**
   - 1.3 Maximum operating **PRESSURE**
   - 1.4 If not a refined petroleum product, also **LIQUID VISCOSITY** over entire operating temperature range.
2. **Type of system** where the flow meter will be used, such as:
   - Retail delivery tank truck
   - Aviation refueler
   - Tank truck loading (top or bottom loading)
   - Marine fueling (= retail sale)
   - Railroad fueling (= fuel management system)
   - Etc.

   This will guide us as to which accessories should be included in the flow meter assembly.
3. **Functions** the flow meter should perform.
   - Is an air eliminator required?
   - Is preset (batching) function required?
   - Is a written transaction record (ticket) required?
4. **Communications requirements**, if any.
   - Pulse signal out (sinking or sourcing format, and desired pulse resolution)?
   - Analog signal out (4-20 mA, 0-20 mA, 0-10 VDC)?
   - Serial port communications (RS232, RS422, RS485)?
     - What data should be captured?
     - Distance to PC?
   - Wireless RF (DataLink™ with the EMR³)?
   - If communicating with electronics supplied by others, are there:
     - Scaling requirements (specific pulse resolution)?
     - Frequency requirements (min or max limits)?
     - Voltage requirements?
5. **Codes & Standards** the flow meter (& electronic register) must conform to, and **desired power** (AC or DC).
6. **System lay-out and distances**
   In systems involving electronic components, it is critical that distances be known, since:
   - There are limits on how far pulse signals can travel without an amplifier.
   - The EMR³ register system requires a special cable between the register and the Interconnect Box.

A form that allows quick collection of this information is shown on the next page. Please feel free to copy for your sales people.

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Tuthill
www.tuthill.com

FPP METERS

Phn: 260-747-9060
US: 888-578-3258
Fax: 800-866-4861
FPPWebInquiries@tuthill.com

Name _____ Phone _____ Date _____

Company _____ E-mail _____

To ensure correct selection of flow meter and possible accessories, please provide the following details:

Liquid(s) to be metered: _____

FLOW RATE:	NORMAL	MIN:	MAX:	GPM GPH LPM LPH M^3/H
TEMPERATURE:		MIN:	MAX:	°F °C
PRESSURE:	NORMAL	MIN:	MAX:	PSI BAR kg^2/cm kPa Pa Mpa
VISCOSITY:	@ NORM Temp:	@ MIN Temp:		SSU cSt mm^2/s cP mPa•S
TYPE of PUMP:				Circle units used

Type of operation: _____

Please describe the system (such as: Retail tank truck, rail road fueling in depot, etc.) _____

When making a choice between mechanical & electronic register, consider that the electronic system has lower maintenance requirements, and it is always more accurate than the equivalent mechanical system due to less drag on the flow meter.

For a single flow meter, the mechanical register is usually the lower initial cost. For 2-3 flow meters in one system/installation, the cost is usually comparable (within 5-10%). For 4 or more flow meters in one system, the electronic solution is usually the lower initial cost.

☐ **Custody Transfer service** ☐ **Non-custody transfer, *specify accuracy required*: +/-_____%**

Area classification: ☐ **Non-Hazardous** ☐ **Hazardous. Distance to nearest non-hazardous location:** _____

Accessories:

- ☐ Strainer
- ☐ Strainer/Air Eliminator
- ☐ High Capacity Strainer/Air Eliminator
- ☐ Backpressure Valve
- ☐ Air Check Valve
- ☐ Preset Valve, mechanical
- ☐ 2-stage electronic preset valve
- ☐ 1-stage system security valve

Flanges:

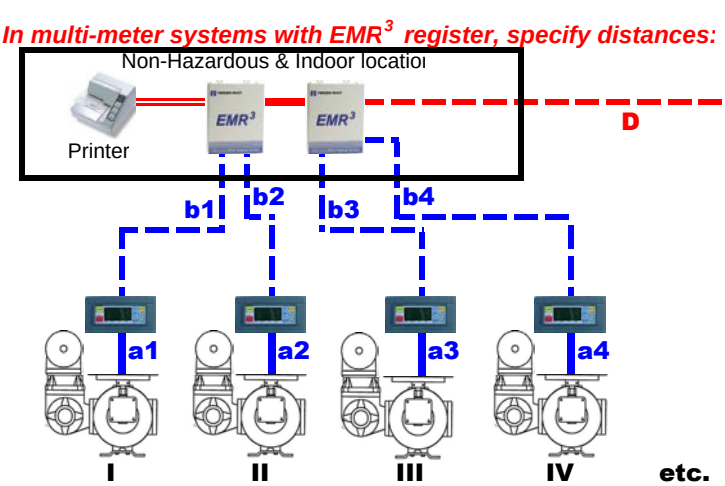
- ☐ Threaded companion flanges
- ☐ Welding companion flanges
- ☐ 150# RF ANSI flange adaptors

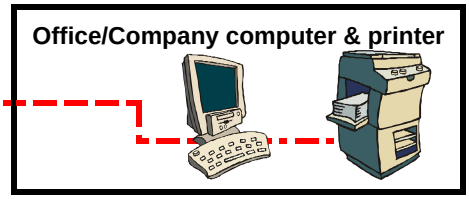
Registration, Functions & Communications:

- ☐ Register ☐ Local ☐ Remote ☐ Local & Remote
- ☐ Preset/Batching ☐ with pump control
- ☐ Printer ☐ Local ☐ Remote ☐ Local & Remote
- ☐ Rate of Flow display per MIN HOUR DAY
- ☐ Temperature/Volume comp.
- ☐ Currency function
- ☐ Remote operation
- ☐ Pulse signal — Resolution/unit: _____ Distance: _____
- ☐ Analog signal ☐ 4-20 mA ☐ 0-20 mA ☐ other: _____
- ☐ Transaction data to PC ☐ Serial Port ☐ Wireless

☐ **without register**, *specify:* ☐ Model: _____ ☐ Voltage: _____

In multi-meter systems with EMR³ register, specify distances:





a1 :	b1 :	c1 :	D :
a2 :	b2 :	c2 :	
a3 :	b3 :	c3 :	
a4 :	b4 :	c4 :	
a5 :	b5 :	c5 :	
a6 :	b6 :	c6 :	
a7 :	b7 :	c7 :	
a8 :	b8 :	c8 :	

= 0 if register is installed on flow meter

When BOTH local & remote register, **C** = the distance from interconnect box to remote register