Tuthill®

2015 PRECISION TS METERS TECHNICAL MANUAL

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This manual provides 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 cannot be responsible for model selections made in contradiction of the information and 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 Service or your Regional Manager.

INDEX

Positive Displacement Meters

Definition
Advantages
Oval Gear Principle

Positive Displacement Meters

A positive displacement meter requires fluid to mechanically displace components in the metering chamber in order for flow measurement. Positive displacement (PD) flow meters measure the volumetric flow rate of a moving fluid or gas by dividing the media into fixed, metered volumes (finite increments or volumes of the fluid). 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 registers are inherently explosion proof.
- Certified for Custody Transfer Service (W&M approved).
- Lower initial cost than a mass flow meter.

Additionally, a correctly selected PD meter has very low Delta P (pressure loss) values compared with a mass flow meter. Less pump horsepower (HP) required to push the liquid through a PD meter leads to:

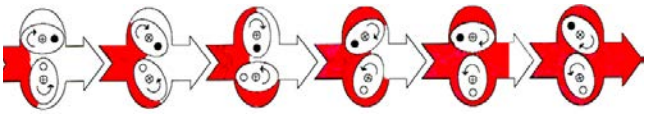
- Lower initial system costs. A system with a mass flow meter requires a PD pump with larger motor.
- Lower long term operating costs. Over the life of the system, energy cost savings can be on a scale of thousands, if not tens of thousands of dollars.

Tuthill manufactures Positive Displacement oval gear flow meters. This manual discusses TS oval gear meters.

Oval Gear

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

As the gears turn, liquid fills the space between the gear and the side of the measuring chamber, alternately in the lower and the upper half of the measuring chamber. In a complete cycle (360° turn of rotors), 4 identical liquid volumes are transferred from the inlet side to the outlet side:



0° 45° 90° 135° 180° 225° etc.

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.

TS Series

1", 1½", 2" and 3"
All sizes are NTEP certified for Custody Transfer service in the US (formerly known as NIST Certification). 1½", 2" & 3" models are certified in Canada, while certain 1", 1½", 2" & 3" models are MID approved.

Custody Transfer certifications are liquid specific, and may vary in terms of maximum flow rate approved. Lack of approval for a liquid category does not mean that the flow meter cannot be used, rather, it must undergo "on location" approval under the supervision of the local authorities.

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

Oval Gear Precision Meter Overview

Flow Meter Model
Accessories
Registration/Controller
Communication

Every flow meter assembly consists of at least two, and in many cases multiple components from the product groups defined below:

1. Basic Flow Meter

- Model size matched to operating parameters.
- Case material matched to liquid requirements.
- Internals may vary with:
  - Liquid characteristics.
  - Actual operating conditions.

2. Accessories

- 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).

3. Register or Controller, mechanical or electronic

- Mechanical Register (simple volume display)
- Electronic Register (advanced 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 must be included in the flow meter assembly.

4. Communication

Many flow meters operate as a stand-alone piece of equipment. However, communication 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 10 for signal types available.

Meter Accessories

Air Eliminator
Strainer
Control Valves

Air Eliminator (AE)

PD meters cannot distinguish between liquid and air/vapors. To avoid recording air/vapors as liquid, an air eliminator should be installed immediately before the flow meter. An air eliminator is mandatory in systems subject to Custody Transfer regulations, unless fluid is supplied by a submersible pump in an underground storage tank. Air eliminators operate on a gravity principle, so this device must be installed in a vertical position.

The operating mechanism consists of a float riding on a center shaft. When air is present the float drops, opening two valve reeds away from the vent ports (1" FNPT). Vent ports must be piped to storage or a collection tank, as a few drops of liquid might exit when the air eliminator vents.

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 (ACV), 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, PTFE opt.

Rating:

To 150 PSI (10 BAR) at 100°F (38°C) if venting to collection tank/system.
To 350 PSI (24 BAR) at 100°F (38°C) in LPG systems

Strainer

It is recommended that every positive displacement flow meter be protected against foreign particles with a strainer and required when using an air eliminator.

Standard Strainer

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 and strainer basket cover have the same bolt pattern, so the 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

Tuthill strainers are manufactured in two sizes, 2" for use with models TS15A & TS20A, and 3" for use with model TS30A. The strainer outlet flange bolts directly to meter body on models TS15A - TS30A, meters. Both strainers have an opening on top, where either a blind cover 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, PTFE opt.

Rating:

To 150 PSI (10 BAR) at 100°F (38°C)

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. Installing a backpressure valve usually eliminates the need for the alternative air check valve.

Materials

Valve Poppet & Stem	Steel/Stainless Steel
Valve Stem & Spring	Stainless Steel/Steel
Seal Ring	Viton™

Air Check Valve

In some regions regulations require use of an air check valve in conjunction with the limited bleed version of the Air Eliminator. This valve is mounted on the flow meter outlet, and requires a connection to one of the air eliminator vent ports.

The air check valve has a spring loaded piston (12-15 PSI) that is held open by system pressure. When the air eliminator opens, the 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 the piston backside, so when the valve opens, flow resumes. The connection between the air eliminator vent port and air check valve must be provided in the field (pipe, tubing or hose).

The air check 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. 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

The Mechanical Preset Valve 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.

The preset valve comes in two versions:

Low Viscosity:	to 50 cSt
High Viscosity:	50-1000 cSt

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

Mechanical Preset Valves are manufactured of Anodized Aluminum and are available in two sizes; 2" for use with models TS15A & TS20A and 3" for use with TS30A. The valve inlet flange bolts directly to meter body on models TS15A, TS20A & TS30A.

Materials:

Valve Body/Piston/Flanges	Anodized aluminum
Valve Stem & Spring	Stainless Steel
All Seal Rings	Viton™ standard, PTFE opt.

Rating:

To 150 PSI (10 BAR) at 100°F (38°C)

Solenoid Preset Valve

The preset valve is available as a solenoid operated valve for use with electronic preset and industrial batch controllers. This valve uses copper tubing and brass solenoids, and is restricted to liquids with viscosity under 50 cSt (233 SSU), and compatible with Viton seals.

This valve is available in two sizes; 2" for use with models TS15A & TS20A, and 3" for use with TS30A. The valve inlet flange bolts directly to meter body on models TS15A, TS20A & TS30A.

The Solenoid Preset 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:

- Explosion Proof solenoids
- DC or AC powered solenoids

Micro Switch Kit for 7889 Preset Counter

VR7856 is 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

Meter Registers, Data and Communications

Mechanical
Gear Plates
Electronic
Pulse, Analog or Serial Port

Mechanical Register

Positive displacement flow meters can be supplied with a mechanical register. Options on mechanical registers can include a preset counter (which could have micro switches for pump or solenoid valve control) and/or a ticket printer. The register might also have an electromechanical pulse generator, to communicate with other instruments. Mechanical registers offer solid, durable performance.

Volume Display

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

The standard register (VR7887) has five-digit reset and an eight-digit accumulative totalizer. The six-digit (VR7886) is available for high capacity registers.

Standard register calibration by model (see page 7 for pattern codes and page 21 for ratio gear plate P/Nos.):

	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

Preset Function

The VR7889 mechanical preset allows the operator to enter volume to be delivered, and features an **EMERGENCY STOP** button allowing the operator to stop the delivery instantly in the event of an emergency.

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

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

The mechanical preset is not recommended for 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:

Model	Min Batch Size		2nd Stage Trip Setting	
TS15	12 gallon	45 liter	3 gallon	11 liter
TS20	20 gallon	75 liter	8 gallon	30 liter
TS30	40 gallon	151 liter	20 gallon	75 liter

Since the preset mounts below the register, it requires an up/down ratio gear plate for the register. This gear plate has a longer drive shaft (extending through the preset), and vertical drive shaft driving both register and preset.

The preset may 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.

Printer (Written Record)

The VR 7888 mechanical ticket printer is available in two versions: zero start and accumulative.

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

The VR 7888 printer installs 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 VR7888 manual for details.

Pulse Signal from Mechanical Register

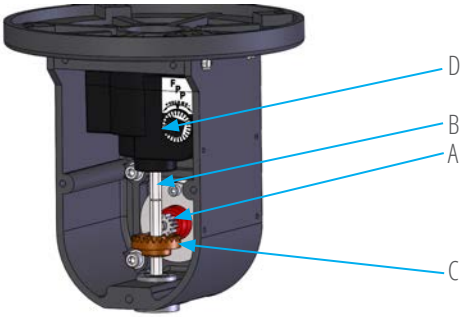
An electromechanical pulse output may be installed on the mechanical register. This is identified in position 14 of the P/No., using:

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

NOTE:

	10:1 Pulse output	100:1 Pulse output
1/10 unit register	= 10 PPU	= 100 PPU
Whole unit register	= 1 PPU	= 10 PPU

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



Mechanical Register Combinations

Mechanical flow meters may be supplied with the following combinations:

- **V03** Without register (meter with RAD adaptor & calibrator only)
- **V04** With Register (1)
- **V07** With Register and Ticket Printer (1)
- **V11** With Register and Preset Counter (1)
- **V17** With Register, Preset Counter and Ticket Printer (1)

(1) Opt. electromechanical pulse output and/or microswitch

Together with strainer, air eliminator and the optional air check valve, all these combinations can be defined in flow meter Assembly No. (=pos.6-8 in the P/No.).

TS Series, Ratio Gear Plates for Mechanical Register

The calibrator assembly is uni-directional. Thus, all ratio gear plates are either Pattern A, B or C, with 2, 4 and 6 gears respectively (the bevel gear is common to all gear plates, and does not count in this respect).

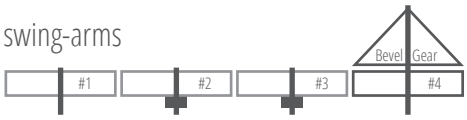
Mass ratio gear plates may be assembled for units of mass (kilograms or pounds). When temperature volume compensation is required, electronic registration and compensation is the only option available.

Pattern A

Standard two post gear plate

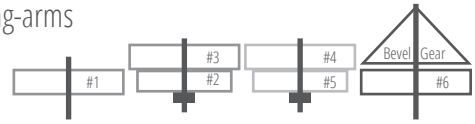
Pattern B

Gear plate with two swing-arms



Pattern C

Compound gear plate with two swing-arms



Electronic Registers

Electronic registers entered the market in the early 1990's. The advanced technology has changed the industry, and there are electronic registers for all different levels of functionality and cost. As the technology has improved, many are competitively priced versus their mechanical register counterparts and offer significant advantages:

- Low maintenance.
- Minimal torque for improved flow meter accuracy.
- Register cannot be reset while operating, and is not damaged if reset is attempted.
- Gland-less meter.
- No calibrator to wear out.
- Automated data collection.

