METER DISASSEMBLY PROCEDURE – 4” through 12” GTS/GTX Meters

Remove the Index or Correcting Device mounted on the gear train housing with 4 screws.

Remove the gear train held with 3 screws. Inspect gear train for wear or damage. The gear train should turn easily by spinning the output drive wriggler. Also, inspect the O-ring above the magnet drive. Replace if damaged.

Next, mark the position of the gear train housing with a pencil. Remove the 4 socket head screws. Lift the gear housing away from the cartridge top plate. Inspect the O-ring at the bottom of the gear housing for damage. Replace if damaged.

Lift the driving magnet out of the cartridge top plate. The magnet should spin freely in the shaft holder.

Remove the measurement cartridge by first removing the O-ring at the bottom of the gear housing for damage. Then, inspect the O-ring at the bottom of the gear housing. Replace if damaged.

Remove the inlet Flo-Guide held with 3 screws. Inspect the straightening vanes for damage and/or dirt buildup. Clean with a mild detergent.

Remove the outlet flow conditioner held by 1 screw in the cartridge opening. Clean and inspect. (GTS only)

Cartridge Disassembly

The measurement unit housing is held to the underside of the top plate with 4 pan head screws. Separate the measurement housing from the top plate, exposing the intermediate gears. Remove the intermediate gears held by cotter pins. Mark the positions of the gears and housing “A” and “B” for reassembly.

To remove the upshaft below the intermediate gear, remove the retaining ring and lift up on the shaft. The bearing can now be removed and inspected and/or oiled.

The rotor is fastened to the rotor shaft with a washer and locknut. Grasp the rotor and remove the locknut. Slide the rotor off the shaft, being careful not to drop the shaft locking pin. Inspect the rotor for missing or damaged blades. If the rotor is not damaged, clean with a damp cloth and a mild detergent. Remove the shim and dust shield behind the rotor.

Next, remove the end cover on the opposite side of the measurement unit held by 2 flat head screws. Inspect and clean the vent screen in the center of the cover plate. The vent allows the clean chamber behind the cover plate to equalize pressure.

To remove the rotor shaft/bearing holder assembly, remove the spring nut located behind the rotor. Slide the bearing assembly out of the measurement unit housing. Inspect the assembly for wear of the main rotor bearings or wear of the worm and worm gear. It is recommended that this assembly be replaced as a complete assembly, if required. Clean and inspect the measurement housing.

Cartridge Reassembly

Insert the bearing holder into the measurement housing, being careful to align the locating pin with the hole in the bearing holder. Secure the bearing holder with the spring nut.

Replace the bearing dust shield and shim on the rotor shaft. Place the locking pin in the shaft groove, align the rotor groove with the groove in the rotor shaft and slide the rotor into position. Secure the rotor with the washer and lock nut. Install the upshaft through the cartridge hole until it fully engages the drive coupling on the bearing holder. Slide the upshaft ball bearing in place and install the retaining ring. Install the adjacent ball bearing and retaining ring. Place the intermediate gears in original positions and fasten with cotter pins. Spin the rotor to be certain the assembly turns freely.

Attach the end cover to the outlet side of the cartridge with 2 flat head screws.

The cartridge measurement assembly can now be fastened to the underside of the top plate with 4 pan head screws. Make certain the gasket between the top plate and cartridge is aligned correctly.

Install the driving magnet assembly in the center of the top plate with the O-ring under the magnet drive. The driven magnet shaft must seat in the coupling of the intermediate gear assembly. Spin the rotor. Check the driving magnet for smooth rotation. Assemble the gear train housing and O-ring with 4 socket head screws, noting the correct position by the pencil lines. Install the gear train using 3 screws.

The cartridge is now ready for spin testing and calibration. See Page 7 for the spin testing procedure.

Note: Always record the final spin time and date on the meter records and/or calibration sheet after recommissioning. The spin time will be used as a comparison for future spin tests.

GENERAL DESCRIPTION

Meters used in the gas industry fall into two general categories: either positive displacement or inferential. Meters in the positive displacement category are diaphragm and rotary. Inferential types include turbine and orifice meters.