Tuthill meters may be supplied ready for use with electronic registers, including factory installed electronic Custody Transfer service registers. Consult Installation Operation Manual for Tuthill specifications.

For flow meters with electronic registers there are additional options to consider:

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

Benefits

- Provides significantly higher pulse resolution (see page 11)
- Minimizes the number of internal parts.
- Allows service of flow meter without removal of register.

Temperature/Volume Compensation

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

Features

- Electronic flow meter with pulse output/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

*Items in blue are the minimum requirements

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

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

  Can be mounted directly on the register mounting flange, or installed remote from the flow meter.

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

- **MID:COM**

  Electrical Requirements

  Operating Voltage: 10-30 VDC unregulated
  Operating Current: Standby 275 mA
  Up to three solenoids activated: 1 Amp additional each

  Operating Environment

  Outdoors exposed to elements
  Temperature Range: -40 °F to 140°F (-40°C to +60°C)
  Humidity: 100% Condensing

Flow Meter Definitions

Types of Measurement
Turn-Down Ratio
Linearity vs. Repeatability
Terminology

Types of Measurement

The three standard approaches to measurement are:

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

There are flow meter principles based on all three measurements. Each type has strengths and weaknesses; no single metering principle is universally better than all others. When comparing different flow meters to each other, it is important to consider:

- Liquid characteristics vs. operating principle
- Operating conditions (flow rate and viscosity)
- Model 'Accuracy' (see below)
- System design
- Operational practices
- Space and weight constraints
- Local codes and approvals
- Purchase and Installation costs
- Long term operating costs, covering:
  - Service costs (ease, frequency and 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

The greater the Turn-Down Ratio, the greater influence on Delta P and Accuracy Curves.

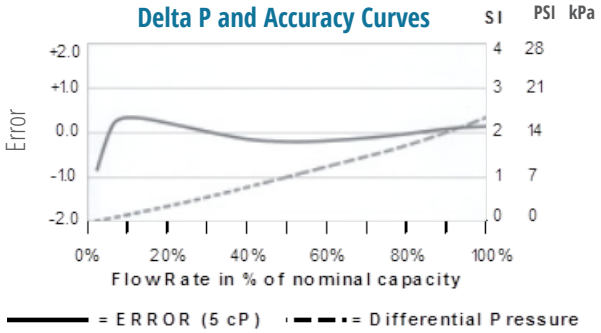
Flow Meter 'Accuracy'

This is frequently a misunderstood term; rather, it is actually flow meter error. There are two different values to consider: flow meter linearity and flow meter repeatability.

Flow Meter Linearity

Linearity is the maximum deviation from 0% error over the operating range of the meter, shown as a +/- value.

Example:



From the curve shown above we can extract error values:

Flow	Error	Notes:
5%	-0.35%	5:1 Turn-Down (20-100%) covers
10%	+0.30%	0.15% - (-0.10%) = 0.25% linearity
20%	+0.15%	0.25/2 = ±0.125% linearity
40%	-0.10%	or
60%	-0.08%	
80%	-0.03%	10:1 Turn-Down (20-100%) covers
100%	+0.05%	(Highest value - Lowest value)/2 = ± lin%

Alternatively, if we wish to consider service from 5-100% = 20:1 Turn-Down Ratio, we find +0.30% - (-0.35%) = .65%/2 = ±0.325%

Flow Meter Repeatability

When multiple tests are performed, 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

For example, six tests showing results ranging from +0.05% to -0.02% against the prover tank equals 0.035% flow meter repeatability. Therefore, when a meter is shown as "+/-0.05% 'accuracy", it is referencing flow meter repeatability.

Meter Terminology

The two terms used to describe the two types of meter assemblies are:

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

Type of Signal

There are several possible communication methods:

Pulse Output Signal

The pulse signal is a simple electrical On/Off signal (digital value). It is restricted in terms of transmission distances; the longer the distance, the potentially weaker the signal. Loss of signal is relative to distance, pulse signal strength, and wire diameter. The K-Factor (the number of pulses per unit of volume) varies by model size.

Electronic flow meters and registers have numerous variables that must 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 pulse output and instruments.
- Type of pulse signal accepted by the receiving instrument.
  - Sinking or Sourcing signal?
  - Single or Quadrature signal?
- Minimum & Maximum pulse frequency accepted.
- Pulse width (on/off time) requirements.
- Voltage ON and OFF values.

TS Series Electric Wave Form Flow Meter

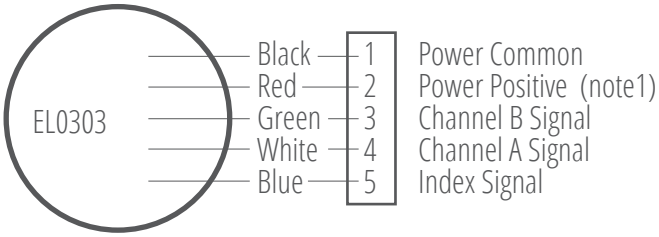
Tuthill 3rd generation electronic flow meters have an internal 'Wave Form' pulse output:

- Completely separated from the process fluid.
- With high pulse resolution
- Standard with Quadrature signal
  (use only channel A for non-Quadrature instruments).

When the raw pulse signal is incompatible with the receiving instrument, Tuthill offers signal conditioners with several functions. In most situations this will ensure proper communications. However, there are instruments on the market, which have frequency limitations (= > pulse ON time requirements). These are not compatible with Tuthill electronic flow meters. In some of these cases, a mechanical flow meter with an electromechanical pulse output on the register will work instead.

Specifications

- Integrated Circuit Hall Effect detector.
- Installed inside flow meter EXP compartment.
- Target: 2-pole magnet in SS housing.
- 64 quadrature output sequences for each revolution.
- Two channel Quadrature output detects forward rotation (A>B) and reverse rotation (B>A).
- 1 Index output for each revolution.
- RoHS compliant.
- 6" leads in 5-position connector.



NOTES:
1. Operating voltage 5VDC to 15VDC.
   24VDC if connected through EL0304 terminal block board.
2. Index pulse occurs once every 64 output pulses
   (no direction change).
3. Outputs have 10KOhm pull-up and sink 20 mA maximum.

Power, std. : 5 to 15VDC, 25 ma maximum with EL0304
55 ma maximum with EL0300
opt. : 24VDC when wired through EL0304 or EL0300

Output : Sinking signal,
open collector transistor, 20 ma maximum.
Signal ON : Equal or close to supply voltage.
Signal OFF: 0.4V maximum.
Square wave, 50/50 DC; symmetrical Quadrature.
Pull-up resistors: 10K ohm to power supply voltage

Temperature : -40°F to +257°F (-40°C to +125°C)

Certifications : EL0303 is Intrinsically Safe (Intertek)
EL0303 in flow meter cover EEx d,
enclosure is rated IP65.

Approvals : W&M certified in Tuthill meters in the US.
W&M certified in Tuthill meters in the EU.

When communicating with non-Tuthill electronics, either a Quadrature Filter or an SCL scaler is required. These components fit inside the pulse output compartment in place of EL0304.

Quadrature Filter = EL0300-6-3-17
Scaler, 100 PPG = EL0300-3-13_
10 PPL = EL0300-3-18_

} P/Nos. shown here reflect 5-12 VDC. Change 3 to 5 for 24VDC.

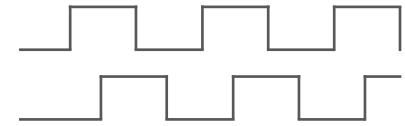
It is distributor and/or buyer responsibility to verify signal compatibility if the flow meter is used with an electronic register, PLC or other device not supplied by Tuthill.

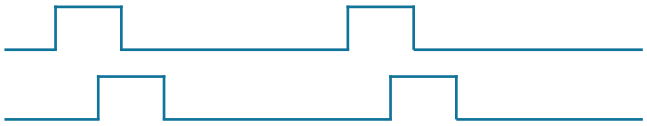
	EL0304 = Raw Pulse Signal
	EL0300-6-3-17 = with Jitter Filter
Frequency:	Fixed as shown for flow rate
Pulse Signal:	Square Wave, 50/50 duty cycle. Pulse ON/OFF time will vary by up to 30% at various positions of oval gears, due to cyclical flow profile from oval gear metering principle.

100 PPG scaler	10 PPL scaler
EL0300-3-13_	EL0300-3-18_
Fixed as shown for flow rate	

Square Wave. With scaled pulse output & fixed pulse width (= ON signal), the duty cycle can no longer be 50/50. Depending upon ON time selected, and flow rate in the system, the duty cycle can stretch to 1/50 or more.

Pulse Signal Profile:





		Pulse Time ON	Pulse Time OFF	Signal Frequency	Pulse Time ON	Pulse Time OFF	Signal Frequency	Pulse Time ON	Pulse Time OFF	Signal Frequency
TS10C	25%	1.38	1.38 ms	363 Hz	1.30	58.7 ms	16.7 Hz	2.50	156 ms	6.3 Hz
	50%	0.69	0.69 ms	725 Hz	1.30	28.7 ms	33.3 Hz	2.50	76.75 ms	12.6 Hz
	75%	0.46	0.46 ms	1088 Hz	1.30	18.7 ms	50 Hz	2.50	50.33 ms	18.9 Hz
	100%	0.34	0.34 ms	1451 Hz	1.30	13.7 ms	66.7 Hz	2.50	37.13 ms	25.2 Hz
TS10A	25%	1.74	1.74 ms	288 Hz	1.30	58.7 ms	16.7 Hz	2.50	156 ms	6.3 Hz
	50%	0.87	0.87 ms	576 Hz	1.30	28.7 ms	33.3 Hz	2.50	76.75 ms	12.6 Hz
	75%	0.58	0.58 ms	864 Hz	1.30	18.7 ms	50 Hz	2.50	50.33 ms	18.9 Hz
	100%	0.43	0.43 ms	1152 Hz	1.30	13.7 ms	66.7 Hz	2.50	37.13 ms	25.2 Hz
TS15C	25%	1.74	1.74 ms	288 Hz	1.30	38.7 ms	25 Hz	2.50	103.2 ms	9.5 Hz
	50%	0.87	0.87 ms	576 Hz	1.30	18.7 ms	50 Hz	2.50	50.33 ms	18.9 Hz
	75%	0.58	0.58 ms	864 Hz	1.30	12.03 ms	75 Hz	2.50	32.72 ms	28.4 Hz
	100%	0.43	0.43 ms	1152 Hz	1.30	13.7 ms	100 Hz	2.50	23.92 ms	37.9 Hz
TS15A	25%	1.97	1.97 ms	253 Hz	1.30	38.7 ms	25 Hz	2.50	103.2 ms	9.5 Hz
	50%	0.99	0.99 ms	507 Hz	1.30	18.7 ms	50 Hz	2.50	50.33 ms	18.9 Hz
	75%	0.66	0.66 ms	760 Hz	1.30	12.0 ms	75 Hz	2.50	32.72 ms	28.4 Hz
	100%	0.49	0.49 ms	1013 Hz	1.30	13.7 ms	100 Hz	2.50	23.92 ms	37.9 Hz
TS20A TS20C	25%	2.03	2.03 ms	247 Hz	1.30	14.7 ms	62.5 Hz	2.50	39.77 ms	23.7 Hz
	50%	1.01	1.01 ms	494 Hz	1.30	6.7 ms	125 Hz	2.50	18.63 ms	47.3 Hz
	75%	0.68	0.68 ms	741 Hz	1.30	4.0 ms	188 Hz	2.50	11.59 ms	71 Hz
	100%	0.51	0.51 ms	988 Hz	1.30	2.7 ms	250 Hz	2.50	8.07 ms	94.6 Hz
TS30A TS30C	25%	2.18	2.18 ms	229 Hz	1.30	10.7 ms	83.3 Hz	2.50	29.2 ms	31.5 Hz
	50%	1.09	1.09 ms	458 Hz	1.30	4.7 ms	167 Hz	2.50	13.35 ms	63.1 Hz
	75%	0.73	0.73 ms	688 Hz	1.30	2.7 ms	250 Hz	2.50	8.07 ms	94.6 Hz
	100%	0.55	0.55 ms	917 Hz	1.30	1.7 ms	333 Hz	2.50	5.43 ms	126 Hz
	115%	0.47	0.47 ms	1054 Hz	1.30	1.31 ms	383 Hz	2.50	4.39 ms	145 Hz
	130%	0.42	0.42 ms	1192 Hz	1.30	1.01 ms	433 Hz	2.50	3.6 ms	164 Hz
	145%	0.38	0.38 ms	1329 Hz	1.30	0.77 ms	483 Hz	2.50	2.97 ms	183 Hz

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.

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). Items to consider:

1. What data you wish to capture?
   This determines which electronic register or controller to 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 Serial Port connections cannot be used in a hazardous environment, this portion of the system must be in a non-hazardous zone.
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 that requires special software.

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, refer to federal, state and local codes to determine correct electrical classification requirements for your application.

Wireless Communications

The **EMR^3 register** is available with wireless communications. With this option, the register will upload transaction data to a home base receiver, any time the unit is within line of sight.

This option requires purchase of:

- One home base receiver
- One transmitter for each register

This option is also the economical solution when the distance between the EMR^3 register and the Interconnect box exceeds 500' (150 m).

Selecting a Precision Meter

Material Recommendations
Model Range

Case Material

Stainless steel is often the material of choice in chemical industry applications. Petroleum and aviation industries prefer lightweight and corrosion resistant aluminum, which is also suitable for many non-corrosive chemicals, including virtually all solvents, alcohols & glycols. To provide broad application coverage, Tuthill manufactures meters in the following materials:

Anodized Aluminum, for 5.5-8.0 pH

356 Aluminum

Aluminum: 92.55%
Remainder: 7.45%
Silicon, Iron, Copper, Manganese, Magnesium, Zinc, Titanium

6061 Aluminum

Aluminum: 97.95%
Remainder: 2.05%
Silicon, Copper, Manganese, Magnesium, Chromium

6262 Aluminum

Aluminum: 96.96%
Remainder: 3.04%
Silicon, Copper, Manganese, Chromium, Lead, Bismuth

Stainless Steel, for 1-14 pH

316 Stainless Steel

Iron: 68.90%
Remainder: 31.10%
Carbon, Manganese, Silicon, Chromium, Nickel, Molybdenum

CF8M Stainless Steel

Iron: 67.84%
Remainder: 32.16%
Carbon, Manganese, Phosphorous, Sulfur, Silicon, Chromium, Nickel, Molybdenum

Oval Gear and Bearing Material Selection

Tuthill meters use PPS (polyphenylene sulfide resin, glass filled), also known as Ryton™ rotor material in most models.

Tuthill has used PPS for more than 20 years. Phillips Chemical Company, supplier of PPS, provides this material for a wide variety of applications, including engine components by Chrysler, Ford, and BMW among many others. It is an excellent choice for precision meter parts because:

- Can be molded with 0.0010" (0.025 mm) precision.
- Is compatible with 90% of the liquids in a chemical listing with 200+ entries. For SS the number was 68%.
- Rated for use to 240°C (464°F) in continuous duty service.
- Lightweight, weighing less than 10% of an equivalent rotor manufactured in SS.

For more information on polyphenylene sulfide (PPS) refer to chemical compatibility chart when making meter selection.

In both aluminum and stainless steel rotor options are:

	Visc < 300cSt	Visc > 300cSt or Temp > 120°F (50°C)
PPS with carbon bearings	Std.	Opt.
PPS with PTFE bearings*	Opt.	Opt.

* PTFE bearings should not be used unless specifically required (please refer to the application recommendations on page 16).

Page 15 provides guidance on case material, seal material and rotor type for many common liquid groups for TS Series meters.

For applications not covered on page 15, some guidance can be found in chemical compatibility lists. Chemical compatibility is not the only issue, so it is critical to consider all aspects of the application and environment. 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 liquid.

High Viscosity (HV) Rotors

- 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 accuracy.
- HV rotors are also required if operating temperature can exceed 50°C (120°F).

Operation Note

Unless you have the five key values, it may not possible to make a sound PD meter model selection:

- Liquid to be metered.
- Operating Pressure Range
- Operating Temperature Range
- Flow Rate Range
- Viscosity Range

Do not operate over 80% of maximum flow capacity on non-lubricating liquids if rotors have PTFE bearings.

Liquid to be Metered

The most important information in making your meter selection is clearly identifying the liquid to be metered. It is impossible to select correct case material, rotor type, bearing material and seals without it.

A guide for common liquid categories is found on page 15 in this manual. For liquids not included in that list, please refer to fluid manufacturers compatibility information.

- Generic descriptions are not satisfactory. 'Additive' can cover liquids with pH values from 1-14.
- Will the user flush the system with a liquid different from the liquid being metered?
- On shear sensitive liquids, such as adhesives, resins and many polymers:
  - Use HV rotors with PTFE bearings
  - Meter should not operate at more than 50% of maximum capacity, Delta P restrictions maximum 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: (see page 20)

Operating Temperature

Flow meter pressure ratings are impacted by operating temperature ranges. It also impacts model and accessory selections in several other areas:

Low Ambient and/or Liquid Temperature

- Mechanical meters are rated to -15°F (-26°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 -15°F (-26°C). Ratings for signal conditioners & electronic registers vary. 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 HV rotors in oval gear meters.
- Manufacturer rating for electronic signal conditioners and registers vary. Refer to spec sheet if higher liquid temperatures can be encountered.
- Maximum operating temperature for mechanical register is +180°F (+80°C). For higher operating temperatures, use a remote electronic register.

Hot Water Service

- In hot water service of 120° F or higher, use stainless steel case material and de-rate meter parameters by 20%.
- Maximum allowable temperature in water service is +194°F (+90°C).

Liquid Category	Examples	Case Material AA	Case Material SS	Rotor Type	TS Series Bearing Material	Rotor Code in Meter Part No.	Seals	Meter Max. Rating with this combo
Alcohols	Ethanol, Iso-propanol, Methanol, etc.	✓	✓	LV	Carbon	B	B	100%
Aldehydes	Benaldehyde, Formaldehyde, etc.	✓	✓	LV	Carbon	B	B	100%
Automotive Fluids	Transmission Fluid, Hydraulic Oil, Glycol and Water	✓	✓	LV	Carbon	B	A	Subject to Viscosity Limits
Caustics	Potassium Hydroxide and Sodium Hydroxide		✓	LV	Carbon	B	B	100%
					PTFE	C	B	80%
Esters and Ethers	Amyl Acetate, Butyl Acetate, Dibutyl Phtalate, etc.	✓	✓	LV	Carbon	B	B	100%
Fertilizer	Clear Nitrogen Solutions	✓	✓	HV	PTFE	J	A	80%
Glycols	Ethylene, Diethylene, Triethylene and Propylene	✓	✓	LV	Carbon	B	A	100%
Halogenated Solvents	Hydrocarbon Solvents, with Fluorine, Cholrine, Bromine, Iodine and Astatine (Perchlorethylene)		✓	LV	Carbon	B	B	100%
Herbicides	Atrazine, Lasso™, Round-Up™, etc.	✓	✓	HV	PTFE	J	B	80%
Ketones	Acetone, Cyclohexanone, MEK, MIBK, etc.	✓	✓	LV	Carbon	B	B	100%
LPG	Butane, Propane, Pentane, and Mixtures	✓	✓	LV	Carbon	B	C	100%
Lube Oil	Automotive Lubricants, Gear Oil and Grease	✓	✓	HV	Carbon	I	A	Subject to Viscosity Limits
Organic Acids	Acetic Acid, Formic Acid, Lactic Acid, Vinegar	✓	✓	LV	PTFE	C	B	80%
Refined Petroleum Products	Avition Fuels (Avgas and Jet Fuel), Gasoline, Diesel Fuel, Gasohol, Kerosene and Light Fuel Oil	✓	✓	LV	Carbon	B	A	100%
	Fuel Sentry Meters on Diesel and Fuel Oil	✓	✓	LV	Carbon	L	A	100%
	Medium and Heavy Fuel Oils, Automotive Lubricants	✓	✓	HV	Carbon	I	A	Subj. to Visc. Limits
Solvents	Benzene, Mineral Spirits, Toluene, Xylene, etc.	✓	✓	LV	Carbon	B	B	100%
Syrups	Corn Syrup, Sugar Syrup, Liquid Sugar	✓	✓	HV	PTFE	I	A	Subj. to Visc. Limits usually <25%
Shear Sensitive Liquids	Adhesives, Glue, Somy, Glycols, Many Resins, etc.	Depends upon PH		HV	PTFE	J	B	Subj. to Visc. Limits usually <50%
Vegetable Oils	Corn, Cotton, Olive, Peanut, Soya, etc.	✓	✓	LV	Carbon	B	A	100%
Water	Drinking and Process Water		✓	LV	Carbon	B	A	< 50°C/120°F 100%
						L	A	> 50°C/120°F 75%
	Distilled, Deionixed or Otherwise Treated Water		✓	LV	PTFE	C	A	< 50°C/120°F 100%
						M	A	> 50°C/120°F 75%