Diaphragm and rotary meters measure gas with compartments that alternately fill and empty. A slight pressure drop across the meter causes the meter and its measurement compartments to rotate. Each stroke of the diaphragm meter and each revolution of the rotary meter traps a small volume of gas, delivering it to the meter outlet.

TYPICAL METER PERFORMANCE

The graph of Fig. 3 shows a typical accuracy curve for the GTS meter. As shown, rated rangeability over the ±1% band is the ratio of maximum flow rate (Qmax) to minimum flow rate (Qmin). Rangeability of GTS meters becomes greater with increasing line pressures.

METER PRESSURE DROP (Differential Pressure in Inches W.C.)

Meter Differential Pressure

The approximate differential pressure developed across the turbine meter at operating conditions can be calculated using the following formula.

\[ \Delta P = \Delta P_{avg} \times \frac{Q}{Q_{max}} \times \left[ 1 - \frac{S}{0.60} \right] \]

Example:

Calculate the differential for the following conditions:

- 6” GTS (ΔPavg = 3.3 in. w.c., Qmax = 35,000 ACFH)

\[ \Delta P = 3.3 \times 60 + 14.48 \times 0.64 \times \frac{Q}{35,000} \]

\[ \Delta P = 11 \text{ in. w.c.} \]

Average Differential Pressures

@ Q = Qmin and @ 0.25 psig in inches w.c.

- 3” GTS 4” GTS 6” GTS 8” GTS 12” GTS

- 45° Rotor 4.5 2.4 3.3 1.6 2.1

- 30° Rotor N/A 3.9 8.9 3.4 N/A

BASIS OF CAPACITY TABLES

Capacity tables are contained in Sales Bulletin SB 4510 in both English and metric units. The tables include values of Qmax and Qmin in standard ft³/hr or M³/hr. Units at each gauge pressure listed. Standard capacities are shown for 45° rotor angle. Extended capacities are listed for 30° rotor angle. The top plate of the meter cartridge is labeled 30° or 45° rotor angle.

Maximum Flow Rates at elevated pressures are equal to the base flow rate at 0.25 psig times the pressure factor, times the compressibility ratio “S” and are independent of the specific gravity of the gas being measured.

\[ Q = Q_{base} \times 0.25 \text{ psig} \times P_{avg} \times \frac{S}{P_{o}} \]

Where \( P_{o} = \) gauge press., \( P_{avg} = \) atm. press., \( S = \) base press., \( S = \) comp. ratio

Minimum Flow Rates are based on the minimum rotor speed that produces a measurement accuracy within an error band of ±1%, as shown in Fig. 3.

Fig. 1

Turbine meters contain no measurement compartments. Instead, a rotor with multiple blades is placed directly in the gas stream. Gas flows through the meter, passing through the rotor blades, causing the rotor to turn. The rotor rotational speed is proportional to the gas flow rate, which is directly related to the gas velocity at the rotor. This is why turbine meters are sometimes referred to as velocity meters.

Fig. 2

Turbine meter rotor revolutions are converted to measured volume by means of internal gearing, resulting in meter output shaft revolutions in either cubic feet or cubic meters. In addition to a mechanical output, turbine meters may be also equipped with high frequency pulsers, where each pulse represents a small increment of volume, defined during meter calibration as a “K” factor.

Since turbine meters measure gas by sensing gas velocity, proper installation is essential, to make certain the gas is uniform as it approaches the measuring element.

Fig. 3

The graph of Fig. 3 shows a typical accuracy curve for the GTS meter. As shown, rated rangeability over the ±1% band is the ratio of maximum flow rate (Qmax) to minimum flow rate (Qmin). Rangeability of GTS meters becomes greater with increasing line pressures.

Fig. 4

This is why turbine meters are sometimes referred to as velocity meters.

Fig. 5

Since turbine meters measure gas by sensing gas velocity, proper installation is essential, to make certain the gas is uniform as it approaches the measuring element.
A temperature factor is not included in equations A & B since it has minimal affect on $Q_{in}$. 