LV = Low Viscosity Rotors
HV = High Viscosity Rotors

A = Viton™
B = PTFE
C = Buna

Meter Coefficient

Viscosity (cSt)	Carbon Bearings		PTFE Bearings	
	LV Rotors	HV Rotors	LV Rotors	HV Rotors
1	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00
50	1.00	1.00	1.00	1.00
100	1.00	1.00	1.00	1.00
200	1.00	1.00	0.90	1.00
300	0.86	1.00	0.73	0.98
400	0.77	1.00	0.62	0.96
500	0.71	1.00	0.57	0.94
600	0.66	1.00	0.53	0.92
700	0.63	1.00	0.50	0.90
800	0.60	1.00	0.48	0.85
900	0.56	1.00	0.45	0.80
1,000	0.54	1.00	0.43	0.75
2,000	-	0.77	-	0.65
3,000	-	0.65	-	0.55
4,000	-	0.58	-	0.46
5,000	-	0.53	-	0.42
6,000	-	0.49	-	0.39
7,000	-	0.47	-	0.37
8,000	-	0.44	-	0.35
9,000	-	0.42	-	0.34
10,000	-	0.41	-	0.32
20,000	-	0.30	-	0.24
30,000	-	0.24	-	0.19
40,000	-	0.20	-	0.16
50,000	-	0.18	-	0.14
60,000	-	0.17	-	0.13
70,000	-	0.14	-	0.11
80,000	-	0.13	-	0.10
90,000	-	0.12	-	0.10
100,000	-	0.11	-	0.09
200,000	-	0.08	-	0.06
300,000	-	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

Model Selection

- Select a meter to operate in 50-85% range of model maximum flow capacity for optimum accuracy and life.
- Intermittent service to 100% of maximum flow capacity 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 Service if operation over 100% of nominal capacity is being considered.

Flow Rate & Viscosity

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

- On low viscosity refined petroleum products, optimum flow meter performance (accuracy & life) is achieved when the flow meter is operating between 50% and 80% of maximum capacity.
- When liquid viscosity can exceed 300 cSt (1500 SSU), HV rotors are recommended.

Maximum Flow Capacity

TS10	40 GPM	150 lpm
TS15	60 GPM	230 lpm
TS20	150 GPM	570 lpm
TS30	200 GPM	760 lpm

The table shown at left shows limits on model flow capacity based on maximum liquid viscosity. Multiply the model maximum flow capacity (above) with the meter coefficient for the maximum meter flow capacity. Your fluid Viscosity can be obtained from the fluid viscosity chart on page 17 and 18.

Example:

Viscosity = 2,000 cSt,
System Max Flow Rate = 22 GPM
Meter Coefficient = 0.77
TS10 Max = 40 GPM
40 GPM x 0.77= 30.8 GPM Maximum flow rate at 2000 cst

In this example, the calculated meter flow capacity is higher than the system max flow rate (22 GPM). Therefore the TS10 is a good choice to proceed with.

If the system max flow rate is higher than the calculated meter flow capacity, you must repeat the process above for the next larger meter until the calculated meter flow capacity is higher.

		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.	18	14	11	8.3	6	4.5	3.6	2.9	1.6		
	Max.	70	48	35	25	17	12	8.9	6.7	3.7	2.8	
No. 4	Min.	375	215	135	85	48	30	20	14	6	4	1.8
	Max.	18,500	7,000	3,000	1,650	650	295	150	80	26	13	4
No. 5 Light	Min.	60,000	22,000	9,000	3,800	1,300	500	240	130	33	17	4.5
	Max.	135,000	50,000	21,000	9,000	3,000	1,200	550	285	70	31	7.8
No. 5 Heavy	Min.	200,000	75,000	30,000	13,000	4,000	1,700	700	350	80	35	8.5
	Max.	?	700,000	180,000	60,000	18,000	6,000	2,200	950	165	68	13
No. 6	Min.	?	?	350,000	15,000	30,000	9,000	3,000	1,400	215	80	14
	Max.	?	?	?	?	?	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
	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	23
	40	300,000	160,000	65,000	32,000	9,500	3,800	1,700	800	170	75	26
	50	550,000	280,000	115,000	55,000	18,000	6,500	2,800	1,250	270	105	21

		Mobilegear® 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 Hydrolic 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 cSt								
		Sp.Gr. @60°F (15.5°C)	30°F -1.1°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 121.1°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						
	Trienthylene	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. Maximum		1,950	755	440	273	150			
	B. Maximum	1.43 - 1.48				12,600	3,150			
	B. Maximum		14,700	4,620	2,290	1,400	630			
	C. Maximum	1.46 - 1.49				52,500	15,750			
	C. Maximum			18,900	7,350	3,570	1,300			
Oil	Coconut	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	0.924	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	
	Grape 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

Checking Meter Model

Bearing:	Carbon	PTFE
Continuous Duty Operation:	10 PSI	3.5 PSI
Intermittent Duty Operation:	15 PSI	5.0 PSI

Viscosity Table

On higher viscosity liquids, ΔP value (Delta P = pressure loss across the flow meter) increases. This is an expression of a higher wear factor. Maximum allowable values 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. Under normal operating conditions, it is recommended that the Delta P value be somewhat less than the maximum value allowed.

To calculate Delta P across the meter, first determine the fluid viscosity using the chart on page 17 or on fluid manufacture's MSDs.

Using the Viscosity Correction Factor chart to the right, determine the Viscosity Correction Factor for your application. If exact viscosity is not listed use next highest viscosity listed.
Example:

- Lube oil (5W20) @ 0 degrees F = 800 cSt
- 800 cSt rounds up to 840 cSt so the viscosity correction factor is 5.00

Determine the maximum flow rate of your system. Using your max flow rate and the chart on page 30 or 31, determine your Delta P on 1cP Viscosity. If your exact flow rate is not listed, choose the next highest listed flow rate.

Example:

Max flow rate = 23 GPM
Meter = TS10
Delta P reads 2.03 PSI

Multiply the viscosity correction factor by the Delta P:

5.00 x 2.03 = 10.15 PSI

If corrected Delta P value exceeds limits shown above, there are 3 possible options:

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

Viscosity		Viscosity Correction Factor	
SSU	cSt	LV Rotors	HV Rotors
40	4	1.08	-
50	7	1.15	-
60	10	1.20	-
70	15	1.30	-
80	17	1.40	-
90	19	1.45	-
100	22	1.50	-
125	27	1.59	-
150	32	1.70	-
175	37	1.79	-
200	42	1.90	-
250	52	2.00	-
300	63	2.10	-
350	74	2.20	-
400	85	2.30	-
450	95	2.42	-
500	105	2.55	-
600	126	2.75	-
700	147	2.90	-
800	168	3.05	-
900	189	3.15	-
1,000	210	3.30	3.10
1,500	315	3.95	3.50
2,000	420	4.60	3.90
3,000	630	-	4.50
4,000	840	-	5.00
5,000	1,050	-	5.30
6,000	1,260	-	5.80
7,000	1,470	-	6.05
8,000	1,680	-	6.25
9,000	1,890	-	6.50
10,000	2,100	-	6.80
15,000	3,150	-	7.70
20,000	4,200	-	8.70
30,000	6,300	-	10.00
40,000	8,400	-	11.00
60,000	12,600	-	12.25
80,000	16,800	-	13.70
100,000	21,000	-	15.00
150,000	31,500	-	17.00
200,000	42,000	-	19.00
300,000	63,000	-	21.00
400,000	84,000	-	23.00
500,000	105,000	-	25.00

Pressure Rating Table

Meter pressure rating depends on temperature and the pressure rating of the lowest-rated component. The following table shows the maximum operating pressure for a given operating temperature and component configuration (meter only, strainer, air eliminator, etc.)

Aluminum Meters

		Anodized Aluminum	CS ANSI Adapter
°F	°C		
100	38	100%	100%
150	66	89%	94%
200	93	79%	90%
225	107	75%	88%
250	121	71%	84%
275	135	62%	81%
300	150	43%	43%

Electronic Meters

Meter Only or with a Strainer		Meter + Carbon Steel ANSI Flanges		Meter with any combination of Air Eliminator or Preset Valve	
psi	bar	psi	bar	psi	bar
400	27	290	20	150	10
356	24.5	273	18.8	134	9
316	21	261	18	119	8
300	20	255	17.6	113	7
284	19.6	244	16.8	107	7
248	17	235	16.2	93	6
172	11	125	8.6	65	4

Mechanical Meters

Meter Only		Meter + Carbon Steel ANSI Flanges		Meter with any combination of Strainer, Air Eliminator or Preset Valve	
psi	bar	psi	bar	psi	bar
150	10	150	10	150	10
134	9	141	9	134	9
119	8	135	9	119	8
113	7	132	9	113	7
107	7	126	8	107	7
93	6	122	8	93	6
65	4	65	4	65	4

Stainless Meters

		Stainless	SS ANSI Adapter
°F	°C		
100	38	100%	100%
150	66	91%	89%
200	93	83%	82%
225	107	79%	80%
250	121	74%	78%
275	135	70%	76%
300	150	67%	74%

Electronic Meters

Meter Only or with a Strainer		Meter + Stainless Steel ANSI Flanges		Meter with any combination of Air Eliminator or Preset Valve	
psi	bar	psi	bar	psi	bar
400	27	275	19	150	10
364	25	245	16	137	9
332	22	226	15	125	8
316	21	220	15	119	8
296	20	215	14	111	7
280	19	209	14	105	7
268	18	204	14	101	6