**METE SIZING**

**Base Conditions**

\[
\begin{array}{l}
\text{P}_{in} = 14.73 \text{ psia} \\
\text{P}_{out} = 14.48 \text{ psia} \\
\text{T}_{in} = 60°F = 60°C \text{ or } 273 \text{ for K} \\
\text{Tf} = \text{Temperature of flowing gas} + 460 \text{ for °R} \text{ or } + 273 \text{ for K} \\
\text{Pa} = 14.48 \text{ psia} \text{ or } 101.325 \text{ kPa absolute} \\
\text{Pb} = 14.73 \text{ psia} \text{ or } 101.325 \text{ kPa absolute} \\
\text{Sp.Gr.} = 0.64 \\
\text{S} = 1.009 \\
\end{array}
\]

If the required flow rate is given in Standard Cubic Feet (or meters) per hour, (SCFH or SCMH) convert this value to actual Cubic Feet (or meters) per hour, e.g.

\[
Q = Q_{in} \times \text{Sp.Gr.} \times \sqrt{\frac{P_{in} + P_{out}}{P_{in}}}
\]

Select the meter with the smallest $Q_{in}$ (0.25 psig or 2.0 kPa) that is larger than Q.

**Example:** Select the proper meter size to handle 145,000 SCFH at 60 psig, $S = 1.009$

\[
Q = 145,000 \times 14.73 \times 1/1.009 = 28,421 \text{ ACFH}
\]

Choose a 6” GTS with $Q_{in} = 35,000 \text{ CFH}$ (45° rotor).

Rangability increases with increased gas density which can result from either increased operating pressure or specific gravity of the gas at a particular pressure:

\[
\text{Rangability} = \text{Rangability}_{in} \times \text{Sp.Gr.} \times \sqrt{\frac{P_{in} + P}{P_{in}}}
\]

\[
\text{Example: From above, 6” GTS (Rangability}_{in} = 18 \text{ PSIG} = 60 \text{ psig Sp.Gr.} = 0.64)
\]

\[
\text{Rangability} = 18 \times \frac{14.73}{14.48} \times \frac{0.64}{0.60} = 14.73 \times 0.60 \times 1.009 = 42 \text{ or } 42:1
\]

Minimum flow rate, $Q_{min}$ is:

\[
Q_{min} = \frac{Q}{50} \times \frac{0.60}{0.60} \times 1.009 = 42 \text{ or } 42:1
\]

Recommended meter installation requires a minimum of 10 pipe diameters upstream, with straightening vanes located 5 pipe diameters from the meter inlet as shown in Fig. 5. A length of 5 pipe diameters is recommended downstream of the meter. Both inlet and outlet piping should be the same nominal size as the meter.

The purpose of the 10 diameters of straight inlet piping is to remove jetting and swirl from the gas stream before the gas reaches the turbine rotor.

Jetting, shown in Fig. 6, is non-uniform gas velocity within the pipe, and can be caused by an upstream regulator, a valve, an elbow or a misaligned flange gasket. Jetting will cause the meter to over-register since the rotor responds to the higher, not the average velocity, in the pipe. For this reason, temperature wells and pressure taps should be located in the downstream piping. Any pressure tap fitting in the upstream piping should be ground flush with the inside pipe wall.

Swirl, Fig. 7, is a condition where the gas velocity is not totally parallel to the axis of the pipe, but has a spiral component. It may be caused by upstream valves, elbows or other fittings. Swirl in the direction of the rotor rotation will cause the turbine meter to over-register and vice-versa.

**INSTALLATION**

Minimum flow rate, $Q_{min}$ is:

\[
Q_{min} = \frac{Q}{50} \times \frac{0.60}{0.60} \times 1.009 = 42 \text{ or } 42:1
\]

**RECOMMENDED INSTALLATION**

GTS Meters in sizes from 4” through 12” have ANSI 150, 300 or 600 flanges, depending on the pressure rating.

The 3” GTS bolts between flanges as shown in Fig. 4. GTX Meters in sizes 4” through 8” have ANSI 150 flanges.