Mechanical Meters

Meter Only		Meter + Stainless Steel ANSI Flanges		Meter with any combination of Strainer, Air Eliminator or Preset Valve	
psi	bar	psi	bar	psi	bar
150	10	150	10	150	10
137	9	134	9	137	9
125	8	123	8	125	8
119	8	120	8	119	8
111	7	117	8	111	7
105	7	114	7	105	7
101	6	111	7	101	6

TS Series, Ratio Gear Plates for Mechanical Register

Meter Model	Unit	Internal Reduction	Packing Gland Ratio	Gear Plate Pattern	Gear # on Ratio Gear Plate A #1	B #2	C #3	D #4	E #5	F #6	SHORT (Standard)	Up/Down Gear Plate (Preset)
TS10A	1/10 Gallon	12:1	2:1	A	54	64					GPTS10T2-1	
	Liter	12:1	2:1	C	29	51	45	45	29	51		
	1/10 Liter	12:1	1:1	C	52	29	47	47	52	29	GPTS10Y-1	
	kg	12:1										
	lbs.	12:1										
TS10C	1/10 Gallon	12:1	2:1	A	47	70					GP560T2-1	
	Liter	12:1	2:1	C	28	55	57	57	29	58	GP560L2-1	
	1/10 Liter	12:1	1:1	A	66	51						
	kg	12:1										
	lbs.	12:1										
TS15A	1/10 Gallon	12:1	1:1	A	70	48					GPTS15-70T2-1	GPTS15-70T2-1-UD
	Liter	12:1	2:1	A	42	75					GPTS15-70L2-1	GPTS15-70L2-1-UD
	1/10 Liter	12:1										
	kg	12:1										
	lbs.	12:1										
TS15C	1/10 Gallon	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-UD
	kg	12:1										
	lbs.	12:1										
TS20A & TS20C	1/10 Gallon	12:1	1:1	A	77	41					GPTS2HT1-1	GPTS2HT1-1-UD
	Whole Gallon	12:1	2:1	C	43	70	60	60	43	70		
	1/10 lpm. gallon	12:1	2:1	C	69	39	70	70	69	39		
	Imperial Gallon	12:1	2:1	A	28	90						
	Liter	12:1	1:1	A	49	69					GPTS2HL1-1	GPTS20L-UD
	dekaliter	12:1	2:1	C	28	54	30	30	29	54		
	kg	12:1										
	lbs.	12:1										
TS30A & TS30C	1/10 Gallon	12:1	1:1	C	64	39	57	57	64	39		
	Whole Gallon	12:1	2:1	A	41	76					GP5201G2-1	GP5201G2-1-UD
	Imperial Gallon	12:1	2:1	C	39	59	57	57	40	59		
	Liter	12:1	1:1	A	59	58					GP590L2-1	GP590L2-1-UD
	dekaliter	12:1	2:1	C	34	75	57	57	64	75		
	kg	12:1										
	lbs.	12:1										

Model Number Specifications

TS = Oval Gear , 1" and up

Mechanical

TS	15	A	Assembly Number	Flange	Calibrator	Pressure Rating	Rotor & Bearing	Drive	Pulse Output	Seals	Strainer	Basket Mesh

Model Number

TS

15

	Size	Nominal Capacity	GPM	GPH	lpm	m^3/h
10	1"	25 mm	40	2,400	150	9
15	1½"	40 mm	60	3,600	230	14
20	2"	50 mm	150	9,000	570	35
30	3"	80 mm	200	12,000	760	46

A

Material	
A	Anodized Aluminum
C	316 Stainless Steel

Assembly Number

Flange

A	NPT
B	BSP
C	150# ANSI Adaptors

Register Calibration

Mechanical Register	
T	1/10 US gallons
U	1/10 Imperial gallons
G	1/1 US gallons
I	1/1 Imperial gallons
Y	1/10 liter
L	1/1 liter

Pressure Rating

C	150 PSI (10 BAR)

Rotor & Bearing

	Type	Mat'l	Bearing
B	LV	PPS	Carbon
I	HV	PPS	Carbon
C	LV	PPS	PTFE
J	HV	PPS	PTFE

Drive

M	Mechanical

Pulse Output

X	none
D	10:1 dry reed
S	100:1 solid state

Seals

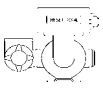
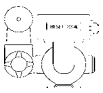
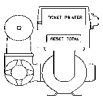
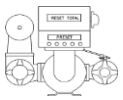
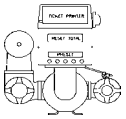
A	Viton™ (std. in Anodized Aluminum Models)
B	PTFE (std. in SS, opt in AA)

Strainer

S	Tuthill 90° Strainer
H	Tuthill High Capacity

Basket Mesh

4	40 Mesh Basket (standard with LV & HT rotors)
2	20 Mesh Basket (standard with HV rotors)

V03		Meter Only - No Register (Register Ready), Calibrator, RAD Adaptor, No Ratio Gear Plate (Distributor to Add)
V04		Meter Only - Calibrator, RAD Adaptor, Ratio Gear Plate & Register
V05		V04 + Strainer
V06		Calibrator, RAD Adaptor, Ratio Gear Plate, Register, Strainer & Air Eliminator
V07		V04 + Zero Start Ticket Printer
V09		V06 + Zero Start Ticket Printer
V11		V04 + 2-Stage Preset Counter & Preset Valve
V13		V06 + 2-Stage Preset Counter & Preset Valve
V17		V06 + 2-Stage Preset Counter, Preset Valve & Zero Start Ticket Printer

TS = Oval Gear , 1" and up

Electrical

TS	20	A	Assembly Number	Flange	Rotors & Seals	Signal Conditions	ATEX Gland	Languages	Misc. Options	Strainer Mesh

Model Number

TS

15

	Size	Nominal Capacity	GPM	GPH	lpm	m^3/h
10	1"	25 mm	40	2,400	150	9
15	1½"	40 mm	60	3,600	230	14
20	2"	50 mm	150	9,000	570	35
30	3"	80 mm	200	12,000	760	46

A

A	Anodized Aluminum Material

Assembly Number

Flange

A	NPT
B	BSP
C	150# ANSI Adaptors

Rotors & Seals

	Seals	Rotors	Bearings
A	Viton	LV	PPS/Carbon
V	Viton	HV	PPS/Carbon
F	Viton	LV	PPS/PTFE
S	Viton	HV	PPS/PTFE
B	PTFE	LV	PPS/Carbon
D	PTFE	HV	PPS/Carbon
E	PTFE	LV	PPS/PTFE
H	PTFE	HV	PPS/PTFE

Signal Conditions

	Volt	
T	5-24	TBB
G	5-12	100 PPG SCL
L	5-12	10 PPL SCL
H	24	100 PPG SCL
K	24	10 PPL SCL

ATEX Gland

A	ATEX Gland

Languages

E	English
S	Spanish
X	Not Applicable

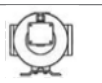
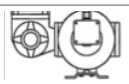
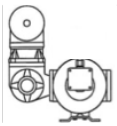
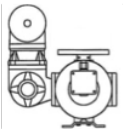
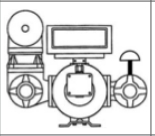
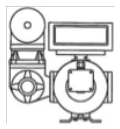
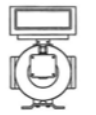
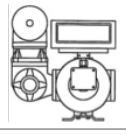
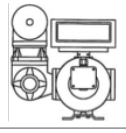
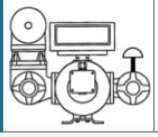
Misc. Options

S	Standard Strainer
T	Standard Strainer & TW/TP

Strainer Mesh

4	40 Mesh
2	20 Mesh
8	80 Mesh
X	Not Applicable

ELECTRICAL

W04		Meter Only - No Register Flange
W05		W04 + Strainer
W06		W04 + Strainer + Air Eliminator
F14		Meter Only - Calibrator, RAD Adaptor, Ratio Gear Plate & Register
F16		Register Flange (Register Ready), Strainer & Air Eliminator
F64		Meter Only - with EMR3 Register
F63		Meter, EMR3 Register, Strainer, Air Eliminator, & Solenoid Preset Valve
F66		Meter, EMR3 Register, Strainer & Air Eliminator
F74		Meter Only - with ELNC register (backlight and 10:1 Pulse)
F76		Meter Only - with ELNC Register (backlight and 10:1 Pulse), Strainer & Air Eliminator
F84		Meter Only - with MID:COM register (backlight and 10:1 Pulse)
F86		Meter Only - with MID:COM Register (backlight and 10:1 Pulse), Strainer & Air Eliminator
F88		Meter, MID:COM Register, Strainer, Air Eliminator, & Solenoid Preset Valve

PRECISION METER APPLICATION CHECKLIST

Name _____ Phone _____ Date _____

Company _____ E-mail _____

Fluid: _____ Application Details: _____

Please provide the ACTUAL operating conditions, not model rating or specified capacity.

	MIN	NORMAL	MAX	Circle Units Used
Flow Rate:				GPM GPH LPM LPH M^3/H
Temperature:				°F °C
Pressure:				PSI BAR kg^2/cm Pa Mpa
Viscosity at:	MIN temp:	NOR temp:	MAX temp:	SSU cSt mm^3/B cP mPa•S
Type of Pump:				

Type of Operation:

Please describe the system and operational requirements

- ☐ Transfer from tank to tank
- ☐ Filling of rail cars, trucks or drums
- ☐ High speed fueling
- ☐ Retail delivery truck
- ☐ Receiving into storage, gravity flow
- ☐ Receiving into storage, pumped flow
- ☐ Fuel Consumption or Management
- ☐ Aviation refueling
- ☐ Aviation de-icing ☐ Hot water/glycol ☐ Type IV glycol
- ☐ Additive injection or blending
- ☐ Other (provide details): _____

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

Code Certifications: ☐ UL ☐ cUL ☐ ATEX ☐ CE ☐ NTEP ☐ MID ☐ UK ☐ Canada W&M ☐ Australia W&M

Required Accuracy: +/- _____

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 (N.C.)
- ☐ Without Register, Specify:

Model: _____

Voltage: _____

Registration, Functions and Communications: Mechanical or Electronic

☐	Register	☐	Local	☐	Remote	☐	Local and Remote
☐	Preset/Batching			☐	with Pump Control		
☐	Printer	☐	Local	☐	Remote	☐	Local and Remote
☐	Rate of Flow Display per	Min	Hour	Day:			
☐	Temperature/Volume comp.						
☐	Currency Function						
☐	Remote Operation						
☐	Pulse Signal	Resolution:			Distance:		
☐	Analog Signal	☐	4-20 mA	☐	0-20 mA	☐	Other:
☐	Transaction Data to PC			☐	Serial Port	☐	Wireless

Flanges:

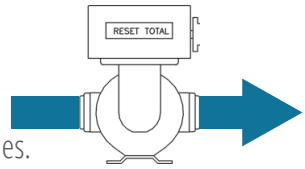
- ☐ Threaded companion flanges
- ☐ Welding companion flanges
- ☐ 150# RF ANSI flange adaptors

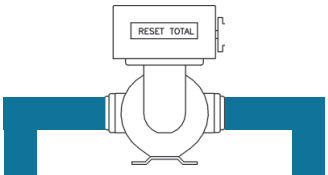
Installation and Start-Up

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

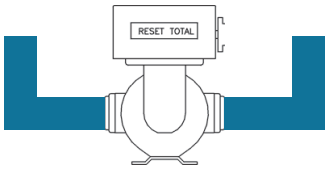
System Design

- Flow meter must be installed on output 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 provide backpressure, to keep meter full of product.
- Flow meters perform best under constant operating conditions.
- Design piping, so that the flow meter will be full of liquid at all times.