**Measurement Unit Disassembly – 3” GTS Meters**

Examine the rotor for dirt buildup, damaged or missing blades. Replace the rotor if damaged. To remove the rotor, place the left hand around the outside diameter of the rotor and loosen the locknut, Item 5, with a 3/8-inch wrench, Fig. B. Pull the rotor off of the shaft, being careful not to drop the shaft key, Item 6. Remove the key and bearing dust shield.

Remove the inlet Flo-Guid® diffuser held by 2 screws, Item 7. Also remove the “Clean Chamber” cover plate and gasket, Items 8 and 9.

Remove 2 pan head screws from recessed holes in the bearing housing. Carefully slide out the bearing housing, Item 10, which is aligned with the measurement unit housing by a pin. Inspect the worm gear and spin the shaft. It should turn freely.

Remove the worm, gear and shaft assembly, Item 11, which has a ball bearing at each end. Inspect the helical worm, the gear and check the ball bearings are free turning.

Remove the nut and lockwasher, Item 12, from the end of the main rotor shaft. Then unscrew the 10-tooth pinion from the main rotor shaft, Item 13.

**Measurement Unit Reassembly – 3” GTS Meters**

Install the upstream main rotor bearing and the “C”-ring. Replace the rotor shaft and downstream rotor bearing from the downstream end of the measurement unit housing. Replace the “C”-ring.

Screw on the 10-tooth pinion (large hole first) and tighten gently. Install the lockwasher and nut and tighten gently using the screwdriver slot at the end of the rotor shaft.

Install the worm, gear and shaft assembly, with ball bearings at each end.

Install the gear housing, being careful to engage the alignment pin into the measurement unit housing and to engage the ball bearing of the worm and gear shaft into the gear housing. DO NOT FORCE THE GEAR HOUSING INTO POSITION. Secure with 2 pan head screws.

Place the “Clean Chamber” gasket and cover over the gear housing and align the mounting holes. Place the inlet Flo-Guid® over the cover plate and align the same 2 holes. Secure Flo-Guid® with 2 flister head screws.

Install the bearing dust shield and key in the rotor shaft, making certain the key has no burrs and that its flat edge is parallel with the rotor shaft.

Install rotor (hub side out) and retaining nut and tighten.

Slide the measurement unit into the body housing from the inlet end until the worm gear drive dog is directly below the output shaft hole.

Install the outlet diffuser with 2 screws.

Install the wary spring washer into the output shaft hole. Then install the driving magnet assembly into the output shaft hole making certain to engage the drive dog without forcing it.

Now assemble the gear housing (after applying grease to the O-ring at the base), using 4 hex socket screws. The casting number on the gear housing should be facing the front of the meter.

Install gear train assembly with 3 round head screws.

The meter is now ready for spin testing and calibration.
SHOP MAINTENANCE PROCEDURES

The paragraphs that follow describe the step-by-step meter disassembly procedure. Partial or complete disassembly may be necessary, as determined by the spin test or the proving results.

Conduct a spin test of the returned meter or cartridge and compare results to the original “as-new” results. Follow the spin test guidelines described above.

Lubricate the meter or cartridge and exercise the meter for approximately 10 minutes to work out the excess oil. Prove the meter or cartridge at flow rates up to 50% or higher with emphasis on the low end, 5% to 25%, where increased friction will have the greatest effect on accuracy. Compare the proof results to the meter’s original results. If the meter’s spin test and/or proof performance is unsatisfactory, inspect for rotor damage, dirt buildup in the flow passages, gearing binds or bearing wear.

METER DISASSEMBLY PROCEDURE - 3” GTS METERS

Remove the index or correcting device and base plate, held with 4 screws. This will expose the gear train assembly under the base plate, Fig. A.

Remove the gear train held with 3 screws, Item 1, Fig. A. Inspect for wear or damage. The gear train should turn easily by spinning the output drive wriggler. Also inspect the O-ring or gasket above the magnet drive. Replace if damaged. Next, remove the gear housing, held with 4 socket head screws, Item 2. Lift the gear housing away from the meter body and inspect the O-ring at the bottom of the gear housing. Replace if damaged. Lift the driving magnet assembly out of the meter body, Item 3. Also remove the wavy washer under the magnet drive. Item 4. The magnet shaft should spin freely in the shaft holder. The entire measurement unit can now be removed from the inlet end of the meter, Fig. B. Grasp the inlet Flo-Guide® and pull the measurement section forward, being careful not to damage the rotor. Remove the outlet Flo-Guide®, held to the meter body with 2 screws. The inside of the body can be inspected for dirt buildup and cleaned. Make certain the lubricating hole on the inside of the body, adjacent to the lubricating fitting, is not clogged.