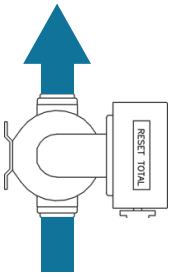


POOR INSTALLATION



GOOD INSTALLATION

- Meters can be installed in vertical lines, only if the flow goes up.
  - TS20 & TS30 with any register.
  - TS10 & TS15 only with remote electronic register.
  - 1" and larger flow meters should be secured to a firm support.



System Design Considerations

- Connections for calibration in place on operating liquid.
- Isolation valves so meter can be serviced in place.
- Install 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 tell-tale pressure gauge near the flow meter.
- Allow at least 14" of space around the meter 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 until ready to install.
- Install flow meter with firm support and without pipe strain.
- Flush the system prior to installing the flow meter. If not possible, install a strainer on the inlet side of the meter and clean after flushing.

Start-Up Procedures

- ***Do not operate the flow meter on air.***
- **Slowly** fill the system with liquid to purge all 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.

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.

Changes in technology and the philosophy of Continuous Improvement have brought changes to the Tuthill Precision Meter lines over the years. To ensure receiving correct spare parts, it is imperative that every inquiry & purchase order for spare parts include the serial number of the flow meter.

On **TS Series** flow meters, the serial number is on the Spec Plate, which is attached on the side of the RAD register adapter.

Electronic registers are also updated regularly, so providing the serial number is critical as well. Separate Serial Numbers apply to the **ELNC & EMR3** electronic registers; please look at the register enclosure for the serial number for these products.

All Tuthill precision flow meters are tested prior to shipment at the factory. However, test fluid on our flow bench 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 required that every flow meter be re-calibrated after installation, on the actual liquid of service.

Meter Calibration

Frequency
Methods & Procedures
Calibration Connections
Meter Test Report

Frequency

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

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.

Methods & Procedures

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

- Certified prover tank.
- Certified Master Meter
- Certified Scale

Re-calibration requires tests of at least 60 seconds duration. Reference NIST Handbook 44.

Recommended Piping and Calibration Connections:

A.1 and 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 and C.2: NC valves on calibration connections.

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

Normal operation : A open, B and C closed.

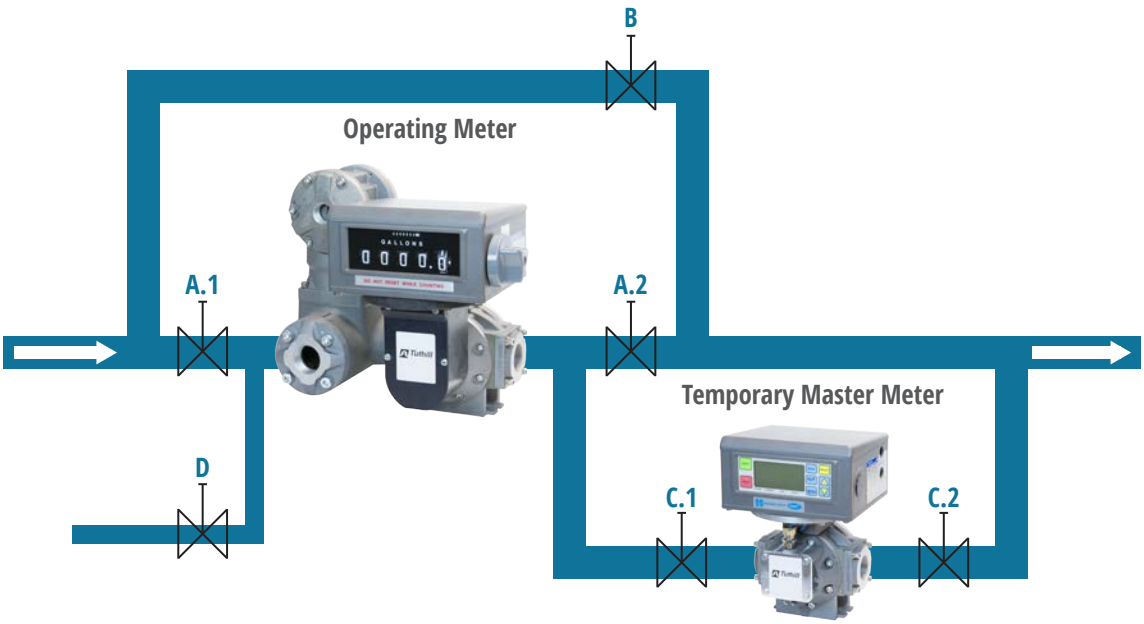
Flow meter service : A, B and C closed.

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

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

Meter Test Report

Tuthill Corporation tests all flow meters prior to shipment. 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.



System Air Elimination

General Comments
When Not Required
Tank Truck Systems
Metering Product Into Storage

PD meters cannot tell the difference between liquid, air or vapors. If air or vapor can occur in the lines, depending on flow volume, an air eliminator is required to avoid recording air/vapor as liquid.

- 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 between strainer and flow meter. Some regions have a regulatory demand for an Air Check Valve, which stops the flow when the air eliminator vents. When Air Check Valve is used, a Backpressure Valve 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) in most applications vent. The only exception to this is on extremely high viscosity liquids (molasses, asphalt, fuel oil No. 6, etc.), where the AE float may function less than desired 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 higher viscosity liquids (>150 cSt = 700 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 (AST), 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

Commonly used for retail delivery, these vehicles can have from 500-3,000 gallon (1892-11,355 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 Air Eliminator is always required**. If the system must satisfy ***Split Compartment Testing***, vehicle design (tanks, manifold and pump) becomes a factor in the efficiency of the Air Eliminator.

Systems not designed to minimize the amount of air drawn into the pump increase the demand upon the AE supplied with the flow meter. On medium viscosity liquids such as diesel fuel and 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 higher viscosity liquids (> 150 cSt = 700 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, Backpressure Valve or Air Check Valve 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 up to 350 GPM (1300 lpm).

Metering Product into Storage

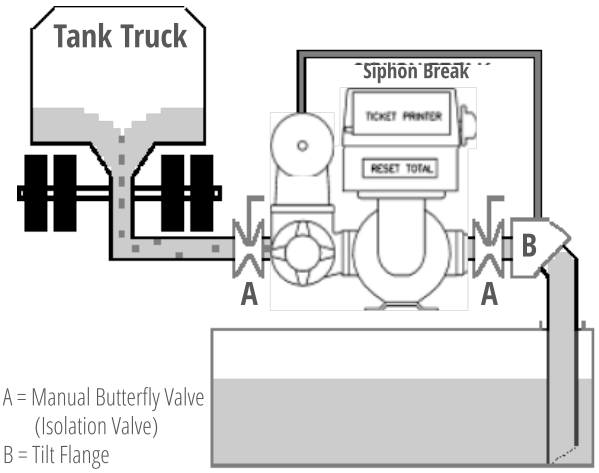
There are 3 possible combinations of delivery system (truck) and receiving tank.

1. Gravity truck into Underground Storage Tank (UST)

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.

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.

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.

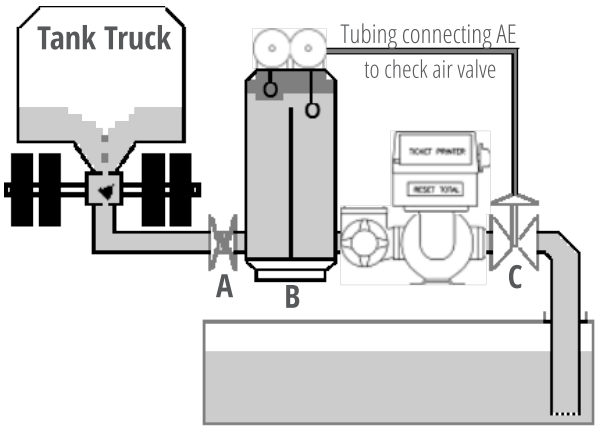


A = Manual Butterfly Valve (Isolation Valve)
B = Tilt Flange

2. 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:

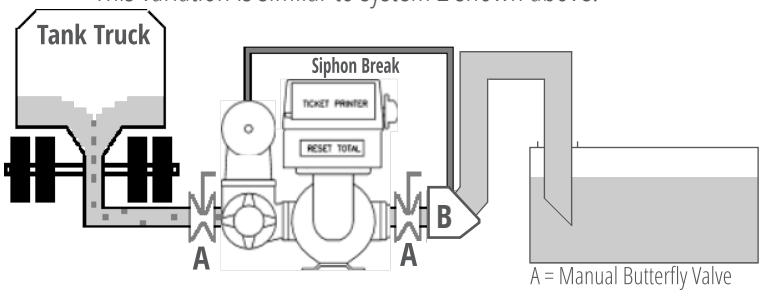


A = Swing Check Valve (Isolation Valve)
B = Bulk Plant Air Eliminator (Dual Head)*
C = Air Check Valve

*Bulk Plant Air Eliminator (Dual Head) not offered by Tuthill. Here the very large tank gives the 'foam' time to separate into air and 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.

3. Truck with Pump into Above Ground Tank

This variation is similar to system 2 shown above.