OPTIONAL INSTALLATIONS

The following installations may result in some degradation in meter accuracy, and should only be used where space does not permit the recommended installation shown in Fig. 5.

Short Coupled Installation

This configuration uses a minimum of 4 pipe diameters ahead of the head of the meter with straightening vanes a minimum of 2 pipe diameters from the meter inlet, Fig. 8. The meter is connected to vertical risers using a standard tee, as shown, to minimize jetting and to facilitate field proving.

The maximum pipe reduction to the risers is one nominal pipe size. Valving, filters or strainers may be installed in the risers.

Close Coupled Piping

This installation would be used where the available space is critical and design considerations have eliminated jetting and abnormal swirl conditions. The meter is connected to vertical risers using a tee as shown. The maximum pipe reduction to risers is one pipe size. Valving, filters or strainers may be installed in the risers.

STRAINERS or FILTERS – CAUTION

Important: Foreign matter in a pipe line, such as welding slag, can cause SERIOUS damage to turbine meters. Upstream piping must be cleared of all foreign matter before the meter is installed and commissioned.

Strainers are recommended where large particles may be present in the piping. They should be selected to operate with low flow distortion.

Filters are recommended where wide pressure fluctuations and dust are present in the pipe. Monitor the pressure drop across the filter to determine the need to replace the filter element.

OVER-RANGE PROTECTION

Turbine meters can be operated up to 150% of capacity for short periods with no damaging effects. However, line blowdowns can cause severe over-ranging of the turbine rotor, causing possible rotor and/or bearing damage. In those installations where adequate pressure is available, either a critical flow orifice or a sonic nozzle may be installed downstream of the meter. It should be sized to limit the meter to approximately 120% of the meter’s rated capacity.

BY-PASS PIPING

By-pass piping will allow the meter to be maintained and calibrated without a service interruption. This should include proper valving relative to the calibration equipment used. When tees are used in by-pass piping for the purpose of transfer proving, make certain the tee connections are in line with the axis of meter flow and are the same pipe diameter as the pipe to avoid jetting and possible calibration errors.

ADDITIONAL INSTALLATION REMINDERS

Add oil – see Lubrication Section, page 6.

Minimize pipe stresses on the meter.

Make certain piping and gaskets are aligned properly to avoid possible errors caused by jetting.

No welding should be done in the immediate area of the meter.

Where liquids may be present, do not install the meter in the low point in the line.

When installation is complete, pressurize the meter slowly and bring the meter up to speed gradually. Shock loading by opening valves quickly will usually result in rotor damage. Perform a leak test with a bubble solution or other approved method.

MAINTENANCE

Routine turbine meter maintenance will insure accuracy and enhance the service life of the meter. Turbine meter maintenance consists of:

Lubrication Inspection
Spin Testing Cleaning
Repair Calibration
Proof Adjustment Cartridge Replacement

Short Coupled Installation

This configuration uses a minimum of 4 pipe diameters ahead of the head of the meter with straightening vanes a minimum of 2 pipe diameters from the meter inlet, Fig. 8. The meter is connected to vertical risers using a standard tee, as shown, to minimize jetting and to facilitate field proving.

The maximum pipe reduction to the risers is one nominal pipe size. Valving, filters or strainers may be installed in the risers.

Close Coupled Piping

This installation would be used where the available space is critical and design considerations have eliminated jetting and abnormal swirl conditions. The meter is connected to vertical risers using a tee as shown. The maximum pipe reduction to risers is one pipe size. Valving, filters or strainers may be installed in the risers.

STRAINERS or FILTERS – CAUTION

Important: Foreign matter in a pipe line, such as welding slag, can cause SERIOUS damage to turbine meters. Upstream piping must be cleared of all foreign matter before the meter is installed and commissioned.