A = Manual Butterfly Valve (Isolation Valve)
B = Tilt Flange

Conversion Tables

Volume

US GPM	US GPH	LPM	m^3/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	0.5	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	15.2	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	15,00	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

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	1.1	1.4	138	0.14
25	1.4	1.8	172	0.17
30	1.8	2.1	207	0.21
35	2.1	2.5	241	0.24
40	2.4	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
1,00	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

Temperature

°F	°C
-40	-40
-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

TS METER SERIES - GALLONS Delta P on 1cP Viscosity

FLOW in % of NOM	TS10 Mechanical: 40 GPM Electronic: 40 GPM				TS15 Mechanical: 60 GPM Electronic: 60 GPM				TS20 Mechanical: 150 GPM Electronic: 150 GPM				TS30 Mechanical: 200 GPM Electronic: 200 GPM			
	GPM	GPH	BPD	ΔP PSI	GPM	GPH	BPD	ΔP PSI	GPM	GPH	BPD	ΔP PSI	GPM	GPH	BPD	ΔP PSI
2	0.8	48	27	0.27	1.2	72	41	0.14	3	180	103	0.14	4	240	137	0.15
4	1.6	96	55	0.29	2.4	144	82	0.15	6	360	206	0.15	8	480	274	0.16
6	2.4	144	82	0.30	3.6	216	123	0.16	9	540	309	0.16	12	720	411	0.17
8	3.2	192	110	0.32	4.8	288	165	0.17	12	720	411	0.17	16	960	549	0.18
10	4.0	240	137	0.35	6.0	360	206	0.18	15	900	514	0.19	20	1200	686	0.20
12	4.8	288	165	0.39	7.2	432	247	0.21	18	1080	617	0.22	24	1440	823	0.23
14	5.6	336	192	0.44	8.4	504	288	0.23	21	1260	720	0.25	28	1680	960	0.26
16	6.4	384	219	0.49	9.6	576	329	0.26	24	1440	823	0.28	32	1920	1097	0.29
18	7.2	432	247	0.53	10.8	648	370	0.28	27	1620	926	0.31	36	2160	1234	0.32
20	8.0	480	274	0.58	12.0	720	411	0.30	30	1800	1029	0.33	40	2400	1371	0.35
22	8.8	528	302	0.64	13.2	792	453	0.33	33	1980	1131	0.37	44	2640	1509	0.39
24	9.6	576	329	0.70	14.4	864	494	0.37	36	2160	1234	0.41	48	2880	1646	0.43
26	10.4	624	357	0.77	15.6	936	535	0.41	39	2340	1337	0.46	52	3120	1783	0.48
28	11.2	672	384	0.84	16.8	1008	576	0.45	42	2520	1440	0.51	56	3360	1920	0.53
30	12.0	720	411	0.92	18.0	1080	617	0.50	45	2700	1543	0.55	60	3600	2057	0.58
32	12.8	768	439	0.99	19.2	1152	658	0.53	48	2880	1646	0.60	64	3840	2194	0.63
34	13.6	816	466	1.06	20.4	1224	699	0.58	51	3060	1749	0.65	68	4080	2331	0.68
36	14.4	864	494	1.14	21.6	1296	741	0.62	54	3240	1851	0.71	72	4320	2469	0.74
38	15.2	912	521	1.22	22.8	1368	782	0.67	57	3420	1954	0.76	76	4560	2606	0.80
40	16.0	960	549	1.30	24.0	1440	823	0.72	60	3600	2057	0.82	80	4800	2743	0.86
42	16.8	1008	576	1.38	25.2	1512	864	0.77	63	3780	2160	0.88	84	5040	2880	0.92
44	17.6	1056	603	1.46	26.4	1584	905	0.81	66	3960	2263	0.94	88	5280	3017	0.98
46	18.4	1104	631	1.53	27.6	1656	946	0.86	69	4140	2366	0.99	92	5520	3154	1.04
48	19.2	1152	658	1.61	28.8	1728	987	0.90	72	4320	2469	1.05	96	5760	3291	1.10
50	20.0	1200	686	1.68	30.0	1800	1029	0.95	75	4500	2571	1.11	100	6000	3429	1.16
52	20.8	1248	713	1.77	31.2	1872	1070	1.00	78	4680	2674	1.17	104	6240	3566	1.23
54	21.6	1296	741	1.86	32.4	1944	1111	1.06	81	4860	2777	1.24	108	6480	3703	1.30
56	22.4	1344	768	1.94	33.6	2016	1152	1.10	84	5040	2880	1.31	112	6720	3840	1.37
58	23.2	1392	795	2.03	34.8	2088	1193	1.16	87	5220	2983	1.38	116	6960	3977	1.44
60	24.0	1440	823	2.11	36.0	2160	1234	1.21	90	5400	3086	1.44	120	7200	4114	1.51
62	24.8	1488	850	2.19	37.2	2232	1275	1.26	93	5580	3189	1.51	124	7440	4251	1.58
64	25.6	1536	878	2.28	38.4	2304	1317	1.32	96	5760	3291	1.59	128	7680	4389	1.66
66	26.4	1584	905	2.37	39.6	2376	1358	1.38	99	5940	3394	1.66	132	7920	4526	1.74
68	27.2	1632	933	2.46	40.8	2448	1399	1.43	102	6120	3497	1.74	136	8160	4663	1.82
70	28.0	1680	960	2.55	42.0	2520	1440	1.50	105	6300	3600	1.81	140	8400	4800	1.90
72	28.8	1728	987	2.64	43.2	2592	1481	1.55	108	6480	3703	1.89	144	8640	4937	1.98
74	29.6	1776	1015	2.73	44.4	2664	1522	1.61	111	6660	3806	1.97	148	8880	5074	2.06
76	30.4	1824	1042	2.81	45.6	2736	1563	1.66	114	6840	3909	2.04	152	9120	5211	2.14
78	31.2	1872	1070	2.90	46.8	2808	1605	1.72	117	7020	4011	2.12	156	9360	5349	2.22
80	32.0	1920	1097	2.98	48.0	2880	1646	1.77	120	7200	4114	2.20	160	9600	5486	2.30
82	32.8	1968	1125	3.07	49.2	2952	1687	1.84	123	7380	4217	2.28	164	9840	5623	2.39
84	33.6	2016	1152	3.17	50.4	3024	1728	1.89	126	7560	4320	2.37	168	10080	5760	2.48
86	34.4	2064	1179	3.27	51.6	3096	1769	1.97	129	7740	4423	2.46	172	10320	5897	2.58
88	35.2	2112	1207	3.37	52.8	3168	1810	2.03	132	7920	4526	2.56	176	10560	6034	2.68
90	36.0	2160	1234	3.48	54.0	3240	1851	2.11	135	8100	4629	2.65	180	10800	6171	2.78
92	36.8	2208	1262	3.59	55.2	3312	1893	2.17	138	8280	4731	2.76	184	11040	6309	2.89
94	37.6	2256	1289	3.70	56.4	3384	1934	2.26	141	8460	4834	2.87	188	11280	6446	3.00
96	38.4	2304	1317	3.81	57.6	3456	1975	2.32	144	8640	4937	2.97	192	11520	6583	3.11
98	39.2	2352	1344	3.93	58.8	3528	2016	2.41	147	8820	5040	3.08	196	11760	6720	3.23
100	40.0	2400	1371	4.05	60.0	3600	2057	2.48	150	9000	5143	3.20	200	12000	6857	3.35
102					61.2	3672	2098	2.57	153	9180	5246	3.31	204	12240	6994	3.47
104					62.4	3744	2139	2.67	156	9360	5349	3.44	208	12480	7131	3.60
106					63.6	3816	2181	2.76	159	9540	5451	3.56	212	12720	7269	3.73
108					64.8	3888	2222	2.86	162	9720	5554	3.69	216	12960	7406	3.86
110					66.0	3960	2263	2.96	165	9900	5657	3.82	220	13200	7543	4.00
112					67.2	4032	2304	3.07	168	10080	5760	3.96	224	13440	7680	4.15
114					68.4	4104	2345	3.19	171	10260	5863	4.12	228	13680	7817	4.31
116					69.6	4176	2386	3.32	174	10440	5966	4.28	232	13920	7954	4.48
118					70.8	4248	2427	3.45	177	10620	6069	4.45	236	14160	8091	4.66
120					72.0	4320	2469	3.59	180	10800	6171	4.63	240	14400	8229	4.85
122					73.2	4392	2510	3.74	183	10980	6274	4.83	244	14640	8366	5.06
124					74.4	4464	2551	3.90	186	11160	6377	5.04	248	14880	8503	5.28
126					75.6	4536	2592	4.08	189	11340	6480	5.26	252	15120	8640	5.51
128					76.8	4608	2633	4.27	192	11520	6583	5.49	256	15360	8777	5.75
130					78.0	4680	2674	4.48	195	11700	6686	5.73	260	15600	8914	6.00
132					79.2	4752	2715	4.71	198	11880	6789	5.99	264	15840	9051	6.27
134					80.4	4824	2757	4.96	201	12060	6891	6.26	268	16080	9189	6.56
136					81.6	4896	2798	5.21	204	12240	6994	6.56	272	16320	9326	6.87
138					82.8	4968	2839	5.46	207	12420	7097	6.88	276	16560	9463	7.20
140					84.0	5040	2880	5.71	210	12600	7200	7.21	280	16800	9600	7.55
142					85.2	5112	2921	5.96	213	12780	7303	7.56	284	17040	9737	7.92
144					86.4	5184	2962	6.21	216	12960	7406	7.95	288	17280	9874	8.32
146					87.6	5256	3003	6.46	219	13140	7509	8.35	292	17520	10011	8.74
148					88.8	5328	3045	6.71	222	13320	7611	8.78	296	17760	10149	9.19
150					90.0	5400	3086	6.96	225	13500	7714	9.23	300	18000	10286	9.67

Only on low viscosity, lubricating liquids (diesel, kerosene, etc.) subject to usual limits on total Delta P. Only on liquids with some viscosity (diesel fuel and higher)

TS METER SERIES - METRIC Delta P on 1cP Viscosity

FLOW in % of NOM	TS10 Mechanical: 150 LPM Electronic: 150 LPM				TS15 Mechanical: 230 LPM Electronic: 230 LPM				TS20 Mechanical: 570 LPM Electronic: 570 LPM				TS30 Mechanical: 760 LPM Electronic: 760 LPM			
	m³/h	LPM	kPa	ΔP BAR	m³/h	LPM	kPa	ΔP BAR	m³/h	LPM	kPa	ΔP BAR	m³/h	LPM	kPa	ΔP BAR
2	0.2	3	1.9	0.02	0.3	5	1.0	0.01	0.7	11	1.0	0.01	0.9	15	1.0	0.01
4	0.4	6	2.0	0.02	0.5	9	1.0	0.01	1.4	23	1.1	0.01	1.8	30	1.1	0.01
6	0.5	9	2.1	0.02	0.8	14	1.1	0.01	2.0	34	1.1	0.01	2.7	45	1.2	0.01
8	0.7	12	2.2	0.02	1.1	18	1.1	0.01	2.7	45	1.2	0.01	3.6	61	1.2	0.01
10	0.9	15	2.4	0.02	1.4	23	1.3	0.01	3.4	57	1.3	0.01	4.5	76	1.4	0.01
12	1.1	18	2.7	0.03	1.6	27	1.4	0.01	4.1	68	1.5	0.02	5.5	91	1.6	0.02
14	1.3	21	3.0	0.03	1.9	32	1.6	0.02	4.8	79	1.7	0.02	6.4	106	1.8	0.02
16	1.5	24	3.4	0.03	2.2	36	1.8	0.02	5.5	91	1.9	0.02	7.3	121	2.0	0.02
18	1.6	27	3.7	0.04	2.5	41	1.9	0.02	6.1	102	2.1	0.02	8.2	136	2.2	0.02
20	1.8	30	4.0	0.04	2.7	45	2.1	0.02	6.8	114	2.3	0.02	9.1	151	2.4	0.02
22	2.0	33	4.4	0.04	3.0	50	2.3	0.02	7.5	125	2.6	0.03	10.0	167	2.7	0.03
24	2.2	36	4.8	0.05	3.3	55	2.6	0.03	8.2	136	2.8	0.03	10.9	182	3.0	0.03
26	2.4	39	5.3	0.05	3.5	59	2.9	0.03	8.9	148	3.2	0.03	11.8	197	3.3	0.03
28	2.5	42	5.8	0.06	3.8	64	3.1	0.03	9.5	159	3.5	0.03	12.7	212	3.7	0.04
30	2.7	45	6.3	0.06	4.1	68	3.4	0.03	10.2	170	3.8	0.04	13.6	227	4.0	0.04
32	2.9	48	6.8	0.07	4.4	73	3.7	0.04	10.9	182	4.1	0.04	14.5	242	4.3	0.04
34	3.1	51	7.3	0.07	4.6	77	4.0	0.04	11.6	193	4.5	0.04	15.5	257	4.7	0.05
36	3.3	55	7.8	0.08	4.9	82	4.3	0.04	12.3	204	4.9	0.05	16.4	273	5.1	0.05
38	3.5	58	8.4	0.08	5.2	86	4.6	0.05	13.0	216	5.3	0.05	17.3	288	5.5	0.06
40	3.6	61	9.0	0.09	5.5	91	4.9	0.05	13.6	227	5.7	0.06	18.2	303	5.9	0.06
42	3.8	64	9.5	0.10	5.7	95	5.3	0.05	14.3	238	6.1	0.06	19.1	318	6.3	0.06
44	4.0	67	10.1	0.10	6.0	100	5.6	0.06	15.0	250	6.5	0.06	20.0	333	6.8	0.07
46	4.2	70	10.6	0.11	6.3	104	5.9	0.06	15.7	261	6.8	0.07	20.9	348	7.2	0.07
48	4.4	73	11.1	0.11	6.5	109	6.2	0.06	16.4	273	7.2	0.07	21.8	363	7.6	0.08
50	4.5	76	11.6	0.12	6.8	114	6.6	0.07	17.0	284	7.6	0.08	22.7	379	8.0	0.08
52	4.7	79	12.2	0.12	7.1	118	6.9	0.07	17.7	295	8.1	0.08	23.6	394	8.5	0.08
54	4.9	82	12.8	0.13	7.4	123	7.3	0.07	18.4	307	8.6	0.09	24.5	409	9.0	0.09
56	5.1	85	13.4	0.13	7.6	127	7.6	0.08	19.1	318	9.0	0.09	25.5	424	9.4	0.09
58	5.3	88	14.0	0.14	7.9	132	8.0	0.08	19.8	329	9.5	0.09	26.4	439	9.9	0.10
60	5.5	91	14.5	0.15	8.2	136	8.3	0.08	20.5	341	9.9	0.10	27.3	454	10.4	0.10
62	5.6	94	15.1	0.15	8.5	141	8.7	0.09	21.1	352	10.4	0.10	28.2	469	10.9	0.11
64	5.8	97	15.7	0.16	8.7	145	9.1	0.09	21.8	363	10.9	0.11	29.1	485	11.4	0.11
66	6.0	100	16.4	0.16	9.0	150	9.5	0.10	22.5	375	11.5	0.11	30.0	500	12.0	0.12
68	6.2	103	17.0	0.17	9.3	154	9.9	0.10	23.2	386	12.0	0.12	30.9	515	12.5	0.13
70	6.4	106	17.6	0.18	9.5	159	10.3	0.10	23.9	397	12.5	0.13	31.8	530	13.1	0.13
72	6.5	109	18.2	0.18	9.8	164	10.7	0.11	24.5	409	13.0	0.13	32.7	545	13.7	0.14
74	6.7	112	18.8	0.19	10.1	168	11.1	0.11	25.2	420	13.6	0.14	33.6	560	14.2	0.14
76	6.9	115	19.4	0.19	10.4	173	11.4	0.11	25.9	432	14.1	0.14	34.5	575	14.8	0.15
78	7.1	118	20.0	0.20	10.6	177	11.9	0.12	26.6	443	14.6	0.15	35.5	591	15.3	0.15
80	7.3	121	20.5	0.21	10.9	182	12.2	0.12	27.3	454	15.1	0.15	36.4	606	15.9	0.16
82	7.5	124	21.2	0.21	11.2	186	12.7	0.13	28.0	466	15.7	0.16	37.3	621	16.5	0.16
84	7.6	127	21.8	0.22	11.5	191	13.1	0.13	28.6	477	16.3	0.16	38.2	636	17.1	0.17
86	7.8	130	22.5	0.23	11.7	195	13.6	0.14	29.3	488	17.0	0.17	39.1	651	17.8	0.18
88	8.0	133	23.3	0.23	12.0	200	14.0	0.14	30.0	500	17.6	0.18	40.0	666	18.5	0.18
90	8.2	136	24.0	0.24	12.3	204	14.5	0.15	30.7	511	18.3	0.18	40.9	681	19.2	0.19
92	8.4	139	24.7	0.25	12.5	209	15.0	0.15	31.4	522	19.0	0.19	41.8	697	19.9	0.20
94	8.5	142	25.5	0.26	12.8	213	15.6	0.16	32.0	534	19.8	0.20	42.7	712	20.7	0.21
96	8.7	145	26.3	0.26	13.1	218	16.0	0.16	32.7	545	20.5	0.20	43.6	727	21.4	0.21
98	8.9	148	27.1	0.27	13.4	223	16.6	0.17	33.4	556	21.3	0.21	44.5	742	22.3	0.22
100	9.1	151	27.9	0.28	13.6	227	17.1	0.17	34.1	568	22.1	0.22	45.5	757	23.1	0.23
102					13.9	232	17.7	0.18	34.8	579	22.8	0.23	46.4	772	23.9	0.24
104					14.2	236	18.4	0.18	35.5	591	23.7	0.24	47.3	787	24.8	0.25
106					14.5	241	19.1	0.19	36.1	602	24.6	0.25	48.2	803	25.7	0.26
108					14.7	245	19.7	0.20	36.8	613	25.4	0.25	49.1	818	26.6	0.27
110					15.0	250	20.4	0.20	37.5	625	26.3	0.26	50.0	833	27.6	0.28
112					15.3	254	21.2	0.21	38.2	636	27.3	0.27	50.9	848	28.6	0.29
114					15.5	259	22.0	0.22	38.9	647	28.4	0.28	51.8	863	29.7	0.30
116					15.8	263	22.9	0.23	39.5	659	29.5	0.30	52.7	878	30.9	0.31
118					16.1	268	23.8	0.24	40.2	670	30.7	0.31	53.6	893	32.1	0.32
120					16.4	273	24.8	0.25	40.9	681	31.9	0.32	54.5	908	33.4	0.33
122					16.6	277	25.8	0.26	41.6	693	33.3	0.33	55.5	924	34.9	0.35
124					16.9	282	26.9	0.27	42.3	704	34.8	0.35	56.4	939	36.4	0.36
126					17.2	286	28.1	0.28	43.0	715	36.3	0.36	57.3	954	38.0	0.38
128					17.5	291	29.5	0.29	43.6	727	37.9	0.38	58.2	969	39.6	0.40
130					17.7	295	30.9	0.31	44.3	738	39.5	0.40	59.1	984	41.4	0.41
132					18.0	300	32.5	0.33	45.0	750	41.3	0.41	60.0	999	43.2	0.43
134					18.3	304	34.2	0.34	45.7	761	43.2	0.43	60.9	1014	45.2	0.45
136					18.5	309	35.9	0.36	46.4	772	45.2	0.45	61.8	1030	47.4	0.47
138					18.8	313	37.7	0.38	47.0	784	47.4	0.47	62.7	1045	49.6	0.50
140					19.1	318	39.4	0.39	47.7	795	49.7	0.50	63.6	1060	52.1	0.52
142					19.4	323	41.1	0.41	48.4	806	52.2	0.52	64.5	1075	54.6	0.55
144					19.6	327	42.8	0.43	49.1	818	54.8	0.55	65.5	1090	57.4	0.57
146					19.9	332	44.6	0.45	49.8	829	57.6	0.58	66.4	1105	60.3	0.60
148					20.2	336	46.3	0.46	50.5	840	60.5	0.61	67.3	1120	63.4	0.63
150					20.5	341	48.0	0.48	51.1	852	63.7	0.64	68.2	1136	66.7	0.67

Only on low viscosity, lubricating liquids (diesel, kerosene, etc.) subject to usual limits on total Delta P. Only on liquids with some viscosity (diesel fuel and higher)

Notes:

Notes:

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